Fw: Review of manuscript

Paul Gunning to: Peter Tsirigotis 05/25/2012 04:32 PM

Peter - Hope all is well with you....

Per my voicemail, I wanted to make sure you are aware of this. I just read through this revision and I have some concerns/questions as oil and gas/climate issues are very sensitive these days. I will be following up with my folks but I wanted to flag it and see if you had any reactions.....

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 05/25/2012 04:12 PM -----

From: Ozge Kaplan/RTP/USEPA/US
To: Alex Macpherson/RTP/USEPA/US@EPA
Cc: Andy Miller/RTP/USEPA/US@EPA, Bruce Moore/RTP/USEPA/US@EPA, Darryl Weatherhead/RTP/USEPA/US@EPA, David Cozzie/RTP/USEPA/US@EPA, Lydia Wegman/RTP/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Melissa Weitz/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Peter Tsirigotis/RTP/USEPA/US@EPA, Ron Evans/RTP/USEPA/US@EPA, Suzanne Waltzer/DC/USEPA/US@EPA
Date: 05/25/2012 03:17 PM
Subject: Re: Review of manuscript

Dear Alex et al.,

Thank you for taking time to review the manuscript. We have incorporated all the comments raised by OAR into our final version. Please find attached the final revised version of the paper. To comply with the journal word limit requirements, I moved some of the figures and tables into supporting information. That file is also attached.

Please let us know if you have any questions.

Have a great Memorial Day weekend.
Ozge

P. Ozge Kaplan, Ph.D.

Research Environmental Engineer
U.S. EPA | ORD | NRMRL | APPCD | APB
109 T.W. Alexander Drive | Mail Drop: E305-02 | Research Triangle Park, NC 27711
+1.919.541.5069 (office) | +1.919.541.7885 (fax) | kaplan.ozge@epa.gov

SI_v1.docx NG LCI Analysis-v16.docx

Alex Macpherson Andy You're welcome, and thanks again for ch... 05/21/2012 12:46:43 PM

From: Alex Macpherson/RTP/USEPA/US
To: Andy Miller/RTP/USEPA/US@EPA
Cc: Bruce Moore/RTP/USEPA/US@EPA, Darryl Weatherhead/RTP/USEPA/US@EPA, David Cozzie/RTP/USEPA/US@EPA, Lydia Wegman/RTP/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Melissa Weitz/DC/USEPA/US@EPA, Ozge Kaplan/RTP/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Peter

Tsirigotis/RTP/USEPA/US@EPA, Ron Evans/RTP/USEPA/US@EPA, Suzanne Waltzer/DC/USEPA/US@EPA
Date: 05/21/2012 12:46 PM
Subject: Re: Review of manuscript

Andy

You're welcome, and thanks again for chance to review. We look forward to seeing the next draft.

Alex

-----Andy Miller/RTP/USEPA/US wrote: -----
To: Alex Macpherson/RTP/USEPA/US@EPA
From: Andy Miller/RTP/USEPA/US
Date: 05/20/2012 05:15PM
Cc: Bruce Moore/RTP/USEPA/US@EPA, Darryl Weatherhead/RTP/USEPA/US@EPA, David Cozzie/RTP/USEPA/US@EPA, Lydia Wegman/RTP/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Melissa Weitz/DC/USEPA/US@EPA, Ozge Kaplan/RTP/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Peter Tsirigotis/RTP/USEPA/US@EPA, Ron Evans/RTP/USEPA/US@EPA, Suzanne Waltzer/DC/USEPA/US@EPA
Subject: Re: Review of manuscript

Thanks, Alex. We'll have a revised draft out soon and will send it around.

Andy
==========
C.A. (Andy) Miller, Ph.D.
National Program Director (acting) for Global Change Research
EPA Office of Research and Development
Research Triangle Park, NC 27711
Ph: 919-541-2920
Cell: 919-699-3072
Fax: 919-541-7885

-----Alex Macpherson/RTP/USEPA/US wrote: -----
To: Ozge Kaplan/RTP/USEPA/US@EPA, Andy Miller/RTP/USEPA/US@EPA
From: Alex Macpherson/RTP/USEPA/US
Date: 05/18/2012 03:23PM
Cc: Melissa Weitz/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Suzanne Waltzer/DC/USEPA/US@EPA, Ron Evans/RTP/USEPA/US@EPA, Darryl Weatherhead/RTP/USEPA/US@EPA, Bruce Moore/RTP/USEPA/US@EPA, David Cozzie/RTP/USEPA/US@EPA, Peter Tsirigotis/RTP/USEPA/US@EPA, Lydia Wegman/RTP/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA
Subject: Review of manuscript

Dear Ozge and Andy,

Attached is our review of your draft manuscript "Comparison of lifecycle greenhouse gas emissions from electricity generation: Coal, conventional and unconventional natural gas". Thank you for the opportunity to review, and we hope you find the review helpful.

We are happy to discuss comments in person if you wish. We also would be happy to provide

comments future drafts of the paper as it is further developed.

Also, with this email, I'm asking that the OAR staff included on this email to not re-circulate this manuscript because it is still under revision. Thanks.

Best,
Alex
(See attached file: NG LCI Analysis-v12 051112 OAR Review v2 .docx)

Summary Comments

This review was provided by OAR technical staff (from OAP and OAQPS, specifically) who have expertise in the oil and natural gas industry, as well as expertise in climate economics and climate change metrics. While we find the paper interesting, well researched, and well-written, we have a number of comments, both major and minor.

The appended word document provides a series of comments and suggestions, as well as some minor proofreading suggestions incorporated through the track changes function. We learned mid-review (of v12) that there is a more recent draft (v13) so some of these suggestions, such as citations of recent literature, may have already been adopted. We also use this email to summarize technical issues or suggestions that we think could improve the paper.

(b)(5) deliberative

[redacted]

[redacted]

[redacted]

(b)(5) deliberative

Additional comments

(b)(5) deliberative

(b)(5) deliberative

[attachment "NG LCI Analysis-v12 051112 OAR Review v2 .docx" removed by Andy Miller/RTP/USEPA/US]

Meeting Invitation Delegated:

Calendar Entry

Subject:	IPCC WG3 Chapter Lead identification
When	
Date:	Thursday 02/07/2013
Time:	12:00 PM - 01:00 PM (1 hour)
Chair:	ReidmillerDR@state.gov
Invitees	
Required (to):	Paul Gunning; Robert.Marlay@hq.doe.gov; Lindsay.Brumbelow@hq.doe.gov; TalleyT@state.gov; MeiselJS@state.gov
Optional (cc):	
Delegated to:	irving.bill@epa.gov
Where	
Attachments:	DOE-PI_Potential WG3 Reviewers_2013.01.29.xlsx IPCC AR5 WGIII_Outline.pdf

---

When: Thursday, February 07, 2013 12:00 PM-1:00 PM (GMT-05:00) Eastern Time (US & Canada) - Updated for 2007.

Note: The GMT offset above does not reflect daylight saving time adjustments.

~~*~*~*~*~*~*~*~*

Paul et al-

To follow on to Trigg's email from earlier today, please find attached a very helpful, detailed spreadsheet of potential Chapter Leads and Chapter Reviewers (duties and time commitment enumerated below) that Bob Marlay (DOE) and company put together for the Government Review of the IPCC WG3 report. In a call with Bob this afternoon, we felt it would be useful for all of us to review the chapter-specific lists of potential reviewers to identify possible Leads and then discuss in a call Thursday. Hopefully, the noon timeslot works for everyone (call-in information is at the very bottom of this email).

Chapter Leads

- Help recruit USG experts to review assigned chapters
  (now through Feb 25)
- Review and comment on the Chapter(s) they are Lead on
  (Feb 25 – Mar 27)
- Convene telecons as needed with chapter reviewers to ensure they are reviewing, discuss common concerns, etc.
  (Feb 25 – Mar 27)
- Attend 3-day workshop in DC with other Chapter Leads to help compile USG submission
  (Apr 2-4)

The role of the Chapter Lead would be mostly complete by Apr 4 (i.e., after the DC Workshop). There will be nothing required of them until the Final Government Distribution is released. At that time (Dec 13, 2013 – Jan 10, 2014), they may be asked to review their chapter (pulling in original reviewers if needed) to ensure comments were addressed sufficiently.

Chapter Reviewers

- Review and comment on their specified chapter(s)

(Feb 25 – Mar 27)

- Participate in conference calls convened by the Chapter Lead (Feb 25 – Mar 27)

The role of Chapter Reviewer would be complete by Apr 2, with the possibility of being asked to read the revised chapter(s) in the Winter 2013-14.

If you have any questions, please don't hesitate to call (202-647-3961).

Thanks-
David

David Reidmiller, PhD
Physical Science Officer
U.S. State Department
Office of Global Change (OES / EGC)
Office: +1-202-647-3961
Mobile: +1-202-341-4709
http://www.state.gov/e/oes/climate/index.htm

1) Call-in using the following numbers:

a. Calling from inside the U.S.: (b)(6) privacy

b. Calling from outside the U.S.: (b)(6) privacy

2) Enter the passcode to join: (b)(6) privacy

3) To sign in as a participant, press #.

- DOE-PI_Potential WG3 Reviewers_2013.01.29.xlsx - IPCC AR5 WGIII_Outline.pdf

From:	Joseph Goffman
To:	(b)(6) privacy - Roque Sanchez; (b)(6) privacy - Rick Duke
Cc:	Paul Gunning; Joel Beauvais; Sarah Dunham
Subject:	Domestic and Global GHG emissions by sector for 2012 and 2030
Date:	01/15/2013 06:41 PM
Attachments:	Emissions Projections Question from Rick Duke_2.xlsx

---

Forwarding material from Paul Gunning and colleagues. Thanks.

Joseph Goffman
Senior Counsel to the Assistant Administrator
Office of Air and Radiation
US Environmental Protection Agency
202 564 3201

(b)(5) deliberative [redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]

(b)(5) deliberative

-
-
-
-
-
-

(b)(5) deliberative [redacted]

[redacted]

[redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

From:	Rona Birnbaum
To:	Sarah Dunham
Cc:	Paul Gunning
Subject:	EPA Adaptation Plan and OAQPS
Date:	05/03/2012 05:31 PM
Attachments:	OAR table.pdf OAQPS information in EPA Plan.docx

---

As discussed:

(b)(5) deliberative [redacted]

[redacted]

From:	Sarah Dunham
To:	Steve Page
Bcc:	Paul Gunning
Subject:	EPA Adaptation Plan
Date:	05/03/2012 08:52 PM
Attachments:	OAR table.pdf OAQPS information in EPA Plan.docx

---

Steve-
Following up on our discussion I asked Rona to pull out some of the specific pieces that you might want to read--see her note below. (b)(5) deliberative [redacted]

I will make sure going forward to keep an eye out for implications for your office.
Sarah

▼ Rona Birnbaum

----- Original Message -----
From: Rona Birnbaum
Sent: 05/03/2012 05:31 PM EDT
To: Sarah Dunham
Cc: Paul Gunning
Subject: EPA Adaptation Plan and OAQPS

As discussed:

(b)(5) deliberative [redacted]

[redacted]

From: Paul Gunning
To: Ben DeAngelo; Marcus Sarofim
Subject: Fw: Appeals court denies rehearing of EPA greenhouse gas case
Date: 12/21/2012 08:14 AM
Attachments: GHG Litigation - DRAFT Talking Point for Rehearing Petition ogc.docx
GHG petition denials.pdf

FYI.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 12/21/2012 08:13 AM -----

From: Isabel DeLuca/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Suzanne Kocchi/DC/USEPA/US@EPA, Erin Birgfeld/DC/USEPA/US@EPA, Anhar Karimjee/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA, Allen Fawcett/DC/USEPA/US@EPA
Date: 12/20/2012 11:41 AM
Subject: Fw: Appeals court denies rehearing of EPA greenhouse gas case

---

FYI -- in case you haven't seen yet.

----- Forwarded by Allison Dennis/DC/USEPA/US on 12/20/2012 11:33 AM -----

From: Allison Dennis/DC/USEPA/US
To: Cathy Milbourn/DC/USEPA/US@EPA, Enesta Jones/DC/USEPA/US@EPA, Julia Valentine/DC/USEPA/US@EPA
Cc: Nate McMichael/DC/USEPA/US@EPA
Date: 12/20/2012 11:00 AM
Subject: Fw: Appeals court denies rehearing of EPA greenhouse gas case

---

FYI on story

AND

(b) (5) [redacted]

Allison Dennis
U.S. Environmental Protection Agency
Office of Air and Radiation Communications

Phone: 202-564-1985
Send mail to:
U.S. Environmental Protection Agency
MC: 6101A
1200 Pennsylvania Ave., NW

Washington, DC 20460

----- Forwarded by John Millett/DC/USEPA/US on 12/20/2012 10:42 AM -----

From: POLITICO Pro Whiteboard <politicoemail@politicopro.com>
To: John Millett/DC/USEPA/US@EPA
Date: 12/20/2012 10:34 AM
Subject: Appeals court denies rehearing of EPA greenhouse gas case

---

12/20/12 10:31 AM EST

The U.S. Court of Appeals for the D.C. Circuit has denied petitions for an en banc rehearing of cases challenging EPA's finding that greenhouse gases are a danger to human health and welfare and several regulations that followed. Two judges voted in favor of the petitions for rehearing and penned dissenting opinions on the denial. The order: http://politico.pro/U0w4yF

You've received this POLITICO Pro content because your customized settings include:

- *Energy Whiteboards*

To change your alert settings, please go to https://www.politicopro.com/member/?webaction=viewAlerts.

This email alert has been sent for the exclusive use of POLITICO Pro subscriber John Millett. Copyright © 2012 by POLITICO LLC. To subscribe to Pro, please go to www.politicopro.com.

From:	Rona Birnbaum
To:	Paul Gunning
Subject:	Fw: Climate Multipollutant Science Assessment workshop slides - for your review
Date:	04/30/2012 04:02 PM
Attachments:	climate consult - dutton - 2012-04-30.pptx

---

fyi - our comments on the attached [problematic] ORD slides:

Steve,

Thanks so much for providing the materials. Rona and I talked through the presentation and we connected with Lydia, and am providing some comments here:

(b)(5) deliberative [redacted]

thanks,

-Ben

Benjamin J. DeAngelo
Senior Analyst
Climate Change Division, Office of Atmospheric Programs
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW (6207J)
Washington, DC 20460

----- Forwarded by Rona Birnbaum/DC/USEPA/US on 04/30/2012 04:00 PM -----

From: John Vandenberg/RTP/USEPA/US
To: Lydia Wegman/RTP/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA

Cc: Steven Dutton/RTP/USEPA/US@EPA, ross.mary@epa.gov
Date: 04/30/2012 12:21 PM
Subject: Climate Multipollutant Science Assessment workshop slides - for your review

---

Hi Lydia, here are draft slides for tomorrow's MSA meeting; your comments can be inserted starting around slide 24.

Rona, we welcome your comments!

Please provide any additions/comments **today s**o we can have this ready to go first thing tomorrow morning.

Thanks,

John

John Vandenberg, PhD
Director, RTP Division
National Center for Environmental Assessment B243-01
Office of Research and Development, USEPA
Research Triangle Park, NC 27711

Tel: 919 541 4527
Fax: 919 541 5078

From: Reid Harvey
To: Paul Gunning
Subject: Fw: Compiled comments on IDR draft report
Date: 07/11/2012 09:25 AM
Attachments: EPA Responses to IDR draft.docx

FYI - you may recall that Jameel volunteered to collate comments on this. We can discuss at our 10am meeting today.

Reid

----- Forwarded by Reid Harvey/DC/USEPA/US on 07/11/2012 09:25 AM -----

From: Jameel Alsalam/DC/USEPA/US
To: Maurice LeFranc/DC/USEPA/US@EPA
Cc: Leif Hockstad/DC/USEPA/US@EPA, BrianB Cook/DC/USEPA/US@EPA, Susan Wickwire/DC/USEPA/US@EPA, Jim Ketcham-Colwill/DC/USEPA/US@EPA, Sara Ohrel/DC/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA
Date: 07/10/2012 06:19 PM
Subject: Compiled comments on IDR draft report

Maurice and everybody,

Attached are the compiled comments. Included are comments from Susan Wickwire, OTAQ, Jim Ketcham-Colwill, Leif Hockstad, Sara Ohrel and myself. Susan also provided the PAMs section to SPD and OAQPS so some more comments on those sections might be coming.

Some major points in the edits:
(b)(5) deliberative [redacted]

best,
Jameel

Jameel Alsalam
Economist, Climate Economics Branch
U.S. Environmental Protection Agency
voice: 202-343-9807
fax: 202-343-2202
alsalam.jameel@epa.gov

From: Paul Gunning
To: craig.beth@epa.gov
Cc: krieger.jackie@epa.gov; Ben DeAngelo
Subject: Fw: Current draft of endangerment brief -- comments due COB Friday
Date: 08/10/2011 08:03 AM
Attachments: ENV_DEFENSE-#546103-v1-endangerment_revised_COMPLETE_draft_august_9_2011.DOC

Beth,

We now a final draft version of the endangerment brief for review (see Ben's note below). I assume you will want to send to Gina. It is a quick turnaround and our deadline is COB Friday.

Since it is a little on the long side, a couple of notes to focus review:

- (b) (5) [redacted]
- [redacted]
- [redacted]

Let me know if you have any questions.

Thanks

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 08/10/2011 07:58 AM -----

From: Ben DeAngelo/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Rona Birnbaum/DC/USEPA/US@EPA
Date: 08/09/2011 04:59 PM
Subject: Fw: Current draft of endangerment brief -- comments due COB Friday

---

Paul,

Here's the draft endangerment brief we just received back from DOJ, incorporating our and OGC's comments from the past several weeks.

Please forward on to Beth for Joe/Gina and any others as needed.

Note OGC's deadline of COB this Friday -- same deadline OGC management is getting.

Let me know if you/Beth or others need anything clarified.

-Ben

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 08/09/2011 04:55 PM -----

From: Carol Holmes/DC/USEPA/US
To: Ben DeAngelo/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Jeremy Martinich/DC/USEPA/US@EPA

Cc: Rona Birnbaum/DC/USEPA/US@EPA, John Hannon/DC/USEPA/US, Steven Silverman/DC/USEPA/US@EPA
Date: 08/09/2011 04:29 PM
Subject: Fw: Current draft of endangerment brief

Hi Ben et al -- here is the latest version of the draft brief. It is the one we are sharing with the OGC Front Office with a deadline for comments of COB Friday. So if you share with OAR management, please use the same deadline. In fact, would you like me or John to share the draft with Gina/Janet/Joe, cc'ing y'all?

As for our review, sooner is better than later, although I appreciate if folks want a break of a full day before starting!

Also, Angie said this incorporates our comments, although there are a few places she plans to double check and/or add to cites, revised language etc. (b) (5) [redacted]

THANKS, Carol

Confidential communication for internal deliberations only, Attorney-client, attorney work product and/or enforcement privilege, Do not distribute outside EPA or DOJ

Carol S. Holmes
Senior Counsel
Office of Civil Enforcement (MC 2241A)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave, NW
Washington, DC 20460
Phone (202) 564-8709

----- Forwarded by Carol Holmes/DC/USEPA/US on 08/09/2011 04:24 PM -----

From: "Lipshultz, Jon (ENRD)" <Jon.Lipshultz@usdoj.gov>
To: Carol Holmes/DC/USEPA/US@EPA, John Hannon/DC/USEPA/US@EPA, Steven Silverman/DC/USEPA/US@EPA, Kristi Smith/DC/USEPA/US@EPA, "Rosen, Perry (ENRD)" <Perry.Rosen@usdoj.gov>, "Berman, Amanda (ENRD)" <Amanda.Berman@usdoj.gov>, "Hostetler, Eric (ENRD)" <Eric.Hostetler@usdoj.gov>, "Booker, Allison (ENRD)" <Allison.Booker@usdoj.gov>, "Roberts, Kathleen (ENRD)" <Kathleen.Roberts@usdoj.gov>
Cc: "Purdy, Angeline (ENRD)" <Angeline.Purdy@usdoj.gov>, "Lorenzen, Thomas (ENRD)" <Thomas.Lorenzen@usdoj.gov>
Date: 08/09/2011 03:36 PM
Subject: Current draft of endangerment brief

All: Attached please find the current, complete version of the draft endangerment brief. It addresses all comments received to date. I am also including Kathleen and Allison on this distribution to begin the cite-checking process with this draft. Please let me or Angie know any questions or comments. Thanks much to everyone for your help! Jack

From: Paul Gunning
To: irving.bill@epa.gov; Allen Fawcett
Cc: kocchi.suzanne@epa.gov
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16
Date: 01/15/2013 09:09 AM
Attachments: winmail.dat
PathwayToLowCarbonEconomy_FullReportA.PDF
ImpactFinancialCrisisCarbonEconomicsGHGcostcurveV21 (1).pdf
Copy of Domestic and World of GHG by sectors through 2030 011413 (4).xlsb
image002.png
image004.png

Allen/Bill

See the email and info. below from Rick Duke at CEQ. Please take a look at the info. and send me any comments/data that you would recommend sending to CEQ. I talked to Sarah about the original request on Friday and the info. we pulled together was never sent over (I can fill you later as to why). I mention this because some of our comments/response to this request may be resend what we "sent" last week.

This is due to CEQ by tomorrow AM so please have your folks take a look and lets try and wrap up our response by later this afternoon.

Thanks

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 01/15/2013 09:00 AM -----

From: Joel Beauvais/DC/USEPA/US
To: "Sarah Dunham" <dunham.sarah@epa.gov>, "Paul Gunning" <gunning.paul@epa.gov>, "Jackie Krieger" <Krieger.Jackie@epamail.epa.gov>
Cc: "Joe Goffman" <Goffman.Joseph@epamail.epa.gov>
Date: 01/15/2013 07:48 AM
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thanks.

Joel

----- Original Mess
From: "Duke, Rick" (b)(6) privacy
Sent: 01/14/2013 10
To: "Stock, James" <(b)(6) privacy >; Joel Beauvais; "Gruenspecht, Howard (Howard.Gruen Gruenspecht@eia.gov>; "Mignone, Bryan" <Bryan.Mignone@hq.doe.gov>; "Reidmiller, David R (ReidmillerDR@state. ov>
C (b)(6) privacy
<(b)(6) privacy (b)(6) privacy
S al GHG emissions by

REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Please find attached a spreadsheet showing Domestic and Global GHG emissions by sector for 2012 and 2030, as roughly estimated based on multiple sources. The key charts are past (b)(5) deliberative [redacted] art, by Wednesday 1/16 at 8:30am.

(b)(5) deliberative [redacted]

Roque: can you please schedule a call 8:30am Wednesday morning for all on this list?

Thanks in advance for what [redacted] you or your staff can offer. I'm reachable on my mobile at (b)(6) privacy if helpful to touch base directly in advance of the call.

Best,
Rick

Current and projected Global GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Global AnthropogenicNon-CO2 GHG Emissions (2011) , McKinsey Pathways to a Low-Carbon Economy (2009)
Note: Allocations of power sector CO2 between buildings and industrial are approximations

[cid:image002.png@01CDF27F.A9046BA0]

Current and projected U.S. GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Inventory of US GHG Emissions and Sinks1990-2010 , McKinsey (2007)

[cid:image004.png@01CDF27F.A9046BA0]

From: Rona Birnbaum
To: Paul Gunning
Subject: Fw: Draft adaptation briefing for Sarah's Monday briefing
Date: 10/18/2012 04:31 PM
Attachments: OAP Director adaptation briefing Oct12 DRAFT.pptx

---

Paul, attached you'll find the briefing for Sarah on Adaptation. It's short and to the point. Bill made a few minor adjustments but it is very similar to what you saw. Let me know if you have any thoughts on this.
Rona
----- Forwarded by Rona Birnbaum/DC/USEPA/US on 10/18/2012 04:29 PM -----

From: Bill Perkins/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Dana Hyland/DC/USEPA/US@EPA
Date: 10/18/2012 02:00 PM
Subject: Draft adaptation briefing for Sarah

Rona,

Enclosed is a draft slide deck from me and Dana for the Sarah briefing on Monday at 11:30 a.m. We slightly tweaked the slides from the Paul briefing in a few places, mainly by moving the vulnerability recap slides to the appendix (given that we only have a half-hour for the briefing and Sarah is very familiar with them already) and by (b)(5) deliberative [redacted] (which seems confusing and unneeded, as you suggested a few days ago). We welcome any comments and edits from you and Paul, and please let us know if you would like to discuss any questions or concerns.

Sincerely,

Bill

Bill Perkins
Climate Analyst
Climate Change Division
U.S. EPA Office of Air and Radiation
202.343.9460 (office) | 202.258.5192 (mobile) | perkins.bill@epa.gov

From: Rona Birnbaum
To: Paul Gunning
Subject: Fw: Draft OAR Vulnerability Assessment Outline
Date: 11/14/2012 10:25 AM
Attachments: Draft OAR Vulnerability Assessment Outline_111312.docx

---

Paul, please see email below with background. (b)(5) deliberative [redacted] We hope to have Sarah "ok" this so that we can go ahead and share with other programs/regions by the end of this week. The coordination aspect of all this is critical. In a few weeks, when folks have started to sketch out the "action items", that's when we should share this with Gina, per our earlier conversation with Sarah. If you are comfortable with this, please forward on to Sarah.
thanks, Rona
----- Forwarded by Rona Birnbaum/DC/USEPA/US on 11/14/2012 10:19 AM -----

From: Dana Hyland/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Bill Perkins/DC/USEPA/US@EPA
Date: 11/14/2012 08:25 AM
Subject: Draft OAR Vulnerability Assessment Outline

Rona,

Attached is an outline of our draft OAR adaptation vulnerability assessment. As each Region and Program Office develop their respective Implementation Plans, we are all starting out with a vulnerability assessment and we will build off that as we craft the rest of our plan. In our outline you will find a brief description of each vulnerability OAR is planning to include.

This outline is the first step and a full draft of the vulnerability assessment will be next. The full draft will have more of a description for each vulnerability and a table that summarizes the text, just like in the EPA Adaptation Plan. Once we've established that foundation, we'll move on to determining our priority actions, which will discuss how OAR plans to address our vulnerabilities.

The OAR workgroup members are all sharing the outline with their Office Directors this week to make sure they are ok with it before we share it with the internal, cross-EPA workgroup for feedback. Please let me know if you, Paul, or Sarah have any questions.

Thank you,
Dana

From: Allen Fawcett
To: Paul Gunning
Cc: Suzanne Kocchi
Subject: Fw: draft SCC deck
Date: 01/29/2013 04:33 PM
Attachments: SCC briefing_1.29.13.pptx
SCC briefing_EXTRA SLIDES_1.29.13.pptx

FYI, just talked to Ann Wolverton. The briefing is at 5:30 tomorrow, and here's the draft slide deck. She's working a bit in the dark on this and doesn't know who will be attending or even who is going to deliver the briefing. She's checking in with Alex Barron to get more info and will fill us in when she knows more.

Allen

----- Forwarded by Allen Fawcett/DC/USEPA/US on 01/29/2013 04:31 PM -----

From: Ann Wolverton/DC/USEPA/US
To: Allen Fawcett/DC/USEPA/US@EPA
Cc: Elizabeth Kopits/DC/USEPA/US@EPA
Date: 01/29/2013 04:31 PM
Subject: Fw: draft SCC deck

Hi Allen,

Here is the draft slide deck.

Ann

----- Forwarded by Ann Wolverton/DC/USEPA/US on 01/29/2013 04:28 PM -----

From: Elizabeth Kopits/DC/USEPA/US
To: Alex Barron/DC/USEPA/US@EPA
Cc: Al McGartland/DC/USEPA/US@EPA, Alex Marten/DC/USEPA/US@EPA, Charles Griffiths/DC/USEPA/US@EPA, Ann Wolverton/DC/USEPA/US@EPA, Steve Newbold/DC/USEPA/US@EPA
Date: 01/29/2013 03:32 PM
Subject: draft SCC deck

Hi Alex,

Here's the draft deck for the SCC briefing, along with an Appendix of extra slides (which we can either distribute or just share if needed as questions arise). We are still working on the graph for slide 17. (b)(5) deliberative [redacted]

Thanks,
Elizabeth

From: Paul Gunning
To: craig.beth@epa.gov
Cc: krieger.jackie@epa.gov
Subject: Fw: EGU preamble comments
Date: 08/11/2011 12:57 PM
Attachments: EGU GHG Standards Proposal FR 08-11-11.docx

Great news. Looks like OGC heard us yesterday! Today's version of the preable is on target and there should be no need to pull Janet into this. We will still have the call at 3:30 but we will use that time to re-affirm that we are on the same page with OGC.

We can talk more at 1PM

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 08/11/2011 12:54 PM -----

From: Ben DeAngelo/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Date: 08/11/2011 12:39 PM
Subject: Fw: EGU preamble comments

Paul and co.,

I received this morning's version of the preamble, and the endangerment sections have been edited much to our liking I think.

(b) (5) [redacted]

See pages 12-13 and 19-21.

There may still be some editing we'd want but appears to me that these revisions satisfy a lot of our concerns.

-Ben

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 08/11/2011 12:26 PM -----

From: Kate Cardamone/DC/USEPA/US
To: Mary Johnson/RTP/USEPA/US@EPA
Cc: Linda Chappell/RTP/USEPA/US@EPA, Jim Ketcham-Colwill/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA
Date: 08/11/2011 11:35 AM
Subject: EGU preamble comments

Thanks, Mary. Do you know who is responsible for making edits to preamble section I.A? OAP provided some comments on this section and I see that one of the

comment boxes is still there (kc4 on page 9, suggest using the full endangerment title). This particular comment is not a big one but I wanted to make sure that someone was charged with reviewing it and making the change.

thanks!
Kate

▼ Mary Johnson---08/11/2011 11:26:58 AM---All, Please use this version of the preamble to make any additional edits. It is the most current v

From: Mary Johnson/RTP/USEPA/US
To: Barrett Parker/RTP/USEPA/US@EPA, Christian Fellner/RTP/USEPA/US@EPA, David Solomon/RTP/USEPA/US@EPA, Erich Eschmann/DC/USEPA/US@EPA, Howard Hoffman/DC/USEPA/US@EPA, Juan Santiago/RTP/USEPA/US@EPA, Kevin Culligan/DC/USEPA/US@EPA, Larry Sorrels/RTP/USEPA/US@EPA, Linda Chappell/RTP/USEPA/US@EPA, Lisa Conner/RTP/USEPA/US@EPA, Marguerite McLamb/RTP/USEPA/US@EPA, Nick Hutson/RTP/USEPA/US@EPA, Peter Westlin/RTP/USEPA/US@EPA, RobertJ Wayland/RTP/USEPA/US@EPA, Steffan Johnson/RTP/USEPA/US@EPA, Steve Fruh/RTP/USEPA/US@EPA, Alex Marten/DC/USEPA/US@EPA, Amanda CurryBrown/RTP/USEPA/US@EPA, Amy Lamson/RTP/USEPA/US@EPA, David Risley/DC/USEPA/US@EPA, DavidA Evans/DC/USEPA/US@EPA, Jameel Alsalam/DC/USEPA/US@EPA, Jim Ketcham-Colwill/DC/USEPA/US@EPA, Joseph Mangino/RTP/USEPA/US@EPA, Kate Cardamone/DC/USEPA/US@EPA, Kim Garnett/RTP/USEPA/US@EPA, Lillian Bradley/RTP/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Mikhail Adamantiades/DC/USEPA/US@EPA, Peter Nagelhout/DC/USEPA/US@EPA, Jeb Stenhouse/DC/USEPA/US@EPA, Ron Evans/RTP/USEPA/US@EPA, Bryan Hubbell/RTP/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Chris Sherry/DC/USEPA/US@EPA
Date: 08/11/2011 11:26 AM
Subject: PLEASE Use this Version of EGU GHG NSPS and Emission Guidelines Preamble to MAKE EDITS

All,

Please use this version of the preamble to make any additional edits. It is the most current version and I believe it incorporates everyone's comments to date. I tried to send this to everyone that has been on the various distribution lists but please forward if you see that I've missed someone.

Thanks.

Mary

EGU GHG Standards Proposal FR 08-11-11.docx

Mary Johnson
Environmental Engineer
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Mail Code D 243-01
Research Triangle Park, NC 27711
Phone: (919) 541-5025

Fax: (919) 541-5450

From:	Paul Gunning
To:	(b)(6) privacy - Dina Kruger
Subject:	Fw: emissions study
Date:	02/16/2012 12:10 PM
Attachments:	petron et al colorado ONG emissions in press 2012.pdf

---

Dina,

Great seeing you today! Here is the NOAA study, let me know what you think.

I hope you have a great holiday weekend and I will be in touch soon.

Paul

Petron, G., et al. (2012), Hydrocarbon emissions characterization in the Colorado Front Range - A pilot study, J. Geophys. Res., doi:10.1029/2011JD016360, in press. http://www.agu.org/pubs/crossref/pip/2011JD016360.shtml

ABSTRACT

The multi-species analysis of daily air samples collected at the NOAA Boulder Atmospheric Observatory (BAO) in Weld County in northeastern Colorado since 2007 shows highly correlated alkane enhancements caused by a regionally distributed mix of sources in the Denver-Julesburg Basin. To further characterize the emissions of methane and non-methane hydrocarbons (propane, n-butane, i-pentane, n-pentane and benzene) around BAO, a pilot study involving automobile-based surveys was carried out during the summer of 2008. A mix of venting emissions (leaks) of raw natural gas and flashing emissions from condensate storage tanks can explain the alkane ratios we observe in air masses impacted by oil and gas operations in northeastern Colorado. Using the WRAP Phase III inventory of total volatile organic compound (VOC) emissions from oil and gas exploration, production and processing, together with flashing and venting emission speciation profiles provided by State agencies or the oil and gas industry, we derive a range of bottom-up speciated emissions for Weld County in 2008. We use the observed ambient molar ratios and flashing and venting emissions data to calculate top-down scenarios for the amount of natural gas leaked to the atmosphere and the associated methane and non-methane emissions. Our analysis suggests that the emissions of the species we measured are most likely underestimated in current inventories and that the uncertainties attached to these estimates can be as high as a factor of two.

From: Rona Birnbaum
To: Paul Gunning
Subject: Fw: EPA Adaptation Plan status update and final edits
Date: 06/20/2012 09:31 AM
Attachments: Final Draft for Submission to CEQ - OAR draft 062012.docx

---

Paul, I wanted to give you an update on the status of the Adaptation Plan as we are now completing final review before it is sent to CEQ. Feel free to forward this note to Sarah as she may decide to forward the information on as an FYI to the other ODs and possibly to Janet, maybe Gina.

- (b)(5) deliberative [redacted]
- [redacted]
- [redacted]
- Given the relatively minor nature of the edits, going through front office review again may not be necessary and a simple FYI may suffice.. If we do decide to go through front office review again, please be aware that OP has asked for our comments COB tomorrow (Thursday June 21st).
- Finally, we just wanted to let you know that the cross-OAR workgroup that we chair is starting to work on the OAR Implementation Plan, and we will provide an update on that later this summer when things have progressed further.

Please let me know if you have any questions.

- Rona

From:	Bill Irving
To:	Rona Birnbaum; Paul Gunning; Chris Sherry; Reid Harvey; Cate Hight
Cc:	Suzanne Kocchi
Subject:	Fw: Fw: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9
Date:	08/08/2012 03:14 PM
Attachments:	8.6.12 petition for reconsideration FINAL.pdf

FYI - here is the actual petition (attached).

Chief - Climate Policy Branch,
Climate Change Division , USEPA
tel +1 202 343-9065 - mobile +1 202 341 3384

----- Forwarded by Bill Irving/DC/USEPA/US on 08/08/2012 03:12 PM -----

From: Howard Hoffman/DC/USEPA/US
To: Bill Irving/DC/USEPA/US@EPA
Date: 08/08/2012 02:36 PM
Subject: Bill -- here's the petition -- Fw: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Howard J. Hoffman EPA-OGC-ARLO
(202) 564-5582 (v); -5603 (fax); (240) 401-9721 (cell)
The contents of this e-mail and any attachments to it
may be attorney-client or deliberative-process privileged.
----- Forwarded by Howard Hoffman/DC/USEPA/US on 08/08/2012 02:37 PM -----

From: Howard Hoffman/DC/USEPA/US
To: Gina McCarthy/DC/USEPA/US@EPA, Janet McCabe/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Cc: Lorie Schmidt/DC/USEPA/US@EPA, Steve Pressman/DC/USEPA/US@EPA, Ariadne Goerke/DC/USEPA/US@EPA, Patricia Embrey/DC/USEPA/US@EPA
Date: 08/08/2012 10:44 AM
Subject: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Here's a heads up that EPA received a petition to reconsider the dismissal of the cap-and-trade Title VI complaint. According to Ariadne Goerke, the OGC attorney assigned to this: (b)(5) deliberative, (b)(5) attorney- privilege

(b)(5) deliberative

Howard J. Hoffman EPA-OGC-ARLO
(202) 564-5582 (v); -5603 (fax); (240) 401-9721 (cell)
The contents of this e-mail and any attachments to it
may be attorney-client or deliberative-process privileged.
----- Forwarded by Howard Hoffman/DC/USEPA/US on 08/08/2012 10:36 AM -----

From: "Brent Newell" [bnewell@crpe-ej.org]
Sent: 08/06/2012 01:42 PM MST
To: Rafael Deleon
Cc: <jackson.lisa@epamail.epa.gov>; Bob Perciasepe; Scott Fulton; Steve Pressman; Helena Wooden-Aguilar; Diane Thompson; <sparino@crpe-ej.org>; Jared Blumenfeld; <mnichols@arb.ca.gov>
Subject: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Mr. DeLeon,

Please see the attached Petition for Reconsideration. A hard copy will follow in the U.S. Mail.

Thank you.

BRENT NEWELL
GENERAL COUNSEL
CENTER ON RACE, POVERTY & THE ENVIRONMENT
47 KEARNY STREET, SUITE 804
SAN FRANCISCO, CA 94108
(415) 346-4179 x304
(415) 346-8723 FAX
BNEWELL@CRPE-EJ.ORG
WWW.CRPE-EJ.ORG

PROVIDING LEGAL AND TECHNICAL ASSISTANCE TO THE GRASSROOTS MOVEMENT FOR ENVIRONMENTAL JUSTICE

Join us on Facebook!

yv9IADwAAAAAAAARGVzY3JpcHRpb246IERlc2NyaXB0aW9uOiBjaWQ6aW1hZ2UwMDEuZ2lmQDAxQ0I4QkMxLkE0N0JCMUYw

PRIVILEGE AND CONFIDENTIALITY NOTICE
THIS MESSAGE IS INTENDED ONLY FOR THE USE OF THE INDIVIDUAL OR ENTITY TO WHICH IT IS ADDRESSED AND MAY CONTAIN INFORMATION THAT IS PRIVILEGED, CONFIDENTIAL AND EXEMPT FROM DISCLOSURE UNDER APPLICABLE LAW AS ATTORNEY CLIENT AND WORK-PRODUCT CONFIDENTIAL OR OTHERWISE CONFIDENTIAL COMMUNICATIONS. IF THE READER OF THIS MESSAGE IS NOT THE INTENDED RECIPIENT, YOU ARE HEREBY NOTIFIED THAT ANY DISSEMINATION, DISTRIBUTION, OR COPYING OF THIS COMMUNICATION OR OTHER USE OF A TRANSMISSION RECEIVED IN ERROR IS STRICTLY PROHIBITED.

********** ATTACHMENT NOT DELIVERED **********

This Email message contained an attachment named
image001.jpg
which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted.

This was done to limit the distribution of computer viruses introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email.

If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name.

For further information, please contact the EPA Call Center at (866) 411-4EPA (4372). The TDD number is (866) 489-4900.

********** ATTACHMENT NOT DELIVERED
****

From: Paul Gunning
To: Franklin.Pamela@epamail.epa.gov
Subject: Fw: Next round of Kerry-Lieberman analysis (deadline: Wed. June 2)
Date: 05/27/2010 12:10 PM
Attachments: WM Implementation Exercise Black Carbon v8.doc
W-M_CCSimplementation.doc
APA required EPA action 24 May 2010 clean.doc
APA.SectionbySection.assignments.26 May 2010.doc
Waxman-Markey memo supporting docs 09.03.09 final2.doc

Pamela (aka - one of the hamsters)

Here is the info..... :)

----- Forwarded by Paul Gunning/DC/USEPA/US on 05/27/2010 12:09 PM -----

From: Cate Hight/DC/USEPA/US

To: Anhar Karimjee/DC/USEPA/US@EPA, Bella Tonkonogy/DC/USEPA/US@EPA, Benjamin Hengst/DC/USEPA/US@EPA, Carol Holmes/DC/USEPA/US@EPA, Cindy Newberg/DC/USEPA/US@EPA, craig.beth@epa.gov, Dina Kruger/DC/USEPA/US@EPA, Drusilla Hufford/DC/USEPA/US@EPA, Bill Irving <irving.bill@epa.gov>, Jackie Ashley/RTP/USEPA/US@EPA, Jennifer Jenkins/DC/USEPA/US@EPA, Jenny Noonan/RTP/USEPA/US@EPA, Joe Bryson/DC/USEPA/US@EPA, Joseph Goffman/DC/USEPA/US@EPA, Julie Rosenberg/DC/USEPA/US@EPA, Kevin Culligan/DC/USEPA/US@EPA, Kimberly Klunich/DC/USEPA/US@EPA, Matt Clouse/DC/USEPA/US@EPA, Maurice LeFranc/DC/USEPA/US@EPA, mclean.brian@epa.gov, Melissa Weitz/DC/USEPA/US@EPA, Patricia Embrey/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA, Sam Napolitano/DC/USEPA/US@EPA, Sarah Dunham/DC/USEPA/US@EPA, Sarah Froman/DC/USEPA/US@EPA

Cc: Jackie Krieger/DC/USEPA/US@EPA

Date: 05/27/2010 09:28 AM

Subject: Re: Next round of Kerry-Lieberman analysis (deadline: Wed. June 2)

Good morning all,

Just wanted to provide a bit of additional formatting info that might help and you put together your pieces for this:

1. You are welcome to send to me a list of "issues" and "potential solutions" you identify according to the format of the "Waxman-Markey supporting docs" document that Jackie sent around (and attached below); or

2. Alternatively, you can put together a one-pager that addresses the specific questions outlined in Jackie's email ([redacted] etc.). If you choose to do this, Jackie and I will distill from this one-pager the major issues and potential solutions you identify. Here are some examples of one-pagers that folks pulled together for the Waxman-Markey exercise:

(b)(5) deliberative

WM Implementation Exercise Black Carbon v8.doc W-M_CCSimplementation.doc

Please don't hesitate to contact me with any questions/concerns. And thanks to all for your help pulling this together!

Cate

Cate Hight
Climate Change Division
U.S. Environmental Protection Agency
(202) 343-9230
http://www.epa.gov/climatechange

Any communication on the mandatory GHG reporting rule is intended to provide general and administrative information about the Rule. This communication does not provide legal advice, and responses to questions received do not have legally binding effect or expressly or implicitly create, expand, or limit any legal rights, obligations, responsibilities, expectations, or benefits in regard to any person. Facility owners or operators and suppliers are responsible for determining how they would be affected by the requirements of the rule.

▼ Jackie Krieger---05/26/2010 05:04:42 PM---Thanks to all for your work in pulling together the summary of the Kerry-Lieberman discussion draft.

From: Jackie Krieger/DC/USEPA/US

To: Jackie Ashley/RTP/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA, Joe Bryson/DC/USEPA/US@EPA, Matt Clouse/DC/USEPA/US@EPA, Kevin Culligan/DC/USEPA/US@EPA, Sarah Froman/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Bill Irving <irving.bill@epa.gov>, Jennifer Jenkins/DC/USEPA/US@EPA, Anhar Karimjee/DC/USEPA/US@EPA, Kimberly Klunich/DC/USEPA/US@EPA, Maurice LeFranc/DC/USEPA/US@EPA, Cindy Newberg/DC/USEPA/US@EPA, Julie Rosenberg/DC/USEPA/US@EPA, Bella Tonkonogy/DC/USEPA/US@EPA, Melissa Weitz/DC/USEPA/US@EPA

Cc: Joseph Goffman/DC/USEPA/US@EPA, mclean.brian@epa.gov, Cate Hight/DC/USEPA/US@EPA, Benjamin Hengst/DC/USEPA/US@EPA, Dina Kruger/DC/USEPA/US@EPA, Sam Napolitano/DC/USEPA/US@EPA, Drusilla Hufford/DC/USEPA/US@EPA, craig.beth@epa.gov, Jenny Noonan/RTP/USEPA/US@EPA, Sarah Dunham/DC/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Patricia Embrey/DC/USEPA/US@EPA, Carol Holmes/DC/USEPA/US@EPA

Date: 05/26/2010 05:04 PM

Subject: Next round of Kerry-Lieberman analysis (deadline: Wed. June 2)

Thanks to all for your work in pulling together the summary of the Kerry-Lieberman discussion draft. When we receive comments from OGC, which will be shortly, we'll send around a final version. In the meantime, here again is the draft.

APA required EPA action 24 May 2010 clean.doc

(b)(5) deliberative

[redacted]

(b)(5) deliberative [redacted]

It seems to make sense for the same individuals/office leads to focus on the same sections as they did for last week's document. I've reattached the section assignments here, with a few clarifications as to who the primary office leads should be in drafting this next round of text. Please be inclusive and work with all of the appropriate staff from other offices/divisions.

APA.SectionbySection.assignments.26 May 2010.doc

You are of course encouraged to work with OGC as appropriate but note that we will provide them with the completed draft for review/comment in its entirety. (b)(5) deliberative [redacted]

I am attaching here the file with the results of our Waxman-Markey recommendations, both as substantive background and as a guide for format.

Waxman-Markey memo supporting docs 09.03.09 final2.doc

The deadline for this work is noon next Wednesday, June 2. If you anticipate a problem in meeting this deadline, or have other questions or concerns, please let me and/or Cate know as soon as possible.

Many thanks for your help!

Jackie Krieger
Chief of Staff
Office of Atmospheric Programs
Phone: (202) 343-9905
Fax: (202) 343-2210
E-Mail: krieger.jackie@epa.gov

From: Suzanne Kocchi
To: Sarah Dunham
Cc: Paul Gunning; Bill Irving; Jennifer Jenkins
Subject: Fw: Preparations for the August 31, 2012 SAB Teleconference - Biogenic Carbon Emissions
Date: 07/26/2012 03:21 PM
Attachments: 7-26-12 Biogenic Carbon Advisory.pdf

Sarah - FYI - We just found out the latest draft of the SAB peer review report is on their website now (despite being told it wouldn't happen until next week). Next step is the full SAB will meet on a public teleconference to have a quality review of the report. That is scheduled for Aug 31. The FR notice announcing the call will be published early next week.

Let us know if you need more. We are scheduled to pre-brief you next Thur ahead of the 8/7 briefing with Gina. Thanks - Suzie

----- Forwarded by Suzanne Kocchi/DC/USEPA/US on 07/26/2012 03:13 PM -----

From: Jennifer Jenkins/DC/USEPA/US
To: Bill Irving/DC/USEPA/US@EPA, Chris Sherry/DC/USEPA/US@EPA, Sara Ohrel/DC/USEPA/US@EPA, Suzanne Kocchi/DC/USEPA/US@EPA
Date: 07/26/2012 02:08 PM
Subject: Re: Fw: Preparations for the August 31, 2012 SAB Teleconference - Biogenic Carbon Emissions

---

To follow up:

The FR notice announcing the Quality Review has left Holly's office and will likely be published tomorrow or Monday.

▼ Jennifer Jenkins---07/26/2012 02:05:33 PM---The SAB report has been posted; see below. I will keep working with Erin today on the public relat

From: Jennifer Jenkins/DC/USEPA/US
To: Suzanne Kocchi/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA
Cc: Sara Ohrel/DC/USEPA/US@EPA, Chris Sherry/DC/USEPA/US@EPA
Date: 07/26/2012 02:05 PM
Subject: Fw: Preparations for the August 31, 2012 SAB Teleconference - Biogenic Carbon Emissions

---

----- Forwarded by Jennifer Jenkins/DC/USEPA/US on 07/26/2012 02 04 PM -----

From: Holly Stallworth/DC/USEPA/US
To: Jennifer Jenkins/DC/USEPA/US@EPA
Date: 07/26/2012 01:57 PM
Subject: Fw: Preparations for the August 31, 2012 SAB Teleconference - Biogenic Carbon Emissions

---

Holly Stallworth, Ph.D.
Economist and Designated Federal Officer
Clean Air Scientific Advisory Committee (CASAC)
Environmental Protection Agency, Mail Code 1400R
1300 Pennsylvania Ave., NW, Washington D.C. 20004
Phone: 202-564-2073

----- Forwarded by Holly Stallworth/DC/USEPA/US on 07/26/2012 01:57 PM -----

From: Angela Nugent/DC/USEPA/US
To:
Date: 07/26/2012 09:43 AM
Subject: Preparations for the August 31, 2012 SAB Teleconference - Biogenic Carbon Emissions

---

Note to Members of the Chartered SAB and SAB Liaisons

Please find pasted below and provided in the attached memorandum [[attachment "Memo carbon emissions-08.31.12.pdf" deleted by Jennifer Jenkins/DC/USEPA/US]] information related to the teleconference planned for August 31, 2012 (11:00 a.m. -2:00 p.m. Eastern Daylight Time) The pdf memorandum contains hot links to key information for the quality review.

The draft report to be quality reviewed is *SAB Review (7-5-12 Draft) of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (September 2011)* The draft reports is posted on the SAB web site and attached to this email [attachment "7-26-12 Biogenic Carbon Advisory.pdf" deleted by Jennifer Jenkins/DC/USEPA/US]
.
Also attached is the standard SAB protocol for quality review. [attachment "Quality Review Protoco-03.13.12.pdf" deleted by Jennifer Jenkins/DC/USEPA/US]

I am sending the request for your response to the supplemental ethics questions for his teleconference by separate email.

Best ,
Angela

++++++++++++++++++++++

July 26, 2012

MEMORANDUM

SUBJECT: August 31, 2012 (11:00 a m -2:00 p m Eastern Daylight Time) Science Advisory Board (SAB) Quality Review Teleconference for the Draft Report *SAB Review (7-5-12 Draft) of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (September 2011)*

FROM: Angela Nugent, Designated Federal Officer

TO: Members of the Chartered SAB and SAB Liaison Members

The purpose of this memorandum is to discuss plans for the quality review of the SAB Biogenic Carbon Emissions Panel's draft report entitled *SAB Review (7-5-12 Draft) of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (September 2011)*. The SAB Quality Review teleconference is scheduled for August 31, 2012 (11:00 a m - 2:00 p m Eastern Daylight Time) This memo provides details about the quality review of this draft report and also provides background on the process for SAB Quality Reviews

All materials for the teleconference will be sent to you by email and will also be posted on the SAB web page for the quality review Because these materials are posted in a structured way on the web, it may be useful for SAB members to access this web page as a convenient tool

To access the agenda and materials (including any public comments received) for the August 31st SAB Quality Review teleconference, please use the calendar link on the SAB website (www epa gov/sab) to navigate to the web page dedicated to the August 31st call or use the direct link provided below:

http://yosemite epa gov/sab/sabproduct nsf/a84bfee16cc358ad85256ccd006b0b4b/0788f5009f0f8bef85257a340004abbd!OpenDocument&Date=2012-08-31

I will forward any written public comments to you as they arrive Please review and consider them before the teleconference and be prepared to acknowledge comments you consider relevant during the quality review discussions

Please let me know if there is anything I can do to provide additional information or help to facilitate your participation in the quality review, a key activity of the chartered SAB

Plans for the August 31, 2012 Teleconference and action items for SAB Members

During the August 31st 11:00 a m - 2:00 p m Eastern Daylight Time teleconference, the discussion will focus on the draft report *SAB Review (7-5-12 Draft) of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (September 2011)*. The links (in the pdf) are "live links" to important SAB web pages for the teleconference:

- Background on the SAB advisory activity,
- Agency review document, the Office of Air and Radiation's *Accounting Framework for Biogenic CO2 Emissions from Stationary Sources*
- Draft panel report

The following SAB members will serve as lead reviewers for the report: Drs James Hammitt, Duncan Patten, Stephen Polasky and Jerald Schnoor

The call-in number will be: (b)(6) privacy

Although lead reviewers have been assigned, we ask all SAB members and liaison members who have not participated in the panel **to please provide written comments to me electronically by August 24, 2012** We ask SAB members specifically to address the four quality review questions below from the vantage point of your own expertise:

1) Were the charge questions to the committee adequately addressed?
2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?
3) Is the draft report clear and logical?
4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Please note that Chartered SAB members' and liaisons' written comments will be compiled, circulated to them, and posted on the SAB webpage dedicated to the teleconference

If you are unable to participate in the August 31, 2012 teleconference, you are presumed to delegate decision authority for disposition of the draft report to participating SAB members

The attached protocol entitled "The role of chartered SAB (Board) members and Board liaisons in Science Advisory Board (SAB) quality reviews" describes the standard approach to SAB quality review, which will be followed for this quality review

Angela Nugent, Ph.D.
Designated Federal Officer, EPA Science Advisory Board
Special Assistant to the Director, EPA Science Advisory Board Staff Office

Mailing Address:
US.Environmental Protection Agency
Mailcode 1400R
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Physical Location/Deliveries
The Science Advisory Board Staff Office
Ronald Reagan Building
1300 Pennsylvania Avenue
Suite 31150
Washington, DC 20004

Telephone: 202-564-2218; Main Fax: 202-565-2098 Secure Fax: 202-565-2091

Email: nugent.angela@epa.gov

From: Paul Gunning
To: krieger.jackie@epa.gov
Subject: Fw: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9
Date: 08/09/2012 01:40 PM
Attachments: 8.6.12 petition for reconsideration FINAL.pdf

Just FYI.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 08/09/2012 01:40 PM -----

From: Bill Irving/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Chris Sherry/DC/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Cate Hight/DC/USEPA/US@EPA
Cc: Suzanne Kocchi/DC/USEPA/US@EPA
Date: 08/08/2012 03:14 PM
Subject: Fw: Fw: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

FYI - here is the actual petition (attached).

Chief - Climate Policy Branch,
Climate Change Division , USEPA
tel +1 202 343-9065 - mobile +1 202 341 3384

----- Forwarded by Bill Irving/DC/USEPA/US on 08/08/2012 03:12 PM -----

From: Howard Hoffman/DC/USEPA/US
To: Bill Irving/DC/USEPA/US@EPA
Date: 08/08/2012 02:36 PM
Subject: Bill -- here's the petition -- Fw: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Howard J. Hoffman EPA-OGC-ARLO
(202) 564-5582 (v); -5603 (fax); (240) 401-9721 (cell)
The contents of this e-mail and any attachments to it
may be attorney-client or deliberative-process privileged.
----- Forwarded by Howard Hoffman/DC/USEPA/US on 08/08/2012 02:37 PM -----

From: Howard Hoffman/DC/USEPA/US
To: Gina McCarthy/DC/USEPA/US@EPA, Janet McCabe/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Cc: Lorie Schmidt/DC/USEPA/US@EPA, Steve Pressman/DC/USEPA/US@EPA, Ariadne Goerke/DC/USEPA/US@EPA, Patricia Embrey/DC/USEPA/US@EPA
Date: 08/08/2012 10:44 AM
Subject: Title VI complaint re: California GHG cap-and-trade program -- Fw: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Here's a heads up that EPA received a petition to reconsider the dismissal of the cap-and-trade Title VI complaint. According to Ariadne Goerke, the OGC attorney assigned to this: (b)(5) deliberative, (b)(5) attorney- privilege

(b)(5) deliberative [redacted]

Howard J. Hoffman EPA-OGC-ARLO
(202) 564-5582 (v); -5603 (fax); (240) 401-9721 (cell)
The contents of this e-mail and any attachments to it
may be attorney-client or deliberative-process privileged.
----- Forwarded by Howard Hoffman/DC/USEPA/US on 08/08/2012 10:36 AM -----

From: "Brent Newell" [bnewell@crpe-ej.org]
Sent: 08/06/2012 01:42 PM MST
To: Rafael Deleon
Cc: <jackson.lisa@epamail.epa.gov>; Bob Perciasepe; Scott Fulton; Steve Pressman; Helena Wooden-Aguilar; Diane Thompson; <sparino@crpe-ej.org>; Jared Blumenfeld; <mnichols@arb.ca.gov>
Subject: Petition for Reconsideration; Coalition for a Safe Environment v. CARB, EPA File No. 09R-12-R9

Mr. DeLeon,

Please see the attached Petition for Reconsideration. A hard copy will follow in the U.S. Mail.

Thank you.

BRENT NEWELL
GENERAL COUNSEL
CENTER ON RACE, POVERTY & THE ENVIRONMENT
47 KEARNY STREET, SUITE 804
SAN FRANCISCO, CA 94108
(415) 346-4179 x304
(415) 346-8723 FAX
BNEWELL@CRPE-EJ.ORG
WWW.CRPE-EJ.ORG

PROVIDING LEGAL AND TECHNICAL ASSISTANCE TO THE GRASSROOTS MOVEMENT FOR ENVIRONMENTAL JUSTICE

Join us on Facebook!

yv9IADwAAAAAAAAARGVzY3JpcHRpb246IERlc2NyaXB0aW9uOiBjaWQ6aW1hZ2UwMDEuZ2lmQDAxQ0I4QkMxLkE0N0JCMUYw

PRIVILEGE AND CONFIDENTIALITY NOTICE
THIS MESSAGE IS INTENDED ONLY FOR THE USE OF THE INDIVIDUAL OR ENTITY TO WHICH IT IS ADDRESSED AND MAY CONTAIN INFORMATION THAT IS PRIVILEGED, CONFIDENTIAL AND EXEMPT FROM DISCLOSURE UNDER APPLICABLE LAW AS ATTORNEY CLIENT AND WORK-PRODUCT CONFIDENTIAL OR OTHERWISE CONFIDENTIAL COMMUNICATIONS. IF THE READER OF THIS MESSAGE IS NOT THE INTENDED RECIPIENT, YOU ARE HEREBY NOTIFIED THAT ANY DISSEMINATION, DISTRIBUTION, OR COPYING OF THIS COMMUNICATION OR OTHER USE OF A TRANSMISSION RECEIVED IN ERROR IS STRICTLY PROHIBITED.

********** ATTACHMENT NOT DELIVERED **********

This Email message contained an attachment named
  image001.jpg
which may be a computer program. This attached computer program could contain a computer virus which could cause harm to EPA's computers, network, and data. The attachment has been deleted.

This was done to limit the distribution of computer viruses introduced into the EPA network. EPA is deleting all computer program attachments sent from the Internet into the agency via Email.

If the message sender is known and the attachment was legitimate, you should contact the sender and request that they rename the file name extension and resend the Email with the renamed attachment. After receiving the revised Email, containing the renamed attachment, you can rename the file extension to its correct name.

For further information, please contact the EPA Call Center at (866) 411-4EPA (4372). The TDD number is (866) 489-4900.

********** ATTACHMENT NOT DELIVERED
****

From:	Ben DeAngelo
To:	Jackie Krieger
Cc:	Paul Gunning; Rona Birnbaum; Lesley Jantarasami; John Hannon
Subject:	Fw: updated oversight list/ new letter -- for Q #17
Date:	08/10/2011 03:40 PM
Attachments:	endangerment_finding_early_guidance_briefing_v6.ppt Endangerment update 080707.ppt Endangerment draft outline 070607.doc Endangerment Option Selection Mar 6,2009 v3.ppt Oversight Requests Status 7-14-11.doc Energy Commerce GHG letter 0714.pdf

---

Suggested response for #17. The power point attachments below provided for #16 also apply here. OGC should review this; am cc'ing John Hannon here.

(b) (5)

[redacted]

[redacted]

[redacted]

[redacted]

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 08/10/2011 03:16 PM -----

From: Ben DeAngelo/DC/USEPA/US
To: Ben DeAngelo/DC/USEPA/US@EPA
Cc: Jackie Krieger/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Date: 08/08/2011 04:16 PM
Subject: Re: Fw: updated oversight list/ new letter -- CORRECTION, for Q #16

Sorry, this is for Q16 not 17.

▼ Ben DeAngelo---08/08/2011 03:51:31 PM---Suggested response for #17. This is consistent with a similar question we got from OIG: EPA followe

From: Ben DeAngelo/DC/USEPA/US
To: Jackie Krieger/DC/USEPA/US@EPA
Cc: Paul Gunning/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Date: 08/08/2011 03:51 PM
Subject: Fw: updated oversight list/ new letter

Suggested response for #16. This is consistent with a similar question we got from OIG:

(b) (5)

[redacted]

endangerment_finding_early_guidance_briefing_v6.ppt Endangerment update 080707.ppt

Endangerment draft outline 070607.doc Endangerment Option Selection Mar 6,2009 v3.ppt

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 08/08/2011 02:16 PM -----

From: Jackie Krieger/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Paul Gunning/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA
Date: 08/08/2011 10:17 AM
Subject: Fw: updated oversight list/ new letter

I've heard from OPAR on these questions (below) and they'd like to get the offices responses soon, as soon as possible this week.

Jackie Krieger
Chief of Staff
Office of Atmospheric Programs
Phone: (202) 343-9905
Fax: (202) 343-2210
E-Mail: krieger.jackie@epa.gov

----- Forwarded by Jackie Krieger/DC/USEPA/US on 08/08/2011 10:13 AM -----

From: Jackie Krieger/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Paul Gunning/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA
Date: 07/15/2011 04:59 PM
Subject: Fw: updated oversight list/ new letter

The question assigned to OAP (and OP?) is number 16 -- on the endangerment finding. Number 17 is also about endangerment but Lorie has a ? there. Are you OK with this assignment? If they give us #17 also? We can talk on Monday. In the meantime I'll ask about a deadline.

Jackie Krieger
Chief of Staff
Office of Atmospheric Programs
Phone: (202) 343-9905
Fax: (202) 343-2210
E-Mail: krieger.jackie@epa.gov

----- Forwarded by Jackie Krieger/DC/USEPA/US on 07/15/2011 04:56 PM -----

From: Lorie Schmidt/DC/USEPA/US
To: Benjamin Hengst/DC/USEPA/US@EPA, Jenny Noonan <noonan.jenny@epa.gov>, Anna Duncan/DC/USEPA/US@EPA, Jackie Krieger/DC/USEPA/US@EPA, Becky Higgins <higgins.becky@epa.gov>, Larry Weinstock/DC/USEPA/US@EPA, Ellen Kurlansky/DC/USEPA/US@EPA, Jeneva Craig/DC/USEPA/US@EPA, Jim Ketcham-Colwill/DC/USEPA/US@EPA, Keith Mason/DC/USEPA/US@EPA, Sabrina Johnson/DC/USEPA/US@EPA, Tamara Saltman/DC/USEPA/US@EPA, Terry Keating/DC/USEPA/US@EPA, Tom Eagles/DC/USEPA/US@EPA, Lora Strine/DC/USEPA/US@EPA, Kevin Culligan/DC/USEPA/US@EPA, Megan Brachtl/DC/USEPA/US@EPA, Jan Cortelyou-Lee/RTP/USEPA/US@EPA, Jonathan Lubetsky/DC/USEPA/US@EPA
Date: 07/14/2011 05:50 PM
Subject: Fw: updated oversight list/ new letter

---

an updated chart, the new Upton letter (which I sent earlier), and my suggestion on which office should take lead on each question -- the ones labeled "goffman" means I will talk to him before we assign them If you disagree with any of the assignments or are uncertain how to answer, let me know.

I deleted the other new letters cuz they aren't ours to worry about.

1. OGC/OAQPS/OTAQ
2. OTAQ/OAQPS
3. OGC
4. OTAQ
5. OTAQ
6. OTAQ
7. OTAQ
8. OTAQ
9. OAQPS
10. OAQPS
11. OAQPS
12. OAQPS
13. OAQPS/PAT CHILDERS
14. OAQPS
15. OGC
16. OAP/OP
17. ????? – DOC REQUEST – OPAR/GOFFMAN
18. GOFFMAN
19. OAQPS
20. GOFFMAN
21. GOFFMAN/OGC
22. ?????
23. PULL FROM PRIOR LETTER
24. GOFFMAN
25. GOFFMAN

----- Forwarded by Lorie Schmidt/DC/USEPA/US on 07/14/2011 04:52 PM -----

From: Tom Dickerson/DC/USEPA/US
To: Arvin Ganesan/DC/USEPA/US@EPA, Joyce Frank/DC/USEPA/US@EPA,

Laura Vaught/DC/USEPA/US@EPA, Steven Kinberg/DC/USEPA/US@EPA, Josh Lewis/DC/USEPA/US@EPA, Diann Frantz/DC/USEPA/US@EPA, Patricia Haman/DC/USEPA/US@EPA, Cheryl Mackay/DC/USEPA/US@EPA, KevinJ Bailey/DC/USEPA/US@EPA, Joseph Goffman/DC/USEPA/US@EPA, Lorie Schmidt/DC/USEPA/US@EPA, Ed Walsh/DC/USEPA/US@EPA, Joel Beauvais/DC/USEPA/US@EPA, Alex Barron/DC/USEPA/US@EPA, Marna McDermott/DC/USEPA/US@EPA
Date: 07/14/2011 04:31 PM
Subject: updated oversight list/ new letters

Here is the updated list:

The new Upton, Whitfield, and Stearns that Arvin got:

Tom Dickerson
Office of Congressional and Intergovernmental Relations
U.S. EPA
(202) 564-3638

From: Reid Harvey
To: Paul Gunning
Subject: Fw: Vehicle Rule and SCC: background and relevant documents
Date: 08/16/2012 11:39 AM
Attachments: OMB comments (EPA response) final version.docx
Oil and Gas RIA (language added to Vehicle RIA) v2.pdf
SCC TSD 03 25 10.pdf

FYI - as we discussed yesterday, here's more background on the (b)(5) deliberative [redacted]

Reid

----- Forwarded by Reid Harvey/DC/USEPA/US on 08/16/2012 11:35 AM -----

From: Kate Shouse/DC/USEPA/US
To: Shaun Ragnauth/DC/USEPA/US@EPA
Cc: Reid Harvey/DC/USEPA/US@EPA, Stephanie Waldhoff/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA
Date: 08/16/2012 10:48 AM
Subject: Vehicle Rule and SCC: background and relevant documents

---

Thanks, Shaun, for volunteering to be on standby next week for any SCC questions that may come up on the vehicle rule. I've listed below background information and notes about OMB comments received to date. I'll send you copies of the latest rulemaking documents in a separate email (they're large). fyi, OTAQ keeps the documents on their network drive that you most likely don't have access to, so if anything for SCC needs to be changed, I recommend sending that text to Sarah Froman so that she can update the master copies of the documents.

(b)(5) deliberative [redacted]

[redacted]

[redacted]

3):

Oil and Gas NSPS Final Rule (aka the "fracking rule"): This file is an excerpt from the oil and gas RIA and shows the additional language that I copied from the oil and gas RIA to the vehicle RIA last week (marked in yellow). Please note that the rest of the language in the vehicle rule RIA came from the oil and gas RIA; I had initially excluded a few sentences to eliminate repetition.

If you need more info about the oil and gas rule, see:
http://www.epa.gov/airquality/oilandgas/actions.html
and for entire oil and gas RIA, see
http://www.epa.gov/ttn/ecas/regdata/RIAs/oil_natural_gas_final_neshap_nsps_ria.pdf.
Rule signed 4/17/12, FR publication expected literally any day now.

Anticipated OMB Comments: No idea if we'll get anything else on SCC. Sometimes they add a sentence here and there at the (literal) 11th hour; if that's the case, it's worthwhile to compare it to text in the SCC TSD:

From: Paul Gunning
To: Eric Ginsburg
Cc: Jackie Ashley
Subject: Re: Alternative pieced
Date: 09/09/2009 04:40 PM
Attachments: Technical Assistance CAFO summarpgy.doc
Sec.331 analysis.xls

Eric,

Here are my suggestions based on our quick call. While it looks like I deleted everything in track changes, I did so just to make it easier to write. I double checked our initial analysis, (see attached) and it appears that (b)(5) deliberative [redacted]

These are my thoughts, Please feel free to move forward from here as you see fit.

Hope this helps.

Paul

Sec.331 analysis.xls

Technical Assistance CAFO summarpgy.doc

▼ Eric Ginsburg---09/09/2009 12:36:29 PM---Since this is going to be for David to talk from, the attached may be more useful to him. Please fe

From: Eric Ginsburg/RTP/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Jackie Ashley/RTP/USEPA/US@EPA
Date: 09/09/2009 12:36 PM
Subject: Alternative pieced

Since this is going to be for David to talk from, the attached may be more useful to him. Please feel free to add thoughts. I didn't hit on the most (b)(5) deliberative [redacted]

[attachment "Technical Assistance CAFO summary.doc" deleted by Paul Gunning/DC/USEPA/US]

****

Eric O. Ginsburg
Senior Program Advisor
Sector Policies and Programs Division (D205-01)
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Ph: (919) 541-0877
Fax: (919) 541-4991
Cell: (919) 724-8995

From:	Jackie Krieger
To:	Joel Beauvais
Cc:	Andrea Drinkard; Bill Irving; Dale Evarts; Jenny Noonan; Karen Orehowsky; Maurice LeFranc; Paul Gunning; Suzanne Kocchi; Erin Birgfeld; Beth Craig; Stacy Angel; Sarah Dunham
Subject:	Re: Doha Side Event Slides - draft outlines
Date:	11/06/2012 11:04 AM
Attachments:	Doha Side Event Outline - US Domestic Actions.docx Doha Side Event Outlne - EPA Intl Actions.docx Goffman GHG Presentation 5.8.12.ppt Cop-17 Domestic Climate ActionsUPDATED.ppt Doha Side Event Outline - US Domestic Actions with assignments.docx

---

Hi everyone (and some new folks from OAP): For the US domestic mitigation actions side event, we've gone into Joel's outline and made (the obvious) assignments, in red attached immediately below. I'm also attaching two older slide decks provided by Andrea that you can draw from if you wish (the first, used by Joe, is too detailed for the COP audience but includes some good information- the other used at the last COP is out-of-date but the level of detail is about right - this is a draft and Andrea may send around the final at some point soon).

Just a couple of notes about the assignments: first, as indicated, for some of the higher-level, messaging overviews we should fill in last, probably with Joel, once we have the program-specific sections assembled; and second, for the last two sections on RE/EE in the power sector and state actions, OAP will provide preliminary materials that can be supplemented or substituted with materials from CEQ/State as necessary.

Please send me and Erin Birgfeld your draft ppts by COB this Friday, Nov 9. We'll work on pulling them together into one package on Monday in order to get Joel a good working draft by Tues the 13th. Let us know if questions, and thanks for your help.

Joel: We'll follow-up separately with you on the international capacity building piece.

File w/ Assignments:

Some useful background:

Jackie Krieger
Chief of Staff
Office of Atmospheric Programs
Phone: (202) 343-9905

▼ Joel Beauvais---11/05/2012 10:29:08 AM---Jackie, Paul, and others - I am attaching outlines for slide decks for two of our three side event

From: Joel Beauvais/DC/USEPA/US
To: Jackie Krieger/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA, Karen Orehowsky/DC/USEPA/US@EPA, Dale Evarts/RTP/USEPA/US@EPA, Jenny Noonan/RTP/USEPA/US@EPA
Cc: Maurice LeFranc/DC/USEPA/US@EPA, Andrea Drinkard/DC/USEPA/US@EPA
Date: 11/05/2012 10:29 AM
Subject: Doha Side Event Slides - draft outlines

Jackie, Paul, and others -

I am attaching outlines for slide decks for two of our three side event presentations for Doha. I am asking OAP to take the lead on putting together slides for the presentations, but as you'll see, some of the Domestic Actions segments implicate OTAQ or OAQPS, so I am including Karen, Dale and Jenny so they're aware and can be involved as appropriate. I will let you guys decide how you want to coordinate on this - Andrea can help to assist and coordinate as appropriate.

A couple quick points on the outlines:

- (b)(5) deliberative [redacted]
- [redacted]
-

We need to have these to State by 2 weeks from today (11/19) and I would like some time to review and revise with you before then. So, if you can **please get me drafts of these (as well as the GHG reporting program presentation) by <u>COB Tuesday 11/13</u>,** that would be great. I think that should be realistic, as most of this can be developed by adapting preexisting materials.

If it would be helpful for us to sit down and walk through the outlines in advance this week, I'd be happy to do so - just let me know.

Joel

From:	Paul Gunning
To:	(b)(6) privacy - Rick Duke
Cc:	Joel Beauvais; (b)(6) privacy - Roque Sanchez Sarah Dunham; Joseph Goffman; Allen Fawcett
Subject:	Re: Domestic and Global GHG emissions by sector for 2012 and 2030
Date:	01/16/2013 04:43 PM
Attachments:	Emissions Projections Question from Rick Duke_2.xlsx

---

Rick,

We just wanted to follow up on the request from this morning's call to send along a short description of the Non-CO2 projections data along with web links to the data/report (see below). Let me know if you have any questions or need anything else.

Thanks

Paul

(b)(5) deliberative

[redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW

Washington, DC 20005

▼ Joseph Goffman---01/15/2013 06:41:25 PM---Forwarding material from Paul Gunning and colleagues. Thanks. Joseph Goffman Senior Counsel to the

From: Joseph Goffman/DC/USEPA/US
To: (b)(6) privacy - Roque Sanchez, (b)(6) privacy - Rick Duke
Cc: Paul Gunning/DC/USEPA/US@EPA, Joel Beauvais/DC/USEPA/US@EPA, Sarah Dunham/DC/USEPA/US@EPA
Date: 01/15/2013 06:41 PM
Subject: Domestic and Global GHG emissions by sector for 2012 and 2030

Forwarding material from Paul Gunning and colleagues. Thanks.

Joseph Goffman
Senior Counsel to the Assistant Administrator
Office of Air and Radiation
US Environmental Protection Agency
202 564 3201

(b)(5) deliberative

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]

(b)(5) deliberative

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

(b)(5) deliberative [redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

From: Paul Gunning
To: Joseph Goffman; Joel Beauvais
Cc: Sarah Dunham
Subject: Re: Domestic and Global GHG emissions by sector for 2012 and 2030
Date: 01/16/2013 01:12 PM
Attachments: Emissions Projections Question from Rick Duke_2.xlsx

---

Joe/Joel,

After you guys had to sign off, we just provided an overview of our non-co2 data. The only request was to send the group a short description along with web links to the data/report (see below). Let me know if you want me to forward along or you would rather follow up on it.

Thanks

Paul

(b)(5) deliberative [redacted]

▼ Joseph Goffman---01/15/2013 06:41:25 PM---Forwarding material from Paul Gunning and colleagues. Thanks. Joseph Goffman Senior Counsel to the

From: Joseph Goffman/DC/USEPA/US
To: (b)(6) privacy - Roque Sanchez, (b)(6) privacy - Rick Duke
Cc: Paul Gunning/DC/USEPA/US@EPA, Joel Beauvais/DC/USEPA/US@EPA, Sarah Dunham/DC/USEPA/US@EPA
Date: 01/15/2013 06:41 PM
Subject: Domestic and Global GHG emissions by sector for 2012 and 2030

Forwarding material from Paul Gunning and colleagues. Thanks.

Joseph Goffman
Senior Counsel to the Assistant Administrator
Office of Air and Radiation
US Environmental Protection Agency
202 564 3201

(b)(5) deliberative [redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]

(b)(5) deliberative

-
-
-
-
-
-
-

(b)(5) deliberative [redacted]

[redacted]

[redacted]

[redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

From: Paul Gunning
To: Rona Birnbaum
Subject: Re: Fw: Climate Multipollutant Science Assessment workshop slides - for your review
Date: 04/30/2012 04:15 PM
Attachments: climate consult - dutton - 2012-04-30.pptx

These look great, thanks for sharing. I can't believe how awful that presentation is!!! I am glad you spoke with Lydia

▼ Rona Birnbaum---04/30/2012 04:02:09 PM---fyi - our comments on the attached [problematic] ORD slides: Steve,

From: Rona Birnbaum/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Date: 04/30/2012 04:02 PM
Subject: Fw: Climate Multipollutant Science Assessment workshop slides - for your review

---

fyi - our comments on the attached [problematic] ORD slides:

Steve,

Thanks so much for providing the materials. Rona and I talked through the presentation and we connected with Lydia, and am providing some comments here:

Clarifying the context and objectives upfront will be very important, especially since (b) (5) [redacted]

thanks,

-Ben

Benjamin J. DeAngelo
Senior Analyst
Climate Change Division, Office of Atmospheric Programs
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW (6207J)
Washington, DC 20460

----- Forwarded by Rona Birnbaum/DC/USEPA/US on 04/30/2012 04:00 PM -----

From: John Vandenberg/RTP/USEPA/US
To: Lydia Wegman/RTP/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA
Cc: Steven Dutton/RTP/USEPA/US@EPA, ross.mary@epa.gov
Date: 04/30/2012 12:21 PM
Subject: Climate Multipollutant Science Assessment workshop slides - for your review

---

Hi Lydia, here are draft slides for tomorrow's MSA meeting; your comments can be inserted starting around slide 24.

Rona, we welcome your comments!

Please provide any additions/comments **today s**o we can have this ready to go first thing tomorrow morning.

Thanks,

John

John Vandenberg, PhD
Director, RTP Division
National Center for Environmental Assessment B243-01
Office of Research and Development, USEPA
Research Triangle Park, NC 27711

Tel: 919 541 4527
Fax: 919 541 5078

From:	Allen Fawcett
To:	Paul Gunning
Cc:	irving.bill@epa.gov; kocchi.suzanne@epa.gov
Subject:	Re: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16
Date:	01/15/2013 04:03 PM
Attachments:	Emissions Projections Question from Rick Duke_2.xlsx

---

Paul,

Here's a potential response for the new Rick Duke request if we want to use it.

Allen

(b)(5) deliberative [redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]

(b)(5)
delibe
rative

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

(b)(5)
delibe
rative
[redacted]

▼ Paul Gunning---01/15/2013 09:10:45 AM---Allen/Bill See the email and info. below from Rick Duke at CEQ. Please take a look at the info. and

From: Paul Gunning/DC/USEPA/US
To: irving.bill@epa.gov, Allen Fawcett/DC/USEPA/US@EPA
Cc: kocchi.suzanne@epa.gov
Date: 01/15/2013 09:10 AM
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Allen/Bill

See the email and info. below from Rick Duke at CEQ. Please take a look at the info. and send me any comments/data that you would recommend sending to CEQ. I talked to Sarah about the original request on Friday and the info. we pulled together was never sent over (I can fill you later as to why). I mention this because some of our comments/response to this request may be resend what we "sent" last week.

This is due to CEQ by tomorrow AM so please have your folks take a look and lets try and wrap up our response by later this afternoon.

Thanks

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 01/15/2013 09:00 AM -----

From: Joel Beauvais/DC/USEPA/US
To: "Sarah Dunham" <dunham.sarah@epa.gov>, "Paul Gunning" <gunning.paul@epa.gov>, "Jackie Krieger" <Krieger.Jackie@epamail.epa.gov>
Cc: "Joe Goffman" <Goffman.Joseph@epamail.epa.gov>
Date: 01/15/2013 07:48 AM
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thanks.

Joel

----- Original Messa
From: "Duke, Rick" [(b)(6) privacy]
Sent: 01/14/2013 10:
To: "Stock, James" <(b)(6) privacy >; Joel Beauvais; "Gruenspecht, Howard (Howard.Gruen Gruenspecht@eia.gov>; "Mignone, Bryan" <Bryan.Mignone@hq.doe.gov>; "Reidmiller, David R (ReidmillerDR@state. ov>
C (b)(6) privacy
<(b)(6) privacy (b)(6) privacy
S obal GHG emissions b
REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Please find attached a spreadsheet showing Domestic and Global GHG emissions by sector for 2012 and 2030, as roughly estimated based on multiple sources. The key charts are pasted below and associated details are provided in the attached spreadsheet. We need to develop refined estimates based on improved sources where available. Please send any comments, including suggested refinements to either chart, by Wednesday 1/16 at 8:30am.

(b)(5) deliberative

Roque: can you please schedule a call 8:30am Wednesday morning for all on this list?

Thanks in advance for what you or your staff can offer. I'm reachable on my mobile at (b)(6) privacy if helpful to touch base directly in advance of the call.

Best,
Rick

Current and projected Global GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Global AnthropogenicNon-CO2 GHG Emissions (2011) , McKinsey Pathways to a Low-Carbon Economy (2009)
Note: Allocations of power sector CO2 between buildings and industrial are approximations

[cid:image002.png@01CDF27F.A9046BA0]

Current and projected U.S. GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Inventory of US GHG Emissions and Sinks1990-2010 , McKinsey (2007)

[cid:image004.png@01CDF27F.A9046BA0]
[attachment "winmail.dat" deleted by Allen Fawcett/DC/USEPA/US] [attachment "PathwayToLowCarbonEconomy_FullReportA.PDF" deleted by Allen Fawcett/DC/USEPA/US] [attachment "ImpactFinancialCrisisCarbonEconomicsGHGcostcurveV21 (1).pdf" deleted by Allen Fawcett/DC/USEPA/US] [attachment "Copy of Domestic and World of GHG by sectors through 2030 011413 (4).xlsb" deleted by Allen Fawcett/DC/USEPA/US] [attachment "image002.png" deleted by Allen Fawcett/DC/USEPA/US] [attachment "image004.png" deleted by Allen Fawcett/DC/USEPA/US]

From:	Paul Gunning
To:	Joel Beauvais
Cc:	Sarah Dunham; Joe Goffman; Paul Gunning; Jackie Krieger; irving.bill@epa.gov; Allen Fawcett
Subject:	Re: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16
Date:	01/15/2013 05:01 PM
Attachments:	winmail.dat PathwayToLowCarbonEconomy_FullReportA.PDF ImpactFinancialCrisisCarbonEconomicsGHGcostcurveV21 (1).pdf Copy of Domestic and World of GHG by sectors through 2030 011413 (4).xlsb image002.png image004.png Emissions Projections Question from Rick Duke_2.xlsx

---

Joel,

Below is our input on the CEQ request. I will look out for the invite for tomorrows call.

Thanks

Paul

(b)(5) deliberative [redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]

(b)(5) deliberative

-
-
-
-
-
-
-

(b)(5) deliberative [redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

▼ Joel Beauvais---01/15/2013 07:48:21 AM---Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thank

From: Joel Beauvais/DC/USEPA/US
To: "Sarah Dunham" <dunham.sarah@epa.gov>, "Paul Gunning" <gunning.paul@epa.gov>, "Jackie Krieger" <Krieger.Jackie@epamail.epa.gov>
Cc: "Joe Goffman" <Goffman.Joseph@epamail.epa.gov>
Date: 01/15/2013 07:48 AM
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thanks.

Joel

----- Original Messa
From: "Duke, Rick" [(b)(6) privacy [redacted]

Sent: 01/14/2013 10:
To: "Stock, James" <(b)(6) privacy Joel Beauvais; "Gruenspecht, Howard v)" <Howard.Gruenspecht@eia.gov>; "Mignone, Bryan" <Bryan.Mignone@hq.doe.gov>; "Reidmiller, David R (ReidmillerDR@state. .gov> (b)(6) privacy >; "Zaidi, Ali" (b)(6) privacy
(b)(6) privacy
GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Please find attached a spreadsheet showing Domestic and Global GHG emissions by sector for 2012 and 2030, as roughly estimated based on multiple sources. The key charts are pasted below and associated details are provided in the attached spreadsheet. We need to develop refined estimates based on improved sources where available. Please send any comments, including suggested refinements to either chart, by Wednesday 1/16 at 8:30am.

(b)(5) deliberative

Roque: can you please schedule a call 8:30am Wednesday morning for all on this list?

Thanks in advance for whatever input y staff can offer. I'm reachable on my mobile at (b)(6) privacy if helpful to touch base directly in advance of the

Best,
Rick

Current and projected Global GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Global AnthropogenicNon-CO2 GHG Emissions (2011) , McKinsey Pathways to a Low-Carbon Economy (2009)
Note: Allocations of power sector CO2 between buildings and industrial are approximations

[cid:image002.png@01CDF27F.A9046BA0]

Current and projected U.S. GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Inventory of US GHG Emissions and Sinks1990-2010 , McKinsey (2007)

[cid:image004.png@01CDF27F.A9046BA0]

From:	Paul Gunning
To:	Joel Beauvais
Cc:	Sarah Dunham; Joe Goffman; Paul Gunning; Jackie Krieger; irving.bill@epa.gov; Allen Fawcett
Subject:	Re: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16
Date:	01/15/2013 05:01 PM
Attachments:	winmail.dat PathwayToLowCarbonEconomy_FullReportA.PDF ImpactFinancialCrisisCarbonEconomicsGHGcostcurveV21 (1).pdf Copy of Domestic and World of GHG by sectors through 2030 011413 (4).xlsb image002.png image004.png Emissions Projections Question from Rick Duke_2.xlsx

---

Joel,

Below is our input on the CEQ request. I will look out for the invite for tomorrows call.

Thanks

Paul

(b)(5) deliberative [redacted]

[redacted]

- [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]

(b)(5) deliberative

-
-
-
-
-
-
-

(b)(5) deliberative [redacted]

Paul M. Gunning
Director, Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

▼ Joel Beauvais---01/15/2013 07:48:21 AM---Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thank

From: Joel Beauvais/DC/USEPA/US
To: "Sarah Dunham" <dunham.sarah@epa.gov>, "Paul Gunning" <gunning.paul@epa.gov>, "Jackie Krieger" <Krieger.Jackie@epamail.epa.gov>
Cc: "Joe Goffman" <Goffman.Joseph@epamail.epa.gov>
Date: 01/15/2013 07:48 AM
Subject: Fw: Domestic and Global GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Talked to Gina and she said we should give feedback. He's asking for it by 8:30 tomorrow am. Thanks.

Joel

----- Original Messa
From: "Duke, Rick" [(b)(6) privacy [redacted]

Sent: 01/14/2013 10:
To: "Stock, James" <(b)(6) privacy Joel Beauvais; "Gruenspecht, Howard v)" <Howard.Gruenspecht@eia.gov>; "Mignone, Bryan" <Bryan.Mignone@hq.doe.gov>; "Reidmiller, David R (ReidmillerDR@state. .gov> (b)(6) privacy >; "Zaidi, Ali" (b)(6) privacy
(b)(6) privacy
GHG emissions by sector for 2012 and 2030 -- REVIEW REQUESTED BY OOB WEDNESDAY 1/16

Please find attached a spreadsheet showing Domestic and Global GHG emissions by sector for 2012 and 2030, as roughly estimated based on multiple sources. The key charts are pasted below and associated details are provided in the attached spreadsheet. We need to develop refined estimates based on improved sources where available. Please send any comments, including suggested refinements to either chart, by Wednesday 1/16 at 8:30am.

(b)(5) deliberative

Roque: can you please schedule a call 8:30am Wednesday morning for all on this list?

Thanks in advance for whatever input y staff can offer. I'm reachable on my mobile at (b)(6) privacy if helpful to touch base directly in advance of the

Best,
Rick

Current and projected Global GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Global AnthropogenicNon-CO2 GHG Emissions (2011) , McKinsey Pathways to a Low-Carbon Economy (2009)
Note: Allocations of power sector CO2 between buildings and industrial are approximations

[cid:image002.png@01CDF27F.A9046BA0]

Current and projected U.S. GHGs by sector (Gt of CO2e)
Source: EIA AEO2013 Early Release, EPA Inventory of US GHG Emissions and Sinks1990-2010 , McKinsey (2007)

[cid:image004.png@01CDF27F.A9046BA0]

From: Paul Gunning
To: Ben DeAngelo
Cc: Rona Birnbaum
Subject: Re: Fw: Draft of responses to petitions for EPA to regulate GHG (and other) emissions from nonroad/mobile and aircraft engines
Date: 06/11/2012 04:00 PM
Attachments: Aircraft Petition Response 6 11 12.docx
Nonroad Petition Response 6-11.docx
FOE-CBD-EJ-Oc Aircraft_GHG_Petition - 12-5-2007.pdf
FOE-CBD-EJ-Oc Marine Petition - 10-3-2007.pdf
ICTA-CFS-FOE nonroad petition 1-29-08.pdf

This is great Ben. I will let Sarah know.

Thanks

Paul

▼ Ben DeAngelo---06/11/2012 03:48:32 PM---Paul, Michael H. forwarded the drafts of the aircraft and nonroad responses to Gina's office. Due

From: Ben DeAngelo/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Rona Birnbaum/DC/USEPA/US@EPA
Date: 06/11/2012 03:48 PM
Subject: Fw: Draft of responses to petitions for EPA to regulate GHG (and other) emissions from nonroad/mobile and aircraft engines

---

Paul,

Michael H. forwarded the drafts of the aircraft and nonroad responses to Gina's office. Due date to the Court is June 18.

For the aircraft response, our statement on our anticipated endangerment schedule now reads:

(b)(5) deliberative [redacted]

I'll also remind Michael that (b)(5) deliberative [redacted]

[redacted]

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 06/11/2012 03:16 PM -----

From: Michael Horowitz/DC/USEPA/US
To: Don Zinger/DC/USEPA/US@EPA

Cc: Lori Stewart/DC/USEPA/US@EPA, Donald Kopinski/AA/USEPA/US@EPA, Glenn Passavant/AA/USEPA/US@EPA, Amber Aranda/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA, Lesley Jantarasami/DC/USEPA/US@EPA, John Hannon/DC/USEPA/US@EPA, Mike Thrift/DC/USEPA/US@EPA, William Charmley/AA/USEPA/US@EPA, Christopher Grundler/AA/USEPA/US@EPA, Lucie Audette/AA/USEPA/US@EPA, Matt Spears/AA/USEPA/US@EPA, Michael Samulski/AA/USEPA/US@EPA
Date: 06/11/2012 02:14 PM
Subject: Draft of responses to petitions for EPA to regulate GHG (and other) emissions from nonroad/mobile and aircraft engines

---

Don,

As promised, I have attached the latest drafts of the responses to the petitions filed by Center for Biological Diversity. I have also attached the original petitions. This is to give Gina a chance to review them before she gets the final copy for signature. The due date is June 18.
As a reminder, CBD and allied groups sent us three petitions several years ago requesting that we make an endangerment findings for GHG emissions from aircraft, ships (also including black carbon) and other nonroad engines and then to promulgate standards regulating these emissions. Litigation following the petitions resulted in a court decision indicating that we had a duty to make an endangerment/cause or contribute finding for aircraft (either positive or negative), but that we had not yet unreasonably delayed in making that finding. The court also found no duty to make an endangerment/
substantial contribution finding for GHG emissions from nonroad engines and vehicles, including vessels. The court also ordered us to answer CBD's petition within 90 days from the court order, which deadline is June 18. Staff from OGC, OTAQ and OAP have been working to put together a draft response consistent with the direction we received from Gina in April. If we can comments back by end of day Wednesday or midday Thursday, we can wrap them up and send a final back up for signature by

next Monday. Thanks.

_____
Michael Horowitz
Attorney Advisor
Office of General Counsel
Air and Radiation Law Office
U.S. Environmental Protection Agency

From:	Paul Gunning
To:	Stacy Kika
Cc:	Erin Birgfeld; Rachel Goldstein
Subject:	Re: Fw: The Economist on Deadline cob tomorrow on landfill methane and N2O
Date:	10/26/2009 05:04 PM

Stacy,

Rachel is on travel. This should work....

1) Is methane abatement at landfills voluntary or mandatory? Someone told me that a new rule was to make it mandatory, but it seems from the website that this is still voluntary, at an EPA "outreach" phase.

By volume, landfill gas is about 50 percent methane and 50 percent carbon dioxide and water vapor. It also contains small amounts of nitrogen, oxygen, and hydrogen, less than 1 percent non-methane organic compounds (NMOC), and trace amounts of inorganic compounds. Some of these compounds have strong, pungent odors (for example, hydrogen sulfide, or H_2S). Non-methane organic compounds consist of certain HAP and VOC, which can react with sunlight to form ground-level ozone (smog) if uncontrolled. Nearly 30 organic HAP have been identified in uncontrolled landfill gas, including benzene, toluene, ethyl benzene, and vinyl chloride. Exposure to these HAP can lead to adverse health effects. Thermal treatment of NMOC (including HAP and VOC) and methane through flaring or combustion in an engine, turbine, boiler, or other device greatly reduces the emission of these compounds.

EPA does not currently regulate methane emissions from landfills. The U.S. EPA, however, does regulate the non-methane organic compounds under the New Source Performance Standards and Emissions Guidelines (NSPS/EG) for municipal solid waste landfills. These regulations require owners/operators of larger landfills to collect and combust their LFG to control NMOC emissions. (A co-benifit is the reduction of methane since it is also in the same LFG waste stream) Under the regulations, landfill owner/operators can either flare or capture and use the LFG as a renewable energy resource. For rule and implementation information for standards of performance for municipal solid waste landfills, go to EPA's Technology Transfer Network Air Toxics Web site.

EPA launched the Landfill Methane Outreach Program (LMOP) to encourage productive use of this resource (recovery and utilization of LFG as energy) as part of the United States' commitment to reduce greenhouse gas emissions under the United Nations Framework Convention on Climate Change. LMOP works with larger landfills who are required by NSPS to collect and combust their LFG to use it as productive energy as well as smaller and medium sized landfills that are not covered under the regulation.

2) What if anything is the EPA doing/requiring regarding abatement of N20, the next biggest greenhouse gas after CO2 and methane.

Agriculture soil management is by far the largest source of N2O emissions (accounts for about 70%) and EPA does not regulate these emissions. As for mobile sources (combustion - second largest source and accounts for about 9 percent of emissions), I believe that the recent EPA/NHTSA proposed standards to reduce GHGs and

improve fuel economy do cover N2O as well. (you should confirm with OTAQ)

http://www.epa.gov/otaq/climate/regulations/420f09047.htm

Paul M. Gunning
Chief, Non-CO2 Programs Branch
Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

▼ Stacy Kika---10/26/2009 04:12:07 PM---Hi Rachel, See below press inquiry. Reporter's deadline is tonight but can extend until tomorrow, O

From: Stacy Kika/DC/USEPA/US
To: Rachel Goldstein/DC/USEPA/US@EPA
Cc: Erin Birgfeld/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA
Date: 10/26/2009 04:12 PM
Subject: Fw: The Economist on Deadline cob tomorrow on landfill methane and N2O

Hi Rachel,

See below press inquiry. Reporter's deadline is tonight but can extend until tomorrow, October 27, 2009.

Thanks,

Stacy

Stacy H. Kika
U.S. Environmental Protection Agency
Climate Change Division- Communications
Email: kika.stacy@epa.gov
Phone: 202.343.9930

----- Forwarded by Stacy Kika/DC/USEPA/US on 10/26/2009 04:07 PM -----

From: Andrea Drinkard/DC/USEPA/US
To: "Erin Birgfeld" <Birgfeld.Erin@epamail.epa.gov>, "Stacy Kika" <Kika.Stacy@epamail.epa.gov>
Date: 10/26/2009 04:00 PM
Subject: Fw: The Economist on Deadline cob tomorrow on landfill methane and N2O

If we could get these answered tonight that would be awesome, though I seem to remember something about rachel going to china this week :-/

▼ Dave Ryan

----- Original Message -----
From: Dave Ryan
Sent: 10/26/2009 03:31 PM EDT
To: Andrea Drinkard
Subject: The Economist on Deadline cob tomorrow on landfill methane and N2O

Dave Ryan
EPA Washington Headquarters Press Officer
PHONE: 202-564-7827
E-MAIL: ryan.dave@epa.gov

----- Forwarded by Dave Ryan/DC/USEPA/US on 10/26/2009 03:30 PM -----

From: "Lane Greene" <lanegreene@economist.com>
To: Dave Ryan/DC/USEPA/US@EPA
Date: 10/26/2009 02:58 PM
Subject: from The Economist

Hy Dave,
questions. (MY filing deadline is tonight. If absolutely no one can answer these today, I can squeeze something in during editing tomorrow.)

1) Is methane abatement at landfills voluntary or mandatory? Someone told me that a new rule was to make it mandatory, but it seems from the website that this is still voluntary, at an EPA "outreach" phase.

2) What if anything is the EPA doing/requiring regarding abatement of N20, the next biggest greenhouse gas after CO2 and methane.

Thanks,
Lane Greene

Lane Greene
The Economist
111 W57th St New York NY
212-698-9767 (office) -- (b)(6) privacy (mobile)

This e-mail may contain confidential material. If you are not an intended recipient, please notify the sender and delete all copies. It may also contain personal views which are not the views of The Economist Group. We may monitor e-mail to and from our network.

Sent by a member of The Economist Group. The Group's parent company is The Economist Newspaper Limited, registered in England with company number 236383 and registered office at 25 St James's Street, London, SW1A 1HG. For Group company registration details go to http://legal.economistgroup.com

Please consider the environment before printing this e-mail.

From: Paul Gunning
To: Rona Birnbaum
Subject: Re: new study on strat ozone and climate
Date: 08/01/2012 06:16 PM

Of course. Thanks for looping me in.
Paul Gunning
Sent by EPA Wireless E-Mail Services.
▼ Rona Birnbaum

----- Original Message -----
From: Rona Birnbaum
Sent: 08/01/2012 05:40 PM EDT
To: Paul Gunning
Subject: Re: new study on strat ozone and climate

Paul, Sarah asked Drusilla to forward this article to me so that we are aware. I asked Marcus to put it into context and identify key messages - - which he did very elegantly with this summary. I think Sarah may also find it useful and I'd like to forward it to her.
----- Forwarded by Rona Birnbaum/DC/USEPA/US on 08/01/2012 05:34 PM -----

From: Marcus Sarofim/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Allison Crimmins/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA, Lesley Jantarasami/DC/USEPA/US@EPA, Michael Kolian/DC/USEPA/US@EPA
Date: 08/01/2012 03:49 PM
Subject: Re: Fw: Interesting New Work

Hi Rona,

You wanted the results of this paper, placed into context: here's my attempt at it:
First, the very short version:

This is an interesting scientific paper that details a mechanism by which summertime storms may contribute to CFC-induced stratospheric ozone loss over the US. The paper suggests that this may be an additional way that climate change can interact with stratospheric ozone. However, it is not clear that the magnitude or understanding of this effect are sufficient such that it should be taken into account in a policymaking context (as is often true of any individual study at the cutting edge of scientific understanding).

Second: the more technical version:

Conclusions of the UV Dosage Levels in Summer paper :
1) the authors have observed that summer storms over the US can inject water vapor into the stratosphere. The authors state that the increased water vapor levels would likely increase the potential for CFCs to destroy ozone. Currently, ozone destruction from CFCs has mainly been observed in the Antarctic stratosphere, and, to a lesser extent, the Arctic, because those are the two locations that are cold enough to create

the right conditions: increased water vapor (or, alternatively, sulfate aerosols) would increase the threshold temperature needed for this ozone destruction, allowing it to happen over regions that have the right weather for this kind of storm/water injection.

2) The authors put forth several implications. First, that this injection of water by storms will delay a stratospheric ozone recovery. Second, that climate change may lead to increased water vapor in the stratosphere, thereby leading to more ozone destruction from CFCs. Third, that geoengineering through sulfates in the stratosphere will also lead to increased ozone destruction.

(b)(5) deliberative [redacted]

[redacted]

-Marcus

Marcus C. Sarofim, PhD
phone: 202-343-9993
fax: 202-343-2202
1310 L Street 827D
Environmental Scientist
Climate Science & Impacts Branch

▼ Rona Birnbaum---07/27/2012 12:52:42 PM---fyi Sarah wanted to make sure that we have this too.

From: Rona Birnbaum/DC/USEPA/US
To: Marcus Sarofim/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA, Allison Crimmins/DC/USEPA/US@EPA, Lesley Jantarasami/DC/USEPA/US@EPA
Cc: Michael Kolian/DC/USEPA/US@EPA
Date: 07/27/2012 12:52 PM

Subject: Fw: Interesting New Work

---

fyi
Sarah wanted to make sure that we have this too.

----- Forwarded by Rona Birnbaum/DC/USEPA/US on 07/27/2012 12:51 PM -----

From: Drusilla Hufford/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA
Cc: Sarah Dunham/DC/USEPA/US@EPA, Jackie Krieger/DC/USEPA/US@EPA
Date: 07/27/2012 11:14 AM
Subject: Interesting New Work

Rona - the NYT today contained this article. I have also attached for you a PDF of the study.

FYI,

Drusilla

NY Times article:

http://www.nytimes.com/2012/07/27/science/earth/strong-storms-threaten-ozone-layer-over-us-study-says.html?pagewanted=1&hp

[attachment "science.1222978.full.pdf" deleted by Marcus Sarofim/DC/USEPA/US]

Drusilla Hufford
U.S. EPA
Mailing address
1200 Pennsylvania Avenue, NW (6205J)
Washington, DC 20460
Office location and express mail delivery
1310 L St., NW
Washington, DC 20005
tel: 202-343-9101
cell: 202-253-2243
fax: 202-343-2363
e-mail: hufford.drusilla@epa.gov
http://www.epa.gov/ozone

From:	Connors, Celeste A.
To:	'Reifsnyder, Daniel A (OES)'; Thompson, John E (OES); Ogden, Peter R; Zaitchik@jhu.edu; Artusio, Christo F; 'chester.j.koblinsky@noaa.gov'; Brian Mclean/DC/USEPA/US@EPA; Paul Gunning/DC/USEPA/US@EPA; Drusilla Hufford/DC/USEPA/US@EPA; 'Rick.Duke@hq.doe.gov'; 'Sarah.Bittleman@osec.usda.gov'
Cc:	Aldy, Joseph E.; Bordoff, Jason E.; Dunwoody, Stephen A.; Burton, Groslyn
Subject:	Short-lived Climate Forcers Mtg. Friday 15 October 2010, 4:00 PM
Date:	10/14/2010 05:12 PM
Attachments:	SLCF_framework_NALS_10122010.docx SLCF background material for COP16 announcement.docx

---

The NSC/NEC will host an interagency meeting on short-lived climate forcers (SLCF) as a possible announcement before COP-16 in Cancun. Please see attached read ahead.

Time: Friday 15 October 2010, 4:00 PM

Location: EEOB, RM 234

Please send your clearance information (name, DOB, SSN#) to Steve Dunwoody (b)(6) privacy Tel: (b)(6) privacy as soon as possible.

Best regards,

Celeste

Celeste Connors
Director for Environment and Climate Change
National Security Council
Tel: (202) 456-9285

Contents

Executive Summary 2
Charge Question 1 10
Charge Question 2 14
Charge Question 3 16
Charge Question 4 22
Charge Question 5 33
Charge Question 6 36
References 40

Executive Summary

This Advisory responds to a request from the EPA Office of Air and Radiation for EPA's Science Advisory Board (SAB) to review and comment on EPA's *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources (Framework, September 2011)*. The *Framework* considers the scientific and technical issues associated with accounting for emissions of biogenic carbon dioxide (CO_2) from stationary sources and develops a framework to adjust the stack emissions from stationary sources using bioenergy based on the induced changes in carbon stocks on land (in soils, plants and forests). To conduct the review, the SAB Staff Office formed the Biogenic Carbon Emissions Panel with experts in forestry, agriculture, greenhouse gas measurement and inventories, land use economics, ecology, climate change and engineering.

The SAB Biogenic Carbon Emissions Panel was asked to review and comment on (1) EPA's characterization of the science and technical issues relevant to accounting for biogenic C02emissions from stationary sources; (2) EPA's framework, overall approach, and methodological choices for accounting for these emissions; and (3) options for improving upon the framework for accounting for biogenic C02 emissions. In the context of EPA's *Framework*, the term "biogenic carbon emissions" refers to emissions of CO_2 from a stationary source directly resulting from the combustion or decomposition of biologically-based materials other than fossil fuels. During the course of deliberations, the SAB Panel reviewed background materials provided by the Office of Air and Radiation and heard from numerous public commenters. This Executive Summary highlights the SAB's main conclusions. Detailed responses to the individual charge questions are provided in the body of the report.

Context

EPA provided very little written description of its motivation for the *Framework* in the document itself. However, through the background information provided and discussion at the public meeting on October 25 – 27, 0211, EPA explained that the context for the report is the treatment of biogenic CO_2 emissions in stationary source regulation. Specifically, under the Clean air Act, stationary sources (e.g. power plants) are often regulated at the point of emissions. In the case of greenhouse gases and this Framework, the question EPA is considering is whether and how to count the biogenic CO_2 emissions from a stationary source.

On June 3, 2010, EPA finalized new thresholds for greenhouse gas emissions that define when Clean Air Act permits under the New Source Review (Prevention of Significant Deterioration program) and Title V operations permits program would be required (also known as the "Tailoring Rule". In the Tailoring Rule, EPA did not exclude biogenic emissions from the determination of applicability thresholds, however in July 2011, EPA deferred for a period of three years the application of permitting requirements to biogenic carbon dioxide (CO_2) emissions from bioenergy and other biogenic stationary sources. In its deferral, EPA committed to conducting a detailed examination of the science and technical issues associated with biogenic CO_2 emissions and submitting its study for review by the Science Advisory Board. The motivation for considering whether or not to adjust biogenic carbon emissions from stationary sources stems from the way the carbon in these feedstocks interacts with the global carbon cycle. Plants take up carbon from the atmosphere to produce products that are consumed by humans

and animals for food, shelter and energy. Plants convert raw materials present in the ecosystem such as carbon from the atmosphere and inorganic minerals and compounds from the soil including nitrogen, potassium, and iron and make these elemental nutrients available to other life forms. Carbon is returned to the atmosphere through respiration by plants and animals and by industrial processes, including combustion and by natural decomposition. Thus, the use of biogenic feedstocks results in both carbon emissions and carbon sequestration.

Categorical inclusion or exclusion

The SAB Panel was asked whether it supported EPA's conclusion that categorical approaches are inappropriate for the treatment of biogenic carbon emissions. A categorical inclusion would treat biogenic carbon emissions as equivalent to fossil fuel emissions while a categorical exclusion would exempt biogenic carbon emissions from greenhouse gas regulation. The decision about a categorical inclusion or exclusion will likely involve many considerations that fall outside the SAB's scientific purview such as legality, feasibility and, possibly, political will. The SAB cannot speak to the legal or implementation difficulties that could accompany any policy on biogenic carbon emissions but this Advisory offers some scientific observations that may inform the Administrator's policy decision.

Carbon neutrality cannot be assumed for all biomass energy a priori. A blanket assumption of carbon neutrality will underestimate the climate impact of bioenergy. There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a priori assumption; it is a conclusion that should be reached only after considering a particular feedstock's production and consumption cycle. There is considerable heterogeneity in feedstock types, sources and production methods and thus net biogenic carbon emissions will vary considerably. Only when bioenergy results in <u>additional</u> carbon being sequestered above and beyond the anticipated baseline (the "business as usual" trajectory) can there be a justification for concluding that such energy use results in little or no increase in carbon emissions.

Given that some biomass could have positive net emissions, a categorical exclusion would remove any responsibility on the stationary source for CO_2 emissions from its use of biogenic material from the entire system (*i.e.*, the global economy) and provide no incentive for the development and use of best management practices. Conversely, a categorical inclusion would provide no incentive for using biogenic sources that compare favorably to fossil energy in terms of greenhouse gas emissions.

Biogenic Accounting Factor (BAF) Calculation

The *Framework* presented an alternative to a categorical inclusion or exclusion by offering an equation for calculating a Biogenic Accounting Factor (BAF) that adjusts the onsite biogenic emissions at the stationary source based on feedstock growth, decomposition, carbon stored in products, leakage and site sequestration effects. In consideration of its own regulatory boundaries, EPA constrained BAF to lie somewhere between 0 (categorical exclusion) and 1 (categorical inclusion) however scientifically, BAF could be below 0 or above 1. In terms of their greenhouse gas implications, some feedstocks could be better than carbon neutral and other

feedstocks might do more harm than fossil fuels. In keeping with its regulatory boundaries, EPA's constrained BAF to lie at or above 0 because it was not allowing for the possibility of granting credits to bioenergy if it creates net emissions reductions. EPA did not allow BAF to rise above 1 because it was not considering the possibility of "penalizing" biogenic energy that might be "dirtier" than fossil fuels. As a result of this artificial constraint on BAF, EPA's *Framework* could, inadvertently, encourage the use of biological feedstocks that have higher greenhouse gas emissions than fossil fuels just as it could, inadvertently, discourage the use of biogenic feedstocks that are superior to fossil fuels in terms of their greenhouse gas consequences.

To calculate BAF for biomass from roundwood trees, EPA conjured the concept of regional carbon stocks (with the regions unspecified) and posed a "rule" whereby any bioenergy usage that takes place in a region where carbon stocks are increasing would be automatically assigned a BAF of 0. This leads to the nonsensical conclusion that a ton of carbon emitted in one part of the country may be treated differently from a ton of carbon emitted elsewhere. The atmospheric response to an additional ton of carbon is the same, regardless of its geographic origin. Thus, EPA's creation of artificially contrived regions and the assignment of BAF based on geography is not justified scientifically.

While EPA's proposed equation for BAF has overarching problems, the variables in the equation capture many of the factors necessary for estimating the offsite carbon change associated with stationary source biomass emissions from agricultural feedstocks. These include factors to represent the carbon embodied in products leaving a stationary source, the proportion of feedstock lost in conveyance, the offset represented by sequestration, the site-level difference in net carbon flux as a result of harvesting, the emissions that would occur anyway from removal or diversion of nongrowing feedstocks (e.g. corn stover) and other variables. For short recovery feedstocks where carbon recovery and "anyway" emissions are within one to a few years (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), the *Framework* may, with some adjustments and appropriate data, accurately represent direct carbon changes in a particular region. For waste materials (municipal solid waste), the *Framework* needs to consider the mix between biogenic and fossil carbon as well as the potential capture of methane (CH_4) emissions from landfills. Given that CH_4 emissions from landfills are often captured, crediting waste material for avoided emissions (as the *Framework* currently does) may not always be appropriate. For long carbon recovery feedstocks (roundwood), the *Framework* does not capture the carbon outcome given its omission of the time path for carbon recovery following harvest. For these feedstocks, the Framework does not allow determination of the incremental impact of a stationary facility holding everything else the same or establish causality between bioenergy use and observed carbon outcomes. Additionally, the measurement of the carbon impact of the facility is scale sensitive. These issues are discussed in greater detail below.

Leakage is a phenomenon by which efforts to reduce emissions in one place shift emissions to another location or sector The *Framework's* equation for BAF includes a term for leakage, however EPA decided that calculating values for leakage was outside the scope of the *Framework*. It should be recognized that incorporating leakage, however difficult, may change the BAF results radically. "Bad" leakage (called "positive" leakage in the literature) occurs

when the use of biogenic feedstocks causes price changes which, in turn, drive changes in consumption and production outside the boundary of the stationary source, even globally, that lead to increased carbon emissions. One type of positive leakage could occur if land is diverted from food/feed production to bioenergy production which increases the price of conventional agricultural and forest products in the world market and leads to conversion of carbon rich lands to crop production and the release of carbon stored in soils and vegetation.. The use of biogenic feedstocks can also affect the price of fossil fuels by lowering demand for them and thereby increasing their consumption elsewhere. "Good" leakage (called "negative" leakage in the literature) could occur if the use of biomass leads to carbon offsetting activities elsewhere. The latter could arise for example, if increased demand for biomass and higher prices generates incentives for investment in forest management which increases forest carbon sequestration.

The existing literature in the social sciences shows that the overall magnitude of leakage is highly uncertain and differs considerably across studies and within a study, depending on underlying assumptions. Rather than eschewing the calculation of leakage altogether, EPA could instead, try to ascertain the directionality of net leakage, whether it is positive (leading to increased carbon emissions elsewhere) or negative (leading to carbon offsetting activities) and incorporate that information in its decision making. Moreover, EPA should investigate leakage that may occur in other media, e.g. fertilizer runoff into waterways. In cases where prior research has indicated directionality, if not magnitude, such information should be used.

Causality and Additionality

EPA's stated objective was to accurately reflect the carbon outcome of biomass use by stationary sources. To accurately capture the carbon outcome, this requires selecting a time period and determining what would have happened anyway without the harvesting and comparing that impact with the carbon trajectory associated with harvesting of biomass for bioenergy within that time frame. Although any "business as usual" projection would be uncertain, it is the only means by which to gauge the incremental impact of biomass harvesting. The *Accounting Framework* discusses this approach, calling it an "anticipated future baseline" approach but does not attempt it. Instead a fixed reference point and an assumption of geographic regions were chosen to determine the baseline for whether biomass harvesting for bioenergy facilities is having a negative impact on the carbon cycle. The choice of a fixed reference point may be the simplest to execute, but it does not properly address the additionality question, i.e. the extent to which forest stocks would have been growing or declining over time in the absence of bioenergy. The use of a fixed reference point baseline coupled with a division of the country into regions implies that forest biomass emissions could be considered carbon neutral simply because forest stocks are increasing in a particular region from the base year. This is not justified scientifically because from a mass balance perspective, a reduction in the rate of increase of carbon stocks is equivalent to an increase in emissions; rather it is an artifact based on the choice of baseline and the assumption of unspecified geographic regions. The reference point estimate of regionwide net emissions or net sequestration does not indicate, or estimate, the difference in greenhouse gas emissions (the actual carbon gains and losses) over time that are associated with biomass use. Instead, the *Framework* captures changes over an undefined space, in a sense, substituting space for time. As a result, the *Framework* fails to capture the causal connection between biomass harvesting and atmospheric impacts.

By forgoing the anticipated future baseline approach, the *Framework* fails to capture the difference in CO_2 concentrations the atmosphere sees over some time frame as a result of stationary source use of forest biomass. For faster growing biomass like agricultural crops, the incorporation of a time frame is not necessary. For wood harvested specifically for energy use (roundwood) and logging residues, the *Framework* does not incorporate a) the time path of carbon accumulation in forests (before or after energy emissions from harvested roundwood) or b) the time path of the "anyway" emissions that would have occurred on the land if logging residue were not used for energy production. By not incorporating a time interval, the *Framework* fails to capture the contribution to climate change made by temporary carbon losses. Thus for long recovery feedstocks where carbon recovery occurs over decades, the *Framework* does not capture the carbon outcome, defined as "what the atmosphere sees." EPA might consider adopting a GWP index to represent feedstocks with long recovery times. As pioneered by Cherubini *et al.* (2011), GWP_{bio} incorporates a time dimension into the calculation, taking into account the fact that sequestration in new growth is spread over a time interval of years. GWP_{bio} is a unit-based index that uses CO_2 impulse response functions from C cycle models in the elaboration of atmospheric decay functions for biomass-derived CO_2 emissions. GWP_{bio} is expressed as a function of the rotation period of the biomass.

Scale

The use of a regional scale is a central weakness of the *Framework*. EPA employed regions as an artificial construct to avoid the need for site-specific chain of custody carbon accounting with separate streams for each feedstock and as an alternative to capturing changes in carbon stocks over time. EPA used a variable for the Level of Atmospheric Reduction (LAR) to capture the proportion of potential gross emissions that are offset by sequestration during feedstock growth, however the calculation of LAR captures landscape wide changes rather than facility-specific carbon emissions associated with actual fuelsheds. However, it makes the estimate of the BAFs sensitive to the choice of the spatial region. As shown in EPA's own case study, the choice of the appropriate regional scale has significant implications for the emissions attributed to a facility.

Recommendations for Revising BAF

To implement the *Framework*, EPA faces daunting technical challenges. Although the SAB would prefer an alternative to the calculation of a BAF (as described below), if EPA decides to revise the *Framework*, the SAB recommends the following improvements.

- Develop a separate BAF equation for each feedstock category. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues, long rotation trees and waste materials.
- Separate out feedstocks which could be classified as "anyway" emissions so that their BAF would automatically be either set to 0 or modeled as a decay function.
- Develop an equation for perennial energy crops and short rotation woody biomass.

- Use an anticipated baseline approach for long recovery feedstocks like roundwood.
    - For forest biomass from roundwood harvested for bioenergy, omit the regional scale and incorporate a time dimension, modifying certain factors in the BAF equation to include the timescale over which carbon is decomposed or released back to the atmosphere. Consider employing integrated forest sector models and/or Cherubini's $GWP_{bio.}$
    - Modify the variable that represents the proportion of emissions that are offset by sequestration during feedstock growth (LAR) so that it is scale insensitive.
- Develop an equation for municipal solid waste to take into account the mix of biogenic waste with fossil fuel waste as well as the possibility of methane capture in landfills.
- Consider information about the directionality of leakage as well as leakage into other media.

Alternatives to BAF

In a perfect world with full information and unlimited policy choices, carbon limits (or prices) would be implemented economy-wide and not selectively enacted for particular sources or sectors. Economic research has shown that the most cost-effective way to reduce greenhouse gas emissions (or any other pollution) is to regulate or tax across all sources until they face a marginal cost of emissions reduction that equals the marginal benefit of emissions reduction and is equal across sources. In EPA's less perfect world with limited authority under the Clean Air Act, the most efficient economy-wide solution is not within its menu of choices. EPA's regulation of stationary sources will exclude other users of biomass (e.g. consumers of ethanol) that have equivalent impacts on the carbon cycle as well as downstream consumers of products produced by these facilities.

In this second-best world with limited policy instruments that can be applied only to limited sources, it would be desirable for EPA to ascribe all changes in greenhouse gas emissions (both upstream and downstream of the stationary source) caused by the operation of the stationary facility to that source. Ideally, these emissions would need to be determined on a facility-specific basis however facility-specific calculations face some daunting practical challenges, including chain of custody accounting and estimation of market mediated effects or "leakage."

Given the choices facing EPA, one hybrid approach for EPA to consider would be a categorical inclusion with opt-out provisions. Stationary sources would be subject to a categorical inclusion unless they opted out by certifying that their biomass was sustainably harvested and produced using best management practices. By making the stationary source responsible for demonstrating "sustainability", the source would be linked to its land base. This would remove the perverse situation of a responsible bioenergy facility, using feedstock produced in a highly sustainable manner, being penalized because it happens to be located in a region where other, less sustainable forest activities are causing carbon stocks to decline. It would also avoid the

problem of a bioenergy facility that uses biomass harvested in an unsustainable manner benefiting from operating in a region where carbon stocks happen to be growing. A certification system may not control for market-mediated effects or leakage and it may increase complexity and costs of accounting for the carbon emissions of a stationary source. The SAB cannot offer an opinion on the legal feasibility of such an approach. Certification systems have been successfully employed in Europe and, to a lesser extent, in the U.S. via the Sustainable Forestry Initiative.

Given the conceptual deficiencies, described above, and prospective difficulties with implementation, the SAB urges the Agency to "think outside the box" about policy options that go beyond categorical inclusion, exclusion or calculating a BAF for each facility. We offer the following three options for the Agency's consideration:

1. Consider developing a generic BAF for each feedstock category.
2. Consider certification systems.
3. Consider offset systems.

Option 1: Consider developing a generic BAF for each feedstock category. An alternative to revising the *Framework* and calculating a BAF for each stationary facility is to develop general BAFs for each category of feedstocks, differentiating among feedstocks using general information on how their harvest and combustion interacts with the carbon cycle. EPA might need to develop a separate BAF equation for each of the other categories of feedstocks, using forest growth models to plot carbon paths that track regrowth following harvest. Many more case studies would be needed to develop an accounting focused on feedstocks rather than the facility. These generic BAFs would be applied by stationary facilities to determine their quantity of biogenic emissions that would be subject to EPA's tailoring rule.

Option 2: Consider certification systems in a hybrid approach. A categorical inclusion with an opt-out provision whereby facilities could opt out by certifying that their biomass was sustainably harvest and produced using best management practices. Such "sustainability" would need to be certified by an authority using valid scientific measurements. Requiring stationary facilities to use only "certified" feedstocks would be administratively simpler than quantifying a specific net change in greenhouse gases associated with a particular stationary facility. Certification apparoach can avoid the arbitrary scale issues and can perhaps avoid or reduce leakage.

Option 3: Consider offsets. An offset is a reduction in emissions of carbon dioxide or other greenhouse gas made in order to offset an emission made elsewhere. The use of offsets could accompany either Option 1 or Option 2 above or even a calculated BAF for each facility (using the *Framework*). If offsets were allowed, it would make possible a variety of gains from trade that facilities could use to lower costs. For example, a fossil or biogenic CO_2 emitter could contract with land owners to offset their emissions through forest protection and regrowth or carbon accumulation in soils.

Conclusion

As EPA has recognized, the greenhouse gas implications of bioenergy are more complex and subtle than the greenhouse gas impacts of fossil fuels. In recognition of the complicated role that bioenergy plays in the carbon cycle, the *Framework* provides a structure to account for net climate impacts. The focus of the *Framework*, however, is on point source emissions from stationary facilities. As a result, the *Framework's* boundaries are drawn only so far as to account for any offsetting carbon sequestration that may be attributed to the facility's use of a biogenic feedstock. These narrow regulatory boundaries are in conflict with a more comprehensive carbon accounting that considers the entire carbon cycle and the possibility of gains from trade between sources, among sources or between sources and sinks. As far as the climate is concerned, it makes no difference if land use change is used to offset CO_2 that was of fossil origin or of biogenic origin. By staying within boundaries drawn narrowly around the stationary source, the *Framework* eclipses a more comprehensive approach to greenhouse gas reductions that would address all sources and sinks. While the *Framework* , to some degree, extends carbon accounting upstream, a more comprehensive carbon accounting would extend downstream—to emissions from by-products, co-products, or products such as ethanol combustion or ethanol by-products such as dried distillers grains (DDGs) that are sold as livestock feed and will soon become CO_2 (or CH_4). It would also extend upstream and account for the carbon emissions due to the use of fertilizer to produce the biogenic feedstock.

The *Framework's* main contribution is to lay the groundwork for future developments in accounting for biogenic emissions while forcing important questions.

Charge Question 1

1. **In reviewing the scientific literature on biogenic CO2 emissions, EPA assessed the underlying science of the carbon cycle, characterized fossil and biogenic carbon reservoirs, and discussed the implications for biogenic CO2 accounting.**

   1.1. Does the SAB support EPA's assessment and characterization of the underlying science and the implications for biogenic CO2 accounting?

EPA has done an admirable job of reviewing the science behind the carbon cycle and greenhouse gas emissions and their relationship to climate change, extracting some of the critical points that are needed to create the proposed accounting framework. At the same time, there are several important scientific issues that are not addressed in the EPA document, as well as scientific issues that are briefly discussed but not sufficiently explored in terms of how they relate to the *Framework*. In the following section, we describe a series of deficiencies with the EPA assessment and characterization of the science behind biogenic CO_2 accounting, and suggest some areas where the treatment of the existing scientific understanding of ecosystems and the carbon cycle could be strengthened.

1) Timescale

One fundamental deficiency in the EPA report is the lack of discussion of the different timescales inherent in the carbon cycle and the climate system that are critical for establishing an accounting system. This is a complicated subject because there are many different timescales that are important for the issues associated with biogenic carbon emissions. At the global scale, there are multiple timescales associated with mixing of carbon throughout the different reservoirs on the Earth's surface. When carbon dioxide is released into the air from burning fossil fuels, roughly 45% stays in the air over the course of the following year. Of the 55% that is removed, roughly half is taken up by the ocean, mostly in the form of bicarbonate ion, and the other half is taken up by the terrestrial biosphere, primarily through reforestation and enhanced photosynthesis. The airborne fraction (defined as the fraction of emissions that remains in the air) has been remarkably constant over the last two decades.

There is considerable uncertainty over how the magnitude of ocean and terrestrial uptake will change as the climate warms during this century. If the entire ocean were to instantly reach chemical equilibrium with the atmosphere, the airborne fraction would be reduced to 20% to 40% of cumulative emissions, with a higher fraction remaining in scenarios with higher cumulative emissions. In other words, the ocean chemical system by itself cannot remove all the CO_2 released in the atmosphere. Because carbon uptake by the ocean is limited by the rate of mixing between the shallow and deeper waters, this complete equilibration is expected to take thousands of years. Over this century, if global CO_2 emissions continue to rise, most models predict that ocean uptake will stabilize between 3 to 5 GtC/y, implying that the fraction of emissions taken up by the ocean will decrease. For the terrestrial biosphere, there is a much wider envelope of uncertainty; some models predict that CO_2 uptake will continue to keep pace with the growth in emissions, while other models suggest that CO_2 uptake will decline, even

becoming a net source of CO_2 to the atmosphere if processes such as release of carbon from the tundra or aridification of the tropics were to occur.

Over the timescale of several thousand years, once ocean equilibration is complete and only 20% to 40% of cumulative emissions remains in the atmosphere, dissolution of carbonate rocks on land and on the ocean floor will further reduce the airborne fraction to 10% to 25% over several thousand years to ten thousand years. This last remnant of anthropogenic CO_2 emissions will stay in the atmosphere for more than 100,000 years, slowly drawn down by silicate weathering that converts the CO_2 to calcium carbonate, as well as slow burial of organic carbon on the ocean floor. The size of this "tail" of anthropogenic CO_2 depends on the cumulative emissions of CO_2, with higher cumulative emissions resulting in a higher fraction remaining in the atmosphere.

Another important timescale for considering accounting systems for biogenic carbon emissions is the period over which the climate responds to carbon dioxide and other greenhouse gases. Several different climate modeling studies have demonstrated that the peak warming in response to greenhouse gas emissions is primarily sensitive to cumulative greenhouse gas emissions over a period of roughly 100 years, and is relatively insensitive to the emissions pathway within that time frame. What this means is that an intervention in forests or farming that results in a change in storage of carbon or emissions reductions must endure for significantly longer than 100 years in order to have any real influence on the peak climate response.

Timescales are also important at a more local scale. Given the EPAs objective is to account for the atmospheric impact of biogenic emissions, it is important to consider the turnover times of different biogenic feedstocks in justifying how they are incorporated into the accounting framework. The fundamental differences in stocks and their turnover times as they relate to impact on the atmosphere is not well discussed or linked into the current framework. (Page 6 raises the issue but does not delve into what it means for biogenic carbon accounting).
If a carbon stock is cycling quickly on land, turning over and being replaced fully in less than 100 years (as discussed above), it may have a beneficial impact when it is consumed for energy, displacing the combustion of fossil fuel. If the carbon stock, or some part of it, turns over more slowly, i.e., much longer than 100 years, the timing of release begins to matter.
There is a continuum of carbon stock size and turnover among the biogenic feedstock sources included in this framework, but there is little background discussion of the variation in the stock and turnover and how that informs the accounting method. The current framework sets up categories of feed stocks based on their source, but these grouping have little to do with their carbon stock and turnover or how they are accounted for in the current framework. The science section could walk through the carbon stocks covered by the scope of the accounting framework and their relevant turnover times.

The timescale over which land carbon may change, coupled with the scientific understanding of the timescale of the climate system response, could have been used in the report to support the EPA accounting method against criticisms from several environmental groups who point to the idea of a carbon debt when biomass is harvested and taken from a forest. The idea of a carbon debt is technically correct, but fails to recognize that the climate response is based on cumulative emissions over 100 years. This means that the climate system is not sensitive to the imbalance in the carbon cycle that might occur over decades from harvesting of biomass for bioenergy

facilities. The carbon debt is a serious problem if the time for regrowth is much more than 100 years. However, the annual accounting method proposed by the EPA does not fit well with this framework. A scientifically rigorous evaluation of the biomass harvest on the carbon cycle must consider what the impact will be on the 100 year timescale. Annual accounting of carbon stocks is likely to give inaccurate assessments of the overall carbon cycle impacts.

A subtle but important point for estimating carbon outcome and "what the atmosphere see" is that the measurement should be in the form of change in global warming potential on say the commonly used 100 year basis. For short recovery time feedstocks such as perennial grasses the difference in global warming potential is almost identical to CO_2 emissions minus carbon change on the land (CO_2 eq). For feedstocks with long recovery time one must compute the change in global warming potential by calculating the cumulative radiative forcing of the initial CO2 emission minus the carbon change on the land (CO_2 eq) (using an integral convolution) to 100 years, then dividing by the integral of radiative forcing for a simple CO_2 emission to 100 years. This estimate of GWP in CO_2 equivalents will be less than an estimate using CO_2 emission minus carbon change on the land (CO_2 eq) over 100 years. The more detailed calculation of change in GWP_{100} properly takes into account absorption of the initial CO_2 emission by oceans and terrestrial CO_2 fertilization.

2. Disturbance

Because ecosystems respond in complicated ways to disturbances (e.g. harvesting, fire) over long periods of time, and with a high degree of spatial heterogeneity, the state of knowledge about disturbance and impacts on carbon stocks and turnover should be reviewed within the context of relevant timescales. This is highly relevant to producing accurate estimates of biogenic emissions from the land. There is also insufficient treatment given to the existing literature on the impact of different land management strategies on soil carbon, which is important for understanding how carbon stocks may change over many decades. A short list of relevant publications is provided in the Reference section.

3. Space for time substitution

A discussion of the literature on the value and limitations of space for time substitutions should be discussed as it is a fundamental part of the *Accounting Framework* presented. The implications for different baseline conditions on space-time substitution should also be part of this methods review.

4. Non-CO_2 Greenhouse Gases

The *Framework* does not incorporate greenhouse gases other than CO_2. This fails to account for the difference between biomass feedstocks in terms of their production of other greenhouse gases. The most important of these is likely to be N_2O produced by the application of fertilizer (Crutzen et al., 2007). In particular, if the biomass feedstock is from an energy crop that results in different N_2O emissions vis-a-vis other crops, should this be counted? Is it negligible? This issue is not introduced in the science section. N_2O is relatively long-lived (unlike methane), and therefore the climate impacts of heavily fertilized biomass (whether in forests or farms) are

greater than non-fertilized biomass. There is a substantial literature on N_2O from fertilizer use that was not discussed in the *Framework*. If this is a life cycle comparability/fairness issue with fossil fuels this needs to be explicitly discussed. If we are not counting certain emissions from fossil fuels either because they are counted elsewhere or outside the mandate, then how do those compare to the emissions from biogenic fuels that are counted elsewhere or outside the mandate? How significant are they compared to those emitted and counted?

Charge Question 2

2. Evaluation of biogenic CO_2 accounting approaches

In this report, EPA considered existing accounting approaches in terms of their ability to reflect the underlying science of the carbon cycle and also evaluated these approaches on whether or not they could be readily and rigorously applied in a stationary source context in which onsite emissions are the primary focus. On the basis of these considerations, EPA concluded that a new accounting framework is needed for stationary sources.

2.1. Does the SAB agree with EPA's concerns about applying the IPCC national approach to biogenic CO_2 emissions at individual stationary sources?

Yes. The IPCC national approach is a inventory of global greenhouse emissions (*i.e.*, all emissions are counted). It is comprehensive in quantifying all emissions sources and sinks, but does not describe linkages among supply chains. In other words, it is essentially a "production-based inventory" or "geographic inventory" rather than a "consumption-based inventory" (Stanton *et. al*., 2011. Moreover, it offers a static snapshot of emissions at any given time, but it does not expressly show changes in emissions over time. As such, the IPCC national approach does not explicitly link biogenic CO_2 emission sources and sinks to stationary sources, nor does it provide a mechanism for measuring changes in emissions as a result of changes in the building and operation of stationary sources using biomass.

2.2. Does the SAB support the conclusion that the categorical approaches (inclusion and exclusion) are inappropriate for this purpose, based on the characteristics of the carbon cycle?

Note that the Panel sought and got clarification from EPA that this question refers to "a priori" categorical inclusion and exclusions as inappropriate.

A decision about a categorical inclusion or exclusion will likely involve many considerations that fall outside the SAB's scientific purview such as legality, feasibility and, possibly, political will. The SAB cannot speak to the legal or implementation difficulties that could accompany any policy on biogenic carbon emissions but below are some scientific observations that may inform the Administrator's policy decision.

The notion that biomass is carbon neutral arises from the fact that the carbon released as CO2 upon combustion was previously removed from the atmosphere as CO2 during plant growth. Thus, the physical flow of carbon in the biomass combusted for bioenergy represents a closed loop that passes through a stationary source. Under an accounting framework where life cycle emissions associated with the production and use of biomas are attributed to a stationary source, assuming carbon neutrality of biomass necessarily implies that the net sum of carbon emissions from all sources and sinks is zero, including all supply chain and market-mediated effects. Therefore, carbon neutrality cannot be assumed for all biomass energy a priori (Rabl et al., 2007; Johnson, 2009, Searchinger et. al, 2009). There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a

priori assumption; it is a conclusion that should be reached only after considering a particular feedstock production and consumption cycle. There is considerable heterogeneity in feedstock types, sources, production methods and leakage effects; thus net biogenic carbon emissions will vary considerably.

Given that some biomass could have positive net emissions, a categorical exclusion would remove any responsibility on the stationary source for CO_2 emissions from its use of biogenic material from the entire system (*i.e.*, the global economy) and provide no incentive for the development and use of best management practices. Conversely, a categorical inclusion would provide no incentive for using biogenic sources that compare favorably to fossil energy in terms of greenhouse gas emissions.

2.3. Does the SAB support EPA's conclusion that a new framework is needed for situations in which only onsite emissions are considered for non-biologically-based (i.e., fossil) feedstocks?

Through discussions with the Agency at the public meeting, EPA agreed that this question is redundant with other charge questions and therefore does not need to be answered here.

2.4. Are there additional accounting approaches that could be applied in the context of biogenic CO_2 emissions from stationary sources that should have been evaluated but were not?

Several other agencies are developing methods for assessing greenhouse gas emissions by facilities that could inform the approach developed by the EPA. These include the DOE 1605(b) voluntary greenhouse gas registry targeted to entities which has many similar characteristics to the approach proposed by EPA for stationary sources. There is also the Climate Action Registry developed in California that uses a regional approach to calculate baselines based on inventory data and may inform the delineation of geographic regions and choice of baselines in the EPA approach. USDA is also developing in parallel an accounting approach for forestry and agricultural landowners. It would be beneficial if the EPA and USDA approaches could be harmonized to avoid conflicts and take advantage of opportunities for synergy.

Charge Question 3

3. Evaluation of methodological issues. EPA identified and evaluated a series of factors in addition to direct biogenic CO_2 emissions from a stationary source that may influence the changes in carbon stocks that occur offsite, beyond the stationary source (e.g., changes in carbon stocks, emissions due to land-use and land management change, temporal and spatial scales, feedstock categorization) that are related to the carbon cycle and should be considered when developing a framework to adjust total onsite emissions from a stationary source.

3.1. Does SAB support EPA's conclusions on how these factors should be included in accounting for biogenic CO_2 emissions, taking into consideration recent advances and studies relevant to biogenic CO_2 accounting?

For agricultural feedstocks, the factors identified by EPA to adjust the CO_2 emissions from a stationary source for direct off-site changes in carbon stocks are appropriate but suffer from significant estimation and implementation problems.

Municipal solid waste biomass is either disposed of in a landfill or combusted in facilities at which energy is recovered. Smaller amounts of certain waste components (food and yard waste) may be processed by anaerobic digestion and composting. The CO_2 released from the decomposition of biogenic waste in landfills, compost facilities or anaerobic digesters could reasonably be assigned a BAF of 0 but applying a 0 to all municipal solid waste does not take into account the fact that when waste is burned for energy recovery, both fossil and biogenic CO are released. The *Framework* should take into account the mix of biogenic waste with fossil fuel waste since the combustion of municipal solid waste results in the production of both biogenic and fossil carbon. In addition, the *Framework* should account for the fact that CH_4 emissions from landfills are sometimes captured already.

For forest-derived woody biomass, the calculation of BAF would need to account for the time path of carbon recovery and emissions from logging residue. The *Framework* recognizes some of the challenges associated with defining the spatial and temporal timescale and in choosing the appropriate baseline but ultimately chooses an approach that disregards any consideration of the timescales over which biogenic carbon stocks are accumulated or depleted. Instead the *Framework* substitutes a spatial dimension for time in assessing carbon accumulation; and creates an accounting system that generates outcomes sensitive to the regional scale at which carbon emissions attributed to a stationary source are evaluated. Below are some comments on particular factors.

Level of Atmospheric Reduction (LAR): The scientific justification for constraining the range of LAR to be greater than 0 but less than 1 is not evident since it is possible for feedstock production to exceed feedstock consumption. The term also combines two very separate concepts, regrowth of feedstock (GROWTH) and avoided emissions (AVOIDEMIT) from the use of residues that would have been decomposed and released carbon emissions anyway. These two terms are not applicable together for a particular feedstock and representing them as additive

terms in the accounting equation can be confusing. Additionally, the value of LAR, for forest biomass, is sensitive to the size of the region for which growth is compared to harvest.

Loss (L): This is included in the *Accounting Framework* to explicitly adjust the area needed to provide the total feedstock for the stationary facility. It is a term used to include the emissions generated by the feedstock lost during storage, handling and transit. This is based on the strong assumption that most of the carbon in the feedstock lost during transit is immediately decomposed and therefore released to the atmosphere, an assumption that lacks scientific justification. It is therefore important to separate the use of this Loss term for estimating the area needed to provide the feedstock and for estimating the carbon emissions released by the operation of the stationary source. To more accurately estimate the actual loss of carbon due to these losses one would need to model the carbon storage and fluxes associated with the feedstock lost, which is likely to be a function of time. The number of years considered would be a policy decision; the longer the period, the larger the proportion of the loss that would be counted. The *Accounting Framework* tacitly assumes an infinitely long horizon that results in the release of all the carbon stored in the lost feedstock.

Products (PRODC). The removal of products from potential gross emissions is justified scientifically, however, the scientific justification for treating all products equally in terms of their impact on emissions is not clear. In the case of some products (e.g., fuels like ethanol and paper) the stored carbon will be released rapidly while in the case of other products such as furniture it might be released over a longer period of time. The *Framework* implicitly assumes that all products have infinite life-spans, an assumption with no scientific foundation. For products that release their stored carbon rapidly, the consequences for the atmosphere are the same as those associated with the carbon stored in the underlying feedstock; thus a distinction between the two is not scientifically justified. To precisely estimate the stores of products so as to estimate the amount released, one would need to track the stores as well as the fluxes associated with products pools. The stores of products could be approximated by modeling the amount stored over a specified period of time; the exact time period would have to be a policy decision.

A second way in which PRODC is used is as a means of pro-rating all area based terms such as LAR, Site-TNC and Leakage. This is potentially problematic because it makes the emissions embodied in co-products dependent on the choice of regional scale at which LAR is estimated. As the size of the region contracts, LAR tends towards zero and the amount of gross emissions embodied in PRODC increases and exacerbates the implications of the scale sensitivity of the LAR value.

Avoided Emissions (AVOIDEMIT): This term refers to transfers of emissions within the system or to emissions that occur regardless, although in different places (i.e., at the point source or at the field site). Since the concept reflected in “avoided emissions” is actually “equivalent field-site emissions” it would be clearer to refer to it by a term that reflects the actual concept being used. As with the Loss term, the assumption of instantaneous decomposition or total combustion of the crop or forest residue needs scientific support. Some of the materials that are harvested might take decades to centuries to fully decompose. To be scientifically-based the hypothetical store of harvested fuel stock would have to be tracked. To approximate these stores one could

compute the average amount remaining after a period of years. The number of years considered would be a policy decision; the longer the period, the less would be counted. The *Framework* tacitly assumes an infinite number of years.

Sequestration (SEQP). Including sequestration in the *Framework* is appropriate. However, the approach taken is subject to the same problems as those described for Products. There is no scientific literature cited to support the idea that all the materials produced by biogenic fuel use do not decompose. This is the subject of ongoing research, but it seems clear that these materials do decompose. The solutions to creating a more realistic and scientifically justified estimate are the same as for the Products term (see above).

Leakage. The *Framework* includes a term for leakage but is silent on the types of leakage that would be included and how leakage would be measured. EPA said it was not providing a quantification methodology for leakage because assessing leakge requires policy- and program-specific details that are beyond the scope of the report. There are several conceptual and implementation issues that merit further discussion in the *Framework*.

The use of biogenic feedstocks could lead to leakage by diverting feedstocks and land from other uses and affecting the price of conventional forest and agricultural products which can lead to indirect land use changes that release carbon stored in soils and vegetation. The use of these feedstocks can also affect the price of fossil fuels by lowering demand for them and increasing their consumption elsewhere. These leakage effects could be positive (if they lead to carbon emissions elsewhere) or negative (if they lead to carbon uptake activities). The latter, could arise for example, if increased demand for biomass and higher prices generates incentives for investment in forest management that increases forest carbon sequestration. Some research has shown that when a future demand signal is strong enough, expectations about biomass demand for energy (and thus revenues) can reasonably be expected to produce anticipatory feedstock production changes with associated changes in land management and land-use (e.g. Sedjo forthcoming; Rose, McCarl, Latta, forthcoming). Thus price changes can lead to changes in consumption and production decisions outside the boundary of the stationary source, even globally.

While the existence of non-zero leakage is very plausible, the appropriateness of attributing emissions that are not directly caused by a stationary facility to that facility is questionable. While first principles in environmental economics show the efficiency gains from internalizing externalities by attributing direct environmental damages to responsible parties that are directly responsible for them, they do not unambiguously show the social efficiency gains from attributing economic or environmental effects (such as leakage) that occur due to price changes induced by its actions to that facility. Moreover, leakage caused by the use of fossil fuels is not included in assessing fossil emissions generated by a stationary facility. Thus, the technical basis for attributing leakage and inherent inconsistency involved in including leakage and the different sources of leakage that will be included in this *Framework* needs to be assessed. Including some types of leakage (for e.g., due to agricultural commodity markets) and not others (such as those due to fossil fuel markets) and for biomass and not fossil fuels would be a policy decision without the underlying science to support it.

The empirical assessment of the magnitude of leakage and the method for attributing it to different stationary sources would need to be based on complex global economic modeling that involves comparisons of production, consumption and land use decisions with the use of a biogenic feedstock to those in a baseline scenario without the use of this feedstock. Thus it would use an anticipated baseline. This approach would introduce an inconsistency between the anticipated baseline that is needed to assess leakage and reference point baseline proposed for assessing LAR. The existing literature in the social sciences that is assessing the magnitude of leakage shows that its overall magnitude is highly uncertain and differs considerably across studies and within a study depending on underlying assumptions.

The use of a regional scale for assessing LAR implies that there could be cross-regional leakage; its presence and magnitude will be a function of the characteristics of the regions created (size and composition). The more regions created from a given area, the more leakage will occur from each region. If this leakage is not accounted for elsewhere in the *Framework*, for e.g., increased harvesting of biomass for pulp and paper manufacture in one region due the operations of a stationary facility in a different region, then this leakage could have an atmospheric outcome. With many regions involved, it would become extremely difficult to determine which of the multiple regions generated a particular leakage observed. Where many regions are involved simultaneously, disturbances may make identifying the unique leakage from a particular region almost impossible to determine. In sum, the precision associated with qualitatively estimating negative leakage accurately may involve huge errors that could be so great as to overwhelm any usefulness of the development of high quality data for other interrelated parts of the assessment. If the magnitude of leakage cannot be calculated, however, its direction should at least be stated and incorporated in some fashion. A default assumption that leakage is zero is neither helpful nor accurate.

Thus, on balance, the *Framework*, while including many important elements suffers from significant estimation and implementation problems. Some of these implementation issues with estimating BAF and leakage that will be discussed further in response to charge question 4.

3.2. Does SAB support EPA's distinction between policy and technical considerations concerning the treatment of specific factors in an accounting approach?

A clear line cannot be drawn between policy and technical considerations. There is insufficient information given on EPA's policy context and menu of options to fully evaluate the *Framework*. Because the reasonableness of any accounting system depends on the regulatory context to which it is applied the *Framework* should describe the Clean Air Act motivation for this proposed accounting system, how it regulates point sources for greenhouse gases and other pollutants, making explicit the full gamut of Clean Air Act policy options for how greenhouses gases could be regulated, including any potential implementation of carbon offsets or certification of sustainable forestry practices, as well as its legal boundaries regarding upstream and downstream emissions. Technical considerations can influence the feasibility of implementing a policy just as policy options can influence the technical discussion. The two need to go hand in hand rather than be treated as separable.

The *Framework* explicitly states that it was developed for the policy context where it has been determined that a stationary source emitting biogenic CO_2 requires a means for "adjusting" its total onsite biogenic emissions estimate on the basis of information about growth of the feedstock and/or avoidance of biogenic emissions and more generally the carbon cycle. However, in the discussion on the treatment of specific factors it states in several places that this treatment could depend on the program or policy requirements and objectives. Certain open questions described as "policy" decisions (e.g. the selection of regional boundaries, marginal versus average accounting, inclusion of working or non-working lands, inclusion of leakage) made the evaluation of the *Framework* difficult. Clearly, the policy context matters and EPA's reticence in describing the policy context and in taking positions on open questions (as well as lack of implementation details) meant that the *Framework* was inadequately defined for proper review and evaluation.

Specifically, if the policy context is changed, for example, if carbon accounting is needed to support a carbon cap and trade or carbon tax policy, then the appropriateness of the *Framework* needs to be evaluated relative to alternative approaches such as life cycle analysis for different fuel streams. Modifying how certain factors are measured or included may not be sufficient. In fact, a different *Framework* would probably make sense if a national or international greenhouse gas reduction commitment exists. Furthermore, the BAFs developed for regulating the emissions from stationary sources would likely conflict with measures of greenhouse gas emissions from bioenergy used in other regulations such as California's cap and trade system for regulating greenhouse gases.

In a perfect world with full information and unlimited policy choices, carbon limits (or prices) would be implemented economy-wide and not selectively enacted for particular sources or sectors. Economic research has shown that the most cost-effective way to reduce greenhouse gas emissions (or any other pollution) is to regulate or tax across all sources until they face a marginal cost of emissions reduction that equals the marginal benefit of emissions reduction and is equal across sources. In our less perfect world with EPA's limited authority under the Clean Air Act, the most efficient economy-wide solution is not within EPA's menu of policy choices. EPA's regulation of stationary sources will exclude other users of biomass that have equivalent impacts on the carbon cycle as well as downstream emissions from consuming the products produced by these facilities.

In this second-best world with limited policy instruments that can be applied only to limited sources, it would be desirable for EPA to ascribe all changes in greenhouse gas emissions (both upstream and downstream of the stationary source) caused by the operation of the stationary source to that source. Ideally, these emissions would need to be determined on a facility-specific basis but facility-specific calculations would require a chain of custody accounting and involve other daunting challenges such as estimating leakage effects.

As will be discussed in Section 6.3, given the sub-optimal choices facing EPA, one hybrid approach would be a categorical inclusion with opt-out provisions. Stationary sources would be subject to a categorical inclusion unless they opted out by certifying that their biomass was sustainably harvested and produced using best management practices. By making the stationary source responsible for demonstrating "sustainability", the source would be linked to its land base.

This would remove the perverse situation of a responsible bioenergy facility, using feedstock produced in a highly sustainable manner, being penalized because it happens to be located in a region where other, less sustainable forest activities are causing carbon stocks to decline. It would also avoid the problem of a bioenergy facility that uses biomass harvested in an unsustainable manner benefiting from operating in a region where carbon stocks happen to be growing. This may, however, increase complexity and costs of accounting for the carbon emissions of a stationary source and require the development of certification systems that can certify that biomass used by a facility was harvested sustainably. Caution is also advised that such an approach could create global leakage effects that may overwhelm any carbon reduction achieved. The case could occur in which a facility using sustainably produced biomass has an apparent benefit on a regional scale but net negative effects on a global scale. The SAB cannot offer an opinion on the legal feasibility of a categorical inclusion with opt-out provisions based on certified feedstocks but we commend it to the Agency's attention for consideration.

3.3. Are there additional factors that EPA should include in its assessment? If so, please specify those factors.

As stated above, for agricultural biomass from energy crops and crop residues, the factors included in the *Framework* capture most of the direct off-site adjustments needed to account for the changes in carbon stocks caused by a facility using agricultural feedstocks although they do not account for leakage. For forest biomass, the *Framework* needs to incorporate a) the time path of carbon recovery in forests (after energy emissions from harvested roundwood) or b) the time path of the "anyway" emissions that would have occurred on the land if logging residue were not used for energy production. For municipal solid waste biomass, the *Framework* needs to consider other gases and CH_4 emissions from landfills when municipal solid waste is used for energy production. Given that methane emissions from landfills are often captured, crediting waste material for avoided emissions of methane may be inappropriate. The carbon impact of using waste for energy production should be measured relative to the CH_4 emissions, if any, that would be released during decomposition in a landfill. Note that the *Framework* should account for the fact that CH4 emissions from landfills are sometimes captured already. N_2O emissions, especially from fertilizer use, should also be considered. Furthermore, the inclusion of non-CO_2 greenhouse gases in general should be consistent between biogenic and fossil fuel accounting. For instance, there are also transportation related emissions losses in the delivery of natural gas.

3.4. Should any factors be modified or eliminated?

For reasons discussed above, factors such as PRODC, AVOIDEMIT and SEQP need to be modified to include the timescale over which carbon is decomposed or released back to the atmosphere. LAR needs to be modified to be scale insensitive and to address additionality. Factors can be separated by feedstocks according to their relevance for accounting for the carbon emissions from using those feedstocks. For example, GROW and leakage may not be relevant for crop and forest residues.

Charge Question 4

4. Evaluation of Accounting Framework

EPA's *Accounting Framework* is intended to be broadly applicable to situations in which there is a need to represent the changes in carbon stocks that occur offsite, beyond the stationary source, or in other words, to develop a "biogenic accounting factor" (BAF) for biogenic $C0_2$ emissions from stationary sources.

4.1. Does the *Framework* accurately represent the changes in carbon stocks that occur offsite, beyond the stationary source (i.e., the BAF)?

For agricultural biomass, the variables in EPA's proposed equation for BAF represent the basic factors necessary for estimating the offsite carbon change associated with stationary source biomass emissions, including changes in storage of carbon at the harvest site. For short recovery feedstocks, where carbon recovery and "anyway" emissions are within one to a few years (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), with some adjustments and appropriate data, the *Framework* can accurately represent carbon changes offsite. However, for long recovery feedstocks where carbon recovery and most "anyway" emissions occur over decades (i.e., wood harvested specifically for energy use (roundwood) and logging residue), the *Framework* does not accurately account for carbon stocks changes offsite for several reasons discussed below in response to charge question 4.2.

The *Framework* also does not consider other greenhouse gases (e.g. N_2O from fertilizer use and CH_4 emissions from landfills). Excluding CH_4 because it is not "CO_2" is not a legitimate rationale. It would need to be included to estimate the "difference in CO_2 (equivalent)" the atmosphere sees. In addition, excluding CH_4 from landfills is inconsistent with the *Framework's* desire to account for displaced on-site changes in CO_2. For the same reasons, the basis for excluding N_2O emissions is unclear. It also needs to be included to estimate the net changes in atmospheric greenhouse gases. Accounting for N_2O from fertilization would be consistent with tracking changes in soil carbon which are a response to agricultural management systems, which includes fertilizer decisions.

4.2. Is it scientifically rigorous?

The SAB did not find the *Framework* to be scientifically rigorous. Specifically, we identified a number of deficiencies that need to be addressed.

The following issues require additional scientific support.

Timescale: One deficiency in the EPA report is the lack of discussion and proper consideration of the different timescales inherent in the carbon cycle and the climate system that are critical for establishing an accounting system. This is a complicated subject because there are many different timescales that are important for the issues associated with biogenic carbon emissions.

An important timescale for considering accounting systems for biogenic carbon emissions is the period over which the climate responds to carbon dioxide and other greenhouse gases. Several different climate modeling studies have demonstrated that peak warming in response to greenhouse gas emissions is primarily sensitive to cumulative greenhouse gas emissions over a period of roughly 100 years, and is relatively insensitive to the emissions pathway within that time frame.[1] What this means is that an intervention in forests or farming that results in a change in storage of carbon must endure for significantly longer than 100 years in order to have any real influence on the peak climate response.

If a carbon stock is cycling quickly on land, turning over and being replaced fully in less than 100 years then it may be beneficial to use biogenic carbon to displace the combustion of fossil fuel. If the carbon stock, or some part of it, turns over more slowly, i.e., much longer than 100 years, the timing of release begins to matter. Examples of the former are forest harvest and regrowth, even including accelerated harvests, and energy crops. Examples of the latter are land conversion to a significantly difference average carbon stock. The fundamental differences in stocks and their turnover times as they relate to impact on the atmosphere is not well discussed or linked into the current framework. Differences among feedstocks in their turnover times could justify how different feedstocks need to be incorporated into the *Framework*. At the moment, there is little background discussion of the variation in the stock and turnover and how that informs the accounting method. A fuller discussion of timescale of turnover of biogenic carbon stocks could inform the *Framework*, perhaps justifying the groupings of feedstocks based on their carbon cycling and likely impact on the atmosphere; those that have little or no impact, have partial impact, or can have significant impact.

Scientific understanding of the timescale over which the climate system responds to cumulative emissions implies that the carbon release caused by harvesting and combusting biomass at stationary sources is a serious problem if the time for regrowth is much more than 100 years. This means that the climate system is not sensitive to the imbalance in the carbon cycle that might occur over decades from harvesting of biomass for bioenergy facilities. A scientifically rigorous evaluation of the biomass harvest on the carbon cycle must consider the temporal characteristics of the cycling. Annual accounting of carbon stocks is likely to give highly distorted assessments of the overall carbon cycle impacts.

The *Framework* also does not consider the length of time it takes ecosystems to respond to disturbances, such as those due to the harvesting of biomass, nor does it consider the spatial heterogeneity in this response. This has implications for the accuracy with which the impact of different land management strategies on carbon stocks in soil and vegetation is estimated.

The *Accounting Framework* subtracts the emissions associated with products, including ethanol, paper, and timber, from the calculation of emissions from a stationary source, through the PRODC term. While EPA may not have the discretion to treat all emissions equally, distinguishing between immediate emissions from the facility and downstream emissions (as

[1] Allen, M. R., D. J. Frame, C. Huntingford, C. D. Jones, J. A. Lowe, M. Meinshausen and N. Meinshausen. (2009). "Warming caused by cumulative carbon emissions towards the trillionth tonne." Nature **458**(7242): 1163-1166. Allen et al. (2009)

these products will inevitably be consumed within a short period of time) does not make sense scientifically. From the perspective of the carbon cycle and the climate system, there is no difference between these two types of emissions. All these facilities extract biomass from the land, and the vast majority of that biomass is converted to carbon dioxide, adding to cumulative emissions and, hence, a climate response.

Spatial scale: There is no peer reviewed literature cited to support the delineation of spatial scales for biogenic CO_2 accounting. In addition, the *Accounting Framework* allows different carbon pools to be accounted for at different spatial scales with little justification. The atmospheric impact of feedstocks is gauged on a regional basis in terms of its impact on forest carbon stocks (except for case study 5). On the other hand, impacts due to land use change or removal of residues such as corn stover (as captured in the SITE-TNC variable) which impact soil C pools are accounted for using site specific accounting.

The *Accounting Framework's* use of a regional scale for accounting for the net changes to the atmosphere is an artificial construct developed to (a) avoid the need for site-specific chain of custody carbon accounting with separate streams for each feedstock and (b) as an alternative to capturing changes in carbon stocks over time. The calculation of LAR captures landscape wide changes rather than facility-specific carbon emissions associated with actual fuelsheds. Thus, the *Accounting Framework* captures changes over space, in a sense, substituting space for time. This approach attempts to simplify implementation using available forest inventory data and avoids the need for accounting for changes in carbon stocks specific to the site or feedstock sourcing region (fuelshed) which may be more complex and costly and difficult to verify. However, it makes the estimate of the BAFs sensitive to the choice of the spatial region chosen for accounting purposes. There is no peer reviewed literature to support a decision about the appropriate spatial scale for determining LAR, and as shown by case study #1, there are significant implications of this choice for the emissions attributed to the facility. Specifically, a ton of carbon emitted in one part of the country may be treated differently from a ton of carbon emitted elsewhere.

Additionality: A key question is whether the harvesting of biomass for bioenergy facilities is having a negative impact on the carbon cycle relative to emissions that would have occurred in the absence of biomass usage. This requires determining what would have happened anyway without the harvesting and comparing the impact with the harvesting of biomass for a bioenergy facility in order to isolate the incremental or additional impact of the bioenergy facility. However, while the *Framework* discusses the "business as usual" or "anticipated future baseline" approach, it implements a reference point approach that assesses carbon stocks on a regional basis at a given point in time relative to a historic reference carbon stock.

For forest carbon stocks, the choice of a fixed reference point may be the simplest to execute, but it does not actually address the question of the extent to which forest stocks would have been growing/declining over time in the absence of this bioenergy facility. The use of a fixed reference point baseline implies that forest biomass emissions could be considered carbon neutral if forest stocks are increasing. This is simply an artifact based on the choice of the baseline that will be used. The problem is thus: a region with decreasing carbon stocks may in actuality have more carbon than what would have happened without the facility using biomass. Similarly, a

region with increasing carbon stocks may have less than would have happened without the facility using biomass. By default, this approach creates "sourcing" and "non-sourcing" regions. Thus, a carbon accumulating region is a "source" of in situ carbon that can be given to support biomass use, and a carbon losing region is a "non-source" of carbon and cannot support biomass use. The reference year approach provides no assurances at all that a "source" region is gaining carbon due to biomass use, or that a "non-source" region is losing carbon and will not gain carbon due to biomass use.

For example, for roundwood use, a region may have carbon accumulation with respect to the reference year (and be assigned LAR=1 according to the *Framework*); however, harvest of a 150+ year old forest in the region for energy production would be regarded as a carbon stock gain even though there is less carbon than there would have been otherwise and we would recover only a portion of its carbon within the next 100 years. Likewise, a region which has a slight overall annual loss of carbon (LAR=0), could actually provide roundwood from light thinning of a mid-aged forest, yielding greater regional carbon than there would have been otherwise, where most of the carbon would recover within 100 years. The *Framework*, however, would view the roundwood supply as carbon stock loss. Since we want to estimate the "difference in atmospheric greenhouse gases" over some period we must estimate how carbon recovery differs between a biomass use case and a case without biomass use (business as usual case).

Substitution of Space for Time in Measuring Carbon Stock Changes: The *Framework* uses a single year's carbon accumulation – for an entire region – to compute the BAF offset for the current annual biomass combustion emissions. This approach is based in part on the idea that we can estimate carbon recovery over many years from current year harvest using information from one year of carbon accumulation over a wide area (a region). However the BAF is sensitive to the chosen size and composition of the region, particularly if the reference point baseline is used.

Assessing uncertainty: The *Framework* acknowledges uncertainty but does not discuss how it will be characterized and incorporated to assess the potential uncertainty in the estimate of the "carbon outcome" and the BAF value. There are numerous drivers that can change biogenic carbon stocks, even in the absence of biomass harvesting for energy. These include changes in economic conditions, domestic and international policy and trade decisions, commodity prices, and climate change impact. There is considerable uncertainty about the patterns of future land use, for example, whether land cleared for bioenergy production will stay in production for decades to come. The potential impact of these forces on biogenic carbon stocks and the uncertainty of accounting needs to be considered further. Ideally, EPA should put their BAF estimates into context by characterizing the uncertainties associated with BAF calculations and estimating uncertainty ranges. This information can be used to give an indication of the likelihood that the BAFs will achieve the stated objective. The uncertainty within and among variables for any estimate may vary widely between feedstocks and across regions. If a regional BAF is to be used, and there is not scientifically justifiable reason for doing so, at the very least, the uncertainty evaluation should be able to assess if an assigned BAF value for one feedstock in one area can be confirmed to be significantly different than a BAF estimated and assigned in another case. If there is no significant difference then they should be assigned one common value. In addition, uncertainty information would allow policy makers to assign BAF values

after deciding on their aversion to the risk of assigning values that are too high or too low. Characterizing the uncertainty and risks is a scientific question. Selecting an acceptable risk level is a policy decision.

Leakage: The *Framework* states that the likelihood of leakage and the inclusion of a leakage term will be based on a qualitative decision. There is essentially no science in the document about how leakage might be quantified and no examination of the literature regarding non-hypothetical leakage scenarios (consider Murray et al 2004). Any discussion/decisions regarding a leakage term should be based on quantitative assessment and science. A number of statements/assumptions were made regarding the area and intensity of wood harvest increases to accommodate biomass access. There was no examination of the scientific literature on wood markets and therefore no science-based justification for these statements/assumptions.

Other areas: Other areas that require more scientific justification include assumptions regarding biomass losses during transport and their carbon implications, the choice of a 5 year time horizon instead of one that considered carbon cyclind, and the decision to include only CO_2 emissions and exclude other greenhouse gas emissions need more science based justification. Additionally, assumptions about the impacts of forest harvests on soil carbon and land use changes on carbon sequestration need to be more rigorously supported.

Inconsistencies: We found a number of inconsistencies within the proposed framework that should be resolved or justified:

(1) Adjustments for fossil fuel emissions: Fossil fuel CO_2 emissions from stationary sources under the Clean Air Act are currently not adjusted for offsite greenhouse gas emissions or carbon stock changes. Does that imply that by default BAFs should be zero as well? No, because, unlike fossil fuels, biogenic feedstocks have carbon sequestration that occurs within a timeframe relevant for offsetting CO_2 emissions from the biomass' combustion. There are also relevant non-CO_2 greenhouse gas emissions associated with biogenic energy feedstocks (discussed below). What about greenhouse gas emissions generated during fossil fuel and biomass feedstock production and transport? It is practical to be consistent in the handling of these greenhouse gas emissions within the *Framework*—either excluding or including them for both fossil and biomass feedstocks. Including them would imply the need for a lifecycle analysis for both.

(2) Biogenic and fossil fuel emissions accounting for losses: The *Framework's* handling of carbon losses during handling, transport, and storage introduces an inconsistency between how fossil emissions are counted at a stationary source and how biomass emissions are counted. For biomass emissions the *Framework* includes emissions associated with loss of feedstock between the land and the stationary source. For natural gas the emissions attributed to the stationary source do not include fugitive greenhouse gas emissions from gas pipelines. Why would loss emissions be included for biomass when they are not included for natural gas?

(3) Inconsistency in the consideration of land management and the associated greenhouse gas flux accounting: The *Framework* accounts for soil carbon stock changes, which are a

function of land management system, soil, and climatic conditions. However, it does account for the non-CO2 greenhouse gas changes that are jointly produced with the soil carbon changes, as well as influence both the below and above ground carbon stock changes associated with the land management system.

(4) Reference year and BAU baseline use: The *Framework* proposes using a reference year approach: however, it implicitly assumes projected behavior in the proposed approach for accounting for soil carbon changes and municipal waste decomposition.

4.3. Does it utilize existing data sources?

First, and most importantly, the *Framework* does not provide implementation specifics. Therefore, it is difficult to assess data availability and use. These issues are discussed here and in Section 4.4 and 4.5 that follow.

A more meaningful question is "Are the proposed data sets adequate to account for the effects of biogenic carbon cycling on CO_2 emissions from a facility?" The *Framework* does use existing data, but the data are not adequate to attribute emissions to a facility. For example, the *Framework* mentions the use of the USDA Forest Service's Forest Inventory and Analysis (FIA) data at some unspecified scale. However, carbon stock change data are likely not very accurate at the scale of the agricultural or forest feedstock source area for a facility.

The *Framework* requires data and/or modeling of land management activities and their effects on CO_2 emissions and stock changes. For example for agricultural systems, data are required on the type of tillage and the effect of such tillage on soil carbon stocks for different soil types and climatic conditions. Such data are not likely to be available at the required scales. For example, in one of the case studies, the Century model is used to model soil C stocks. Is the use of this particular model proposed as a general approach to implement the *Framework*? Since this model generally addresses soil carbon only to a depth of 20 centimeters, does that represent a boundary for the *Framework*? Recent work has shown that such incomplete sampling can grossly misestimate changes in soil carbon for agricultural practices such as conservation tillage (Baker *et al.*, 2007; Kravchenko and Robertson, 2011). Which version of the model? Would EPA run this model, and select parameters appropriate for each feedstock production area for each facility? How robust are the predictions of this model for the range of soils, climatic conditions, and management practices expected to be covered by the *Framework*? Could some other model be used that produces different results for a given facility?

The *Framework* implies that data are required from individual feedstock producers. Collecting such data would be costly and burdensome. Additionally, to the extent that feedstocks are part of commodity production and distribution systems that mix material from many sources, it is not likely to be feasible to determine the source of all feedstock materials for a facility.

The *Framework* includes a term for leakage but eschews the need to provide any methodology for its quantification. Mysteriously, example calculations are carried out for leakage in one of

the case studies. However, leakage can be positive or negative, and while many publications speculate about certain types of leakage, no data are presented, nor are data sources for different types of leakage discussed and suggested. The *Framework* does provide an example calculation of leakage in the footnote to a case study, but this does not a substitute for a legitimate discussion of the literature and justification and discussion of implications of choices. In addition, such data are unlikely to be available at the scales required. The implications and uncertainties caused by using some indicator or proxy to estimate leakage need to be discussed. If leakage cannot be estimated well is it possible to put an error range on the leakage value (e.g., a uniform distribution) and assess the impact of this uncertainty on the overall uncertainty in the BAF value? For some cases, such as the conversion of agricultural land to biomass production from perennial crops, leakage may be described as likely increasing net emissions. In cases such as this where prior research has indicated directionality, if not magnitude, usch information should be used. As previously noted, there is also a consistency issue with the reference year approach because leakage estimates implicitly assume an anticipated baseline approach of some sort.

In summary, it is not clear that all of the data requirements of the *Framework* can be met. Furthermore, even if the data are acquired, they may not be adequate to attribute emissions to a facility.

4.4. Is it easily updated as new data become available?

The details of implementing the *Framework* are not clear, as discussed for other sub-questions. Thus it is also not clear how feasible it would be to update the calculations. However, if many of the data requirements cannot be met currently, as stated above, it is very likely that many of the data will not be easy to update.

In principal it would be feasible to update the calculations as new data become available. Some kinds of data, such as those from FIA are updated periodically, thus it would be feasible to update the analysis. However, as discussed for other sub-questions, it is not clear exactly what data and resolution are required and whether all the required data are readily available.

An annual or five-year time frame is suggested for updating calculations. For some kinds of data, such as soil and forest carbon stocks, these time frames are too short to detect significant changes based on current or feasible data collection methodologies; implying that statistical or process models would be used to estimate short-term changes for reporting purposes.

Lastly, if BAF is not under the control of the facility, it would introduce considerable uncertainty for the facility if the BAF were recalculated frequently. If the goal of a policy using this framework was to reduce greenhouse gas emissions, an overly costly or burdensome accounting framework might not achieve that goal.

However, if the accounting is infrequent, shifts in the net greenhouse gas impact may not be captured.

4.5. Is it simple to implement and understand?

It is neither. While the approach of making deductions from the actual emissions to account for biologically-based uptake/recovery is conceptually sound, it is not intuitive to understand because it involves tracking emissions from the stationary source backwards to the land that provides the feedstock rather than tracking the disposition of carbon from the feedstock and land forwards to combustion and products. The *Framework* also appears to be difficult to implement, and possibly unworkable, especially due to the requirements for the many kinds of data required to make calculations for individual facilities. Additionally, the categories (variable names) in the *Framework* do not match those used in the scientific literature and are therefore not intuitive. Lastly, many elements of the *Framework* are implicit rather than explicit. For example, we assume that there should be a time frame during which changes in atmospheric greenhouse gases will be assessed, but this time frame is not explicit. The time frame for specific processes is often implicit, such as the emissions of CO_2 from biomass that is lost in transit from the production area to the facility; this loss is assumed to be instantaneous.

Much more detailed information is required about how the *Framework* would be implemented. For example, the specific data sources and/or models to be used and frequency of updating calculations and crediting as discussed under other sub-questions. To assess the adequacy of data, more information is needed on implementation and the degree of uncertainty acceptable for policymakers to assign BAF values.

4.6. Can the SAB recommend improvements to the framework to address the issue of attribution of changes in land-based carbon stocks?

As mentioned in response to Charge Question 4.2, the *Framework* uses a reference year baseline approach to determining BAF. In the case of long recovery feedstocks such as the use of wood biomass for energy, this makes the estimation of LAR scale specific and prevents the determination of any incremental or additional impact of the bioenergy facility on emissions. An alternative approach to gauge the difference in greenhouse gas emissions associated with the use of forest-derived woody biomass would be to adopt the anticipated baseline approach of estimating a “business as usual” trajectory of emissions and comparing it with a trajectory that incorporates bioenergy. The anticipated baseline approach should be applied to determine changes in forest stocks due to the use of forest material for bioenergy as well as to determine the changes in land use and soil carbon for all types of feedstocks.

In developing this anticipated baseline for forest materials, it is important to distinguish between three broad categories of wood biomass for energy: (a) logging residues from roundwood harvested solely for timber or pulp, (b) roundwood harvested solely for bioenergy and (c) mixtures of logging residues (a) and roundwood (b) where it is difficult to distinguish between logging residue and pulpwood harvested for energy. Sathre (2011) argues that as long as wood biomass for fuel has low value relative to other products it is unlikely that forest sites will be harvested solely for fuel. Wood being removed for fuel from these operations can be considered logging residue for estimating BAF. However, it may be necessary to specify guidelines for distinguishing logging residue from pulpwood harvested for bioenergy.

In the case of logging residues, it is arguably reasonable to assign them a BAF equal to zero because they could be considered “anyway” emissions over a time period relevant for attaining

climate stabilization, e.g 100 or somewhat more years. More accuracy could be achieved by projecting the emissions from decay of those residues over time and comparing that to the biomass use case in which those residues are used for energy generation. For temperate climates, emissions from logging residue can be over 80% to near 100% within 100 years (Schlamadinger et al. 1995) (Palosuo et al. 2001). Factors that determine the extent of decay of logging residue (emissions versus C addition to soil) and the rate of decay include temperature, precipitation and type of decay fungi. Decay in very dry conditions is very slow, particularly for large logs. Conifers in the west tend to be decayed by brown rot fungi which do not break down lignin (about one-third of wood carbon). Hardwoods tend to be decayed by white rot fungi which break down all wood including lignin. (Jessie Glazer, personal communication). Forest Service FIA plot re-measurement data on dead and down wood for the East is currently being analyzed to estimate rates of wood decay and may help in estimating logging residue decay.

In the case of roundwood harvested solely for bioenergy, it is more important to incorporate the temporal dimension since their emissions remain in the atmosphere for some time before being captured by biomass regrowth. The anticipated baseline would be a projection of forest emissions in the absence of an increment in roundwood use for bioenergy while accounting for both natural and human disturbances in forests. This would require making assumptions about average growth rates, natural disturbances and landowner behavior. Integrated forest sector models such as the Forest Service RPA Forest Sector models or FASOM could be used to project cases with and without increased roundwood use for energy. This type of analysis would estimate both direct emissions from wood energy use and well as direct land carbon change (on land providing biomass) and indirect land carbon change (a form of negative leakage). U.S. forest and agricultural land carbon change could be estimated by models such as FASOM and the Forest Service RPA models include effects of changes in forest management intensity and forest land area. Indirect land use changes outside the US would require a using a global model. There would be many sources of uncertainty but alternate runs may be able to put boundaries on this uncertainty. Historically revenue provided for wood from forests has resulted in substantial investment to expand and increase forest growth and, based on this record, is an effect contained in projections by numerous forest sector models.

In the case of long recovery feedstocks, Cherubini (2011) provides a method to estimate the global warming potential (GWP_{bio}) of biomass harvested from a forest of given age and regrown to the same age. GWP_{bio} is the ratio of (a) cummulative radiative forcing (over a certain period) associated with an initial emissions minus absorption by forest regrowth and oceans divided by (b) cumulative radiative forcing of the initial emission alone with absorption by oceans). This could be a metric for LAR. This estimate would be appropriate if one could reasonably assume that the human caused disturbance of forest site will be limited after biomass harvest in the biomass use case, and the age of the timber at the time of harvest is known. In addition the estimate assumes for the BAU case that there would have been near term harvest for timber that would have limited growth. The estimate would need to be adjusted to assess variations in this assumption. Cherubini's method may be able to use FIA data on age of forest areas harvested to estimate an average GWP_{bio} / LAR. In addition to using Cherubini's method, FIA data might be used to see what recovery is made by actual FIA plots that have been harvested and remeasured.

One concern about the anticipated baseline approach is the uncertainty associated with a projection given potential future changes in markets, policies, technologies, and biophysical circumstances. Note that what is of interest here is the difference between two projections, i.e. whether carbon emissions increase or decrease as a result of using feedstock X. To the extent that each projection is driven by the same factors, the uncertainty of concern is only the uncertainty reflected in the delta between two projections. Presumably this would be lower than the uncertainty about a single projection. Unlike the reference year approach, the BAU baseline approach can provide an actual estimate of greenhouse gas change. The reference year approach does not even attempt to estimate changes, and will be prone to errors in either direction.

A general issue in being able to make LAR or BAF estimates for wood from forests is to identify combinations of limited conditions or plausibly assumed conditions for the BAU case and the biomass use case over time that allow a constrained estimate. Given a constrained estimate – such as the Cherubini method – we can assess the effect of varying the assumptions on LAR or BAF..

4.7. Are there additional limitations of the accounting framework itself that should be considered?

A number of important limitations of the *Framework* are discussed below:

Framework ambiguity: Key *Framework* features were left unresolved, such as the selection of regional boundaries (the methods for determining as well as implications), marginal versus average accounting, inclusion of working or non-working lands in the region when measuring changes in forest carbon stocks, inclusion/exclusion of leakage, and specific data sources for implementation. As a result, the *Framework's* implementation remains ambiguous. The ambiguity and uncertainty in the text regarding what are stable elements versus actual proposals also clouded the evaluation. If EPA is entertaining alternatives and would like the SAB to entertain alternatives, then the alternatives should be clearly articulated and the proposed *Framework* and case studies should be presented with alternative formulations to illustrate the implementation and implications of alternatives.

Feedstock groups: The proposal designates three feedstock groupings. However, it is not clear what these mean for BAF calculations, if anything. The *Framework* does not incorporate the groupings into the details of the methodology or the case studies. As a result, it is currently impossible to evaluate their implications.

Potential for Unintended consequences: The proposed *Framework* is likely to create perverse incentives for investors and land-owners and result in unintended consequences. For investors, the regional baseline reference year approach will create regions that are one of two types — either able to support bioenergy from forest roundwood (up to the gain in carbon stock relative to the reference year), or not. As a result, a stationary source investor will only entertain keeping, improving, and building facilities using biomass from regions designated as able to support bioenergy. However, as noted previously, regions losing carbon relative to the reference year, could actually gain carbon stock in relative terms due to improved biomass use and management to meet market demands. In addition, the definitions of regions would need to change over time.

The designation of regions as able or not to support bioenergy that comes from the reference year approach will create economic rents and therefore financial stakes in the determination of regions and management of forests in those regions.

The proposed *Framework* could also potentially create perverse incentives for land-owners. For instance, land owners may be inclined to clear forest land a year or more in advance of growing and using energy crops. Similarly, land owners may be more inclined to use nitrogen fertilizers on feedstocks or other lands in conjunction with biomass production. Such fertilization practices have non-CO_2 greenhouse gas consequences (specifically N_2O emissions) that would not be captured by the *Framework.* Agricultural intensification of production via fertilization is a possible response to increased demand for biomass for energy.

Assessment of Monitoring and Estimation Approaches: The *Framework* is also missing a scientific assessment of different monitoring/estimation approaches and their uncertainty. This is a critical omission as it is essential to have a good understanding of the technical basis and uncertainty underlying the use of existing data, models, and lookup tables. A review of monitoring and verification for carbon emissions from different countries, both from fossil and biogenic sources, was recently released by the National Research Council that may provide some guidance.

Charge Question 5

Case Studies

5. EPA presents a series of case studies in the Appendix of the report to demonstrate how the accounting framework addresses a diverse set of circumstances in which stationary sources emit biogenic CO_2 emissions. Three charge questions are proposed by EPA.

5.1. Does the SAB consider these case studies to be appropriate and realistic?
5.2. Does the EPA provide sufficient information to support how EPA has applied the accounting framework in each case?
5.3. Are there alternative approaches or case studies that EPA should consider to illustrate more effectively how the framework is applied to stationary sources?

Overall Comments

In general, case studies are extremely valuable for informing the reader with examples of how the *Framework* would apply for specific cases. While they illustrate the manner in which a BAF is calculated, the data inputs are illustrative and may or may not be the appropriate values for an actual biomass to energy project. Moreover, they are simplistic relative to the manner in which biomass is converted to energy in the real world. For all case studies, there should be additional definition of the contexts, examples of how the 'data' are collected or measured, and a discussion of the impacts of data uncertainty. Overall, the case studies did not fully cover the relevant variation nin feedstocks, facilities, regions, etc. of potential BAFs that is required to evaluate the methodology. From a clarity and 'teaching' point of view, it might be useful to start with a specific forestry or agricultural feedstock example as the 'base case', and then add in the impacts of the more detailed cases, e.g., additional loses, products, land use changes. This may be more useful than a series of completely separate examples, each including different pieces of the framework/equation.

5.1 Does the SAB consider these case studies to be appropriate and realistic?

The case studies did not incorporate "real-world" scenarios which would have served as models for other situations that may involve biogenic carbon emissions. More would have been learned about the proposed *Framework* by testing it in multiple, unique case studies with "real world" data development and inclusion. The current set of case studies did not fully cover the relevant variation in feedstocks, facilities, regions, etc. of potential BAFs that would be required to evaluate the methodology. Among other things, additional case studies for landfills, switchgrass, waste, and other regions are necessary, as well as illustrations of the implementation of feedstock groups, and framework alternatives.

For example, Case Study 4 considers a scenario where corn stover is used for generating electricity. While it is possible that this particular scenario could be implemented, for the present time and maybe into the future, this particular case study does not mirror a "real world" case in that very few if any electrical generation facilities would combust corn stover or agricultural crop residues only. A more likely scenario might be a co-firing facility with a fossil fuel at low

percentages. Additionally, the assumptions made in this case about biomass yield and the rate of growth of yield are not realistic. The yield of corn stover is expected to vary considerably across the region expected to supply biomass to a facility and to grow over time and not be uniform as assumed in the Framework.

In another example, Case Study 5 calculates the net biogenic emissions from converting agricultural land in row crops to poplar for electricity production. This case study is also not representative of "real world" agricultural conditions as switching from one energy crop to another is not realistic. The formula provided for estimating the standing stock of carbon in the aboveground biomass in the poplar system is not intuitive. The methods for determining biomass yield as well as for measuring changes in soil carbon, which will depend on current use of the land (whether it is conventionally tilled or under a perennial grass), are not described.

5.2. Does the EPA provide sufficient information to support how EPA has applied the accounting framework in each case?

There remained considerable uncertainty in many of the inputs. In addition, some sensitivity/uncertainty analysis would be useful. The results of this analysis may guide EPA in further model development. For example, if the BAF is determined to be zero, or not statistically different from zero in most case studies, then this could pave the way for a simpler framework. As discussed in Section XS, a simpler framework based on categorization of feedstocks could be designed to identify cases where biomass to energy generally results in a BAF of 0, 1 or something in between.

5.3. Are there alternative approaches or case studies that EPA should consider to illustrate more effectively how the framework is applied to stationary sources?

The major recommendation is additional case studies be performed and that these case studies be designed to describe actual or proposed biomass to energy projects where the framework would be used based on "real-world" situations of biomass development, production, and utilization.

For example, Case Study 1 describes the construction of one new plant. What would happen if ten new plants were to be proposed for a region? In each case study, we would like to see development of the required data and an assessment of whether data development can be standardized and/or simplified. And how would the introduction of multiple facilities at the same time impact the accounting for each facility? We support the suggestion in the report that look-up tables be developed. However, only by trying to develop these look-up tables can EPA assess whether this is workable.

All terms/values used to determine the BAF need to be referenced to actual conditions throughout the growth/production/generation processes that would occur in each case study including how these values would actually be implemented by one or more parties/entities involved.

Examples of needed case studies could be perennial herbaceous energy crop, annual energy/biomass sorghums, rotations with food and energy crops, cropping systems on different

land and soil types, municipal solid waste and internal reuse of process materials and assessments across alternative regions that represent distinctly different types.

For example it would be very useful to consider the application of this framework to a cellulosic ethanol plant fueled with coal or gas, and consider the emission of CO_2 from fermentation (not combustion) and the production of ethanol which is rapidly combusted to CO_2 in a non-stationary engine. There are three major sources of CO_2 emissions (list them here), but only one is included in this framework, only two may be considered under the clean-air action, but all three are emissions to the atmosphere. This lack of internal consistency makes the evaluation difficult.

Among the case studies, we suggest that there be two on municipal solid waste. One case study should be on waste combustion with electrical energy recovery. Here, as described in the report, a BAF of zero is appropriate and this case study is quite simple. EPA should also perform a case study on landfill disposal of municipal solid waste. Here it is important to recognize that landfills are repositories of biogenic organic carbon in the form of lignocellulosic substrates (e.g., paper made from mechanical pulp, yard waste, food waste). There is literature to document carbon storage and EPA has recognized carbon storage in previous greenhouse gas assessments of municipal solid waste management. There are potentially also avoided CH_4 decomposition emissions that need to be accounted for.

In Case Study 3 the data used in Table 3 to describe the 'paper co-product' will vary with the grade of paper. The 'carbon content of product' may vary between 30% to 50% depending on the grade and the amount of fillers and additives. Also, some significant carbon streams in a mill can go to landfills and waste water treatment. The submitted comments from NCASI include a useful example of the detail/clarity that could be used to enhance the value of the Case Studies.

After completion of the case studies, there should be a formal evaluation of (1) whether the results make sense and achieve appropriate results with respect to biogenic CO_2 emissions (2) the ease with which data were developed and the model implemented, and (3) whether the results are robust and useful in recognition of the uncertainty in the various input parameters, and (4) whether the model results lead to unintended consequences as discussed in response to charge question 4.7.

Case studies could be developed to assess and develop a list of feedstocks or applications that could be excluded from accounting requirements as anyway emissions. A sensitivity analysis using case studies could be used to develop reasonable offset adjustment factors if they are needed to adjust anyway feedstocks for impact on long term stocks like soil if needed.

Charge Question 6

6. Overall, this report is the outcome of EPA's analysis of the science and technical issues associated with accounting for biogenic CO_2 emissions from stationary sources.

- **Does the report – in total – contribute usefully to the advancement of understanding on accounting for biogenic CO_2 emissions from stationary source?**
- **Does it provide a mechanism for stationary sources to adjust their total onsite emissions on the basis of the carbon cycle?**
- **Does the SAB have advice regarding potential revisions to this draft study that might enhance the utility of the final document?**

6.1. Does the report-in total-contribute usefully to advancement of understanding of accounting for biogenic CO_2 emissions from stationary sources?

Yes, the *Framework* contributes to advancing understanding of accounting for biogenic emissions and addresses many issues that arise in such an accounting system. It is thoughtful and far reaching in the questions it tackles. Its main contribution is to force important questions and offer some ways to deal with these. The report covers many of the complicated issues associated with the accounting of biogenic CO_2 emissions from stationary sources and acknowledges that choices made in the *Framework* to address them will have implications for the estimates of CO_2 emissions obtained. These include those raised by SAB and discussed above, related to the choice of baseline, region selection and the averaging of emissions/stocks over space and time. However, the solutions offered in many cases, particularly those related to the use of harvested wood for bioenergy, lack a scientific justification.

6.2. Does it provide a mechanism for stationary sources to adjust their total onsite emissions on the basis of the carbon cycle?

Clearly the *Framework* offers a mechanism to adjust total on-site emissions. For short recovery feedstocks, where carbon recovery and "anyway" emissions are within one to a few years (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), the Framework could, with some modifications, accurately represent the direct carbon changes offsite however leakage, both positive and negative, remains a troublesome matter if left unresolved. However, the *Framework* offers no scientifically sound way to define a region for measuring LAR for forest biomass. The definition of the regional scale can make a large difference to the estimate of emissions from a facility using wood as a biomass. Moreover, if there is no connection between actions of the point source and what happens in the region there is no scientific foundation for using regional changes in carbon stocks to assign a BAF to the source.

The *Framework* also does not make a clear scientific case for use of waste or what is called "anyway" emissions. Scientifically speaking, all biogenic emissions are "anyway" emissions. Even most woody biomass harvested from old growth forests, would, if left undisturbed eventually die, decompose, returning carbon to the atmosphere. The appropriate distinction is not whether the product is waste or will eventually end up in the atmosphere anyway, but

whether the stationary source is leading to an increase or a decrease in biogenic carbon stocks and associated change in GWP. To do this, the *Framework* must consider the time period for "anyway" emissions and that this may vary across different types of waste feedstocks.

An important limitation of the proposed *Framework* is that the accounting system replaces space for time and applies responsibility to things that happen on the land, to a point source, for which the agent who owns that point source has no direct control. The proposed approach would estimate an individual point source's BAF based on average data in a region in which it is located. Any biogenic carbon accounting system that attempts to create responsibility or give credit at a point source for carbon changes upstream or downstream from the point source must relate those responsibilities and credits to actions under control of the point source. However, the *Framework* does not clearly specify a cause and effect relationship between a facility and the biogenic CO_2 emissions attributed to it. In particular, If the BAF is assigned to a plant when it is approved for construction, as the BAF is currently designed, those emissions related to land use change will have nothing to do with that actual effect of the point source on land use emissions because the data on which it is based would predate the operation of the plant.

The dynamics of carbon accumulation in vegetation and soils present a challenge for any accounting system because in principle it implies that BAF estimates such as those proposed by EPA should be based on anticipated future changes in vegetation. These future changes depend on natural processes such as fires and pests that are not easily foreseen, and because of climate change and broader environmental change we face a system that is certainly not stable, and so projecting forward based on current or historical patterns is likely to generate significant errors and biases of unknown direction and magnitude. More important, however, is that land use decisions are under control of landowners, whose actions would need also to be projected. The *Framework* recognizes this issue and chooses to use a Reference Point Baseline. The limitations of this approach for adjusting the CO_2 emissions from biogenic sources have been discussed above. As discussed in response to the next charge question, an alternative to using this approach would be to develop an accounting system based on observable and measured changes rather than projections as discussed in response to the charge question that follows.

EPA's regulatory boundaries, and hence the *Framework*, are in conflict with a more comprehensive carbon accounting that considers the entire carbon cycle and the possibility of gains from trade between sources, among sources or between sources and sinks. For example, by restricting its attention to the regulation of point source emissions, EPA's analysis does not allow for the possibility that a fossil CO_2 emitter could contract with land owners to offset their emissions through forest protection and regrowth or carbon accumulation in soils. As far as the climate is concerned, it makes no difference if land use change is used to offset CO_2 that was of fossil origin or of biogenic origin, however, by staying within boundaries drawn narrowly around the stationary source, the *Framework* eclipses a more comprehensive approach to greenhouse gas reductions that would address all sources and sinks and take advantage of gains from trade. Scientifically, a comprehensive carbon accounting would extend downstream—to emissions from by-products, co-products, or products such as ethanol combustion or ethanol by-products

such as distillers dried grains (DDGs) that are sold as livestock feed and will soon become CO_2 (or CH_4).

6.3. Does the SAB have any advice regarding potential revisions that might enhance the final document?

Overall, the *Framework* would be enhanced by including a description of the regulatory context that has motivated the development of this framework and by specifying the boundaries for regulating upstream and downstream emissions while implementing the regulation. The motivation for the *Framework* should have been explained as it related to Massachusetts vs. EPA (CITE), the Supreme Court ruling that found greenhouse gas emissions were subject to Clean Air Act requirements if they were found to endanger public welfare and the environment. The *Framework* should also make explicit the constraints within which greenhouse gases can be regulated under the Clean Air Act. In doing this, EPA could be clear that these issues have not been settled but that some assumptions were necessary to make a decision about the accounting framework. EPA could also stipulate that further development of a regulatory structure might require changes to the accounting system. While the SAB understands the EPA's interest in describing an accounting system as a first step and potentially independent of the regulatory structure, the reader needs this background in order to understand the context for the accounting structure and to evaluate the scientific integrity of the approach.

Similarly, the *Framework* is mostly silent on how possible regulatory measures under the Clean Air Act may relate to other policies that affect land use changes or the combustion/oxidation of products from the point sources that will release carbon or other greenhouse gases. For example if a regulatory or incentive system exists to provide credits for carbon offsets through land use management then under some conditions it would be appropriate to assign a BAF of 1 to biogenic emissions given that the carbon consequences were addressed through other policies.

The *Framework* does not describe how it will address emissions downstream from a point source such as in the case of a biofuels or paper production facility where the product (biofuels, paper) may lead to CO_2 emissions when the biofuels are combusted or the paper disposed of and possibly incinerated. For example, if paper products are incinerated the incinerator may well be a point source that comes under Clean Air Act regulation. However, biofuels used in vehicles would not be subject to regulation as a point source. EPA needs to make clear the implicit assumptions on how biogenic carbon will be treated upstream and downstream from the point source if this *Framework* is used to regulate CO_2 emissions under the constraints imposed by the Clean Air Act for regulating stationary sources.

Recommendations for Revising BAF

Overall, the SAB would prefer an alternative to the calculation of the BAF, given the daunting technical and implementation challenges associated with implementing the *Framework*. If EPA decides to revise the *Framework*, below we offer a summary of recommendations for specific improvements in the calculation of BAF.

1. Develop a separate BAF equation for each feedstock category. Many of the issues raised in previous responses regarding the treatment of specific factors included in the *Framework* are specific to particular feedstocks. The clarity of the *Framework* would be improved by differentiating among feedstocks based on how their management and use interacts with the carbon cycle. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues and long rotation trees. A BAF equation should be developed for each of these categories of feedstocks, preferably separating out "anyway" emissions feedstocks from those that have significant emissions.
    - Use an anticipated baseline approach for long recovery feedstocks like roundwood, employing integrated forest sector models and/or Cherubini's $GWP_{bio.}$(as discussed in Section 4.6).
    - Develop an equation for municipal solid waste to take into account the mix of biogenic waste with fossil fuel waste in combustion facilities as well as the possibility of methane capture in landfills (as discussed in Section 3.1).
2. Consider information about the directionality of leakage and leakage into other media (as discussed in Section 3.1).
3. Omit the regional scale and incorporate a time dimension (as discussed in Sections 3.1, 4.2 and elsewhere). Certain factors in the BAF equation should be modified to include the timescale over which carbon is decomposed or released back to the atmosphere. The variable that represents the proportion of emissions that are offset by sequestration during feedstock growth (LAR) needs to be modified to be scale insensitive and to address additionality.

Alternatives to BAF

Given the conceptual deficiencies and prospective difficulties with implementation, the SAB encourages EPA to "think outside the box" to search for an alternative to a categorical inclusion , exclusion or a facility-specific BAF. We offer the following three options for the Agency's consideration:

1. Develop a generic BAF for each feedstock category.
2. Consider certification systems.
3. Consider offset systems.

Option 1: Develop a generic BAF for each feedstock category. An alternative to revising the *Framework* and calculating a BAF for each stationary facility is to develop general BAFs for each category of feedstocks, differentiating among feedstocks using general information on how their harvest and combustion interacts with the carbon cycle. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues, long rotation trees and waste materials. Special attention should be given by which feedstocks could be classified as "anyway" emissions so that their BAF would automatically be either set to 0 or modeled as a

decay function. For longer recovery feedstocks, EPA would need to use forest growth models to plot carbon paths that track regrowth following harvest or adopt a calculation of GWP_{bio} (as discussed in Section 4.6). Many more case studies would be needed to develop an accounting focused on feedstocks rather than the facility. These generic BAFs would be applied by stationary facilities to determine their quantity of biogenic emissions that would be subject to EPA's tailoring rule.

Option 2: Consider certification systems in a hybrid approach. This hybrid approach combined a categorical inclusion with an opt-out provision whereby facilities could opt out by certifying that their biomass was sustainably harvest and produced using best management practices. Such "sustainability" would need to be certified by an authority using valid scientific measurements. Requiring stationary facilities to use only "certified" feedstocks would be administratively simpler than quantifying a specific net change in greenhouse gases associated with a particular stationary facility. Certification apparoach can avoid the arbitrary scale issues and can perhaps avoid or reduce leakage. By making the stationary source responsible for demonstrating "sustainability", the source would be linked to its land base. This would remove the perverse situation of a responsible bioenergy facility, using feedstock produced in a highly sustainable manner, being penalized because it happens to be located in a region where other, less sustainable forest activities are causing carbon stocks to decline. It would also avoid the problem of a bioenergy facility that uses biomass harvested in an unsustainable manner benefitting from operating in a region where carbon stocks happen to be growing.

Option 3: Consider offsets. The use of offsets could accompany either Option 1 or Option 2 above or even a calculated BAF for each facility (using the *Framework*). An offset system would allow sources (e.g. a stationary energy producer) to contract with sinks (e.g. landowner) to offset their emissions through forest protection and regrowth or carbon accumulation in soils. Plants would need to meet a required BAF on an annual basis by acquiring carbon uptake credits equal to their emissions. Since the atmosphere is indifferent between emissions reductions and carbon accumulation, an offset need not be on a specific piece of land or even associated with the specific point source. Offsets would need to be certified by an authority using valid scientific measurements. Point sources could acquire certified storage credits, irrespective of their relationship to the point source. For example, a landfill, a forest product producer, or biomass waste energy generator could acquire credits for new production of lumber or paper products to offset carbon in forest products that went through them or to offset land fill emissions or stack emissions. Allowing flexibility in who could acquire these credits would encourage market forces to seek these out. As firms compete to acquire certified carbon uptake or storage a market will develop for these certified credits that will provide incentives for maintaining uptake/stocks consistent with requirements for credits. Measurement and certification can be based on observed carbon uptake or stock accumulation. These certifications can be over periods that make sense and need not be made daily or annually. If concern exists that stocks of soil carbon cannot be reliably estimated except over longer periods, then certifications may be limited to period of 5 or 10 years. A certification system would also allow stationary source fossil emitters to compete for biogenic credits.

References --- to be compiled

EPA-SAB-12-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: SAB Review of EPA's Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources (September 2011)

Dear Administrator Jackson:

EPA's Science Advisory Board (SAB) was asked to review and comment on the EPA's *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources (Framework, September 2011)*. The *Framework* considers the scientific and technical issues associated with accounting for emissions of biogenic carbon dioxide (CO_2) from stationary sources and develops a method to adjust the stack emissions from stationary sources using biological material based on the induced changes in carbon stocks on land (in soils, plants and forests). A panel of experts was formed under the auspices of the SAB to conduct the review. Advice is provided through the chartered SAB. The panel, comprised of experts in forestry, agriculture, greenhouse gas measurement and inventories, land use economics, ecology, climate change and engineering met in a face-to-face meeting and held four teleconferences.

Assessing the greenhouse gas implications of using biomass to produce energy is a daunting task and the EPA is to be commended for its effort. The context for the *Framework* arose when the EPA established thresholds for greenhouse gas emissions from stationary sources for the purposes of Clean Air Act permits under the New Source Review (Prevention of Significant Deterioration program) and Title V operations program. The Agency had to consider how to include biogenic emissions in determining whether thresholds for regulation have been met. In July 2011, the EPA deferred for a period of three years the application of permitting requirements to biogenic carbon dioxide emissions from bioenergy and other biogenic stationary sources, while committing to a detailed examination of the issues associated with biogenic CO_2.

The Agency sought a method of "adjusting" biogenic carbon emissions from stationary sources to credit those emissions with carbon uptake during sequestration or, alternatively, avoided emissions from natural decay (e.g., from residues and waste materials). Without a way of adjusting those emissions, the Agency's options would be either a categorical inclusion (treating biogenic feedstocks as equivalent to fossil fuels) or a categorical exclusion (excluding biogenic emissions from determining applicability thresholds for regulation). The purpose of the *Framework* was to propose a method for calculating the adjustment or Biogenic Accounting Factor (BAF) for biogenic feedstocks based on their interaction with the carbon cycle.

In general, the SAB found that the science and technical issues relevant to accounting for biogenic CO_2 emissions are different for each feedstock category and sometimes differ within a category. For instance,

forest-derived woody biomass has a much longer rotation period than agricultural feedstocks. The *Framework* includes most of the elements that would be needed to gauge changes in CO_2 emissions; however, the reference year approach employed does not provide an estimate of the additional emissions and the sequestration changes in response to biomass feedstock demand. Estimating additionality is essential, as it is the crux of the question at hand. To do so requires an anticipated baseline approach. Because forest-derived woody biomass is a long-rotation feedstock, the *Framework* would need to model a "business as usual" scenario along some time scale and compare that carbon trajectory with a scenario of increased demand for biomass. Although this would not be an easy task, it would be necessary to estimate carbon cycle changes associated with the biogenic feedstock. In addition, an anticipated baseline would be needed to estimate additional changes in soil carbon stock over time. In general the *Framework* should provide a means to estimate the effect of stationary source biogenic feedstock demand, on the atmosphere over time.

In the attached report, the SAB provides some suggestions for an "anticipated baseline" approach while acknowledging the uncertainty and difficulty associated with modeling future scenarios. It would be particularly important to capture market and landscape level effects, specifically the complex interaction between electricity generating facilities and forestry markets; market driven shifts in planting, management and harvests; induced displacement of existing uses of biomass; land use changes; and the relative contribution of different feedstock source categories (logging residue, pulpwood or roundwood harvest). A landscape, versus stand or plot, perspective is important because simultaneous management decisions may affect net carbon emissions over time.

For agricultural feedstocks, the variables in the *Framework* capture most of the factors necessary for estimating the carbon change associated with the feedstock use, including a factor to represent the carbon embodied in products leaving the stationary source, the proportion of feedstock lost in conveyance, the offset represented by sequestration, the site-level difference in net carbon flux and the emissions that would occur "anyway" from removal or diversion of nongrowing feedstock (e.g., corn stover) and other variables. For short rotation agricultural feedstocks where carbon accumulation occurs within one to a few years, the *Framework* can, with some adjustments to address estimation problems (including an anticipated baseline for soil carbon changes) and careful consideration of data and implementation, represent direct carbon changes in a particular region. As recognized by the Agency, for many waste feedstocks (municipal solid waste, construction and demolition waste, industrial wastes, manure, tire-derived wastes and wastewater), combustion to produce energy releases CO_2 that would have otherwise been returned to the atmosphere from the natural decay of waste. The Agency chose not to model natural decomposition in the *Framework* but modeling the decay of agricultural and forest residues based on their alternate fate (e.g., whether the materials would have been disposed in a controlled or uncontrolled landfill or left on site, or subject to open burning) could be incorporated to improve scientific accuracy.

The *Framework* does not discuss the different time scales inherent in the carbon cycle nor does it characterize potential intertemporal tradeoffs associated with the use of biogenic feedstocks. However it is important that intertemporal tradeoffs be made transparent for policymakers. For forest-derived roundwood, carbon debts and credits can be created in the short run with increased harvesting and planting respectively but in the long run, net climate benefits can accrue with net forest growth. While it is clear that the Agency can only regulate emissions, its policy choices about regulating emissions will

be better informed with consideration of the temporal distribution of biogenic emissions and associated carbon sequestration or avoided emissions.

Overall, the SAB found that quantification of most components of the *Framework* has uncertainties, technical difficulties, data deficiencies and implementation challenges. These issues received little attention in the *Framework*, but are important considerations relevant to scientific integrity and operational efficiency. Moreover, the Agency should consider consistency between biogenic carbon accounting and fossil fuel emissions accounting. Ideally both fossil fuels and biogenic feedstocks should be subject to the same emissions accounting. While there are no easy answers to accounting for the greenhouse gas implications of bioenergy, further consideration of the issues raised by the SAB and revisions to the *Framework* could result in more scientific rigor in accounting for biogenic emissions. A dissenting opinion, offered in Appendix E, recommends that the Agency abandon the *Framework* altogether and instead choose to exempt biogenic CO_2 emissions from greenhouse gas regulation so long as aggregate measures of land-based carbon stocks are steady or increasing.

Given the challenges associated with improving and implementing the *Framework*, the SAB encourages EPA to consider developing default BAFs by feedstock category and region. Under EPA's *Framework*, facility-specific BAFs would be calculated to reflect the incremental carbon cycle and net emissions effects of a facility's use of a biogenic feedstock. With default BAFs, biogenic emissions from a facility would be based on the weighted combination of default BAFs relevant to a facility's feedstock consumption and location. The defaults might vary by region, prior land use and current land management practices due to the differences these might cause in the interaction between feedstock production and the carbon cycle. They are likely to be more scientifically robust in that they could rely on readily available data. The defaults would also have administrative advantages in that they would be easier to implement and update. Facilities could also be given the option of demonstrating a lower BAF for their feedstocks.

The SAB acknowledges that practical considerations will weigh heavily in the Agency's calculus. In fact, any method that might be adopted or considered, including methods proposed by the SAB, should be subject to an evaluation of the costs of compliance and the carbon emissions savings likely to be achieved as compared to both a categorical inclusion and a categorical exclusion. Uncertainties in the assessment of both the costs and the emissions savings should be analyzed and used to inform the choice of policy.

The SAB appreciates the opportunity to provide advice on the *Framework* and looks forward to your response.

Sincerely,

Enclosure

U.S. Environmental Protection Agency
Science Advisory Board
Biogenic Carbon Emissions Panel

CHAIR

Dr. Madhu Khanna, Professor, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, Urbana, IL

MEMBERS

Dr. Robert Abt, Professor of Forestry, Department of Forestry and Environmental Resources, College of Natural Resources, North Carolina State University, Raleigh, NC

Dr. Morton Barlaz, Professor, Civil, Construction, and Environmental Engineering, Engineering, North Carolina State University, Raleigh, NC

Dr. Richard Birdsey, Program Manager, Climate, Fire, and Carbon Cycle Sciences, Northern Research Station, USDA Forest Service, Newtown Square, PA

Dr. Marilyn Buford, National Program Leader, Silviculture Research, Research & Development, USDA Forest Service, Washington, DC

Dr. Mark Harmon, Professor and Richardson Chair, College of Forestry, Oregon State University, Corvallis, OR

Dr. Jason Hill, Assistant Professor, Bioproducts and Biosystems Engineering, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota, St. Paul, MN

Dr. Stephen Kelley, Professor and Department Head, Forest Biomaterials, College of Natural Resources, North Carolina State University, Raleigh, NC

Dr. Richard Nelson, Director and Department Head, Engineering Extension Programs, Kansas State University Center for Sustainable Energy, Manhattan, KS

Dr. Lydia Olander, Director, Ecosystem Services Program, Nicholas Institute for Environmental Policy Solutions, Duke University, Durham, NC

Dr. John Reilly, Senior Lecturer and Co-Director, Joint Program on the Science and Policy of Global Change, Center for Environmental Policy Research, E19-439L, Massachusetts Institute of Technology, Cambridge, MA

Dr. Charles Rice, Distinguished Professor, Department of Agronomy, Soil Microbiology, Kansas State University, Manhattan, KS

Dr. Steven Rose, Senior Research Economist, Energy and Environmental Analysis Research Group, Electric Power Research Institute, Palo Alto, CA

Dr. Daniel Schrag, Professor of Earth and Planetary Sciences, Harvard University, Cambridge, MA

Dr. Roger Sedjo,[*] Senior Fellow and Director of the Center for Forest Economics and Policy Program, Resources for the Future, Washington, DC

Dr. Ken Skog, Supervisory Research Forester, Economics and Statistics Research, Forest Products Laboratory, USDA Forest Service, Madison, WI

Dr. Tristram West, Ecosystem Scientist, Joint Global Change Research Institute, University of Maryland, College Park, MD

Dr. Peter Woodbury, Senior Research Associate, Department of Crop and Soil Sciences, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY

SCIENCE ADVISORY BOARD STAFF

Dr. Holly Stallworth, Designated Federal Officer, U.S. Environmental Protection Agency, Science Advisory Board (1400R), 1200 Pennsylvania Avenue, NW, Washington, DC 20460

[*] / Dr. Sedjo's dissenting opinion is offered in Appendix E.

U.S. Environmental Protection Agency
Science Advisory Board
BOARD

CHAIR

Dr. Deborah L. Swackhamer, Professor and Charles M. Denny, Jr. Chair in Science, Technology and Public Policy, Hubert H. Humphrey School of Public Affairs and Co-Director of the Water Resources Center, University of Minnesota, St. Paul, MN

SAB MEMBERS

Dr. George Alexeeff, Director, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Oakland, CA

Dr. David T. Allen, Professor, Department of Chemical Engineering, University of Texas, Austin, TX

Dr. Pedro Alvarez, Department Chair and George R. Brown Professor of Engineering, Department of Civil & Environmental Engineering, Rice University, Houston, TX

Dr. Joseph Arvai, Svare Chair in Applied Decision Research, Institute for Sustainable Energy, Environment, & Economy, Haskayne School of Business, University of Calgary, Calgary, Alberta, Canada

Dr. Claudia Benitez-Nelson, Full Professor and Director of the Marine Science Program, Department of Earth and Ocean Sciences, University of South Carolina, Columbia, SC

Dr. Patricia Buffler, Professor of Epidemiology and Dean Emerita, Department of Epidemiology, School of Public Health, University of California, Berkeley, CA

Dr. Ingrid Burke, Director, Haub School and Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, Laramie, WY

Dr. Thomas Burke, Professor and Jacob I. and Irene B. Fabrikant Chair in Health, Risk and Society Associate Dean for Public Health Practice, Johns Hopkins Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD

Dr. Terry Daniel, Professor of Psychology and Natural Resources, Department of Psychology, School of Natural Resources, University of Arizona, Tucson, AZ

Dr. George Daston, Victor Mills Society Research Fellow, Product Safety and Regulatory Affairs, Procter & Gamble, Cincinnati, OH

Dr. Costel Denson, Managing Member, Costech Technologies, LLC, Newark, DE

Dr. Otto C. Doering III, Professor, Department of Agricultural Economics, Purdue University, W. Lafayette, IN

Dr. Michael Dourson, President, Toxicology Excellence for Risk Assessment, Cincinnati, OH

Dr. David A. Dzombak, Walter J. Blenko, Sr. University Professor of Environmental Engineering, Department of Civil and Environmental Engineering, College of Engineering, Carnegie Mellon University, Pittsburgh, PA

Dr. T. Taylor Eighmy, Senior Vice President for Research, Office of the Vice President for Research, Texas Tech University, Lubbock, TX

Dr. Elaine Faustman, Professor and Director, Institute for Risk Analysis and Risk Communication, School of Public Health, University of Washington, Seattle, WA

Dr. John P. Giesy, Professor and Canada Research Chair, Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Dr. Jeffrey K. Griffiths, Professor, Department of Public Health and Community Medicine, School of Medicine, Tufts University, Boston, MA

Dr. James K. Hammitt, Professor, Center for Risk Analysis, Harvard University, Boston, MA

Dr. Barbara L. Harper, Risk Assessor and Environmental-Public Health Toxicologist, and Division Leader, Hanford Projects, and Program Manager, Environmental Health, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), West Richland, WA

Dr. Kimberly L. Jones, Professor and Chair, Department of Civil Engineering, Howard University, Washington, DC

Dr. Bernd Kahn, Professor Emeritus and Associate Director, Environmental Radiation Center, Georgia Institute of Technology, Atlanta, GA

Dr. Agnes Kane, Professor and Chair, Department of Pathology and Laboratory Medicine, Brown University, Providence, RI

Dr. Madhu Khanna, Professor, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, Urbana, IL

Dr. Nancy K. Kim, Senior Executive, Health Research, Inc., Troy, NY

Dr. Cecil Lue-Hing, President, Cecil Lue-Hing & Assoc. Inc., Burr Ridge, IL

Dr. Judith L. Meyer, Professor Emeritus, Odum School of Ecology, University of Georgia, Lopez Island, WA

Dr. James R. Mihelcic, Professor, Civil and Environmental Engineering, University of South Florida, Tampa, FL

Dr. Christine Moe, Eugene J. Gangarosa Professor, Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA

Dr. Horace Moo-Young, Dean and Professor, College of Engineering, Computer Science, and Technology, California State University, Los Angeles, CA

Dr. Eileen Murphy, Director of Research and Grants, Ernest Mario School of Pharmacy, Rutgers University, Piscataway, NJ

Dr. James Opaluch, Professor and Chair, Department of Environmental and Natural Resource Economics, College of the Environment and Life Sciences, University of Rhode Island, Kingston, RI

Dr. Duncan Patten, Director, Montana Water Center, and Research Professor, Hydroecology Research Program, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT

Dr. Stephen Polasky, Fesler-Lampert Professor of Ecological/Environmental Economics, Department of Applied Economics, University of Minnesota, St. Paul, MN

Dr. C. Arden Pope, III, Professor, Department of Economics, Brigham Young University, Provo, UT

Dr. Stephen M. Roberts, Professor, Department of Physiological Sciences, Director, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL

Dr. Amanda Rodewald, Professor of Wildlife Ecology, School of Environment and Natural Resources, The Ohio State University, Columbus, OH

Dr. Jonathan M. Samet, Professor and Flora L. Thornton Chair, Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA

Dr. James Sanders, Director and Professor, Skidaway Institute of Oceanography, Savannah, GA

Dr. Jerald Schnoor, Allen S. Henry Chair Professor, Department of Civil and Environmental Engineering, Co-Director, Center for Global and Regional Environmental Research, University of Iowa, Iowa City, IA

Dr. Gina Solomon, Deputy Secretary for Science and Health, Office of the Secretary, California Environmental Protection Agency, Sacramento, CA

Dr. Daniel O. Stram, Professor, Department of Preventive Medicine, Division of Biostatistics, University of Southern California, Los Angeles, CA

Dr. Peter S. Thorne, Director, Environmental Health Sciences Research Center and Professor and Head, Departmment of Occupational and Environmental Health, College of Public Health, University of Iowa, Iowa City, IA

Dr. Paige Tolbert, Professor and Chair, Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA

Dr. John Vena, University of Georgia Foundation Professor in Public Health and Head, Department of Epidemiology and Biostatistics, Georgia Cancer Coalition Distinguished Scholar, College of Public Health , University of Georgia, Athens, GA

Dr. Robert Watts, Professor of Mechanical Engineering Emeritus, Tulane University, Annapolis, MD

Dr. R. Thomas Zoeller, Professor, Department of Biology, University of Massachusetts, Amherst, MA

SCIENCE ADVISORY BOARD STAFF

Dr. Angela Nugent, Designated Federal Officer, U.S. Environmental Protection Agency, Science Advisory Board (1400R), Washington, DC

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board (SAB), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The SAB is structured to provide balanced, expert assessment of scientific matters related to problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports of the SAB are posted on the EPA website at http://www.epa.gov/sab.

TABLE OF CONTENTS

List of Figures ..... **ii**
Acronyms and Abbreviations ..... **iii**
1. EXECUTIVE SUMMARY **4**
2. INTRODUCTION **13**
3. RESPONSES TO EPA's CHARGE QUESTIONS **15**
3.1. THE SCIENCE OF BIOGENIC CO_2 EMISSIONS 15
3.2. BIOGENIC CO_2 ACCOUNTING APPROACHES 18
3.3. METHODOLOGICAL ISSUES 20
3.4. ACCOUNTING FRAMEWORK 29
3.5. CASE STUDIES 40
3.6. OVERALL EVALUATION 42
4. DEFAULT BAFs BASED ON FEEDSTOCK CATEGORIES **47**
REFERENCES **48**
APPENDIX A: Charge to the Panel **A-1**
APPENDIX B: Temporal Changes in Stand Level Biogenic Emissions Versus Fossil Emissions **B-1**
APPENDIX C: Fate of Landscape Residue after Harvest and System Storage of Carbon **C-1**
APPENDIX D: Carbon Balances over Time in an Existing Forest System **D-1**
APPENDIX E: Dissenting Opinion from Dr. Roger Sedjo **E-1**

List of Figures

Figure B-1: Surface temperature change from biogenic emissions versus fossil fuel over time. Adapted from Cherubini et al. (2012) and reprinted with copyright permission. B-2
Figure C-1: Fate of residue/slash left after harvest as function of k and time since harvest. C-1
Figure C-2: Landscape average store of residue/slash as function of k and harvest interval. C-2
Figure D-1: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is established and continued. The result is a continued carbon balance. D-2
Figure D-2: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is replaced by a 25 year clear-cut harvest system in 2010. The result is a carbon debt. D-2
Figure D-3: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is replaced by a 100 year clear-cut harvest system in 2010. The result is a carbon gain. D-3

Acronyms and Abbreviations

AVOIDEMIT	Avoided Emissions
BAF	Biogenic Accounting Factor
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DOE	Department of Energy
EPA	Environmental Protection Agency
FASOM	Forestry and Agricultural Sector Optimization Model
GHG	Greenhouse gases
GROW	Growth
GtC/y	Gigatons of carbon per year
GTMM	Global Timber Market Model
GTP	Global Temperature Potential
GWP	Global Warming Potential
GWPbio	Global Warming Potential of biomass
I	Carbon Input
K	Proportion of Carbon Lost per unit of time
LAR	Level of Atmospheric Reduction
LEAK	Leakage
N_20	Nitrous Oxide
NSR	New Source Review
PRODC	Carbon in Products
PSD	Prevention of Significant Deterioration
RPA	Resources Planning Act
SAB	Science Advisory Board
SEQP	Sequestered Fraction
SITE_TNC	Total Net Change in Site Emissions
SRTS	Sub-regional Timber Supply Model
USDA	United States Department of Agriculture

1. EXECUTIVE SUMMARY

Biogenic CO_2 emissions from bioenergy are generated during the combustion or decomposition of biologically-based material. Biogenic feedstocks differ from fossil fuels in that they may be replenished in a continuous cycle of planting, harvesting and regrowth. The same plants that provide combustable feedstocks for electricity generation also sequester carbon from the atmosphere. Plants convert raw materials present in the ecosystem such as carbon from the atmosphere and inorganic minerals and compounds from the soil (including nitrogen, potassium, and iron) and make these elemental nutrients available to other life forms. Carbon is returned to the atmosphere by plants and animals through decomposition and respiration and by industrial processes, including combustion. Biogenic CO_2 is emitted from stationary sources through a variety of energy-related and industrial processes. Thus, the use of biogenic feedstocks results in both carbon emissions and carbon sequestration.

EPA's *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources (Framework, September 2011)* explores the scientific and technical issues associated with accounting for emissions of biogenic carbon dioxide (CO_2) from stationary sources and develops a method to adjust the stack emissions from bioenergy based on the induced changes in carbon stocks on land (in soils, plants and forests). The context for the *Framework* is the treatment of biogenic CO_2 emissions in stationary source regulation given the unique feature of plant biomass in providing uptake of carbon dioxide (CO_2) from the atmosphere during the photosynthesis. Under the Clean Air Act, major new sources of certain air pollutants, defined as "regulated New Source Review (NSR) pollutants" and major modifications to existing major sources are required to obtain a permit. The set of conditions that determine which sources and modifications are subject to the Agency's permitting requirements are referred to as "applicability" requirements. Since greenhouse gases are included in the definition of a "regulated NSR pollutant," EPA has to make a determination about whether a source meets the "applicability threshold" to trigger permitting requirements. As of January 2011, for facilities already covered by the PSD or Title V programs, greenhouse gas emission increases of 75,000 tons per year (tpy) or more, on a carbon dioxide equivalent (CO_2e) basis, would be subject to technology requirements under the PSD program. As of July 1, 2011, more facilities became subject to regulation based on their greenhouse gas emissions. Specifically new and existing stationary sources (that are not already covered by the PSD or Title V programs) that emit greenhouse gas emissions of at least 100,000 tpy became subject to greenhouse gas regulation even if they do not exceed the permitting thresholds for any other pollutant. The question before the Agency, and hence, the motivation for the *Framework*, is whether and how to consider biogenic greenhouse gas emissions in determining these thresholds for permitting. The SAB's consensus advice is highlighted in this Executive Summary with more details in the attached report. A dissenting opinion is found in Attachment E.

Categorical inclusion or exclusion

In approaching these questions, EPA considered whether it could a priori categorically include or exclude biogenic emissions in its greenhouse gas accounting. Thus, before doing its own analysis, EPA considered whether it could make a categorical determination. A categorical inclusion would count all biogenic carbon emissions at the combustion source, similar to fossil fuel emissions while a categorical exclusion would exempt biogenic carbon emissions from greenhouse gas regulation. The Agency

rejected both extremes and asked the SAB whether it supported their conclusion that a priori categorical approaches are inappropriate for the treatment of biogenic carbon emissions.

The decision about a categorical inclusion or exclusion will likely involve many considerations that fall outside the SAB's scientific purview such as legality, feasibility and, possibly, political will. The SAB cannot speak to the legal or regulatory complexities that could accompany any policy on biogenic carbon emissions but this Advisory offers some scientific observations that may inform the Administrator's policy decision.

Carbon neutrality cannot be assumed for all biomass energy a priori. There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a priori assumption; it is a conclusion that should be reached only after considering a particular feedstock's production and consumption cycle. There is considerable heterogeneity in feedstock types, sources and production methods and thus net biogenic carbon emissions will vary considerably. Of course, biogenic feedstocks that displace fossil fuels do not have to be carbon neutral to be better than fossil fuels in terms of their climate impact.

Given that some biomass could have positive net emissions, a categorical exclusion would remove any responsibility on the stationary source for CO_2 emissions from its use of biogenic material and provide no incentive for the development and use of best management practices. Conversely, a categorical inclusion would provide no incentive for using biogenic sources that compare favorably to fossil energy in terms of greenhouse gas emissions. The dissenting opinion in Attachment E offers support for a categorical exclusion so long as aggregate measures of land-based carbon stocks are steady or expanding.

Biogenic Accounting Factor (BAF) Calculation

The *Framework* presents an alternative to a categorical inclusion or exclusion by offering an equation for calculating a Biogenic Accounting Factor (BAF) would be used to adjust the onsite biogenic emissions at the stationary source emitting biogenic CO_2 on the basis of information about growth of the feedstock and/or avoidance of biogenic emissions and more generally the carbon cycle.

Forest-Derived Woody Biomass

The EPA's stated objective was to accurately reflect the carbon outcome of biomass use by stationary sources. For forest-derived woody biomass, the *Framework* did not achieve this objective. To calculate BAF for biomass from roundwood trees, the Agency proposed the concept of regional carbon stocks (with the regions unspecified) and posed a "rule" whereby any bioenergy usage that takes place in a region where carbon stocks are increasing would be assigned a BAF of 0. This decouples the BAF from a particular facility's biogenic emissions and the sequestration (offset) associated with its particular feedstock. Emissions from a stationary facility would be included or excluded from greenhouse gas regulation depending on a host of factors in the region far beyond the facility's control.

To accurately capture the carbon outcome, an anticipated baseline approach is needed, and a landscape level perspective. An anticipated baseline requires selecting a time period and determining what would have happened anyway without the harvesting and comparing that impact with the carbon trajectory

associated with harvesting of biomass for bioenergy. Although any "business as usual" projection would be uncertain, it is the only means by which to gauge the incremental impact of woody biomass harvesting. The *Framework* discusses this anticipated future baseline approach but does not attempt it. Instead a fixed reference point and an assumption of geographic regions were chosen to determine the baseline for whether biomass harvesting for bioenergy facilities is having a negative impact on the carbon cycle. The choice of a fixed reference point may be the simplest to execute, but it does not properly address the additionality question, i.e., the extent to which forest stocks would have been growing or declining over time in the absence of bioenergy. The Agency's use of a fixed reference point baseline coupled with a division of the country into regions implies that forest biomass emissions could be granted an exemption simply because the location of a stationary facility is in an area where forest stocks are increasing. The reference point estimate of regionwide net emissions or net sequestration does not indicate, or estimate, the difference in greenhouse gas emissions (the actual carbon gains and losses) over time that stem from biomass use. As a result, the *Framework* fails to capture the causal connection between forest biomass growth and harvesting and atmospheric impacts and thus may incorrectly assess net CO_2 emissions of a facility's use of a biogenic feedstock.

A landscape, versus stand or plot, perspective is important because land-management decisions are simultaneous, e.g., harvesting, planting, silvacultural treatments. Thus, there are concurrent carbon stock gains and losses that together define the net implications over time. A landscape level analysis, and BAF calculation, will capture these.

Agricultural and Waste Feedstocks

For faster growing biomass like agricultural crops, the anticipated future baseline approach is still necessary to reflect changes in dynamic processes, e.g., soil carbon, "anyway" emissions, and landscape changes. For agricultural feedstocks in general, the *Framework* captures many of the factors necessary for estimating the offsite carbon change associated with use of short rotation (agricultural) feedstocks. These include factors to represent the carbon embodied in products leaving a stationary source, the proportion of feedstock lost in conveyance, the offset represented by sequestration, the site-level difference in net carbon flux as a result of harvesting, the emissions that would occur "anyway" from removal or diversion of nongrowing feedstocks (e.g., corn stover) and other variables. In addition to the anticipated baseline, a noticeable omission is the absence of consideration of nitrous oxide (N_2O) emissions from fertilizer use, potentially a major onsite greenhouse gas loss that could be induced by a growing bioenergy market.

For short rotation feedstocks where carbon accumulation and "anyway" emissions are within one to a few years (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), the *Framework* may, with some adjustments to address estimation problems (including an anticipated baseline for soil carbon changes, residue disposition and land management) and careful consideration of data and implementation, accurately represent direct carbon changes in a particular region. For logging residues and other feedstocks that decay over longer periods, decomposition cannot be assumed to be instantaneous and the *Framework* could be modified to incorporate the time path of decay of these residues if they are not used for bioenergy. This time path should consider the alternative fate of these residues, which in some cases may involve removal and burning to reduce risks of fire or maintain forest health.

For waste materials (municipal solid waste), the *Framework* should consider the alternate disposition of waste material (what would happen if not used as feedstock) in an anticipated baseline (counterfactual) framework. This anticipated baseline should include emissions and partial capture of methane (CH_4) emissions from landfills. In general, when accounting for emissions from wood mill waste and pulping liquor, the EPA should recognize these emissions are part of a larger system that includes forests, solid wood mills, pulp mills and stationary energy sources. Accounting for greenhouse gases in the larger system should track all emissions or forest stock changes over time across the outputs from the system so as to account for all fluxes. Within the larger system, the allocation of fluxes to wood/paper products or to a stationary source is a policy decision. The Agency should consider how its *Framework* meets the scientific requirement to account (allocate) all emissions across the larger system of forests, mills and stationary sources over time.

Leakage

Leakage is a phenomenon by which efforts to reduce emissions in one place affect market prices that shift emissions to another location or sector. The *Framework's* equation for BAF includes a term for leakage, however the Agency decided that calculating values for leakage was outside the scope of the *Framework*. While that decision was expedient, it should be recognized that incorporating leakage, however difficult, may change the BAF results radically. "Bad" leakage (called "positive" leakage in the literature) occurs when the use of biogenic feedstocks causes price changes which, in turn, drive changes in consumption and production outside the boundary of the stationary source, even globally, that lead to increased carbon emissions. One type of positive leakage could occur if land is diverted from food/feed production to bioenergy production which increases the price of conventional agricultural and forest products in world markets and leads to conversion of carbon -rich lands to crop production and the release of carbon stored in soils and vegetation. The use of biogenic feedstocks can also affect the price of fossil fuels by lowering demand for them and thereby increasing their consumption elsewhere. "Good" leakage (called "negative" leakage in the literature) could occur if the use of biomass leads to carbon -offsetting activities elsewhere. The latter could arise for example, if increased demand for biomass and higher prices generate incentives for investment in forest management, beyond the level needed directly for bioenergy production, which increases net forest carbon sequestration.

The existing literature in the social sciences shows that the overall magnitude of leakage, associated with the use of bioenergy for fuel is highly uncertain and differs considerably across studies and within a study, depending on underlying assumptions. It will also differ by feedstock and location. Rather than eschewing the calculation of leakage altogether, the Agency might instead, try to ascertain the directionality of net leakage -- whether it is positive (leading to increased carbon emissions elsewhere) or negative (leading to carbon offsetting activities) -- and incorporate that information in its decision making. In some cases even net directionality may be hard to establish. In cases where prior research has indicated directionality, if not magnitude, such information should be used to explore supplementary policy approaches to prevent positive leakage at the source or to control it where it occurs. In addition, the Agency should be alert to leakage that may occur in other media (e.g., fertilizer runoff into waterways) and the need for targeted policies to prevent or abate it. However, consistency with the treatment of fossil fuels is something to consider (discussed below).

Time scale

The *Framework* seeks to determine annual changes in emissions and sequestration rather than assessing the manner in which these changes will impact the climate over longer periods of time. In so doing, it does not consider the different ways in which use of bioenergy impacts the carbon cycle and global temperature over different time scales. Nor does it consider temporal differences of climate effects on the environment. Some recent studies have shown some intertemporal tradeoffs that should be highlighted for policymakers. In the short/medium run, at the stand level, there can be a lag time between emissions (through combustion) and sequestration (through regrowth) with the use of forest biomass. At the landscape level, there can be concurrent debts and credits with harvesting and planting. The impacts of the temporal pattern on climate response depend on the framework used. Some modeling exercises have shown that the probability of limiting warming to or below 2°C in the twenty-first century is dependent upon cumulative emissions by 2050 (Meinshausen et al. 2009). This suggests that an early phase of elevated emissions from forest biomass could reduce the odds of limiting climate warming if warming is limited to 2°C. Other modeling exercises by the same research team have shown that in long run scenarios (100 years or more) in which total emissions were fixed, climate response is relatively insensitive to the emissions pathway (Allen et al. 2009). Other studies have shown that harvesting of biomass for bioenergy may have minimal effect on peak warming if regrowth is sufficient to compensate for carbon losses that accompany harvest on a cumulative basis (NRC 2011; Cherubini et al. 2012). This suggests that an intervention in forests or farming that results in an increase in storage of carbon or emissions reductions that endures longer than 100 years (or be "permanent") may reduce the peak climate response. Conversely, interventions that reduce storage of carbon or increase emissions for longer than approximately 100 years may have a negative effect on peak warming response. The accumulation of live plant, dead matter, and soil carbon should not be assumed to occur automatically or be permanent; rather growth and accumulation should be monitored and evaluated for changes resulting from management, market forces or natural causes.

If the climate effect of biogenic feedstocks is explored, the degree to which biogenic feedstocks curtails fossil fuel use should be assessed and quantified. Given the slow response of the carbon and climate system, if biogenic feedstocks displace the use of fossil fuels for longer than 100 years, then there may be a beneficial climate effect. In contrast, if the use of biogenic feedstocks does not displace fossil fuels, then any presumed beneficial climate consequences of biogenic carbon may be overestimated.

Spatial Scale

The use of unspecified "regions" as fuelsheds in combination with a reference year baseline is a central weakness of the *Framework* with respect to forest-derived feedstocks. The EPA used a variable for the Level of Atmospheric Reduction (LAR) to capture the proportion of potential gross emissions that are offset by sequestration during feedstock growth, however the calculation of LAR captures landscape wide changes rather than facility-specific carbon emissions associated with actual fuelsheds. As a result, the estimates of the BAFs are sensitive to the choice of the spatial region as shown in the Agency's own case study.

Implementation details

The EPA's *Framework* was lacking in implementation details. Implementation is crucial and some of the Agency's current proposals will be difficult to implement. Data availability and quality, as well as procedural details (e.g., application process, calculation frequency) are important considerations for assessing the feasibility of implementation and scientific accuracy of results.

Consistency with fossil fuel emissions accounting

For comparability, there should be consistency between fossil fuel and biogenic emissions accounting. Fossil fuel feedstock emissions accounting from stationary sources under the Clean Air Act are not adjusted for offsite greenhouse gas emissions and carbon stock changes. Unlike fossil fuels, however, biogenic feedstocks have carbon sequestration that occurs within a relevant timeframe. While EPA's primary goal is to account for this offsetting sequestration, its biogenic emissions accounting should be consistent with emissions accounting for fossil fuels for other emissions accounting categories—including losses, international leakage, and fossil fuel use during feedstock extraction, production and transport. Including some accounting elements for biomass and not for fossil fuels would be a policy decision without the underlying science to support it.

Recommendations for Revising BAF

The Agency faces daunting technical challenges if it wishes to implement the *Framework's* facility-specific BAF approach. If the EPA decides to retain and revise a facility-specific *Framework*, the SAB recommends consideration of the following improvements.

- Develop a separate BAF equation for each feedstock category as broadly categorized by type, region, prior land use and current management practices. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues, municipal solid waste, trees/forests with short accumulation times, trees/forests with long accumulation times and agricultural residue, wood mill residue and pulping liquor.
    - For long-accumulation feedstocks like roundwood, use an anticipated baseline approach to compare emissions from increased biomass harvesting against a baseline without increased biomass demand. For long rotation woody biomass, sophisticated modeling is needed to capture the complex interaction between electricity generating facilities and forest markets and landscape level effects, in particular: market driven shifts in planting, management and harvests; induced displacement of existing users of biomass; land use changes, including interactions between agriculture and forests; and the relative contribution of different feedstock source categories (logging residuals, pulpwood or roundwood harvest).
    - For residues, consider alternate fates (e.g., some forest residues may be burned if not used for bioenergy) and information about decay. An appropriate analysis using decay functions would yield information on the storage of ecosystem carbon in forest residues.
    - For materials diverted from the waste stream, consider their alternate fate, whether they might decompose over a long period of time, whether they would be deposited in anaerobic landfills, whether they are diverted from recycling and reuse, etc. For feedstocks that are found to have relatively minor impacts, the Agency may need to weigh ease of implementation against scientific accuracy. After calculating decay rates and considering alternate fates, including

avoided methane emissions, the Agency may wish to declare certain categories of feedstocks with relatively low impacts as having a very low BAF or setting it to 0 or possibly negative BAFs in the case where methane emissions are avoided.

- Incorporate various time scales and consider the tradeoffs in choosing between different time scales.
- For all feedstocks, consider information about carbon leakage to determine its directionality as well as leakage into other media.

Default BAFs

Given the conceptual and scientific deficiencies of the *Framework* described above, and the prospective difficulties with implementation, the SAB recommends consideration of default BAFs by feedstock category and region. Under EPA's *Framework*, facilities would use individual BAFs designed to capture the incremental carbon cycle and net emissions effects of their use of a biogenic feedstock. With default BAFs by feedstock category, facilities would use a weighted combination of default BAFs based on their particular bundle of feedstocks. The defaults are likely to be more scientifically robust in that they could rely on readily available data and reflect landscape and aggregate demand effects, including previous land use. Default BAFs might also vary by region and current land management practices due to differences these might cause in the interaction between feedstock production and the carbon cycle. The defaults would also have administrative advantages in that they would be easier to implement and update. Default BAFs for each category of feedstocks would differentiate among feedstocks using general information on their role in the carbon cycle. An anticipated baseline would allow for consideration of prior land use, management, alternate fate (what would happen to the feedstock if not combusted for energy) and regional differences. They would be applied by stationary facilities to determine their quantity of biogenic emissions that would be subject to the EPA's Tailoring Rule. Facilities could also be given the option of demonstrating a lower BAF for the feedstock they are using. This would be facilitated by making the BAF calculation transparent and based on data readily available to facilities. Properly designed, a default BAF approach could provide incentives to facilities to choose feedstocks with the lower greenhouse gas impacts.

The SAB also explored certification systems as a possible way to obviate the need to quantify a specific net change in greenhouse gases associated with a particular stationary facility. Carbon accounting registries have been developed to account for and certify CO_2 emissions reductions and sequestration from changes in forest management. Theoretically, for the EPA's purposes, a certification system could be tailored to account for emissions of a stationary facility after a comprehensive evaluation. Ultimately, the SAB concluded that it could not recommend certification without further evaluation because such systems could also encounter many of the same data, scientific and implementation problems that bedevil the *Framework*.

Conclusion

With the increasing threat of global climate change, it is important to have scientifically sound methods to account for greenhouse gas emissions caused by human activities. As the Agency has recognized, the greenhouse gas implications of bioenergy are more complex and subtle than the greenhouse gas impacts of fossil fuels. Unlike fossil fuels, forests and other biological feedstocks can grow back and sequester CO_2 from the atmosphere. Given the complicated role that bioenergy plays in the carbon cycle, the *Framework* was written to provide a structure to account for net CO_2 emissions. The *Framework* is a step forward in considering biogenic carbon emissions.

The focus of the *Framework* is on point source emissions from stationary facilities with the goal of accounting for any offsetting carbon sequestration that may be attributed to the facility's use of a biogenic feedstock. To create an accounting structure, the Agency drew boundaries narrowly in accordance with its regulatory domain. These narrow regulatory boundaries are intended to account for biogenic carbon uptake and release associated with biomass that is combusted for energy purposes. As

such, this *Framework* does not consider, nor is it intended to consider, all greenhouse gas emissions associated with the production and use of biomass energy. Comprehensive accounting for both biogenic and fossil fuels would extend through time and space to estimate the long-term impacts on net greenhouse gas emissions. To estimate net impact that can be attributed to bioenergy, the EPA would need to calculate the net change in global emissions over time resulting from increased use of biomass feedstocks as compared to a future without increased use of biogenic feedstocks. To capture this difference, the boundaries of analysis would need to include all factors in the life cycle of the feedstock and its products although computing global emissions changes for individual facilities has its own daunting challenges.

The boundaries imposed by EPA's regulatory authority necessarily restrict its policy choices, however economic research has shown that the most cost-effective way to reduce greenhouse gas emissions (or any other pollution) is to regulate or tax across all sources until they face equal marginal costs. Given the Agency's authority under the Clean Air Act, the most cost-effective economy-wide solution is not within its menu of choices. The Agency's regulation of stationary sources does not include other users of biomass (e.g. consumers of ethanol) that also have impacts on the carbon cycle as well as downstream consumers of products produced by these facilities. Note that EPA can only regulate end-of-stack emissions and thus has to design a system that fits within its regulatory authority.

The Agency has taken on a difficult but worthy task and forced important questions. Practical considerations will, no doubt, weigh heavily in the Agency's calculus. In fact, any method that might be adopted or considered, including methods proposed by the SAB, should be subject to an evaluation of the costs of compliance and the carbon emissions savings likely to be achieved as compared to both a categorical inclusion and a categorical exclusion. Uncertainties in the assessment of both the costs and the emissions savings should be analyzed and used to inform the choice of policy. In this Advisory, the SAB offers suggestions for how to improve the *Framework* while encouraging the Agency to think about options outside its current policy menu. While the task of accounting for biogenic carbon emissions defies easy solutions, it is important to assess the strengths and limitations of each option so that a more accurate carbon footprint can be ascribed to the various forms of bioenergy.

2. INTRODUCTION

Greenhouse gas (GHG) emissions from the largest stationary sources became subject to regulation under the Prevention of Significant Deterioration (PSD) and Title V Operating Permit Programs of the Clean Air Act in January 2011. To target these regulations, EPA enumerated specific conditions under which these Clean Air Act permitting requirements would apply. Initially, only sources currently subject to the PSD permitting program or Title V (i.e., those that are newly-constructed or modified in a way that significantly increases emissions of a pollutant other than greenhouse gases) would be subject to permitting requirements for their greenhouse gas emissions. For these projects, only greenhouse gas emission increases of 75,000 tons per year (tpy) or more, on a carbon dioxide equivalent (CO_2e) basis, would be subject to technology requirements under the PSD program. As of July 1, 2011, more facilities became subject to regulation based on their greenhouse gas emissions. Specifically, new and existing stationary sources (that are not already covered by the PSD or Title V programs) that emit greenhouse gas emissions of at least 100,000 tpy are subject to greenhouse gas regulation even if they do not exceed the permitting thresholds for any other pollutant. For these facilities, the PSD and Title V requirements would be triggered. The PSD program imposes "best available control technology" requirements to control greenhouse gas emissions. Title V generally does not impose technology requirements but rather requires covered facilities to report an overall compliance plan for meeting the requirements of the Clean Air Act.

EPA's staged-approach to regulating greenhouse gases from stationary sources sought to focus on the nation's largest greenhouse gas emitters and hence "tailored" the requirements of these Clean Air Act permitting programs to cover power plants, refineries, and cement production facilities that meet certain conditions while exempting smaller sources like farms, restaurants, schools and other facilities. The question before the agency, and hence, the motivation for this SAB review, is whether and how to consider biogenic greenhouse gas emissions in determining whether facilities meet certain thresholds (as defined above) for Clean Air Act permitting. Biogenic CO_2 emissions from bioenergy are generated during the combustion or decomposition of biologically based material.

It is in this context that the EPA Office of Air and Radiation requested the EPA's Science Advisory Board (SAB) to review and comment on its *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources (Framework, September 2011)*. The *Framework* considers the scientific and technical issues associated with accounting for emissions of biogenic carbon dioxide (CO_2) from stationary sources and develops a framework to adjust the stack emissions from stationary sources using bioenergy based on the induced changes in carbon stocks on land (in soils, plants and forests). Because of the unique role of biogenic feedstocks in the overall carbon cycle, EPA deferred for a period of three years the application of permitting requirements to biogenic CO_2 emissions from bioenergy and other biogenic stationary sources. In its deferral, EPA committed to conduct a detailed examination of the science and technical issues associated with biogenic CO_2 emissions and submit its study for review by the Science Advisory Board. To conduct the review, the SAB Staff Office formed the Biogenic Carbon Emissions Panel with experts in forestry, agriculture, greenhouse gas measurement and inventories, land use economics, ecology, climate change and engineering.

The SAB was asked to review and comment on (1) the agency's characterization of the science and technical issues relevant to accounting for biogenic CO_2 emissions from stationary sources; (2) the agency's framework, overall approach, and methodological choices for accounting for these emissions; and (3) options for improving upon the framework for accounting for biogenic CO_2 emissions (See Appendix A: Charge to the SAB Panel).

The Biogenic Carbon Emissions Panel held a face-to-face meeting in October 25 – 27, 2011, and teleconferenced four times during 2012. During the course of deliberations, the SAB Panel reviewed background materials provided by the Office of Air and Radiation and heard from numerous public commenters. This Advisory provides the SAB's main conclusions. Highlights are provided in the Executive Summary and detailed responses to the individual charge questions are provided in the body of the report.

3. RESPONSES TO EPA's CHARGE QUESTIONS

3.1. The Science of Biogenic CO_2 Emissions

Charge Question 1: In reviewing the scientific literature on biogenic CO_2 emissions, EPA assessed the underlying science of the carbon cycle, characterized fossil and biogenic carbon reservoirs, and discussed the implications for biogenic CO2 accounting.

Does the SAB support EPA's assessment and characterization of the underlying science and the implications for biogenic CO2 accounting?

EPA has done an admirable job of reviewing the science behind the carbon cycle and greenhouse gas emissions and their relationship to climate change, extracting some of the critical points that are needed to create the proposed *Framework*. At the same time, there are several important scientific issues that are not addressed in the EPA document, as well as scientific issues that are briefly discussed but not sufficiently explored in terms of how they relate to the *Framework*. In the following section, the SAB describes a series of deficiencies with the EPA characterization of the science behind biogenic CO_2 accounting and suggests some areas where the science could be strengthened.

Time scale

One fundamental deficiency in the EPA report is the lack of discussion of the different time scales inherent in the carbon cycle and the climate system that are critical for establishing an accounting system. This is a complicated subject because there are many different time scales that are important for the issues associated with biogenic carbon emissions. At the global scale, there are multiple time scales associated with mixing of carbon throughout the different reservoirs on the Earth's surface. When carbon dioxide is released into the air from burning fossil fuels, roughly 45% stays in the air over the course of the following year. Of the 55% that is removed, roughly half is taken up by the ocean, mostly in the form of bicarbonate ion, and the other half is taken up by the terrestrial biosphere, primarily through reforestation and enhanced photosynthesis. The airborne fraction (defined as the fraction of emissions that remains in the air) has been remarkably constant over the last two decades.

There is considerable uncertainty over how the magnitude of ocean and terrestrial uptake will change as the climate warms during this century. If the entire ocean were to instantly reach chemical equilibrium with the atmosphere, the airborne fraction would be reduced to 20 to 40% of cumulative emissions, with a higher fraction remaining in scenarios with higher cumulative emissions. In other words, the ocean chemical system by itself cannot remove all the CO_2 released in the atmosphere. Because carbon uptake by the ocean is limited by the rate of mixing between the shallow and deeper waters, this complete equilibration is expected to take thousands of years. Over this century, if global CO_2 emissions continue to rise, most models predict that ocean uptake will stabilize between 3 to 5 gigatons per year (GtC/y), implying that the fraction of emissions taken up by the ocean will decrease. For the terrestrial biosphere, there is a much wider envelope of uncertainty; some models predict that CO_2 uptake will continue to keep pace with the growth in emissions, while other models suggest that CO_2 uptake will decline, even becoming a net source of CO_2 to the atmosphere if processes such as release of carbon from the tundra or aridification of the tropics were to occur.

Over the time scale of several thousand years, once ocean equilibration is complete and only 20 to 40% of cumulative emissions remains in the atmosphere, dissolution of carbonate rocks on land and on the ocean floor will further reduce the airborne fraction to 10 to 25% over several thousand years to ten thousand years. Excess anthropogenic CO_2 emissions will stay in the atmosphere for more than 100,000 years, slowly drawn down by silicate weathering that converts the CO_2 to calcium carbonate, as well as slow burial of organic carbon on the ocean floor. The size of this "tail" of anthropogenic CO_2 depends on the cumulative emissions of CO_2, with higher cumulative emissions resulting in a higher fraction remaining in the atmosphere.

Another important time scale for considering accounting systems for biogenic carbon emissions is the period over which the climate responds to carbon dioxide and other greenhouse gases. The importance of the timing of emissions depends on whether one uses a global warming limit or a cumulative emissions limit. Some modeling exercises have shown that the probability of limiting warming to 2 °C or below in the twenty-first century is dependent upon cumulative emissions by 2050 (Meinshausen et al. 2009). This suggests that an early phase of elevated emissions from forest biomass could reduce the odds of limiting climate warming if warming is limited to 2 °C. Another climate modeling study has demonstrated that peak warming in response to greenhouse gas emissions is primarily sensitive to cumulative greenhouse gas emissions over a period of roughly 100 years, and, so long as cumulative emissions are held constant, is relatively insensitive to the emissions pathway within that time frame (Allen et al. 2009). What this means is that an intervention in forests or farming that results in either an increase or decrease in storage of carbon or emissions reductions must endure longer than 100 years to have an influence on the peak climate response as long as cumulative emissions from all sources are constant. Conversely, if these changes last less than 100 years, harvesting of biomass for bioenergy resulting in release of carbon dioxide will have a relatively small effect on peak warming. While the harvesting of trees for bioenergy can result in a carbon debt even at the landscape level (Mitchell et al. 2012), this may not reflect potential climate benefits at longer time scales if biomass is regrown repeatedly and substituted for coal over successive harvest cycles (Galik and Abt 2012).

Time scales are also important for individual feedstocks and their regeneration at a more local scale. Given that the EPA's objective is to account for the atmospheric impact of biogenic emissions, it is important to consider the turnover times of different biogenic feedstocks in justifying how they are incorporated into the *Framework*. The fundamental differences in stocks and their turnover times as they relate to impacts on the atmosphere are not well discussed or linked. If a carbon stock is cycling quickly on land and regrowth is sufficient to compensate for carbon losses from harvesting, it may have a beneficial impact when it displaces fossil fuel over successive cycles of growth and harvest (assuming this temporal displacement exceeds 100 years). If the carbon stock, or some part of it, turns over more slowly, if regrowth is not assured or if feedstocks are not being used to continuously displace fossil fuels, the impact on climate worsens.

There is a continuum of carbon stock size and turnover among the biogenic feedstock sources included in the *Framework*, but there is little background discussion of the variation in stock and turnover and how that informs the accounting method. The *Framework* sets up categories of feedstocks based on their source, but these groupings do not translate into differential treatment in the *Framework*. The science section could walk through the carbon stocks covered by the scope of the *Framework* and their relevant turnover times.

Appendix B discusses a set of studies by Cherubini and co-authors (Cherubini et al. 2011; 2012) that provide examples for estimating the temporal distribution of atmospheric impacts from biomass harvesting by framing the analysis in terms of global warming potentials (GWPs) and global temperature potentials (GTPs) for harvested biomass. Figure B-1 in Appendix B, adapted from Cherubini et al. (2012), depicts mean surface temperature changes for a simple contrived comparison of biogenic emissions from a single stand over hundreds of years as compared to comparable fossil emissions. While much is assumed regarding global activity (emissions, landscape responses, investment behavior), Figure B-1 demonstrates the importance of the time horizon and the weight to place on temperature increases that occur in the short term versus temperature increases that occur later. As shown in Figure B-1, a 50-year time horizon (or less) would obscure the longer-term climate consequences of bioenergy. The GTPbio value would continue to decline for time horizons beyond 100 years since there is no net temperature increase after 100 years. The choice of weighting of temperature effects at different time horizons could be influenced by the estimated damages associated with the temperature increases as well as the social rate of time preference for avoiding damages. The discussion by Kirschbaum (2003, 2006) of the impact of temporary carbon storage (the inverse of temporary carbon release from biomass harvesting for bioenergy) points out that the exact climate impact of temporary CO_2 storage (or emissions) depends on the type of impact, as some depend on peak temperature, whereas others, such as melting of polar ice sheets, depend more on time-averaged global temperature. There is no scientifically correct answer when choosing a time horizon, although the *Framework* should be clear about what time horizon it uses, and what that choice means in terms of valuing long term versus shorter term climate impacts.

Disturbance

Because ecosystems respond in complicated ways to disturbances (e.g., harvesting, fire) over long periods of time, and with a high degree of spatial heterogeneity, the state of knowledge about disturbance and impacts on carbon stocks and turnover should be reviewed within the context of relevant time scales and spatial extents. This is highly relevant to producing accurate estimates of biogenic emissions from the land. There is also insufficient treatment given to the existing literature on the impact of different land management strategies on soil carbon, which is important for understanding how carbon stocks may change over many decades.

Non-CO_2 Greenhouse Gases

The *Framework* does not incorporate greenhouse gases other than CO_2. Ideally both fossil fuels and biogenic fuels should be subject to the same emissions accounting to fully capture the difference between the two types of fuels in terms of their greenhouse gas emissions. For biogenic feedstocks, the most important source of non-CO_2 emissions is likely to be N_2O produced by the application of fertilizer (Crutzen, et al. 2007). In particular, if the biomass feedstock is from an energy crop that results in different N_2O emissions vis-a-vis other crops, should this be counted? Is it negligible? This issue is not introduced in the science section. N_2O is relatively long-lived (unlike methane) and therefore the climate impacts of heavily fertilized biomass (whether in forests or farms) are greater than non-fertilized biomass. There is a substantial literature on N_2O from fertilizer use that was not discussed in the *Framework*. If the decision to not count non-CO_2 greenhouse gases stems from a need to render the carbon accounting for biogenic sources parallel with fossil fuels, this needs to be explicitly discussed.

3.2. Biogenic CO_2 Accounting Approaches

Charge Question 2: In this report, EPA considered existing accounting approaches in terms of their ability to reflect the underlying science of the carbon cycle and also evaluated these approaches on whether or not they could be readily and rigorously applied in a stationary source context in which onsite emissions are the primary focus. On the basis of these considerations, EPA concluded that a new accounting framework is needed for stationary sources.

2(a). Does the SAB agree with EPA's concerns about applying the IPCC national approach to biogenic CO_2 emissions at individual stationary sources?

Yes. The IPCC national approach is an inventory of global greenhouse emissions (i.e., all emissions are counted). It is comprehensive in quantifying all emissions sources and sinks, but does not describe linkages among supply chains. In other words, it is essentially a "production-based inventory" or "geographic inventory" rather than a "consumption-based inventory" (Stanton et al. 2011). Moreover, it offers a static snapshot of emissions at any given time, but it does not expressly show changes in emissions over time. As such, the IPCC national approach does not explicitly link biogenic CO_2 emission sources and sinks to stationary sources, nor does it provide a mechanism for measuring changes in emissions as a result of changes in the building and operation of stationary sources using biomass.

2(b). Does the SAB support the conclusion that the categorical approaches (inclusion and exclusion) are inappropriate for this purpose, based on the characteristics of the carbon cycle?

A decision about a categorical inclusion or exclusion will likely involve many considerations that fall outside the SAB's scientific purview, such as legality, feasibility and, possibly, political will. The SAB cannot speak to the legal or full implementation difficulties that could accompany any policy on biogenic carbon emissions but some scientific observations that may inform the Administrator's policy decision are offered below.

The notion that biomass is carbon neutral arises from the fact that the carbon released as CO_2 upon combustion was previously removed from the atmosphere as CO_2 during plant growth. Thus, the physical flow of carbon in the biomass combusted for bioenergy represents a closed loop that passes through a stationary source. Under an accounting framework where life cycle emissions associated with the production and use of biomass are attributed to a stationary source, assuming carbon neutrality of biomass implies that the net sum of carbon emissions from all sources and sinks is zero, including all supply chain and market-mediated effects. Carbon neutrality cannot be assumed for all biomass energy *a priori* (Rabl et al. 2007; E. Johnson 2009; Searchinger et al. 2009). There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate *a priori* assumption; it is a conclusion that should be reached only after considering a particular feedstock production and consumption cycle. There is considerable heterogeneity in feedstock types, sources, production methods and leakage effects; thus net biogenic carbon emissions will vary considerably.

Given that some biomass combustion could have positive net emissions, a categorical *exclusion* would remove any responsibility on the stationary source for CO_2 emissions from its use of biogenic material from the entire system (i.e., the global economy) and provide no incentive for the development and use of best management practices. Conversely, a categorical *inclusion* would provide no incentive for using biogenic sources that compare favorably to fossil energy in terms of greenhouse gas emissions.

The commentary above merely reflects some scientific considerations. The SAB recognizes that, in reality, the EPA may face difficult tradeoffs between ease of implementation and other goals (e.g., maximizing scientific accuracy by modeling the decomposition of logging residues). While an alternative approach of default Biogenic Accounting Factors (BAFs) is offered for the agency's consideration (see Section 4), the SAB cannot advise the Agencyon the legal feasibility of any approach.

2(c). Does the SAB support EPA's conclusion that a new framework is needed for situations in which only onsite emissions are considered for non-biologically-based (i.e., fossil) feedstocks?

Through discussions with the Panel at the public meeting, the EPA agreed that this question is redundant with other charge questions and therefore does not require a separate response.

2(d). Are there additional accounting approaches that could be applied in the context of biogenic CO_2 emissions from stationary sources that should have been evaluated but were not?

Several other agencies are developing methods for assessing greenhouse gas emissions by facilities that could inform the approach developed by the EPA. These include the DOE 1605(b) voluntary greenhouse gas registry targeted to entities, which has many similar characteristics to the approach proposed by EPA for stationary sources. There is also the Climate Action Registry developed in California that uses a regional approach to calculate baselines based on inventory data and may inform the delineation of geographic regions and choice of baselines in the EPA approach. USDA also is developing in parallel an accounting approach for forestry and agricultural landowners. It would be beneficial if the EPA and USDA approaches could be harmonized to avoid conflicts and take advantage of opportunities for synergy.

3.3. Methodological Issues

Charge Question 3: EPA identified and evaluated a series of factors in addition to direct biogenic CO_2 emissions from a stationary source that may influence the changes in carbon stocks that occur offsite, beyond the stationary source (e.g., changes in carbon stocks, emissions due to land-use and land management change, temporal and spatial scales, feedstock categorization) that are related to the carbon cycle and should be considered when developing a framework to adjust total onsite emissions from a stationary source.

3(a). Does SAB support EPA's conclusions on how these factors should be included in accounting for biogenic CO_2 emissions, taking into consideration recent advances and studies relevant to biogenic CO_2 accounting?

The SAB's response to this question differs by feedstock. On balance, the *Framework* includes many important factors but some factors suffer from significant estimation and implementation problems.

For agricultural feedstocks, the factors identified by EPA to adjust the CO_2 emissions from a stationary source for direct off-site changes in carbon stocks are appropriate but suffer from significant estimation and implementation problems. The *Framework* includes factors to represent the carbon embodied in products leaving a stationary source, the proportion of feedstock lost in conveyance, the offset represented by sequestration, the site-level difference in net carbon flux as a result of harvesting, the emissions that would occur "anyway" from removal or diversion of non-growing feedstocks (e.g., corn stover) and other variables. In some cases, energy crops like miscanthus and switchgrass have significant potential to sequester carbon in the soil and be sinks for carbon rather than a source (Anderson-Teixeira et al. 2009). In other cases, the production of bioenergy could result in by-products like biochar which sequester significant amounts of carbon. A large value of the SITE_TNC and/or SEQP variables in the accounting equation could result in a negative BAF for such feedstocks. The *Framework* should clarify how a negative BAF would be used and whether it could be used by a facility to offset fossil fuel emissions. Restricting BAF to be non-negative would reduce incentives to use feedstocks with a large sequestration potential.

For waste materials (municipal solid waste, manure, wastewater, construction debris, etc.), the *Framework* assigns a BAF equal to 0 for biogenic CO_2 released from waste decay at waste management systems, waste combustion at waste incinerators or combustion of captured waste-derived CH_4. The *Framework* further states that for any portion of materials entering a waste incinerator that is harvested for the purpose of energy production at that incinerator, biogenic CO_2 emissions from that material would need to be accounted according to the *Framework* calculations. Municipal solid waste biomass is either disposed of in a landfill or combusted in facilities at which energy is recovered. Smaller amounts of certain waste components (food and yard waste) may be processed by anaerobic digestion and composting. The SAB concurs with the *Framework* that the CO_2 released from the decomposition of biogenic waste in landfills, compost facilities or anaerobic digesters could reasonably be assigned a BAF of 0. In addition, given that methane (CH_4) is a more potent greenhouse gas than CO_2, the *Framework* should account for CH_4 emissions from landfills in cases where the methane is not captured. The SAB recognizes that EPA may address methane in other regulatory contexts.

When accounting for emissions from waste sources including logging residue, wood mill waste and pulping liquor, the EPA should recognize that these emissions are part of a larger system where they can be co-products with commercial products. For logging residue, wood mill waste and pulping liquor the larger system includes forests, solid wood mills, pulp mills and stationary energy sources. Accounting for greenhouse gases in the larger system needs to track all biomass emissions or forest stock changes and needs to assure they are allocated over time across the outputs (product and co-products) from the system so as to account for all fluxes. Within the larger system, the allocation of fluxes to wood/paper products or to emissions from a stationary source can be supported by scientific reasoning but is ultimately a policy decision. The Agency should consider how the *Framework* meets the scientific requirement to account for (allocate) all emissions to products and co-products across the larger system of forest, mills and stationary sources over time.

For roundwood, the calculation of BAF would need to account for the time path of carbon accumulation and emissions from logging residue and apply a landscape perspective. The landscape perspective is important because of simultaneous management decisions that emit and sequester greenhouse gases concurrently and therefore define the net implications over time. The *Framework* recognizes some of the challenges associated with defining the spatial and temporal time scale and in choosing the appropriate baseline. Ultimately, however, the *Framework* chooses an approach that disregards any consideration of the time scales over which biogenic carbon stocks are accumulated or depleted and does not actually estimate carbon stock changes associated with biomass use. Instead the *Framework* attempts to substitute a spatial dimension for time and creates an accounting system that generates outcomes sensitive to the regional scale at which carbon emissions attributed to a stationary source are evaluated.

Below are some comments on particular factors.

<u>Level of Atmospheric Reduction (LAR)</u>: The term refers to the proportional atmospheric carbon reduction from sequestration during feedstock regrowth (GROW) or avoided emissions (AVOIDEMIT) from the use of residues that would have been decomposed and released carbon emissions “anyway.” The scientific justification for constraining the range of LAR to be greater than 0 but less than 1 is not evident since it is possible for feedstock production to exceed feedstock consumption. These two terms are not applicable together for a particular feedstock and representing them as additive terms in the accounting equation can be confusing. Additionally, the value of LAR for forest biomass is sensitive to the size of the region for which growth is compared to harvest.

<u>Loss (L)</u>: This term is included in the *Framework* to explicitly adjust the area needed to provide the total feedstock for the stationary facility. It is a term used to include the emissions generated by the feedstock lost during storage, handling and transit based on the strong assumption that most of the carbon in the feedstock lost during transit is immediately decomposed. It is therefore important to separate the use of this Loss term for estimating the area needed to provide the feedstock and for estimating the carbon emissions released by the operation of the stationary source. To more accurately estimate the actual loss of carbon due to these losses, one would need to model the carbon storage and fluxes associated with the feedstock lost, which are likely to be a function of time. The number of years considered would be a policy decision; the longer the period, the larger the proportion of loss that would be counted. The *Framework* tacitly assumes an infinitely long horizon that results in the release of all the carbon stored in the lost feedstock.

Products (PRODC): The removal of products from potential gross emissions is justified scientifically; however, the scientific justification for treating all products equally in terms of their impact on emissions is not clear. For some products (e.g., ethanol and paper), the stored carbon will be released rapidly while for other products, such as furniture, it might be released over a longer period of time. The *Framework* implicitly assumes that all products have infinite life-spans, an assumption without justification or scientific foundation. For products that release their stored carbon rapidly, the consequences for the atmosphere are the same as for combustion of the feedstock. To precisely estimate the stores of products so as to estimate the amount of carbon released, one would need to track the stores as well as the fluxes associated with product pools. The stores of products could be approximated by modeling the amount stored over a specified period of time.

A second way in which PRODC is used is as a means of prorating all area–based terms such as LAR, SITE-TNC and Leakage. This is potentially problematic because it makes the emissions embodied in co-products dependent on the choice of regional scale at which LAR is estimated. As the size of the region contracts, LAR tends towards zero and the amount of gross emissions embodied in PRODC increases and exacerbates the implications of the scale sensitivity of the LAR value.

Avoided Emissions (AVOIDEMIT): This term refers to transfers of emissions that would occur "anyway" from removal or diversion of non-growing feedstocks like corn stover and logging residues. In the *Framework*, feedstocks may be mathematically credited with avoided emissions if the residues would have decayed "anyway." Specifically, AVOIDEMIT is added to GROW in the numerator in determining the LAR or proportion of emissions that are offset by sequestration or avoided emissions. As with the Loss term, there is an implicit assumption of instantaneous decomposition that appears to be a simplifying assumption. While this may be a convenient assumption, it should be explained and justified. To improve scientific accuracy, the EPA could explore some sample calculations (as described below), taking into account regional differences in decay rates. Once this information is gathered and analyzed, the EPA may then need to make a decision that weighs scientific accuracy against administrative expediency and other factors.

Since the concept reflected in "avoided emissions" is actually "equivalent field-site emissions," it would be clearer to refer to it this way since emissions are not so much avoided as they are shifted to another venue. With residues left in the forest, some of the materials might take decades to fully decompose. For accuracy, the hypothetical store of carbon would have to be tracked. To approximate these stores, one could compute the average amount of carbon remaining after a period of years.

The scientific theory behind losses and stores of ecosystem carbon was developed by Olson (1963) and could be applied to the fate of residues and slash in both forest and agricultural systems. The store of carbon in an ecosystem depends upon the amount of carbon being input (I) and the proportion of carbon lost per time unit, referred to as the rate-constant of loss (k). Specifically the relationship is I/k. In the case of residues or slash that are burned in the field or in a bioenergy facility, the store of carbon is essentially zero because most of the input is lost within a year ($k > 4.6$ per year assuming at least 99% of the material is combusted within a year). On the other hand, if the residue or slash does not lose its carbon within a year, the store of carbon would be greater than zero and, depending on the interval of residue or slash creation, could be greater than the initial input. Appendix C provides more information

on the fate of residue after harvest and landscape storage of carbon. For example, if slash is generated every 25 years (I=100 per harvest area/25=4 per year) and the slash is 95% decomposed within 25 years (k=0.12 per year), one cannot assume a store of zero because the average ecosystem store in this case would actually be 33% of the initial input (4/0.12=33.3). If the input occurred every 5 years (I=100 per harvest/5=20 per year) for the same decay rate-constant, then the average store would be 167% of the initial input (20/0.12=167). Moreover, it cannot be assumed that because the rate-constant of loss (k) is high, that the stores will always be low. That is because the input (I) is a function of the interval of residue or slash generation; the shorter the interval of generation, the higher the effective input because a higher proportion of the forest or agricultural system is contributing inputs. For example, if there is 1 unit of residue/slash generation per harvest, then an annual harvest on a system basis creates 1 unit of material; if there is 1 unit of residue/slash generation per harvest, then a harvest every 10 years creates an average harvest of 0.1 units (1 unit/10 years = 0.1 unit per year). This relationship means that if residue or slash is generated annually and 95% is lost to decomposition in that period, then the forest system could store 33% of the initial input (I/k=1/3). For the values of k usually observed in agricultural setting (50% per year), an annual input would lead to a store in excess of 145% of the initial input (I/k=1/0.69). Burning of this material would cause a decrease in carbon stores analogous to that of reducing mineral soil stores as accounted for in SITE_TNC, but this loss is not accounted for in the proposed *Framework*.

There are several ways in which losses from residue/slash decomposition could be used in the *Framework*. One is to track the annual loss of carbon from decomposition. This would be analogous to tracking the regrowth of feedstock annually, but in this case it would be the annual decomposition loss. The annual decomposition loss would then be credited as equivalent to combustion as fuel. The advantage of this system is that it would track the time course of release. The disadvantage is that it increases transaction costs. An alternative based on a fuelshed (or other larger area) would be to calculate the average fraction of residue or slash that would remain over the harvest interval and subtract that from the amount harvested. The difference between the amount harvested and the amount that would have remained is an index of the equivalent amount of release via decomposition. For example, if 10 metric tons of either residue or slash is created per year in a fuelshed and 65% of the slash would have decomposed on average over a given harvest interval, then decomposition would have been equivalent to a release of 65% of the amount of fuel used (6.5 metric tons). This would mean that 3.5 metric tons that would have been stored was lost by combustion; hence 6.5 metric tons would be credited in the current calculation of LAR. However, if 35% of the slash would have decomposed on average over the harvest interval, then use of 10 metric tons as fuel would reduce carbon stores of residues and slash by 6.5 metric tons. This would result in a so-called “avoided emissions” credit of 3.5 metric tons.

In addition to considering actual decomposition losses, the *Framework* needs to consider the starting point of residue and slash harvest. The carbon released by combustion will be a function of the starting point, with systems that start with residues and slash having a different timeline of release than those that newly create residue and slash. The former will have the release rate linearly related to the harvest interval, whereas the latter will likely have a curvilinear relationship that is a function of the rate-constant of loss (k).

Instead of a simplifying assumption of instantaneous decomposition, a more accurate calculation could be developed that determines a loss rate-constant appropriate to the material and climate to estimate the amount of carbon that could have been stored had the material not been burned. This amount could be approximated by using the relationships developed by Olson (1963) and reducing the number of calculations involved. When approximations are used, they should be checked against more precise methods to determine the magnitude of possible approximation errors. Several mechanisms could be used to simplify the estimation of these numbers, ranging from calculators that require entry of a few parameters (e.g., average amount of residue or slash generated, the area of source material, the interval of harvest) to look-up tables that are organized around the parameters used to generate them. While there is some uncertainty regarding the loss rate-constants, these sorts of parameters are routinely used in scientific assessments of the carbon cycle and their uncertainty is not much greater than any other parameter required by the *Framework*.

The *Framework* should provide guidance on how logging residue will be distinguished from forest feedstock since that will influence the BAF for that biomass and create incentives to classify as much material as possible as residue and slash despite the fact that some of the "residue/slash" material such as cull trees would be "regenerated" via feedstock regrowth.

Total Net Change in Site Emissions (SITE_TNC): This term is the annualized difference in the stock of land-based carbon (above and below ground, including changes in standing biomass and soil carbon) that results on the site where the feedstock is produced.

The estimates of SITE_TNC will be site-specific and will depend on the knowledge about previous history of land use at that site, the specific agricultural or forestry management practices utilized and the length of time over which they have been practiced. To the extent that the use of bioenergy leads to a change in these practices relative to what would have been the case otherwise, it will be important to use an anticipated baseline approach to determine the stock of land based carbon in the absence of bioenergy and to compare that to the stock with the use of bioenergy. As discussed below in response to charge question 4(f), this anticipated baseline could be developed at a regional or national scale and include behavioral responses to market incentives. Alternatively, look-up tables could be developed based on estimates provided by existing large scale models such as CENTURY or FASOM for feedstock based and region specific SITC_TNC estimates.

It should be noted that soil carbon sequestration is not a permanent reduction in CO_2 emissions. The *Framework*, however, treats permanent reductions in emissions, for example, due to a reduction in the LOSS of biomass to be equivalent to reductions due to an increase in soil carbon sequestration which could be temporary. Since soil carbon sequestration is easily reversible with a change in land management practices, the implementation of this *Framework* will need to be accompanied by frequent monitoring to determine any changes in soil carbon stocks and to update the BAF value for a facility.

Sequestration (SEQP): This term refers to the proportion of feedstock carbon embodied in post-combustion residuals such as ash or biochar. Including sequestration in the *Framework* is appropriate; however, the approach taken is subject to the same problems as those described for Products. There is no scientific literature cited to support the idea that all the materials produced by biogenic fuel use do not decompose. This is the subject of ongoing research, but it seems clear that these materials do

decompose. The solutions to creating a more realistic and scientifically justified estimate are the same as for the Products term (see above).

Leakage (LEAK): The *Framework* includes this term for leakage but is silent on the types of leakage that would be included and how leakage would be measured. EPA representatives said the *Framework* did not provide a quantification methodology for leakage because assessing leakage requires policy- and program-specific details that are beyond the scope of the report. However, there are several conceptual and implementation issues that merit further discussion in the *Framework*.

The use of biogenic feedstocks could lead to leakage by diverting feedstocks and land from other uses and affecting the price of conventional forest and agricultural products, which can lead to indirect land use changes that release or increase carbon stored in soils and vegetation. The use of these feedstocks could also affect the price of fossil fuels by lowering demand for them and increasing their consumption elsewhere (also referred to as the rebound effect on fuel consumption); this would offset the greenhouse gas savings from the initial displacement of fossil fuels by bioenergy (Chen and Khanna 2012). Leakage effects will vary by feedstock and location and could be positive (if they lead to carbon emissions elsewhere) or negative (if they lead to carbon uptake activities). As will be discussed in Section 3.4 [in response to question 4(f)], the latter could arise, for example, if increased demand for biomass and higher prices generate incentives for investment in forest management that increases forest carbon sequestration. Some research has shown that when a future demand signal is strong enough, expectations about biomass demand for energy (and thus revenues) can reasonably be expected to produce anticipatory feedstock production changes with associated changes in land management and land-use (e.g., Sedjo and Sohngen, in press, 2012). Thus price changes can lead to changes in consumption and production decisions outside the boundary of the stationary source, even globally.

While the existence of non-zero leakage is very plausible, the appropriateness of attributing emissions that are not directly caused by a stationary facility to that facility has been called into question (Zilberman et al. 2011). While first principles in environmental economics show the efficiency gains from internalizing externalities by attributing direct environmental damages to responsible parties, they do not unambiguously show the social efficiency gains from attributing economic or environmental effects (such as leakage) that occur due to price changes induced by its actions to that facility (Holcombe and Sobel, 2001). Moreover, leakage caused by the use of fossil fuels is not included in assessing fossil emissions generated by a stationary facility. Liska and Perrin (2009) show that military activities to secure oil supplies from the Middle East lead to indirect emissions that could increase the carbon intensity of gasoline. Thus, the technical basis for attributing leakage to stationary sources and inherent inconsistency involved in including some types of leakage and for some fuels makes the inclusion of leakage as a factor in the BAF calculation a subjective decision. Including some types of leakage (for example, due to agricultural commodity markets) and not others (such as those due to the rebound effect in fossil fuel markets) and for biomass and not fossil fuels would be a policy decision without the underlying science to support it.

Empirically, assessing the magnitude of leakage is fraught with uncertainty. Capturing leakage would entail using complex global economic models that incorporate production, consumption and land use decisions to compare scenarios of increased demand for biogenic feedstocks with a baseline scenario without increased demand. Global models that include trade across countries in agricultural and forest

products can aid in determining the leakage effects on land use in other countries. Global models of the forestry sector include Sedjo and Sohngen (2012) and Ince et al. (2011). Existing models would need to be expanded to include the multiple lignocellulosic feedstocks considered in this *Framework* that can compete to meet demand for bioenergy to determine net leakage effects. Methods would then need to be developed to assign leakage factors to individual feedstocks. The existing literature assessing the magnitude of leakage from one use of a biogenic feedstock (corn ethanol) shows that its overall magnitude in the case of leakage due to biofuel production is highly uncertain and differs considerably across studies and within a study depending on underlying assumptions (Khanna et al. 2011; Khanna and Crago 2012). Other feedstock-use combinations would also need to be evaluated. If the magnitude of leakage is plagued with too much uncertainty, if possible, its direction should at least be stated and recognized in making policy choices. Depending on the level of uncertainty, supplementary policies might be possible to reduce leakage due to changes in land use, such as restrictions on the types of land that could be used to produce the biogenic feedstocks and the types of biogenic feedstocks that could be used to qualify for a BAF less than 1. Some of these implementation issues with estimating BAF and leakage will be discussed further in Section 3.4.

3(b). Does SAB support EPA's distinction between policy and technical considerations concerning the treatment of specific factors in an accounting approach?

A clear line cannot be drawn between policy and technical considerations in an accounting approach. In fact, the lack of information on EPA's policy context and the menu of options made it more difficult to fully evaluate the *Framework*. Because the reasonableness of any accounting system depends on the regulatory context to which it is applied, the *Framework* should describe the Clean Air Act motivation for this proposed accounting system, including how the Agency regulates point sources for greenhouse gases and other pollutants. The document should make explicit the full gamut of Clean Air Act policy options for how greenhouses gases could be regulated, including any potential implementation of carbon offsets or certification of sustainable forestry practices. The *Framework* also should describe the EPA's legal boundaries regarding upstream and downstream emissions. Technical considerations can influence the feasibility of implementing a policy just as policy options can influence the technical discussion. The two need to go hand in hand rather than be treated as separable.

The *Framework* explicitly states that it was developed for the policy context where it has been determined that a stationary source emitting biogenic CO_2 requires a means for "adjusting" its total onsite biogenic emissions estimate on the basis of information about growth of the feedstock and/or avoidance of biogenic emissions and more generally the carbon cycle. However, in the discussion on the treatment of specific factors it states in several places that this treatment could depend on the program or policy requirements and objectives. Certain open questions described as "policy" decisions (e.g., the selection of regional boundaries, marginal versus average accounting, inclusion of working or non-working lands, inclusion of leakage) made the evaluation of the *Framework* difficult. Clearly, the policy context matters and the EPA's reticence in describing the policy context and in taking positions on open questions (as well as lack of implementation details) meant that the *Framework* was inadequately defined for proper review and evaluation.

Specifically, if the policy context is changed -- for example, if carbon accounting is needed to support a carbon cap and trade or carbon tax policy -- then the appropriateness of the *Framework* would need to

be evaluated relative to alternative approaches such as life cycle analysis for different fuel streams. Modifying how certain factors are measured or included may not be sufficient. In fact, a different *Framework* would likely be needed if a national or international greenhouse gas reduction commitment exists. Furthermore, the BAFs developed for regulating the emissions from stationary sources would likely conflict with measures of greenhouse gas emissions from bioenergy used in other regulations such as California's cap and trade system for regulating greenhouse gases.

Economic research has shown that the most cost-effective way to reduce greenhouse gas emissions (or any other pollution) is to regulate or tax across all sources until they face equal marginal costs. The most cost-effective solution would involve setting carbon limits (or prices) on an economy-wide basis and not selectively for particular sources or sectors. Given the EPA's limited authority under the Clean Air Act, the most efficient economy-wide solution is not within its menu of policy choices. EPA's regulation of stationary sources will exclude other users of biomass also have equivalent impacts on the carbon cycle as well as downstream emissions from consuming the products produced by these facilities. Note that biogenic emissions accounting would still be an issue even under an economy-wide emissions policy.

3(c). Are there additional factors that EPA should include in its assessment? If so, please specify those factors.

As stated above, for agricultural biomass from energy crops and crop residues, the factors included in the *Framework* capture most of the direct off-site adjustments needed to account for the changes in carbon stocks caused by a facility using agricultural feedstocks although they do not account for leakage. However, an anticipated baseline is needed for soil carbon, residue disposition and land management changes. For forest biomass, the *Framework* needs to incorporate the time path of carbon accumulation in forests (after energy emissions from harvested roundwood) and forest investment and multi-stand decisions. As discussed in Section 3.1, EPA should consider the time path of the "anyway" emissions that would have occurred on the land if logging residue were not used for energy production and weigh the benefits of scientific accuracy against the administrative simplicity of assuming instantaneous decomposition. For municipal solid waste biomass, the *Framework* needs to consider other gases and CH_4 emissions from landfills. Given that methane emissions from landfills are sometimes not captured, crediting waste material for avoided emissions of methane may be inappropriate. As the *Framework* states, the carbon impact of using waste for energy production in combustion facilities should nonetheless be subjected to a biogenic accounting framework. It should be gauged relative to the CH_4 emissions, if any, that would be released during decomposition in a landfill. N_2O emissions, especially from fertilizer use, should also be considered. Furthermore, the inclusion of non-CO_2 greenhouse gases in general should be consistent between biogenic and fossil fuel accounting. For instance, there are also transportation -related emissions losses in the delivery of natural gas.

3(d). Should any factors be modified or eliminated?

For reasons discussed above, factors such as PRODC, AVOIDEMIT and SEQP could be improved by incorporating the time scale over which biomass is decomposed or carbon is released back to the atmosphere. LAR needs to be modified to be scale insensitive and to address additionality. Factors can be separated by feedstocks according to their relevance for accounting for the carbon emissions from

using those feedstocks. For example, GROW and leakage may not be relevant for crop and forest residues.

3.4. Accounting Framework

Charge Question 4: EPA's Accounting Framework is intended to be broadly applicable to situations in which there is a need to represent the changes in carbon stocks that occur offsite, beyond the stationary source, or in other words, to develop a "biogenic accounting factor" (BAF) for biogenic $C0_2$ emissions from stationary sources.

Question 4(a). Does the Framework accurately represent the changes in carbon stocks that occur offsite, beyond the stationary source (i.e., the BAF)?

For agricultural biomass, the variables in EPA's proposed equation for BAF represent the basic factors necessary for estimating the offsite carbon change associated with stationary source biomass emissions, including changes in storage of carbon at the harvest site. For short accumulation feedstocks, where carbon accumulation and "anyway" emissions are within one to a few years (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), with some adjustments to address estimation problems (including an anticipated baseline for soil carbon changes, residue disposition and land management) and careful consideration of data and implementation, the *Framework* can accurately represent carbon changes offsite. However, for long accumulation feedstocks where carbon accumulation and "anyway" emissions occur over decades [i.e., wood harvested specifically for energy use (roundwood) and logging residue], the *Framework* does not accurately account for changes in carbon stocks offsite for several reasons discussed below in response to charge question 4(b).

The *Framework* also does not consider other greenhouse gases (e.g., N_2O from fertilizer use and CH_4 emissions from landfills). Excluding CH_4 because it is not "CO_2" is not a legitimate rationale. It would need to be included to estimate the "difference in CO_2e the atmosphere sees." In addition, excluding CH_4 emissions from landfills is inconsistent with the *Framework's* desire to account for displaced on-site changes in CO_2. For the same reasons, the basis for excluding N_2O emissions from biomass production is unclear. It also needs to be included to estimate the net changes in atmospheric greenhouse gases. Accounting for N_2O from fertilization would be consistent with tracking changes in soil carbon which are a response to agricultural management systems, which includes fertilizer decisions.

Question 4(b). Is the Framework scientifically rigorous?

The SAB did not find the *Framework* to be scientifically rigorous. Specifically, the SAB identified a number of deficiencies that need to be addressed.

Time scale: As discussed previously, one deficiency in the *Framework* is the lack of proper consideration of the different time scales inherent in the carbon cycle and the climate system that are critical for establishing an accounting system. This is a complicated subject because there are many different time scales that are important for the issues associated with biogenic carbon emissions.

Scientific understanding of the time scale over which the climate system responds to cumulative emissions implies that the carbon release caused by harvesting and combusting biomass at stationary sources is a serious problem if carbon storage, on average, is reduced over long periods of time. So long as rates of growth across the landscape are sufficient to compensate for carbon losses from harvesting

over the long run, the climate system is less sensitive to the imbalance in the carbon cycle that might occur in the short run from harvesting of biomass for bioenergy facilities. A scientifically rigorous evaluation of the impact of biomass harvest on the carbon cycle should consider the temporal characteristics of the cycling as well as the spatial simultaneous decisions made across stands and plots. Annual accounting of carbon stocks, while helpful in tracking net carbon emissions, is likely to give an inaccurate assessment of the overall climate and atmospheric carbon cycle impacts.

The *Framework* also does not consider the length of time it takes ecosystems to respond to disturbances, such as those due to the harvesting of biomass, nor does it consider the spatial heterogeneity in this response. This has implications for the accuracy with which the impact of different land management strategies on carbon stocks in soil and vegetation is estimated.

The *Framework* subtracts the emissions associated with products -- including ethanol, paper, and timber -- from the calculation of emissions from a stationary source, through the PRODC term. While the EPA may not have the discretion to treat all emissions equally, distinguishing between immediate emissions from the facility and downstream emissions (as these products will inevitably be consumed within a short period of time) does not make sense scientifically. From the perspective of the carbon cycle and the climate system, all these facilities extract biomass from the land and the vast majority of that biomass is converted to carbon dioxide, adding to cumulative emissions and, hence, a climate response.

Spatial scale: There is no peer reviewed literature cited to support the delineation of spatial scales for biogenic CO_2 accounting and different carbon pools to be accounted for at different spatial scales. For example, the atmospheric impact of feedstocks is gauged on a regional basis in terms of its impact on forest carbon stocks (except for case study 5) while impacts due to land use change are accounted for at the site level.

The *Framework's* use of a regional scale for accounting for the net changes to the atmosphere is an artificial construct developed to (a) avoid the need for site-specific chain of custody carbon accounting with separate streams for each feedstock and (b) as an alternative to capturing changes in carbon stocks over time. The calculation of LAR uses regional landscape wide carbon changes but does not actually estimate changes attributable to biomass demand (see next discussion). This approach attempts to simplify implementation using available forest inventory data and circumvents the need for accounting for changes in carbon stocks specific to the site or feedstock sourcing region (fuelshed) which may be more complex, costly and difficult to verify. However, as noted, it doesn't provide an actual estimate of carbon changes due to stationary source biomass demand, and it makes the estimate of the BAFs sensitive to the choice of the spatial region chosen for accounting purposes. As shown by case study 1, there are significant implications of this choice for the emissions attributed to a facility.

Additionality: A key question is whether the harvesting of biomass for bioenergy facilities is having a negative impact on the carbon cycle relative to emissions that would have occurred in the absence of biomass usage. This requires determining what would have happened anyway without the harvesting and comparing the impact with the increased harvesting of biomass for bioenergy in order to isolate the incremental or additional impact of the bioenergy facility. However, while the *Framework* discusses the "business as usual" or "anticipated future baseline" approach, it implements a reference point approach

that assesses carbon stocks on a regional basis at a given point in time relative to a historic reference carbon stock.

For forest carbon stocks, the choice of a fixed reference point may be the simplest to execute, but it does not actually address the question of the extent to which forest stocks would have been growing/declining over time in the absence of a particular bioenergy facility. The use of a fixed reference point baseline implies that forest biomass emissions could be considered carbon neutral if forest stocks are increasing. This is simply an artifact based on the choice of the baseline that will be used. The problem is thus: a region with decreasing carbon stocks may in actuality have more carbon than what would have happened without the increased harvesting of biomass. Similarly, a region with increasing carbon stocks may have less stores carbon than would be the case without the facility using biomass. By default, this approach creates "sourcing" and "non-sourcing" regions. Thus, a carbon accumulating region is a "source" of in situ carbon that can be given to support biomass use, and a carbon losing region is a "non-source" of carbon and cannot support biomass use. The reference year approach provides no assurances at all that a "source" region is gaining carbon due to biomass use, or that a "non-source" region is losing carbon due to biomass use.

For example, for roundwood use under the *Framework*, a region may have carbon accumulation with respect to the reference year (and be assigned LAR=1 according to the *Framework*); however, harvest of a 150+ year old forest in the region for energy production would not be counted in a facility's greenhouse gas emissions even though there is less carbon storage than there would have been otherwise and only a portion of the forest's carbon would be recovered within the next 100 years. To estimate the "difference in atmospheric greenhouse gases" over some period, one must estimate how carbon accumulation differs between a biomass use case and a case without biomass use (business as usual case).

Assessing uncertainty: The *Framework* acknowledges uncertainty but does not discuss how it will be characterized and incorporated to assess the potential uncertainty in the estimate of the BAF value. Selecting an acceptable risk level is a policy decision but characterizing uncertainty and risks is a scientific question. There are numerous drivers that can change biogenic carbon stocks, even in the absence of biomass harvesting for energy. These include changes in economic conditions, domestic and international policy and trade decisions, commodity prices, and climate change impacts. There is considerable uncertainty about the patterns of future land use, for example, whether land cleared for bioenergy production will stay in production for decades to come. The potential impact of these forces on biogenic carbon stocks and the uncertainty of accounting need to be considered further. Ideally, the EPA should put its BAF estimates into context by characterizing the uncertainties associated with BAF calculations and estimating uncertainty ranges. This information can be used to give an indication of the likelihood that the BAFs will achieve the stated objective. The uncertainty within and among variables for any estimate may vary widely between feedstocks and across regions. Finally, it should be pointed out that while parameter uncertainty is important to consider throughout the *Framework*, alternative policy options (e.g., categorical inclusion and exclusion) do not have parameter uncertainty yet their effect on atmospheric carbon is also uncertain.

Leakage: The *Framework* states that the likelihood of leakage and the inclusion of a leakage term will be based on a qualitative decision. There is essentially no guidance in the document about how leakage

might be quantified and no examination of the literature regarding possible leakage scenarios (consider Murray et al. 2004). A number of statements/assumptions were made regarding the area and intensity of wood harvest increases to accommodate biomass access. There was no examination of the scientific literature on wood markets and therefore no science-based justification for these statements/assumptions.

Other areas: Other areas that require more scientific justification include assumptions regarding biomass losses during transport and their carbon implications, the choice of a 5-year time horizon instead of one that considered carbon cycling, and the decision to include only CO_2 emissions and exclude other greenhouse gas emissions. Additionally, assumptions about the impacts of harvests on soil carbon and land use changes on carbon sequestration need to be more rigorously supported.

Inconsistencies: Below are some inconsistencies within the *Framework* that should be resolved or justified:

(1) Consistency with fossil fuel emissions accounting: Fossil fuel feedstock emissions accounting from stationary sources under the Clean Air Act are not adjusted for offsite GREENHOUSE GAS emissions and carbon stock changes. Does that imply that by default BAFs should be zero as well? No, because, unlike fossil fuels, biogenic feedstocks have carbon sequestration that occurs within a timeframe relevant for offsetting CO_2 emissions from the biomass' combustion. For comparability, however, biomass and fossil fuels emissions accounting should be similar for other emissions categories. These include non-CO_2 GREENHOUSE GAS emissions, losses, leakage, and fossil fuel use during feedstock extraction, production and transport. This issue is also discussed in Section 3.3.1.

(2) Biogenic and fossil fuel emissions accounting for losses: The *Framework's* handling of carbon losses during handling, transport, and storage introduces an inconsistency between how fossil emissions are counted at a stationary source and how biomass emissions are counted. For biomass emissions the *Framework* includes emissions associated with loss of feedstock between the land and the stationary source. For natural gas the emissions attributed to the stationary source do not include fugitive greenhouse gas emissions from gas pipelines. Why would loss emissions be included for biomass when they are not included for natural gas?

(3) Inconsistency in the consideration of land management and the associated greenhouse gas flux accounting: The *Framework* accounts for soil carbon stock changes, which are a function of the land management system, soil, and climatic conditions. However, it does not account for the non-CO_2 greenhouse gas changes like N_2O that are jointly produced with the soil carbon changes. Soil carbon changes influence both the below and above ground carbon stock changes associated with changes in the land management system.

(4) Reference year and BAU baseline use: The *Framework* proposes using a reference year approach: however, it implicitly assumes projected behavior in the proposed approach for accounting for soil carbon changes and municipal waste decomposition.

(5) Definition of soil. There is a good deal of variation in the *Framework* as to the definition of "soil." At one point it appears to be defined as all non-feedstock carbon such as slash, surface litter, and dead roots as well as carbon associated with mineral soil. In other places, the *Framework* seems only to consider the carbon associated with mineral soil. Unfortunately this inconsistency in the use of the term "soil" creates confusion regarding interpretation and implementation. When soil is defined as non-feedstock carbon (that is all forms of dead carbon) and then implemented as mineral soil carbon (one form of dead carbon), it is impossible to ensure a mass balance as dead material above- and below ground is accounted for in one place, but then not elsewhere. Inconsistent definitions of soil carbon mean that statements regarding the impact of management cannot be unequivocally assessed. For example, if the broader definition of soil is being invoked, then the statement that management of forests can reduce soil carbon could be justified (Harmon et al. 1990; Johnson and Curtis 2001). However, if the narrower definition of mineral soil carbon is being invoked, then there is very little empirical evidence to justify this statement (Johnson and Curtis 2001); and in fact there is evidence that forest management can at least temporarily increase mineral soil carbon.

Soil carbon should be defined and used consistently throughout the document. If defined broadly, then consistent use of subcategories would eliminate much confusion. For example, if organic horizons such as litter are part of the soil, then consistently referring to total soil, organic soil horizons, and mineral horizons would be essential. Had that been done, the confusion about the impact of forest management on soil carbon would have been eliminated as management can greatly influence organic horizons, but have little effect on mineral horizons. If defined narrowly to only include mineral soil, then the EPA should develop a terminology for the other carbon pools (e.g., organic horizons, aboveground dead wood, and belowground dead wood) that ensures that mass balance is possible.

To define soil carbon, EPA should consider the merits of an aggregated soil term versus subcategories based on source of the carbon, the controlling processes, and their time dynamics. While the aggregated term "soil" is simple, it potentially combines materials with very different sources, controlling processes, and time dynamics, creating an entity that will have extremely complex behavior. It also creates the temptation of a broad term being used for a subcategory. Separating into woody versus leafy materials would account for different sources and to some degree time dynamics. In contrast, separating into feedstock versus non-feedstock material (as appears to be done in the *Framework*) creates a poorly defined boundary as woody branches would be soil if they are not used, but could be viewed as not being soil if they are. A feedstock-based system also does not separate materials into more uniform time dynamics (if leaves and wood are not harvested, then materials with lifespans that differ an order of magnitude are combined). Controlling processes, be they management or natural in nature, differ substantially for above- versus belowground carbon; hence they should be divided.

Underlying the need for a clear definition of soil in the document is the complexity of soil outcomes that differ based on conditions. Some noteworthy omissions from forest soil science might have informed the *Framework's* treatment of soil carbon in forest ecosystems (Alban and Perala 1992; Mattson and Swank 1989; Binkley and Resh 1999; Black and Harden 1995;

Edwards and Ross-Todd 1983; Gilmore and Boggess 1963; Goodale et al. 2002; Grigal and Berguson 1998; Homann et al. 2001; Huntington 1995; Johnson and Curtis 2001; Laiho et al. 2003; Mroz et al. 1985; Nave et al. 2010; Richter et al. 1999; Sanchez et al. 2007; Schiffman and Johnson 1989; Selig et al. 2008; Tang et al. 2005; Tolbert et al. 2000).

Question 4(c). Does the Framework utilize existing data sources?

First, and most importantly, the *Framework* does not provide implementation specifics. Therefore, it is difficult to assess data availability and use. These issues are discussed here and in the sections that follow.

A more meaningful question is "Are the proposed data sets adequate to account for the effects of biogenic carbon cycling on CO_2 emissions from a facility?" The *Framework* does use existing data, but the data are not adequate to attribute emissions to a facility. For example, the *Framework* mentions the use of the USDA Forest Service's Forest Inventory and Analysis (FIA) data at some unspecified scale. However, carbon stock change data are likely not very accurate at the scale of the agricultural or forest feedstock source area for a facility.

The *Framework* requires data and/or modeling of land management activities and their effects on CO_2 emissions and stock changes. For example for agricultural systems, data are required on the type of tillage and the effect of such tillage on soil carbon stocks for different soil types and climatic conditions. Such data are not likely to be available at the required scales. In one of the case studies, for example, the Century model is used to model soil carbon stocks. Is the use of this particular model proposed as a general approach to implement the *Framework*? Since this model generally addresses soil carbon only to a depth of 20 centimeters, does that represent a boundary for the *Framework*? Recent work has shown that such incomplete sampling can grossly misestimate changes in soil carbon for agricultural practices such as conservation tillage (Baker et al. 2007; Kravchenko and Robertson 2011). Which version of the model? Would EPA run this model and select parameters appropriate for each feedstock production area for each facility? How robust are the predictions of this model for the range of soils, climatic conditions, and management practices expected to be covered by the *Framework*? Could some other model be used that produces different results for a given facility?

The *Framework* implies that data are required from individual feedstock producers. Collecting such data would be costly and burdensome. Additionally, to the extent that feedstocks are part of commodity production and distribution systems that mix material from many sources, it is not likely to be feasible to determine the source of all feedstock materials for a facility.

The *Framework* includes a term for leakage but eschews the need to provide any methodology for its quantification. Example calculations are carried out for leakage in one of the case studies without any explanation for their source. However, leakage can be positive or negative, and while many publications speculate about certain types of leakage, no data are presented, nor are data sources for different types of leakage suggested or discussed. The *Framework* does provide an example calculation of leakage in the footnote to a case study, but this does not a substitute for a legitimate discussion of the literature and justification and discussion of implications of choices. In addition, such data are unlikely to be available at the scales required. The implications and uncertainties caused by using some indicator or proxy to

estimate leakage need to be discussed. If leakage cannot be estimated well, is it possible to put an error range on the leakage value (e.g., a uniform distribution) and assess the impact of this uncertainty on the overall uncertainty in the BAF value? For some cases, such as the conversion of agricultural land to biomass production from perennial crops, leakage may be described as likely increasing net emissions. In cases such as this where prior research has indicated directionality, if not magnitude, such information should be used. As previously noted, there is also a consistency issue with the reference year approach because leakage estimation will require an anticipated baseline approach of some sort.

In summary, it is not clear that all of the data requirements of the *Framework* can be met. Furthermore, even if the data are acquired, they may not be adequate to attribute emissions to a facility.

Question 4(d). Is it easily updated as new data become available?

In principal it would be feasible to update the calculations as new data become available. Some kinds of data, such as those from FIA, are updated periodically, could be used to update the analysis. However, as discussed for other sub-questions, it is not clear exactly what data and resolution are required and whether all the required data are readily available.

The *Framework* uses an annual or five-year interval for updating calculations. For some kinds of data, such as soil and forest carbon stocks, this interval is too short to detect significant changes based on current or feasible data collection methodologies. This implies that statistical or process models would be used to estimate short-term changes for reporting purposes.

Lastly, if BAF is not under the control of the facility, frequent calculation of the BAF would introduce considerable uncertainty for the facility. This would particularly be the case if a leakage factor were included in the BAF and would need to be updated frequently with changes in market conditions. However, if the accounting is infrequent, shifts in the net greenhouse gas impact may not be captured. Clearly, the EPA will have to weigh tradeoffs between the accuracy of greenhouse gas accounting and ease of implementation and other transactions costs.

Question 4(e). Is it simple to implement and understand?

It is neither. While the approach of making deductions from the actual emissions to account for biologically based uptake/accumulation is conceptually sound, it is not intuitive to understand because it involves tracking emissions from the stationary source backwards to the land that provides the feedstock rather than tracking the disposition of carbon from the feedstock and land forwards to combustion and products. The *Framework* also appears to be difficult to implement, and possibly unworkable, especially due to the many kinds of data required to make calculations for individual facilities. Additionally, the factors (variable names) in the *Framework* do not match those used in the scientific literature and may be misunderstood. Lastly, many elements of the *Framework* are implicit rather than explicit. For example, the time frame during which changes in atmospheric greenhouse gases will be assessed is not explicit. The time frame for specific processes is often implicit, such as the emissions of CO_2 from biomass that is lost in transit from the production area to the facility; this loss is assumed to be instantaneous.

Much more detailed information is required about how the *Framework* would be implemented. It would be helpful to know the specific data sources and/or models to be used. To assess the adequacy of data, more information is needed on implementation and the degree of uncertainty acceptable for policymakers to assign BAF values.

Question 4(f). Can the SAB recommend improvements to the framework to address the issue of attribution of changes in land-based carbon stocks?

The *Framework* uses a reference year baseline approach to determining BAF in combination with a regional spatial scale. As mentioned in response to charge question 4(b), this approach is not adequate in cases where feedstocks accumulate over long time periods because it does not allow for the estimation of the incremental effect on greenhouse gas emissions over time of feedstock use. To gauge the incremental effect on forest carbon stocks due to the use of forest-derived woody biomass (specifically, the value of the LAR), an anticipated baseline approach is needed. This involves estimating a "business as usual" trajectory of emissions and forest stocks and comparing it with alternate trajectories that incorporate increased demand for forest biomass over time. The anticipated baseline approach should also be applied to determine soil carbon for all types of feedstocks for soils, residue, waste disposition and land management.

An anticipated baseline approach must incorporate market effects even when direct effects of the use of biogenic feedstocks on carbon emissions are being estimated. The projected baseline level of forest carbon stocks will need to be compared with the level in the case when there is demand for roundwood for bioenergy to assess the change in forest stocks due to the demand for bioenergy. The case with demand for bioenergy should consider the possibility that investment in long-lived trees could be driven by expectations about wood product prices and biomass prices, leading landowners to expand or retain land in forests, plant trees, shift species composition, change management intensity and adjust the timing of harvests. The role of demand and price expectations/anticipation is well developed in the economics literature (e.g., see Muth 1992) and also in the forest modeling literature (Sedjo and Lyon 1990; Adams et al. 1996; Sohngen and Sedjo 1998), which includes anticipatory behavior in response to future forest carbon prices and markets (Sohngen and Sedjo 2006; Rose and Sohngen 2011). The U.S. Energy Information Administration (EIA) has projected rising energy demands for biogenic feedstock based on market and policy assumptions, which could be met from a variety of sources, including energy crops and residues, but also short rotation woody biomass and roundwood (EIA 2012; Sedjo 2010; Sedjo and Sohngen 2012). The extent to which price expectations and anticipation of future demand for bioenergy are going to drive forest management decisions, and regional variations in them, would need to be empirically validated. One study shows forest carbon change in a decade (and thereafter) that exceeds the modeled increased cumulative wood energy emissions over the decade (Sedjo and Tian, in press, 2012). This would be the case if demand is anticipated to increase in the future. Some other modeling studies suggest more limited responses to increased wood energy demand that differ across regions. One such model for the United States indicates a large response in the South, in the form of less forest conversion to non-forest use, but much less response in the North and West (USDA FS 2012; Wear 2011).

To capture both the market, landscape and biological responses to increased biomass demand, a bioeconomic modeling approach is needed with sufficient biological detail to capture inventory

dynamics of regional species and management differences as well as market resolution that captures economic response at both the intensive (e.g., changing harvest patterns, utilization or management intensity) and extensive margins (e.g., land use changes). While several models have these features [USDA Forest Service Resources Planning Act (RPA) models in Wear 2011; Sub-regional Timber Supply in Abt et al. in press 2012; Forest and Agricultural Sector Optimization Model (FASOM) in Adams et al. 2005; and the Global Timber Market Model (GTMM) in Sohngen and Sedjo 1998], they differ in scope, ecological and market resolution, and how future expectations are formed. FASOM and GTMM employ dynamic long term equilibria that adopt the rational expectations philosophy that decisions incorporate expectations about future prices and market opportunities. In the RPA and SRTS models, agents respond to current supply, demand, price signals so that expectations are assumed to be driven by current market conditions. While the rational expectations approach has internal logical consistency and can better simulate long-term structural change, it is not designed for prediction but instead to evaluate potential futures and deviations between futures. These models should incorporate the multiple feedstocks (including crop and logging residues) from the agricultural and forest sectors that would compete to meet the increased demand for bioenergy.

Energy policies can influence the mix of feedstocks used, such as the use of logging residues and the level of projected traditional wood demand, and thus the impact of woody bioenergy demand on timber markets (Daigneault et al. in press 2012). A lower level of timber demand from pulp and paper mills and sawmills, for example, will lead to lower harvest levels and fewer available logging residues. If only residues are allowed to qualify as renewable, then the woody bioenergy industry is explicitly tied to the future of the traditional wood industries. However, if roundwood is used for bioenergy, then the market outcome is more complicated. A lower level of traditional harvest could lead to fewer available residues (which could raise the price of residues and set a physical upper limit on residue supply), but could also lead to higher inventory levels and lower roundwood prices, which would favor increased roundwood utilization for bioenergy. Modeling the interaction across traditional wood consumers, bioenergy consumers, changes in the utilization and mix of products and the displacement of one wood consumer by another as markets evolve will be difficult, but could have a significant impact on the estimate of the carbon consequences of bioenergy use.

As with any modeling, uncertainties will need to be assessed. Models that include price expectations effects or the impact of current year prices would need to be validated. However, validation means different things for different kinds of models. For an econometric model, reproducing history is a form of validation, as is evaluating errors in near-term forecasts. Simulation models are not forecast models. They are designed to entertain scenarios. Validation for simulation models is evaluating parameters and judging the reasonableness of model responses—both theoretically and numerically—given assumptions. Evaluation will help improve representation of average forest and agricultural land management behavior. Evidence affirming or indicating limitations of the effect of prices on investment in retaining or expanding forest area across various U.S. regions may be found by a review of empirical studies of land use change.

Selection of an appropriate model requires judgment and understanding of the structure and assumptions of alternative models and their strengths and weaknesses. This could be supplemented with one or more approaches to choosing a model. These include validation of existing models at the relevant temporal and spatial scale by a means appropriate to the model type, as well as using more than one model to

compare and triangulate outcomes. Note that models of different types (e.g., projections vs. forecasting models) require different types of evaluation.

The anticipated baseline approach could be based on a national/global scale model or a regional scale after weighing the strengths and weaknesses of the two approaches. An example of a regional scale model is that by Galik and Abt (2012) where they tested the effects of various scales on greenhouse gas outcomes and found that in the southern United States, market impacts (negative leakage) had a significant impact on forest carbon impacts, but the results were dependent on time period evaluated and were particularly sensitive to scale. The authors evaluated carbon consequences of bioenergy impacts from stand level to state level and found that as scale increased, market responses mitigated forest carbon impacts. In addition to being sensitive to scale, another disadvantage of the regional scale models is that they would not account for leakage across different regions. However, regional models can incorporate greater heterogeneity in forest growth rates, their carbon impacts and in the price responsiveness of forest management decisions. The SAB has not conducted a detailed review of these models to suggest which model and which scale would be the most appropriate.

While market effects are important, there is value in making separate estimates of biological land carbon changes alone (without market effects). Specifically, biophysical process response modeling results are a critical input to economic modeling. Ecosystem modeling is not a substitute for economic modeling, which is necessary to estimate behavioral changes driven by biomass feedstock demand that produces the estimates emissions and sequestration changes. Ecosystem modeling would establish carbon storage in the absence of positive or negative leakage and may have lower uncertainty – especially for logging residue – than the estimate with leakage. Appendix D depicts three biological scenarios for the total carbon storage in a forest system, including live, dead, and soil stores of carbon. Graphically, Figure D-2 in Appendix D shows how the storage of carbon in a forest system could respond to a shorter harvest interval. Note that all graphs in Appendix D show the biological response and do not account for management changes that could be induced through markets or policies.

Modeling physical land carbon responses over time (without market effects) would show how carbon storage varies by such factors as length of harvest rotations, initial stand age and density, thinning fraction, and growth rates. These carbon responses to management decisions are important inputs for economic modeling of management changes and their carbon consequences. Such modeling could also include the effect of avoided fire emissions on forest land due to biomass removal. This information could indicate what forest conditions and practices could provide higher rates of accumulation, information that might be helpful for EPA in designing its policy response so that incentives could be provided to favor harvest in areas with a higher likelihood of carbon accumulation.

Question 4(g). Are there additional limitations of the accounting framework itself that should be considered?

A number of important limitations of the *Framework* are discussed below:

Framework ambiguity: Key *Framework* features were left unresolved, such as the selection of regional boundaries (the methods for determining as well as implications), marginal versus average accounting, inclusion of working or non-working lands in the region when measuring changes in forest carbon

stocks, inclusion/exclusion of leakage, and specific data sources for implementation. As a result, the *Framework's* implementation remains ambiguous. The ambiguity and uncertainty in the text regarding what are stable elements versus actual proposals also clouded the evaluation. If the EPA is entertaining alternatives and would like the SAB to comment on alternatives, then the alternatives should be clearly articulated and the proposed *Framework* and case studies should be presented with alternative formulations to illustrate the implementation and implications of alternatives.

Feedstock groups: The proposal designates three feedstock groupings. However, it is not clear what these mean for BAF calculations, if anything. The *Framework* does not incorporate the groupings into the details of the methodology or the case studies. As a result, it is currently impossible to evaluate their implications.

Potential for Unintended consequences: The proposed *Framework* is likely to create perverse incentives for investors and land-owners and result in unintended consequences. For investors, the regional baseline reference year approach will create regions that are one of two types — either able to support bioenergy from forest roundwood (up to the gain in carbon stock relative to the reference year), or not. As a result, a stationary source investor will only entertain keeping, improving, and building facilities using biomass from regions designated as able to support bioenergy. However, as noted previously, regions losing carbon relative to the reference year could actually gain carbon stock in relative terms due to improved biomass use and management to meet market demands. In addition, the definitions of regions would need to change over time. The designation of regions (and their corresponding LARs) that comes from the reference year approach will create economic rents and therefore financial stakes in the determination of regions and management of forests in those regions.

The proposed *Framework* could also create perverse incentives for landowners. For instance, landowners may be inclined to clear forest land a year or more in advance of growing and using energy crops. Similarly, landowners may be more inclined to use nitrogen fertilizers on feedstocks or other lands in conjunction with biomass production. Such fertilization practices have non-CO_2 greenhouse gas consequences (specifically N_2O emissions) that are not presently captured by the *Framework*. It should be noted that agricultural intensification of production via fertilization is a possible response to increased demand for biomass for energy. If onsite N_2O emissions are not accounted for, the carbon footprint of agricultural feedstocks could be significantly underestimated.

Assessment of Monitoring and Estimation Approaches: The *Framework* lacks a scientific assessment of different monitoring/estimation approaches and their uncertainty. This is a critical omission as it is essential to have a good understanding of the technical basis and uncertainty underlying the use of existing data, models and look-up tables. A review of monitoring and verification for carbon emissions from different countries, both from fossil and biogenic sources, was recently released by the National Research Council that may provide some guidance (National Research Council 2010).

3.5. Case Studies

Charge Question 5: EPA presents a series of case studies in the Appendix of the report to demonstrate how the accounting framework addresses a diverse set of circumstances in which stationary sources emit biogenic CO_2 emissions. Three charge questions are proposed by EPA.

Overall Comments

In general, case studies are extremely valuable for informing the reader with examples of how the *Framework* would apply for specific cases. While they illustrate the manner in which a BAF is calculated, the data inputs are illustrative only and may or may not be the appropriate values for an actual biomass-to-energy project. Moreover, the case studies are simplistic relative to the manner in which biomass is converted to energy in the real world. For all case studies in the *Framework*, additional definition of the context is needed, along with examples of how the data are collected or measured, and a discussion of the impacts of data uncertainty. Overall, the case studies did not fully cover the relevant variation in feedstocks, facilities, regions, etc. of potential BAFs that is required to evaluate the methodology. For clarity, it might be useful to start with a specific forestry or agricultural feedstock example as the base case, then add the impacts of the more detailed cases, e.g., additional losses, products, land use changes. This may be more useful than a series of completely separate examples, each illustrating different pieces of the *Framework*.

Question 5(a). Does the SAB consider these case studies to be appropriate and realistic?

The case studies did not incorporate "real-world" scenarios which would have served as models for other situations that may involve biogenic carbon emissions. More would have been learned about the proposed *Framework* by testing it in multiple, unique case studies with more realistic data development and inclusion. Additional case studies for landfills and waste combustion, switchgrass, waste, and other regions would be useful, as well as illustrations of the implementation of feedstock groups, and *Framework* alternatives.

For example, Case Study 4 considers a scenario where corn stover is used for generating electricity. While it is possible that this scenario could be implemented, this particular case study is not realistic because very few electrical generation facilities would combust corn stover or agricultural crop residues only. A more likely scenario might be supplementing a co-firing facility with a low percentage of corn stover. Additionally, the assumption of uniform corn stover yields across the region is not realistic. Variation should be expected in the yield of corn stover across the region.

In another example, Case Study 5 calculates the net biogenic emissions from converting agricultural land in row crops to poplar for electricity production. This case study is also not representative of "real world" agricultural conditions as switching from one energy crop to another is uncommon. The formula provided for estimating the standing stock of carbon in the aboveground biomass in the poplar system is not intuitive. The methods for determining biomass yield and measuring changes in soil carbon (which will depend on current use of the land) are not described.

Question 5(b). Does the EPA provide sufficient information to support how EPA has applied the accounting framework in each case?

There remained considerable uncertainty in many of the inputs. In addition, some sensitivity/uncertainty analysis would be useful. The results of this analysis may guide the EPA in further model development. For example, if the BAF is determined to be zero, or not statistically different from zero in most case studies, then this could pave the way for a simpler framework. As discussed in Section 4 below, a simpler approach could be designed to develop default BAFs for categories of feedstocks based on how their management and use interacts with the carbon cycle.

Question 5(c). Are there alternative approaches or case studies that EPA should consider to illustrate more effectively how the framework is applied to stationary sources?

Additional case studies should be designed based on actual or proposed biomass to energy projects to capture realistic situations of biomass development, production, and utilization. For example, Case Study 1 describes the construction of one new plant. What would happen if 10 new plants were to be proposed for a region? And how would the introduction of multiple facilities at the same time impact the accounting for each facility?

All terms/values used to determine the BAF need to be referenced to actual conditions throughout the growth/production/generation processes that would occur in each case study including how these values would actually be implemented by one or more involved parties. Regional look-up tables could be valuable and EPA could learn a great deal by trying to develop look -up tables.

Additional case studies could be developed for perennial herbaceous energy crops, annual energy/biomass sorghums, rotations with food and energy crops, cropping systems on different land and soil types, municipal solid waste and internal reuse of process materials. Each of these feedstocks should be assessed across alternative regions so that the variation in carbon changes across regions could be gauged.

For example it would be very useful to consider the application of the *Framework* to a cellulosic ethanol plant fueled with coal or gas, and consider the emissions of CO_2 from fermentation (not combustion) and the production of ethanol which is rapidly combusted to CO_2 in a non-stationary engine. While such an operation is associated with three major sources of CO_2 emissions (listed here), only one is included in the *Framework*; only two may be considered under EPA's regulatory authority, yet all three are emissions to the atmosphere. It would be useful for EPA to at least describe the emissions that are excluded from consideration so that biogenic carbon emissions from stationary sources can be viewed in context.

At least two case studies are needed on municipal solid waste. One case study should be on waste combustion with electrical energy recovery. EPA should also perform a case study on landfill disposal of municipal solid waste. Here it is important to recognize that landfills are repositories of biogenic organic carbon in the form of lignocellulosic substrates (e.g., paper made from mechanical pulp, yard waste, food waste). There is literature to document carbon storage and the EPA has recognized carbon storage in previous greenhouse gas assessments of municipal solid waste management.

In Case Study 3 the data used in Table 3 to describe the 'paper co-product' will vary with the grade of paper. The 'carbon content of product' may vary between 30 to 50% depending on the grade and the amount of fillers and additives. Also, some significant carbon streams in a mill can go to landfills and waste water treatment. The submitted comments from NCASI include a useful example of the detail/clarity that could be used to enhance the value of the Case Studies.

After completion of the case studies, there should be a formal evaluation of (1) the ease with which data were developed and the model implemented, (2) whether the results are robust and useful in recognition of the uncertainty in the various input parameters, and (3) whether the model results lead to unintended consequences.

Case studies could be developed to assess and develop a list of feedstocks or applications that could be excluded from accounting requirements as "anyway" emissions. A sensitivity analysis using case studies could be used to develop reasonable offset adjustment factors if they are needed to adjust anyway feedstocks for impact on long term stocks like soil if needed.

3.6. Overall Evaluation

Charge Question 6: Overall, this report is the outcome of EPA's analysis of the science and technical issues associated with accounting for biogenic CO_2 emissions from stationary sources.

Question 6(a). Does the report-in total-contribute usefully to advancement of understanding of accounting for biogenic CO_2 emissions from stationary sources?

Yes, the *Framework* contributes to advancing the understanding of accounting for biogenic emissions and addresses many issues that arise in such an accounting system. It is thoughtful and far reaching in the questions it tackles. Its main contribution is to force important questions and offer some ways to deal with these. It covers many of the complicated issues associated with the accounting of biogenic CO_2 emissions from stationary sources and acknowledges that its choices will have implications for the estimates of CO_2 emissions obtained. These include those raised by SAB and discussed above, related to the choice of baseline, region selection and the averaging of emissions/stocks over space and time. However, the solutions offered in many cases, particularly those related to the use of harvested wood for bioenergy, lack transparency or a scientific justification.

Question 6(b). Does it provide a mechanism for stationary sources to adjust their total onsite emissions on the basis of the carbon cycle?

Clearly the *Framework* offers a mechanism to adjust total on-site emissions. For short accumulation feedstocks (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), the *Framework* could, with some modifications and careful consideration of data and implementation, accurately represent the direct carbon changes offsite. Leakage, however, both positive and negative, remains a troublesome matter if left unresolved. Moreover, the *Framework* offers no scientifically sound way to define a region. The definition of the regional scale can make a large difference to the estimate of emissions from a facility using wood as a biomass. Moreover, if there is no connection between actions

of the point source and what happens in the region, there is no foundation for using regional changes in carbon stocks to assign a BAF to the source.

The *Framework* also does not make a clear scientific case for use of waste or what is called "anyway" emissions. Scientifically speaking, all biogenic emissions are "anyway" emissions. Even most woody biomass harvested from old growth forests, would, if left undisturbed, eventually die and decompose, returning carbon to the atmosphere. The appropriate distinction is not whether the product is waste or will eventually end up in the atmosphere anyway, but whether the stationary source is leading to an increase or a decrease in biogenic carbon stocks and associated change in GWP. To do this, the *Framework* must consider an anticipated baseline and the time period for "anyway" emissions and that this may vary across different types of waste feedstocks.

An important limitation of the proposed *Framework* is that the accounting system replaces space for time and applies responsibility for things that happen on the land to a point source, for which the agent who owns that point source has no direct control. The proposed approach, which attempts to estimate facility-feedstock specific BAFs, would estimate an individual point source's BAF based on average data in a region in which it is located. Any biogenic carbon accounting system that attempts to create responsibility or give credit at a point source for carbon changes upstream or downstream from the point source must relate those responsibilities and credits to actions under control of the point source. However, the *Framework* does not clearly specify a cause and effect relationship between a facility and the biogenic CO_2 emissions attributed to it. In particular, if the BAF is assigned to a plant when it is approved for construction, as the BAF is currently designed, those emissions related to land use change will have nothing to do with the actual effect of the point source on land use emissions because the data on which it is based would predate the operation of the plant.

The dynamics of carbon accumulation in vegetation and soils and carbon and methane release through decomposition present a challenge for any accounting system because anticipated future changes in vegetation should, in principle, be factored into BAF. These future changes depend on natural processes such as fires and pest outbreaks that are not easily foreseen, and because of climate change and broader environmental change, we face a system that is hard to predict. Projecting forward based on current or historical patterns is subject to biases of unknown direction and magnitude. More importantly, land use decisions are under the control of landowners, who will be responding to unknown future events. The *Framework* recognizes this issue and chooses to use a Reference Point Baseline, the serious limitations of which have been discussed previously.

Overall, the EPA's regulatory boundaries, and hence the *Framework*, are in conflict with a more comprehensive carbon accounting that considers the entire carbon cycle and the possibility of gains from trade between sources, among sources or between sources and sinks to offset fossil fuel combustion emissions. Scientifically, a comprehensive greenhouse gas accounting would extend downstream – to emissions from by-products, co-products or products such as ethanol combustion or ethanol by-products such as distillers dried grains that are sold as livestock feed that ultimately becomes CO_2 (or CH_4). However, doing so would need to consider consistency with fossil fuel emissions accounting and emissions currently regulated (such as by EPA with vehicle greenhouse emissions standards). As for gains from trade, by restricting its attention to the regulation of point source emissions, EPA's analysis does not allow for the possibility that a fossil CO_2 emitter could contract with land owners to offset their

emissions through forest protection and regrowth or carbon accumulation in soils. Bioenergy would still need to confront the issue of crediting offset carbon accumulation however. By staying within boundaries drawn narrowly around the stationary source, the *Framework* eclipses a more comprehensive approach to greenhouse gas reductions that would address all sources and sinks and take advantage of gains from trade.

Question 6(c). Does the SAB have any advice regarding potential revisions that might enhance the final document?

Overall, the *Framework* would be enhanced by including a description of its regulatory context and specifying the boundaries for regulating upstream and downstream emissions while implementing the regulation. The motivation for the *Framework* should be explained as it relates to Clean Air Act requirements and any recent court rulings. The *Framework* should also make explicit the constraints within which greenhouse gases can be regulated under the Clean Air Act. In doing this, the EPA could be clear that these issues have not been settled but that some assumptions were necessary to make a decision about the *Framework*. The EPA could also stipulate that further development of a regulatory structure might require changes to the accounting system. While the SAB understands the EPA's interest in describing an accounting system as a first step and potentially independent of the regulatory structure, the reader needs this background in order to understand the boundaries and context for the accounting structure and to evaluate the scientific integrity of the approach.

Similarly, the *Framework* is mostly silent on how possible regulatory measures under the Clean Air Act may relate to other policies that affect land use changes or the combustion/oxidation of products from the point sources that will release carbon or other greenhouse gases. For example if a regulatory or incentive system exists to provide credits for carbon offsets through land use management then under some conditions it would be appropriate to assign a BAF of 1 to biogenic emissions given that the carbon consequences were addressed through other policies.

The *Framework* does not make explicit how it does or does not address emissions downstream from a point source such as in the case of a biofuels or paper production facility where the product (biofuels, paper) may lead to CO_2 emissions when the biofuels are combusted or the paper disposed of and possibly incinerated. For example, if paper products are incinerated the incinerator may well be a point source that comes under Clean Air Act regulation. However, biofuels used in vehicles would not be subject to regulation as a point source. Though biofuel combustion emissions are already regulated, along with combustion of gasoline, via EPA's vehicle greenhouse gas emissions standards, the EPA needs to make clear the implicit assumptions on how biogenic carbon will be treated upstream and downstream from the point source if this *Framework* is used to regulate CO_2 emissions under the constraints imposed by the Clean Air Act for regulating stationary sources.

The *Framework* is lacking in implementation details. Implementation is crucial and some of the EPA's current proposals will be difficult to implement. Data availability and quality, as well as procedural details (e.g., application process, calculation frequency) are important considerations for assessing the feasibility of implementation and scientific accuracy of results. Implementation details (e.g., data, technical processes, administrative procedures, timing) need to be laid out, discussed and justified.

Among other things, the discussion should note alternatives, uncertainty and implications via case studies.

Recommendations for Revising BAF

In response to the charge to the SAB, recommendations are offered here for revising the *Framework*. In the next section, the SAB suggests an alternative – default BAFs. If EPA decides to revise the *Framework*, the following recommendations for specific improvements to the document (and methodology) are summarized here. Many of the issues raised in previous responses regarding the treatment of specific factors included in the *Framework* are specific to particular feedstocks. The clarity of the *Framework* would be improved by differentiating among feedstocks based on how their management and use interacts with the carbon cycle. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues and long rotation trees, as grown in different regions, on different prior land-use types and with different management practices. A BAF equation could be developed for each of these categories of feedstocks.

If EPA decides to revise the *Framework*, the following recommendations for specific improvements are summarized below.

- Develop a separate BAF equation for each feedstock category as broadly categorized by type, region, prior land use and current management practices. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues, perennial crops, municipal solid waste, long rotation trees and waste materials including wood mill residue and pulping liquor.
    - For long-accumulation feedstocks like woody biomass, use an anticipated baseline and landscape approach to compare emissions from increased biomass harvesting against a baseline without increased biomass demand. For long rotation woody biomass, sophisticated modeling is needed to capture the complex interaction between electricity generating facilities and forest markets, in particular, market driven shifts in planting, management and harvests, induced displacement of existing uses of biomass, land use changes, including interactions between agriculture and forests and the relative contribution of different feedstock source categories (logging residuals, pulpwood or roundwood harvest).
    - For residues, consider incorporating information about decay after an appropriate analysis in which storage of ecosystem carbon is calculated based on decay functions.
    - For materials diverted from the waste stream, consider their alternate fate, whether they might decompose over a long period of time, whether they would be deposited in anaerobic landfills, whether they are diverted from recycling and reuse, etc. Implementation complexity, cost and scientific accuracy should be considered. For feedstocks that are found to have relatively minor impacts, the EPA may need to weigh ease of implementation against scientific accuracy. After calculating decay rates and considering alternate fates, EPA may wish to declare certain categories of feedstocks with relatively low impacts as having a very low BAF or setting it to 0.
- Incorporate various time scales and consider the tradeoffs in choosing between different time scales.

- For all feedstocks, consider information about carbon leakage to determine its directionality as well as leakage into other media.

4. DEFAULT BAFs BASED ON FEEDSTOCK CATEGORIES

There are no easy answers to accounting for the greenhouse gas implications of bioenergy. Given the uncertainties, technical difficulties and implementation challenges associated with implementing the facility-specific BAF approach embodied in the *Framework*, the SAB encourages the EPA to "think outside the box" and look at alternatives to the *Framework* and its implementation as proposed. One promising alternative is default BAFs for each feedstock category. Given the conceptual and scientific deficiencies of the *Framework*, and the prospective difficulties with implementation, the SAB recommends consideration of default BAFs by feedstock type, region, land management and prior land use. Under EPA's *Framework*, facilities would use individual BAFs designed to capture the incremental carbon cycle and net emissions effects of their use of a biogenic feedstock. With default BAFs, facilities would use a weighted combination of default BAFs relevant to their feedstock consumption and location.

The defaults BAFs would rely on readily available data and reflect landscape and aggregate demand effects, including previous land use. The defaults would also have administrative advantages in that they would be easier to implement and update. Default BAFs for each category of feedstocks would differentiate among feedstocks using general information on their role in the carbon cycle. An anticipated baseline would allow for consideration of prior land use, management, alternate fate (what would happen to the feedstock if not combusted for energy) and regional differences. Default BAFs might vary by region, prior land use and current land management practices due to differences these might cause in the interaction between feedstock production and the carbon cycle. They would be applied by stationary facilities to determine their quantity of biogenic emissions that would be subject to the Agency's Tailoring Rule. Case studies should be used to evaluate default BAFs applicability to heterogeneous facilities. Facilities could also be given the option of demonstrating a lower BAF for the feedstock they are using. This would be facilitated by making the BAF calculation transparent and based on data readily available to facilities. Default BAFs should be carefully designed to provide incentives to facilities to choose feedstocks with the lower greenhouse gas impacts.

The SAB also explored certification systems as a possible way to obviate the need to quantify a specific net change in greenhouse gases associated with a particular stationary facility. Carbon accounting registries have been developed to account for and certify CO_2 emissions reductions and sequestration from changes in forest management. Ultimately, however, the SAB concluded that it could not recommend certification without further evaluation. Moreover, such systems could encounter many of the same data, scientific and implementation problems that bedevil the *Framework*.

REFERENCES

Abt, K.L., Abt, R.C. and Galik, C.G. (2012, In Press). Effect of bioenergy demands and supply response on markets, carbon and land use. *Forest Science*.

Adams, D., Alig, R., Callaway, J., Winnett, S. and McCarl, B. (1996). The Forest and Agricultural Sector Optimization Model (FASOM): Model Structure, Policy and Applications. Portland, OR: USDA Forest Service, Pacific Northwest Experiment Station.

Adams, D.; Alig, R.; McCarl, B. and Murray, B. (2005, February). Bruce McCarl Website. Retrieved April 2012, from Texas A & M Agricultural Economics: http://agecon2.tamu.edu/people/faculty/mccarl-bruce/papers/1212FASOMGHG_doc.pdf.

Alban, D.H. and Perala, D.A. (1992). Carbon Storage in Lake States Aspen Ecosystems. *Canadian Journal of Forest Research*, 1107-1110.

Allen, M. R., Frame, D. J., Huntingford, C., Jones, C. D., Lowe, J. and Meinshausen, M. (2009). Warming Caused by Cumulative Carbon Emissions toward the Trillionth Tonne. *Nature*, 1163 - 1166.

Anderson-Teixeira, K.; Davis, S.; Masters, M.; Delucia, E. (2009). Changes in soil organic carbon under biofuel crops. *Global Change Biology Bioenergy*, 75-96.

Baker, J., Ochsner, T., Venterea, R. and Griffis, T. (2007). Tillage and soil carbon sequestration—What do we really know? *Agriculture, Ecosystems and Environment*, 118.

Binkley, D. and Resh, S.C. (1999). Rapid changes in soils following Eucalyptus afforestation in Hawaii. *Soil Science Society of America Journal*, 222-225.

Black, T. and Harden, J.W. (1995). Effect of timber harvest on soil carbon storage at Blodgett Exp Forest, California. *Canadian Journal of Forest Research*, 1385 - 1396.

Chen, X., and Khanna, M. (2012). The Market Mediated Effects of Biofuel Policies. Agbioforum. 15 (1), 11.

Cherubini, F., Peters, G., Berntsen, T., Stromman, A. and Hertwich, E. (2011). CO2 Emissions from Biomass Combustion for Bioenergy: Atmospheric Decay and Contribution to Global Warming. *Global Change Biology Bioenergy*, 413 - 426.

Cherubini, F., Guest, G. and Stromman, A. (2012). Application of Probability Distributions to the Modeling of Biogenic CO2 Fluxes in Life cycle Assessment. *Global Change Biology Bioenergy*, 1 - 15.

Crutzen, P., Mosier, A., Smith, K. and Winiwarter, W. (2007). N2O Release from Agro-biofuel Production Negates Global Warming Reduction by Replacing Fossil Fuels. *Atmos. Chem. Phys. Discussion*, 11191 - 11205.

Daigneault, A.; Sohngen, B. and Sedjo, R. (In press, 2012). An Economic Approach to Assess the Forest Carbon Implications of Biomass Energy. *Environmental Science & Technology*, Forthcoming.

Edwards, N.T. and Ross-Todd, B.M. (1983). Soil carbon dynamics in a mixed deciduous forest following clear cutting with and without residue. *Soil Science Society of America Journal*, 1014-1021.

Energy Information Administration (EIA). (2012). Annual Energy Outlook 2012 Early Release Overview. Washington, D.C.: U.S. Department of Energy.

Galik, C.S. and Abt, R.C. (2012). The effect of assessment scale and metric selection on the greenhouse gas benefits of woody biomass. *Biomass and Bioenergy*, In Press.

Gilmore, A.R.; Boggess, W.R. (1963). Effects of past agricultural practices on the survival and growth of planted trees. *Soil Science Society of America Proceedings*, 98-101.

Goodale, C.L.; Apps, M.J.; Birdsey, R.A.; Field, C.B.; Heath, L.S.; Houghton, R.A.; Jenkins, J.C.; Kohlmaier, G.H.; Kurz, W.; Liu, S.R.; Nabuurs, G.J.; Nilsson, S. and Shvidenko, A.Z. (2002). Forest carbon sinks in the Northern Hemisphere. *Ecological Applications*, 891 - 899.

Grigal, D.F.and Berguson, W.E. (1998). Soil carbon changes associated with short-rotation systems. *Biological Biogengineering*, 371-377.

Harmon, M., Ferrell, W., and Franklin, J. (1990). Effects on carbon storage of conversion of old-growth to young forests. *Science*, 699 - 702.

Holcombe, R., and Sobel, R. (2001). Public Policy Toward Pecuniary Externalities. *Public Finance Review*, 29.

Homann, P.S.; Bormann, B.T. and Boyle, J.R. (2001). Detecting treatment differences in soil carbon and nitrogen resulting from forest manipulations. *Soil Science Society of America Journal*, 463-469.

Huntington, T. (1995). Carbon sequestration in an aggrading forest ecosystem in the southeastern USA. *Soil Science Society of America Journal*, 1459-1467.

Ince, P., Kramp, A., Skog, K., Spelter, H. and Wear, D. (2011). U.S. Forest Products Module: A Technical Document Supporting the Forest Service 2010 RPA Assessment. Madison, WI: U.S. Forest Service, Forest Products Laboratory.

Johnson, D.W. and Curtis, P.S. (2001). Effects of forest management on soil C and N Storage: meta analysis. *Forest Ecology and Management*, 227-238.

Johnson, E. (2009). Goodbye to carbon neutral: Getting biomass footprints right. *Environmental Impact Assessment Review*, 29.

Khanna, M.; Crago, C. and Black, M. (2011). Can biofuels be a solution to climate change? The implications of land use change-related emissions for policy. *Interface Focus*, 233-247.

Khanna, Madhu; and Crago, C.L. (2012). Measuring Indirect land Use Change with Biofuels: Implications for Policy. *Annual Review of Resource Economics.* DOI: 10.1146/annurev-resource-110811-114523.

Kirschbaum, M.U.F. (2003). Can Trees Buy Time? An Assessment of the Role of Vegetation Sinks as Part of the Global Carbon Cycle. *Climatic Change*, 58: 47-71.

Kirschbaum, M.U.F. (2006). Temporary Carbon Sequestration Cannot Prevent Climate Change. *Mitigation and Adaptation Strategies for Global Change*. 11: 1151-1164.

Kravchenko, A. and Robertson, G. (2011). Whole Profile Soil Carbon Stocks: The Danger of Assuming Too Much from Analyses of Too Little. *Soil Science Society of America Journal*, 75.

Laiho, R.; Sanchez, F.; Tiarks, A.; Dougherty, P.M. and Trettin, C.C. (2003). Impacts of intensive forestry on early rotation trends in site carbon pools in the southeastern U.S. *Forest Ecology and Management*, 177-189.

Liska, A. and Perrin, R. (2009). Indirect land use emissions in the life cycle of biofuels: regulations vs science. *Biofuels, Bioproducts and Biorefining*, 318-328.

Mattson, K.G. and Swank, W.T. (1989). Soil and detrital carbon dynamics following forest cutting in the Southern Appalachians. *Biology and Fertility of Soils*, 247-253.

Meinshausen, M.; Meinshausen, N.; Hare, W.; Raper, S.C.B.; Frieler, K.; Knutti, R.; Frame, D.J.and Allen, M.R (2009). Greeenhouse-gas emission targets for limiting global warming to 2°C. Nature 458:1158-1162.

Mitchell, S.R., Harmon, M.E. and O'Connell, K.E.B. (2012) Carbon debt and carbon sequestration parity in forest bioenergy production. *Global Climate Change Bioenergy* (2012), doi: 10.1111/j.1757-1707.2012.01173.x

Mroz, G.D.; Jurgensen, M.F.and Frederick, D.J. (1985). Soil nutrient changes following whole tree harvesting on 3 Northern Hardwood Sites. *Soil Science Society of America Journal*, 1552-1557.

Murray, B.C.; McCarl, B.A.; Lee, H. (2004). Estimating Leakage from Forest Carbon Sequestration Programs. *Land Economics*, 109-124.

Muth, J. (1992). Rational Expectations and the Theory of Price Movements. In International Library of Critical Writings in Economics, Volume 1 (pp. 3-23). Aldershot, UK: Elgar.

National Research Council. (2010). Verifying Greenhouse Gas Emissions: Methods to Support International Climate Agreements. Washington, D.C.: The National Academies Press.

Nave, L.E.; Vance, E.D.; Swanston, C.W. and Curtis, P.S. (2010). Harvest impacts on soil carbon storage in temperate forests. *Forest Ecology and Management*, 857-866.

Olson, J. S. (1963). Energy Storage and the Balance of Producers and Decomposers in Ecological Systems. *Ecology*, 322 - 331.

Rabl, A., Benoist, A., Dron, D., Peuportier, B., Spadaro, J. and Zoughaib, A. (2007). How to Account for CO2 Emissions from Biomass in a Life Cycle Analysis. *International Journal of Life Cycle Analysis*.

Richter, D.D.; Markewitz, D.; Trumbore, S.W. and Wells, C.G. (1999). Rapid accumulation and turnover of soil carbon in a re-establishing forest. *Nature*, 56-58.

Rose, S. and B. Sohngen. 2011. Global Forest Carbon Sequestration and Climate Policy Design. J*ournal of Environment and Development Economics*. Vol. 16, no. 4. : 429-454.

Sanchez, F.G.; Coleman, M.; Garten Jr., C.T.; Luxmoore, R.J.; Stanturf, J.W.; Trettin, C. and Wullschleger, S.D. (2007). Soil carbon, after 3 years, under short-rotation woody crops grown under varying nutrient and water availability. *Biomass and Bioenergy*, 793-801.

Schiffman, P.M.and Johnson, W.C. (1989). Phytomass and detrital carbon storage during forest regrowth in the southeatsern U.S. Piedmont. *Canadian Journal of Forest Research*, 69-78.

Searchinger, T., Hamburg, S., Melillo, J., and Chameides, W. (2009). Fixing a Critical Climate Accounting Error. *Science*, 326.

Sedjo, R. (2010). The Biomass Crop Assistance Program: Some Implications for the Forest Industry. Washington, D.C. Resources for the Future.

Sedjo, R., and Lyon, K. (1990). The Long Term Adequacy of World Timber Supply. Washington, D.C. Resources for the Future.

Sedjo, R., and Sohngen, B. (In Press, 2012). Wood as a Major Feedstock for Biofuel Production in the U.S.: Impacts on Forests and International Trade. *Journal of Sustainable Forests*.

Sedjo, R. and Tian, X. (2012). What is the Carbon Footprint of Wood Biomass Energy. *Journal of Forestry*, Forthcoming.

Selig, M.F.; Seiler, J.R.and Tyree, M.C. (2008). Soil carbon and CO2 efflux as influenced by the thinning of loblolly pine. *Forest Science*, 58-66.

Sohngen, B., and Sedjo, R. (1998). A Comparison of Timber Market Models: Static Simulation and Optimal Control Approaches. *Forest Science*, 24-36.

Sohngen, B. and Sedjo, R. (2006). Carbon Sequestration in Global Forests Under Different Carbon Price Regimes. The Energy Journal: Special issue, Multi-Greenhouse Gas Mitigation and Climate Policy, 109-162.

Stanton, E., Bueno, R., Ackerman, F., Erickson, P.; Hammerschlag, R. and and Cegan, J. (2011). Consumption-Based Greenhouse Gas Emissions Inventory for Oregon - 2005. Technical Report. Somerville, MA: Stockholm Environment Institute-U.S. Center.

Tang, J.; Qi, Y.; Xu, M.; Misson, L.; Goldstein, A.H. (2005). Forest thinning and soil respiration in a ponderosa pine plantation in the sierra Nevada. *Tree Physiology*, 57-66.

Tolbert, V.R.; Thornton, F.C.; Joslin, J.D.; Bock, B.R.; Bandaranayake, W.; Hoiuston, A.; Tyler, D.; Pettry, D.W. and Green, T.H. (2000). Increasing belowground carbon sequestration with conversion of agricultural lands to production of bioenergy crops. *New Zealand Journal of Forest Science*, 138-149.

USDA Forest Service. (2012). The Future of America's Forests and Rangelands - The 2010 Resources Planning Act (RPA) Assessment. Washington, D.C.: USDA, In Press.

Verified Carbon Standard Association. (n.d.). Verified Carbon Standard: A Global Benchmark for Carbon. Retrieved from http://www.v-c-s.org/methodologies/find

Vokoun, M., Wear, D., and Abt, R. (2009). Testing for Change in Structural Elements of Forest Inventories. *Forest Science*, 455 - 466.

Wear, D. (2011). Forecasts of county-level land uses under three future scenarios: a technical document supporting the Forest Service 2010 RPA Assessment. Ashville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.

Zilberman, D.; Hocman, G. and Rajagopal, D. (2011). On the Inclusion of Indirect Land Use in Biofuel Regulations. *University of Illinois Law Review*, 413-434.

APPENDIX A: Charge to the Panel

MEMORANDUM

To: Holly Stallworth, DFO
Science Advisory Board Staff Office

From: Paul Gunning, Acting Director
Climate Change Division

Subject: Accounting Framework for Biogenic Carbon Dioxide (CO_2) Emissions from Stationary Sources and Charge Questions for SAB peer review

The purpose of this memorandum is to transmit the draft *Accounting Framework for Biogenic CO_2 Emissions* study and the charge questions for consideration by the Science Advisory Board (SAB) during your upcoming peer review in fall 2011.

In January 2011, the U.S. Environmental Protection Agency (EPA) announced a series of steps it would take to address biogenic CO_2 emissions from stationary sources. In addition to specific regulatory action, EPA committed to conduct a detailed examination of the science and technical issues related to accounting for biogenic CO_2 emissions and to develop an accounting framework for those emissions. The study transmitted today is that examination.

The study identifies key scientific and technical factors that should be considered when constructing any framework for accounting for the impact of utilizing biologically-based feedstocks at stationary sources. It then provides EPA's recommendations on those issues and presents a framework for "adjusting" estimates of onsite biogenic CO_2 emissions (i.e., a "biogenic accounting factor" or BAF) on the basis of information about the carbon cycle.

As indicated in the accompanying materials, advice on these issues will be important as EPA moves through the steps to address biogenic CO_2 emissions from stationary sources. We look forward to the SAB's review.

Please contact me if you have any questions about the attached study and charge.

Charge Questions

EPA is providing this study, *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources* (September 15, 2011), to the Science Advisory Board (SAB) to review EPA's approach on accounting for biogenic CO_2 emissions from stationary sources, including the scientific basis and methodological components necessary to complete that accounting.

Objective

EPA is charging the SAB to review and comment on (1) EPA's characterization of the science and technical issues relevant to accounting for biogenic CO_2 emissions from stationary sources; (2) EPA's framework, overall approach, and methodological choices for accounting for these emissions; and (3) options for improving upon the framework for accounting for biogenic CO_2 emissions.

This charge does not ask the SAB for regulatory recommendations or legal interpretation of the Clean Air Act statutes related to stationary sources.

Charge Questions

1. *Evaluation of the science of biogenic CO_2 emissions*

In reviewing the scientific literature on biogenic CO_2 emissions, EPA assessed the underlying science of the carbon cycle, characterized fossil and biogenic carbon reservoirs, and discussed the implications for biogenic CO_2 accounting. Does the SAB support EPA's assessment and characterization of the underlying science and the implications for biogenic CO_2 accounting?

2. *Evaluation of biogenic CO_2 accounting approaches*

In this report, EPA considered existing accounting approaches in terms of their ability to reflect the underlying science of the carbon cycle and also evaluated these approaches on whether or not they could be readily and rigorously applied in a stationary source context in which onsite emissions are the primary focus. On the basis of these considerations, EPA concluded that a new accounting framework is needed for stationary sources.

2(a). Does the SAB agree with EPA's concerns about applying the IPCC national approach to biogenic CO2 emissions at individual stationary sources?

2(b). Does the SAB support the conclusion that the categorical approaches (inclusion and exclusion) are inappropriate for this purpose, based on the characteristics of the carbon cycle?

2(c). Does the SAB support EPA's conclusion that a new framework is needed for situations in which only onsite emissions are considered for non-biologically-based (i.e., fossil) feedstocks?

2(d). Are there additional accounting approaches that could be applied in the context of biogenic CO2 emissions from stationary sources that should have been evaluated but were not?

3. *Evaluation of methodological issues*

EPA identified and evaluated a series of factors in addition to direct biogenic CO_2 emissions from a stationary source that may influence the changes in carbon stocks that occur offsite, beyond the stationary source (e.g., changes in carbon stocks, emissions due to land-use and land management change, temporal and spatial scales, feedstock categorization) that are related to the carbon cycle and should be considered when developing a framework to adjust total onsite emissions from a stationary source.

3(a). Does SAB support EPA's conclusions on how these factors should be included in accounting for biogenic CO2 emissions, taking into consideration recent advances and studies relevant to biogenic CO2 accounting?

3(b). Does SAB support EPA's distinction between policy and technical considerations concerning the treatment of specific factors in an accounting approach?

3(c). Are there additional factors that EPA should include in its assessment? If so, please specify those factors.

3(d). Should any factors be modified or eliminated?

4. *Evaluation of accounting framework*

EPA's accounting framework is intended to be broadly applicable to situations in which there is a need to represent the changes in carbon stocks that occur offsite, beyond the stationary source, or in other words, to develop a "biogenic accounting factor" (BAF) for biogenic CO_2 emissions from stationary sources.

4(a). Does the framework accurately represent the changes in carbon stocks that occur offsite, beyond the stationary source (i.e., the BAF)?

4(b). Is it scientifically rigorous?

4(c). Does it utilize existing data sources?

4(d). Is it easily updated as new data become available?

4(e). Is it simple to implement and understand?

4(f). Can the SAB recommend improvements to the framework to address the issue of attribution of changes in land-based carbon stocks?

4(g). Are there additional limitations of the accounting framework itself that should be considered?

5. *Evaluation of and recommendations on case studies*

EPA presents a series of case studies in the Appendix to demonstrate how the accounting framework addresses a diverse set of circumstances in which stationary sources emit biogenic CO_2 emissions.

5(a). Does the SAB consider these case studies to be appropriate and realistic?

5(b). Does the EPA provide sufficient information to support how EPA has applied the accounting framework in each case?

5(c). Are there alternative approaches or case studies that EPA should consider to illustrate more effectively how the framework is applied to stationary sources?

6. *Overall evaluation*

Overall, this report is the outcome of EPA's analysis of the science and technical issues associated with accounting for biogenic CO_2 emissions from stationary sources.

6(a). Does the report – in total – contribute usefully to the advancement of understanding on accounting for biogenic CO2 emissions from stationary source?

6(b). Does it provide a mechanism for stationary sources to adjust their total onsite emissions on the basis of the carbon cycle?

6(c). Does the SAB have advice regarding potential revisions to this draft study that might enhance the utility of the final document?

APPENDIX B: Temporal Changes in Stand Level Biogenic Emissions Versus Fossil Emissions

Cherubini et al. (2011) analyzes temperature increases on the basis of GWP (global warming potential) whereas Cherubini et al. (2012) analyzes climate impacts using GTP (global temperature potential). GWP is the time integral of the change in radiative forcing from a pulse emission of CO_2 (in this case, from harvested biomass) and subsequent sequestration by biomass growth, whereas GTP is the integral of actual temperature response to a pulse emission of CO_2 and subsequent sequestration by biomass growth. Both studies use a simple contrived comparison of biogenic emissions from a single stand over hundreds of years to comparable fossil emissions. Much is assumed regarding for instance global activity and emissions, and climate and carbon cycle dynamics. Also, importantly, landscape responses and investment behavior are not reflected which represent concurrent and related emissions and sequestration that affect net global emissions changes.

Both studies incorporate a suite of carbon uptake mechanisms (such as oceanic uptake) in addition to regrowth in forest stands. In this context, the GTPbio, discussed by Cherubini (2012), is a more accurate metric for the actual climate response. The idea of the GTPbio is simple: it represents the increase in global average temperature over a given period due to a transient increase in carbon dioxide in the atmosphere (between the initial biomass combustion or respiration and the ultimate regrowth of the carbon stock) relative to the temperature response to a release of an equivalent amount of fossil CO_2 at time 0 (expressed as a fraction between 0 and 1). To calculate a GTPbio value, a time scale must be specified. The calculation for GTPbio is the ratio of the <u>average</u> temperature increase with biogenic emissions followed by reabsorbtion by biomass regrowth over, say, 100 years divided by the <u>average</u> temperature increase from the initial emission alone <u>over</u> 100 years. For short accumulation feedstocks, such as perennial grasses, GTPbio would be a very small fraction due to fast carbon accumulation times (ignoring leakage effects). For feedstocks with long accumulation times, one must compute the change in global temperature over time, accounting for the decline in temperature change as carbon is reabsorbed.

Cherubini et al. (2011, 2012) provide an artificial simplified example for a single forest stand. The same type of metric could be used to compare temperature changes or changes in radiative forcing associated with increased biomass energy use for one year or more for a landscape or nation – taking into account the land carbon change over time associated with increased biomass energy use. This would involve comparison of a business as usual case to an increased biomass use case. A simpler metric that compares the cumulative radiative forcing of biogenic feedstocks to the cumulative radiative forcing of fossil fuels over time could also be used, e.g.. Cherubini's GWPbio. However the broader literature should be considered regarding the climate implications of alternative emissions pathways (see charge question 1 response) while considering uncertainty in global emissions, climate response and the carbon cycle.

Figure B-1 demonstrates the importance of the time horizon or, more specifically, the weight to place on temperature increases that occur in the short term versus temperature increases that occur later. Consider a scenario in which biomass is harvested, but the carbon stock is replaced within a 100 year time scale. The GTPbio for a 100-year regrowth and a 100 year time horizon is roughly 0.5, meaning that the time-integrated global average temperature increase within that 100 year period is 50% of the temperature

increase caused by an equivalent amount of fossil carbon (or straight CO_2 release without regrowth of biomass). However, using the average temperature increase for the biogenic case over 100 years masks the fact that although there will be an initial increase in temperature near the beginning of the 100 year period the reabsorption of carbon in the forest will bring the effect on ground temperature to nearly zero by year 100, giving an average temperature that was 50% of the average fossil temperature increase over 100 years. In fact the instantaneous temperature change for the biogenic case falls below zero slightly before 100 years because oceans initial absorb extra CO_2 in response to the initial biogenic emission (see Figure B-1, adapted from Cherubini 2012, Figure 5a). The temperature effect equilibrates to zero as the ocean CO_2 is balanced. A more precise picture of intertemporal effects is shown in Figure B-1, adapted from Cherubini et al. (2012).

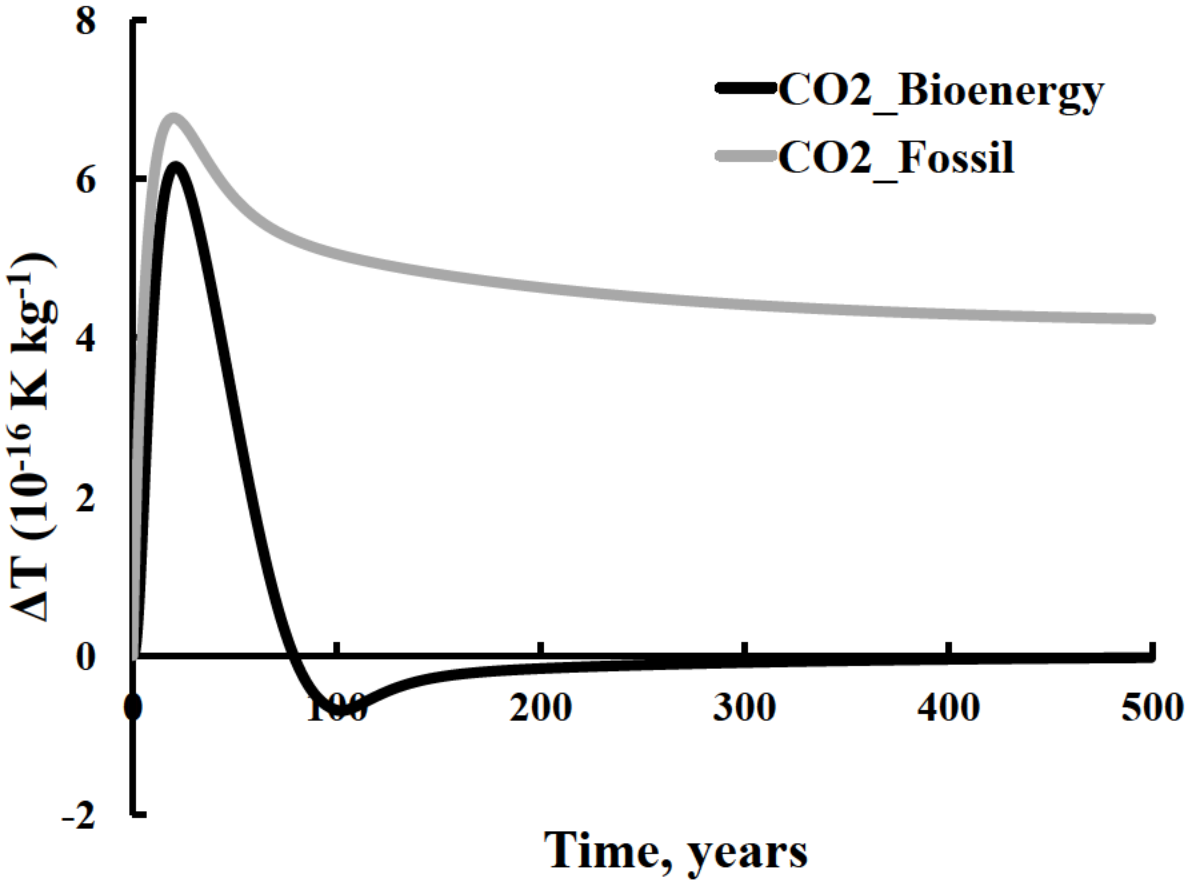


Figure B-1: Surface temperature change from biogenic emissions versus fossil fuel over time. Adapted from Cherubini et al. (2012) and reprinted with copyright permission.

Cherubini et al. (2012) have shown that if biomass is harvested and the carbon is reabsorbed within a 100 year time scale, the global average temperature increase over that 100 year period is 50% of the temperature increase caused by an equivalent amount of fossil carbon. We might conclude that biogenic emissions are roughly 50% as damaging as fossil fuels, however the high point of temperature increase created by biogenic emissions occurs early in the 100 year cycle and is back to zero by the time the carbon is reabsorbed. For the case where carbon is recovered within 100 years Cherubini et al. (2012) have shown that at 20 years, the average temperature increase (over 20 years) from biogenic fuel is 97%

of the temperature increase caused by an equivalent amount of fossil carbon; for years 21 to 100 years, the average increased is 0.37 and for years 101 to 500, the increase is 0.02.

A current practice for international reporting under IPCC guidelines and international treaty negotiations is to use greenhouse gas emissions and sink values that represent the cumulative radiative forcing for greenhouse gases over a 100 year period with uniform weighting over 100 years. Greenhouse gas values are reported in tons CO_2 equivalent where one ton of CO_2 equivalent is an index for the cumulative radiative forcing for a pulse emission of one ton of CO_2 over 100 years. The CO_2 equivalent for a ton of other greenhouse gases is given by how many times more radiative forcing it produces over 100 years compared to CO_2 (e.g., 21 times for CH_4) (EPA 2012).

APPENDIX C: Fate of Landscape Residue after Harvest and System Storage of Carbon

The decomposition of materials left after harvest can be estimated from the negative exponential decay equation (Olson 1963): $C_t=C_0 \exp[-kt]$ where C_t=is the amount at any time t, C_0 is the initial amount, k is the rate-constant of loss, and t is time. Solving this function for a range of rate-loss constants results in the relationship shown in Figure C-1 for a range of k that covers the most likely range for decomposition rates of leafy to woody material in North America. In no case does the store instantaneously drop to zero as assumed in the *Framework*.

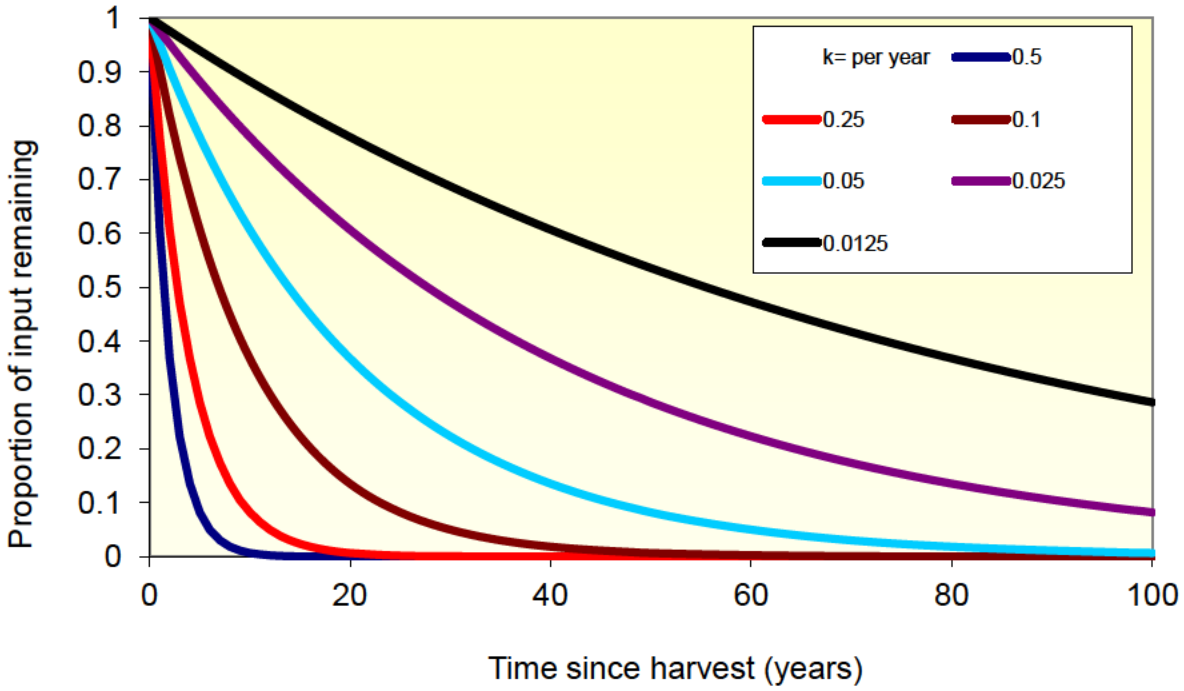


Figure C-1: Fate of residue/slash left after harvest as function of k and time since harvest.

The amount of carbon stored on average in a forest system or fuel-shed comprised of units or stands that generate equal amounts of residue or slash is given by: I/k, where I is the average forest input of residue or slash. To create a relative function independent of the amount of residue or slash created, the input of each harvest unit or stand can be set to either 1 (to give the proportion of the input) or 100 (to give a percent of the input). The average forest input (I) would therefore be equal to $1/R_H$ or $100/R_H$ where R_H is the harvest return interval. Using this relationship to solve the average store relative to the input is presented in Figure C-2 for the most likely range of decomposition rates for leafy to woody material in North America. This indicates that there are a wide range of possible cases in which the store of residue or slash can exceed the initial input (shown by the horizontal line indicating storage of 1). This means that combusting this material will cause the store to drop by the amount indicated, and this amounts to the net flux of carbon to the atmosphere. To a large degree there is a negative relationship between the harvest interval and k; materials with high values of k (i.e., leafy) are typically harvested with short intervals between harvests and material with low values of k (i.e., large wood) are typically harvested with long interval between harvests. This suggests that the effect of harvesting residues and slash is largely independent of the loss rate-constant.

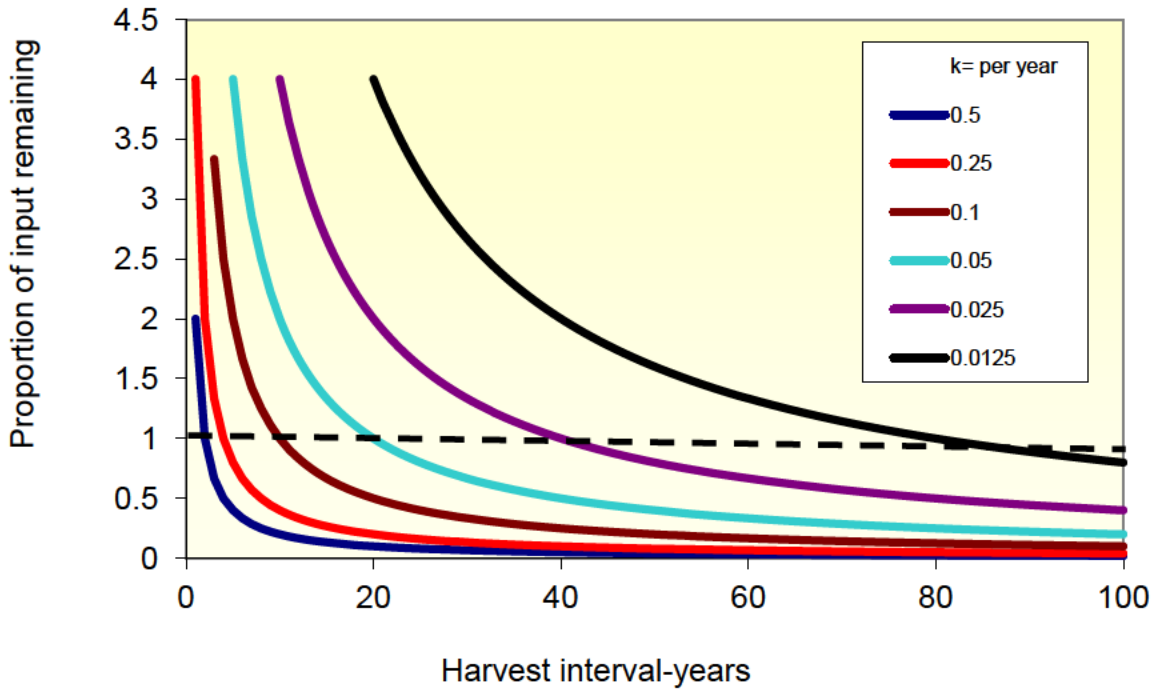


Figure C-2: Landscape average store of residue/slash as function of k and harvest interval.

APPENDIX D: Carbon Balances over Time in an Existing Forest System

To determine whether a forest harvest system for existing forest acreage creates a carbon debt, or alternatively, a gain it is appropriate to examine this problem at the landscape-level (or in the context of biogenic carbon a fuel-shed basis). Note the discussion that follows refers only to existing managed forests (and their stored carbon) and not broader landscape effects such as the expansion or contraction of forest area. At the forest system level there are three possible cases: (1) a relatively constant, steady-state store of carbon if the harvest system is continued unchanged, (2) an increase of carbon stores to a higher steady state if the intensity of harvest declines, and (3) a decrease of carbon stores to a higher steady-state if the intensity of harvest increases. These cases are illustrated in Figures 4-6 which are based on the online Forest Sector Carbon Calculator used in the forest system landscape mode (http://landcarb.forestry.oregonstate.edu/default.aspx) .

In Figure D-1, a 50-year clear-cut harvest rotation was practiced until 2010 and then continued for 500 years. This resulted in no carbon debt. If tracked at the stand scale one would see carbon levels rising and falling, but over time the net balance is zero. In contrast, if one converted the 50-year clear-cut harvest rotation system to a 25-year clear-cut harvest rotation system as in Figure D-2 there would have been a decline in carbon stores in the ecosystem. This decline would be considered a carbon debt and while not permanent (i.e., forever), it would remain as long as the 25-year management system persists. If the 50-year clear-cut harvest rotation was replaced by a 100-year clear-cut system at year 2010, then there would have been a gain carbon stores (Figure D-3). That gain would remain as long as that 100-year clear-cut system of management was maintained. All these simulations all assumed that soil productivity is maintained regardless of harvest interval.

At the existing forest level (as opposed to the stand level), live, dead, and soil stores all acted the same. Each of these pools either remained in balance (i.e., no net gain) or could increase or decrease depending on how the interval of harvest changes. The steady-state store of all three pools is controlled by the I/k relationship developed by Olson (1963), where I is the input of carbon to the pools and k is the proportion lost from the system in respiration and harvest (the live also has a loss related to mortality of trees). As the harvest interval decreases the input to the pool (I) decreases and the proportion lost via harvest (k) increases. This explains why the ecosystem stores decrease when the harvest interval is shortened and why they increase when the harvest interval is increased. A similar response happens when one takes a larger share of the carbon stores away when there is a harvest.

These dynamics have several important implications that need to be considered in the context of biogenic carbon: (1) long-term carbon debts, gains, and balances are best examined at the forest system-level (not to mention the broader agriculture-forest landscape level), (2) all forest carbon pools can exhibit either debts, gains, or remain relatively constant, (3) most systems of forest management will reach a steady-state if maintained over a long enough period and this steady-state can be maintained as long as the management system is continued, and (4) ultimately reaching a steady-state does not determine if there has been a loss or gain in carbon as this depends on how harvest management changes from one steady-state to the next.

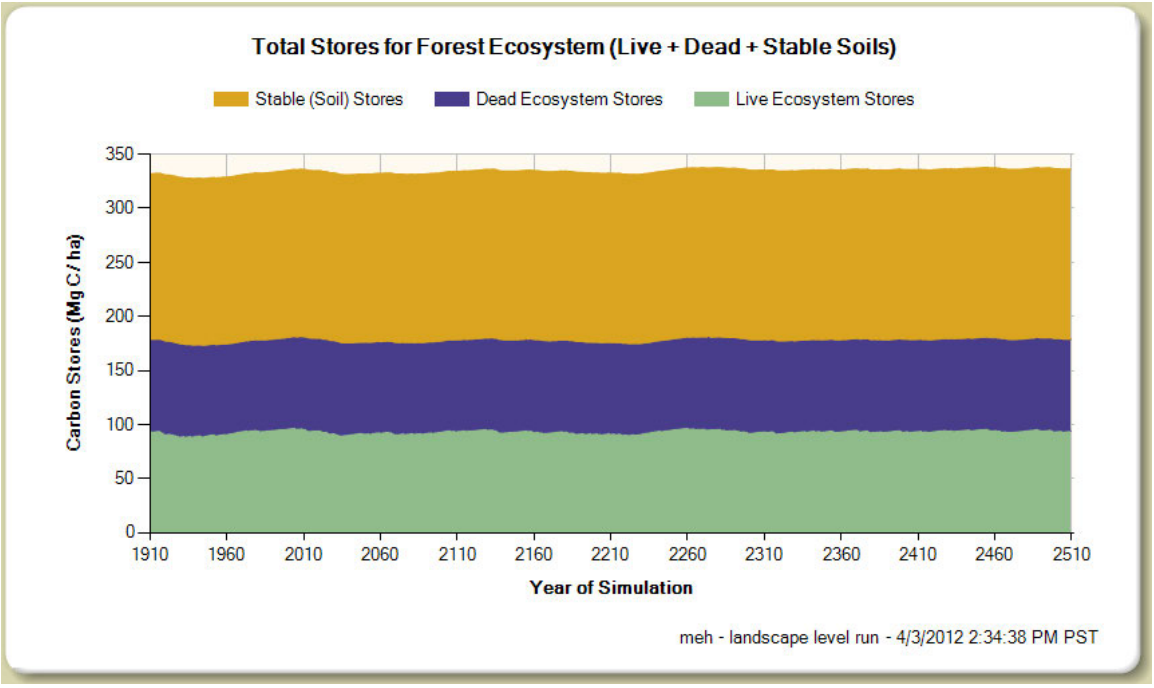


Figure D-1: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is established and continued. The result is a continued carbon balance.

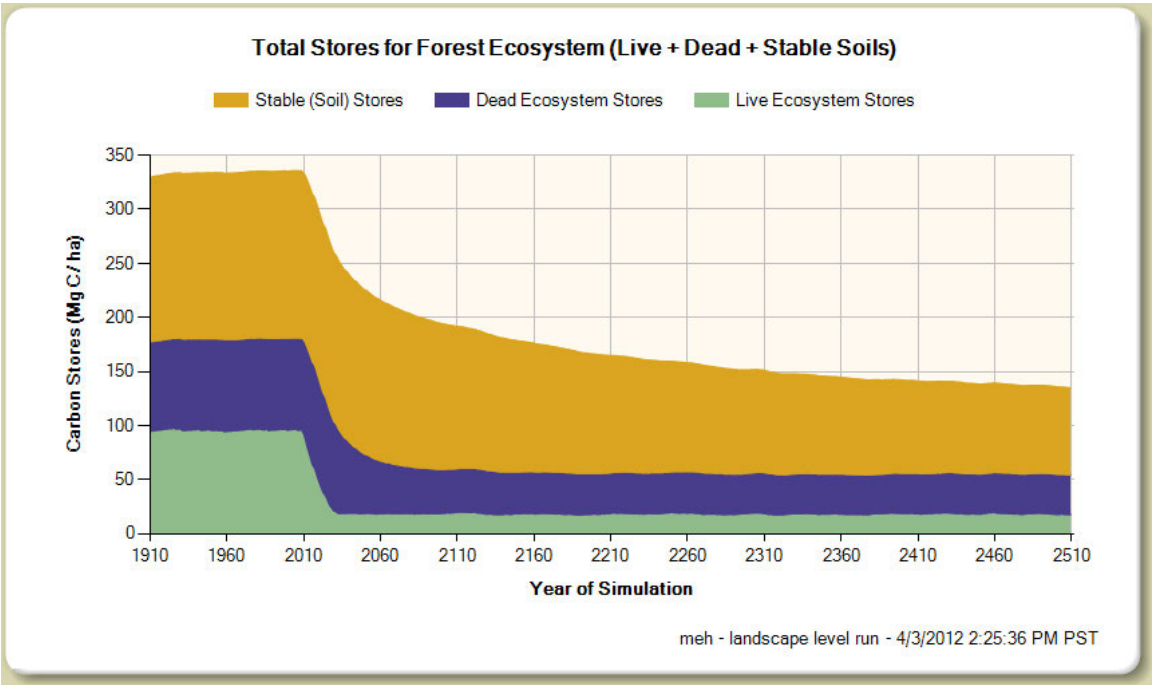


Figure D-2: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is replaced by a 25 year clear-cut harvest system in 2010. The result is a carbon debt.

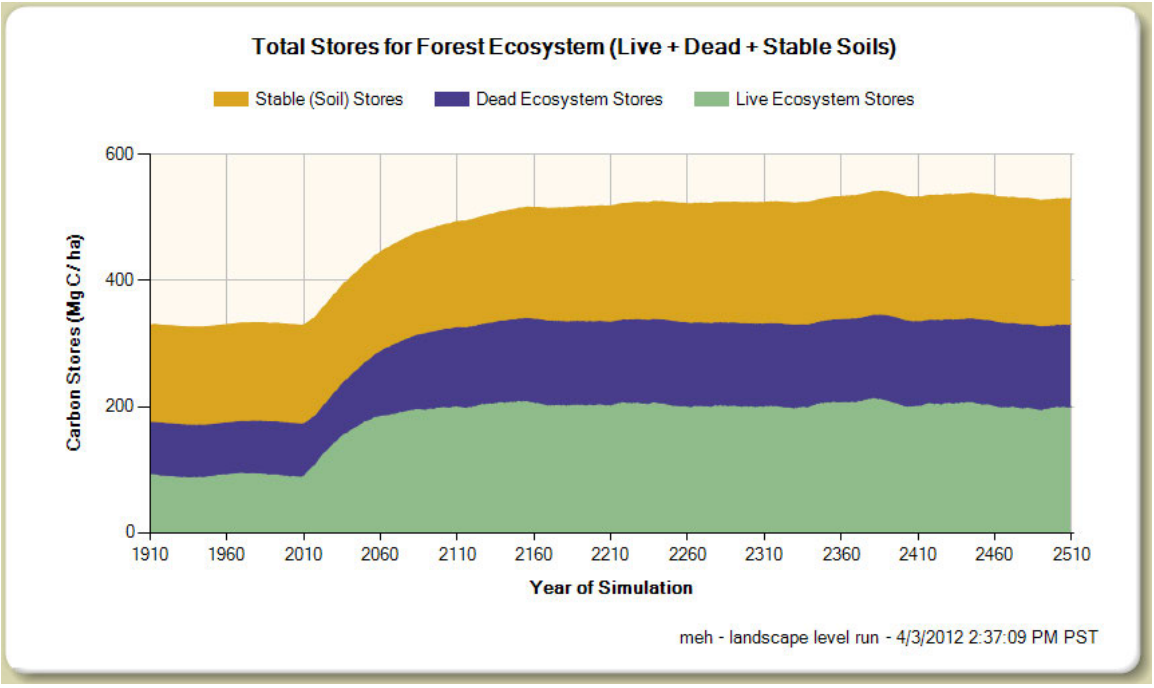


Figure D-3: Changes in carbon stores of major forest ecosystem pools when a 50 year clear-cut harvest system is replaced by a 100 year clear-cut harvest system in 2010. The result is a carbon gain.

APPENDIX E: Dissenting Opinion from Dr. Roger Sedjo

Introduction

EPA's Science Advisory Board (SAB) was asked to review and comment on the EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (Framework September 2011). The motivation for the Accounting Framework "is whether and how to consider biogenic greenhouse gas emission in determining thresholds … for Clean Air Act permitting" (p. 4). To my knowledge the SAB Report has been complete and is being submitted to the broader SAB process. The comments below (and page numbers cited) relate to the SAB Report draft of 6-15-12 (SAB 2012).

I take fundamental issue with many of the elements of the SAB Report. Although I largely agree with the Report's criticisms of the absence of supporting science for many of the Framework's suggested approaches, I find unconvincing and unscientific much of the Report's attempt to salvage large elements Framework's approach. My comments focus largely, but not entirely, to forest issues in the Report not only because that is the area of my greatest expertize but also because the defects in the Framework approach are most egregious in forestry.

The EPA considered whether to categorically include biogenic emission in its greenhouse gas accounting or whether to categorically exclude biogenic emissions (p 6-7). The Agency rejected both extremes and asked the SAB whether it supported their conclusion that categorical approaches are inappropriate for treatment of biogenic carbon emissions. However, I do not believe that this issue was properly vetted within the SAB process. Although the statement that "carbon neutrality cannot be assumed for all biomass energy a priori" (p 7) is correct, it misrepresents the serious position developed by the Intergovernmental Panel on Climate Change (IPCC 2006) and commonly used included a critical qualification regarding the condition of land cover generally and forest stock specifically. This requirement is missing from the simplistic evaluation statement. This position is supported in the Appendix to this piece, (USDA appendix by Hohenstein, 2012), which notes that the major IPCC rationale does not claim "a priori" neutrality. The IPCC, which suggested this approach, makes carbon neutrality contingent on an aggregate monitoring approach that focuses on the changes in aggregate land use and forests. Thus, the definitive development of the wide spread exclusion of biogenic and wood does not, in fact, involve an a priori assumption of neutrality. Rather it involves a qualification (for wood) that the forest stock be constant or expanding. I should note here that consideration of that important qualification was largely absence from the evaluation by the SAB and, in my judgment, aggressively discouraged by the organizers from the SAB discussion.

Finally, if the proposed Accounting Framework were capable of providing reliable accounting, one might give it serious consideration as an alternative to the IPCC approach in achieving the EPA objectives. However, as is acknowledged by the Report (e.g., p. 15), the proposed Accounting Framework is replete with problems as are the calculations of the elements necessary for calculating the Biological Accounting Factor (BAF). The acknowledged scientific weaknesses in the EPA document are identified throughout the SAB Report.

This paper demonstrates below that the SAB Report has not adequately addressed some of these issues and has not found ways to estimate in a scientifically acceptable way the values of some of the requisite components of the BAF.

Defects in the Accounting Framework

Questions raised in the Report about the Framework run from the appropriateness of the proposed use of the same accounting framework for the various feedstocks, which are different, to issues dealing with the appropriate baseline and questions concerning the relevant timescale. The SAB Report essentially embraces a variant of the BAF approach, which was developed in the Framework, even though the Report points to numerous important weaknesses of the BAF approach. The BAF is a simple accounting model that tries to identify and measure the various components and impacts of carbon emissions and accumulations from biomass energy sources. Ultimately, the Report essentially embraces the general BAF approach but applies it differently to individual biogenic feedstocks. However, the Report acknowledges throughout that a number of the components of the BAF cannot be adequately measured.

For example, the Report acknowledges that for important major elements of the Framework, e.g., leakage, there is no satisfactory monitoring or measurement system. Leakage, which can be either positive of negative, may involve the deflection of deforestation and associated emission out of woodshed under consideration or it may involve sequestration associated with offsetting forest management outside of that woodshed. Thus, the values of these major elements are essentially empirical, could be either positive or negative, but have their impacts outside of the area of direct observation. But, without accurate leakage values, the BAF approach proposed cannot accurately estimated for carbon changes. It cannot even determine the sign of the changes with any great accuracy. Thus, although the Reports states that "it is important to have scientifically sound methods to account for greenhouse gas emission caused by human activities" (p 13), it acknowledges that the it is widely acknowledged in the literature that leakage cannot to be readily measured with any accuracy (Murray et al. 2004; Macauley et al. 2009). Nevertheless, in contradiction of this finding the Report suggests that "the Agency … try to ascertain the directionality of net leakage … and incorporate that information into decision making." (p 9-10). This suggestion flies in the face of the concept of "scientifically sound methods."

Indeed, the application of the proposed framework would either need to leave these elements of the BAF empty, as suggested in the USDA letter posted on the SAB website, or nonscientific guesses would need to be imposed, as suggested in parts of the Report. In either case large errors in measurement appear almost inevitable and, rather than providing the regulators with accurate information, would provide misinformation to regulators and would likely redound to errors in the application of regulations. The idea introduced in the Report of default BAFs does not do anything to address their fundamental lack of scientific rigor.

Other thorny issues involve questions of the boundaries of a woodshed and/or a region, which relate to the leakage question, the intermixing of industrial wood and biomass so that significant portions of any harvest are used for each, and the export of biomass for energy, e.g., the large flow of wood pellets to Europe, where their emissions for the production of bioenergy will not be captured in the accounting. Finally, any accounting approach that tries to monitor each biomass using unit is surely going to be time

consuming and expensive, perhaps too expensive to justify the use of the biomass for energy (Sedjo and Sohngen 2012).

An important defect is that the Report embraces a carbon-debt framework. However, this framework is an artifact of an arbitrary decision of how the accounting system is applied. If the forest is sustainability managed, then there is no carbon-debt. Withdrawals equal growth for both biomass and carbon. Accounting debts can occur in some circumstances, however. For a mature forest stand, if the accounting period begins with the harvest of the stand, as in the Manomet Study, a debt is incurred for that stand. Note that net carbon sequestration could be occurring in that forest but on different stands. Most forests are multi-aged and hence will have net growth occurring on some stands while stock reductions occur on other stands.

An additional source of confusion regarding carbon debt is related to the accounting period. If the accounting focuses on a stand and the accounting period begins with the harvest, a debt will be establishment for the forest stand. However, if the accounting begins with the forest establishment, e.g., at tree planting, then the initial post planting growth is building up a stock of carbon that will be released at harvest. Thus, any future debt from that stand will have been offset in advance of the harvest and no intertemporal net carbon debt is incurred.
Thus, although an accounting debt can be found for mature stands, the debt is an artifact of the time period selected and the choice of how narrowly to define the relevant forest stands. Furthermore, a carbon debt will not be occurred for sustainably managed forests. In the aggregate, the U.S. forest system is more than sustainable as demonstrated by the FIA's data going back to a least 1952. Thus, a fully accounting of the entire managed US forest does not find a carbon-debt.

In summary, the Report identifies a host of problems with the proposed Accounting Framework, and reports that "the SAB did not find the Framework to be scientifically rigorous" (p 30). Indeed, although the Framework is said to "include most of the elements that would be needed to gauge changes in CO2 emissions," the problems with the effective of monitoring, measurement and verification of several of the components are daunting.

Alternative Approaches for Accounting for Biogenic Carbon

One wonders why the SAB exerted so much effort to try to save the Accounting Framework, containing as it does, such fundamental defects. It is my understanding that the SAB was asked to review and comment on the Framework, but not necessarily to save it. Indeed, as noted above, EPA's change included the question of "whether … to consider biogenic greenhouse gas emission in determining thresholds … for Clean Air Act permitting" (p. 4).
Nevertheless, despite the identification of very serious defects in the approach, there is a considerable attempt in the SAB process to downplay the problems and ignore the lack of scientific bases for measuring some of the elements, apparently in order to preserve a variant of the approach, no matter how defective.

There are at least two basic ways that one might approach the problem of estimating the net emissions associated with biogenic energy. The highly regarded scientific organization, Intergovernmental Panel on Climate Change (IPCC) has suggested an aggregate approach that would focus on the changes in

aggregate land use and forests to determine whether, for example, aggregate forest stocks are expanding or contracting. This approach has been supported by the USDA (Hohenstein 2012) in a response to an earlier draft report by the SAB.

In the context of measuring the total aggregate forest the issue of leakage and anticipatory management within the US does not arise since to total system is evaluated. Where the aggregate is subdivided into a few large international regions, these issues are more easily captured since flows in forest biomass are measured in the international trade statistics and individual woodshed monitoring is not necessary. Indeed, for the US this approach can easily be put in place at low cost since the Forest Service has been undertaking Forest Inventory Assessments (FIA) for over fifty years.

The alternative to the IPCC approach, suggested by the Accounting Framework, involves the individual audit of each separate woodshed associated with a facility and an attempt to estimate the impact of each individual operation on net emissions. Such an approach would be a monitoring nightmare complicated by the fact that wood feedstock could, and likely would on occasion, be brought into one region from other small regions as required, this situation would involve leakage. Leakage could be replete since more regions would almost surely involve more leakage. Not only is the individual wood shed audit approach much more expensive, it also is inadequate since wood sheds are not always well defined and wood will undoubtedly flow across various woodsheds and leakage will occur. However, such detail is entirely unnecessary for purposes of the broad monitoring of biogenic facilities and their effects on atmospheric carbon. The relevant consideration is not the infinitesimal impact of each individual facility. Rather, the concern is with the grand aggregate impact of the bioenergy system on net emissions. If this approach does not properly account for the effects of leakage and anticipatory forest management (reverse leakage), the BAF estimates will have basic errors.

The Framework approach and the SAB Report appear to accept the notion that the Framework Accounting approach is superior to the IPCC approach. However, no evidence of this is provided either in argumentation or in analytical studies. Nevertheless, it is probably indisputable that the costs of the Accounting Framework approach with its estimated BAFs are far higher than those associated with the IPCC approach.

Five Summarizing Points

First, the guidelines provided by the EPA for the SAB Report essentially accept the Framework view and dismisses the IPCC suggested approach with regard to biogenic feedstocks within the land use sector, including forests. This was done despite that fact that there was no serious discussion by our SAB group of the adequacy or viability of the IPCC approach. Indeed the IPCC approach was dismissed by the EPA as inadequate on rather flimsy grounds. I note that my position is supported in the letter by William Hohenstein, Director of the Climate Change Program Office posted at the SAB website. The letter states that USDA “prefers the IPCC accounting framework” approach and takes issue with the rationale used by the SAB Report and its dismissal of the IPCC approached. USDA differs with the assertion of the SAB Report and maintains “the IPCC approach is not equivalent to an a priori assumption that these feedstocks are produced in a carbon neutral manner or an assertion that land use activities contributing feedstocks to the energy sector can be managed without consideration of atmospheric outcome.”

Second, an attempt to assess the carbon debt of individual stands fundamentally misses the point since it is the entire forest, not individual stands that are relevant to the carbon footprint as seen by the atmosphere. As such, the attempt to imperfectly apply the BAF to individual forests is costly and irrelevant to the aggregate U.S. carbon footprint.

Third, although the Report acknowledges the dynamic nature of market driven supply systems that would be providing the biogenic energy feedstock, it essentially uses a static approach that largely ignores various market responses and adaptations to changing circumstances. Although the Report acknowledges that investment decisions for trees must predate their utilization by years and indeed decades, this reality is not incorporated into any BAF calculation. Indeed, while investment decisions must be driven by the anticipation of the existence and size of future markets, these considerations are acknowledged for wood biomass in parts of the Report and then disregarded in the application of the approach for regulatory purposes. Thus, the actual approach suggested is essentially static, missing the essential dynamic nature of the supply process. Despite these basic defects, the Report recommendations are treated as if they are scientifically sound.

Fourth, the Report erroneously states that incentives for producing replacement bioenergy crops are absence. Such a result would occur in viable markets only if there were no anticipation of increasing future demand. However, a variety of signals, including requirements of renewal portfolio standards and forecasts of dramatic biomass energy demand increases over the next couple of decades by various authoritative organizations, e.g., EIA.

Fifth, the Report tends to support a very expensive and onerous regulatory accounting system rather than a much more efficient system such as suggested by the IPCC. This support is given without any apparent serious assessment or rationale that the regulatory results of the BAF system will be equal to or superior to those that would result from a much less expensive and less onerous IPCC type approach.

In summary, I find that although the SAB Report provides a useful critique of the Accounting Framework and the BAF approach. However the Report falls into the trap of trying to make a basically defective system functional and tends to support many aspects of that flawed system. In the end the Report largely ignores its own criticisms and supports a fundamentally flawed approach. Thus, since the motivation for the Accounting Framework "is whether and how to consider biogenic greenhouse gas emission in determining thresholds … for Clean Air Act permitting" (p. 4), it can rationally be concluded that biogenic greenhouse gas emission are best not considered in determining thresholds or perhaps considered only of the forest and land use conditions as such that they do not meet minimal IPCC conditions.

References:

Hohenstein, William. 2012. Comments submitted to the EPA SRB regarding the Environmental Protection Agency's draft Accounting Framework for Biogenic CO2 Emissions from Stationary Sources on behalf of USDA. May 25.

IPCC. 2006. Guidelines for National Greenhouse Gas Inventories: Agriculture, Forestry and Other Land Use Volume 4.

Macauley, Molly K., Daniel F. Morris, Roger A. Sedjo, Kate Farley, Brent L. Sohngen "Forest Measurement and Monitoring: Technical Capacity and "How Good Is Good Enough?" RFF Report | December 2009.

Murray, B.C.; McCarl, B.A.; Lee, H. (2004). Estimating Leakage from Forest Carbon Sequestration Programs. Land Economics, 109-124.

Sedjo, Roger and Brent Sohngen. 2012. "Carbon Sequestration in Forests and Soils," in Annual Review of Resources Economics.

SAB. 2012. 6-15-12 Deliberative Draft report of the Biogenic Carbon Emission Panel.

CRPE

CENTER ON RACE, POVERTY & THE ENVIRONMENT

47 KEARNY STREET, SUITE 804, SAN FRANCISCO, CA 94108 TEL 415-346-4179 FAX 415-346-8723 WWW.CRPE-EJ.ORG

August 6, 2012

Via Electronic and U.S. Mail

Rafael DeLeon, Director
Office of Civil Rights
U.S. Environmental Protection Agency
Mail Code 1201A
1200 Pennsylvania Ave NW
Washington, D.C. 20460

Re: Petition for Reconsideration; *Coalition for a Safe Environment v. California Air Resources Board,* EPA File No. 09R-12-R9

Dear Mr. DeLeon:

Complainants Coalition for a Safe Environment, Association of Irritated Residents, California Communities Against Toxics,, Society for Positive Action, and West County Toxics Coalition (collectively "Complainants") petition EPA to accept their Title VI complaint alleging that the California Air Resources Board ("CARB") violated Title VI of the Civil Rights Act when CARB adopted the Cap and Trade regulation which, by allowing pollution trading and offsets, denies communities living near Cap and Trade facilities the benefits of co-pollutant reductions and allows increases in such pollution when facilities expand.

On July 12, 2012, the Office of Civil Rights ("OCR") erroneously rejected the complaint as not ripe. *See* Letter from Rafael DeLeon to Brent Newell and Sofia Parino, Rejection of Title VI Complaint, dated July 12, 2012 (hereafter "DeLeon Letter"), attached as Exhibit 1. OCR found that "the allegations in the complaint are speculative in nature and anticipate future events that may not occur." *Id*. at 2. OCR further found that "the actions to be taken in response to the new compliance obligations and the results of those actions are unknown and unpredictable." *Id*. at 2. OCR concluded that "a meaningful review cannot be conducted at this time" and rejected the complaint.

The Supreme Court articulated the question of ripeness as "best seen in a twofold aspect, requiring us to evaluate both the fitness of the issues for judicial decision and the hardship to the parties of withholding court consideration." *Abbott Labs. v. Gardner*, 387 U.S. 136, 149 (1967).

As the Complaint alleged, CARB adopted a regulation that, rather than requiring all facilities to reduce greenhouse gas (and resulting co-pollutant emissions) on-site, allows all facilities to purchase allowances and offsets from a third-party, thus avoiding on-site pollution reductions. The Complaint further alleged that communities living near cap and trade facilities already suffer disparate and adverse impacts from co-pollutant emissions, and that cap and trade denies those communities a benefit of co-pollutant reductions by allowing trading. In addition, when facilities expand, they may also purchase offsets or allowances to meet their compliance obligations even when increasing greenhouse gas and co-pollutant emissions.

The adoption of the Cap and Trade regulation and the denial of benefits could not be more ripe for review. OCR concluded, without any factual analysis, that the allegations in the complaint "may not occur" and that it is "unknown and unpredictable" what actions regulated entities will take. *Id*. at 2. Cap and Trade is a reality, has been adopted by CARB, has been approved by the Office of Administrative Law, and CARB has been implementing Cap and Trade for nearly a year. The Complainants need not, and should not, wait until facilities in their communities actually purchase allowances and offsets, and use such allowances and offsets in their compliance demonstration, for this Complaint to be ripe. CARB violated Title VI by adopting a final regulation that permitted such conduct to occur.

Complainants will suffer undue hardship from OCR's decision to reject the Complaint. Rather than having the EPA protect their right to live free of discrimination from federally-funded agencies like CARB, the Complainants apparently must endure the denial of co-pollutant reductions *before* having their complaint investigated and resolved by OCR, which could take years given OCR's history of processing Title VI complaints. OCR has further exacerbated that hardship by failing to articulate when a complaint alleging that Cap and Trade violates Title VI would be ripe. Complainants are left in the untenable position of not knowing when OCR would consider the Complaint ripe, and simultaneously face the short 180-day limitations period in which they must file a new complaint.

OCR accepted a similar Title VI Complaint in *Communities for a Better Environment v. South Coast Air Quality Management District*, EPA File No. 10R-97-R9, which alleged that South Coast Rule 1610 allowed pollution trading that disparately and adversely affected communities of color. EPA cannot square its acceptance of that complaint also a regulatory challenge to a trading scheme with its unsubstantiated conclusions here that trading "may not occur" and its effects are "unknown and unpredictable."

Even if OCR maintains that this Complaint is not ripe, it should accept the complaint, articulate which factual events must transpire, and hold the complaint in abeyance pending the fruition of those events. That was exactly the action OCR took when OCR recently accepted the complaint in *Greenaction v. San Joaquin Valley Air Pollution Control District*, EPA File No. 11R-09-R9. *See* Letter from Rafael DeLeon to Bradley Angel, dated August 6, 2010, attached as Exhibit 2. In *Greenaction*, the Complaint alleged that the operation of the proposed Avenal Power Plant would violate Title VI. *Id* at 2-3. OCR accepted the complaint, but held the complaint in abeyance pending the issuance of a Prevention of Significant Deterioration permit by EPA. "OCR will hold the investigation of this allegation in abeyance because the Clean Air Act Prevention of Significant Deterioration pre-construction permit application for the Avenal power plant is pending approval from EPA and, thus, the allegations are not yet ripe for review." *Id*. at 3.

Finally, OCR disingenuously endorses CARB's Adaptive Management Plan. The Adaptive Management Plan "requires CARB to take a range of actions to monitor co-pollutant emissions and address any unanticipated adverse impacts caused by the Cap-and-Trade regulation." DeLeon Letter at 2. OCR fails to acknowledge that the Adaptive Management Plan is a *discretionary* plan, whereby CARB stated its intent to exercise its *discretion* to determine if an adverse impact has occurred, and then will use its *discretion* to take action CARB deems appropriate. *See* Adaptive Management Plan, attached as Exhibit 3. Nothing in the Adaptive Management Plan guarantees that Cap and Trade will not inflict a disparate and adverse impact. Furthermore, the Adaptive Management Plan was not adopted as part of the Cap and Trade Regulation, *see* Cal. Code Regs. tit. 17 § 95801 *et seq*., and is thus nothing more than CARB's non-binding intent to exercise its discretion in the future. OCR should not cite or rely on the Adaptive Management Plan as a basis for Cap and Trade's compliance with Title VI.

Complainants respectfully request that OCR (1) articulate a standard for ripeness that will inform the public when a complainant should file a Title VI complaint; and (2) accept this Complaint for investigation. Even if OCR finds that this complaint is still not ripe for review, then OCR should nevertheless accept the complaint for investigation and hold the complaint in abeyance pending the action OCR deems necessary for ripeness. Thank you for your time and courtesy.

Sincerely,

Brent Newell
General Counsel

cc: Lisa P. Jackson, EPA Administrator
USEPA Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, N. W.
Mail Code: 1101A
Washington, DC 20460

Jared Blumenfeld, Regional Administrator
EPA Region IX
75 Hawthorne Street
Mail Code: ORA-I
San Francisco, CA 94105

Mary Nichols, Chairman
California Air Resources Board
1001 I Street
Sacramento, CA 95814-2828

cc: Robert Perciasepe (by electronic mail)

Diane Thompson (by electronic mail)

Scott Fulton (by electronic mail)

Steve Pressman (by electronic mail)

Helena Wooden-Aguilar (by electronic mail)

EXHIBIT 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 12 2012

OFFICE OF
CIVIL RIGHTS

CERTIFIED MAIL #7004 2510 0004 2241 6398
RETURN RECEIPT REQUESTED

In Reply Refer to:
EPA File No. 09R-12-R9

Brent Newell
Attorney
Center on Race, Poverty and the Environment
47 Kearny Street, Suite 804
San Francisco, CA 94108-5528

Sofia Parino
Attorney
Center on Race, Poverty and the Environment
47 Kearny Street, Suite 804
San Francisco, CA 94108-5528

Re: Rejection of Title VI Administrative Complaint

Dear Mr. Newell and Ms. Parino:

The United States Environmental Protection Agency (EPA) Office of Civil Rights (OCR) has reviewed your complaint filed on behalf of the Coalition for a Safe Environment, the Association of Irritated Residents, California Communities Against Toxics, the Society for Positive Action, and the West County Toxics Coalition. OCR received the complaint on June 8, 2012. The complaint alleges that the California Air Resources Board (CARB) violated Title VI of the Civil Rights Act of 1964, as amended (Title VI), 42 U.S.C. §§ 2000d *et seq.*, and EPA's nondiscrimination regulations at 40 C.F.R Part 7 in approving the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms Regulation, Including Compliance Offset Protocols (Cap-and-Trade program). OCR is responsible for conducting a preliminary review of complaints alleging discrimination by programs or activities that receive financial assistance from EPA for acceptance, rejection, or referral to another federal agency.

CARB issued regulations implementing the Cap-and-Trade program on October 20, 2011, pursuant to AB 32, the California Global Warming Solutions Act. That Act established statewide 2020 greenhouse gas (GHG) emissions limits and directed CARB to develop a plan to reduce GHG emissions to the statewide limit of 1990 levels by 2020. Enforceable compliance obligations for GHG emissions from affected sources will begin on January 1, 2013.

OCR finds that this complaint is not ripe for review. The allegations in the complaint are speculative in nature and anticipate future events that may not occur. The actions to be taken in response to the new compliance obligations and the results of those actions are unknown and unpredictable. As a result, a meaningful review cannot be conducted at this time. Therefore, OCR rejects your complaint and its allegations.

While this decision does not reach the merits of the complaint, OCR notes that CARB took the proactive step of adopting an Adaptive Management Plan that requires CARB to take a range of actions to monitor co-pollutant emissions and address any unanticipated adverse impacts caused by the Cap-and-Trade regulation. The Plan states that such actions could include, for example, the adoption of additional regulatory requirements and using funds obtained from the sale of allowances to support local mitigation projects.

If you have any questions about this matter, please contact Helena Wooden-Aguilar, Assistant Director, Office of Civil Rights by telephone at 202-564-0792, by email at Wooden-Aguilar.Helena@epa.gov or by mail at U.S. EPA, 1200 Pennsylvania Ave., NW, Mail Code 1201A, Washington, D.C., 20460-0001.

Sincerely,

Rafael DeLeon

Rafael DeLeon
Director

cc: Stephen G. Pressman, Associate General Counsel
Civil Rights & Finance Law Office (MC 2399A)

Jared Blumenfeld, Title VI Contact, U.S. EPA Region 9
75 Hawthorne Street
Mail Code: ORA-1
San Francisco, CA 94105

California Air Resources Board
Ms. Mary Nichols, Chairman
1001 "I" Street
Sacramento, CA 95814-2828

EXHIBIT 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG - 6 2010

OFFICE OF
CIVIL RIGHTS

RETURN RECEIPT REQUESTED
Certified Mail #7009-2820-0002-1759-4019

In Reply Refer to:
EPA File No. 11R-09-R9

Mr. Bradley Angel
Executive Director
Greenaction for Health and Environmental Justice
703 Market Street
Suite 501
San Francisco, California 94103

Re: Partial Acceptance and Referral of Administrative Complaint

Dear Mr. Angel:

This letter is in reference to the administrative complaint you filed with the U.S. Environmental Protection Agency (EPA) Office of Civil Rights (OCR) on October 15, 2009, on behalf of Greenaction for Health and Environmental Justice (Greenaction). Your complaint alleges that the California Energy Commission (Energy Commission) and the San Joaquin Valley Air Pollution Control District (APCD) violated Title VI of the Civil Rights Act of 1964, as amended (Title VI), 42 U.S.C. §§ 2000d *et seq.*, and EPA's nondiscrimination regulations implementing Title VI, found at 40 C.F.R. Part 7. OCR is partially accepting your complaint for investigation and partially referring your complaint to the U.S. Department of Energy (DOE). We are referring the allegations against the Energy Commission to DOE for its consideration because the Energy Commission receives financial assistance from DOE and not from EPA.

Pursuant to EPA's nondiscrimination regulations, OCR conducts a preliminary review of discrimination complaints to determine acceptance, rejection, or referral. 40 C.F.R. § 7.120(d)(1). To be accepted for investigation, a complaint must meet the jurisdictional requirements described in EPA's nondiscrimination regulations. First, it must be in writing. Second, it must describe an alleged discriminatory act that, if true, may violate EPA's nondiscrimination regulations (*i.e.*, an alleged discriminatory act based on race, color, national origin, sex, age, or disability). Third, it must be filed within 180 calendar days of the alleged discriminatory act. 40 C.F.R. § 7.120(b). Finally, the complaint must be filed against an applicant for, or a recipient of, EPA financial assistance that allegedly committed the discriminatory act. 40 C.F.R. § 7.15.

After careful consideration, OCR is accepting the following allegations against APCD.

1. **APCD intentionally discriminated against Avenal and Kettleman City residents of color and Spanish-speakers by failing to notify or involve residents (*e.g.*, failing to publish information in Spanish, failing to hold public hearings) during the decision-making process prior to APCD issuing the corrected Notice of Final Determination of Compliance (FDOC) for the proposed Avenal power plant on November 4, 2008.**

On January 14, 2010, OCR sent you a letter requesting additional information regarding the dates associated with each alleged discriminatory act described in your complaint. Your March 3, 2010 response states that you did not learn of the corrected notice of FDOC until June 2009.

This allegation is accepted for investigation. The complaint is in writing and states an alleged discriminatory act that would violate EPA's nondiscrimination regulations (*i.e.*, discrimination from lack of public participation during the approval process). Additionally, APCD is a recipient of EPA financial assistance. Although the complaint was filed more than 180 days after the date of the alleged discriminatory act, OCR has the authority to waive the 180-day time limit for good cause. 40 C.F.R. § 7.120(b)(2). Based on the jurisdictional review, OCR is waiving the 180-day timeliness requirement because the complainant could not reasonably be expected to have known about the alleged discriminatory act within the 180-day period in light of the circumstances.[1] Waiving the timeliness requirement is a jurisdictional decision and does not constitute a finding of fact or violation of EPA's nondiscrimination regulations. No substantive determination about this allegation will be made until the completion of a full investigation.

2. **The operation of the proposed Avenal power plant will result in additional adverse health impacts on the residents of color of Avenal and Kettleman City, who are already impacted by multiple pollution sources.**

The complaint and your March 3, 2010 response to our request for clarification letter state that the proposed Avenal power plant will have an adverse disparate impact on the Avenal and Kettleman City residents of color living near the proposed Avenal power plant.

This allegation is accepted for investigation because it meets EPA's jurisdictional requirements, but the investigation is being held in abeyance. The complaint is in writing, and states an alleged discriminatory act that would violate EPA's

[1] Guidance from the U.S. Department of Justice provides that agencies may waive the timeliness requirement in a number of situations, including cases where "[t]he complainant could not reasonably be expected to know the act was discriminatory within the respective filing period." U.S. Dep't of Justice, *Investigation Procedures Manual for the Investigation and Resolution of Complaints Alleging Violations of Title VI and Other Nondiscrimination Statues*, Sept. 1998 at 35.

nondiscrimination regulations (*i.e.*, adverse disparate health impacts from the upcoming operation of the Avenal power plant). Additionally, APCD is a recipient of EPA financial assistance and the complaint was timely filed. However, OCR will hold the investigation of this allegation in abeyance because the Clean Air Act Prevention of Significant Deterioration pre-construction permit application for the Avenal power plant is pending approval from EPA and, thus, the allegations are not yet ripe for review.

Remaining Allegations

1. California Energy Commission

Your complaint asserts that the Energy Commission failed to provide meaningful opportunities for public comment in the approval of the proposed power plant and failed to conduct a thorough environmental review of the health impacts on nearby residents.

A complaint must be filed against an applicant for, or a recipient of, EPA assistance to be accepted by EPA for investigation. 40 C.F.R. § 7.15. The Energy Commission does not receive EPA assistance. Therefore, OCR does not have the authority to accept the allegations against this entity for investigation. Because OCR has determined that the Energy Commission receives financial assistance from DOE, EPA is forwarding this allegation to DOE.

2. Executive Order 12898 and Environmental Law

Finally, your complaint raises allegations related to Executive Order 12898, including discrimination on the basis of income, and allegations related to violations of environmental laws. OCR does not have authority over these matters, but EPA's Office of Environmental Justice and Region 9 are currently engaged in these issues in Kettleman City and Avenal. OCR, therefore, defers to them with respect to these concerns.

Pursuant to EPA's nondiscrimination regulations, APCD is being notified of the acceptance of this complaint. APCD may respond to the notice of acceptance of this complaint within 30 calendar days of receiving it. EPA's nondiscrimination regulations provide that OCR must attempt to resolve complaints informally, whenever possible. 40 C.F.R. § 7.120(d)(2). Accordingly, OCR may discuss, at any point during the process, offers to informally resolve the complaint, and may, to the extent appropriate, facilitate an informal resolution process with the involvement of affected stakeholders.

You should be aware that no one may intimidate, threaten, coerce, or engage in other retaliatory conduct against anyone because he or she has either taken action or participated in an action to secure rights protected by the nondiscrimination statutes EPA enforces. Any individual alleging such harassment or intimidation may file a complaint with EPA.

If you have any questions or need clarification regarding this letter, please contact Anthony Napoli of the OCR External Compliance and Complaints Program via Federal

Relay Service 866-377-8642, and provide the relay operator his telephone number 202-233-0651. He may also be reached via electronic mail at Napoli.Anthony@epa.gov, or by mail at: U.S. EPA, Office of Civil Rights (Mail Code 1201A), 1200 Pennsylvania Ave., N.W., Washington, D.C. 20460-1000.

Sincerely,

Rafael DeLeon
Acting Director

cc: Stephen G. Pressman, Associate General Counsel
Civil Rights and Finance Law Office (2399A)

Charles Lee, Director
Office of Environmental Justice

Jo Ann Asami, EPA Region 9

Seyed Sadredin, Air Pollution Control Officer
San Joaquin Valley Air Pollution Control District

Karen Douglas, Chair
California Energy Commission

William A. Lewis, Jr., Acting Director
Office of Economic Impact and Diversity
U.S. Department of Energy

EXHIBIT 3

California Environmental Protection Agency

Air Resources Board

Adaptive Management Plan for the Cap-and-Trade Regulation

October 10, 2011

This Page Intentionally Blank

Table of Contents

I. Executive Summary 1

II. Introduction 1

III. Adaptive Management 2

A. Objectives of ARB's Adaptive Management Plan 3

B. Questions that Frame Review and Analysis Under the Adaptive Management Plan 4

IV. Information Gathering 6

A. Localized Air Quality Data 6

1. Greenhouse Gas Mandatory Reporting Regulation (MRR) 6
2. Compliance Instrument Tracking System 7
3. Local Air District Permits for Covered Entities 7
4. California Energy Commission (CEC) Power Plant Permitting 9
5. Economic Forecast Data 9
6. Air Quality Monitoring Data 9
7. Continuous Emissions Monitors (CEMs) 14
8. Criteria Pollutant and Toxic Contaminant Emissions Inventory Databases 14

B. Forest Data 18

1. U.S. Forest Protocol Project Data 18
2. Forest Buffer Account Information 19
3. Greenhouse Gas Mandatory Reporting Regulation (MRR) 20
4. ARB's Updated GHG Statewide Inventory for Forests 20
5. California Forest Practices Act as Administered by CalFire 20
6. Timber Yield Tax and Harvest Values Schedules 21
7. Fire and Resource Assessment Program (FRAP) 21
8. Geographic Information System (GIS) and Geodatabases 21
9. Special Monitoring Projects (CalFire, Department of Fish and Game, Regional Water Quality Control Boards) 22

V. Review and Analysis 22

A. Local Air Quality Impacts 23

B. Forest Impacts 25

C. Causation 26

1. Localized Air Quality 26
2. Forest Impacts 27

VI. Response 27

VII. Public Process for this Adaptive Management Plan 28

This Page Intentionally Blank

I. Executive Summary

This document describes the Air Resources Board's (ARB or Board) recommended adaptive management plan. The plan is focused on two specific areas: localized air quality impacts from the proposed cap-and-trade regulation (cap-and-trade regulation or Regulation) and forest impacts from the proposed Compliance Offset Protocol for U.S. Forest Projects (U.S. Forest Protocol) contained in the Regulation. The plan is being released for public comment, and will be presented to the Board for consideration at the October 20-21, 2011, Board meeting. If adopted, the plan will require ARB to take a range of actions in these two areas to monitor and respond as appropriate to address unanticipated adverse impacts that are caused by the Regulation or the U.S. Forest Protocol.

Adaptive management is a process of information gathering, review and analysis, and response that promotes flexible agency decision-making. It is particularly appropriate where complex systems are involved, where the effects of an agency's decisions and actions play out over an extended period of time, and where the agency must meet multiple objectives – as in the case of the proposed Regulation. Adaptive management is consistent with ARB's long-standing approach to program implementation which incorporates on-going evaluation of how programs and regulations are implemented on the ground, regular updates to the Board, and adjustments to program implementation and regulatory requirements, as necessary.

In this plan, ARB is focusing on the two aforementioned areas where, although not anticipated, unintended environmental impacts could occur. The adaptive management plan focuses on these two areas because they were identified in the environmental analysis accompanying the rulemaking as areas where the potential for unanticipated impacts could occur and because they were specifically identified as being of special concern in public comments. It is important to note, however, that this focused adaptive management plan should be viewed in the larger context of ARB's planned oversight of the proposed Regulation and the U.S. Forest Protocol, which includes comprehensive monitoring of auctions, reserve sales, allowance holdings, compliance offset credit generation and use, reported emissions, leakage, and other aspects of the Regulation. Additionally, the adaptive management plan should also be viewed in the context of ARB's larger air pollution control programs, which already incorporate systems to measure air quality and emissions in an effort to continuously improve air quality in California.

Plan Elements

The key elements of this adaptive management plan are: (1) data and data source identification (information gathering); (2) analysis to determine whether an adverse impact is caused by the cap-and-trade regulation (review and analysis); and (3) identifying potential actions ARB could take to address these impacts and committing to take appropriate action (response).

What Data Will ARB Gather for Evaluation?

ARB identified data sources for the evaluation of potential localized air quality impacts. These include cap-and-trade specific data such as greenhouse gas (GHG) emissions, and the holdings of allowances and compliance offset credits, as well as traditional criteria pollutant and air toxics information such as air pollution control district permits, air monitoring data, and emission inventories. If the Board approves the Regulation and this plan, ARB will work with local air districts and stakeholders to refine plan details concerning air quality data gathering prior to initiation of the first compliance period on January 1, 2013.

ARB has identified data sources for the evaluation of potential unanticipated forest impacts resulting from the U.S. Forest Protocol. These include information that must be reported under the protocol, as well as emission inventories, timber harvest plans, the Fire and Resource Assessment Program, and information from other states (should forest offset projects occur in other states). As part of the adaptive management plan, ARB intends to contract with an independent third-party to assist in determining the best ways to filter and analyze the data needed to evaluate potential unanticipated impacts in this sector. ARB will work with the appropriate agencies and stakeholders to refine plan details related to data filtering and analysis.

How Will ARB Review and Analyze the Data?

As part of this plan, ARB will analyze the collected data to determine whether an environmental change such as an increase in emissions has occurred, and whether the change is caused, directly or indirectly, by the cap-and-trade regulation or the U.S. Forest Protocol. If the analysis indicates a change has occurred as a result of the Regulation or U.S. Forest Protocol, ARB will evaluate whether such change had or is likely to have an adverse impact.

It is unlikely that ARB will be able to rely on any single analysis or data source. The complex interplay of possible economic drivers, as well as other regulatory drivers, will most likely require ARB to conduct multiple analyses. It may not be possible to identify a direct causal relationship between the environmental change and the Regulation or U.S. Forest Protocol. Therefore, ARB will evaluate the weight of available evidence to determine the reason for the change.

In conducting the analysis, it will be necessary to consider normal variations, existing trends, and other factors that may be responsible for changes in the data. For example, air quality data can vary significantly from year-to-year because of meteorology. Additionally, changes in economic activity can produce large impacts on air quality and emissions trends, and factors such as rainfall can have significant impacts on emissions as a result of California's utilization of hydroelectric power as a source of energy.

The following is an illustrative example of the stepwise approach ARB will take to analyze the data for determining a localized impact:

- Monitor facilities subject to the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) for GHG emissions increases. Increases in GHGs could indicate that an increase in other pollutants has occurred. If an increase is apparent, then;
- Review indicators to assess if the change was caused by the Regulation (e.g., the result of a compliance response to the Regulation) or some other factor (e.g., the result of increased production due to economic growth). If the change is determined to be caused by the Regulation, then;
- Work with the local air district to review co-pollutant emissions for appropriate sources and geographic areas to determine whether the change had or is likely to have adverse impacts on local air quality.

How Will ARB Respond?

In the event that an unanticipated adverse localized air quality or forest impact is identified and determined to have been caused by the Regulation or U.S. Forest Protocol, this plan requires ARB to take action to respond appropriately. While it is not feasible in this plan to identify all potential actions that could be pursued, ARB is committed to promptly developing and implementing appropriate responses through a public process, including consideration and approval by the Board as necessary.

ARB would consider a range of options to address localized adverse air quality impacts. These could include the adoption of additional regulatory requirements, using funds obtained from the sale of allowances to support local mitigation projects, coordination with other agencies to provide additional incentives for energy efficiency or other emission reduction activities within the community, or modifications to the Regulation.

For unanticipated impacts from the U.S. Forest Protocol, ARB could consider revising the types and/or geographic location of forest offset projects, or disallowing the use of certain types of U.S. Forest Protocol compliance offset credits. Other types of responses are also possible and would be considered and implemented as necessary.

Public Process for this Adaptive Management Plan

ARB is soliciting comments on this plan. The Board will consider this plan at its October 20-21, 2011, Board meeting. Interested members of the public may present comments orally or in writing at the meeting, and comments may be submitted by postal mail or electronic submittal before the meeting.

Postal Mail: Clerk of the Board, Air Resources Board
1001 I Street, Sacramento, California 95814

Electronic submittal: http://www.arb.ca.gov/lispub/comm/bclist.php

Upon Board approval, ARB will work with our local air district partners, departments of the Natural Resources Agency (resource agencies), and stakeholders to implement the plan based on the following schedule:

October 10, 2011	ARB releases Draft Adaptive Management Plan for comment.
October 20-21, 2011	Board considers Adaptive Management Plan for approval.
November 2011	Staff works with local air districts, resource agencies, and stakeholders to finalize specific details concerning data gathering under the Adaptive Management Plan.
Early 2012	ARB contracts for third-party forestry expertise.
Mid-2012	Staff updates Board on Adaptive Management Plan implementation.
December 2012	Staff releases Adaptive Management Implementation Report (prior to first compliance period).
December 2013	Staff updates Board on Adaptive Management implementation.
December 2014	Staff releases Adaptive Management Report for calendar year 2013.
December 2015	Staff releases Adaptive Management Report for calendar year 2014 and end of first compliance period.
Ongoing	Staff releases Adaptive Management Report annually.

II. Introduction

In December 2010, ARB considered the proposed cap-and-trade regulation. As part of the rulemaking, an environmental impacts analysis was prepared and included in Appendix O to the Staff Report: Initial Statement of Reasons and entitled Functional Equivalent Document (FED). The environmental analysis concluded that increases in localized air pollution or forest project related impacts caused by the Regulation or U.S. Forest Protocol are unlikely based on available data and current laws that control localized air pollution and regulate forest activities. However, ARB could not determine that increases would not ever occur. In addition, commenters raised concerns about the potential for localized air impacts and the potential for impacts to forest resources related to forest offset projects. ARB, therefore, committed to use an adaptive management approach as an integral part of the implementation of the cap-and-trade program in order to address unanticipated impacts that could result from the Regulation related to these two specific areas.

The areas of focus in this adaptive management plan are localized air quality impacts and impacts from the U.S. Forest Protocol on special status species, sensitive habitats, and federally protected wetlands (hereafter referred to as forest impacts). It is important to note, however, that the elements of monitoring, review, and feedback contained in adaptive management will be more generally applied to the cap-and-trade regulation to ensure that all of its objectives, including GHG emissions reductions, are achieved. Accordingly, the focused adaptive management plan in this document must be viewed in the larger context of our planned oversight of the cap-and-trade regulation which includes comprehensive monitoring of auctions, reserve sales, allowance holdings, compliance offset credits generation and use, reported emissions, leakage, and other aspects of the program.

The plan includes a description of what is meant by adaptive management, ARB's objectives in implementing the plan, and a process for systematic data compilation, evaluation, and public review. The key elements of this adaptive management plan are: (1) data and data source identification (information gathering); (2) analysis to determine whether an adverse impact is caused by the cap-and-trade regulation (review and analysis); and (3) identifying potential actions ARB could take to address these impacts and committing to take appropriate action (response).

Staff anticipates that data gathering will be straightforward. The work of review and analysis, however, will be challenging because there could be many reasons for a change in localized air emissions or forest management practices. Examples are a change in laws unrelated to the Regulation; economic growth related to recovery from the economic downturn; adoption of a new technology within an industry; and increased consumer demand for a specific product.

Under the plan, ARB staff would work with the local air districts where facilities subject to the Regulation are located in an effort to refine a specific, systematic approach for efficiently compiling, interpreting, and evaluating the data. Because ARB is not expert

in forestry practices, ARB plans to contract with an independent third-party (ARB contractor) to assist it in determining the best ways to filter and analyze the data needed to evaluate potential, unanticipated impacts related to forestry.

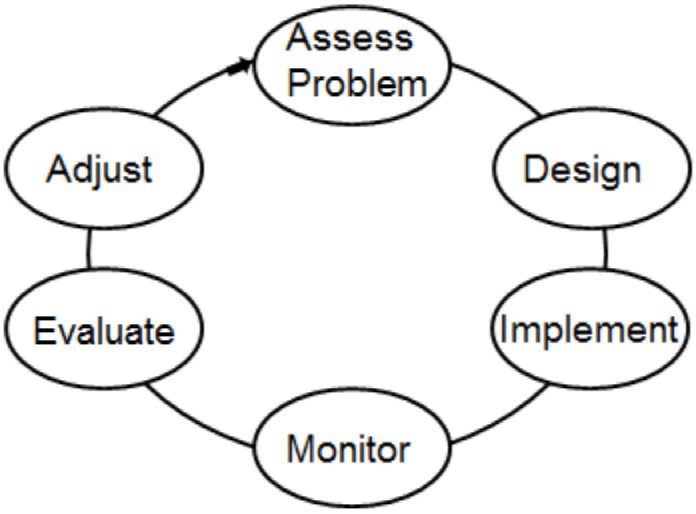
ARB will consider approval of this plan at the October 20-21, 2011, Board meeting. Upon Board approval, ARB will work with the local air districts, resource agencies, and stakeholders to implement the plan. The timeline for completion of this work is before the beginning of the first compliance period in January 2013. The first adaptive management report is planned for December 2012, and will focus on the first phase of implementation. Annually thereafter, staff will provide reports to the public and the Board on the implementation of the adaptive management plan. The annual adaptive management plan reports will, among other things, outline the data collected and the trends observed, and discuss any recommended responses.

III. Adaptive Management

Adaptive management is a process of information gathering, review and analysis, and response that promotes flexible agency decision-making. It is particularly appropriate where complex systems are involved, where the effects of an agency's decisions and actions play out over an extended period of time, and where the agency must meet multiple objectives – as in the case of the proposed Regulation. Adaptive management is consistent with ARB's long-standing approach to program implementation which incorporates on-going evaluation of how programs and regulations are implemented on the ground, regular updates to the Board, and adjustments to program implementation and regulatory requirements, as necessary.

Figure 1, representing the adaptive management process, illustrates how new information is used to refine and adjust agency action to continually meet its defined objective[1].

Figure 1: Adaptive Management Process



Implementation of the cap-and-trade regulation is expected to begin in January of 2012 (assuming it is approved by the Board). Using the adaptive management approach, ARB will assess whether there are unanticipated, adverse localized air quality or forestry impacts from the Regulation or U.S. Forest Protocol and evaluate the data discussed in this plan for indicators of unintended adverse impacts. If adverse impacts in these areas are found and demonstrated to be the result of the Regulation or U.S. Forest Protocol, ARB is committed to taking appropriate action and adjusting the operation of the program to minimize the effect or occurrence of the action that caused the impact.

A. Objectives of ARB's Adaptive Management Plan

The objectives of ARB's adaptive management plan include:

- Identify potential localized emission increases and forest impacts caused by the cap-and-trade regulation.
- Establish a process to address unanticipated adverse local air quality and forest impacts.
- Keep the public and Board informed of impacts attributed to the cap-and-trade regulation.

[1] United State Department of the Interior: http://www.doi.gov/initiatives/AdaptiveManagement/whatis.html

The strategies that ARB will employ to achieve these objectives include:

- Identify data sources.
- Use data to assess if there has been or is anticipated to be an increase in localized emissions or change in forest ecology.
- Assess if the change is caused directly, or indirectly, by the cap-and-trade regulation.
- Use data to assess if there has been or is anticipated to be an adverse impact.
- Share data and reports with the Board and public annually.
- Report to the Board as needed but, at a minimum, annually in conjunction with the issuance of the annual adaptive management plan report.
- Take appropriate action to address any adverse impacts related to localized emissions or forestry caused by the Regulation.

B. Questions that Frame Review and Analysis Under the Adaptive Management Plan

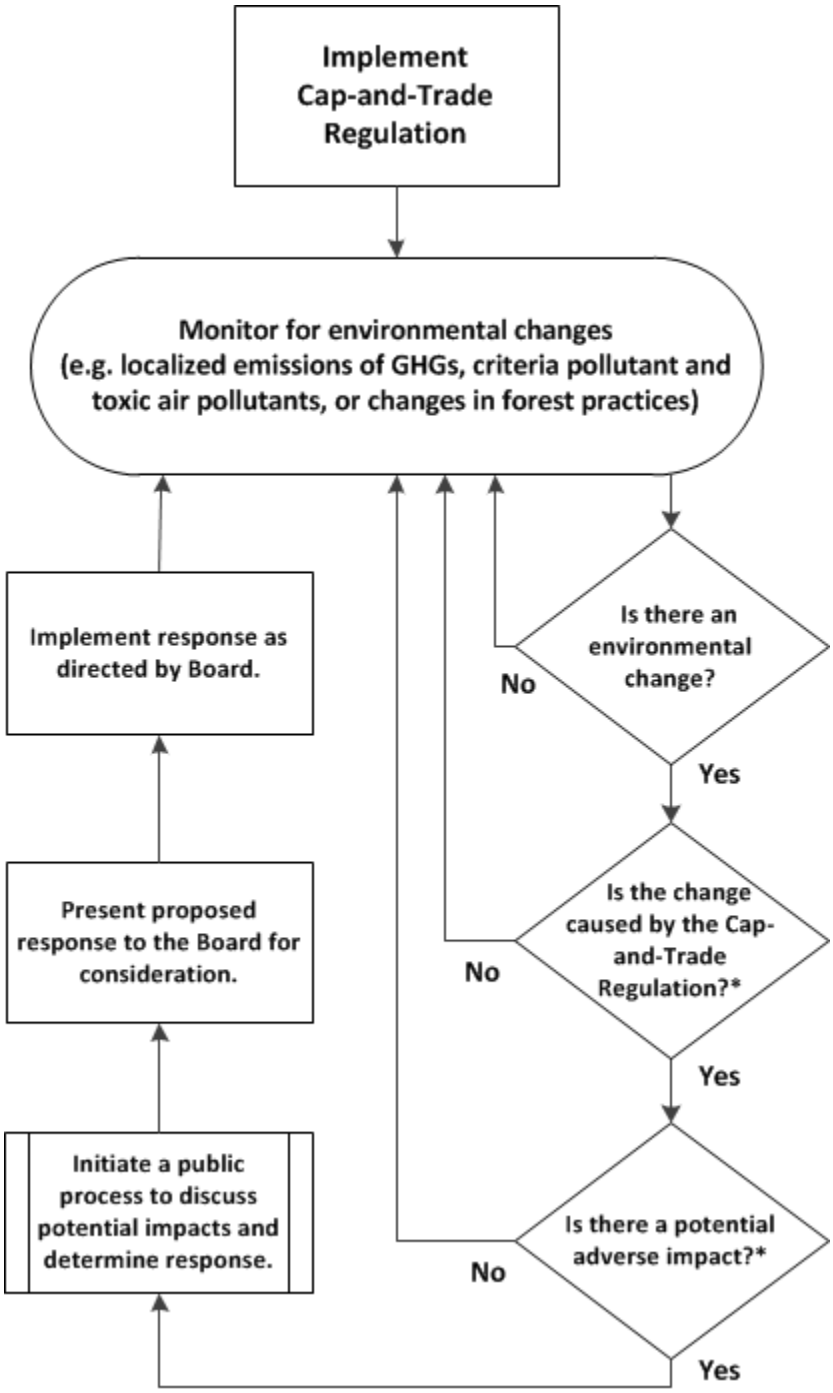
The key questions that must be answered on an on-going basis by the adaptive management plan are:

- Has an environmental change (e.g., increase in emissions or transition in forest practices used) occurred?
- Is the environmental change caused, directly or indirectly, by the cap-and-trade regulation or U.S. Forest Protocol?
- Has the environmental change had an adverse localized air quality or forest impact?
- What action could ARB take to address an adverse impact linked to the cap-and-trade program or U.S. Forest Protocol?

The key elements of this adaptive management plan are: (1) data and data source identification (information gathering); (2) analysis to determine whether an adverse impact is caused by the cap-and-trade regulation (review and analysis); and (3) identifying potential actions ARB could take to address these impacts and committing to take appropriate action (response).

Figure 2, representing the flow of ARB's adaptive management plan, illustrates how ARB will implement adaptive management, monitor and evaluate data, and make adjustments to the Regulation, if necessary.

Figure 2: ARB Adaptive Management Plan Flow Chart



* These questions will be addressed based on the evaluation of a range of data sets and will involve technical judgment and other available tools and methods.

IV. Information Gathering

In this section, ARB discusses the information to be gathered for review and evaluation. Because this section discusses at various places why staff is gathering certain data – that is, why it is relevant – this section also necessarily previews the next section on analysis and review.

A. Localized Air Quality Data

ARB identified data sources for the evaluation of potential localized air quality impacts. These include GHG inventories, traditional criteria pollutants and air toxics emissions data, local air district or state agency permit information, air monitoring data, special monitoring studies, and other sources of data including new cap-and-trade program specific data such as GHG emissions, and the use of allowances and compliance offset credits to comply with the Regulation. If the Board approves this plan, ARB will work with local air districts and stakeholders to finalize specific details concerning data gathering, including the best means to transmit, filter, and analyze the data for localized air quality impacts, and complete the details before initiation of the first compliance period in January 2013.

It is important to remember that many factors can cause changes at facilities, and that once an increase has been detected, additional sources of data must be used to assess if the increase is the result of the cap-and-trade regulation. Below are a number of sources of information that ARB will consider in determining if an adverse impact resulting from the cap-and-trade regulation has occurred or will occur. As ARB implements the adaptive management plan, it may find additional sources of data to include or it may find that some sources of data are not useful to continue to monitor.

1. Greenhouse Gas Mandatory Reporting Regulation (MRR)

Reporting of annual GHG emissions by major sources is required by AB 32. ARB approved the MRR in December 2007, and it became effective in January 2009. Revisions to the regulation were considered by the Board at its December 2010, Board hearing, and ARB staff is proposing additional modifications based on Board direction and stakeholder comments, prior to finalizing the regulation for 2012 reporting. More on the MRR can be found at:

http://arb.ca.gov/cc/reporting/ghg-rep/ghg-rep.htm

The current MRR requires reporting emissions of six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6). It is applicable to: facilities in California that generate 25,000 metric tons of CO_2 per year ($MTCO_2$/year) or greater; electrical generating facilities that produce 1 megawatt (MW) or greater, or that generate 2,500 $MTCO_2e$ or greater per year; and retail providers and marketers of electrical power. Facilities report directly to ARB, and are required to use the methodologies in the MRR,

providing consistency across the State. The first reporting year was in 2009 (for 2008 data, which was not third-party verified). Beginning in 2010 (for 2009 data), the reported data were subject to third-party verification by ARB-accredited verifiers, which requires that data are reported within ninety-five percent accuracy. For 2010 (2009 data), about ninety-five percent of all reporting facilities were able to report their data with less than five percent error. The verification deadline is currently December 1.

The pending, proposed amendments to the MRR cover three GHGs: CO_2, CH_4, and N_2O. The other gases that were previously covered are proposed to be covered in various new regulations (e.g., high global warming potential gases and SF_6 regulations). The proposed amendments are applicable to: facilities in California that generate between 10,000-25,000 $MTCO_2e$/year (no verification) and 25,000 $MTCO_2e$/year or more (verification required); fuel and CO_2 suppliers; and electric power entities. The first reporting year is in 2012 which will include 2011 emissions data that are third-party party verified. The verification deadline will be September 1 starting in 2012 and continuing in future years.
`

The GHG MRR database involves the collection of total annual combustion emissions for a facility by fuel types and includes specific chemical process emissions. Device-level emissions are limited in most cases. Thus, MRR GHG data are summarized at a higher level than the criteria pollutant California Emission Inventory Development and Reporting System (CEIDARS) inventory, which is available at the device and process level. However, the GHG data are reported annually and available approximately nine months after the end of the inventory year making it the most current data source in any year. Due to differences in the level of detail in data collected from these two sources, it may be difficult to evaluate consistency in emissions trends.

The MRR data could be used to track increases in GHG emissions, or equipment changes at facilities covered under the proposed Regulation, identify fuel type changes, and help point to potential impacts resulting from co-pollutants.

2. Compliance Instrument Tracking System

The Compliance Instrument Tracking System will contain the records of compliance instrument ownership for the Regulation. It will contain information related to accounts, record compliance instrument transfers, facilitate compliance verification, and support market oversight. Reviewing the number of compliance offset credits and allowances held by facilities covered by the proposed Regulation could provide information on potential plans to increase emissions at a facility. It is important to note that holdings in these accounts are confidential data, and therefore, this information will not be publicly available, but can be monitored by ARB staff.

3. Local Air District Permits for Covered Entities

Local air districts permit stationary sources that are sources of air pollutants. These permits are required prior to construction of new facilities or modification at existing

facilities subject to local air district regulations. Additionally, the facility must maintain its permit and continue to abide by the restrictions contained therein to continue to operate.

Local Air District Existing Permits

The permitted level of emissions is typically based on the maximum expected throughput or maximum rated capacity of a piece of equipment or process. It is possible that emissions increases could occur at a facility and the facility would still meet the legal requirements of their operating permit. Because of this, permit activity will not show increases that may have occurred within the conditions legally authorized by the existing permit(s). However, information from these permits could still provide valuable insight into whether a facility covered under the proposed Regulation has, or could, increase emissions by understanding emissions trends for existing facilities.

Local Air District Permits to Modify Facilities Covered by Cap-and-Trade Program

When construction of a new facility, or modification to an existing facility, is proposed, the facility operator must apply with the local air district for permission to construct most equipment that will emit criteria or toxic pollutants. This permission is known as a permit to construct or authority to construct. Not all proposed facilities that are issued a permit or authority to construct are constructed.

A local air district conducts an engineering evaluation on the equipment and processes in the permit application to determine the potential emissions. The proposed construction is evaluated for emissions of criteria pollutants and local impacts of emissions of toxic air pollutants, if applicable. The project is typically subject to requirements under its permit conditions that reduce emissions (known as controlled emissions), depending on factors such as the attainment status of the local air district or the local impact of toxic air pollutant emissions from the project. Additionally, most projects that require a permit to construct generally are subject to the California Environmental Quality Act (CEQA). Projects that will have a significant effect on the environment must undertake feasible mitigation. It is important to note that the local air district may, or may not, be the lead agency in the CEQA assessment.

As part of this permitting process, local air districts' rules to meet federal and State requirements for new source review (NSR) programs may be applicable, especially to large sources covered under the Regulation. These rules are intended to improve or maintain a region's air quality by assuring that new emissions from new and modified facilities do not slow progress toward cleaner air or worsen air quality in regions that attain air quality standards. The best available control technology (BACT) provisions of NSR provide assurance that emissions from any large new or modified industrial source will be stringently controlled. Additionally, if new construction or modification results in the facility exceeding a district's NSR offset thresholds, then the facility must either reduce emissions elsewhere at the facility or obtain emission reduction credits (ERCs) in amounts greater than the direct emissions increase. These ERCs must be obtained from within the region or from areas close by, thus mitigating the increase in emissions at the facility in terms of regional air quality.

Working with local air districts, ARB will implement a process to track permit applications for modifications to facilities subject to the Regulation, or for construction of new facilities that would be subject to the Regulation.

4. California Energy Commission (CEC) Power Plant Permitting

The CEC permits thermal power plants that have the capacity to generate fifty megawatts (MW) or greater. Local municipalities permit those with less than a fifty MW generating capacity. Local air districts also permit power plants that are combustion sources. However, CEC and local municipality permits may provide greater advanced notice of proposed facilities. Additionally, the CEC tracks announced projects with generating capacity of 50 MW or greater that have not yet filed for review. Not all facilities that are issued a permit are constructed. ARB currently works with CEC to track permit applications for construction of new power plant facilities or modification of existing power plant facilities.

5. Economic Forecast Data

A variety of economic forecast data are available from local, State, and federal agencies. Including forecast data in the analysis will be useful for evaluating the proportion of emission changes related to economic factors. Examples of specific forecasts from agencies that could be used include economic and energy forecasts based on the estimates adopted by the CEC published in Integrated Energy Policy Reports. Examples of academic economic forecasts that could be used include the California and Metro forecast published by the Business Forecasting Center at the University of the Pacific and the UCLA Anderson Forecast published by the Anderson School of Management at the University of California, Los Angeles. ARB will use these types of economic forecasts for comparison with emissions trends to determine if emissions are consistent with changes in the economy, or in specific economic sectors. If emissions are substantially different than changes in the economy, then the data could suggest that changes in emissions are related to factors other than economic change.

6. Air Quality Monitoring Data

In California, ambient air quality is routinely measured for gaseous, toxics, and particulate air pollutants. The extensive network is designed to cover the diverse range of topography, meteorology, emissions, and air quality in California, while adequately representing a large population. In general, the network tends to be denser in areas with more severe air quality problems and in areas with larger populations. The monitoring stations are operated by ARB, local air districts, the National Park Service, and private contractors.

The data collected by the monitoring network are used to track air quality progress, evaluate emissions inventory and air quality models, analyze neighborhood or regional source attribution, and evaluate the success of emission control programs. The

measured data form a backbone for air quality management programs, provide the public with information on current conditions and progress in improving air quality, and are used by health researchers, business interests, environmental groups, air quality planners, and others.

The ambient air quality monitoring network captures data representative of a broad range of sources and regions throughout the State. Monitors are designed to represent pollutant levels on different spatial scales, ranging from near-source localized impacts up to broad regional-scale conditions. Although a few monitors are located so they will represent small areas dominated by specific local sources, most monitors are designed to represent the combined impact of multiple, distributed sources over the scale of a neighborhood or city or more. Thus, detecting the impact of changes at an individual facility can be difficult.

Monitors are also designed to represent different periods of time. A number of pollutants, including gaseous pollutants such as ozone (O_3), oxides of nitrogen (NO_x), and carbon monoxide (CO) are reported hourly. Many other pollutants, such as particulate matter (PM), hydrocarbons, and toxics are typically measured as 24-hour averages on a less-than-daily schedule. Hourly values can sometimes be used to represent a significant source by selecting hours when the monitor was downwind of that source. Daily values, however, usually represent a varying mix of wind directions, so the impact of a specific source is harder to detect.

Levels of air pollutants fluctuate from year-to-year for various reasons, including changes in human activity and differences in weather conditions. A longer term record of measurements at a monitor helps establish the expected level of variability. Special studies in which monitors operate for a few years often lack the track record needed to assess this variability and thus may have less utility in tracking the impacts of emission changes.

ARB reviews data collected as part of the routine network and evaluates air quality trends on an ongoing basis. ARB will use this data to assess, within the context of normal air quality variability, whether any unusual trends are being observed. Staff will also work with local air districts to review and evaluate data from localized monitoring networks and special studies.

The following sections describe the various types of air quality monitoring networks that are currently operating in California, data from which will be considered under the adaptive management plan.

<u>Statewide Criteria Pollutant Monitoring Network</u>: The statewide criteria pollutant monitoring network consists of more than 250 monitoring locations with over 700 monitors that measure O_3, PM, NO_x, sulfur dioxide (SO_x), CO, hydrogen sulfide (H_2S) and lead. Each site in the monitoring network includes a combination of one or more monitors that collect either continuous or non-continuous air quality data. As mentioned above, gaseous monitoring data for O_3, NO_x, SO_x, CO, and H_2S, are collected hourly.

Lead monitoring data and most particulate monitoring data reflects a 24-hour average which is collected on schedules ranging from daily, up to once every sixth day. A subset of particulate monitoring sites also collect hourly data. Data for pollutants that are directly emitted, such as PM, SO_x, and CO, tend to represent concentrations over a smaller area, such as a neighborhood. In contrast, data for pollutants that are formed in the atmosphere, such as O_3, generally represents larger scale regions such as a city or county.

Statewide Toxics Monitoring Network: The statewide toxics monitoring network includes 17 sites that collect 24-hour samples two or three times each month. This network collects data for cancer-causing compounds, such as benzene, 1,3 butadiene, and formaldehyde. Data for toxic metals such as arsenic, cadmium, and chromium are also collected. The toxics monitoring network is focused on major urban areas of the state and the sites are generally co-located with other criteria pollutant monitoring. As such, the toxics network represents the combined emissions of widespread and distributed sources, rather than localized emission impacts from individual sources.

Additional toxics monitoring has been conducted by some local air districts for special purposes, some short-term, and some for ongoing interests. The South Coast Air Quality Management District and the Bay Area Air Quality Management District have been especially active in this respect. These data can assist in evaluating trends in ambient air toxics as a comparison to changes observed at covered facilities.

Localized Monitoring Networks: In addition to ARB's long-term statewide ambient monitoring network, there are several source-oriented monitoring networks that are operated by local air districts. These networks are intended to manage air quality improvement efforts and to discern near source, localized air quality impacts (from refineries, ports, and industries within communities). This data can assist in evaluating trends in ambient air quality as a comparison to changes observed at covered facilities. Some selected examples of the near-source programs are:

Bay Area Refinery Monitoring Program: The Bay Area Air Quality Management District (BAAQMD) Regulation 9 requires monitoring of SO_2 and H_2S near potential major sources of either pollutant. Each of the five oil refineries as well as an associated carbon plant within the BAAQMD jurisdiction is subject to Regulation 9 as a condition of their BAAQMD operating permit. Covered facilities are required to operate a minimum of three Ground Level Monitoring (GLM) sites with instruments capable of recording pollutant concentrations in the ambient air outside of the property line of their facility.

There are twenty GLM monitoring sites surrounding the covered facilities in the Bay Area. Five of the facilities covered are located in northwest Contra Costa County and one is located in southwest Solano County. Of the twenty GLM sites, thirteen have instruments that monitor both SO_2 and H_2S, five measure H_2S only, and two measure SO_2 only. This network has been operational for the last ten to

fifteen years, though location and site conditions may have changed over this time period.

South Coast Ports Monitoring: This monitoring network, operated by the Ports of Long Beach and Los Angeles, measures air quality at the ports and nearby communities to better manage local air quality improvement efforts. Monitoring was initiated at both ports in 2006. O_3, CO, NO_x, SO_x, and PM are collected on a real-time basis. The Port of Long Beach operates two monitoring stations: one in the Inner Port area, near West Long Beach, and the second in the Outer Port area, near the breakwater. The Port of Los Angeles operates four monitoring stations, located in the Outer Harbor area at Berth 47, at the Terminal Island Treatment Plant, in the community of San Pedro, and in the community of Wilmington. The six-monitor network was developed under the Green Port Policy.

South Coast Lead Monitoring: The South Coast Air Quality Management District has collected lead data for a number of years at five sampling sites located near lead-related facilities that were established as part of the District's Rule 1420 (Emissions Standard for Lead). The purpose of Rule 1420 is to reduce lead emissions from non-vehicular sources. It applies to all facilities that use or process materials containing lead, including primary or secondary lead smelters, foundries, lead-acid battery manufacturers or recyclers, as well as facilities that produce lead-oxide, brass, and bronze. The samplers are located at or beyond the property line of the facility and comply with United State Environmental Protection Agency (U.S. EPA) siting and operating criteria. Lead samples are generally collected on a 1-in-6 day schedule, although samples are collected more frequently at sites with the highest concentrations.

Special Studies: A subset of monitoring is special studies conducted by ARB or local air districts. The information obtained from these types of studies may be helpful in establishing "initial conditions. If additional follow-up studies are undertaken (i.e., MATES III was a follow-up to MATES II), then the data collected may provide a useful input in establishing changes in conditions (depending upon the design and location of follow up studies). The following describes two of these special studies conducted by local air districts. In addition, ARB special studies, including those using mobile monitors, may provide additional sources of data.

Multiple Air Toxics Exposure Study III (MATES III): The Multiple Air Toxics Exposure Study III (MATES III) was a monitoring and evaluation study conducted in the South Coast Air Basin (Basin). The study is a follow on to previous air toxics studies in the Basin and is part of the South Coast Air Quality Management District Governing Board's Environmental Justice Initiative. The study consists of several elements, including a monitoring program, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize risk across the Basin. It focuses on the carcinogenic risk from exposure to air toxics.

A network of ten fixed sites was used to monitor toxic air contaminants once every three days for two years. The location of the sites was the same as in the previous MATES II Study to provide comparisons over time. The one exception was the addition of the West Long Beach site. In addition to the fixed sites, five additional locations were monitored for periods of several months using moveable monitoring platforms. These micro-scale sites were chosen to determine if there were gradients between communities that would not be picked up by the fixed locations. Over 30 gaseous and particulate air toxics were measured.

Community Air Risk Evaluation (CARE) Program: The CARE program was initiated in 2004 by the Bay Area Air Quality Management District to evaluate and reduce health risks associated with exposures to outdoor toxic air contaminants in the Bay Area. The program is being carried out in three phases.

The goal of Phase I was to develop an emissions inventory for year 2000 and compile demographics and health statistics in order to identify high sites and locations of sensitive populations. In Phase 1, an annual emissions inventory was developed for diesel PM, benzene, formaldehyde and other toxic air contaminants (TACs) for localized areas. Additional studies conducted to verify TAC emissions estimates and improve the Bay Area toxic inventory include a telephone survey of residential wood burning, a carbon-14 analysis to determine new versus old carbon fractions in the ambient air, a chemical mass balance (CMB) study to estimate the source contributions to various ambient PM compounds, and a CMB analysis of organic PM compounds.

The goal of Phase II was to improve the TAC inventory and begin preliminary regional (Bay Area) and local (priority communities) scale modeling to estimate significant sources of diesel PM and TACs. Using regional modeling, the CARE program identified areas within the Bay Area, where high TAC exposures of sensitive populations–youth and seniors—intersect areas with high TAC emissions and areas with high poverty levels. This analysis identified six impacted communities where special studies, grant funding, emission reduction efforts, and enforcement actions have been focused TAC emissions reduction measures are in place throughout the Bay Area but, through the Bay Area Air Quality Management District's *Mitigation Action Plan*, special attention has been given to promoting and tracking progress in the impacted areas.

The goal of Phase III is to conduct an extensive exposure assessment to identify and rank the communities as to their potential TAC exposures, and determine the types of activities that place them at highest risk. The District will also pursue additional mitigation measures and provide a metric to assess their effectiveness in reducing overall exposure.

7. Continuous Emissions Monitors (CEMs)

Many large industrial facilities have continuous emissions monitors (CEMs) installed on equipment that are sources of air pollutants. As the name implies, CEMs units continuously monitor the concentrations of pollutants in the exhaust stream of the emission source. Typically, these monitors are required by the local air district's permit to operate, or rule provisions, to ensure that the equipment does not violate the permit conditions.

Local air districts receive data from CEMs units that are in place to satisfy permit or rule requirements. ARB will work with the local air districts to determine whether CEMs data would be useful for identifying overall facility emissions and, if so, ARB will include it in the adaptive management process.

8. Criteria Pollutant and Toxic Contaminant Emissions Inventory Databases

In addition to the GHG inventories discussed above, ARB and local air districts develop inventories of criteria pollutant and toxic contaminants. These emission inventories are used in a multitude of air quality programs to understand the relative contribution of sources, to develop control strategies for State Implementation Plans, track regional progress towards air quality goals, conduct risk assessments, and support regulatory development. Inventories are calculated estimates of emissions that are released from sources into the air where they disperse. When used in combination with other sources of data, such as economic activity and trends, ambient air quality, facility permit data and more specialized air quality data or studies, inventories can be helpful in understanding potential changes and impacts on the air quality of regions and sub-regions.

As part of the State's comprehensive inventory development process, local air districts collect emission information directly from the facilities and businesses that are required to obtain an air pollution operating permit. That data includes information about the nature of the facility's processes, the location of the facility, the type of pollutants emitted and the mass of the pollutants emitted. Facilities work with their respective local air districts to determine the best methodology to estimate their emissions, and the methodologies for estimating criteria pollutant emissions may vary across districts. Local air districts report the criteria pollutant data to ARB annually. Emission inventories of toxic pollutants are developed in a similar way and are collected through the Air Toxics "Hot Spots" Program. Local air districts collect toxic inventory data and report it to ARB every four years as defined by California statute.

It is important to note that inventories in general represent calculated estimates of emissions, except where facilities are required to use CEMs to measure emissions from stacks. For the most part, facilities (and broader source categories) rely on average emission factors and estimates of activity to determine the total estimated emissions. For these reasons, inventories are most useful for understanding relative contributions

and long term trends, inventories are not generally designed to detect day-by-day or even month-by-month changes.

In addition, many external factors can influence the variability in emissions, and it is essential to take these factors into account when looking at emission trends. For example, a facility's emissions can vary because of changes in facility-specific product demand, fuel cost or availability, cost or availability of electric power, economic conditions; labor availability; production material availability; routine maintenance; or unusual events such as power outages or breakdowns. In recent years, the economic downturn has had a dramatic impact on activity resulting in lower emissions. As the economy recovers, a commensurate increase in emissions should be expected. Another factor that has to be considered when comparing inventories is the improvement in methods used for estimating emissions. Over time, our understanding of emission rates and activity from sources has improved substantially. With new methods, the resulting emission estimate may be different. Therefore, a change in emissions at a facility from year-to-year may be the result of a better characterization of emissions rather than a real world increase or decrease. The following sections describe some of the available emission inventory data and databases maintained by ARB. Local air districts also maintain data on their facilities; two of these are also described.

a. California Emission Inventory Development and Reporting System (CEIDARS)

The federal Clean Air Act requires states to compile emission inventories of criteria pollutants. California's statewide emissions inventory is maintained by ARB, and is populated with data submitted by the local air districts, as well as that collected by ARB. The criteria pollutant emission inventory includes information on the emissions of reactive organic gases (ROG), NO_x, SO_x, CO, and PM. Data are gathered on an ongoing basis and stored in CEIDARS. A summary of the criteria pollutant inventory is published in ARB's Air Quality and Emissions Almanac. More information on CEIDARS and the Almanac can be found at:

http://www.arb.ca.gov/ei/general.htm

http://www.arb.ca.gov/aqd/almanac/almanac.htm

CEIDARS contains California's comprehensive inventory and includes information on approximately 13,000 individual facilities such as electric power plants and refineries. There are also about 135 aggregated point source categories. Aggregated point sources are not inventoried as individual facilities but are estimated as a group and reported as a single source category (e.g., gas stations and dry cleaners). In addition to individual facilities, CEIDARS includes approximately 80 source categories made up of sources of pollution, such as architectural coatings and consumer products, spread across a region and mobile sources - all on-road vehicles such as automobiles and trucks; plus off-road vehicles such as trains, ships, aircraft; and farm equipment.

Emission estimates within CEIDARS are based on a snap-shot of a variety of dynamic and variable processes. The data in CEIDARS represent annual average estimates for a specific calendar year. Annual average emissions are stored for each county, air basin, and district. There is also a Facility Search Tool that provides direct access to the year-by-year emissions reported for individual facilities, both criteria and toxics:

http://www.arb.ca.gov/app/emsinv/facinfo/facinfo.php

CEIDARS data can be used to look at trends in emissions as a comparison to observed changes at covered sources.

b. California Toxic Inventory (CTI)

ARB collects toxic emissions from thousands of facilities in California. The CTI provides annual average estimates of toxic emissions and is updated every four years. CTI data is stored in CEIDARS (described above).

Toxic pollutant emissions from stationary sources include point source data provided by local air districts pursuant to the Air Toxics “Hot Spots” Program (AB 2588). The Air Toxics "Hot Spots" Information and Assessment Act (AB 2588, 1987, Connelly) was enacted in 1987, and requires stationary sources to report the types and quantities of certain substances routinely released into the air. The goals of the Air Toxics "Hot Spots" Act are to collect emission data, to identify facilities having localized impacts, to ascertain health risks, to notify nearby residents of significant risks, and to reduce those significant risks to acceptable levels.

For sources without AB 2588 data, the CTI is developed by dis-aggregating (also known as “speciating”) CEIDARS-based estimates of total organic gas (TOG) and PM for area, mobile, and natural sources using the most recent speciation profiles. Speciation profiles provide species-specific mass ratios (i.e., chemical-species-to-total TOG or PM) and are based on source tests from representative emission sources. The “speciated” emissions for each source category are then reconciled with reported stationary point source toxics data to establish a complete inventory. More information on the CTI can be found at:

http://www.arb.ca.gov/toxics/cti/cti.htm

CTI data can be used to evaluate trends in emissions of air toxics as a comparison to observed changes at covered sources.

c. Data for Non-vehicular Source, Consumer Products and Architectural Coatings Fees

The Health and Safety Code authorizes ARB to impose additional fees on non-vehicular sources (facilities) that emit 250 tons or more per year of any nonattainment pollutant or its precursors. While the data used for the fee program

initially comes from ARB CEIDARS database, ARB provides the facilities and the local air districts an opportunity to update and correct emission estimates. These updates are more current than the annual criteria pollutant submittals. The fee program includes approximately 60 facilities. These fees are used by ARB to mitigate or reduce air pollution created by non-vehicular sources in the State.

http://www.arb.ca.gov/ei/nscpac_fees/nscpac_fees.htm

This data provides another source of emission data that can be compared to observed changes at covered emission sources.

d. South Coast AQMD Annual Emission Reporting (AER) Program

The South Coast Air Quality Management District's Annual Emission Reporting (AER) program was developed to track emissions of air contaminants from permitted facilities. The data collected by AER is used to update the comprehensive emissions inventory for the District, which includes Orange County, the non-desert portions of Los Angeles and San Bernardino counties, and the Riverside county areas west of the Palo Verde Valley. Fees for emissions of air contaminants are assessed based on the reported data. These fees help to cover the costs of evaluating, planning, inspecting, and monitoring air quality efforts. Under this program, those who emit more, pay more toward air pollution control efforts – and at the same time are given an incentive to reduce emissions. On January 1, 2008, the South Coast Air Quality Management District moved AER from a fiscal year basis (July 1 through June 30 of the following year) to a calendar year basis (January 1 through December 31 of each year). The compiled inventory is published in each update of the Air Quality Management Plan. More on the AER can be found at:

http://www.aqmd.gov/aer/aer.html

e. South Coast AQMD RECLAIM Program

The REgional CLean Air Incentives Market (RECLAIM) program is a cap-and-trade program operated by the South Coast Air Quality Management District. It encompasses most of the Basin's largest NO_x and SO_x stationary sources. It was developed to make significant progress in cleaning up the worst air in the nation. It is a multi-industry program with each facility having annual allocations and declining balances. Developed in the early 1990s, RECLAIM was seen as an innovation compared to previous command-and-control programs. Benefits included lower costs and greater flexibility for industry participants, and secured emission reductions with better emissions monitoring for environmental and community interests. More information on RECLAIM can be found at:

http://www.aqmd.gov/reclaim/index.htm

Nearly 80 percent of emissions under RECLAIM are from major sources, which are monitored by CEMs. Therefore, the accuracy of these emission data is of utmost importance in determining if RECLAIM is achieving its emission goals. In order to assure the highest accuracy, several checks are imposed on CEMs – initial certification and re-certification when modified, daily calibration checks, routine quality assurance and quality checks (QA/QC), and a semi-annual relative accuracy test audit (RATA).

B. Forest Data

ARB identified data sources for the evaluation of potential forest impacts caused by the U.S. Forest Protocol. Some of the data sources described below are readily available and some are expected to be available at a later date. ARB expects that it will be able to review and analyze some of the data sets without expert assistance. Other data sets require ARB to work with other State agencies and academia, as well as out-of-state resource agencies to interpret the data, and to conduct further analysis using the data.

In 2012, ARB plans to hire a contractor to develop a process to track data to detect environmental changes resulting from the U.S. Forest Protocol. ARB will also coordinate with and utilize the forestry expertise of the resource agencies during the implementation of this adaptive management plan. By working with these forestry experts and stakeholders, ARB can best ensure that the robustness of the adaptive management approach for the U.S. Forest Protocol is equal to that of the adaptive management approach for local air quality. Details as to how the data will be used will be developed through the work of the ARB contractor and the expertise of the resource agencies. That process is further described in the Review and Analysis section of this plan.

1. U.S. Forest Protocol Project Data

The proposed Regulation requires reporting of information on the performance of the forest offset projects prior to the issuance of compliance offset credits. Data reported under the U.S. Forest Protocol includes summarized forest project monitoring data, an annual update of the project's forest carbon inventory that calculates the amount of GHG reductions and carbon sequestration. This information will be in the offset project data annual report.

ARB will collect U.S. Forest Protocol data for each individual forest project. This information will be submitted annually by the project developer to ARB through the annual report. Forest project developers will assemble the annual report, and then submit it for verification to ARB or an accredited registry, and it must be verified by an ARB-accredited third party offset project verifier. ARB will not obtain this forest project level data until the first annual report is submitted during the first reporting cycle in 2013.

Based on the project type, the annual report will contain the following forest project information where applicable:

- Forest project name, location, type of project and project operator.
- Reporting period.
- Ownership, including any changes in ownership.
- Statement of compliance with all applicable laws and regulations.
- Estimated carbon stocks in all required carbon pools.
- Explanation of any decrease over a 10-year consecutive period in the standing live carbon pool.
- Description of how the project meets the definition of natural forest management.
- Projections of baseline and actual harvesting volumes from the forest project area over a 100 year period.
- Estimate of harvest volumes and associated carbon in harvested wood products.
- Estimate of mill efficiency.
- Baseline carbon estimates for all carbon pools.
- Uncertainty discount for avoided conversion projects.
- Forest carbon inventory (updated annually) following all required protocol calculation methodologies and models.
- Calculation of carbon sequestration and GHG reductions.
- Calculation of GHG removal enhancements.
- Description and explanation of the unintentional "reversal."[2]
- Reversal risk rating.
- Calculation of Forest Buffer Account contribution.

This information will be useful to get a better understanding of each forest project. Each forest project is unique and may not have the same ecosystem characteristics to make comparisons amongst forest projects. Using the annual report data, ARB will work with the ARB contractor to implement a specific process to review the data sources and track data to assess potential forest impacts.

2. Forest Buffer Account Information

Due to the possibility that forest projects could unintentionally "reverse" their carbon storage because of wildfire, pest infestation, or disease, negating the benefits of those projects, ARB will create and maintain a Forest Buffer Account holding a percentage of ARB-issued compliance offset credits from forest offset projects. ARB will annually monitor the number of compliance offset credits in the Forest Buffer Account as it relates to the number of reported reversals.

The Forest Buffer Account is a mechanism to replace offset credits in the event of an unintentional reversal, thereby insuring that GHG reductions reflected in offset credits

[2] "Reversal" refers to an event that abruptly releases stored carbon, such as a high intensity wildfire.

are permanent. A portion of the offset credits issued to forest projects must be placed into the Forest Buffer Account to cover unintentional reversals.

3. Greenhouse Gas Mandatory Reporting Regulation (MRR)

In addition to the reporting of GHG emissions from fossil fuel combustion, the MRR also requires reporting of CO_2 emissions from biomass derived fuels, including forest biomass. As part of the recent proposed modifications to the MRR, ARB addressed stakeholder concerns related to potential increased use of forest-derived wood and wood waste. In the MRR, end users of solid biomass fuels would report the mass of fuel consumed by fuel type, and end users of forest biomass would also report location of forest biomass used.

4. ARB's Updated GHG Statewide Inventory for Forests

ARB is responsible for developing and maintaining California's statewide GHG emission inventory, which includes a sector on GHG emissions and atmospheric sequestration of CO_2 from forests and rangelands. ARB is working with U.C. Berkeley to develop a next-generation GHG inventory system for forests, rangeland, and other wildlands statewide. The contractor will develop procedures to use in combination with ground-based biometric data from the U.S. Department of Agriculture - Forest Service Forest Inventory and Analysis plots, satellite remote sensing data, and other data on disturbance processes (fire, harvest, land use conversion, etc.). This data will be used to develop estimates of CO_2 uptake and GHG emissions across the landscape statewide (at appropriate spatial and temporal scales).

5. California Forest Practices Act as Administered by CalFire

The California Forest Practices Act provides a CEQA functional equivalent process for reviewing and permitting timber harvests. This process evaluates project-level and cumulative impacts (usually at a planning watershed scale) to ensure that all impacts are mitigated to a level less than significant. Impacts to State and federally listed and non-listed species and their habitats, and water resources (e.g., watercourses, lakes, marshes, meadows and wet areas; water supply; watersheds; riparian areas) are considered, as well as soils, archaeological resources, and hazards from wildfire, insects and disease. The California Department of Forestry and Fire Protection (CalFire) inspects projects to evaluate compliance with prescribed mitigations and timber restocking, and corrective action is taken if necessary to ensure satisfactory project completion. Large landowners must develop long-term landscape-level management plans and provide regular reporting to CalFire on compliance with projected levels of timber harvesting. Some landowners also conduct ongoing surveys or monitoring of habitat or water quality at the request of other state agencies.

6. Timber Yield Tax and Harvest Values Schedules

The California State Board of Equalization has a Timber Yield Tax program that sets harvest values of timber and collects an in lieu tax when it is harvested. This data is aggregated by county and provides forest land ownership and timber harvest volumes.

7. Fire and Resource Assessment Program (FRAP)

CalFire implements the FRAP program that conducts periodic assessments of California's forests and rangelands. The forest and range assessment report includes a detailed assessment of ecosystem characteristics within California's forests.

For the 2010 assessment, FRAP's analytical framework is based on defining assets and threats specific to each subtheme. Geographic information systems (GIS) technology is used to combine or "overlay" assets and threats, to determine areas of both high value and high threat. These priority landscapes rank areas for where action is needed in terms of applying various tools that can result in the desired future landscape condition. The 2010 Assessment will also take into consideration various existing planning efforts, ranging from statewide plans (i.e., California's Wildlife Action Plan) to Community Wildfire Protection Plans. The final Assessment product will combine qualitative, quantitative, and geospatial data.

8. Geographic Information System (GIS) and Geodatabases

Several GIS databases are available that report activities and processes occurring on federal, State, and private forest lands in California. These include activities such as timber operations (i.e., road building, thinning, harvest, replanting) and non-timber related activities (i.e., prescribed burning, salvage logging in areas hit by wildfire, replanting, and treatment for disease/pest infestations). Fires of all categories are also carefully mapped using GIS.

<u>CalFire - Forest Practice GIS</u>
CalFire's Forest Practice GIS captures current and historic timber harvesting activities for over 4 million acres of California timberland. These data layers include silviculture, yarding, new road construction, watercourse classifications, and timberland conversions, which are tracked through GIS. Once in GIS, this information can be graphically represented on maps and is available for the analyses of local and regional cumulative impact assessments, and to meet the requirements of California's Forest Practice Rules.

Available geodatabases and GIS data layers include: Timber Harvesting Plans from 2000 to 2010; non-industrial timber management plans from 1991 to 2010; and notice of timber operations from 1991 to 2009.

U.S. Forest Service, Region 5 - GIS Clearinghouse
The U.S. Forest Service clearinghouse developed a geodatabase that maps activities (i.e. harvest, thinning, vegetation fuels management, reforestation) accomplished on national forest lands in California for the approximate period of October 2003 to December 2010.

9. Special Monitoring Projects (CalFire, Department of Fish and Game, Regional Water Quality Control Boards)

CalFire conducts a statewide monitoring program that analyzes the effectiveness of timber harvest rules and best management practices to protect water quality and also participates in cooperative instream monitoring programs in various parts of the State. Other studies are conducted by responsible State and federal agencies, including the Department of Fish and Game, Department of Conservation's California Geological Survey (previously known as the Division of Mines and Geology), and the Regional Water Quality Control Boards, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

V. Review and Analysis

ARB will take a stepwise approach to evaluating the data gathered as part of the adaptive management plan. In doing this, ARB will first evaluate data that will provide a forward look at potential emissions increases or forest impacts and is readily available to identify potential impacts at the earliest opportunity. The indicators that ARB investigates will be prioritized, or "tiered" based on the order in which they will be used to assess if unanticipated adverse impacts have occurred as a result of the Regulation or U.S. Forest Protocol. First tier indicators would indicate a potential environmental change. Second tier indicators would indicate if an environmental change was caused by the Regulation or U.S. Forest Protocol. Third tier indicators would indicate if an environmental change caused by the Regulation or U.S. Forest Protocol caused an adverse impact.

If the weight of evidence indicates that the answer to any of the following questions is "yes", then the evaluation moves to the next tier, ultimately culminating in the appropriate response to the adverse impact if all questions are answered in the affirmative. Staff will prioritize the order of investigations to answer the following questions:

1. Has an environmental change taken place?
   If yes, then;
2. Is the environmental change caused by the Regulation or U.S. Forest Protocol?
   If yes, then;
3. Has a change that is determined to be caused by the Regulation or U.S. Forest Protocol caused an adverse impact?
   If yes, then;
4. Identify the options for responding and take appropriate action.

Different indicators will be used to assess the answer to these questions. The weight of evidence available from this approach will guide ARB's conclusions on whether or not the cap-and-trade regulation was the cause of a potential adverse impact.

A. Local Air Quality Impacts

Tier 1 Indicators:
Tier 1 indicators will be used to assess if a change in operation or project development has taken place that could be caused by the Regulation (determined in the Tier 2 analysis) and could result in adverse localized air quality impacts (determined in the Tier 3 analysis). If there is a positive result in screening Tier 1 indicators, ARB will initiate the next step to investigate whether the change was caused by the Regulation. Tier 1 indicators do not rely on monitoring of criteria pollutants or toxic air pollutants but do show changes in operation or project development that could result in increases in criteria pollutants or air toxics that ARB will analyze further in Tier 2 and Tier 3 (discussed below).

Indicators

- Covered facility annual GHG emissions.
- Fuel volume, or new fuel used.
- New local air district or CEC application for permit to construct or modify submitted by a facility covered by the Regulation.
- Holdings of compliance instruments.

Example Analyses

The types of analyses that draw on Tier 1 indicators may include:

- Identify covered facilities reporting an increase in annual GHG emissions through MRR.
- Identify covered facilities reporting increased fuel volume used or a new fuel used as reported through the MRR (e.g., biomass or tires).
- Identify covered facilities reporting new equipment through the MRR; investigate use of equipment and if emissions increased due to new equipment.
- Identify covered facilities that have applied for new permits for construction or modification; investigate if the project is likely to increase localized emissions and the primary driver for the new facility or modifications (cap-and-trade regulation, efficiency, etc.).
- Identify covered facilities that are holding compliance offset credits above the amount they are expected to need for compliance.
- Identify facilities or geographic regions that show GHG emissions increases greater than expected from average economic growth.
- Identify regions in the State where facilities are located and areas where multiple facility emissions could contribute to localized air quality impacts.

No single Tier 1 indicator alone would necessarily reflect that an impact caused by the Regulation has occurred. They would only reflect that there has been, or potentially could be, an environmental change. Additional investigation would be necessary if significant change is observed in one indicator or if a variety of Tier 1 indicators reflect environmental changes.

Tier 2 Indicators:
If the analysis of Tier 1 indicators indicates that there has been an environmental change, then ARB will investigate the Tier 2 indicators to assess if the environmental change was caused by the Regulation. A positive result in screening will cause initiation of the next step.

It is likely that determining the cause of a change will require the use of multiple Tier 2 indicators. Additionally, it is highly probable that most changes will have multiple causes (e.g., growing economies, changes in world-wide manufacturing trends, etc.). Potential causes identified at this time are:

- Economic growth related to recovery from the recent recession.
- Global manufacturing trends and availability of new technology.
- Changes in a company's business model.
- Dry rainfall year leading to decrease in hydroelectric power production.
- Impacts of other regulatory programs (i.e., Renewable Portfolio Standard, reduction of once-through-cooling practices for electricity generation, federal or local regulations, etc.).
- Changes in emission factors or other methodologies used to report or calculate emissions.
- Cap-and-trade regulation.

Indicators

- Forecasted economic growth.
- Facility-specific product demand.
- Consumer demand.
- Meteorological conditions (e.g., rainfall or ambient temperature).

Example Analyses

The types of analyses that draw on Tier 2 indicator data may include:

- Assess if changes in emissions are comparable to changes in the economy or consumer demand.
- Assess if manufacturing trends or changes in common business models have occurred that may result in activities that increase emissions.
- Assess if hydroelectric power production has decreased and if fossil fuel energy production increased as a result.

- Assess if there have been any regulatory or policy changes that impacted emissions.
- Monitor industry-specific trade data to assist in determining whether/where potential changes may occur.
- Assess methodology changes in how emissions are reported or calculated.

Tier 3 Indicators:
If an environmental change is attributed to the Regulation, ARB will review Tier 3 indicators to assess if the change has had an adverse impact. An increase in NO_x at a facility with a 100 foot tall exhaust stack may have no discernable impact on the local community if the design allows emissions to disperse. However, increased toxic air pollutant emissions monitored at a facility's fence line may indicate an adverse impact. As with Tier 2 indicators, it is likely that investigation of multiple indicators will be required to assess if an adverse impact to localized air quality has occurred.

Indicators

- Criteria and toxic pollutant emissions.
- Changes in ambient air quality monitoring data:
  - Criteria pollutants;
  - Toxic air pollutants; and
  - Localized monitoring networks.
- Emissions measured in facility CEMs data.
- Emissions determined in California Clean Air Act Fee Program data.

Example Analyses

The types of analyses that draw on Tier 3 indicators data may include:

- Identify covered facilities reporting an increase in facility annual emissions (criteria pollutants or toxic air pollutants) through review of local air district emission surveys, special purpose monitoring, or CEMs data; investigate reason for emissions increase.
- Identify criteria pollutant or toxic air pollutant monitoring network data indicating increased ambient concentrations; investigate reason that monitored ambient concentrations increased.
- Compare activity reported through the criteria pollutant inventory or specialized inventories supporting programs such as RECLAIM.

B. Forest Impacts

The environmental impacts analysis in the FED concluded that increased forest project related impacts attributable to the Regulation, or the U.S. Forest Protocol are unlikely based on available data and current laws that regulate forest activities. However, ARB could not determine that increases would not ever occur. ARB, therefore, committed to use an adaptive management approach as an integral part of the cap-and-trade

program to evaluate data for potential unanticipated impacts that could be caused by the Regulation, or the U.S. Forest Protocol.

ARB will use the same approach to evaluate forest impacts as is being used for local air quality impacts. Under this proposed adaptive management plan, in 2012, ARB will hire a contractor to develop and implement a specific process to track data to detect environmental changes resulting from the U.S. Forest Protocol. ARB will also coordinate with and utilize the forestry expertise of the resource agencies during the implementation of this adaptive management plan. By working with these forestry experts, ARB can best ensure that the robustness of the adaptive management approach for the U.S. Forest Protocol is equal to that of the adaptive management approach for local air quality. Details as to how the data will be used will be developed through the work of the ARB contractor and the expertise of the resource agencies.

The ARB contractor will develop Tier 1, Tier 2, and Tier 3 indicators and analyses. The ARB contractor will conduct the review and analysis under ARB's direction and the results will be incorporated into the annual adaptive management reports. Additionally, the ARB contractor will be called upon to review the usefulness of the data sources, including screening forest offset project annual report data. ARB will work with the ARB contractor to assess if any relevant data sets are missing from the list set forth in the previous section, as well as investigate the effectiveness of the existing data sources. Additionally, the ARB contractor will educate staff in general forest practices, indicators of potential forest impacts, and forest assessments and analyses.

C. Causation

In conducting the analysis, it will be necessary to consider normal variations, existing trends, and other factors that may be responsible for changes in the data. For example, air quality data can vary significantly from year-to-year because of meteorology. Additionally, changes in economic activity can produce large impacts on air quality and emissions trends, and factors such as rainfall can have significant impacts on emissions as a result of California's utilization of hydroelectric power as a source of energy.

ARB recognizes that the results of the data review are unlikely to point absolutely to the cap-and-trade regulation or U.S. Forest Protocol as the cause of a potential adverse impact, and that a judgment will need to be made based on the weight of evidence available. It is likely that it will be necessary for ARB to use several sources of data in combination to conclude that an adverse impact is attributable to the Regulation or U.S. Forest Protocol.

1. Localized Air Quality

If initial screening and analysis of the data point to a potential impact, then ARB will take steps to assess why the change occurred. An example scenario that would indicate a change to be further investigated is as follows: a new application is received by a local air district for a permit to construct or modify a cogeneration unit at a facility. For this

case, ARB would work with the local air district to obtain the details of the project and the environmental analysis. If the project is likely to increase emissions, then ARB would consult with the local air district on the impact of the new unit on overall facility emissions. If the weight of the evidence were to indicate that the cogeneration facility is 1) being proposed as a result, directly or indirectly, of the cap-and-trade regulation; and 2) would increase localized emissions and result in an adverse impact to public health, then the adaptive management plan would require ARB to move to the next step – devising and implementing a response.

2. Forest Impacts

As with potential local air quality impacts, if initial screening and analysis of the data point to a potential impact then ARB will take steps to assess the cause of the change. ARB will work with forestry experts to refine the details of the screening and analysis process to ensure that the robustness of the adaptive management approach for the U.S. Forest Protocol is equal to that of the adaptive management approach for local air quality. The areas to refine are: (1) data and data source identification (information gathering) and (2) analysis to determine whether an adverse impact is caused by the U.S. Forest Protocol (review and analysis).

VI. Response

If the process described above confirms that there has been an adverse impact to local air quality or a forest impact caused by the cap-and-trade regulation or U.S. Forest Protocol, under the adaptive management plan, ARB is committed to developing and implementing appropriate responses through a public process, including consideration and approval by the Board as necessary. ARB would work to ensure that the level of response is commensurate with the level of the impact.

ARB would consider a range of options to address localized adverse air quality impacts. These could include the adoption of additional regulatory requirements, using funds obtained from the sale of allowances to support local mitigation projects, coordination with other agencies to provide additional incentives for energy efficiency or other emission reduction activities within the community, or modifications to the Regulation.

For unanticipated impacts from the U.S. Forest Protocol, ARB could consider revising the types and/or geographic location of forest offset projects, or disallowing the use of certain types of U.S. Forest Protocol compliance offset credits. Other types of responses are also possible and would be considered and implemented as necessary.

The examples are illustrative and not intended to be an exhaustive list of appropriate responses. What responses may be appropriate depends on what impacts are identified, the specific causes of those impacts, and the responses available at some future point in time (which may be different than the responses available today). These considerations support the use of adaptive management, which will allow ARB to devise the most appropriate response should unintended consequences occur. While it is not

feasible in this plan to identify all possible future responses, it is clear that ARB has many tools available to it should unanticipated consequences occur.
This plan requires that where adverse impacts related to localized air quality or to forestry occur, ARB must take appropriate action. In most cases, this will require staff to identify potential responses and promptly take a recommended response to the Board for approval.

VII. Public Process for this Adaptive Management Plan

As mentioned earlier, the Board will consider this plan at the October 20-21, 2011, Board meeting. Upon Board approval, ARB will work with stakeholders, local air districts, and resource agencies to finalize specific details of data gathering.

An important part of the public process is reporting. The first adaptive management report is planned for December 2012, and will focus on the first phase of implementation. Annually thereafter, staff will provide reports to the public and the Board on the implementation of the adaptive management plan. The annual adaptive management plan reports will, among other things, outline the data collected and the trends observed, and discuss any recommended responses.

The plan would be implemented based on the following schedule:

October 10, 2011	ARB releases Draft Adaptive Management Plan for comment.
October 20-21, 2011	Board considers Adaptive Management Plan for approval.
November 2011	Staff works with local air districts, resource agencies, and stakeholders to finalize specific details concerning data gathering under the Adaptive Management Plan.
Early 2012	ARB contracts for third-party forestry expertise.
Mid-2012	Staff updates Board on Adaptive Management Plan implementation.
December 2012	Staff releases Adaptive Management Implementation Report (prior to first compliance period).
December 2013	Staff updates Board on Adaptive Management implementation.
December 2014	Staff releases Adaptive Management Report for calendar year 2013.

December 2015	Staff releases Adaptive Management Report for calendar year 2014 and end of first compliance period.
Ongoing	Staff releases Adaptive Management Report annually.

This Page Intentionally Blank

From:	Courtney Upshall
To:	Paul Gunning; Sally Rand
Subject:	2009 Annual Report: Comments due 8/27
Date:	08/23/2010 05:52 PM
Attachments:	[redacted]

Please review the attached document, including your section, the Executive Summary, AND the Demonstrating Progress section at the back of the report and get your comments/edits back to me by **Friday August 27**. Consider this the final review so if you have any issues with anything (e.g., text, data, figures, program logos, pictures) let me know. Please do NOT spend time commenting on footnote , figure, or table numbering. While EPA is reviewing, Cadmus will review text again to ensure consistency of style and voice across the document. This will also include:

- Check consistency of acronym use and verify each acronym is spelled out on first usage
- Check numbering for pages, figures, charts, footnotes, cross-references, table of contents, table of figures, table of tables,
- Check and correct widows

Please also consider Cadmus's following comments:

Methane

Page 43, Methane photo – Cadmus updated the Methane photo, but understands that this may not be the final photo. Paul - can we touch base about the photo for the section??

Page 48, LMOP sidebar – Last year the LMOP sidebar included two paragraphs, however since the second paragraph seemed to be discussing the program results overall, Cadmus moved the second paragraph out of sidebar and incorporated it as part of the LMOP intro. Is this change okay with EPA?

Courtney Upshall
U.S. Environmental Protection Agency
Climate Protection Partnerships Division
Phone: (202) 343-9948
Fax: (202) 343-2203
E-mail: Upshall.Courtney@epa.gov

[redacted]

From:	Suzanne Kocchi
To:	Joseph Goffman
Cc:	Paul Gunning; Jennifer Jenkins; Cate Hight; Bill Irving
Subject:	biomass RTC ready for USDA
Date:	06/28/2011 05:27 PM
Attachments:	RTC_6-28_final.docx

Here is a courtesy copy of the RTC you can forward to USDA. Please let me know when you do and I will send to OMB. Thanks- Suzie

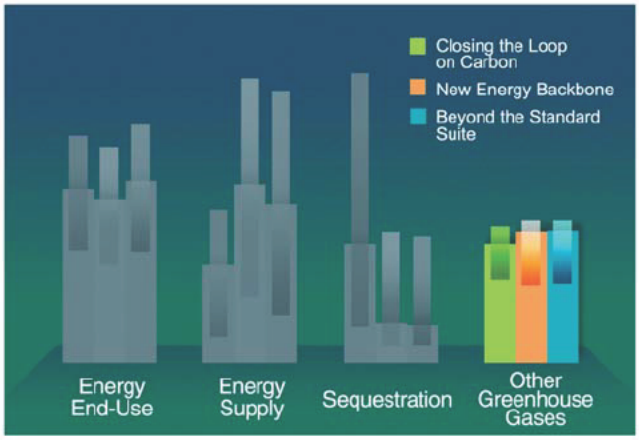
RTC_6-28_final.docx

Reducing Emissions of Non-CO_2 Greenhouse Gases

Several gases other than carbon dioxide (CO_2) are known to have greenhouse gas (GHG) warming effects. When concentrated in the Earth's atmosphere, these "non-CO_2" GHGs can contribute to climate change. The more significant of these are methane (CH_4), which can arise from natural gas production, transportation and distribution systems, bio-degradation of waste in landfills, coal mining, and agricultural production; nitrous oxide (N_2O) from industrial and agricultural activities; and certain fluorine-containing substances, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) from industrial sources (Box 7-1).

The Intergovernmental Panel on Climate Change's (IPCC) *Third Assessment Report* (IPCC 2001) states that "well-mixed" non-CO_2 gases, including methane, nitrous oxide, chlorofluorocarbons, and other gases with high global warming potentials (GWPs) may be responsible for as much as 40 percent of the estimated increase in radiative climate forcing between the years 1750 and 2000.[1] In addition, emissions of black carbon (soot), organic carbon and other aerosols, as well as tropospheric ozone and ozone precursors, have important effects on the Earth's overall energy balance.

Developing technologies for commercial readiness that can reduce emissions of these non-CO_2 GHGs



Other Greenhouse Gases Potential Contributions to Emissions Reduction

Potential contributions of Other Greenhouse Gases to cumulative GHG emissions reductions to 2100, across a range of uncertainties, for three advanced technology scenarios. See Chapter 3 for details.

BOX 7-1

WHAT ARE THE "OTHER" GHGs?

The term "non-CO_2 GHGs" covers a broad category of gases and aerosols, but usually refers to methane, nitrous oxide, and the high global warming potential (GWP) gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Tropospheric ozone, tropospheric ozone precursors, and black carbon (soot) also have important climatic effects. Of these, only ozone is a GHG. Chlorofluorocarbons (CFCs) and other related chemicals contribute to both global warming and stratospheric ozone depletion. Because these chemicals are already being phased out under the Montreal Protocol, they are not addressed in this plan. To streamline terminology for purposes of readability, and unless otherwise noted, the terms "non-CO_2 GHGs" and "other GHGs", include methane, nitrous oxide, high-GWP gases, tropospheric ozone, tropospheric ozone precursors, and black and organic carbon aerosols.

[1] The radiative forcing due to increases in the well-mixed GHGs between the years 1750 and 2000 is estimated to be 2.43 Wm-2: 1.46 Wm-2 from CO_2; 0.48 Wm-2 from CH_4; 0.34 Wm-2 from the halocarbons (CFC and HCFC); and 0.15 Wm-2 from N_2O.

is an important component of a comprehensive strategy to address concerns about climate change. A recent modeling study (Placet et al. 2004) showed that there is a considerable amount of uncertainty about future rate of growth of non-CO_2 emissions, but most models project that emissions will increase over time in the absence of constraints (see Chapter 3). One set of scenarios that included a wide range of advanced technologies[2] for reducing emissions of non-CO_2 gases showed that emissions could potentially be reduced by a range of between 125 and 160 gigatons (Gt) of carbon-equivalent emissions (cumulatively) over a 100-year planning horizon, as shown in Figure 3-19 and highlighted on the figure above. Although bracketed by a range of uncertainties, this figure suggests both the potential role for advanced technology and a long-term goal for contributions from other GHGs in the future global economy.

In the context of global warming, emissions of the non-CO_2 GHGs are usually converted to a common and roughly comparable measure of the "equivalent CO_2 emissions." This conversion is performed based on physical emissions, weighted by each gas' global warming potential (GWP). The GWP is the relative ability of a gas to trap heat in the atmosphere over a given timeframe, compared to the CO_2 reference gas (per unit weight). GWP values allow for a comparison of the impacts of emissions and reductions of different gases, although they typically have an uncertainty of ±35 percent (EPA 2005). The choice of timeframe is significant and can change relative GWPs by orders of magnitude. All non-CO_2 gases are compared to CO_2, which has a GWP of one. The GWPs of other GHGs, using a 100-year time horizon, range from 23 for methane to 22,200 for SF_6, as shown in Box 7-2.

BOX 7-2

GLOBAL WARMING POTENTIALS OF SELECTED GHGs (100-Year Time Horizon)

GAS	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	23
Nitrous oxide (N_2O)	296
Hydrofluorcarbons:	
HFC-23	12000
HFC-125	3400
HFC-134a	1300
HFC-143a	4300
HFC-152a	120
HFC-227ea	3500
HFC-236fa	9400
HFC-43-10mee	1500
Fully Fluorinated Species:	
CF_4	5700
C_2F_6	11900
C_4F_{10}	8600
C_6F_{14}	9000
SF_6	22200

(Source: IPCC 2001)

Non-CO_2 gases have different GWPs due to differences in atmospheric lifetimes and effectiveness in trapping heat. Methane and some HFCs have relatively short atmospheric lifetimes as compared to other non-CO_2 gases. Thus, emissions reductions among these gases manifest themselves as lower atmospheric concentrations in a matter of a few decades. PFCs and SF_6, in contrast, can remain in the atmosphere for thousands of years. Emissions of these GHGs essentially become permanent additions to the Earth's atmosphere, with concomitant increases in the atmosphere's ability to capture and retain radiant heat. Finally, tropospheric ozone and black carbon aerosols (soot) are very short-lived in the atmosphere (i.e., remaining airborne for a period of days to weeks) and therefore do not become well-mixed in the atmosphere. Primarily for this reason, GWP metrics have not been assigned to these gases and aerosols, but they are nonetheless recognized as significant contributors to climate change.

There is a strong record of successful collaboration between industry and government to reduce emissions of non-CO_2 gases, and these partnerships provide a solid foundation from which to pursue additional technological developments and more substantial future emission reductions. Some highlights of the current activities include:

- Industry and the U.S. Environmental Protection Agency (EPA) have developed nine successful public/private partnerships to reduce emissions of methane and high-GWP gases.[3] These programs have led to substantial emission reductions; with U.S. methane emissions in 2003 10 percent below

2 The technologies discussed in this chapter were included in this set of scenarios.

3 The Landfill Methane Outreach Program, Natural Gas STAR Program, AgSTAR Program, Coalbed Methane Outreach Program, SF_6 Emission Reduction Partnership for Electric Power Systems, Voluntary Aluminum Industrial Partnership, SF_6 Emission Reduction Partnership for the Magnesium Industry, PFC Reduction/Climate Partnership with the Semiconductor Industry, and HCFC-22 Partnership Program.

BOX 7-3

The United States is collaborating with 17 countries (Argentina, Australia, Brazil, Canada, China, Colombia, Ecuador, Germany, India, Italy, Japan, Mexico, Nigeria, Russia, South Korea, Ukraine, and the United Kingdom) and over 220 organizations from the private sector, financial community, and other governmental and non-governmental institutions to undertake activities to capture and use methane at landfills, coal mines, oil and gas systems, and agricultural operations.

The United States is committing up to $53 million over the next five years to facilitate the development and implementation of methane projects in developing countries and countries with economies in transition. EPA plays a lead role in the partnership and coordinates efforts with several other departments, including the Departments of State and Energy, the U.S. Trade and Development Agency and the U.S. Agency for International Development. See http://www.methanetomarkets.org.

1990 levels and emissions of many sources of high-GWP gases also declining (EPA 2005). They also provide excellent forums for transferring technical information in an efficient and cost-effective manner. The partnership programs host or participate in annual technical conferences with the respective industries. Public-private partnerships help facilitate effective use of the technologies that are or will soon become available.

- The Federal Government is currently addressing agricultural sources of methane and nitrous oxide through a combination of voluntary partnerships and research, development, and demonstration (RD&D) efforts. Cooperative efforts between Government and the agriculture industry are needed to evaluate and develop technologies for lowering N_2O emissions from soils and methane emissions from livestock enteric fermentation.
- The U.S. Department of Energy (DOE) and EPA have teamed to co-fund the development of the first ventilation air methane (VAM) project in the United States utilizing a thermal flow reversal reactor to oxidize mine ventilation air, which contains low concentrations of methane. The process generates thermal energy that can have many uses. EPA is also working cooperatively with Natural Resources Canada (NRCan) to deploy a similar technology developed by NRCan's CANMET Energy Technology Centre (CETC).
- An international network of those involved in research on non-CO_2 GHGs has been formed by the International Energy Agency (IEA) Greenhouse Gas R&D Programme, EPA, and the European Commission Directorate General Environment. The experts involved in this network cover emissions, abatement options, and systems modeling for policy advice. The network provides an international forum for identification of needed research, as well as creating opportunities for international deployment of non-CO_2 emission reduction technologies.
- An international analytical effort has been undertaken by the Stanford Energy Modeling Forum (EMF) to better characterize the role of non-CO_2 mitigation in addressing climate change.[4] This multi-year effort has led to the development of data on the cost and performance of currently available and near-to-market technologies to reduce non-CO_2 emissions. In addition, the 19 international modeling teams participating in the project have incorporated data on non-CO_2 gases into their economic and integrated assessment models and are improving the capabilities needed to analyze comprehensive climate strategies focusing on both CO_2 and non-CO_2 options.
- Established in November 2004, the Methane to Markets Partnership (Box 7-3) is a new global initiative to advance international cooperation on the recovery and use of methane as a valuable clean energy source. The partnership will increase energy security, enhance economic growth, improve air quality, improve industrial safety, and reduce GHG emissions throughout the world. Methane to Markets has the potential to reduce net methane emissions by up to 50 million metric

4 Results from this study, EMF 21, are to be published in a special issue of the Energy Journal in 2005. See http://www.stanford.edu/group/EMF/research/index.htm.

tons of carbon equivalent annually by 2015 and continue at that level or higher in the future.

These partnerships and others that are discussed in this chapter demonstrate the potential for significant near-term emission reductions from currently available technologies. In addition, longer-term analyses have identified the potential for current and future technologies to lead to even more significant emission reductions. Historically, non-CO_2 gases were either not included or were treated in a cursory manner in climate change modeling and scenario studies. This situation is changing, however, and many modelers are incorporating the non-CO_2 gases into their models and are developing the capability to assess the role of the non-CO_2 gases in addressing climate change. Studies published to date indicate that substantial mitigation of future increases in radiative forcing could be achieved by reducing emissions of these other GHGs. It is possible that such reductions could contribute as much as one-half of the abatement levels needed to stay within a total radiative forcing gain that would be consistent with commonly discussed stabilization ranges of CO_2 concentrations.[5]

Achieving significant reductions in the emissions of the non-CO_2 gases is possible, taking into account the current achievements in reducing emissions as well as the results of detailed analyses of the technical and economic potential to reduce emissions from particular sources and sectors. Based on the information presented in this chapter, it is possible to achieve CH_4 emissions reductions of 40 to 60 percent by 2050, and 45 to 70 percent by 2100. Emissions of N_2O can be reduced by 25 to 30 percent by 2050, and 50 percent by 2100 (DeAngelo et al. forthcoming, Delhotal et al. forthcoming). In addition, it is possible to reduce emissions of high-GWP gases by 55 to 75 percent by 2050, and 60 to 80 percent by 2100 (Schaefer 2006).

There are a number of potentially fruitful areas for technologies to mitigate growth in emissions of non-CO_2 GHGs and strong promise that over time emissions could be reduced substantially. The strategy for addressing non-CO_2 GHGs has two key elements. First, it focuses on the key emission sources of these GHGs and identifies specific mitigation options and research needs by gas, sector, and source. Given the diversity of emission sources, a generalized technology approach is not practical. Second, the strategy emphasizes both the expedited development

Target Areas for Reducing Emissions of Non-CO_2 GHGs (2000 Emissions in Tg CO_2 Equivalent)

TARGET AREA	U.S. EMISSIONS	% OF TOTAL U.S. NON-CO_2	GLOBAL EMISSIONS	% OF GLOBAL NON-CO_2
CH_4 Emissions from Energy and Waste	371	34	2836	31
CH_4 and N_2O Emissions from Agriculture	444	41	5428	60
Emissions of High Global Warming Potential (GWP) Gases	139	13	368	4
N_2O Emissions from Combustion and Industrial Sources	98	9	390	4
Emissions of Tropospheric Ozone Precursors and Black Carbon	N/A*			

* Emissions estimates exist but they cannot be converted into CO_2 equivalent units.
Sources: EPA 2005, 2004

Table 7-1. Target Areas for Reducing Emissions of Non- CO_2 GHGs(2000 Emissions in Tg CO_2 Equivalent) [6]

5 U.S. Climate Change Science Program, Prospectus for Synthesis and Assessment Product 2.1. http://www.climatescience.gov/Library/sap/default.htm.

6 For this chapter, the GWP-weighted emissions of methane (estimated at 21) are presented in terms of equivalent emissions of carbon dioxide (CO_2), using units of teragrams of carbon dioxide equivalents (Tg CO_2 equivalent). To convert the emission estimates included in this chapter to giga-tonnes of carbon (GtC), multiply the emissions estimate by .000272. For example, 200 Tg CO_2 equivalent X (.000272) = .054 GtC.

U.S. and Global Methane (CH_4) Emissions from Energy and Waste (2000 Emissions in Tg CO_2 Equivalent)

SOURCE	U.S. EMISSIONS	% OF TOTAL U.S. NON-CO_2 GHG EMISSIONS	GLOBAL EMISSIONS	% OF GLOBAL NON-CO_2 GHG EMISSIONS
Landfills	130.7	12	814	9
Coal Mining	56.2	5	439	5
Natural Gas and Oil Systems	149.7	14	1013	11
Wastewater Treatment	34	3	569	6
Total	**371**	**34**	**2836**	**31**

** Emissions estimates exist but they cannot be converted into CO_2 equivalent units. Sources: EPA 2005, 2004*

Table 7-2. U.S. and Global Methane (CH_4) Emissions from Energy and Waste (2000 Emissions in Tg CO_2 Equivalent)

and deployment of near-term and close-to-market technologies and expanded R&D into longer-term opportunities leading to large-scale emission reductions. By stressing both near- and long-term options, the strategy offers maximum climate protection in the near term and a roadmap to achieve dramatic gains in later years.

The discussion of the key emission sources of other GHGs is organized around five broad categories—or "target areas"—listed in Table 7-1. Following the table, each target area is discussed in subsequent technology sections. Each of these technology sections includes a sub-section describing the current portfolio. The technology descriptions include a link to the CCTP Technology Options for the Near and Long Term (CCTP 2003).

7.1 Methane Emissions from Energy and Waste

In 2000, methane emissions from the energy and waste sectors accounted for 31 percent of global non-CO_2 GHG emissions (Table 7-2), and nearly 50 percent of global methane emissions. The major emission sources in these sectors include coal mining, natural gas and oil systems, landfills, and wastewater treatment. As Table 7-2 shows, among the energy and waste-related methane emission sources, oil and gas systems, and landfills are the largest emission sources, accounting for 9 and 11 percent, respectively, of global non-CO_2 emissions.

The energy and waste sectors present some of the most promising and cost-effective near-term reduction opportunities. Reducing methane emissions, the primary component of natural gas, can be cost-effective in many cases due to the market value of the recovered gas. Efforts in the United States to voluntarily encourage these economically attractive opportunities have already been successful by focusing on the deployment of available, cost-effective technologies. As Table 7-3 shows, emissions from the key sources in the United States have declined in absolute terms by about 16 percent since 1990, equal to about 65 teragrams of carbon dioxide equivalent (Tg CO_2 equivalent).

Despite this success, significant opportunities remain for further emission reductions through the expanded deployment of currently available technologies and the development of promising new technologies. These longer-term technologies could lead to substantial additional methane reductions in the future. The remainder of this section discusses these technical opportunities for the three major emission sources in this category: landfills, oil and gas systems, and coal mines.

Landfills

Methane emissions from landfills result from the decomposition of organic material (yard waste, food waste, etc.) by bacteria in an anaerobic environment. Emission levels are affected by site-specific factors such as waste composition, moisture, and landfill size. Landfills are the second largest anthropogenic methane emission source in the United States, releasing an estimated 131 Tg CO_2 equivalent to the atmosphere in 2003 (EPA 2005). Globally, landfills

Change in U.S. Methane (CH_4) Emissions from Energy and Waste

SOURCE	1990 EMISSIONS	2000 EMISSIONS	% CHANGE
Landfills	172	130.7	- 24
Coal Mining	82	56.2	- 32
Natural Gas & Oil	148	149.7	+1
Total	**402**	**337**	**- 16**

Source: EPA 2005.

Table 7-3. Change in U.S. Methane (CH_4) Emissions from Energy and Waste

are also a significant emission source, accounting for an estimated 814 Tg CO_2 equivalent in 2000 or almost 10 percent of global non-CO_2 emissions (Table 7-2). The majority of emissions currently come from developed countries, where sanitary landfills facilitate the anaerobic decomposition of waste. Emissions from developing countries, however, are expected to increase as solid waste will be increasingly diverted to managed landfills as a means of improving overall waste management. By 2020, three regions are projected to each account for more than 10 percent of global methane emissions from landfills: Africa (16 percent), Latin America (13 percent) and Southeast Asia (12 percent) (EPA 2004).

Potential Role of Technology

The principal approach to reduce methane emissions from landfills involves the collection and combustion (through use for energy or flaring) of landfill gas (LFG). LFG utilization technologies can be divided into two main categories: electricity generation and direct gas use. About 75 percent of the projects in the United States involve electricity generation, using reciprocating engines or combustion turbines. Direct use technologies account for about 25 percent of total projects, but their implementation has grown in recent years. Some of these technologies use LFG directly as a medium-Btu fuel, while others require the gas to be upgraded and delivered to a natural gas pipeline.

Technology Strategy

Additional CH_4 emission reductions at landfills can be achieved through RD&D efforts focused on improvements in LFG collection efficiency, gas utilization technologies, and alternatives to existing solid waste management practices. In the near term, RD&D efforts focused on improving collection efficiency and demonstrating promising emerging gas use technologies can yield significant benefits. These approaches could increase emission reductions from the waste currently contained in landfills, which will emit CH_4 for 30 or more years. Longer-term reductions will result from research on advanced utilization technologies and development of solid waste management alternatives, such as bioreactor landfills.

Current Portfolio

The current Federal portfolio focuses on three areas:

- Research and development of anaerobic and aerobic bioreactor landfills that more quickly stabilize the readily decomposable organic constituents of the waste stream through enhanced microbiological processes. The goal is to have three to five commercial full-scale anaerobic and aerobic bioreactor landfill demonstration units operational by the close of 2006 plus increased market penetration 2007–2012. An additional goal is to further evaluate environmental and public-health impacts, and design and operational issues.[7]
- R&D of emerging technologies that facilitate the conversion of LFG to readily usable forms, such as compressed natural gas/liquefied natural gas, and methanol/ethanol. Near-term goals to convert landfill gas to alternative uses include verifying performance of LNG conversion technology application on landfill gas and converted vehicle

[7] See Section 4.1.1 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-411.pdf.

performance, development of additional commercially available LNG vehicles (e.g., solid waste collection trucks), and development of distribution/fueling infrastructure. Mid-term goals target research on cost-effective separation technology applications for pipeline quality gas production (Figure 7-1) and to evaluate and demonstrate technologies for producing commercial carbon dioxide.[8]

- R&D on improving LFG collection efficiency and enhancing electricity production from LFG through new and improved electricity generation technologies (fuel cells, microturbines, Organic Rankine Cycle, and Stirling-Cycle engines).[9]

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

Future applied research efforts in the near term could focus efforts to improve LFG collection efficiencies, including research on the design, construction, and operational effectiveness of horizontal wells and other new gas collection systems. Research could also be targeted on the development of additional economical gas utilization technologies and optimizing methane oxidation by cover soils or other advanced cover materials. Development and deployment of near-term technologies to recover LFG from current waste disposal sites could reduce emissions by 50 percent (Delhotal et al. forthcoming).

Over the long term, emissions could theoretically be eliminated through the commercialization and deployment of advanced waste processing and treatment systems such as integrated systems approaches for waste management that could reduce the magnitude of landfill waste and nearly eliminate new landfill waste, such as:

- Source-separation of the solid waste stream into processing categories (recyclables, organics, inerts, etc.) for complete recycling and reuse. This could include (1) designing products to tag and identify waste for recycling; (2) facilitating the decomposition of organics through mechanical biological treatment, followed by rapid and controlled aerobic composting of drier feedstocks, and anaerobic decomposition of wet organics in digesters along with enhanced methane gas recovery; and (3) alternatively, using engineered bacteria that process/break down organic waste without producing methane.

Figure 7-1. Capturing and marketing methane emissions from energy and waste systems can be an economically attractive means for reducing GHG emissions.

Courtesy: EPA

- Centralized or distributed waste management systems that include on-site conversion of waste to hydrogen, other fuels, or electricity. These systems would include pyrolosis, whereby waste is significantly reduced in volume to a glass-like cullet, and gasification, whereby waste is converted to a liquid fuel.
- Potential technology options include sort/weight recognition technology; tagging and tracking technology; large and small-scale waste conversion to fuels, power, and products; and genetically engineered bacteria.

Coal Mines

Coal mines are a significant methane emission source in the United States and worldwide, accounting for

8 See Section 4.1.2 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-412.pdf.

9 See Section 4.1.3 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-413.pdf.

about 10 percent of total anthropogenic methane emissions (EPA 2004). Methane trapped in coal deposits and in the surrounding strata is released during normal mining operations in both underground and surface mines. In addition, handling of the coal after mining (e.g., through storage, processing, and transportation) results in methane emissions. Underground mines are the largest source of coal mine methane (CMM) emissions.

Emissions of CMM in the United States in 2000 were 56 Tg CO_2 equivalent and are projected to increase to 70 Tg CO_2 equivalent by 2010 (EPA 2005). Worldwide emissions of methane from the coal industry are estimated to be 432 Tg CO_2 equivalent and are expected to rise to 495 Tg CO_2 equivalent by the year 2010 as coal production increases (EPA 2004). Globally, almost all CMM emissions come from the major coal producing countries and regions of China; India; the United States; the Confederation of Independent States; Australia; Central, Eastern, and Western Europe; the United Kingdom; and Southern Africa.

Underground mines present the greatest opportunities for reducing emissions; however, emission reductions are also possible at surface mines. Emissions from both underground and surface mines vary, depending on the technology used to mine the coal, the rate of coal production, the technologies employed to remove the methane from the mines, and the local geological conditions.

Potential Role of Technology

Upstream and downstream technologies are integral to reducing methane emissions from coal mines. The most important upstream technological contributions are in the recovery of methane from mine degasification operations and in the oxidation of low-concentration methane in mine ventilation air. Degasification systems are used to remove methane from the coal seams to provide for a safe working environment. These systems generally consist of boreholes drilled into the coal seams and adjacent strata, with in-mine and surface gathering systems used to extract and collect methane. CMM can be recovered in advance of mining or after mining has occurred, and recovery may consist of surface wells, in-mine boreholes, or some combination of the two.

From a technical viewpoint, the most appropriate drainage technology depends on the surface topography, subsurface geology, reservoir characteristics, mine layout, and mine operations. Degasification technologies are used around the world and are commonplace in most of the aforementioned countries. Surface gob wells are used to extract methane after mining has occurred, and in-mine horizontal boreholes are standard at many gassy mines. However, advanced degasification employing long-hole in-mine directional drilling has only been successful in a limited number of countries, including the United States, Australia, China, Japan, United Kingdom, Germany, and Mexico; it is currently being tested in Ukraine. Only the United States and Australia have had success with pre-mine drainage using surface wells. Although gas drainage is practiced primarily at underground mines, drainage is also occurring at surface mines in some countries, including the United States, Australia, and Kazakhstan. Horizontal boreholes can be drilled into the coal seam ahead of mining and the methane extracted.

In a number of countries, commercially applied technologies have led to large reductions in CMM emissions through use of the captured methane. These technologies have included the use of CMM as fuel for power generation (primarily internal combustion engines), injection into the natural gas pipeline system and local gas distribution networks, boiler fuel for use at the mine, local heating needs, thermal drying of coal, vehicle fuel, and as a manufacturing feedstock (e.g., methanol, carbon black, and dimethyl ether production). Technology advances in gas processing over the past decade have also resulted in projects to upgrade the quality of CMM and liquefy the gas, which in turn provide more end-use options and improve access to markets.

Although considerable effort is still directed at improving methane drainage recovery efficiencies and broadening the application of end-use technologies, attention is also focused on the capture and use of coal mine ventilation air methane (VAM). Mine ventilation air generally contains less than 1 percent methane in accordance with regulatory standards. The low concentration greatly limits possible uses of the methane. However, VAM is the largest source of underground methane emissions, and presents a significant opportunity to further mitigate GHG emissions from coal mines if capture and use technologies can be successfully applied. Worldwide VAM emissions in 2000 were 238 Tg CO_2 equivalent and are expected to increase to 282 Tg CO_2 equivalent by 2010 and 308 Tg CO_2 equivalent by 2020. Emissions of VAM in the United States in 2000 were about 37 Tg CO_2 equivalent and are anticipated to rise slightly to 40 Tg CO_2 equivalent by 2010 and remain steady thereafter (EPA 2003a).

Technology Strategy

RD&D efforts aimed at emerging methane reduction technologies for coal mines could target VAM and advanced coalbed methane drilling techniques. The development of technologies to use VAM will enable overall emission reductions at underground mines to reach 90 percent, as compared to the current technical recovery limit of 30 to 50 percent (EPA 1999). The most promising approach for recovering VAM emissions is through commercialization of technologies that convert the low-concentration (typically under 1 percent) methane directly into heat using thermal or catalytic flow reversal reaction processes. The heat can then be employed for power production or other heating. Demonstration projects in Australia, Canada, and the United Kingdom have shown that these technologies can be technically viable. The world's first commercial unit is expected to be operative in Australia in 2006, generating enough thermal energy to supply a 6-MW steam turbine. Future efforts will need to focus on continued testing and commercial deployment of VAM combined with market development support to ensure that it is seen by industry as an energy resource, rather than being vented to the atmosphere.

The other potentially important approach to reduce emissions is the development of advanced drilling technologies. Over the 1990s, advances in steerable motors and stimulation techniques have increased the ability to recover a higher percentage of the total methane in coal seams. This methane, much of which is high quality, may then find a viable market. The most promising technologies include in-mine and surface directional drilling systems, which may enable fewer wells to produce more gas, and advanced stimulation techniques, such as nitrogen injection, that increase the recovery efficiency of surface wells. There is also considerable interest in CO_2 injection; however, this is currently not an option for mine degasification. Injecting the CO_2 into the coal seam renders the coal seams unmineable due to the hazard of releasing too much CO_2 into the mine workings. Although it is difficult to characterize the potential for enhanced gas drainage, these technologies have been shown to obtain drainage efficiencies of 70 to 90 percent (EPA 1999). Future RD&D activities will need to focus on the continued testing and commercial deployment of directional drilling and use of other gases in coalbed methane recovery. In addition, market development support will be needed to ensure that increased drained emissions are put to productive use, rather than vented to the atmosphere.

Figure 7-2. Capturing and using methane from coal mine ventilation air represents an economic opportunity to reduce GHG emissions.

Courtesy: DOE

Current Portfolio

The current Federal portfolio focuses on two areas:

- Research on advances in **coal mine ventilation air systems** is focused on use of VAM in flow reversal reactors; concentrators to increase the methane concentration to levels that will support oxidation; lean fuel turbines; and as combustion air in small-scale reciprocating engines or large-scale mine-mouth power plants, or as co-combustion medium with waste coal (Figure 7-2). The goal of coal mine ventilation air systems' research, development, demonstration, and deployment (RDD&D) program is market penetration by 2005–2010, ultimately leading by the end of the program to the majority of ventilation air methane emissions mitigated.[10]
- Research on advances in **CMM recovery systems** is focused on improving mine drainage system technology through improved directional drilling technologies, in-mine hydraulic fracturing techniques, development of nitrogen and inert gas injection techniques and improved drilling technologies.[11]
- The **Coalbed Methane Outreach Program** (CMOP) is working to demonstrate technologies that can eliminate the remaining emissions from degasification systems, and is addressing methane

[10] See Section 4.1.4 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-414.pdf.

[11] See Section 4.1.5 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-415.pdf.

emissions in mine ventilation air. Due to enhanced market opportunities for natural gas and power, further refinement of technical options for the capture and utilization of mine methane, a growing reliance on methane degasification in the Western United States, and CMOP's anticipated success in reducing ventilation air methane over the next few years.

Future Research Directions

- The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. RD&D efforts will be focused on achieving full commercialization and deployment of VAM and advanced coalbed methane drilling techniques. These technologies alone could reduce emissions from underground mining operations by 90 percent (EPA 2003a).
- RD&D efforts will be focused on developing new, fully automated mining systems that will almost eliminate methane emissions. Since underground mining represents about 83 percent of U.S. coal mine methane emissions, this would represent the potential for a 75 percent reduction in overall U.S. methane emissions from this source.

Natural Gas and Petroleum Systems

Methane emissions from the oil and gas industry accounted for approximately 11 percent of global non-CO_2 emissions in 2000 (EPA 2004). Russia and the United States accounted for over 30 percent of global methane emissions from oil and gas systems. Emissions occur throughout the production, processing, transmission, and distribution systems and are generally process related. Normal operations, routine maintenance, and system upsets are the primary contributors. Emissions vary greatly from facility to facility and are largely a function of operation and maintenance procedures and equipment. However, over 90 percent of methane emissions from oil and gas systems are associated with natural gas rather than oil-related operations (EPA 2005, 2004).

As demand for oil and gas increases, global methane emissions are projected to increase by more than 72 percent between 1990 and 2020 (EPA 2004). However, in many developed countries there is increasing concern about the contribution of oil and gas facilities to deteriorating local air quality, particularly emissions of non-methane volatile organic compounds (NMVOCs). Measures designed to mitigate NMVOC emissions, such as efforts to reduce leaks and venting, have the ancillary benefit of reducing methane emissions. In addition, as economies in many Eastern European countries undergo restructuring, efforts are underway to modernize gas and oil facilities. For example, Germany expects to reduce emissions from the former East German system through upgrades and maintenance. Russia also plans to focus on opportunities to reduce emissions from its oil and gas system as part of modernization.

Potential Role of Technology

Reducing methane emissions from the petroleum and natural gas industries necessitates both procedural and technology improvements. Methane emission reduction strategies generally fall into one of three categories: (1) technologies or equipment upgrades that reduce or eliminate equipment venting or fugitive emissions, (2) improvements in management practices and operational procedures, or (3) enhanced management practices that take advantage of improved technology. Each of these technologies and management practices requires a change from business as usual in the schedule and conduct of daily operations. To date, over 90 emission reduction opportunities have been identified by corporate partners in EPA's Natural Gas STAR Program. In many cases, these actions are cost-effective and widely applicable across industry sectors.

Technology Strategy

Despite the current availability of cost-effective methane emission reduction opportunities in the natural gas and petroleum industry, RDD&D efforts could have an important impact on future methane emissions. Both in the near and long terms, RDD&D efforts could focus on increasing market penetration of current emission reduction technologies, improving leak detection and measurement technologies, and developing advanced end-use technologies.

- **Current Emission Reduction Technologies** – Perhaps the greatest environmental benefits would be associated with an enhanced demonstration and deployment effort focused on currently available emission reduction technologies. In 2000, deployment of these technologies in the United States reduced emissions by 15 Tg CO_2

equivalent, approximately 12 percent of total industry emissions (EPA 2005). An enhanced effort would encourage additional technology penetration and emissions reductions.

- **Leak Detection and Measurement** – Additional benefits could be realized through improvements in and deployment of leak detection and measurement technologies. Although potential industry-wide emission reductions are difficult to quantify, improved identification and quantification of methane losses and leaks would promote mitigation activities. New technologies will allow for quick, relatively inexpensive detection of leaks that are cost-effective to repair. Some of the emerging leak detection and measurement technologies include the Hi-Flow™ Sampler and hand-held optimal imaging cameras that can visualize methane leaks (e.g., Image Multi-Spectral Sensor [IMSS] camera).
- **Advancing End-Use Technologies** – Research aimed at advancing fuel cell and microturbine technologies could reduce emissions at remote well sites by enabling remote power generation at these locations. For example, power generated from the lower-quality gas can be used to support instrument air systems and eliminate the need for gas-driven pneumatic devices and pumps.

Current Portfolio

The current Federal R&D portfolio primarily focuses on leak detection measurement and monitoring technologies for natural gas systems. Advanced leak detection and measurement technologies enable quick and cost-effective detection and quantification of fugitive methane leaks (Figure 7-3). Natural gas systems' RDD&D goals related to measurement and monitoring technologies are focused on completing of the development and deployment of advanced measurement technologies like the Hi-Flow™ and on advancing the development of imaging technology for methane leak measurement and facilitate demonstration and deployment.[12]

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

Pipelines carrying natural gas as well as facilities where natural gas is liquefied are a source of fugitive emissions of methane. Advances in materials, seals, and valve technology could eliminate or reduce these emissions at the source. Possible research may include:

- Development of more accurate and cost-effective leak detection and measurement equipment, which could be effective in reducing fugitive and vented emissions from gas production, processing, transmission, and distribution operations.
- Long-term research to explore revolutionary equipment designs. This might focus on "smart equipment," such as smart pipes or seals, that could alert operators to leaks or self-repairing pipelines made of material that can regenerate and automatically seal leaks. Development of additional technologies could enable emission reductions of 50 percent by the middle of the century.

Enhanced leak-detection and measurement efforts can yield significant methane emission reductions. Demonstration of improved technologies has indicated that emissions at compressor stations and gas-processing plants can be reduced cost effectively by as much as 80 to 90 percent. More importantly, an enhanced demonstration and deployment effort focused on currently available emission reduction technologies would encourage additional technology

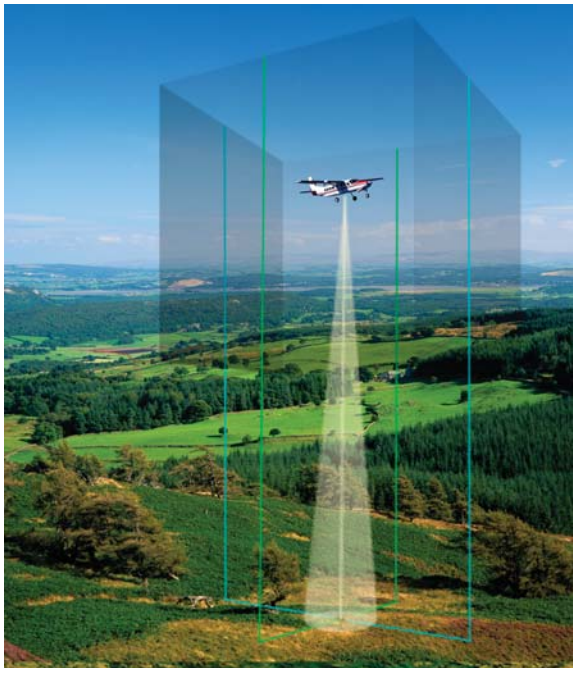


Figure 7-3. Advances in leak detection and measurement systems for natural gas pipelines are enabling significant reductions in methane emissions.

Courtesy: ITT Corporation

[12] See Section 4.1.6 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-416.pdf.

U.S. and Global CH_4 and N_2O Emissions from Agriculture (2000 Emissions in Tg CO_2 Equivalent)

SOURCE	U.S. EMISSIONS	% OF TOTAL U.S. NON-CO_2 GHG EMISSIONS	GLOBAL EMISSIONS	% OF GLOBAL NON-CO_2 GHG EMISSIONS
N_2O Emissions from Agriculture	282	26%	2875	32%
Enteric Methane Emissions	116	11%	1712	19%
Methane Emissions from Manure	38	3%	199	2%
Methane Emissions from Rice Production	8	< 1%	643	7%
Total	**443**	**40%**	**5429**	**60%**

Sources: EPA 2005, 2004.

Table 7-4. U.S. and Global CH_4 and N_2O Emissions from Agriculture (2000 Emissions in Tg CO_2 Equivalent)

penetration. In the United States alone, this effort could reduce emissions by an estimated 37 Tg CO_2 equivalent in 2010.

7.2 Methane and Nitrous Oxide Emissions from Agriculture

Over 40 percent of total U.S. non-CO_2 GHGs come from methane (CH_4) and nitrous oxide (N_2O) emissions from agriculture (EPA 2005). Globally, agricultural sources of methane and nitrous oxide contribute an estimated 5,428 Tg CO_2 equivalent, nearly 60 percent of global non-CO_2 emissions (EPA 2004). These emissions result from natural biological processes inherent to crop and livestock production and cannot be realistically eliminated, although they can be reduced. For example, emissions of oxides of nitrogen (NO_X) can likely be decreased by 15 to 35 percent through programs that improve crop nitrogen use efficiency, through plant fertilizer technology, precision agriculture, and plant genetics (DeAngelo 2006). Table 7-4 shows N_2O and methane emissions from agricultural sources (Tg CO_2 equivalent).

Key research efforts have focused on the largest agriculture GHG emission sources:

- Nitrous oxide emissions from agricultural soil management.
- Methane and nitrous oxide emissions from manure management.
- Methane emissions from livestock enteric fermentation.

Advanced Agricultural Systems for Nitrous Oxide Emissions Reductions

Low efficiency of nitrogen use in agriculture is primarily caused by large nitrogen losses due to leaching and gaseous emissions (ammonia, nitrous oxide, nitric oxide, and nitrogen). In general, N_2O emissions from mineral and organic nitrogen can be decreased by nutrient and water management practices that optimize a crop's natural ability to compete with processes that result in plant-available nitrogen being lost from the soil-plant system.

Potential Role of Technology

Key technologies in the area of nutrient management can be applicable to N_2O mitigation. They focus on the following areas:

- **Precision agriculture** – targeted application of fertilizers, water, and pesticides.
- **Cropping system models** – tools to assist farmer management decisions.
- **Control release fertilizers and pesticides** – delivery of nutrients and chemicals to match crop demand and timing of pest infestation.
- **Soil microbial processes** – use of biological and

chemical methods, such as liming, to manipulate microbial processes to increase efficiency of nutrient uptake, suppress N_2O emissions, and reduce leaching.

- **Agricultural best management practices** – limiting N-gas emissions, soil erosion, and leaching.
- **Soil conservation practices** – utilizing buffers and conservation reserves.
- **Livestock manure utilization** – development of mechanisms to more effectively use livestock manure in crop production.
- **Plant breeding** – to increase nutrient use efficiency and decrease demand for pesticides.

Technology Strategy

Technologies and practices that increase the overall nitrogen efficiency while maintaining crop yields represent viable options to decrease N_2O emissions. Focused RDD&D efforts are needed in a number of areas to develop new technologies and expanded deployment of commercially available technologies and management practices (Figure 7-4).

- Further development of precision agriculture technologies to meet the fertilizer and energy reduction goals could lead to increased adoption of these technologies and improved performance.
- "Smart materials" for prescription release of nutrients and chemicals for major crops currently require modest breakthroughs in materials technology to reach fruition.
- Soil microbial processes could also be manipulated to increase N-use efficiency; however, further development is needed to ensure full efficacy and avoid the introduction of environmental risks.
- First-generation integrated system models, technology, and supporting education and extension infrastructure need to be implemented, and research on using these techniques to improve management expanded.
- Genetically designed major crop plants could utilize fertilizer more efficiently.
- Increased extension efforts are needed to fully utilize best management practices.
- Basic research on process controls and field monitoring programs are needed to ensure that theoretical understanding exists as technology evolves and that changes in management practices to mitigate GHG emissions actually function as theorized.
- Accurate measurement technologies and protocols are needed for assessment and verification.

Figure 7-4. Technologies and farming practices, such as precision agriculture and no-till planting, can increase the overall nitrogen efficiency while maintaining crop yields, resulting in reduced nitrous oxide emissions.

Photo: Tim McCabe, USDA Natural Resources Conservation Service

Current Portfolio

Although many mitigation options for N_2O emissions can be readily identified, their implementation has not been carried out on a large scale. Other than programs to limit nitrogen losses, programs that directly address the issue of N_2O emissions from agricultural soil management are very limited. The current Federal portfolio focuses on N_2O emissions from agricultural soil management; precision agriculture; understanding and manipulation of soil microbial processes; expert system management; and the development of inexpensive, robust measurement and monitoring technologies. Research for reductions in N_2O emissions focus on improved production efficiencies and reduced energy consumption by developing and deploying precision agriculture technologies, sensors/monitors and information-management systems, and smart materials for prescription release utilized in major crops. An additional goal is to improve fertilizer efficiency and reduce nitrogen inputs by developing advanced fertilizers and technologies, methods of manipulating soil microbial processes, and genetically designed major crop plants.[13]

[13] See Section 4.2.1 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-421.pdf.

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

In general, an improved understanding of the interaction and interrelationship among methane, carbon dioxide, and nitrous oxide emissions in agricultural environments is needed. This should involve a systems approach across gases and agricultural systems to synergize related technologies. Other possible further research activities include:

- Precision agriculture in general requires advances in rapid, low-cost, and accurate soil nutrient and physical property characterization; real-time characterization of crop water need; real-time crop yield and quality characterization; real-time insect and pest infestation characterization; autonomous control systems; and integrated physiological model and massive data/information management systems.
- Improved understanding of specific soil microbial processes is required to support development of methods for manipulation of these processes and to identify how manipulation impacts GHG emissions.
- To continue to improve systems management, models that represent an accurate understanding of plant physiology must be coupled with soil process models, including decomposition, nutrient cycling, gaseous diffusion, water flow, and storage on a mass balance basis, to understand how ecosystems respond to environmental and management change.

Other options could include improved utilization of the nitrogen in manure on croplands/pasturelands to offset use of synthetic nitrogen and decrease the quantity of nitrogen excreted from livestock by better matching the intake of nitrogen (e.g., protein) with the actual dietary requirements of the animals. A large portion of the N_2O emissions from soils comes from livestock waste directly deposited on pastures, and this has significant mitigation potential both in the United States and globally.

Wide-scale implementation of these technologies and improved management systems in the United States could lead to reductions in nitrous oxide emissions from agriculture of 15 to 35 percent. In some developing countries, where greater inefficiencies are identified and where potential use of nitrogen is likely to increase greatly in the future as the demand for more crop and pasture production increases, the potential is even greater.

Methane and Nitrous Oxide Emissions from Livestock and Poultry Manure Management

Globally, nitrous oxide and methane emissions from livestock and poultry manure management totaled approximately 400 Tg CO_2 equivalent in 2000 (EPA 2004). Livestock and poultry manure has the potential to produce significant quantities of methane and nitrous oxide, depending on the waste management practices. When manure is stored or treated in systems that promote anaerobic conditions, such as lagoons and tanks, the decomposition of the biodegradable fraction of the waste tends to produce methane. When manure is handled as a solid, such as in stacks or deposits on pastures, the biodegradable fraction tends to decompose aerobically, greatly reducing methane emissions; however, this practice increases emissions of nitrous oxide, which has a greater global warming potential. Practices are needed that minimize both GHGs simultaneously.

Potential Role of Technology

Methane reduction and other environmental benefits can be achieved by utilizing a variety of technologies and processes. Aeration processes, such as aerobic digestion, auto-heated aerobic digestion, and composting, remove and stabilize some pollutant constituents from the waste stream. These technologies facilitate the aerobic decomposition of waste and prevent methane emissions. Anaerobic digestion systems, in contrast, encourage methane generation, and the collection and transfer of manure-generated off-gases to energy-producing combustion devices (such as engine generators, boilers, or odor control flares). Solids separation processes remove

some pollutant constituents from the waste stream through gravity, mechanical, or chemical methods. These processes create a second waste stream that must be managed using techniques different from those already in use to manage liquids or slurries. Separation processes offer the opportunity to stabilize solids aerobically (i.e., to control odor and vermin propagation).

Technology Strategy

Methane collection from anaerobic digestion systems plays an important role in reducing emissions from livestock manure management (Figure 7-5). In addition, these systems can provide additional odor-control and energy benefits by collecting and producing electricity from the combustion of methane-using devices, such as engine generators and boilers. Although the use of commercial farm-scale anaerobic digesters has increased over the past five years due to private sector activities, significant opportunity remains. Currently there are only 12 companies that provide proven commercial-scale anaerobic digestion systems and gas utilization options for farm applications in the United States. As of 2003, an estimated 40 anaerobic digester systems, which produce about 1 million kWh/year, were in use at commercial swine and dairy farms in the United States (EPA 2003b).

Expanded technology research and extension efforts could include commercial-scale demonstration projects and evaluation of emerging technologies to determine their effectiveness in reducing emissions, overall environmental benefits, and cost-effectiveness. For example, a number of emerging anaerobic digester systems adopted from the sewage industry are currently under evaluation for farm-scale applications. In addition, it is important to encourage research on odor and nitrogen emission control and ensure that it is coordinated with research on methane production and emission technology development.

Current Portfolio

Methane reduction and other environmental benefits can be achieved by utilizing a variety of technologies and processes, including aeration processes to remove and stabilize some pollutant constituents from the waste stream; anaerobic digestion systems that collect and transfer manure-generated off-gases to energy-producing combustion devises (such as engine generators, boilers, or odor control flares); and solids separation processes to remove some pollutant constituents from the waste stream. The goals of this research activity are to reduce costs and improve biological efficiencies of methane and nitrous oxide emissions by developing new types of digesters; developing separation processes for solid and liquid fractions; and on developing, applying, and evaluating process performance of aeration systems for manure waste streams. The current Federal portfolio focuses these technologies.[14]

Figure 7-5. Methane collection from anaerobic digestion systems plays an important role in reducing emissions from livestock manure management.

Courtesy: EPA

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

- Future research could address technologies to reduce carbon in waste lagoons by solids separation and increase aeration of lagoon waste systems. Additional research could facilitate the shift from anaerobic lagoons to solid waste management systems.
- Future research can lead to improved separation processes that remove solids from liquids for improved waste management and stabilization development of new types of digestors with reduced costs and improved biological efficiencies, development of centralized anaerobic digestion

[14] See Section 4.2.2 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-422.pdf.

systems for multiple farm operations, and development of aeration processes and pollution control methods for manure waste streams.

Expanded extension efforts to the livestock, agricultural, energy, and regulatory communities in a number of key livestock-producing states (for example, by expanding the activities currently conducted through the AgSTAR Program[15]), could lead to additional emissions reductions in the United States. In addition, research that utilizes new technological developments in analytical instrumentation and molecular biology related to a commercial farm's operational ability would be useful. If such activities were undertaken globally, the emission reductions could be substantial.

Methane Emissions from Livestock Enteric Fermentation

Methane emissions from enteric fermentation are the second largest global agricultural GHG source, contributing an estimated 1712 Tg CO_2 of emissions in 2000 (EPA 2004). Methane emissions occur through microbial fermentation in the digestive system of livestock. The amount of methane emitted depends primarily on the animal's digestive system, and the amount and type of feed. Ruminant livestock such as dairy cattle, beef cattle, and buffalo emit the most methane per animal, while non-ruminant livestock such as swine, horses, and mules emit less. Because methane emissions represent an economic loss to the farmer—where feed is converted to methane rather than to product output—viable mitigation options can entail efficiency improvements to reduce methane emissions per unit of beef or milk.

Potential Role of Technology

Reductions in this energy loss can be achieved through increased nutritional efficiency. The goal of much livestock nutrition research has been to enhance production efficiency in order to indirectly reduce methane per unit of product through breed improvements, increased feeding efficiency through diet management, and strategic feed selection. Without reductions in national herds, however, this approach will not result in net decreases of enteric methane. Historic and near-term projected trends show both a decreasing herd size and reduced methane emissions on a per unit product basis.

Technology Strategy

Technologies that would likely reduce methane emissions in addition to enhancing production efficiency include precision nutrition; and improvements in grazing management, feed efficiency, and livestock production efficiency. Research includes but is not limited to investigating between-animal differences to determine if traits for reduced methane production can be inherited, and dietary manipulation of grains, oils, and fats that reduce methane production. Key technologies include the following:

- Precision nutrition can minimize excess nutrients, particularly nitrogen, while meeting the nutritional needs of the ruminal microflora and those of the animal for growth, milk production, and digestion.
- Improved grazing management can increase forage yield and digestibility.
- Using ionophores to improve feed efficiency can inhibit the formation of CH_4 by rumen bacteria.
- Improving livestock production efficiency with natural or synthetic hormone feed additives or implants can increase milk production and growth efficiency and reduce feed requirements.

Current Portfolio

The current Federal research portfolio focuses on improved feed and forage management and treatment practices to increase the digestibility and reduce residence digestion time in the rumen, best-management practices to increase animal reproduction efficiency, and use of growth promotants and other agents to improve animal efficiency. Enteric emissions reduction goals focus on improved production efficiencies for forage and feedstuffs; increased digestibility; means to reach these goals include genetically designed forages; manipulation of ruminal microbial processes to sequester hydrogen, making it unavailable to methanogens; and genetically designed bacteria that can compete with natural microbes.[16]

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology

15 For additional information on the AgSTAR Program, see http://www.epa.gov/agstar/.

16 See Section 4.2.3 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-423.pdf.

options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

In general, an improved understanding of the interaction and interrelationship among methane, carbon dioxide, and nitrous oxide emissions in agricultural environments is needed. This should involve a systems approach across gases and agricultural systems to synergize related technologies. Possible research activities include:

- Further research is needed with precision agriculture technologies such as genetic engineering of plants to enhance digestibility of feeds, reduce fertilizer requirements, and provide appropriate nutrients to enhance beneficial microbial competitiveness; development of livestock with increased productivity and dietary energy use efficiency that can be productive in various environments and use reduced feed resources; and development of models that represent accurate understanding of animal nutrient needs.
- Longer-term research is needed to improve understanding of specific rumen microbial processes to support development of methods for making desirable engineered microbes competitive with natural rumen microbes and development of vaccinations that can reduce methane production in the rumen.

It is estimated that an increase in production efficiency of approximately 25 percent could be realized if maximum implementation were to occur. A large potential exists as well in developing countries, where the livestock population is expected to increase significantly over the next few decades and where production efficiency is currently low (i.e., high methane per unit product).

Methane Emissions from Rice Fields

Another significant source of global anthropogenic methane is rice production. Rice is the dietary staple of a large proportion of the world's population. It is generally grown in flooded paddy fields, where methane is generated by the anaerobic decomposition of organic matter in the soil. Traditional wet cultivation emits an estimated 642 Tg CO_2 equivalent of methane (EPA 2004). Emissions from this source have leveled off in the past two decades.

Although water management, fertilizer selection, cultivar selection, and nutrient management are potential options for limiting methane emissions from rice fields, further research and development is needed to determine their cost-effectiveness and feasibility. Currently, there is no research ongoing in this area.

A number of opportunities for future research exist in this area, some of which include plant genetics, water management, and nutrient management. In general, the greatest challenges for mitigating methane emissions from rice fields arise from uncertainties in effecting changes in cultivation management, which affects rice yields; and developing feasible management practices that reduce methane emissions without increasing nitrogen losses and reducing yields. In addition, reduction of methane emissions

U.S. and Global Emissions of High-GWP Gases (2000 Emissions in Tg CO_2 Equivalent)

SOURCE	U.S. EMISSIONS	% OF TOTAL U.S. NON-CO_2 GHG EMISSIONS	GLOBAL EMISSIONS	% OF GLOBAL NON-CO_2 GHG EMISSIONS
Substitutes for Ozone-Depleting Substances	75	7	126	1
Industrial Use of High-GWP Gases	64	6	242	3
Total	**139**	**13**	**368**	**4**

Sources: EPA 2005, EPA 2004.

Table 7-5. U.S. and Global Emissions of High-GWP Gases (2000 Emissions in Tg CO_2 Equivalent)

could be difficult to implement because, in many cases, the necessary actions could involve significant changes in agricultural practices (e.g., shifting to different water management regimes). In principle, application of known techniques could reduce methane emissions by 30 to 40 percent by the year 2020. Achieving these large emission reductions would, however, require finding suitable incentives and delivery mechanisms to induce changes in current practices.

7.3 Emissions of High Global-Warming Potential Gases

In 2000, high-GWP gases represented 13 percent of total U.S. non-CO_2 GHG emissions and 4 percent of global non-CO_2 emissions (Table 7-5). There are two different types of emission sources in this category, and each has different R&D priorities. As discussed below, emissions of high-GWP gases used as substitutes for ozone-depleting substances (ODSs) that are being phased out under the Montreal Protocol are currently increasing. High-GWP gases are also used or emitted by several other industries, and in many cases these emissions can be readily managed or eliminated. Table 7-5 shows emissions of substitutes for ODSs and high-GWP gases (Tg CO_2 equivalent).

Substitutes for Ozone Depleting Substances

High-GWP gases used as substitutes for ODSs are a growing emissions source in the United States and globally. These high-GWP gases are being used as replacements for chemicals (like CFCs) that deplete the stratospheric ozone layer (Box 7-2). ODSs, which are also GHGs, are being phased out under the Montreal Protocol and, thus, are not counted in national inventories. To address ozone depletion, the refrigeration, air conditioning, fire suppression, foam blowing, solvent cleaning, and other industries are in the midst of the ODS phaseout.

Potential Role of Technology

For many industries, the ODS phaseout is accomplished by switching to alternative chemicals. For most industries, the most popular and highest performing alternatives are chemicals like HFCs, which do not deplete the ozone layer but are potent GHGs. At the same time, the phaseout is providing industries with an opportunity to improve processes and practices related to chemical use, management, and disposal in ways that reduce the emissions of HFCs and PFCs, where those chemicals are used as alternatives. As the ODS phaseout continues, opportunities exist to find better life-cycle climate performance alternatives and/or continue reducing emissions.

Technology Strategy

To reduce emissions of GHGs used as ODS substitutes, focus might be given to the following: (1) finding alternative gases with lower or no GWP to perform, safely and efficiently, the same function currently served by the HFCs and PFCs; (2) exploring technologies that can reduce the use of these chemicals and/or the rate at which they are emitted; and (3) supporting responsible handling practices and principles that reduce unintended and unnecessary emissions.

Current Portfolio

The Federal R&D portfolio is focused on the two largest sources of hydrofluorocarbon emissions. These emissions arise from the supermarket refrigeration and motor vehicle air conditioning sectors.

- **Motor Vehicle Air Conditioning: Hydrofluorocarbon Emissions** – The motor vehicle industry phased out the use of CFC-12 (with a GWP of about 10,000) in new car air conditioners between 1992 and 1994, and since then has used exclusively HFC-134a (with a GWP of 1300). R&D is underway to commercialize even lower-GWP refrigerants, mainly CO_2 (GWP=1) and HFC-152a (GWP=120). Due to the high-pressure and toxic effects of CO_2, and the flammability of HFC-152a, additional safety engineering and risk mitigation technologies are being developed. Furthermore, research and testing are needed to maintain or improve the energy efficiency (and hence gas usage and CO_2 emissions) of the new air conditioners. In the United States, direct refrigerant GWP emissions can be reduced by more than 95 percent and indirect fuel use emissions reduced by 30 percent or more, for a total reduction of total vehicle fuel emissions (in vehicles with air conditioning) by up to 2 percent.
- **Supermarket Refrigeration: Hydrofluorocarbon Emissions** – Supermarkets are phasing out the use of ozone-depleting

refrigerants and substituting HFCs, which are potent GHGs. Technologies under development include distributed refrigeration, which reduces the need for excessive refrigerant piping (and hence emissions), and secondary-loop refrigeration, which segregates refrigerant-containing equipment to a separate, centralized location while using a benign fluid to transfer heat from the food display cases. The RDD&D goals for reducing HFC emissions from supermarket refrigeration include improving costs and energy-use performance of these new technologies and educating store designers and builders regarding new technologies and how these technologies can be integrated into new or retrofitted stores at a net savings.[17]

- The Significant New Alternatives Program (SNAP) has continued its progress in phasing down the use of global warming, ODSs like CFCs and hydrochlorofluorocarbons (HCFCs). SNAP has worked closely with industry to research, identify and implement climate and ozone friendly alternatives, supporting a smooth transition to these new technologies. In addition, SNAP has initiated programs with different industry sectors to monitor and minimize emissions of global warming gases like HFCs and perfluorocarbons (PFCs) used as substitutes to ozone-depleting chemicals.

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

- Continuation of the responsible-use practices developed to control emissions of ODSs has had and will continue to have a substantial effect on HFC and PFC emissions. Research indicates that approximately 80 percent of previous ODS uses have been replaced through conservation methods and use of non-fluorocarbon technologies. Continued emphasis on this success is needed, for example, by using equipment and technologies to reduce emissions during service and maintenance.

Figure 7-6. Astron Remote Plasma Source (for NF3 CVD chamber cleaning) , an important technology for reducing PFC emissions from semiconductor manufacturing.

Courtesy: EPA

- Long-term research could focus on technologies that hold the most potential for reducing or eliminating total GHG emissions, including associated energy production emissions, and are practical for their applications. Key areas for consideration over the long term are the investigation of new technologies and processes to replace current uses of ODSs and avoid or reduce emissions of high-GWP gases. This includes research to find alternative refrigerant/AC working fluids that are not high-GWP gases. Another approach is research on solid state refrigeration and AC systems that not only eliminates the working fluid, but reduces the overall energy use.
- A focused RD&D program to develop and deploy safe, high-performing, cost-effective climate protection technologies could result in U.S. emission reductions of 50 percent or more by 2020. However, due to the long lifetimes of many of the products that use these gases, efforts need to be taken in the near term to realize the stock turnover necessary to achieve these reductions in a cost-effective manner.

[17] See Section 4.3.6 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-436.pdf.

Industrial Use of High-GWP Gases

High-GWP synthetic gases are generally used in applications where they are critical to highly complex manufacturing processes and provide safety and system reliability, such as in semiconductor manufacturing, electric power transmission and distribution, and magnesium production and casting. High-GWP gases are also emitted as byproducts from the manufacture of refrigerants (HCFC-22) and from the production of primary aluminum.

Potential Role of Technology

Incremental improvements to current technology have been made through the initiation of voluntary public-private industry partnerships. EPA's partnerships with industries, including the U.S. primary aluminum producers, HCFC-22 manufacturing, electric utility industry, magnesium producers, and semiconductor industry, are identifying new technologies and process improvements that not only reduce emissions of high-GWP gases but also improve production efficiency, thereby saving money. With continued support, production technologies are expected to further improve, allowing these industrial sectors to cost effectively reduce and possibly eliminate emissions of high-GWP gases.

Technology Strategy

High-GWP gas-emitting industries are implementing an RDD&D strategy focused on pollution prevention. The industries have established long-term goals of reducing, and in some cases eliminating high-GWP emissions, and are pursuing these goals by investigating and implementing source reduction, alternative process chemicals, high-GWP gas capture and reuse, and abatement.

While the U.S. sources of high-GWP emissions are well defined, they are also very diverse, and thus a customized approach for each industry is required. New and enhanced R&D will accelerate and expand options to stabilize and reduce emissions. Opportunities exist for both near- and long-term RD&D on technologies, including alternative chemicals for plasma etching for semiconductors and magnesium melt protection, as well as continued demonstration of advanced plasma abatement devices for the semiconductor industry.

Current Portfolio

The current Federal portfolio for reducing industrial emissions of high-GWP gases focuses on five areas:

- **Research on the Semiconductor Industry: Abatement Technologies** – Abatement of high-GWP gases from the exhaust gas stream in semiconductor processing facilities may be achieved by two mechanisms: (1) thermal destruction and (2) plasma destruction. The RDD&D goals for the thermal-destruction mechanism target lowering high-GWP emissions from waste streams by more than 99 percent, while minimizing (1) NO_X emissions to levels at or below emissions standards, (2) water use and burdens on industrial wastewater-treatment systems, (3) fabrication floor space, (4) unscheduled outages, and (5) maintenance costs. Plasma-destruction mechanism goals focus on the application of plasma technology (Figure 7-6) to develop a cost-effective POU abatement device that lowers exhaust stream concentrations of high-GWP gases by two to three orders of magnitude from etchers and plasma-enhanced chemical vapor deposition chambers; and transforms those gases into molecules that can be readily removed from air emissions using known scrubbing technologies.[18]
- **Research on the Semiconductor Industry: Substitutes for High-GWP Gases** – One method of reducing high-GWP gas emissions from the semiconductor industry is to use an alternative chemical or production process. Identifying and replacing high-GWP gases with more environmentally friendly substitutes for chemical vapor deposition clean and dielectric etch processes is a preferred option when viewed from the perspective of EPA's pollution prevention framework. The goal of reducing high-GWP gases in the semiconductor industry is to identify the chemical and physical mechanisms that govern chemical vapor deposition chamber cleaning and etching with perfluorocarbons and non-perfluorocarbons as well as govern process performance so that emissions of high-GWP gases may be significantly reduced without either adversely affecting process productivity or increasing health and safety hazards.[19]
- **Semiconductors and Magnesium: Recovery and Recycle** – Three recovery-and-recycle technologies are being investigated and evaluated:

[18] See Section 4.3.1 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-431.pdf.

membrane separation, cryogenic capture, and pressure swing absorption. The goal in this area is to develop and demonstrate a cost-effective, universally applicable recovery-and-recycle technology (all fabrication facilities and all high-GWP gases) that can yield "virgin"-grade high-GWP gases for semiconductor fabrication or magnesium plant reuse or sufficiently pure high-GWP gases for further use or purification elsewhere.[20]

- **Aluminum Industry: Perfluorocarbon Emissions** – Current efforts to reduce perfluorocarbon emissions from primary aluminum production focus on using more efficient smelting processes to reduce the frequency and duration of anode effects, which create the PFC. Another concept, now in the research and development phase, involves replacing the carbon anode with an inert anode. Doing so would completely eliminate process-related PFC emissions. The goal to reduce PFC emissions in the aluminum industry is to develop a commercially viable inert anode technology design by 2007, with commercialization expected by 2010–2015. If successful, the nonconsumable, inert anode technology would have clear advantages over conventional carbon anode technology, including energy efficiency increases, operating cost reductions, elimination of PFC emissions, and productivity gains.[21]
- **Research for Electric Power Systems and Magnesium: Substitutes for SF_6** – The challenge is to identify substitutes to SF_6 with low or no global-warming potential that satisfy the magnesium industry's melt protection requirements and meet the electric power industry's high-voltage insulating needs (Figure 7-7).[22]

Figure 7-7. Improvements to production technologies, such as alternative cover gases, can cost-effectively reduce, and possibly eliminate, emissions of high global warming potential gases, in this case sulfur hexafluoride (SF_6).

Credit: 3M™ Performance Materials Division

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

Long-term research might focus on technologies that hold the most potential for reducing or eliminating total GHG emissions, including associated energy production emissions, and that are practical for their applications. Many of these research efforts may prove to be high risk due to unknown commercial viability, and thus are unlikely to be pursued by the industry without significant government funding. Possible research activities include:

- Research to identify environmentally friendly alternative cover gases to replace SF_6 for

19 See Section 4.3.2 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-432.pdf.

20 See Section 4.3.3 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-433.pdf.

21 See Section 4.3.4 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-434.pdf.

22 See Section 4.3.5 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-435.pdf.

magnesium melt protection. Another possible option is to develop and deploy manufacturing processes that eliminate the need for a cover gas such as injection molding of thixotropic metal alloys (i.e., semi-solid metal casting).

- Research focused on improved process controls and computer-based operator-training tools to further reduce PFC emissions from aluminum smelting.
- Research on the potential to use pure fluorine to replace SF_6 and PFCs in chemical vapor deposition (CVD) chamber cleaning and plasma etching processes in numerous electronics manufacturing processes. Although fluorine is not a GHG, it is a toxic and corrosive substance and designing systems to use it would be a challenge.
- Research could focus on finding alternatives to the use of SF_6 in high-voltage electric transformers, switchgear and circuit breakers, and in airborne military radar systems. Alternatives include new electric equipment designs that do not require GHG dielectric gases and solid state technologies and materials that do not require dielectric gases.

Significant opportunities exist to reduce emissions. A focused RD&D program to develop safe, high-performing, cost-effective climate protection technologies could result in emission reductions of 40 percent or more over the near term and a dramatic reduction and, in some cases, elimination of emissions by key industries within a few decades.

7.4 Nitrous Oxide Emissions from Combustion and Industrial Sources

Stationary and mobile source combustion and the production of various industrial acids account for about eight percent of non-CO_2 emissions in the United States and four percent globally (EPA 2005, 2004). U.S. emissions of N_2O associated with industrial acid production declined significantly after 1996 due to voluntary industry action and could remain relatively stable. Although generally not accounted for in N_2O emission inventories, significant emissions of NO_X from combustion sources are chemically transformed in the atmosphere and are eventually deposited as nitrogen compounds, which subsequently result in emissions of N_2O in a manner similar to emissions from fertilizer application (Figure 7-8). In 2000, the U.S. N_2O emissions from combustion and industry accounted for nearly 10 percent of total non-CO_2 GHG emissions, with the combustion sources accounting for over 70 percent of these (EPA 2005). Table 7-6 shows N_2O emissions from combustion and industrial sources. R&D priorities differ between N_2O combustion and industrial sources. The priorities for reducing N_2O emissions for each of the sources are discussed below.

U.S. and Global N_2O Emissions from Combustion and Industrial Sources (2000 Emissions in Tg CO_2 Equivalent)

SOURCE	U.S. EMISSIONS	% OF TOTAL U.S. NON-CO_2 GHG EMISSIONS	GLOBAL EMISSIONS	% OF GLOBAL NON-CO_2 GHG EMISSIONS
Combustion	68	6	230	2
Industrial Sources	26	2	160	2
Total	**93**	**9**	**390**	**4**

Sources: EPA 2005, 2004.

Table 7-6. U.S. and Global N_2O Emissions from Combustion and Industrial Sources (2000 Emissions in Tg CO_2 Equivalent)

Combustion

Combustion of fossil fuels by mobile and stationary sources is the largest non-agricultural contributor to N_2O emissions. Nitrous oxide can be formed under certain conditions during the combustion process and during treatment of exhaust or stack gases by catalytic converters. Since N_2O emissions do not contribute significantly to ozone formation or other public health problems, N_2O has not been regulated as an air pollutant and has historically not been a focus of emission control research.

Potential Role of Technology

A better understanding is needed of how and when N_2O forms and how N_2O emissions can best be prevented and reduced. For both stationary and mobile combustion sources, N_2O emissions appear to vary greatly with different technologies and under different operating conditions, and the phenomena involved are poorly understood. For stationary sources, catalytic NO_X reduction technologies can reduce N_2O emissions. Other NO_X control technologies either have no impact or can increase N_2O.

Technology Strategy

A key to identifying the most promising approaches and technologies for reducing N_2O emissions is understanding how N_2O is formed during combustion and under what circumstances catalytic technologies contribute to N_2O emissions. The main research thrust in the near term is to improve scientific understanding of these basic questions.

Current Portfolio

The current Federal research portfolio on N_2O emissions from combustion is focused on better understanding the formation and magnitude of N_2O emissions from fuel combustion and catalytic-converter operation; evaluating the climate-forcing potential of atmospheric nitrogen deposition, especially from combustion; and developing emission models to assess the potential climate benefits from changes in emissions from nitrogen oxide. The goal in this area is to determine linkages of NO_X emissions from transportation combustion and catalytic-converter operation to climate-change impacts due to nitrogen deposition and develop enhanced modeling capabilities.[23]

In addition, Federal research on advanced engine/combustion technologies and alternative fuel vehicles will contribute to a reduction in N_2O emissions. Research in these areas is described in the Transportation section of Chapter 4 (Reducing Emissions from Energy End-Use and Infrastructure).

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

Limited but recent additional collection of nitrous oxide test data have provided statistically reliable emissions estimates for most gasoline-powered passenger cars and light duty trucks. It will be important to develop vehicle- and engine-testing programs to generate nitrous oxide emissions data for a variety of vehicles and engines equipped with a range of current and advanced emission-control technologies and operated over a range of real-world operating conditions, particularly for diesel engines. In addition, future research could determine the effect of catalyst formulation including noble metal loadings and compositions for alternative catalysts that result in less nitrous oxide formation. Also, an intensified research effort is needed to assess the role of airborne nitrogen compounds emitted from combustion and deposited onto the ground, and how they interact with soil-generated nitrous oxide emissions.

The development of new combustion technologies and catalyst formulations that reduce or eliminate nitrous oxide emissions will require new Federal efforts to facilitate joint public-private RD&D activities that can effectively address the reduction of nitrous oxide emissions from combustion and industrial sources. This could include research that would form the basis for identification of new technologies in the future. Some areas for near-term study are outlined below:

[23] See Section 4.4.2 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-442.pdf.

Figure 7-8. Nitrogen oxides from combustion sources are chemically transformed in the troposphere, resulting in the formation of nitrogen compounds that are deposited on the ground. These compounds, in turn, give rise to emissions of nitrous oxide, a GHG.

Courtesy EPA

- Characterizing nitrous oxide from diesel and advanced technology engines through collaborative research between the EPA National Vehicle and Fuels Emission Laboratory (NVFEL), state air agencies and manufacturers of vehicles/engines. This research may include a variety of vehicles and engines equipped with a range of current and advanced emission control technologies and operated over a range of real-world operating conditions.
- Characterizing nitrous oxide from heavy-duty diesel vehicles that meet future (2007/2010) emission standards. Research is now being started in this area. As these vehicles will most likely use catalytic after-treatment, they may be an additional source of nitrous oxide that previously had not existed. Research on how to minimize these emissions is also needed. Emissions of nitrous oxide from combustion sources could be significantly reduced with improved catalyst technologies and other advances.

Industrial Sources

Nitric acid is an inorganic compound used primarily to make synthetic commercial fertilizer. As a raw material, it also is used for the production of adipic acid and explosives, for metal etching, and in the processing of ferrous metals. Facilities making adipic acid used to be high emitters of nitrous oxide, but now that adipic acid plants in the United States have implemented nitrous oxide abatement technologies, nitric acid production is the largest industrial source of nitrous oxide emissions.

Potential Role of Technology

The nitric acid industry currently controls NO_X emissions using both non-selective catalytic reduction (NSCR) and selective catalytic reduction (SCR) technologies. NSCR is very effective at controlling nitrous oxide while SCR can actually increase nitrous oxide emissions. NSCR units, however, are generally not preferred in modern plants because of high energy costs and associated high gas temperatures. A catalyst to reduce nitrous oxide emissions from SCR plant is being developed in the Netherlands, and a manufacturer of nitric acid is testing a catalyst for use in the ammonia burners in nitric acid plants. Both research groups claim to be capable of reducing nitrous oxide emissions by up to 90 percent and their technology can be easily installed on existing plants. These technologies could be available for commercial application by 2010. Another manufacturer has developed an integrated destruction process; however, this process is only considered suitable for use on new plants because of the high capital costs and long operational down times needed to retrofit existing plants.

Technology Strategy

Additional research is needed to develop new catalysts that reduce nitrous oxide with greater efficiency, and to improve NSCR technology to make it a preferable alternative to SCR and other control options.

Current Portfolio

The current Federal portfolio focuses on developing catalysts that reduce nitrous oxide to elemental nitrogen with greater efficiency and promoting the use of NSCR over other NO_X control options such as SCR and extended absorption. The goal in this area is to focus on development of catalysts that reduce nitrous oxide to elemental nitrogen with greater efficiency and to promote the use of NSCR over other NO_X control options such as SCR and extended absorption.[24]

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks

[24] See Section 4.4.1 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-441.pdf.

to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

The use of a catalyst that can reduce a higher percentage of nitrous oxide emissions might be a promising avenue for future research. Current technology is primarily implemented to reduce NO_X emissions, not to reduce nitrous oxide. In the longer term, in order to achieve further reductions in nitrous oxide emissions from nitric acid production, an advanced NSCR technology that is not energy intensive will likely need to be developed and implemented at most nitric acid production facilities.

7.5 Emissions of Tropospheric Ozone Precursors and Black Carbon

Understanding of the role of black carbon (BC) and tropospheric ozone in climate change is still evolving. Large uncertainties remain with regard to emission levels, atmospheric concentrations, net climatic effects, and mitigation potential. However, research to date indicates that these substances influence the global radiation budget, particularly at regional scales. Complicating our understanding is that BC, which tends to have a warming effect, is co-emitted with organic carbon (OC), which tends to have a cooling effect on climate, much like sulfate aerosols.

Mitigation options for BC and tropospheric ozone can already be identified in various sectors. However, for particular emission sources it is often difficult to precisely quantify the emission implications of different mitigation scenarios for these substances, and even more difficult to quantify the climatic implications of such scenarios. Activities to reduce tropospheric ozone precursors and BC will have large public health and local air quality benefits, in addition to their role in mitigating climate change. In fact, it is expected that even in the absence of climate-change-driven mitigation actions, reductions in tropospheric ozone and BC will be achieved as local and regional air quality concerns are addressed, in the United States and many other countries.

Potential Role of Technology

Ozone and particulate matter (PM), of which BC is a component, have been key targets of air pollution control efforts in the United States for many years. National, State, and local regulations have aimed at reducing the significant human health and environmental impacts from high levels of tropospheric ozone and particulate matter. Emission control programs directed toward reducing ozone have focused on the primary precursors that contribute to formation of 1-hour peak ozone concentrations in and near urban centers, such as i.e., emissions of NO_X and volatile organic compounds (VOC).

Programs aimed at reducing PM have led to significant advances in emission control technologies in the transportation, power generation, and industrial sectors, which have and will continue to reduce emissions of BC in the United States. Power plants and other large combustion sources use control technologies such as high-efficiency electrostatic precipitators, fabric filters, and scrubbers to reduce particulate matter, including BC. Regulatory efforts for other stationary sources have addressed biomass burning and include new source performance standards for residential wood heaters and limits on open and agricultural burning.

Technology Strategy

The approach to address the most significant sources of tropospheric ozone precursors and BC involve the following abatement technology areas:

- **Transportation control technologies:** PM emissions smaller than 2.5 microns (PM 2.5) from on- and off-road diesel vehicles (the largest source of BC emissions in the United States) are being targeted by stricter vehicle emission standards, where per-vehicle PM emissions are expected to be reduced by 90 percent over the next decade. Total national mobile source PM 2.5 emissions are expected, by 2020, to decline by 53 percent compared to 1996 levels and by 24 percent compared to projected 2020 baseline levels.
- **Temperature reduction in cities:** Heat islands form as cities replace natural vegetation with pavement for roads, buildings, and other

structures. There are several measures available to reduce the urban heat island effect that can decrease ambient air temperatures, energy use for cooling purposes, GHG emissions, and the chemical formation of smog (ozone and precursors). (See Urban Heat Island Technologies in the Buildings subsection of Chapter 4.)

- **Biomass burning:** Important sources of BC aerosols in the United States include combustion of not only fossil fuels but also biomass. Available options to reduce open biomass burning include changing the frequency and conditions of prescribed burning and reducing open waste burning. However, open biomass burning emits greater amounts of OC relative to BC, meaning that, from a strictly climate-carbonaceous aerosol perspective, reducing these emissions could lead to net warming.

Current Portfolio

The current Federal portfolio focuses on the representative technologies listed below. Transportation goals are focused on developing cost-effective NO_X and PM (black carbon) engine and vehicle controls, especially for diesel engines, hybrid-diesel, and gasoline drive trains for medium- and heavy-duty vehicles (Figure 7-9). Goals for temperature reduction in cities are focused on understand and quantifying the impacts that heat island reduction measures have on local meteorology, energy use, GHG emissions, and air quality. Basic research goals are focused on better understanding of the joint role of BC and OC in climate change, including establishing linkages between air pollution and climate change by enhancing modeling capabilities; designing integrated emissions control strategies to benefit climate, regional and local air quality simultaneously.[25]

- Transportation control technologies include advanced tailpipe NO_X controls (including NO_X adsorbers), particulate matter filters (traps) for diesel engines (including catalyzed traps capable of passive regeneration), and hybrid and fuel cell vehicles.
- Representative technologies for temperature reduction in cities include the following:
  - Strategically planted shade trees.
  - Reflective roofs: There are over 200 ENERGY STAR® roof products, including coatings and single-ply materials, tiles, shingles and membranes. Energy savings with reflective roofs range as high as 32 percent during periods of peak electricity demand (and average 15 percent for the summer season).
  - Reflective paving materials: There are several reflective pavement applications being developed, including new pavement and resurfacing applications, asphalt, concrete, and other material types.
- Alternatives to biomass burning include prescribed burning programs (which are directed at minimizing wildfires) and regulation or banning of open burning (such as in land clearing).

Future Research Directions

The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. The current portfolio supports the main components of the technology development strategy and addresses the highest priority current investment opportunities in this technology area. For the future, CCTP seeks to consider a full array of promising technology options. From diverse sources, suggestions for future research have come to CCTP's attention. Some of these, and others, are currently being explored and under consideration for the future R&D portfolio.

Basic research is needed to both better understand the role of black and organic carbon and tropospheric ozone precursors in climate change, and to achieve emission reductions in the near and long terms. Much of this research is a focus of the Administration's Climate Change Science Program. Some of the areas where basic research is needed include the following:

- The study of the roles of tropospheric ozone and BC and OC in global warming has begun only relatively recently. Although there are strong indications that these pollutants are important actors in climate change, much more research is needed to address the complex optical, chemical, and meteorological factors involved. For BC, this new research would be aimed at establishing more clearly how these pollutants affect solar radiation and cloud formation. For BC and tropospheric ozone, new research could focus on how

[25] See Section 4.5.1 (CCTP 2005): http://www.climatetechnology.gov/library/2005/tech-options/tor2005-451.pdf.

atmospheric concentrations vary with geography, time, and the presence of other compounds in the atmosphere.

- Greater understanding of the use of different definitions of and measurement protocols for BC (and its differentiation from elemental carbon and organic carbon), and the implications of such differences for climate assessments, is also needed. Much of this work is underway.
- Advanced, real-time measurement techniques for fine PM and carbonaceous soot are needed. It is difficult to measure the composition, number, volume, and mass densities of nanometer-size particles at combustion sources and in the atmosphere.
- Quantification of the synergies and potential tradeoffs among GHGs, BC, OC, tropospheric ozone, and other criteria air pollutants for different mitigation options, whether these options are targeted for climate, air quality, or both issues.
- Regarding BC emissions from open biomass burning, potential mitigation options include wildfire suppression and altering prescribed burning practices. However, it remains difficult to quantify emission reduction benefits due to large uncertainties in the time dynamics of wildfires and uncertainties in emissions factors resulting from different kinds of fires. Furthermore, the climate benefits are difficult to quantify because greater amounts of OC relative to BC are emitted from biomass burning. Further research into this area could support practices that reduce both BC and OC emissions for health and regional haze concerns, while at the same time understanding the net climatic effects. This type of effort could also enhance carbon sequestration on forestlands.
- A thorough study of life-cycle GHG and particulate matter emissions is needed to resolve questions of the overall climate impacts of vehicle emissions (including CO_2 and organic carbon particles) of vehicles operating on gasoline as compared to diesel fuel (taking into account the future schedule of diesel vehicle PM standards).
- Jet fuel additives could be found that minimize emission of carbonaceous particles (e.g., black carbon/soot) from aircraft engines during take-off, landing, and cruising.

Figure 7-9. Research is needed to better understand the role of particulate matter (e.g., black carbon) emissions from combustion in climate change mitigation.

Courtesy: EPA

- Computational models of soot formation are needed to enable inexpensive design of combustion devices and their optimum operational conditions.

Research and development of alternative, non-carbon based fuels could lead to significant reductions in emissions of tropospheric ozone precursors and BC in the longer term. Additional longer-term research needs include the following:

- Efforts to develop technologies to reduce NO_X emissions from on-road heavy-duty diesel engines are moving beyond engine-based technologies to exhaust after-treatment technologies.
- For both NO_X and particulate control technologies for diesel engines, designs capable of being retrofitted onto engines in the existing fleet could significantly accelerate the heath and climate benefits of these technologies by reducing the time that is otherwise required for engines to be retired and replaced by new models.

Improved understanding is necessary to translate these measures into quantifiable reductions in ozone precursors, BC, OC, and the associated climate effects.

7.6 Summary

This chapter reviews various forms of advanced technology, their potential for reducing emissions of non-CO_2 GHGs, and the R&D strategies intended to accelerate the development of these technologies. Although uncertainties exist about both the level at which GHG concentrations might need to be stabilized and the nature of the technologies that may come to the fore, the long-term potential of advanced technologies to reduce emissions of non-CO_2 GHGs is estimated to be significant, both in reducing emissions (as shown in the figure at the beginning of this chapter) and in reducing the costs for achieving those reductions, as suggested by Figure 3-21. Further, the advances in technology development needed to realize this potential, as modeled in the associated analyses, animate the R&D goals for each technology area focused on reducing emissions of non-CO_2 GHGs.

As one illustration among many hypothetical cases analyzed,[26] GHG emissions were constrained to a high level over the course of the 21st century in such a way that a stabilized GHG concentration levels could ultimately be attained. The lowest-cost arrays of advanced technology to reduce emissions of non-CO_2 GHGs, when compared to a reference case, resulted in reduced or avoided emissions of about 150 Gt of carbon equivalent over the 100-year planning horizon. This amounted to roughly 25 percent of all GHG emissions reduced, avoided, captured and stored, or otherwise withdrawn and sequestered needed to attain this level. Similarly, the costs for achieving such emissions reductions were reduced by roughly a factor of 3. See Chapter 3 for other cases and other scenarios.

As described in this chapter, CCTP's technology development strategy supports achievements in this range. The overall strategy is summarized schematically in Figure 7-10. Advanced technologies are seen entering the marketplace in the near-, mid-, and long-terms, where the long-term is sustained indefinitely. Such a progression, if successfully realized worldwide, would be consistent with attaining the potential for reducing emissions of non-CO_2 GHGs portrayed at the beginning of this chapter.

The timing and pace of technology adoption are uncertain and must be guided by science and supported by appropriate policies (see Approach 7, Chapters 2 and 10). In the case of the illustration above, the first GtC per year (1GtC/year) of reduced or avoided emissions, as compared to an unconstrained reference case, would need to be in place and operating, roughly, around 2050. For this to happen, a number of new or advanced technologies to reduce emissions of non-CO_2 GHGs would need to penetrate the market at significant scale before this date. Other cases would suggest faster or slower rates of deployment. See Chapter 3 for other cases and other scenarios.

Throughout Chapter 7, the discussions of the current activities in each area support the main components of this approach to technology development. The activities outlined in the current portfolio sections address the highest-priority investment opportunities for this point in time. Beyond these activities, the chapter identifies promising directions for future research, identified in part by the technical working group and assessments and inputs from non-Federal experts. CCTP remains open to a full array of promising technology options as current work is completed and changes in the overall portfolio are considered.

[26] In Chapter 3, various advanced technology scenarios were analyzed for cases where global emissions of GHGs were hypothetically constrained. Over the course of the 21st century, growth in emissions was assumed to slow, then stop, and eventually reverse in order to ultimately stabilize GHG concentrations in the Earth's atmosphere at levels ranging from 450 to 750 ppm. In each case, technologies competed within the emissions-constrained market, and the results were compared in terms of energy (or other metric), emissions, and costs.

Technologies for Goal #4: Reduce Emissions of Other Gases

	NEAR-TERM	MID-TERM	LONG-TERM
Methane from Energy & Waste	• Bioreactor Landfill Technology • Methane to Markets • New Drilling Techniques for Recovery of Coal bed Methane • Leak Detection, Measurement, and Mitigation Technologies for Oil & Natural Gas Systems	• Advanced Landfill Gas Utilization (e.g., Fuel Cells, Microturbines), Cover, and Collection Technologies • Ventilation Air Methane Technology • Advanced End-Use Technologies to Use Methane at Remote Well Sites	• Integrated Waste Management System with Automated Sorting, Processing & Recycle • Automated Coal Mining to Eliminate Methane Emissions • Smart Pipes and Self-Repairing Pipelines
Methane & N_2O from Agriculture	• Anaerobic Digesters that Produce Heat and Electricity • Precision Agriculture • Improved Livestock Production Efficiency	• Better Understand Relationship among CH_4, CO_2, N_2O, N_2 & C in Agriculture • Soil Microbial Processes • Prescription Release of Nutrients and Chemicals for Crops • Genetically Designed Forages and Bacteria to Improve Digestion Efficiency	• Zero-Emission Agriculture
High GWP Gases	• Advanced Refrigeration Technologies (Distributed and Secondary-Loop) • Advanced Abatement, Recovery, and Recycling Technologies • Advanced Aluminum Smelting Processes to Reduce Anode Effect	• Alternative Refrigeration Fluids (Non-GHG) • Substitutes for SF_6 in High-Voltage Applications and Magnesium Production • Inert Anode to Eliminate PFC Emissions in Aluminum Production	• Solid-State Refrigeration/AC Systems • New Equipment and Process Designs that do not Require High-GWP Gases
N_2O from Combustion	• Catalytic Reduction of N_2O in Nitric Oxide Plants • Better Understand N_2O Emissions from Vehicles	• Catalysts That Reduce N_2O to Elemental Nitrogen in Diesel Engines • Understand Role of N Compounds from Combustion with Soils and N_2O	• Advanced Vehicles and Non-Carbon Based Fuels
Ozone Precursors & Black Carbon	• Particulate Matter Control Technologies for Vehicles • Reflective Roofs to Reduce Heat Island Effects • Better Understand Effects of Ozone Precursors & Black Carbon	• Model Linkages Between Air Pollution and Climate Change • Jet Fuel Additives to Minimize Black Carbon and Soot	

Figure 7-10. Technologies for Goal #4: Reduce Emissions of Other Gases
(Note: Technologies shown are representations of larger suites. With some overlap, "near-term" envisions significant technology adoption by 10–20 years from present, "mid-term" in a following period of 20–40 years, and "long-term" in a following period of 40–60 years. See also List of Acronyms and Abbreviations.)

7.7 References

DeAngelo, B., F. de la Chesnaye, R. Beach, A. Sommer, and B. Murray. Forthcoming. Methane and nitrous oxide mitigation in agriculture. *Energy Journal*.

Delhotal, K. Casey, F. C. de la Chesnaye, A. Gardiner, J. Bates, and A. Sankovski. 2006. Mitigation of methane and nitrous oxide emissions from waste, energy and industry. *Energy Journal*.

Intergovernmental Panel on Climate Change (IPCC). 2001. *Climate change 2001: the scientific basis*. Cambridge, UK: Cambridge University Press.

Placet, M., K.K. Humphreys, and N.M. Mahasenan. 2004. *Climate change technology scenarios: energy, emissions and economic implications.* Richland, WA: Pacific Northwest National Laboratory. http://www.pnl.gov/energy/climatetechnology.stm

Schaefer, D., D. Godwin, and J. Harnish, 2006. Estimating Future Emissions and Potential Reductions of HFCs, PFCs, and SF_6. *Energy Journal* (forthcoming).

U.S. Climate Change Technology Program (CCTP). 2003. *Technology options for the near and long term.* DOE/PI-0002. Washington, DC: U.S. Department of Energy. http://www.climatetechnology.gov/library/2003/tech-options/index.htm

Update is at http://www.climatetechnology.gov/library/2005/tech-options/index.htm

U.S. Environmental Protection Agency (EPA). 1999. *U.S. methane emissions 1990 – 2020: inventories, projections, and opportunities for reductions.* #430-R-99-013. Washington, DC: U.S. Environmental Protection Agency. http://www.epa.gov/methane/reports/methaneintro.pdf

U.S. Environmental Protection Agency (EPA). 2003a. *Assessment of the worldwide market potential for oxidizing coal mine ventilation air.* #430-R-03-002. Washington, DC: U.S. Environmental Protection Agency. http://www.epa.gov/coalbed/pdf/ventilation_air_methane.pdf

U.S. Environmental Protection Agency (EPA). 2003b. Current status of farm-scale digesters. *AgSTAR Digest.* #430-F-02-028. Washington, DC: U.S. Environmental Protection Agency. http://www.epa.gov/agstar/pdf/handbook/appendixa.pdf

U.S. Environmental Protection Agency (EPA). 2004. *Global emissions of non-CO_2 greenhouse gases, 1990 – 2020.* Washington, DC: Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA). 2005. *Inventory of U.S. greenhouse gas emissions and sinks: 1990 – 2003*. #430-R-05-003. Washington, DC: U.S. Environmental Protection Agency. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR69V4ZS/$File/05_complete_report.pdf.

From:	Alex Macpherson
To:	Lydia Wegman; Bruce Moore; Ron Evans; David Cozzie; Suzanne Waltzer; Paul Gunning
Subject:	CO emissions study
Date:	02/14/2012 03:15 PM
Attachments:	petron et al colorado ONG emissions in press 2012.pdf

---

All,

Attached is the paper that is discussed in the Nature 2-pager that has been circulating re: gas emissions in CO.

Haven't read it yet though....

Alex

Petron, G., et al. (2012), Hydrocarbon emissions characterization in the Colorado Front Range - A pilot study, J. Geophys. Res., doi:10.1029/2011JD016360, in press. http://www.agu.org/pubs/crossref/pip/2011JD016360.shtml

ABSTRACT

The multi-species analysis of daily air samples collected at the NOAA Boulder Atmospheric Observatory (BAO) in Weld County in northeastern Colorado since 2007 shows highly correlated alkane enhancements caused by a regionally distributed mix of sources in the Denver-Julesburg Basin. To further characterize the emissions of methane and non-methane hydrocarbons (propane, n-butane, i-pentane, n-pentane and benzene) around BAO, a pilot study involving automobile-based surveys was carried out during the summer of 2008. A mix of venting emissions (leaks) of raw natural gas and flashing emissions from condensate storage tanks can explain the alkane ratios we observe in air masses impacted by oil and gas operations in northeastern Colorado. Using the WRAP Phase III inventory of total volatile organic compound (VOC) emissions from oil and gas exploration, production and processing, together with flashing and venting emission speciation profiles provided by State agencies or the oil and gas industry, we derive a range of bottom-up speciated emissions for Weld County in 2008. We use the observed ambient molar ratios and flashing and venting emissions data to calculate top-down scenarios for the amount of natural gas leaked to the atmosphere and the associated methane and non-methane emissions. Our analysis suggests that the emissions of the species we measured are most likely underestimated in current inventories and that the uncertainties attached to these estimates can be as high as a factor of two.

From:	Rona Birnbaum
To:	Paul Gunning
Cc:	Bill Perkins
Subject:	draft Adaptation Plan for OAP clearance
Date:	05/01/2012 05:08 PM
Attachments:	EPA Adaptation Plan -- Clearance Draft.docx Adaptation plan backgrounder.docx

---

Paul, can you please forward on to Sarah? Thanks! Rona

Enclosed is the draft EPA Adaptation Plan for Office Director clearance, along with a 1-page background document. All of our comments have been addressed, and the document is clean. Ideally, this can receive clearance so that it can be forwarded on to Gina on Thursday to give her as much time as possible for review. The other OAR Office Directors are also receiving this through their workgroup members for review/clearance.

As the lead for OAR, all offices agree that OAP will forward on to Gina, when ready.

Bill and I are available to answer any questions as needed.

From:	Jackie Krieger
To:	Don Zinger
Cc:	Sarah Dunham; Paul Gunning; Rona Birnbaum; OAR Special Assistants
Subject:	Draft Adaptation Plan for OAR Clearance
Date:	05/07/2012 08:40 AM
Attachments:	EPA Adaptation Plan -- Clearance Draft.docx Adaptation plan backgrounder.docx

---

Hi Don.

As discussed, I'm forwarding for Gina's review/clearance the draft EPA Adaptation Plan (along with a one-page backgrounder). OAR staff briefed Gina on this a few weeks ago. The Policy Office made all the changes OAR requested and all OAR Office Directors have cleared except for Steve's concerns that you and I talked about this morning (as the lead for OAR, the offices agreed that OAP would forward on to Gina, when ready).

For clearance, when we're ready, Gina (or you) simply needs to let us know that OAR has cleared, and staff here will let OP/Joel know.

OP asked for program office clearance by today to allow time for a 3-week public comment period in May (June will focus on reviewing comments, making revisions, and obtaining final clearance; CEQ has asked for all agencies to submit their plans by June 29th). Clearly that may not be possible -- that's OK, we'll work it out with OP.

Let us know if you or Gina have questions. Thanks for your help

Jackie Krieger
Chief of Staff
Office of Atmospheric Programs
Phone: (202) 343-9905

From:	Bill Perkins
To:	Paul Gunning
Cc:	Rona Birnbaum
Subject:	Draft EPA Adaptation Plan
Date:	04/30/2012 04:02 PM
Attachments:	Compiled OAR comments on Draft EPA Adaptation Plan 0426.docx

---

Paul,

Congratulations on your new position! I look forward to working with you going forward.

Rona asked me to share with you the current draft of the EPA Adaptation Plan. I am enclosing the draft of the Plan as of last week, and it includes all our OAR comments as well. (It was originally six documents which I merged into one, so the formatting looks a bit odd in most places, but I thought it would be easier for you as one document). The planned timeline going forward is:

by tomorrow morning -- we receive revised draft from OP for clearance
by tomorrow COB -- a cover letter from our OAR workgroup, along with the clearance draft, is ready to go to program office director clearance (OAP, OAQPS, OTAQ, ORIA)
Thursday lunchtime -- program office clearance complete, cover letter revised as needed and sent along with clearance draft to Sarah for her to give to Gina
COB next Monday, May 7 -- requested deadline from OP for completion of AA-level clearance

I am of course standing by to answer any questions or walk you through this in more detail as desired, and thank you.

Sincerely,

Bill

Bill Perkins
Climate Change Analyst
Climate Change Division
U.S. Environmental Protection Agency
202.343.9460 | perkins.bill@epa.gov

From:	Allen Fawcett
To:	Paul Gunning; Suzanne Kocchi
Subject:	Economic Analysis Slides with IPM sectioin
Date:	11/28/2012 08:20 AM
Attachments:	Climate Economic Analysis - Gina Briefing - DRAFT 11-28-12.pptx

---

Sorry this is just before the meeting, but here is the latest version of the slides with the contribution from CAMD, and a simplified intro slide.

Allen

From:	Reid Harvey
To:	Paul Gunning
Subject:	FASOM peer review
Date:	07/09/2012 12:53 PM
Attachments:	fasom final peer review report with attachments.pdf

---

Here's the final package that we will post on our website when we are ready. I'll let you know our timing once I discuss specifics with Sara Ohrel tomorrow. I want to make sure we have a desk statement done first as backup in case there are any external inquiries. Sara and I have discussed that with Erin so will include her as well when we get close.

Reid

From:	Maurice LeFranc
To:	Cindy Newberg; Paul Gunning; Erika Sasser; Sara Terry; Dale Evarts; Ben DeAngelo; Terry Keating; Jackie Krieger; Mike Flynn; Mike Flynn
Subject:	focal area and criteria slides for CCAC
Date:	03/12/2012 02:50 PM
Attachments:	OAR Focal Area Ideas version 4.docx SLCFs - criteria Mar 7.docx

---

Here is the last version of the focal area slides and the criteria one-pager. These were included as background for Gina's briefing last week and were sent over to State as input into CCAC. Thanks for all of the work that went into this.

Maurice N. LeFranc, Jr.
Senior Advisor on International Climate Change

U.S. Environmental Protection Agency /Office of Air and Radiation
Ariel Rios Building / MC 6101-A
1200 Pennsylvania Avenue
Washington, DC 20460

Phone: (202) 564-1813
Mobile: (202) 450-7863

Embargoed for use until Wednesday, Dec 5, 2007 12:01AM Central Standard Time

December 5, 2007

Hon. Stephen L. Johnson
Administrator
United States Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Mail Code 1101A
Washington, DC 20460

Re: Petition for Rulemaking Under the Clean Air Act to Reduce the Emission of Air Pollutants from Aircraft that Contribute to Global Climate Change

Dear Administrator Johnson:

Global warming is one of the most pressing environmental challenges of our time. Concentrations of greenhouse gases,[1] primarily from society's burning of fossil fuels and the destruction of forests, are increasing in the Earth's atmosphere, trapping solar energy that would otherwise be radiated back into space. This phenomenon is having profound impacts on the Earth and its inhabitants, including a rise in global temperatures, more extreme weather events, severe flooding and droughts, the spread of infectious diseases, and the extinction of numerous species. As one of the world's largest emitters of greenhouse gases, the United States must act to address this urgent situation by reducing emissions from all sectors of its economy.

Aircraft engines represent an increasing and potent source of greenhouse gas emissions, due in part to the unprecedented growth in air travel in the United States and internationally. In 2005, aircraft accounted for three percent of the United States' total carbon dioxide emissions

[1] "Greenhouse gases" are atmospheric gases responsible for causing global warming and climate change. The major greenhouse gases are carbon dioxide ("CO_2"), methane ("CH_4") and nitrous oxide ("N_2O").

and 12 percent of such emissions from the U.S. transportation sector.[2] In fact, the United States is responsible for almost *half* of worldwide carbon dioxide emissions from aircraft, nearly five times the amount of the next largest emitter.[3] Moreover, aircraft emissions are projected to substantially increase in the coming decades, and globally, are expected to more than triple by mid-century.[4] Recent reports show that at altitude, aircraft emissions have a greater impact on global warming than previously understood, and are more harmful than land-based fuel combustion.[5] While some countries have already begun taking steps in response to these challenges,[6] the United States has thus far ignored its responsibility to address this growing source of greenhouse gas emissions.

Therefore, pursuant to the Administrative Procedure Act, 5 U.S.C. § 553(e), and the Clean Air Act, 42 U.S.C. § 7571, Petitioners file this Petition for Rulemaking and respectfully request that you undertake the following mandatory duties:

> (1) Make a finding that greenhouse gas emissions from aircraft engines may reasonably be anticipated to endanger public health and welfare pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A);
>
> (2) Issue proposed standards for greenhouse gas emissions from aircraft engines pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A); and
>
> (3) Promulgate final regulations within 90 days of the issuance of such proposed standards pursuant to Section 231(a)(3) of the Clean Air Act, 42 U.S.C. § 7571(a)(3).

Given the urgent threats to public health and welfare posed by global climate change, prompt consideration must be given to this petition. Therefore, Petitioners hereby request a substantive response to this petition within one hundred eighty (180) calendar days. Petitioners

---

[2] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005*, (2007), at 2-1, *available at*: http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf [hereinafter "EPA *Inventory*"].

[3] ROYAL AERONAUTICAL SOCIETY, AIR TRAVEL – GREENER BY DESIGN, Report of the Greener Design Science and Technology Sub-Group (July 2005) at 7 Fig. 7, *available at*: http://www.greenerbydesign.org.uk/_FILES/publications/GbD%20-%202005%20Science%20and%20Technology%20Report.pdf [hereinafter Greener by Design Report].

[4] Sir Nicholas Stern, STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE, Cambridge University Press (Oct. 30, 2006) at 172, *available at*: www.sternreview.org.uk, [hereinafter Stern Report].

[5] Ian A. Waitz, *et al.*, AVIATION AND THE ENVIRONMENT: A NATIONAL VISION STATEMENT, FRAMEWORK FOR GOALS AND RECOMMENDED ACTIONS, Report to the United States Congress (Dec. 2004) at 18, *available at*: http://web mit.edu/aeroastro/partner/reports/congrept_aviation_envirn.pdf [hereinafter AVIATION AND THE ENVIRONMENT].

[6] *Commission Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2006&nu_doc=818.

will consider litigating to compel a response that is unreasonably delayed in order to achieve the requested agency action.[7]

PETITIONERS

Friends of the Earth is a public interest, non-profit advocacy organization, whose mission is to defend the environment and champion a just and healthy world. The organization works to stop environmental damage from the current model of economic and corporate globalization, and to protect human health and the planet by reducing dependence on fossil fuels. Founded in San Francisco in 1969 by David Brower, Friends of the Earth now maintains its headquarters in Washington, D.C. and is the U.S. voice of the world's largest network of grassroots environmental groups, with affiliates in 70 countries.

Oceana is a non-profit international advocacy organization dedicated to protecting and restoring the world's oceans through policy, advocacy, science, law, and public education. Oceana has over 280,000 members and supporters around the world. Oceana is organized under the laws of the District of Columbia, and maintains its headquarters in Washington, D.C. It has offices or staff in five states (Alaska, California, Massachusetts, New York, and Oregon) and three foreign countries (Chile, Belgium, and Spain). Through its policy, scientific, litigation, and grass-roots activities, Oceana has been a prominent advocate for protecting threatened and endangered marine species and marine ecosystems. Many marine ecosystems and species, such as the loggerhead sea turtle and species of deep sea corals, are threatened by global warming and ocean acidification.

The Center for Biological Diversity ("the Center") is a non-profit organization with offices in San Francisco, Los Angeles, and Joshua Tree, California, Phoenix and Tucson, Arizona, Silver City, New Mexico, Portland, Oregon, and Washington, D.C. The Center is a national membership organization with over 35,000 members in the United States. The Center's mission is to ensure the preservation, protection, and restoration of biodiversity, native species, ecosystems, public lands and waters, and public health. Because climate change from society's production of greenhouse gases is one of the foremost threats to the earth's biodiversity, the environment, and public health, the Center's Climate, Air, and Energy Program works to reduce United States greenhouse gas emissions in order to protect these resources. The Center has advocated in local, state, and federal forums for the reduction of greenhouse gas pollution. The Center has petitioned to have some of the first species to be threatened by global warming listed under the U.S. Endangered Species Act, including the polar bear, staghorn and elkhorn corals in the Caribbean, twelve of the world's penguin species, the American pika, and the Kittlitz's murrelet, a small seabird that feeds at the base of tidewater glaciers in Alaska. These species will not survive unless the United States substantially reduces its greenhouse gas emissions. The Center has previously requested that EPA regulate greenhouse gases from automobiles under

[7] This petition follows the petition for rulemaking under Section 213(a)(4) of the Clean Air Act, 42 U.S.C. § 7547(a)(4), to regulate greenhouse gas emissions from marine vessels submitted by Petitioners on October 3, 2007. As described in that petition, marine engines contribute approximately five percent of total domestic carbon dioxide emissions from transportation-related fossil fuel combustion, and shipping worldwide is estimated to account for almost three percent of global greenhouse gas emissions. Moreover, global warming emissions from marine vessels are expected to triple by 2030.

Section 202 of the Clear Air Act, and was a party in the successful case overturning EPA's decision not to do so. The Center submits this petition on behalf of itself and its adversely affected members.

STATEMENT OF LAW

The Clean Air Act, 42 U.S.C. §§ 7401 *et seq.* (the "Act"), provides the Administrator of the U.S. Environmental Protection Agency ("EPA") with the exclusive authority to regulate air pollutants from aircraft engines. Pursuant to Section 231(a)(2)(A):

> The Administrator shall, from time to time, issue proposed emission standards applicable to the emission of any air pollutant from any class or classes of aircraft engines which in his judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare.

42 U.S.C. § 7571(a)(2)(A). In doing so, the Administrator is required to consult with the Administrator of the Federal Aviation Administration ("FAA"). *Id.* at § 7571(a)(2)(B). The Act further requires EPA to promulgate final regulations within 90 days of the issuance of its proposed emissions standards. *Id.* at § 7571(a)(3). In addition, Section 232 of the Act requires the Secretary of Transportation, acting through the FAA, to prescribe regulations that ensure compliance with the standards issued by EPA under section 231. *Id.* at § 7572(a); *see* 49 C.F.R. § 1.47(g). States and other political subdivisions are prohibited from adopting or attempting to enforce any emissions standards for aircraft engines unless they are identical to standards promulgated by EPA. 42 U.S.C. § 7573.

Although EPA has occasionally issued standards regulating air pollution from aircraft engines under Section 231,[8] it has not previously considered limiting emissions from aircraft based on the contribution of those emissions to global warming. However, it is clear that EPA's authority under Section 231 extends to greenhouse gas emissions from aircraft engines. Section 302(g) of the Clean Air Act broadly defines the term "air pollutant" to include:

> [A]ny air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term 'air pollutant' is used.

Id. at § 7602(g). The U.S. Supreme Court has firmly established that greenhouse gases – including carbon dioxide – constitute air pollutants under Section 302(g) of the Act. *Massachusetts, et al. v. EPA, et al.*, 127 S. Ct. 1438, 1462 (2007) ("*Mass. v. EPA*") ("Greenhouse gases fit well within the Clean Air Act's capacious definition of 'air pollutant' in

[8] *See, e.g.*, EPA Final Rule for Control of Air Pollution From Aircraft and Aircraft Engines; Emission Standards and Test Procedures, 70 Fed. Red. 69,664, 69,666 (Nov. 17, 2005) (establishing new emission standards for oxides of nitrogen ("NOx")and discussing history of EPA's regulation of aircraft engine emissions).

section 302(g)").[9] Following that decision, the President confirmed the need for EPA to use its authority to protect the environment from greenhouse gas emissions from mobile engine sources. *See* Executive Order 13432: Cooperation Among Agencies in Protecting the Environment with Respect to Greenhouse Gas Emissions From Motor Vehicles, Nonroad Vehicles, and Nonroad Engines, 72 Fed. Reg. 27,717 (May 16, 2007).

Given these mandates, EPA has the authority to regulate greenhouse gas emissions from aircraft engines as "air pollutants" pursuant to Section 231(a)(2)(A) of the Act. Moreover, as demonstrated below, given the rapidly increasing contribution of greenhouse gas emissions from aircraft, combined with mounting evidence that these emissions, at altitude, have a significantly greater global warming impact than land-based fuel combustion, it is EPA's clear statutory duty to do so.

STATEMENT OF FACTS

A. Global Climate Change Background.

There is no longer any scientific dispute that human production of greenhouse gases, including carbon dioxide, methane, and nitrous oxide, are responsible for the unprecedented rate of warming observed over the past century.[10] According to the Intergovernmental Panel on Climate Change ("IPCC"),[11] "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[12] Moreover, "[m]ost of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."[13] Thus, the world's leading scientific body on the subject has now concluded, with greater than 90 percent certainty, that emissions of greenhouse gases are responsible for climate change.[14]

---

[9] While that decision dealt with the regulation of motor vehicles pursuant to Section 202(a)(1), 42 U.S.C. § 7521(a)(1), the definition of "air pollutant" in Section 302(g) applies throughout the Act.

[10] *See* EPA, Climate Change – Science, http://www.epa.gov/climatechange/science/index.html; GOVERNMENT ACCOUNTABILITY OFFICE, CLIMATE CHANGE: AGENCIES SHOULD DEVELOP GUIDANCE FOR ADDRESSING THE EFFECTS ON FEDERAL LAND AND WATER RESOURCES (August 2007) at 10, *available at*: http://www.gao.gov/new.items/d07863.pdf [hereinafter GAO Report].

[11] The IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide an authoritative international statement of scientific understanding of climate change. Its various Working Group and Assessment Reports on climate change are available at: http://www.ipcc.ch/.

[12] IPCC, SUMMARY FOR POLICYMAKERS: CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS; CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Feb. 2007) at 5 [hereinafter Working Group I Summary]. In particular, the IPCC found in its recent reports that total global surface temperature increased 0.76°C (1.37°F) between 1850-1899 and 2001-2005. *Id.* In the Arctic, temperatures at the top of the permafrost layer have increased since the 1980s by up to 3°C (5.4°F), while annual average artic sea ice has shrunk by 2.7 percent per decade, with even larger decreases in summer of 7.4 percent per decade. *Id.* Global sea levels rose at an average rate of 1.8 millimeters per year between 1961 and 2003. *Id.*

[13] *Id.* at 10 (emphasis in original).

[14] *See id.* at 3 n.6 (explaining the use of the term "very likely").

In the words of the IPCC, carbon dioxide is "the most important anthropogenic greenhouse gas."[15] The primary source of carbon dioxide emissions since the pre-industrial period has been the combustion of fossil fuels, with land-use changes responsible for another significant but smaller contribution.[16] Not surprisingly, the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million ("ppm") to 379 ppm in 2005, by far exceeding the natural range over the last 650,000 years (180 to 300 ppm), as estimated by ice core samples.[17]

The United States is responsible for over 20 percent of the world's greenhouse gas emissions, and remains one of the largest emitters on a per capita basis.[18] As the largest source of domestic greenhouse gas emissions, carbon dioxide from fossil fuel combustion alone accounted for 79 percent of total warming emissions in 2005.[19] One of the primary sources of such emissions is from the transportation sector, which in 2005 accounted for 33 percent of carbon dioxide emissions in the United States and about 28 percent of all greenhouse gas emissions from anthropogenic activities.[20] According to the IPCC, greenhouse gas emissions from transport are expected to increase 80 percent between 2002 and 2030.[21]

B. Aircraft Engines Emit Greenhouse Gases and Have a Disproportionate Impact on Global Warming.

Aircraft engine emissions are composed of approximately 70 percent carbon dioxide, 30 percent water vapor, and less than one percent each of oxides of nitrogen ("NO_X"), carbon monoxide, oxides of sulfur, and other trace components including hydrocarbons such as methane and soot.[22] These emissions contribute to global warming in several ways. First, aircraft emit significant amounts of carbon dioxide, the primary greenhouse gas produced by anthropogenic activities in the United States and globally. In 2005, aircraft contributed three percent of the United States' total carbon dioxide emissions, and 12 percent of such emissions from the

---

[15] *Id.* at 2; *see* EPA *Inventory*, *supra* note 2, at 2-1.

[16] Working Group I Report Summary, *supra* note 12, at 2.

[17] *Id*.

[18] United Nations Environment Programme /GRID-Arendal, *National carbon dioxide (CO2) emissions per capita; CO2 2002, available at*: http://maps.grida.no/go/graphic/national_carbon_dioxide_co2_emissions_per_capita.

[19] EPA *Inventory*, *supra* note 2, at 2-1.

[20] *Id*. at 2-10, 2-23.

[21] IPCC, CLIMATE CHANGE 2007: MITIGATION OF CLIMATE CHANGE; CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (May 2007) at 357 [hereinafter WORKING GROUP III REPORT].

[22] FAA, OFFICE OF ENVIRONMENT AND ENERGY, AVIATION AND EMISSION: A PRIMER (Jan. 2005) at 1, *available at*: http://www faa.gov/regulations_policies/policy_guidance/envir_policy/media/aeprimer.pdf [hereinafter FAA Report].

transportation end-use sector.[23] However aircraft carbon dioxide emissions, if measured at ground level, are only "a fraction" of aviation's total contribution to climate change.[24]

NO_X emissions from aircraft contribute to the formation of ozone, a greenhouse gas. Moreover, emissions of NO_X in the upper troposphere and tropopause, where most aviation emissions occur, result in greater concentrations of ozone than ground-level emissions.[25] Aircraft also contribute to climate change by altering cloud cover patterns. Aircraft engines emit water vapor, a greenhouse gas that forms condensation trails, or "contrails," when released at high altitude. Contrails are visible line clouds that form in cold, humid atmospheres and contribute to the global warming impact of aircraft.[26] In addition, the persistent formation of contrails is associated with the spread of cirrus clouds.[27] An increase in cirrus cloud cover tends to warm the surface of the Earth, further contributing to global warming.[28]

Therefore, greenhouse gas emissions from aircraft at altitude have a greater global warming impact than their carbon dioxide emissions alone, or than emissions of greenhouse gases at ground level. In fact, a recent report by the UK Royal Commission on Environmental Protection stated that the net effect of ozone, contrail, and aviation-induced cirrus is expected to be three times the radiative forcing due to the CO_2 emitted from aircraft.[29] The report concludes that if these estimates are correct and the anticipated growth in aviation realized, aviation may be responsible for between six and ten percent of anthropogenic forcing of climate by 2050.[30]

C. Aviation's Impact on Global Warming Is Predicted to Increase Dramatically in the Next Few Decades.

Greenhouse gas emissions from aircraft are anticipated to increase substantially in the coming decades because of a projected growth in air transport both in the United States and

---

[23] EPA *Inventory*, *supra* note 2, at 3-8.e, Table 3-7.

[24] Bows, Alice, Kevin Anderson and Paul Uphan, *Technical Report: Contraction and Convergence: UK carbon emissions and the implications for UK air traffic*, TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH (Feb. 2006) at 18, *available at* http://www.tyndall.ac.uk/research/theme2/project_overviews/t3_23.shtml, click link at "Technical Report". *See also*, IPCC, TECHNICAL SUMMARY; CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, (May 2007) at 51 [hereinafter Working Group III Technical Summary].

[25] EPA *Inventory*, *supra* note 2, at 1-4; *see also* IPCC, AVIATION AND THE GLOBAL ATMOSPHERE (1999) at Chapter 1.3.3, *available at*: http://www.grida.no/climate/ipcc/aviation/index htm [hereinafter IPCC Aviation Report].

[26] IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS; CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Feb. 2007) at 186 [hereinafter Working Group I Report].

[27] IPCC, AVIATION AND THE GLOBAL ATMOSPHERE, (June 1999) at Summary for Policymakers, 4.5 [hereinafter IPCC Aviation Report].

[28] *Id.*

[29] ROYAL COMMISSION ON ENVIRONMENTAL PROTECTION (RCEP), THE ENVIRONMENTAL EFFECTS OF CIVIL AIRCRAFT IN FLIGHT, London, UK (Nov. 29, 2002) at 18, *available at*: http://www.rcep.org.uk/avreport htm.

[30] *Id*. at 19.

worldwide.[31] According to the FAA, greenhouse gas emissions from domestic aircraft are expected to increase 60 percent by 2025.[32] The IPCC estimates that increases in air transport over the next 50 years will result in a three-fold increase in aircraft CO_2 emissions, a 13 percent increase in ozone, a growth in contrail cover at a rate faster than that of the growth in aviation fuel consumption, and cirrus cloud increases by a factor of four.[33]

International air transport agreements ("ATAs") negotiated by the United States facilitate these increases. For example, the United States recently signed an agreement with China to amend the countries' existing ATA to *double* passenger flights by 2012, and give U.S. and Chinese cargo carriers unfettered access to markets.[34] Similarly, the United States recently amended its ATA with the European Union (the "Open Skies Agreement") to authorize every U.S. and EU airline to fly between every city in the European Union and the United States, and to operate without restriction on the number of flights, aircraft, and routes.[35]

In short, there is an unrelenting global demand for increased air transport of both passengers and goods – a demand that appears undeterred by escalating flight delays and new terrorist threats, and one that is being facilitated by the policies of the United States government and its trading partners. It should therefore come as no surprise that globally, carbon dioxide emissions from aircraft could grow by more than three-fold by mid-century, making air travel one of the fastest-growing producers of greenhouse gases.[36]

D. Existing and Developing Aviation Procedures and Technologies Can Reduce Greenhouse Gas Emissions.

Given that aircraft require a significant amount of fuel to operate, and that each gallon of jet fuel contributes 21 pounds of carbon dioxide when burned,[37] relatively minor improvements in fuel efficiency can result in significant reductions in greenhouse gases. As described below, aviation procedures and aircraft designs are available today that can significantly increase fuel efficiency and decrease greenhouse gas emissions. Technologies currently being developed are expected to result in even further improvements within the next few years. In fact, according to a recent assessment, with total fuel consumption as an objective, design, operational and

---

[31] Air transport in the United States is expected to increase by 3.5 percent annually over the next decade, and approximately five percent per year worldwide. AVIATION AND THE ENVIRONMENT, *supra* note 5, at 21; ICAO Working Paper, *Towards a Carbon Neutral and Eventually Carbon Free Future*, INT'L AIR TRANSPORT ASS'N, A36-WP/85 EX/33, (Aug. 28, 2007) at ¶ 2.2.

[32] FAA Report, *supra* note 22, at 10.

[33] IPCC Aviation Report, *supra* note 27, at Summary for Policymakers 4.1, 4.2, 4.5, and 4.6.

[34] Fact Sheet, U.S. Department of Treasury, Second Meeting of the U.S.-China Strategic Economic Dialogue (May 23, 2007), *available at*: http://www.treas.gov/press/releases/hp417.htm.

[35] Statement by U.S. Department of Transportation Secretary Peters on the U.S. – EU Open Skies Agreement (Mar. 22, 2007), *available at*: http://www.dot.gov/affairs/peters032207.htm.

[36] Stern Report, *supra* note 4, at 172.

[37] Energy Information Association, Voluntary Reporting of Greenhouse Gases Program, *available at*: http://www.eia.doe.gov/oiaf/1605/factors.html.

technology improvements could result in a ten percent reduction over 2005 levels in carbon dioxide and other fuel-related emissions from aircraft.[38]

Voluntary measures alone will not be sufficient to bring about the changes that are needed to address the significant and growing climate impacts of aviation.[39] Regulations that set mandatory and increasingly stringent standards are needed not only to ensure that existing technologies and operations are implemented in the near-term, but also to increase incentives for the development of new technologies and procedures in the future.[40] EPA itself has acknowledged that Section 231 of the Clean Air Act authorizes it to set "technology-forcing" standards for aircraft engines as long as the standards give manufacturers sufficient lead time. Final Rule for Control of Air Pollution From Aircraft and Aircraft Engines; Emission Standards and Test Procedures, 70 Fed. Red. 69,664, 69,676 (Nov. 17, 2005). Thus, it is imperative that the agency set standards to force the adoption and use of these existing measures, and also to encourage development of improved technologies and procedures that will reduce emissions even further.

1. Improved Aviation Operations and Procedures Can Reduce Greenhouse Gas Emissions Significantly.

There are numerous existing operational measures that can reduce fuel use, and consequently, greenhouse gas emissions from aircraft. Mandating the use of these procedures will result in immediate, near-term, and meaningful improvements in aviation's climate impact.[41] The IPCC estimates that improved aircraft operational practices can reduce greenhouse gas emissions by six to twelve percent.[42] Some operational measures for reducing emissions include:

---

[38] Nicolas Antoine and Ilan Kroo, *Framework for Aircraft Conceptual Design and Environment Performance Studies*, AIAA JOURNAL, Vol. 43, No. 10, 2108 (Oct. 2005).

[39] According to the IPCC, given the anticipated five percent annual growth in aviation, increases in greenhouse gas emissions from aircraft will outpace improvements that can be expected through evolutionary changes in engine and aircraft design. WORKING GROUP III REPORT, *supra* note 21, at 326.

[40] The European Commission's proposal to include aviation emissions in the European carbon trading system illustrates how such regulatory standards can spur industry to more rapidly develop and deploy cleaner aircraft. Under the proposal, greenhouse gas emissions from aviation would be capped and airlines that are unable to meet emission standards would be required to purchase carbon dioxide allowances or offsets. *Commission Directive amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2006&nu_doc=818. Many European airlines are taking steps to modernize their fleets and to purchase more fuel efficient aircraft, but the U.S. airline industry's fleets remain outdated and domestic airline companies have been slow to order newer, more fuel efficient aircraft. Kyle Peterson, *U.S. airlines bide their time as fleet needs grow*, REUTERS (June 12, 2007), *available at*: http://uk reuters.com/article/basicIndustries/idUKN1226568120070612.

[41] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 33-34.

[42] Working Group III Technical Summary, *supra* note 24, at 51.

- minimizing engine idling time on runways[43] and employing single engine taxiing;[44]
- reducing engine thrust and reverse during high-intensity periods such as take-off and landing;[45]
- optimizing timetables, route networks, and flight frequencies to reduce stopovers, especially for short- and medium-haul flights, [46] and to make possible the selection of more fuel-efficient routes;[47]
- reducing the use of auxiliary power units;[48]
- reducing the amount of excess fuel carried;[49]
- more regular maintenance and cleaning of engines and airframes to correct minor deterioration;[50]

Additionally, designing aircraft to operate at lower altitudes and reduced speed could help avoid contrails and cirrus cloud formation, thereby further reducing environmental impacts.[51]

A 2004 Report to Congress, prepared on behalf of the FAA and the National Aeronautics and Space Administration ("NASA"), outlined numerous available operational changes that could be implemented to reduce the global warming impacts of aircraft.[52] In addition to those mentioned above, these measures include continuous descent approach procedures which have been shown not only to reduce noise impacts by keeping aircraft higher for longer, but also to reduce fuel burn and emissions of pollutants.[53] Another example successfully piloted at San Francisco International Airport combined existing technologies to increase the number of landings per hour, with the aim of reducing delays by 25 percent and decreasing the need for aircraft to circle while awaiting clearance for landing.[54]

---

[43] CONTROLLING AIRPORT RELATED POLLUTION, CCAP & NESCAUM (June 2003) at III-8, *available at*: http://bronze.nescaum.org/workgroup/aircraftport/Aviation_Final_Report.pdf, [hereinafter CCAP Report].

[44] AVIATION AND THE ENVIRONMENT, supra note 5, at 34.

[45] CCAP Report, *supra* note 43, at III-9-11.

[46] For the purposes of this petition, short-haul flights refer to flights between 300 and 600 miles. Medium-haul flights refer to flights between 600 and 1,000 miles. Long-haul flights refer to flights greater than 1,000 miles.

[47] CCAP Report, *supra* note 43, at III-9-11; *see also* AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[48] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[49] *Id.*

[50] *Id.*

[51] Antoine *et al.*, *supra* note 38, at 2102 and 2109.

[52] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[53] *Id.*

[54] *Id.*

Measures to reduce the global warming impact of aviation should be a central consideration in the development of new air traffic management systems.[55] Improvements in air traffic management procedures alone could reduce aviation fuel use by between six and eighteen percent, and other operations measures could result in a further two to six percent improvement in efficiency.[56] Unfortunately, the Next Generation Air Transportation System ("NextGen"), the U.S. government's most recent initiative to update and improve America's air traffic system,[57] currently does not include any measures to address the climate change impacts of aviation. In fact, neither the 2005 nor the 2006 NextGen progress report contains a single reference to climate change.[58]

2. Existing, More Efficient Aircraft Designs Can Reduce Greenhouse Gas Emissions.

The airline industry could also meet requirements to reduce greenhouse gas emissions by adopting more efficient aircraft designs and technologies. In fact, designs and technologies are available today that can increase the fuel efficiency of aircraft and minimize such emissions.

One way to reduce the fuel consumption of aircraft is to reduce their weight.[59] One way to achieve such reductions is through the use of lighter composite materials for airframes.[60] For example, the frame of the Boeing 787 Dreamliner, which is scheduled to enter service in 2008, is made primarily from carbon composite, making the aircraft much lighter and 20 percent more fuel efficient than any metal aircraft of similar size.[61]

Weight could also be removed from the nacelle of the aircraft, which holds the engine, fan, thruster and exhaust of a jet engine. The use of lighter materials for the nacelle, and the application of design techniques which can help offset the weight of the engine and fan, can reduce drag and fuel burn, thus improving aircraft efficiency.[62] Another option for reducing weight is the use of efficiently designed propeller aircraft, which are generally lighter than jet-propelled aircraft, for short-haul flights.[63]

---

[55] Thea Sebastian & Rick Pitz, *NextGen Air Transportation System Progress Reports Ignore Climate Change*, CLIMATE SCIENCE WATCH (July 2007), *available at*: http://www.climatesciencewatch.org/file-uploads/NextGen_final_18jul07.pdf.

[56] International Civil Aviation Organization, ENVIRONMENTAL REPORT 2007 (2007) at 108, available at http://www.icao.int/icao/en/env/pubs/Env_Report_07.pdf [hereinafter ICAO ENVIRONMENTAL REPORT].

[57] NextGen is comprised of representatives of the Department of Transportation (with FAA as the lead planning agency), Homeland Security, the Departments of Defense and Commerce, NASA, and the White House Office of Science and Technology Policy, with the oversight of the Joint Planning and Development Office ("JPDO").

[58] Sebastian & Pitz, *supra* note 55, at 7.

[59] Greener by Design Report, *supra* note 3, at 15.

[60] Antoine *et al.*, *supra* note 38, at 2107.

[61] Boeing, Boeing 787 Dreamliner Will Provide New Solutions for Airlines, Passengers, http://www.boeing.com/commercial/787family/background html [hereinafter Boeing 787 Dreamliner Background].

[62] Greener by Design Report, *supra* note 3, at 10.

[63] Greener by Design Report, *supra* note 3, at 12

Other technological adjustments also show promise for marked improvements. The 787, for example, uses advances in engine technology, including the lightest fan system currently certified in the industry, a more fuel-efficient compressor, and a contra-rotating system,[64] that Boeing claims will contribute as much as eight percent of the increased efficiency of the new airplane.[65] Small changes to the bodies of aircraft, such as winglets on the tips of aircraft wings that improve aerodynamics,[66] the use of electric fuel and air pumps inside planes, disk and airfoil blade materials that can withstand higher operating pressures and temperatures,[67] and the employment of unducted-fan engines,[68] are all available technologies that can achieve significant fuel savings and lower emissions. Given the fact that aircraft use large amounts of fuel, even incremental improvements in fuel efficiency can result in significant emissions reductions.

While these technologies are currently available, there are many more advances in aircraft design in the works. Boeing and NASA, for example, are working on the development of a "blended wing" aircraft.[69] Blended wing designs incorporate the engine, wings, and body of an aircraft into a single lifting surface and result in increased fuel efficiency and fewer emissions.[70] This type of aircraft could reduce fuel burn by 20 to 30 percent over an equivalent sized conventional aircraft carrying the same load.[71] In July 2007, the NASA development group successfully tested a blended wing aircraft.[72] Although current blended wing designs are not as comfortable as existing passenger aircraft, the use of a blended wing design for freighter or tanker aircraft transport could reduce emissions in the near term.[73] Another promising technology is a "silent aircraft" being developed by the Massachusetts Institute of Technology and Cambridge University that would burn 25 percent less fuel than current planes, simultaneously achieving the environmental goals of reducing greenhouse gas emissions and reducing noise.[74]

---

[64] Rolls Royce, Trent 1000, Leading Technology, *available at*: http://www rolls-royce.com/civil_aerospace/products/airlines/trent1000/technology_flash.jsp.

[65] Boeing 787 Dreamliner Background, *supra* note 63.

[66] FAA Report, *supra* note 22, at 19. The IPCC has recently estimated that winglets can reduce fuel consumption by around seven percent. Working Group III Report, *supra* note 21, at 354.

[67] NASA Fact Sheet, Safeguarding Our Atmosphere; Glenn Research Reduces Harmful Aircraft Emissions, *available at:* http://www nasa.gov/centers/glenn/about/fs10grc.html.

[68] *Green Fingers; Rolls-Royce pitches open-rotor concept for Europe's Nacre*, AVIATION WEEK & SPACE TECHNOLOGY; AIR TRANSPORT, p. 49, Vol. 165, No. 14.

[69] NASA, X-48 Blended Wing Body, *available at*: http://www nasa.gov/centers/dryden/research/X-48B/index.html.

[70] Greener by Design Report, *supra* note 3, at 22.

[71] Working Group III Report, *supra* note 21, at 354.

[72] *X-48B Blended Wing Body Aircraft makes first flight*, ASSOC. PRESS (July 27, 2007), *available at:* http://www komotv.com/news/boeing/8763787 html.

[73] Greener by Design Report, *supra* note 3, at 20.

[74] The Silent Aircraft Initiative, MIT-Cambridge Institute, *available at*: http://silentaircraft.org/efficiency/.

Advances in aircraft fuel efficiency can have multiple benefits by facilitating improvements in operational practices. For example, more fuel efficient aircraft may help reduce or eliminate stopovers that require additional take-off periods, the most fuel consumptive stage during short- and medium-haul flights.[75]

These technology improvements, combined with aircraft design improvements and operational changes, have the potential to achieve significant reductions in greenhouse gas emissions. The 2004 Report to Congress concluded, however, that without more funding and the development of goals to specifically address the global warming impacts of aircraft, future emissions reductions goals – while technologically feasible – may not be met because an insufficient number of technology options will be brought to a readiness level that would allow them to be transitioned into the industry.[76] Thus, the report recommends that "[f]or the long term, but commencing immediately, integrated programs should be strengthened to bring economically reasonable advanced technologies to levels of development that allow more rapid insertion into aircraft and engines."[77]

3. The Use of Alternative Fuels Could Further Reduce Greenhouse Gas Emissions from Aviation.

Efforts are currently underway to develop and certify alternative fuels that could reduce the global warming impact of aircraft. In April of 2007, Boeing, Virgin Atlantic, and GE Aviation announced an environmental partnership to develop alternative aviation fuels.[78] The consortium is planning to test an alternative-fueled flight in 2008.[79] Boeing also recently entered into an agreement with Air New Zealand and Rolls-Royce to conduct a biofuel demonstration flight in the second half of 2008 using an Air New Zealand Boeing 747-400 equipped with Rolls-Royce engines.[80] According to Air New Zealand's Chief Executive, advances in technology have made biofuels a viable possibility for use in aviation far sooner than anticipated.[81] Academic and private institutes in the United States and around the world are also working to find sustainable ways to produce biofuels suitable for use in aviation.[82]

---

[75] Greener by Design Report, *supra* note 3, at 8, Figure10 and Figure 11.

[76] AVIATION AND THE ENVIRONMENT, supra note 5, at 36.

[77] *Id*.

[78] *Boeing and Virgin Atlantic Announce Environmental Partnership*, NAFTC ENEWS (May 2007), *available at*: http://www naftc.wvu.edu/eNews/May07/virgin html.

[79] Anita LaFond, *Boeing, Virgin Atlantic Join For Biofuel Development; Virgin Atlantic Puts In Big Order For Boeing's Dreamliners*, MANUFACTURING.NET; MANAGEMENT NEWS NOW (Apr. 24, 2007), *available at*: http://www manufacturing.net/article.aspx?id=140037&menuid=272.

[80] Richard Black, *Biofuel Trial Flight Set for 747*, BBC NEWS ONLINE (Sept. 28, 2007), *available at*: http://news.bbc.co.uk/2/hi/science/nature/7017694.stm.

[81] *Id*.

[82] *See, e.g.*, Baylor Institute for Air Sciences, *available at*: http://www.baylor.edu/bias/; *see also Boeing and Virgin launch biofuel efforts*, MACHINE DESIGN (June 21, 2007), *available at*: http://machinedesign.com/ContentItem/67970/BoeingandVirginlaunchbiofueleffort.aspx.

Although the benefits of requiring the use of biofuels for any transportation sector remain uncertain,[83] to the extent that concerns are sufficiently addressed, the development of alternative fuels for use in aircraft is promising. Regulatory measures limiting greenhouse gas emissions from aircraft would increase the incentives to develop and use alternative fuels that could significantly reduce the global warming impacts of aviation.

ARGUMENT

Pursuant to the Clean Air Act, EPA is required to prescribe emission standards for air pollutants from aircraft engines when such emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. 42 U.S.C. § 7571(a)(2)(A). As discussed herein, it is indisputable that greenhouse gas emissions, including those from aircraft engines, are air pollutants that are causing and contributing to global climate change with severe environmental consequences for the planet and all of its inhabitants. EPA has broad discretion in promulgating regulations to limit greenhouse gases from aviation. Moreover, numerous measures are currently available that can reduce the global warming impacts of aircraft emissions, and new technologies and other procedures under development can be brought online to further reduce emissions within reasonable timeframes. Consequently, Petitioners request that EPA undertake its mandatory duty to regulate greenhouse gas emissions from aircraft engines.

A. Greenhouse Gas Emissions from Aircraft Engines Are Air Pollutants Under the Clean Air Act.

Under Section 302(g) of the Clean Air Act, an "air pollutant" is defined as "any air pollution agent or combination of such agents, including any physical, [or] chemical…substance or matter which is emitted into or otherwise enters the ambient air." 42 U.S.C. § 7602(g). This definition has long been interpreted by courts in an extremely broad manner. *See, e.g., Alabama Power Co. v. Costle*, 636 F.2d 323, 353 n. 60 (D.C. Cir. 1979). Furthermore, the Supreme Court recently held that carbon dioxide and other greenhouse gases "are without a doubt 'physical [and] chemical…substance[s] which [are] emitted into…the ambient air.'" *Mass. v. EPA*, 127 S. Ct. at 1460. As a result, the greenhouse gases that Petitioners here request EPA to regulate under Section 231 of the Clean Air Act fall within the definition of "air pollutant" under Section 302(g).

B. Emissions of Greenhouse Gases from Aircraft Engines Endanger Public Health and Welfare.

Pursuant to the requirements of Section 231, greenhouse gas emissions from aircraft engines must be regulated under the Clean Air Act because they cause or contribute to the endangerment of public health and welfare. As discussed above, there is now substantial

[83] Many issues, primarily those of land available for growing biostocks, the costs of processing and refining them, as well as lifecycle greenhouse gas emissions from biofuels, remain to be resolved before the widespread introduction of biofuels to transportation industries could be sustainable or result in life-cycle net reductions in greenhouse gas emissions.

evidence that greenhouse gas emissions from anthropogenic sources are resulting in changes to the global climate, with profound implications for all life on the planet. These impacts include increased global air and water temperatures, rising sea levels, the spread of infectious diseases, an increased number of extreme weather events, impacts on air quality and the availability of drinking water, changes in ecosystems and wildlife habitat, and the potential extinction of countless species.

The Clean Air Act does not require proof of actual harm when determining what constitutes an endangerment to public health and welfare. Rather, EPA is required to take a precautionary approach in regulating pollution that "may reasonably be anticipated to endanger public health or welfare." 42 U.S.C. § 7571(a)(2)(A); *see Mass. v. EPA*, 127 S. Ct. at 1463 ("Nor can EPA avoid its statutory obligation by noting the uncertainty surrounding various features of climate change and concluding that it would therefore be better not to regulate at this time"); *Lead Industries Ass'n v. EPA*, 647 F.2d 1130, 1155 (D.C. Cir. 1980) ("requiring EPA to wait until it can conclusively demonstrate that a particular effect is adverse to health before it acts is inconsistent with both the Act's precautionary and preventive orientation and the nature of the Administrator's statutory responsibilities"). Regardless, there is now substantial evidence that greenhouse gas emissions, including those contributed by aircraft engines, may reasonably be anticipated to endanger public health and welfare.[84]

1. Aircraft Greenhouse Gas Emissions Cause and Contribute to the Endangerment of Public Health.

Global climate change is expected to have significant impacts on human health in numerous ways, including increased heat-related mortalities, the spread of infectious disease vectors, greater air and water pollution, an increase in malnutrition, and greater casualties from fires, storms, and floods.[85] As EPA itself has stated:

> Throughout the world, the prevalence of some diseases and other threats to human health depend largely on local climate. Extreme temperatures can directly lead to loss of life, while climate-related disturbances in ecological systems, such as changes in the range of infective parasites, can indirectly impact the incidence of serious infectious diseases. In addition, warm temperatures can increase air and water pollution, which in turn harm human health.[86]

---

[84] In fact, EPA found more than a decade ago that aircraft NOx emissions at cruise altitudes are "directly harmful to human health and the environment" since they are "considered to be a precursor of tropospheric ozone and a contributor to greenhouse gas." 62 Fed. Reg. 25,356, 25,358 (May 8, 1997).

[85] IPCC, SUMMARY FOR POLICYMAKERS: CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY, WORKING GROUP II CONTRIBUTION TO THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE FOURTH ASSESSMENT REPORT (April, 2007) at 3 [hereinafter Working Group II Report]; *see generally* Paul R. Epstein and Evan Mills, CLIMATE CHANGE FUTURES: HEALTH, ECOLOGICAL AND ECONOMIC DIMENSIONS (Nov. 2005), *available at*: http://www.climatechangefutures.org/report/index html [hereinafter Epstein & Mills].

[86] EPA, Climate Change, Health and Environmental Effects; *available at*: http://www.epa.gov/climatechange/effects/health html [hereinafter EPA Climate Change Effects].

Negative health effects from rising temperatures and sea levels worldwide, especially in developing countries, are expected to outweigh any anticipated benefits of climate change on human health in temperate areas.[87] Even though such impacts may be mediated through complex interactions of physical, ecological, and social factors, the World Health Organization ("WHO") has previously estimated that climate change was responsible for at least 154,000 deaths worldwide in 2000.[88]

Climate change is expected to increase the risk from certain infectious diseases, especially vector-born diseases spread by mosquitoes such as malaria, dengue fever, yellow fever, and encephalitis in warm areas.[89] In the northeastern United States, hotter, longer, and drier summers punctuated by heavy rainstorms may also create more favorable conditions for outbreaks of West Nile Virus.[90] Furthermore, the spread of warmer winters is expected to create ideal conditions for the northward expansion of Lyme disease from the United States into southern Canada.[91]

An increase in the frequency and severity of extreme weather events, such as hurricanes, heat waves, and floods, resulting from climate change may result in more deaths, injuries, and stress-related disorders.[92] For example, in heavily populated delta regions, coastal areas, and small islands, sea level rise is anticipated to exacerbate flooding, storm surges, beach erosion, and other hazards, thus threatening vital infrastructure and settlements.[93] In the United States, sea levels have already risen five to six inches more than the global average along the Mid-Atlantic and Gulf Coast during the last century due to coastal lands that are subsiding.[94] By the end of this century, coastal flooding in New York City that now occurs once every 100 years could strike once each decade, while Atlantic City and Boston could experience such flooding every other year.[95]

Moreover, cities that already experience hot summers are expected to be further challenged by an increasing number, intensity, and duration of heat waves during the 21st century and a resulting increase in heat-related illnesses and deaths.[96] Temperatures in the northeastern United States are expected to increase between 2.5°F to 4.5°F in the winter months and 1.5°F to 3.5°F in the summer by the end of the century, with cities such as Hartford and

---

[87] Working Group II Report, *supra* note 85, at 7.

[88] WHO, THE WORLD HEALTH REPORT 2002: REDUCING RISKS, PROMOTING HEALTHY LIFE (Oct. 2002) at 72, *available at*: http://www.who.int/whr/2002/en/.

[89] Epstein & Mills, *supra* note 85, at 32-47; EPA Climate Change Effects, *supra* note 85.

[90] PETER C. FRUMHOFF, *ET AL.*, CONFRONTING CLIMATE CHANGE IN THE U.S. NORTHEAST: SCIENCE, IMPACTS, AND SOLUTIONS (July 2007) at xi, *available at*: http://www.climatechoices.org/ne/resources_ne/nereport.html [hereinafter Northeast Report].

[91] Epstein & Mills, *supra* note 85, at 46.

[92] *Id.* at 53-64.

[93] Working Group II Report, *supra* note 85, at 8-11.

[94] EPA Climate Change Effects, *supra* note 86.

[95] Northeast Report, *supra* note 90, at x-xi.

[96] Working Group II Report, *supra* note 85, at 10.

Philadelphia averaging more than 30 days with high temperatures above 100°F each year.[97] Segments of the population that are particularly vulnerable, such as those with heart problems, asthma, the elderly, infants, and the homeless, can be especially at risk to extreme heat.[98]

In addition to an increase in the frequency and severity of heat waves, higher temperatures and sunlight, combined with other pollutants such as NO_X and volatile organic compounds, may increase concentrations of ground-level ozone.[99] In Philadelphia, for instance, the number of days failing to meet federal air quality standards for ozone is expected to quadruple by the end of the century.[100] Breathing ozone can trigger a variety of health problems, including chest pain, coughing, throat irritation, and congestion, and repeated exposure can lead to bronchitis, emphysema, asthma, and permanent scarring of lung tissue.[101]

Climate change may also indirectly affect the concentration of particulate matter in the air by increasing sources such as wildfires and dust from dry soils.[102] Exposure to such particles can affect both the lungs and heart and has been linked to a variety of problems, including increased respiratory symptoms such as irritation of the airways, coughing or difficulty breathing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease.[103] As with other forms of air pollution, certain vulnerable segments of the population, such as children with asthma and the elderly, are the most likely to be affected.[104]

Warming in the western United States is projected to decrease snowpack, cause more winter flooding and reduced summer flows, and exacerbate competition for already over-allocated freshwater resources.[105] Moreover, rising sea levels are expected to increase the salinity of surface and ground water through salt water intrusion, threatening drinking water supplies in places like New York City, southern Florida, and California's Central Valley.[106]

Together, these findings amply demonstrate that global warming presents an unprecedented, long-term, and wide-ranging threat to public health. Reducing greenhouse gas emissions from aircraft is a necessary step towards addressing these impacts.

---

[97] Northeast Report, *supra* note 90, at ix-x.

[98] EPA Climate Change Effects, *supra* note 86.

[99] *Id.*

[100] Northeast Report, *supra* note 90, at x.

[101] EPA, Ground Level Ozone, Health and Environment, *available at*: http://www.epa.gov/air/ozonepollution/health html.

[102] EPA Climate Change Effects, *supra* note 86.

[103] EPA, Particulate Matter, Health and Environment, *available at*: http://www.epa.gov/air/particlepollution/health html.

[104] *Id*.

[105] Working Group II Report, *supra* note 85, at 10.

[106] EPA Climate Change Effects, *supra* note 86.

2. Aircraft Greenhouse Gas Emissions Cause and Contribute to the Endangerment of Public Welfare.

Emissions of greenhouse gases from aircraft engines are also endangering public welfare,[107] and many of these effects are directly related to the public health impacts discussed above. For example, global climate change is already resulting in well-documented impacts on climate and weather, including air and ocean temperature increases, widespread melting of snow and ice, changes in precipitation amounts and wind patterns, and more frequent extreme weather events such as hurricanes, heat waves, floods, and droughts.[108] Coastal areas are projected to be exposed to increased risk, such as erosion and flooding, due to climate change and sea level rise.[109] As the IPCC has stated, "[m]any millions more people are projected to be flooded every year due to sea-level rise by the 2080s."[110]

In its recent assessment, the IPCC concluded that "[o]bservational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases."[111] With regard to natural systems involving snow, ice, and frozen ground such as permafrost, the evidence shows an enlargement and increased number of glacial lakes, increasing ground instability in permafrost regions, and rock avalanches in mountain regions.[112] In Glacier National Park, the estimated number of glaciers has dropped from 150 to 26 since 1850, and the remaining glaciers will be gone in the next 25 to 30 years if the current rate of melting continues.[113] It is also likely that temperature increases associated with global climate change will alter the disturbance regimes of northern hemisphere forests, resulting in earlier and longer fire seasons, an increase in disease and pests, and a greater amount of areas burned and experiencing high to extreme fire danger.[114] Climate change is expected to alter the geographic distribution of these forests, including New England sugar maples and boreal forests in Alaska, which may shift northward or to higher elevations.[115]

Sea level rise is also resulting in the loss of wetlands and increasing damage from coastal flooding in many areas.[116] Coastal wetlands, including salt marshes and mangroves, are projected to be negatively affected by sea level rise, especially where they are constrained on their landward side or starved of sediment.[117] Wetlands can provide habitat for numerous

---

[107] "Welfare" is defined under the Clean Air Act to include "effects on soil, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate." 42 U.S.C. § 7602(h).

[108] Working Group I Report Summary, *supra* note 12, at 5-9; *see* GAO REPORT, *supra* note 10, at 5-6.

[109] Working Group II Report, *supra* note 85, at 6.

[110] *Id.* at 7.

[111] *Id.* at 1.

[112] *Id.*

[113] GAO REPORT, *supra* note 10 at 18.

[114] Working Group II Report, *supra* note 85, at 3.

[115] EPA Climate Change Effects, *supra* note 86.

[116] Working Group II Report, *supra* note 85, at 3.

[117] *Id.* at 6-7.

species and nursery areas for fish, serve as a basis for many communities' economic livelihoods, provide recreational opportunities, and protect local areas from flooding.[118] During the 21st century, sea level rise could convert as much as 22 percent of the world's coastal wetlands into open water.[119] EPA has estimated that a two foot rise in sea level could eliminate 17-43 percent of wetlands in the United States, with more than half of the loss occurring in Louisiana.[120]

Global climate change directly affects terrestrial biological systems, as evidenced by the poleward and upward shifts in the ranges of numerous plant and animal species, as well as the earlier timing of spring events such as bird migration and egg-laying.[121] As the IPCC has found, "[t]he resilience of many ecosystems is likely to be exceeded in this century by an unprecedented combination of climate change, associated disturbances (*e.g.*, flooding, drought, wildfire, insects, ocean acidification)," and other global change drivers such as pollution and over exploitation of resources.[122] In the Arctic, detrimental effects are expected to mammals, migratory birds, and other organisms from reductions in sea ice,[123] increased coastal erosion, and an increase in the depth of seasonal thawing of permafrost.[124] Not surprisingly, approximately 20-30 percent of plant and animal species assessed so far will be at an increased risk of extinction if global average temperatures exceed 1.5-2.5°C (2.7-4.5°F).[125] According to one estimate, up to 35 percent of species in the regions sampled will be committed to extinction by 2050 under a high climate-warming scenario.[126]

Changes in global climate are also expected to have numerous impacts on marine and freshwater biological systems, such as shifts in ranges and changes in algal, plankton, and fish abundance in high latitude oceans, increases in algal and zooplankton abundance in high-latitude and high-altitude lakes, and range changes and earlier migrations of fish in rivers.[127] In addition, the acidification of the oceans, which has already decreased in pH by 0.1 units on average due to the absorption of increasing atmospheric levels of carbon dioxide, is expected to harm marine shell forming organisms and species dependant on them.[128]

Corals are particularly vulnerable to thermal stress and already have low adaptive capacity to changes in their ecosystem.[129] For example, an increase in sea surface temperature

---

[118] EPA Climate Change Effects, *supra* note 86.

[119] *Id.*

[120] *Id.*

[121] Working Group II Report, *supra* note 85, at 2.

[122] *Id.* at 5.

[123] This is especially true for species like the polar bear, which is evolutionarily adapted to life on the sea ice and spends only short periods on land. *See* 72 Fed Reg. 1,064 (Jan. 9, 2007) (Proposed Rule To List the Polar Bear as Threatened Under the Endangered Species Act).

[124] Working Group II Report, *supra* note 85, at 11.

[125] *Id.* at 6.

[126] Chris D. Thomas, *et al.*, *Extinction Risk From Climate Change*, NATURE 427 (Jan. 8, 2004) at 145-48.

[127] Working Group II Report, *supra* note 85 at 2.

[128] *Id.* at 6; *see* GAO REPORT, *supra* note 10, at 22.

[129] Working Group II Report, *supra* note 85, at 6.

of approximately 1-3°C (1.8-5.4°F) is projected to result in more frequent coral bleaching events and widespread mortality.[130] This is because even slightly elevated ocean temperatures can destroy the symbiotic relationship in corals between algae and animal polyps, leading to the collapse of entire reefs.[131] As the GAO has reported, continued increases in water temperatures in the Florida Keys may result in more coral bleaching events and will adversely affect the area's tourism and fishing industries.[132] In addition, the lobster fisheries in Long Island Sound and the coastal waters off Rhode Island and South Cape Cod are likely to decline significantly by 2050, while cod is expected to disappear by the end of the century.[133]

Agriculture is highly sensitive to changes in climate, including increased temperatures and shifting rainfall patterns, as well as weather extremes, such as droughts, floods, and severe storms. The IPCC reports that temperature increases resulting from greenhouse gas emissions are likely to impact agricultural practices in the northern hemisphere, such as an earlier spring planting of crops.[134] Parts of Massachusetts, New Jersey, and Pennsylvania are likely to become unsuitable for growing popular varieties of apples, blueberries, and cranberries, while milk production across the northeastern United States is projected to decline between five and 20 percent during certain months.[135] In addition, an increase in the frequency of droughts and floods is also expected to negatively affect crop production, especially at low latitudes.[136] Crop losses attributed to pests, pathogens, and weeds could also increase from the current 42 percent to over 50 percent of potential yields within the coming decade.[137]

In sum, there is no dispute that global warming presents an unprecedented and wide-ranging threat to public welfare. As a result, EPA must take the necessary steps toward regulating greenhouse gas emissions from aircraft engines pursuant to Section 231 of the Clean Air Act.

C. EPA Has Broad Discretion in Promulgating Regulations to Limit Greenhouse Gas Emissions from Aircraft Engines.

---

[130] *Id.* The National Marine Fisheries Service has found that shallow reef habitats are especially vulnerable to increases in global air and sea temperatures due to coral bleaching. 76 Fed. Reg. 26,852, 26,858 (May 9, 2006) (Final Rule to List Elkhorn (*Acropora palmata*) and Staghorn (*A. cervicornis*) Corals as Threatened Under the Endangered Species Act). *See also* International Coral Reef Initiative, Okinawa Declaration on Conservation and Restoration of Endangered Coral Reefs of the World (July 2, 2004) (finding that "the increase in sea surface temperatures, the decrease in carbonate levels as well as sea-level rise, caused by increasing anthropogenic CO2 in the atmosphere, all act synergistically to stress coral reefs, which lead to severe bleaching and extensive coral mortality"), *available at*: http://www.icriforum.org/secretariat/oki_declaration html.

[131] Epstein & Mills, *supra* note 85, at 10, 77-79.

[132] GAO REPORT, *supra* note 10, at 30-31.

[133] Northeast Report, *supra* note 90, at xi.

[134] Working Group II Report, *supra* note 85, at 3.

[135] Northeast Report, *supra* note 90, at xi.

[136] Working Group II Report, *supra* note 85, at 6.

[137] Epstein & Mills, *supra* note 85, at 29.

While EPA's determination of whether greenhouse gas emissions from aircraft endanger public health or welfare presents a straightforward "yes or no" question, the realm of potential regulatory responses to an affirmative finding is quite broad. This flexibility stems from Congress' recognition, in drafting the Clean Air Act, that not all pollutants could be controlled in the same manner. *See, e.g.*, 42 U.S.C. § 7408(b) (requiring EPA to provide information regarding air pollution control techniques for criteria pollutants, including "available technology and alternative methods of prevention and control of air pollution," as well as "data on alternative fuels, processes, and operating methods which will result in elimination or significant reduction of emissions"). Accordingly, Congress provided EPA with broad authority to craft emissions standards that utilize multiple approaches in achieving pollution reductions. *See Mass. v. EPA*, 127 S. Ct. at 1462 (once EPA makes a finding of endangerment regarding greenhouse gas emissions from motor vehicles, it "no doubt has significant latitude as to the manner, timing, content, and coordination of its regulations with those of other agencies").

Specifically, Section 231 of the Act requires EPA to "issue proposed emission standards" applicable to any air pollutants from aircraft engines that contribute to air pollution that may reasonably be anticipated to endanger public health or welfare. 42 U.S.C. § 7571(a)(2)(A). The Act broadly defines "emission standard" as:

> a requirement established by the State or the Administrator which limits the quantity, rate, or concentration of emissions of air pollutants on a continuous basis, including any requirement relating to the operation or maintenance of a source to assure continuous emission reduction, and any design, equipment, work practice or operational standard promulgated under this chapter.

Id. at § 7602(k).

As this definition demonstrates, EPA has the authority to regulate greenhouse gas emissions from aircraft through the use of operational or maintenance requirements, and any design, equipment, work practice or operational standards. *See, e.g.*, *Engine Mfrs. Ass'n v. South Coast Air Quality Mgmt. Dist.*, 541 U.S. 246, 252-53 (2004) (state rule prohibiting the purchase or lease of vehicles that fail to meet stringent emission requirements constituted a "standard relating to the control of emissions" under Section 209(a); such a broad interpretation was "consistent with the use of 'standard' throughout Title II of the CAA"). In fact, the only limitation on EPA's discretion to set "emission standards" for aircraft engines is the Act's restriction on changes that "would significantly increase noise or adversely affect safety." *Id.* at § 7571(a)(2)(B)(ii).

Moreover, Section 231 allows EPA to limit emissions by establishing technology-forcing standards for aircraft engines. Congress deliberately chose such an approach in the Clean Air Act to require EPA to "'press for the development and application of improved technology rather than be limited by that which exists today,'" *Natural Resources Defense Council v. U.S. EPA*, 655 F.2d 318, 328 (D.C. Cir. 1981) (quoting S. Rep. No. 91-1196, 91st Cong., 2d Sess. 24 (1970)), and to force the industry "to develop pollution control devices that might at the time appear to be economically or technologically infeasible." *Union Elec. Co. v. EPA*, 427 U.S. 246, 257 (1976). Although Section 231 does place a greater emphasis on safety considerations

than other provisions in the Act, EPA has agreed that "section 231(b)'s forward-looking language" does not preclude the agency from setting technology-forcing standards. *See* 70 Fed. Reg. at 69,676 ("EPA does not agree that a technology-forcing standard would be precluded by section 231, in light of section 231(b)'s forward-looking language. Nor would EPA have to demonstrate that a technology is currently available universally or over a broad range of aircraft in order to base a standard on the emissions performance of such technology – the Agency is not limited in identifying what is 'technologically feasible' as what is already technologically achieved.").

EPA also has broad authority to regulate emissions from all classes of aircraft, including both new and in-use aircraft and aircraft engines. 42 U.S.C. § 7571(a)(2)(A) (authorizing EPA to issue proposed emission standards for air pollutants from "any class or classes of aircraft engines"); *see, e.g.*, 40 C.F.R. § 87.10 (prescribing fuel venting emissions standards for new and in-use aircraft). While Congress limited EPA's authority to regulate only "new" motor vehicles and engines under Sections 202 and 213 of the Clean Air Act, 42 U.S.C. §§ 7521 & 7547, Section 231 contains no such restriction. "[W]here Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion." *Bates v. United States*, 522 U.S. 23, 29-30 (1997) (quotations omitted); *see Reiter v. Sonotone Corp.*, 442 U.S. 330, 339 (1979) ("In construing a statute we are obliged to give effect, if possible, to every word Congress used.").

The duty to regulate air pollution from aviation has not been left to EPA alone. Instead, Section 231 of the Act requires EPA to consult with the FAA in developing emissions standards for aircraft engines. 42 U.S.C. § 7571(a)(2)(B)(i). The FAA is also required by Section 232 to promulgate its own regulations "to insure compliance with all standards prescribed under section 7571" by EPA. *Id.* at § 7572(a). In issuing such regulations, the FAA "may execute any power or duty vested in [the FAA Administrator] by any other provision of law." *Id. See, e.g.*, 49 U.S.C. §§ 40103(b) (authorizing FAA to prescribe air traffic regulations for using navigable airspace efficiently); 44505(a) (FAA shall develop and evaluate systems, procedures, facilities, and devices to provide for safe and efficient navigation and air traffic control); 44704 (requiring FAA to control or eliminate emissions from aircraft fuels that EPA finds endanger public health or welfare); 47107(a)(16) (authorizing FAA to condition approval of airport development projects or alterations based on operational efficiency).

D. EPA's Authority to Address the Global Warming Impacts of Aircraft is Consistent with International Law.

The Convention on International Civil Aviation (the "Chicago Convention"),[138] to which the United States is a Party, supports EPA's discretion to regulate greenhouse gas emissions from aircraft. While the convention encourages parties to cooperate in securing the highest practicable degree of uniformity,[139] Article 38 recognizes the right of States to depart from

[138] Convention on International Civil Aviation, Dec. 7, 1944, T.I.A.S. 1591, 61 Stat. 1180.

[139] Article 37 provides: "Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation."

international airworthiness standards and procedures where they deem necessary by giving notice to the International Civil Aviation Organization ("ICAO")[140]: "Any State ... which deems it necessary to adopt regulations or practices differing in any particular respect from those established by an international standard, shall give immediate notification to the [ICAO] of the differences between its own practice and that established by the international standard." As EPA itself has recognized:

> The Chicago Convention does not require all Contracting States to adopt identical airworthiness standards. Although the Convention urges a high degree of uniformity, it is expected that States will adopt their own airworthiness standards, and it is anticipated that some states may adopt standards that are more stringent than those agreed upon by ICAO.

70 Fed. Reg. at 69,667. Thus, the convention permits countries to adopt aircraft emissions standards that are more stringent than the ICAO standards, and EPA, in consultation with the FAA, "retains the discretion to adopt more stringent emissions standards if the international consensus standards ultimately prove insufficient to protect U.S. air quality." *Id*. at 69,664.

In fact, the ICAO is strongly encouraging States to adopt programs to address the significant and increasing climate impacts from aircraft. During the most recent meeting of the ICAO Assembly in September 2007, the Assembly amended its policies and practices related to environmental protection to encourage States to proactively address aviation's contribution to global warming.[141] Pursuant to a new Appendix K – "*ICAO Programme of Action on international aviation and climate change*," the ICAO Assembly is urging States to undertake an array of measures to address the climate impacts of aircraft including by: (1) encouraging development of "more environmentally friendly efficient engine and aircraft designs"; (2) accelerating "the development and implementation of fuel efficient routings and procedures to reduce aviation emissions"; (3) accelerating efforts "to achieve environmental benefits through the application of satellite-based technologies that improve the efficiency of air navigation";[142] and (4) reducing barriers "to enable implementation of new ATM operating concepts for environmentally efficient use of airspace."[143] A comprehensive program specifically designed to address the climate impacts of all aircraft operating in the United States is clearly needed.

Finally, adopting standards to address the climate impact of aviation is consistent with the United States' obligation under the UN Framework Convention on Climate Change

---

[140] The ICAO, a UN specialized agency established pursuant to the Chicago Convention, is responsible for coordinating and regulating international aviation.

[141] *See* Resolution 17/1: *Consolidated statement of continuing ICAO policies and practices related to environmental protection* (amending Resolution A35-5 (WP/35)), A/36-WP/355 P/53 (Sept. 9, 2007), *available at*: http://www.icao.int/icao/en/assembl/a36/wp/wp355_en.pdf.

[142] The FAA recently announced that it was proposing a new rule requiring all aircraft flying in the nation's busiest airspace to have satellite-based navigation. 72 Fed. Reg. 56,947 (Oct. 5, 2007). However, more is needed in both the near- and long-term to address greenhouse gas emissions from aircraft. For example, while FAA estimates that the rule will result in approximately nineteen million metric tons less carbon dioxide emissions, the vast majority of this reduction, eighteen million tons, would not take place until between 2017 and 2035. *Id*. at 56,965.

[143] *Id*. at Appendix K, ¶ 14.

("UNFCCC"). Article 4 of the UNFCCC obligates the United States to "adopt national policies and take corresponding measures on the mitigation of climate change, by limiting anthropogenic emissions of greenhouse gases."[144]

E. EPA Has the Authority Under Both the Clean Air Act and International Law to Regulate Greenhouse Gas Emissions from Foreign Aircraft Operating in the United States.

As described above, *all* aircraft operating in the United States contribute to global warming. Therefore, EPA must regulate greenhouse gas emissions from not only U.S. certified aircraft, but also foreign aircraft arriving in and departing from the United States.

Designing a regulatory program to address the climate impacts from aviation that extends to foreign aircraft operating within the United States is consistent with U.S. law. First, the Clean Air Act gives EPA unambiguous authority to regulate air pollutants from both U.S.-certified aircraft and foreign aircraft. Pursuant to Section 231(2)(A) of the Act, EPA is authorized to set emission standards from "any class or classes of aircraft engines." 42 U.S.C. § 7571(a)(2)(A). The EPA regulations define "aircraft" as "any airplane for which a U.S. standard airworthiness certificate or equivalent foreign airworthiness certificate is issued." 40 C.F.R § 87.1. The FAA, which is responsible under the Act for prescribing regulations to implement emission standards for aircraft established by EPA, 42 U.S.C. § 7572(a), also has authority to regulate foreign aircraft. *See, e.g.*, 14 C.F.R. § 129.11 (operation specifications for foreign air carriers and foreign operators of U.S.-registered aircraft engaged in common carriage); 14 C.F.R. § 91.711 (special rules for foreign civil aircraft).

In addition, establishing greenhouse gas emission standards for foreign aircraft operating within U.S. airspace is consistent not only with general principles of international law but also the United States' obligations under both the UNFCCC and the Chicago Convention. International law requires nations to ensure that activities within their territory do not cause transboundary environmental harm. For example, in adopting the 1972 Declaration of the United Nations Convention on the Human Environment ("Stockholm Declaration") and the 1992 Rio Declaration on Environment and Development, the United States and 179 other nations agreed that States must "ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[145] The preamble to the UNFCCC, to which the United States is a party, applies this well-established principle to greenhouse gas emissions.[146] Allowing aircraft flying within

---

[144] United Nations Framework Convention on Climate Change (UNFCCC), art. 4, § 2(a), May 9, 1992, Doc. A/AC.237/18, (Part 11)/Add.1 and Corr.1, 31 I.L.M. 848.

[145] Stockholm Declaration of the United Nations Conference on the Human Environment, Principle 21, G.A. Res. 2997, U.N. GAOR, 27th Sess., U.N. Doc. A/ Conf.48/14/Rev/1, 11 I.L.M. 1416 (1972); Rio Declaration on Environment and Development, *supra*, at Principle 2. The Heavy Metals Protocol to the Convention on Long-Range Transboundary Air Pollution, which the United States has accepted, echoes the Rio Declaration's agreement that states must prevent transboundary harm. Heavy Metals Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, preamble, June 24, 1998, U.N. Doc. E/ECE/EB.AIR/66/1999, U.N. Sales No. E.99.II.E.21 (1999).

U.S. airspace, whether U.S. or foreign, to continue to emit significant and increasing levels of greenhouse gases that are contributing to global climate change contravenes this principle.

International law also recognizes the sovereign right of nations to regulate activities within their jurisdiction or control, especially where those activities adversely affect the health and welfare of their own citizens.[147] Therefore, EPA has the authority not only to regulate and establish emissions standards for aircraft certified pursuant to U.S. laws and regulations – whether traveling domestically or abroad – but also to address greenhouse gas emissions from foreign aircraft operating within U.S. territory.

Finally, the United States' obligations under the Chicago Convention do not constrain EPA's authority to adopt a program to address aviation's global warming impacts that includes foreign aircraft as well. In fact, numerous State Parties to the Chicago Convention have endorsed this view. For example, the European Commission, recognizing climate change as "the most significant adverse impact of aviation,"[148] adopted a proposal in December 2006 to include greenhouse gas emissions from all domestic and international flights arriving in and departing from EU airports, including U.S.-certified aircraft, in the EU Emissions Trading Scheme ("ETS").[149] The European Parliament recently voted to strengthen the proposal by moving the compliance date from 2012 to 2011.[150] If the proposal is adopted, aircraft from non-EU countries not meeting the emission standards established within the EU will be required to purchase greenhouse gas emission allowances in order to land at and take off from European airports.

In addition, a wide array of measures is available to address the climate impacts from aircraft, including many endorsed by the ICAO, such as developing new operational and procedural measures. Many of these could be applied to foreign aircraft without imposing more

---

[146] UNFCCC Preamble, *supra* note 144 ("States have, in accordance with the Charter of the United Nations and the principles of international law…the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction"); *see also United States v. Canada*, Arbitral Tribunal, 1941, 3 UN Rep. Int'l Arb. Awards (1941) ("under the principles of international law, as well as the law of the United States, no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.")

[147] Restatement of the Law Third, The Foreign Relations Law of the United States, The American Law Institute, Vol. 1 § 402 (stating that "[A] state has jurisdiction to prescribe law with respect to... conduct that, wholly or in substantial part, takes place within its territory."

[148] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 12.

[149] *Commission Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0818en01.pdf.

[150] Resolution on the proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, EUR. PARL. DOC. (COM(2006)0818 – C6-0011/2007 – 2006/0304(COD)) (Nov. 13, 2007), *available at*: http://www.europarl.europa.eu/sides/getDoc.do?Type=TA&Reference=P6-TA-2007-0505&language=EN.

stringent airworthiness standards as provided under Article 33 of the convention.[151] Finally, EPA must recognize that its primary responsibility is to protect U.S. public health and welfare, and the United States' obligations under international agreements such as the Chicago Convention are applicable only to the extent they do not endanger U.S. public health and welfare.

In sum, EPA has a clear and unambiguous mandate under the Clean Air Act to set emissions standards for aircraft, including foreign aircraft, necessary to prevent the significant harm that will occur as a result of global warming.

CONCLUSION

Based on the foregoing, Petitioners respectfully request that EPA:

(1) Make a finding that greenhouse gas emissions from aircraft engines may reasonably be anticipated to endanger public health and welfare pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A);

(2) Issue proposed standards for greenhouse gas emissions from aircraft engines pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A); and

(3) Promulgate final regulations within 90 days of the issuance of such proposed standards pursuant to Section 231(a)(3) of the Clean Air Act, 42 U.S.C. § 7571(a)(3).

Sincerely,

Alice R. Thomas
George M. Torgun
Martin Wagner
Earthjustice
426 17th Street, 6th Floor
Oakland, CA 94612
(510) 550-6700

Attorneys for Petitioners Friends of the Earth, Oceana, and the Center for Biological Diversity

[151] Convention on International Civil Aviation, art. 33, Dec. 7, 1944, T.I.A.S. 1591, 61 Stat. 1180 ("Certificates of airworthiness and certificates of competency and licenses issued or rendered valid by the contracting State in which the aircraft is registered, shall be recognized as valid by the other contracting States, provided that the requirements under which such certificates or licenses were issued or rendered valid are equal to or above the minimum standards which may be established from time to time pursuant to this Convention.").

Message Information

Date	10/03/2007 12:46 PM
From	**"Sarah Burt" <sburt@earthjustice.org>**
To	Stephen Johnson/DC/USEPA/US@EPA; Margo Oge/DC/USEPA/US@EPA
cc	"Bilsky, Eric" <ebilsky@oceana.org>; "Savitz, Jackie" <JSavitz@oceana.org>; "Fugere, Danielle" <DFugere@foe.org>; "Shore, Teri" <TShore@foe.org>; <ksiegel@biologicaldiversity.org>; "Martin Wagner" <mwagner@earthjustice.org>; "Timothy Ballo" <tballo@earthjustice.org>
Subject	Petition to Regulate Emissions from Marine Shipping Vessels That Contribute to Climate Change

Message Body

Dear Administrator Johnson,

Attached please find a petition for rulemaking under the Clean Air Act to reduce the emission of air pollutants from marine shipping vessels that contribute to global climate change. A paper copy has also been sent via certified mail. Petitioners request a substantive response to this petition within one hundred and eighty calendar days.

Respectfully submitted,

2007 OCT -3 PM 3:17

Sarah Burt
Associate Attorney
Earthjustice
426 17th Street, 6th Floor
Oakland, CA 94612
T: 510-550-6700
F: 510-550-6740
www.earthjustice.org

Because the earth needs a good lawyer

* * * * * * *

The information contained in this email message may be privileged, confidential and protected from disclosure. If you are not the intended recipient, any dissemination, distribution or copying is strictly prohibited. If you think that you have received this email message in error, please notify the sender by reply email and delete the message and any attachments.

* * * * * * *

Marine GHG Petition FINAL 07-10-02 .pdf

OEX Processing Information

Processed Date :

Processed By

PO Office Category:

Message Count

October 3, 2007

Hon. Stephen L. Johnson
Administrator
United States Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Mail Code 1101A
Washington, DC 20460

Re: Petition for Rulemaking Under the Clean Air Act to Reduce the Emission of Air Pollutants from Marine Shipping Vessels that Contribute to Global Climate Change

Dear Administrator Johnson:

Every day the people of the United States, and the world, become more aware of the gravity and the urgency of the challenge posed by global climate change. This challenge must be met by all nations and by all sectors of the economy.

The ships that ply the world's waterways emit a significant share of the pollutants causing global climate change.[1] In fact, only six countries in the world emit more carbon dioxide than the world's fleet of marine vessels: the United States, China, Russia, India, Japan

[1] Veronika Eyring and Jim Corbett, *Comparing Fuel Consumption, Carbon Dioxide and Other Emissions from International Shipping and Aircraft: A Summary of Recent Research Findings*, DLR-Institute of Atmospheric Physics, (2007), *available at* http://www.pa.op.dlr.de/SeaKLIM/Fuel_Emissions_International_Shipping.html, *cited in* Friends of the Earth International (FOEI), *Prevention of Air Pollution from Ships: Recent Findings on Global Warming Justifying the Need for Speedy Reductions of Greenhouse Gas Emissions from Shipping*, submitted to Marine Environment Protection Committee, IMO, (May 4, 2007), at p.2. *See also* CE Delft, et al., *Greenhouse Gas Emissions for Shipping and Implementation Guidance for the Marine Fuel Sulfur Directive*, (2006), at 185.

and Germany.[2] Thus, the marine transport industry should be asked to make a significant contribution to reducing emissions that contribute to global climate change.[3] Oceana, Friends of the Earth, and the Center for Biological Diversity therefore petition the Administrator of the United States Environmental Protection Agency ("Administrator" or "EPA"), pursuant to the Administrative Procedure Act, 5 U.S.C. §§ 551-559, 701-706 (2000), (pursuant to 5 U.S.C. § 553(e), "[e]ach agency shall give an interested person the right to petition for the issuance, amendment, or repeal of a rule,") the Clean Air Act, 42 U.S.C. §§ 7401-7671q (1990), ("the Act"), and the Act's implementing regulations, to control and reduce the emissions of marine shipping vessels that contribute to global climate change. In this petition we request that EPA promulgate regulations (1) requiring marine shipping vessels to meet emissions standards by operating in a fuel-efficient manner, using cleaner fuels, and/or employing technical controls, so as to reduce emissions of carbon dioxide, nitrous oxide, and black carbon, and (2) controlling the manufacture and sale of fuels used in marine shipping vessels by imposing fuel standards to reduce emission products that contribute to global warming.

Given the gravity of the threat to public health and welfare that global climate change represents and the significant contribution of marine shipping vessels and aircraft engines to ambient concentrations of global climate change pollutants, EPA must not delay any longer in regulating these emissions.

EPA is required to give prompt consideration to this petition. In keeping with the urgency of addressing global warming, Petitioners hereby request a substantive response to this petition within one hundred eighty (180) calendar days. Petitioners will consider litigating to compel a response that is unreasonably delayed.

This petition is organized in the following manner:

BACKGROUND.....4
I. PETITIONERS.....4
II. STATUTORY BACKGROUND.....5
A. The Administrator Has the Authority to Set Emissions Standards for Nonroad Engines and Vehicles.....5

[2] United Nations, Department of Economic and Social Affairs, Statistics Division, *Carbon Dioxide Emissions, Thousands of Metric Tons, available at* http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=749 (August 1, 2007); based on 2004 data from Carbon Dioxide Information Analysis Center, *available at* http://cdiac.ornl.gov/trends/emis/tre_tp20.htm.

[3] Marine vessel emissions also pose significant other threats to human health and welfare. These threats are being addressed by EPA in its ongoing rulemaking process to set standards for emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds from new and existing nonroad engines or nonroad vehicles. Change in Deadline for Rulemaking to Address the Control of Emissions from New Marin Compression-Ignition Engines at or Above 30 Liters per Cylinder, 72 Fed. Reg. 20948, 20977 (April 27, 2007). *See also Friends of the Earth v. EPA*, No. 07-1572 (D.D.C. filed Sept. 5, 2007). As is further explained below, the *Friends of the Earth* case and this petition are seeking complementary controls that will enhance health and welfare more effectively than if either proceeding were going forward alone.

B. The Administrator Has the Authority to Prohibit the Manufacture or Sale of Fuels....6

III. FACTUAL BACKGROUND....6

A. Global Climate Change Is Occurring....6

B. Carbon Dioxide....7

C. Nitrogen Oxides and Nitrous Oxide....9

D. Black Carbon....11

ARGUMENT....13

I. THE ADMINISTRATOR SHOULD PROMULGATE REGULATIONS CONTROLLING GREENHOUSE GAS AND BLACK CARBON EMISSIONS FROM MARINE SHIPPING VESSELS....14

A. The Administrator Has the Legal Authority to Regulate Global Climate Change Emissions from Marine Shipping Vessels....14

B. EPA Should Exercise Its Authority to Promulgate Regulations Limiting Global Climate Change Emissions from Marine Shipping Vessels....23

C. Effective Regulation of Global Climate Change Emissions from Marine Shipping Vessels Is Possible....23

II. EPA SHOULD REGULATE THE COMPOSITION OF MARINE SHIPPING VESSEL FUEL TO CONTROL GLOBAL CLIMATE CHANGE RELATED EMISSIONS....39

A. EPA Has the Authority to Prohibit the Manufacture and Sale of Fuels Used in Marine Shipping Vessels....39

B. EPA Should Exercise Its Authority To Promulgate Regulations Requiring the Manufacture and Sale of Cleaner Fuels for Use in Marine Shipping Vessels....40

CONCLUSION....40

BACKGROUND

In this background section, we set forth a description of the petitioners and their interest in protecting the environment from the injury threatened by global climate change, the statutory regime under which the Administrator has authority to regulate global climate change emissions, and the science behind the worldwide consensus that the global climate change challenge must be met.

I. PETITIONERS

Oceana is a non-profit international advocacy organization dedicated to protecting and restoring the world's oceans through policy, advocacy, science, law, and public education. Oceana has over 280,000 members and supporters around the world. Oceana is organized under the laws of the District of Columbia, and maintains its headquarters in Washington, D.C. It has offices or staff in five states (Alaska, California, Massachusetts, New York, and Oregon) and three foreign countries (Chile, Belgium, and Spain). Through its policy, scientific, litigation, and grass-roots activities, Oceana has been a prominent advocate for protecting threatened and endangered marine species and marine ecosystems. Many of these species, such as loggerhead sea turtles and species of deep sea corals, are threatened by global warming and ocean acidification.

Friends of the Earth is a public interest, not-for-profit advocacy organization, whose mission is to defend the environment and champion a just and healthy world. Friends of the Earth maintains its headquarters in Washington, DC, and is the U. S. voice of the world's largest network of environmental groups with affiliates in 70 countries. The Bluewater Team (formerly Bluewater Network) based in San Francisco works to stop environmental damage from vehicles and vessels, and to protect human health and the planet by reducing dependence on fossil fuels. Over nearly a decade of advocacy to clean up the shipping industry, the Bluewater Team has achieved more stringent regulations for air pollution and wastewater discharges from marine vessels along the West Coast of the United States and has urged the EPA through petitions and litigation to adopt more stringent national regulations to reduce emissions of oxides of nitrogen and various other pollutants, (including sulfur oxides, hydrocarbons, particulate matter, carbon monoxide, airborne toxics, and greenhouse gases), from the world shipping fleet.

Center for Biological Diversity ("The Center") is a non-profit organization with offices in San Francisco, Los Angeles, and Joshua Tree, California, Phoenix and Tucson, Arizona, Silver City, New Mexico, Portland, Oregon, and Washington, D.C. The Center is a national membership organization with over 35,000 members in the United States. The Center's mission is to ensure the preservation, protection, and restoration of biodiversity, native species, ecosystems, public lands and waters, and public health. Because climate change from society's production of greenhouse gases is one of the foremost threats to the earth's biodiversity, the environment, and public health, the Center's Climate, Air, and Energy Program works to reduce United States greenhouse gas emissions in order to protect these resources. The Center has advocated in local, state, and federal forums for the reduction of greenhouse gas emissions. The Center has petitioned to have some of the first species to be threatened by global warming listed under the U.S. Endangered Species Act, including the polar bear, staghorn and elkhorn corals in

the Caribbean, and the Kittlitz's murrelet, a small seabird that feeds at the base of tidewater glaciers in Alaska. These species will not survive unless the United States substantially reduces its greenhouse gas emissions. The Center has previously requested EPA regulate greenhouse gases under Section 202 of the Clear Air Act, and was a party in the successful case overturning EPA's decision to not regulate greenhouse gases from automobiles. The Center submits this petition on behalf of itself and its adversely affected members.

II. STATUTORY BACKGROUND

The Administrator has the authority under the Clean Air Act to control global climate change emissions through his authority to set emissions standards for new nonroad engines and new nonroad vehicles and through his authority to require the manufacture and sale of cleaner fuels.

A. The Administrator Has Authority to Set Emissions Standards for Nonroad Engines and Vehicles.

The Clean Air Act provides the EPA with authority to limit the emission of pollutants from "nonroad" engines and vehicles, a broad category of mobile sources that includes marine vessels and their engines, 42 U.S.C. §§ 7550(10), (11); 40 C.F.R. § 89.2 (2005) (defining "marine engine" and "marine vessel" in the context of regulating emissions from nonroad vehicles and engines). Section 213(a) of the Act, creates a specific regulatory program to reduce emissions from such sources. 42 U.S.C. § 7547(a). This section first directs the EPA to address nonroad emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds.[4] *Id.* § 7547(a)(1)-(3). By reducing emissions of these three pollutants, regulations will not only reduce asthma, lung disease, and other adverse health impacts, but also reduce global warming, because the ozone formed from these emissions contributes to climate change.[5] However, nonroad engines and vehicles emit other pollutants that contribute even more significantly to global climate change than carbon monoxide, nitrogen oxides, and volatile organic compounds.

Having required the swift creation of a regulatory system to address nonroad emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds, section 213(a) then sets up a framework for the future regulation of additional pollutants. Under section 213(a)(4), the EPA's

[4] EPA has failed to meet its statutory deadline for setting standards for emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds from new and existing nonroad engines or nonroad vehicles, having announced on April 27, 2007, that it is postponing its rulemaking on this topic until December 17, 2009. Change in Deadline for Rulemaking to Address the Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder, 72 Fed. Reg. 20,948. Friends of the Earth is currently pursuing an action under section 304(a) of the Clean Air Act, 42 U.S.C. § 7604(a), to compel EPA to carry out its nondiscretionary duty to promulgate regulations containing standards applicable to emissions from Category 3 marine diesel engines as required by section 213(a) of the Act, 42 U.S.C. § 7547(a). *See* Friends of the Earth v. EPA, No. 07-1572 (D. D.C. filed Sept. 5, 2007). By targeting emissions that cause global climate change but are not addressed by section 213(a)(1), this petition is complementary to that ongoing rule-making.

[5] For example, nitrogen oxides react with other substances to form the greenhouse gas ozone. See section III(C) of the Background section of this petition for a more detailed explanation of how nitrogen oxides contribute to global climate change.

authority to take regulatory action hinges on two key findings: a finding that emissions from new nonroad engines or vehicles "significantly contribute to air pollution," and a finding that a class or category of new nonroad engines or vehicles "cause[s] or contribute[s] to such air pollution." 42 U.S.C. § 7547(a)(4). Thus, if the EPA finds that emissions from new nonroad engines or vehicles, in the aggregate, significantly contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, then the EPA has the authority to establish standards applicable to specific classes or categories of new nonroad engines or vehicles that the EPA determines cause or contribute to such air pollution. *Id; see also Bluewater Network v. EPA*, 370 F.3d 1, 13-14 (D.C. Cir. 2004) (explaining the operation of section 213(a)(4)).

B. The Administrator Has the Authority to Prohibit the Manufacture or Sale of Fuels.

The Clean Air Act establishes a system for the regulation of fuels that turns on a single finding: whether any emission product of a fuel causes or contributes to air pollution which may reasonably be anticipated to endanger the public health or welfare. 42 U.S.C. § 7545(c)(1). Upon making the finding, the EPA has the authority to control or eliminate the manufacture or sale of the offending fuel. *Id.* Section 211 of the Act provides the EPA with considerable authority to regulate the content of fuels manufactured or sold for use in nonroad vehicles and engines, allowing the Administrator to promulgate such regulations as he "may deem appropriate." *Id.*

III. FACTUAL BACKGROUND

The existence of global climate change is beyond dispute. Carbon dioxide, nitrogen oxides, nitrous oxide, and black carbon – all emissions products of marine engines and vessels – contribute to global climate change.

A. Global Climate Change Is Occurring.

There is no longer any serious dispute that global climate change is happening and causing harm. In a report published earlier this year the Intergovernmental Panel on Climate Change (IPCC)[6] expressed in the strongest language possible its finding that global warming is occurring: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[7]

---

[6] The IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide an authoritative international statement of scientific understanding of climate change. Its various Working Group and Assessment Reports on climate change are available at: http://www.ipcc.ch/.

[7] IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [SUMMARY FOR POLICYMAKERS,] (Feb., 2007) at 5, (*available at* http://www.ipcc.ch/spm2feb07.pdf), [hereinafter WORKING GROUP I SUMMARY].

Evidence of dramatic changes in Earth's climate abounds. Changes in climatically sensitive indicators support the inference that the average temperature in the Northern Hemisphere over the last half-century is likely higher than at any time in the previous 1,300 years, while ice-core records indicate that the polar regions have not experienced an extended period of temperatures significantly warmer than today's in about 125,000 years.[8] Further, the IPCC reports "numerous long-term changes in climate" observed at "continental, regional and ocean basin scales," including "changes in Arctic temperatures and ice, widespread changes in precipitation levels, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones."[9]

B. Carbon Dioxide

1. Contribution to Global Climate Change

Carbon dioxide's behavior in the atmosphere is well understood. Carbon dioxide is a "radiative forcing" gas, meaning that it alters the balance of incoming and outgoing energy in Earth's atmosphere.[10] Carbon dioxide absorbs terrestrial radiation leaving the Earth's surface, trapping this heat in the atmosphere.[11] As levels of carbon dioxide increase, primarily from the burning of fossil fuels, less and less heat escapes the atmosphere to space, and the planet warms.[12]

As the Supreme Court has recently recognized, there is a consensus in the scientific community that the increasing atmospheric concentration of carbon dioxide is a leading cause of global climate change:

> A well-documented rise in global temperatures has coincided with a significant increase in the concentration of carbon dioxide in the atmosphere. Respected scientists believe the two trends are related. For when carbon dioxide is released into the atmosphere, it acts like the ceiling of a greenhouse, trapping solar energy and retarding the escape of reflected heat. It is therefore a species-the most important species-of a "greenhouse gas."

Massachusetts v. EPA, 549 U.S. ___, 127 S. Ct. 1438, 1446 (2007). If anything, this modest statement by the Court understates the true extent of the scientific consensus on the causes of global warming. For example, the IPCC recently concluded that "[m]ost of the observed

---

[8] *Id.* at 1.

[9] *Id.* at 7.

[10] *See* Solomon, S., et al., *Technical Summary, Working Group I,* (2007), at 21 n.1, *available at* http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_TS.pdf, [hereinafter "Technical Summary"] (noting that radiative forcing "is an index of the importance of the factor as a potential climate change mechanism").

[11] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005*, (2007), at 1-2, *available at* http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf [hereinafter EPA Inventory].

[12] *Id.* (explaining that changes in the atmospheric concentrations of carbon dioxide "can alter the balance of energy transfers between the atmosphere, space, land, and the oceans").

increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."[13] Thus, the world's leading scientific body on the subject has now concluded, with greater than 90 percent certainty, that emissions of greenhouse gases like carbon dioxide are responsible for climate change.[14]

It is abundantly clear that anthropogenic emissions of carbon dioxide are a principal driver of the observed warming of the planet. Prior to the industrial revolution, over the last 650,000 years the global atmospheric concentration of carbon dioxide ranged from 180 to 300 parts per million ("ppm"), but in 2005, global carbon dioxide levels reached 379 ppm.[15] The increasing concentrations of this radiative forcing gas has led the IPCC to conclude that, "[c]arbon dioxide is the most important anthropogenic greenhouse gas."[16] The IPCC found that increases in atmospheric carbon dioxide concentrations since pre-industrial times exert a radiative forcing effect of approximately +1.66 Watts per square meter (W/m^2), "a contribution which dominates all other radiative forcing agents."[17] In comparison, all other long-lived greenhouse gases combined contribute slightly less than approximately +1 W/m^2.[18]

2. Emissions from Marine Engines and Vessels

Ocean-going ships are responsible for moving 80 percent of all goods shipped into and out of the United States.[19] The sheer number of these ships, coupled with operating practices that use fuel inefficiently and poor government oversight, results in carbon dioxide emissions estimated to be between 600 to 900 million metric tons per year (546 to 818 million short tons per year),[20] equivalent to the emissions from roughly 130 to 195 million cars for one year.[21] Carbon dioxide emissions from shipping worldwide are estimated to make up almost three

---

[13] WORKING GROUP I SUMMARY, at 10 (emphasis in original).

[14] *See id.* at 4, n.6 (explaining the use of the term "very likely").

[15] *Id.* at 2.

[16] *Id.*

[17] Technical Summary at 25. Positive radiative forcing tends to warm the Earth's surface; negative forcing tends to cool it. *Id.* at 21 n.1. The IPCC assigns radiative forcing values as a global and annual average value according to changes relative to a pre-industrial background – the year 1750. *Id.*

[18] *See id.* at 31 (stating that all long-lived greenhouse gases, including CO_2, contribute roughly +2.63 W/m^2). However, because some anthropogenic emissions exert negative radiative forcing (or cooling) effects, the IPCC estimates that the cumulative impact of human activities since 1750 equates to a net positive radiative forcing of approximately +1.6 W/m^2. *Id.*

[19] International Council on Clean Transportation (ICCT) (Mar., 2007) *Air Pollution and Greenhouse Gas Emissions from Ocean-Going Ships: Impacts, Mitigation Options and Opportunities for Managing Growth* at 7, *available at* http://www.theicct.org/documents/MarineReport_Final_Web.pdf (figure given is by weight of cargo).

[20] Eyring and Corbett, *supra* note 1.

[21] Calculated at http://www.usctcgateway.net with data from EPA Inventory, *supra* note 11.

percent of global greenhouse gas emissions.[22] In fact, a single container ship emits more pollution than 2,000 diesel trucks.[23]

Of even greater concern is the projected growth in carbon dioxide emissions from shipping. Over the last three decades, the shipping industry has grown by an average of five percent per year.[24] By 2050, one study predicts total carbon dioxide emissions from ships will grow to about 1700 million metric tons per year (1874 million short tons per year), roughly double their present levels.[25] However, this study "makes some judicious simplifying assumptions that tend to underestimate rather than overestimate fuel consumption and emission levels."[26] Thus, the International Maritime Organization may present a more realistic picture of future carbon dioxide emissions from shipping in projecting a 72 percent increase between 2000 and 2020, assuming a three percent annual rate of growth.[27] Even the IMO study may be too conservative. If fuel consumption increases at the rate forecast by current studies, shipping emissions may double 2002 levels by 2020 and triple them by 2030.[28]

Even when only U.S. emissions are considered, ships account for a significant portion of total carbon dioxide. For example, based on national fuel consumption statistics, ships in the United States emitted nearly 100 million metric tons (110 million short tons) of carbon dioxide in 2005.[29] In all, marine engines contributed about five percent of the total U.S. carbon dioxide emissions from transportation-related fossil fuel combustion.[30]

C. Nitrogen Oxides and Nitrous Oxide

Nitrogen oxides consist of a family of several compounds containing nitrogen and oxygen in varying amounts.[31] Nitrogen oxides play a role in climate change through two primary means: (1) nitrogen oxides react with other substances to form the greenhouse gas ozone, and (2) nitrous oxide is itself a highly potent and long-lived greenhouse gas. Moreover,

---

[22] Eyring and Corbett, *supra* note 1.

[23] Sean Poltrack, *The Maritime Industry and Our Environment: The Delicate Balance of Economic and Environmental Concerns, Globally, Nationally, and Within the Port of Baltimore,* (2000), 8 U. BALT. J. ENVTL. L. 51, 64.

[24] As measured by the increase in metric ton-kilometers of cargo transported. ICCT, *supra* note 19, at 7.

[25] *Id.* at 36, fig. 13.

[26] *Id.* at 36.

[27] International Maritime Organization (IMO) *Study of Greenhouse Gas Emissions from Ships: Final Report to the International Maritime Organization* at 17, Table 1-5, (2000) (modeling future fuel consumption) *available at* http://unfccc.int/files/methods_and_science/emissions_from_intl_transport/application/pdf/imoghgmain.pdf.

[28] FOEI, *supra* note 1, at 2.

[29] EPA Inventory, *supra* note 11, at 3-8 – 3-9, Table 3.7 (based on ship consumption of residual fuel oil, distillate fuel oil, and gasoline).

[30] *See id.* (total CO_2 emissions from the transportation sector were 1995.1 million metric tons in 2005).

[31] EPA, *Technical Bulletin: Nitrogen Oxides (NO_x): Why and How They Are Controlled,* (1999) at 1-2, EPA-456/F-99-006R, *available at* http://www.epa.gov/ttn/catc/dir1/fnoxdoc.pdf.

nitrogen oxide pollution represents an additional burden on oceanic pH levels by lowering pH and increasing acidity.

1. Contribution to Global Climate Change

Emissions of nitrogen oxides contribute to global climate change by influencing the atmospheric concentration of ozone, which the IPCC has determined is the third most damaging greenhouse gas, after carbon dioxide and methane.[32] As nitrogen oxides react with volatile organic compounds, they create ozone in the lower layer of the atmosphere, called the troposphere.[33] Through the production of tropospheric ozone, nitrogen oxide emissions contribute to the warming of the surface-troposphere system.[34]

Nitrogen oxides have also been found to contribute to ocean acidification, thereby amplifying one of the many deleterious impacts of climate change.[35] Approximately one third of all nitrogen oxide emissions end up in the oceans.[36] The impact of these emissions on acidification is intensely felt in specific, vulnerable areas. In some areas it can be as high as 10 to 50 percent of the impact of carbon dioxide.[37] The hardest hit areas are likely to be those directly around the release site, so these emissions are especially significant in and around coastal waters.[38]

Nitrous oxide behaves very similarly to carbon dioxide in that it both directly traps heat in the atmosphere and remains in existence for many decades once emitted.[39] However, nitrous oxide is far more potent, with a global warming potential 298 times that of carbon dioxide over 100 years.[40] According to the IPCC, the concentration of nitrous oxide in the atmosphere in 2005 was 319 parts per billion (ppb), approximately 18 percent higher than its pre-industrial

---

[32] Denman, K.L., et al. *Couplings Between Changes in the Climate System and Biogeochemistry,* (2007), at 544. In: WORKING GROUP I SUMMARY, *supra* note 7. ("The dominant impact of NO_x emissions on the climate is through the formation of tropospheric ozone, the third largest single contributor to positive radiative forcing").

[33] EPA, *NO_x – How Nitrogen Oxides Affect the Way We Live and Breathe*, (1998), *available at* http://www.epa.gov/air/urbanair/nox/noxfldr.pdf.

[34] Denman, *supra* note 32, at 544 ("The dominant impact of NO_x emissions on the climate is through the formation of tropospheric ozone, the third largest single contributor to positive radiative forcing").

[35] Doney, Scott C., et al., *Impact of Anthropogenic Atmospheric Nitrogen and Sulfur Deposition on Ocean Acidification and the Inorganic Carbon System*, (2007), PNAS Vol. 104:14580-14585, at 14580.

[36] *Id.*

[37] *Id.*

[38] *Id.*

[39] *E.g.*, Technical Summary at 27 (discussing the radiative forcing effect of N_2O); *Id.* at 23-24 (discussing the long atmospheric lifetimes of CO_2, CH_4, and N_2O).

[40] *Id.* at 33, Table TS.2.

level.[41] Moreover, data from ice cores indicate that in the 11,500 years before the Industrial Revolution, the level of nitrous oxide in the atmosphere varied by less than about ten ppb.[42]

2. Emissions from Marine Engines and Vessels

Ships are beyond doubt a significant source of nitrogen oxide emissions. Ships contribute as much as 30 percent of the world's nitrogen oxide emissions, an estimated 27.8 million tons per year.[43] In the United States, the EPA has already determined that marine engines and other nonroad engines and vehicles are a "major source" of nitrogen oxides. 59 Fed. Reg. 31,306, 31,307 (June 17, 1994). Recent EPA estimates show nitrogen oxide emissions from ships make up 9.1 percent of all U.S. mobile source nitrogen oxide emissions and 5.2 percent of U.S. nitrogen oxide emissions from all sources. 72 Fed. Reg. 15,938, 15,963, Table II-3 (Apr. 3, 2007) (figures include NO_x emissions from all categories of marine engines). Moreover, based on national fuel consumption statistics, EPA estimates that ships in the United States emitted approximately 2000 metric tons (2205 short tons) of nitrous oxide in 2005.[44]

The contribution of ships to nitrogen oxide emissions is also projected to grow substantially in the coming decades. One EPA study forecasts that nitrogen oxide emissions from ocean-going ships in United States waters will increase by almost 300 percent above 1996 levels by 2030.[45] Moreover, EPA's own modeling indicates that nitrogen oxide emissions from marine engines will grow to over 30 percent of all U.S. mobile source nitrogen oxide emissions by 2030 and will then account for 12.8 percent of total U.S. emissions of nitrogen oxides. 72 Fed. Reg. 15,938, 15,963, Table II-3 (Apr. 3, 2007) (figures include NO_x emissions from all categories of marine engines). At the international level, emissions of nitrogen oxides from ships are projected to nearly double by 2050 and to increase their share of total nitrogen oxide emissions relative to other sources as well.[46]

These gases have a significant impact on the global climate, both through the formation of ozone and as nitrous oxide. Thus, given the large quantity of nitrogen oxides that ships emit, it is not surprising that marine engines' emissions of these pollutants play a significant role in climate change. In fact, nitrogen oxide emissions from ships are believed to have a net warming effect potentially equivalent to the warming effect from ship carbon dioxide emissions.[47]

D. Black Carbon

---

[41] *Id.* at 27.

[42] *Id.*

[43] FOEI, *supra* note 1, at 3.

[44] EPA Inventory, *supra* note 11, at 3-31, Table 3-24.

[45] EPA, *Final Regulatory Support Document: Control of Emissions from New Marine Compression –Ignition Engines at or Above 30 liters per Cylinder*, (Jan. 2003), EPA420-R-03-004, at 4-14, Table 4.3-1.

[46] ICCT, *supra* note 19, at 35, figs. 11 & 12.

[47] *Id.* at 34.

1. Contribution to Global Climate Change

A product of inefficient combustion, black carbon, also known as soot, consists of microscopic solid particles of incompletely burned organic matter.[48] As explained further below, black carbon is a potent warmer, exerting effects on the global climate both while suspended in the atmosphere and when deposited on snow and ice. In fact, one study estimates that a given mass of black carbon will warm the air between 360,000 and 840,000 times more than an equal mass of carbon dioxide.[49] The most pernicious characteristic of black carbon from a climatic perspective is its dark color and correspondingly low albedo, or reflectivity. Because of this dark coloring, black carbon absorbs heat from sunlight.[50]

When suspended in the air, black carbon warms by trapping heat in the top of the atmosphere.[51] The IPCC estimates that atmospheric black carbon exerts a positive radiative forcing effect of +0.2 W/m^2.[52] This direct warming leads to feedback effects which magnify the global warming contribution of black carbon.[53] For example, as black carbon particles absorb sunlight, they warm the air around them, decreasing the relative humidity of the air and thus the liquid water content of other particles suspended in the air.[54] The drying out of these other particles reduces *their* reflectivity, and as they absorb more sunlight the air warms even more.[55] Further, the water evaporated from such particles remains in the air as water vapor, which is itself a greenhouse gas.[56]

When deposited out of the air onto a lighter surface, the darker black carbon causes the surface to absorb more of the sun's energy. Thus, when deposited on snow or ice, black carbon can reduce the snow's reflectivity and accelerate the melting process.[57] As when suspended in the atmosphere, black carbon's deposition onto ice and snow creates positive feedback effects that lead to even greater warming. For example, as snow and ice around them melt away, the deposited black carbon particles can become even more concentrated on and near the surface,

---

[48] *See* W. Chameides and M. Bergin, *Soot Takes Center Stage*, 297 SCIENCE 2214 (Sept. 27, 2002), (explaining that "BC is produced through incomplete combustion of biomass, coal, and diesel fuel").

[49] Mark Z. Jacobson, *Control of Fossil-Fuel Particulate Black Carbon and Organic Matter, Possibly the Most Effective Method of Slowing Global Warming*, 107 JOURNAL OF GEOPHYSICAL RESEARCH 4410 (2002) at 10.

[50] Chameides and Bergin, *supra* note 48, at 2214 (noting that while "greenhouse gases warm by absorbing infrared or terrestrial radiation," "BC warms by absorbing sunlight").

[51] M. Shekar Reddy and Olivier Boucher, *Climate Impact of Black Carbon Emitted from Energy Consumption in the World's Regions*, 34 GEOPHYSICAL RESEARCH LETTERS L11802 (2006) at 1 (stating that "Black carbon (BC) exerts a positive forcing at the top of the atmosphere").

[52] Technical Summary, *supra* note 10, at 29.

[53] Jacobson, *supra* note 49, at 6-8 (discussing twelve ways in which suspended BC affects climate).

[54] *Id.* at 6.

[55] *Id.*

[56] *Id.* at 7.

[57] Reddy and Boucher, *supra* note 51, at 2.

further reducing the reflectivity of the remaining snow and ice.[58] Thus, although the IPCC estimates the radiative forcing effect of black carbon deposition on snow and ice to be +0.1 W/m^2, it acknowledges that the radiative forcing metric may not accurately capture the climatic impacts of black carbon deposition on snow and ice. In the words of the IPCC, "the 'efficacy' may be higher" for black carbon radiative forcing, as it produces a temperature response 1.7 times greater than an equivalent radiative forcing due to carbon dioxide.[59]

Because it can accelerate the melting of snow and ice, black carbon may play a particularly important role in Arctic climate change.[60] Moreover, the radiative forcing of suspended black carbon particles may be amplified at the poles, where there is more light reflected from the Earth's surface, and thus more light available for the black carbon particles to absorb.[61] Because the Arctic has warmed at around twice the rate of the rest of the world over the last 100 years,[62] controlling and reducing black carbon emissions is particularly important.

The impacts of black carbon are not limited to the Arctic, however. Black carbon may be responsible for as much as 25 percent of observed global warming.[63] Thus, the overall contribution of black carbon to global warming may be substantial, perhaps second only to that of carbon dioxide.[64]

2. Emissions from Marine Engines and Vessels

Marine engines account for a significant share of black carbon emissions. Black carbon is a component of the particulate matter emitted from ships and other engines. In fact, approximately 66 percent of anthropogenic black carbon emissions come from the burning of fossil fuels.[65] Ships emit between 50,000 tonnes and 71,400 tonnes of back carbon per year.[66] Thus, in 2000, shipping contributed between 0.4 and 1.4 percent of global black carbon emissions.[67] Moreover, shipping is responsible for all black carbon released over the oceans.[68]

---

[58] Flanner, Mark G., et al., *Present-Day Climate Forcing and Response from Black Carbon in Snow*, 112 JOURNAL OF GEOPHYSICAL RESEARCH D11202 (2007) at 2.

[59] IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, Forster, P., et al. *Changes in Atmospheric Constituents and in Radiative Forcing* (2007) at 184-85.

[60] FOEI, *supra* note 1, at 3.

[61] *See* Forster, *supra* note 59, at 163 ("Additionally, the presence of BC in the atmosphere above highly reflective surfaces such as snow and ice, or clouds, may cause a significant positive RF").

[62] IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, Trenberth, K.E, et al. *Observations: Surface and Atmospheric Climate Change* (2007) at 237.

[63] ICCT, *supra* note 19, at 34.

[64] Chameides and Bergin, *supra* note 48, at 2214.

[65] Reddy and Boucher, *supra* note 51, at 1.

[66] FOEI, *supra* note 1, at 4.

[67] A. Lauer, et al., *Global Model Simulations of the Impact of Ocean-Going Ships on Aerosols, Clouds, and the Radiation Budget*, ATOMS. CHEM. PHYS DISCUSS., 7, (2007) 9419–9464.

Although black carbon from shipping is emitted mainly to the air above the oceans, plumes of black carbon can also travel great distances and deposit on areas far away from the initial emission site. For example, plumes of black carbon from Asia are believed to deposit on snow in the Arctic.[69]

ARGUMENT

As explained above, ships are playing a significant role in global climate change primarily through the emission of four pollutants: carbon dioxide, nitrogen oxides, nitrous oxide, and black carbon. To address this urgent problem, EPA must proceed on multiple fronts. Thus, while EPA's ongoing rulemaking to address nitrogen oxide emissions from Category 3 marine diesel engines will have the secondary effect of helping to curb the growth of some greenhouse gas emissions, the agency must go further. By promulgating regulations in response to this petition to limit greenhouse gas and black carbon emissions from ships and by mandating cleaner fuels for marine diesel engines, EPA can achieve significant reductions in the emissions of climate change pollutants from ships.

I. THE ADMINISTRATOR SHOULD PROMULGATE REGULATIONS CONTROLLING GREENHOUSE GAS AND BLACK CARBON EMISSIONS FROM MARINE SHIPPING VESSELS.

The following sections demonstrate not only that EPA has the legal authority to regulate greenhouse gas and black carbon emissions from ships, but also that EPA should make full use of that authority to promulgate broadly applicable regulations reducing such emissions from all U.S.-flagged ships and all ships traveling within U.S. waters.

A. The Administrator Has the Legal Authority to Regulate Global Climate Change Emissions from Marine Shipping Vessels.

EPA has the legal authority to regulate greenhouse gas and black carbon emissions from ships because, consistent with the threshold determinations required under section 213(a)(4) of the Clean Air Act, greenhouse gas and black carbon emissions from marine engines and vessels significantly contribute to global climate change, which may be reasonably anticipated to endanger public health or welfare. 42 U.S.C. § 7547(a)(4).

In many respects, the legal issues underlying this petition are nearly identical to those that the Supreme Court confronted in *Massachusetts v. EPA*, 549 U.S. ___, 127 S.Ct. 1438 (2007). That case involved a petition to regulate the emissions of greenhouse gases from motor vehicles under section 202(a)(1) of the Act, which provides as follows:

---

[68] Reddy and Boucher, *supra* note 51, at 1.

[69] Joseph R. McConnell, et al., *20th-Century Industrial Black Carbon Emissions Altered Arctic Climate Forcing*, 317 SCIENCE 1381 (2007) 1383.

> The Administrator shall by regulation prescribe . . . , standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare.

42 U.S.C. § 7521(a)(1). A side-by-side comparison with the provision at issue here is instructive:

> If the Administrator determines that any emissions . . . from new nonroad engines or vehicles significantly contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, the Administrator may promulgate . . . standards applicable to emissions from those classes or categories of new nonroad engines and new nonroad vehicles . . . which in the Administrator's judgment cause, or contribute to, such air pollution . . . .

Id. § 7547(a)(4). Although section 202(a)(1) differs from section 213(a)(4) in that the motor vehicles provision uses the mandatory "shall" in place of the more permissive "may," in each case the judgment triggering EPA authority is essentially the same: If the Administrator determines that some particular kind of emissions from the source at issue are sufficiently connected with "air pollution which may reasonably be anticipated to endanger public health or welfare," then the Administrator is empowered to regulate those emissions.

In *Massachusetts v. EPA*, because EPA had declined to regulate carbon dioxide emissions from motor vehicles, in part on the grounds that carbon dioxide did not qualify as a "pollutant" under the Act, the Court faced the initial question of whether carbon dioxide fit the Act's definition of a pollutant. 127 S.Ct. at 1460. After affirming that carbon dioxide indeed fit squarely within the Act's "sweeping definition of 'air pollutant,'" *id.,* the Court turned to the remaining issue of the nature of EPA's duties in responding to the petition at issue:

> Under the clear terms of the Clean Air Act, EPA can avoid taking further action only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do.

Id. at 1462.

In sum, now that the Supreme Court has put to rest the contention that the Clean Air Act does not provide EPA authority to regulate global climate change related emissions, the EPA cannot avoid considering the key questions underlying this petition: (1) do greenhouse gas and black carbon emissions from new nonroad engines and vehicles significantly contribute to climate change, (2) do greenhouse gas and black carbon emissions from new marine vehicles and engines contribute to the overall contribution of new nonroad engines and vehicles to climate change, and (3) may climate change reasonably be anticipated to endanger public health or public welfare. If, as it must, the EPA answers all three questions in the affirmative, then the

EPA has the authority to promulgate regulations limiting emissions of greenhouse gas and black carbon from new marine vehicles and engines.[70]

1. Greenhouse Gas and Black Carbon Emissions from New Marine Engines and Vehicles Significantly Contribute to Global Climate Change

Section 213(a)(4) of the Clean Air Act empowers EPA to regulate specific classes or categories of new nonroad engines and vehicles, such as marine engines and vessels, if EPA first determines that new nonroad engines and vehicles, as a whole, contribute significantly to an air pollution problem.[71] Here, however, it is not necessary to consider the impacts of other classes or categories of nonroad engines or vehicles; new marine engines and vehicles are themselves significant contributors to climate change.

In making significant contributor determinations under section 213(a)(4), the Administrator has looked broadly at the impact of new nonroad vehicles over time.[72] For example, EPA has found that emissions from new nonroad engines and vehicles meet the section 213(a)(4) significant contributor criterion with respect to emissions of hydrocarbons. 67 Fed. Reg. 68,243 (Nov. 8, 2002). In reaching this conclusion, EPA employed two methods of analysis. The agency used a "snapshot" approach that considered the current impact of all nonroad engines and vehicles (both new and existing), and supplemented this approach with modeling to estimate future emissions of nonroad sources. *Id.* at 68,251 (analyzing emissions from nonroad sources in both 2000 and 2030).

Both approaches make sense, as they provide an estimate of the likely impact of new nonroad sources in the future. As a practical matter, emissions from new nonroad engines and vehicles do "significantly contribute" to air pollution when measured over the useful life of those

---

[70] Although emissions from ships do not become subject to regulation unless those emissions "significantly contribute to *air pollution* which may reasonably be anticipated to endanger public health or welfare," 42 U.S.C. § 7547(a)(4) (emphasis added), and although EPA has in the past determined that the term "air pollution," as used in the Act "cannot be interpreted to encompass climate change," 68 Fed. Reg. 52,928 (Sept. 8, 2003), these facts present no barrier to this petition. EPA's determination that climate change does not qualify as "air pollution" was based on its incorrect claim that carbon dioxide was not an "air pollutant" under the Act. 68 Fed. Reg. 52,928. Moreover, in rejecting EPA's overly narrow interpretation of "air pollutant" the Supreme Court also voided EPA's construction of the term "air pollution," noting that because greenhouse gases both enter the ambient air and warm the atmosphere, they are "unquestionably 'agents' of air pollution." *Massachusetts v. EPA*, 127 S. Ct. at 1460 n.26.

[71] 42 U.S.C. § 7547(a)(4). In considering the statutory language of section 213 of the Clean Air Act, the United States Court of Appeals for the District of Columbia Circuit explained that "the language and structure of § 213 as a whole make quite clear that Congress did not intend to require a finding of 'significant contribution' for individual vehicle categories." *Bluewater Network v. EPA*, 370 F.3d at 13. Instead, "Congress drew a distinction between the 'significant contributor' finding required for all new and existing nonroad vehicles, and the 'cause, or contribute to' finding for an individual category of new nonroad vehicles." *Id.* (emphasis omitted). Thus, if all new and existing nonroad engines and vehicles collectively are "significant contributors" to air pollution, then the Act empowers EPA to set standards regulating emissions from each category of new nonroad vehicles and engines that "cause, or contribute to, such air pollution."

[72] Thus, the EPA has made clear that even though the wording of section 213(a)(2)-(3) and 213(a)(4) is slightly different, it understands that Congress intended the same kind of "significant contributor analysis. *Compare* 42 U.S.C. § 7547(a)(2), *with id.* § 7547(a)(4).

nonroad engines and vehicles that are currently new. Moreover, both approaches are consistent with the forward-looking language of section 213(a)(4), which allows EPA to abate the emission of pollution "which may reasonably be anticipated" to endanger public health or welfare. 42 U.S.C. § 7547(a)(4).

Although the Act therefore sets up a complex threshold for regulation under section 213(a)(4), here the task of application is made simple by the large contribution that emissions from ships make and will continue to make to climate change. By any definition of the term "significant," ships contribute significantly to global climate change. Carbon dioxide emissions from international shipping exceed the annual total greenhouse gas emissions from most of the Kyoto Protocol Annex I countries.[73] In the United States, marine engines contribute about five percent of the total U.S. carbon dioxide emissions from transportation-related fossil fuel combustion.[74] It is likely that only six countries in the world contribute more carbon dioxide to the atmosphere than global shipping.[75] These carbon dioxide emissions are augmented by significant emissions of nitrous oxide and black carbon.[76]

The contribution of marine engines and vehicles to global climate change is comparable to the share of emissions of other pollutants that Congress believed to be significant when it enacted section 213. Thus, the Senate Environment and Public Works Committee's report accompanying the Senate's version of the 1990 Clean Air Act Amendments noted that nonroad sources "now make up a *significant* portion of pollution, especially in urban areas." S. Rep. No. 101-228, at 104 (emphasis added). The Committee then cites as an example of this significant contribution to pollution, the fact that "[e]missions inventories from EPA estimate that farm and construction equipment emit 3.7 percent of carbon monoxide nationwide, four percent of nationwide nitrogen oxide, and 1.3 percent of total hydrocarbons." *Id.* As EPA has already recognized, "[t]hese figures provide an indication of how much nonroad vehicles and engines have to contribute to nationwide levels of specified pollutants in order for Congress to consider such nonroad sources significant contributors." 58 Fed. Reg. 28811-12 (May 17, 1993). Moreover, in determining that nonroad engines and vehicles emitted sufficient amounts of ozone precursors to qualify as significant contributors to ground-level ozone pollution, EPA relied on modeling demonstrating that, in the absence of nonroad emissions, ozone levels would decrease between 3 to 8 percent. 59 Fed. Reg. 31,307 (June 17, 1994). EPA further concluded that this level of contribution would satisfy "any reasonable indicator of significance." *Id.* at 31,308.

In sum, new marine vehicles and engines account for such a large and rapidly growing portion of all carbon dioxide, nitrous oxide, and black carbon emissions that they are plainly contributing significantly to global climate change. Thus, provided that global climate change

---

[73] ICCT, *supra* note 19, at 34.

[74] *See id.* (total CO_2 emissions from the transportation sector were 1995.1 million metric tons in 2005).

[75] United Nations, Department of Economic and Social Affairs, Statistics Division, *supra* note 2.

[76] See sections III(C)(2)) & III(D)(2) of the Background, above. They are also significantly augmented by emissions of nitrogen oxides, but the authority to regulate nitrogen oxides falls principally under Section 213(a)(1)-2), 42 U.S.C. § 7547(a)(1)-(2). As explained in n.1, *supra*, the regulations sought in this petition would be complementary to regulations promulgated specifically to address nitrogen oxide.

may be reasonably anticipated to endanger public health or welfare, the Clean Air Act permits EPA to regulate carbon dioxide, nitrous oxide, and black carbon emissions from these sources.[77]

2. Global Climate Change May Reasonably Be Anticipated to Endanger Public Health or Welfare

Climate change is projected to have numerous adverse impacts on public health and welfare. The severity of the effects of climate change, in conjunction with the Clean Air Act's precautionary approach, make clear that climate change can be reasonably anticipated to endanger public health or welfare.

As the "may be reasonably anticipated" language of section 213(a)(4) affirms, the Clean Air Act is a precautionary statute under which proof of actual harm is not required. 42 U.S.C. § 7547(a)(4). Congress directed that regulatory action taken pursuant to an endangerment finding would be designed to "precede, and, optimally, prevent, the perceived threat." *Ethyl Corp. v. EPA*, 541 F.2d 1, 13 (D.C. Cir. 1976). EPA is not required to document "proof of actual harm" as a prerequisite to regulation; rather, EPA is supposed to act where there is "a significant risk of harm." *Id.* at 12-13. In *Ethyl Corp.*, noting the novelty of many human alterations of the environment, the Court of Appeals for the District of Columbia Circuit found:

> Sometimes, of course, relatively certain proof of danger or harm from such modifications can be readily found. But, more commonly, 'reasonable medical concerns' and theory long precede certainty. Yet the statutes and common sense demand regulatory action to prevent harm, even if the regulator is less than certain that harm is otherwise inevitable.

Id. at 24; *accord*, *Industrial Union Dep't v. American Petroleum Institute*, 448 U.S. 607, 656 (1980) (plurality) (agency need not support finding of significant risk "with anything approaching scientific certainty," but rather must have "some leeway where its findings must be made on the frontiers of scientific knowledge," and "is free to use conservative assumptions in interpreting the data," "risking error on the side of overprotection rather than underprotection").

The 1977 Clean Air Act Amendments, Pub. L. No. 95-95, § 401, 91 Stat. 790-91 (August 7, 1977), confirmed and adopted the precautionary interpretation enunciated in *Ethyl*, enacting special provisions designed to "apply this interpretation to all other sections of the act relating to public health protection." H.R. Rep. No. 294 at 49 (1977); *accord*, *id.* at 51 (amendments are designed inter alia to "emphasize the precautionary or preventive purpose of the act (and, therefore, the Administrator's duty to assess risks rather than wait for proof of actual harm)"). Congress rejected the argument that, "unless conclusive proof of actual harm can be found based

[77] Because emissions of carbon dioxide, nitrous oxide, and black carbon each contribute to a single air pollution phenomenon, it is within EPA's authority to determine that the aggregate emissions of these global climate change pollutants from new nonroad engines and vehicles significantly contribute to climate change. In the alternative, should EPA determine that it must consider the emissions of each pollutant in isolation, Petitioners maintain that emissions of carbon dioxide, nitrous oxide, and black carbon from marine shipping vessels each contribute significantly to global climate change when considered alone.

on the past occurrence of adverse effects, then the standards should remain unchanged," finding that this approach "ignores the commonsense reality that 'an ounce of prevention is worth a pound of cure.'" *Id.* at 127.

While the precautionary nature of the Clean Air Act creates a low threshold for findings relating to the negative consequences of air pollution, here there is ample evidence that global climate change is endangering and will continue to endanger public health and welfare.

a. Public Health Impacts

Global climate change is expected to have significant impacts on human health in numerous ways, including increased heat-related mortalities, the spread of infectious disease vectors, greater air and water pollution, an increase in malnutrition, and greater casualties from fires, storms, and floods. EPA has already recognized that climate plays a significant role in public health:

> Throughout the world, the prevalence of some diseases and other threats to human health depend largely on local climate. Extreme temperatures can directly lead to loss of life, while climate-related disturbances in ecological systems, such as changes in the range of infective parasites, can indirectly impact the incidence of serious infectious diseases. In addition, warm temperatures can increase air and water pollution, which in turn harm human health.[78]

Given the ample evidence linking climate change to adverse public health impacts, the EPA must conclude that climate change can be reasonably anticipated to endanger public health.

Perhaps the most direct impact of climate change on human health will occur through increased heat-related mortalities. Heat waves already pose a serious threat to public health, and climate change is predicted to increase the magnitude, frequency, and duration of heat waves in the United States.[79] The Department of State's, *U.S. Climate Action Report 2002*, indicated that rising temperatures will likely produce dramatic increases in summer heat index values in the Northeast, Southeast, and Midwest.[80] By the end of the century, cities such as Hartford and Philadelphia could average nearly 30 days with high temperatures above 100°F each year.[81]

---

[78] EPA, *Climate Change, Health and Environmental Effects, available at* http://www.epa.gov/climatechange/effects/index.html, (last visited Oct. 1, 2007) [hereinafter EPA Climate Change Effects].

[79] IPCC, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY, CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, [SUMMARY FOR POLICYMAKERS] (2007) at 10-11, *available at* http://www.ipcc.ch/SPM13apr07.pdf, [hereinafter WORKING GROUP II SUMMARY].

[80] U.S. Department of State, *U.S. Climate Action Report 2002* at 110.

[81] Peter C. Frumhoff, et al., *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions* (2007) at x, *available at* http://www.climatechoices.org/ne/resources_ne/nereport.html.

Segments of the population that are particularly vulnerable, such as those with heart problems, asthma, the elderly and very young, and the homeless, are especially at risk to extreme heat.[82]

Climate change is also expected to play a role in worsening air quality problems that already affect human health. For example, EPA has recognized that the higher temperatures that result from climate change may result in increased concentrations of ground-level ozone.[83] Breathing ozone can trigger a variety of health problems, including chest pain, coughing, throat irritation, and congestion, and repeated exposure can lead to bronchitis, emphysema, asthma, and permanent scarring of lung tissue.[84] Moreover, climate change may also indirectly affect the concentration of particulate matter in the air by increasing sources such as wildfires and dust from dry soils.[85] Exposure to such particles can affect both the lungs and heart and has been linked to a variety of problems, including increased respiratory symptoms such as irritation of the airways, coughing or difficulty breathing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease.[86] As with other forms of air pollution, certain vulnerable segments of the population, such as children with asthma and the elderly, are the most likely to be affected.[87]

Climate change is also expected to increase the risk from certain infectious diseases, especially vector-born diseases spread by mosquitoes or other insects.[88] Thus, vector-born diseases like malaria and dengue fever may expand their ranges.[89] In the United States, hotter, longer, and drier summers punctuated by heavy rainstorms may also create more favorable conditions for outbreaks of West Nile Virus in the Northeast.[90]

Climate change's role in increasing the frequency and severity of extreme weather events, such as hurricanes, droughts, and floods, may also adversely affect public health. For example, in delta regions, coastal areas, and small islands, sea level rise is anticipated to threaten human populations by exacerbating flooding and increasing the size of storm surges.[91] The Atlantic coast of the Southeast is likely to see such effects and suffer the loss of important buffers against storm damage.[92] In Appalachia, the increase in intense rainfalls is likely to result

---

[82] EPA Climate Change Effects, *supra* note 77.

[83] *Id.*

[84] EPA, *Ground-Level Ozone: Health and Environment, available at* http://www.epa.gov/air/ozonepollution/health.html (last visited Oct. 1, 2007).

[85] EPA Climate Change Effects, *supra* note 77.

[86] EPA, *Particulate Matter: Health and Environment, available at* http://www.epa.gov/air/particlepollution/health.html (last visited Oct. 1, 2007).

[87] *Id.*

[88] EPA Climate Change Effects, *supra* note 77.

[89] *Id.*

[90] Frumhoff, *supra* note 80, at xi.

[91] Working Group II Summary, *supra* note 78, at 9-11.

[92] U.S. Department of State, *supra* note 79, at 110.

in more dangerous flash floods.[93] Meanwhile, warming in the West is projected to decrease mountain snowpack and cause more winter flooding with reduced summer flows.[94] Finally, rising sea levels are expected to increase the salinity of surface and ground water through salt water intrusion, threatening drinking water supplies in places like the New York metropolitan area, Philadelphia, southern Florida, and California's Central Valley.[95]

b. Public Welfare Impacts

The Clean Air Act provides a broad definition of "effects on welfare," that encompasses a host of environmental ills:

> All language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants.

42 U.S.C. § 7602(h). Of particular importance here, "effects on welfare" refers to "effects on . . . weather . . . and climate." Thus, the most basic effect of global climate change – that the Earth's average mean temperature will increase – is directly implicated as an effect on welfare under the Act. As discussed above, global climate change is already resulting in well-documented impacts on climate and weather, including air and ocean temperature increases, widespread melting of snow and ice, changes in precipitation amounts and wind patterns, and more frequent extreme weather such as hurricanes, heat waves, floods, and droughts.[96] However, aside from these direct impacts on weather and climate, there are numerous other ways in which global climate change may be reasonably anticipated to endanger public welfare.

In its recent assessment of the impacts of climate change, the IPCC concluded that "[o]bservational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases."[97] In the United States, the impacts vary by region, but climate change will have significant consequences for ecosystems in many areas. For example, the State Department reports that each of the following are likely results of climate change: (1) water quantity and quality in the Great Lakes will decrease; (2) prairie potholes, an important migratory bird habitat in the Great Plains, will become drier; (3) river temperatures in the Northwest will increase, placing additional stress on migrating fish; and (4) melting of sea ice and permafrost in Alaska will harm ecosystems and

---

[93] *Id.*

[94] Working Group II Summary, *supra* note 78, at 10.

[95] EPA Climate Change Effects, *supra* note 77.

[96] Working Group I Summary , *supra* note 7, at 5-9.

[97] Working Group II Summary, *supra* note 78, at 1.

infrastructure.[98] Climate change is also likely to pose problems for many forested areas in the United States by extending and increasing the intensity of fire seasons and fostering insect outbreaks.[99]

Changes in the Earth's climate are already having an impact on marine and freshwater biological systems. For example, the ranges of algae, plankton, and fish have shifted in many water bodies in response to changes in water temperature, ice cover, oxygen content, salinity, and circulation.[100] Corals are particularly vulnerable to thermal stress and have a limited ability to adapt to changes in their ecosystem.[101] Thus, the IPCC projects that an increase in sea surface temperature of approximately 1° to 3° C (1.8°-5.4° F) will result in widespread coral mortality.[102] Finally, the increasing absorption of carbon dioxide has already decreased ocean pH by 0.1 units on average,[103] and the IPCC predicts that further acidification will harm corals and other shell forming organisms.[104]

Some habitats that are already imperiled by other forces will be particularly susceptible to damage from climate change. For example, sea level rise driven by climate change will contribute to the loss of coastal wetlands.[105] In addition to their role in protecting against floods and storm surges, such wetlands provide habitat for many species, afford recreational opportunities, and play a key role in both nutrient uptake and the economy of the surrounding area.[106] However, because they are generally located within a few feet of sea level, coastal marshes and swamps are particularly vulnerable to rising sea levels.[107] Thus, sea level rise could eliminate up to 22 percent of the world's coastal wetlands by the end of this century.[108] EPA has estimated that a two-foot rise in sea level, a figure that is within range of the IPCC's modeling for sea level rise during the 21st Century, could eliminate between 17 and 43 percent of U.S. wetlands.[109]

---

[98] U.S. Department of State, *supra* note 79, at 110. This is especially true for species like the polar bear, which is evolutionarily adapted to life on the sea ice and spends only short periods on land. *See* 72 Fed Reg. 1064 (Jan. 9, 2007) (Proposed Rule To List the Polar Bear as Threatened Under the Endangered Species Act).

[99] EPA Climate change Effects, *supra* note 77.

[100] Working Group II Summary, *supra* note 78 at 2.

[101] *Id.* at 6.

[102] *Id.* The National Marine Fisheries Service has found that shallow reef habitats are especially vulnerable to increases in global air and sea temperatures due to coral bleaching. 71 Fed. Reg. 26,852, 26,858 (May 9, 2006) (Final Rule to List Elkhorn (*Acropora palmata*) and Staghorn (*A. cervicornis*) Corals as Threatened Under the Endangered Species Act).

[103] Working Group II Summary, *supra* note 78 at 2.

[104] *Id.* at 6.

[105] *Id.* at 3.

[106] EPA Climate Change Effects, *supra* note 77.

[107] *Id.*

[108] *Id.*

[109] *See id.*; Working Group I Summary, *supra* note 7, Table SPM-3.

The welfare impacts of climate change are not limited to impacts on natural systems. For example, climate change will also adversely affect agriculture. EPA has recognized that, "[a]griculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms," and that climate change can adversely affect crop yields in regions where summer heat already limits production, increase the likelihood of severe droughts, and increase the rate of evaporation of moisture from topsoil.[110] Moreover, the increase in heavy precipitation events to which climate change contributes is projected to lead to increased soil erosion.[111]

B. EPA Should Exercise Its Authority to Promulgate Regulations Limiting Global Climate Change Emissions from Marine Shipping Vessels.

Because of the serious consequences of climate change described above, EPA should take immediate action to limit the emissions of greenhouse gas and black carbon from ships. These emissions from ships significantly contribute to air pollution that may reasonably be anticipated to endanger public health or welfare. Though they are already beginning to appear, the adverse impacts of global warming on public health and welfare will only grow worse with time. Delay in the face of such profound consequences is inexcusable. A look back at EPA's response to an earlier request to limit greenhouse gas emissions confirms the need for decisive action on this petition.

In its initial response to the petition that resulted in *Massachusetts v. EPA*, the agency maintained that even if it had the authority to regulate greenhouse gas emissions from motor vehicles, it would refuse to exercise that authority. EPA first noted that the "science of climate change is extraordinarily complex and still evolving." 68 Fed. Reg. 52,930 (Sept. 8, 2003). Therefore, according to the agency, establishing greenhouse gas emission standards for motor vehicles "would require EPA to make scientific and technical judgments without the benefit of the studies being developed to reduce uncertainties and advance technologies." *Id.* at 52,931. Regardless of any merit this argument may have had in 2003, the understanding of climate science has progressed by leaps and bounds since then. Moreover, as discussed below, technologies that are readily available today can significantly reduce global climate change emissions from ships.

EPA also advanced a second pragmatic argument in rejecting the petition to regulate motor vehicle emissions, contending that acting to limit greenhouse gas emissions from motor vehicles "would also result in an inefficient, piecemeal approach to addressing the climate change issue." *Id.* Instead, EPA reasoned, "[a] sensible regulatory scheme would require that all significant sources and sinks of GHG emissions be considered in deciding how best to achieve any needed emission reductions." *Id.* However, the developments following EPA's initial refusal to regulate motor vehicle greenhouse gas emissions have turned this argument on its head. With EPA presently considering a response to requests to limit global climate change emissions from motor vehicles, power plants, and petroleum refineries, and with requests to

---

[110] EPA Climate Change Effects, *supra* note 77.

[111] Working Group II Summary, *supra* note 78, at 14.

regulate carbon dioxide emissions from other major sources all but certain to follow in the coming months, the agency's response to climate change would more likely be inefficient and piecemeal if it *declined* to regulate global climate change emissions from ships. If, as EPA suggests, "a sensible regulatory scheme" is necessarily broad in scope, then EPA's refusal to limit the greenhouse gas and black carbon emissions from ships would only promote an arbitrary and capricious approach to the regulation of global climate change emissions.

C. Effective Regulation of Global Climate Change Emissions from Marine Shipping Vessels Is Possible.

Regulatory measures that can measurably reduce carbon dioxide, nitrous oxide, and black carbon emissions from marine engines and vessels are readily available. Further, implementation of such measures could be accomplished consistent with the Clean Air Act and other statutory requirements.

1. EPA Has Broad Discretion in Promulgating Regulations to Limit Global Climate Change Emissions from Marine Shipping Vessels.

In drafting the Clean Air Act, Congress recognized that some pollutant emissions might not be amenable to control via "end-of-pipe" technologies, and therefore provided EPA with broad authority to craft emissions standards that address multiple aspects of the regulated source, such as operational practices and design requirements.

Although the endangerment finding that triggers EPA's authority to regulate global climate change emissions from ships is essentially a "yes or no" question, the realm of potential regulatory responses to an affirmative endangerment finding is quite broad. In considering EPA's possible responses to the petition at issue in *Massachusetts v. EPA*, the Court noted that it considered the agency to have "significant latitude as to the manner, timing, content, and coordination of its regulations with those of other agencies." 127 S.Ct. at 1462. The specific Clean Air Act provision under which EPA would adopt regulations limiting ship greenhouse gas and black carbon emissions also confers a broad grant of discretion to the Administrator in selecting the appropriate regulatory initiatives to carry out the statutory goal of limiting air pollution reasonably anticipated to endanger public health or welfare. Section 213(a)(4) provides that

> the Administrator may promulgate . . . *such regulations as the Administrator deems appropriate containing standards applicable to emissions* from those classes or categories of new nonroad engines and new nonroad vehicles . . . which in the Administrator's judgment cause, or contribute to, such air pollution, taking into account costs, noise, safety, and energy factors associated with the application of technology which the Administrator determines will be available for the engines and vehicles to which such standards apply.

42 U.S.C. § 7547(a)(4) (emphasis added). Thus, the Act provides EPA with expansive authority to adopt "standards applicable to emissions" that govern the emission of greenhouse gas and black carbon from ships.

Although the Clean Air Act does not define the term "standards applicable to emissions," it does provide a definition for the analogous term "emission standard." *Id.*. § 7602(k). That definition informs the scope of EPA's authority in responding to this petition. The Act defines "emission standard" as

> a requirement established by the State or the Administrator which limits the quantity, rate, or concentration of emissions of air pollutants on a continuous basis, including any requirement relating to the operation or maintenance of a source to assure continuous emission reduction, and any design, equipment, work practice or operational standard promulgated under this chapter.

Id. Accordingly, even if EPA were to determine, for example, that no control technology to scrub carbon dioxide emissions from ship exhaust were available, the Act's definition of "emissions standard" would allow the agency to limit emissions via operational or maintenance requirements, including "design, equipment, work practice, or operational standard[s]." In light of the flexibility that Congress envisioned would often be necessary to limit air pollutant emissions, EPA clearly has the authority to promulgate requirements "relating to the operation or maintenance" of ships.

Moreover, this interpretation of the scope of EPA's authority is consistent with other judicial opinions examining the range of regulatory measures subsumed under the term "standard," as used in the Clean Air Act's mobile source provisions. For example, in *Engine Manufacturers Association v. South Coast Air Quality Management District*, 541 U.S. 246 (2004), the Supreme Court held that fleet purchase restrictions qualified as standards under the Act. *Engine Manufacturers Ass'n* at 252. The Court explained that Congress employed the term "'standard' throughout Title II of the Clean Air Act . . . to denote requirements *such as* numerical emission levels with which vehicles or engines must comply or emissions control technology with which they must be equipped." *Id.* at 253 (emphasis added, internal citations omitted). Thus, the Court concluded that regulations need not apply exclusively to the manufacturers of vehicles to qualify as emissions standards under the Act: "a standard is a standard even when not enforced through manufacturer-directed regulation." *Id.* at 254. Similarly, the Eastern District of California recently determined that regulations requiring that marine engines emit no more pollutants than if their engines had used specified fuels qualified as "standards" under the Act, even though these regulations did not establish a uniformly applicable numerical emissions level. *Pacific Merchant Shipping Association v. Cackette*, No. CIV. S-06-2791, 2007 WL 2492681 (E.D. Cal. Aug. 30, 2007) at *9-10.[112]

---

[112] The California regulations at issue provided:

> [N]o person subject to this section shall operate any auxiliary diesel engine, while the vessel is operating in any of the Regulated California Waters, which emits levels of diesel PM, NO_x, or SO_x in exceedance of the emission rates of those pollutants that would result had the engine used the following fuels:
>
> (A) Beginning January 1, 2007:
>
> 1. marine gas oil, as defined in subsection (d); or

In fact, EPA has already interpreted the scope of its regulatory authority quite broadly in the context of regulating greenhouse gas emissions. In its initial rejection of the petition to regulate motor vehicle greenhouse gas emissions, EPA noted that, "[n]o technology currently exists or is under development that can capture and destroy or reduce emissions of carbon dioxide, unlike other emissions from motor vehicle tailpipes. At present, the only practical way to reduce tailpipe emissions of carbon dioxide is to improve fuel economy." 68 Fed. Reg. 52,929 (Sept. 8, 2003). The EPA did not claim that it did not have the authority, all other things being equal, to regulate fuel economy. Instead, the EPA resisted promulgating regulations by claiming that regulation of fuel economy would conflict with the existing CAFE program. *Id.* ("[t]he only way for EPA to proceed with carbon dioxide emissions standards without upsetting this statutory scheme would be to set a standard less stringent than CAFE for cars and light duty trucks. But such an approach would be meaningless in terms of reducing [greenhouse gas] emissions from the U.S. motor vehicle fleet."). The Court rejected the EPA's argument. *See Massachusetts v. EPA,* 127 S.Ct. at 1462.[113]

Congress wisely provided EPA with expansive authority to craft emissions standards for mobile sources that make optimal use of existing technological and operational capabilities. Although EPA is free to issue standards establishing numerical emissions limits for greenhouse gas and black carbon, nothing in the Clean Air Act prevents EPA from creating multiple compliance alternatives for marine engines and vehicles subject to such regulations.

2. Regulations Limiting Marine Shipping Vessel Speed Would Significantly Reduce Global Climate Change Emissions from Ships.

EPA should adopt restrictions on vessel speed to reduce carbon dioxide, nitrous oxide, and black carbon emissions from marine engines and vessels. Such restrictions would have minimal impact on the global shipping industry and would greatly improve the fuel efficiency of water transport. Reducing vessel speed would also result in a reduction in the emissions of nitrogen oxides from ships, leading to additional climate change benefits.

Studies have shown that the most cost effective, feasible method to reduce emissions from ships is to slow the global fleet.[114] Global climate change emissions are directly

---

2. marine diesel oil, as defined in subsection (d), with a sulfur content of no more than 0.5 percent by weight;

(B) Beginning January 1, 2010: marine gas oil with a sulfur content of no more than 0.1 percent by weight.

13 C.C.R. § 2299.1(e) (as in effect on Aug. 30, 2007). The court concluded that these regulations, "on their face, impose standards relating to the control of emissions." *Pac. Merchant Shipping Ass'n*, 2007 WL 2492681, at *9.

[113] For a more detailed discussion of the Supreme Court's rejection of this argument, see section I(C)(5)(c) of the Argument section of this petition.

[114] FOEI, *supra* note 1, at 6.

proportional to fuel consumption, and the amount of fuel ships consume is directly and exponentially related to vessel speed. Thus, slowing down results in significant savings in fuel.[115] Indeed, the IMO reports that a ten percent reduction in speed would result in a 23.3 percent decrease in emissions.[116] At low speeds, ships are one order of magnitude more efficient than land transport and two orders more efficient than air transport.[117] However, as ship speeds increase much of these efficiencies are lost. Very fast ships have been found to have similar energy demands to airplanes.[118]

In many cases, ships run at high speed to the port of destination and have to wait for days or even weeks to have their cargo loaded or unloaded. Increasing the efficiency at these ports, perhaps by giving ships berthing times as happens at airports, would allow ships to operate at slower speeds without imposing a heavy financial burden.[119]

Recently, George Gratsos, the President of the Hellenic Chamber of Shipping, said at the Bunkerworld Forum in Athens that there would be "few repercussions" to the world economy from a 20 percent reduction in ocean-going ship speeds close to the European Union. This 20 percent reduction in speed however, would result in a 55-65 percent reduction in emissions.[120]

Since the fuel consumption of a ship does not depend primarily on its size, but rather on its speed, the same amount of transport work can be achieved by more slower ships, rather than fewer faster ships.[121] One case study compared the fuel consumption of two fleets, each providing the same transport capacity. The first fleet was made up of ten ships of 16 knot design speed, while the second was comprised of 14 ships of 10.5 knots design speed. The faster fleet consumed 140,000 tons of fuel in comparison to the slower fleet that consumed 60,000 tons of fuel (a decrease of 57 percent in fuel consumption and therefore emissions).[122]

---

[115] Ottar Maestad, et al., *International Climate Policy – Consequences for Shipping*, at 39, SNF-Report No.82/2000, Foundation for Research in Economics and Business Administration, (2000) *available at* http://bora.nhh.no/bitstream/2330/1032/1/R82_00.pdf.

[116] IMO, *supra* note 27, at 17, Table 1-5.

[117] J Isensee and V Bertram, *Quantifying External Costs of Emissions Due to Ship Operation*, 218 PROC. INST. MECH. ENGRS. Part M: J. ENGINEERING FOR THE MARITIME ENVIRONMENT 41 (2004) 44.

[118] *Id.*

[119] FOEI Submission to MEPC (IMO), *Market-based Measures Combined with Other Emissions Reductions Initiatives Have the Potential to Control GHG Emissions from International Shipping.* (Aug. 22, 2007) at 2.

[120] George Gratsos, President of the Hellenic Chamber of Shipping, at the Welcome Address at the Bunkerworld Forum in Athens on Bunkering in the Mediterranean and Black Sea, May 2007. From the standpoint of the shipping firm, it is economically optimal to reduce speed when freight rates are relatively low compared to the cost of fuel. Maestad, et al., *supra* note 114, at 41-42. Thus, recent increases in fuel prices are likely to make reductions in fuel consumption more attractive. Further, as the refining process has developed, the remaining residual fuel has become poorer quality. IMO, *supra* note 27, at 107. This declining fuel quality not only imposes environmental costs, but also imposes additional costs on shipping firms, because it reduces engine longevity. *Id.* at 108. Thus, speed reductions will become more attractive as ships are required to use less polluting, higher quality, more expensive fuels. Isensee and Bertram, *supra* note 116, at 48.

[121] Isensee and Bertram, *supra* note 116, at 49.

[122] *Id.* at 49-50.

A second case study showed that for bulkers[123] carrying coal between ports over a distance of 120 nautical miles, a fleet of five faster ships (16.0 knot) used 77,170 tons of fuel per year, while a fleet of six slower ships (12.6 knot) used only 43,310 tons of fuel. The slower fleet consumed 44 percent less fuel and emitted the equivalent amount of fewer emissions than the faster fleet.[124]

A third case study looked at a Roll-On-Roll-Off[125] ship, with a service speed of 19.5 knots, transporting cars from the port of Gothenburg to the port of Nagoya. The study suggested that although cutting its speed to 17 knots (12.8 percent) would result in a delay of three days (increasing the travel time to 37 days), this lost time could be made up by more efficient handling in the ports.[126]

The Ports of Los Angeles and Long Beach already have a speed reduction scheme in place, providing incentives for ships to remain below a speed of 12 knots. The ports are aiming for 100 percent compliance, which would result in significant reductions in ship emissions. For example, the Port of Los Angeles would see reductions of 37 percent for nitrogen oxides and 49 percent for particulate matter.[127] These figures illustrate another important point regarding regulations limiting vessel speed – they would have pollution reduction benefits extending to nitrogen oxides emissions as well. As discussed above, emissions of nitrogen oxides from ships also contributes to global climate change, and because restrictions on vessel speed would improve the fuel efficiency of ships, they would reduce the emissions of this pollutant per ton of cargo carried.

3. Regulations Requiring the Use of Cleaner Fuels Would Significantly Reduce Climate Change Emissions from Marine Shipping Vessels.

In addition to its authority to regulate the manufacture and sale of fuels under section 211 of the Clean Air Act, EPA also has the authority to mandate the *use* of cleaner fuels in ships pursuant to its authority to set emissions standards under section 213. As noted above, the United States District Court for the Eastern District of California recently concluded that regulations limiting ship emissions to no more than levels that would be obtained when combusting specified fuels fits squarely within the Act's definition of an emissions standard. *Pacific Merchant Shipping Association*, 2007 WL 2492681, at *9.

---

[123] A bulk carrier, bulk freighter, or bulker is a merchant ship used to transport unpackaged bulk cargo such as cereals, coal, ore, and cement.

[124] Isensee and Bertram, *supra* note 116, at 50.

[125] Roll-on/roll-off (RORO or ro-ro) ships are designed to carry wheeled cargo such as automobiles, trailers or railway carriages. This is in contrast to lo-lo (lift on-lift off) vessels which use a crane to load and unload cargo.

[126] Gloria Gerilla, et al., *Environmental Assessment of International Transportation of Products*, 6 JOURNAL OF THE EASTERN ASIA SOCIETY FOR TRANSPORTATION STUDIES 3167 (2005) 3178.

[127] Guy Wilson-Roberts, *California Vessel Speed, Shore Power Meetings Tomorrow*, SUSTAINABLESHIPPING.COM, July 11, 2007, http://www.sustainableshipping.com/news/2007/07/68431.

Adopting stringent restrictions on fuel sulfur content will result in a net reduction in the emissions of several global climate change related air pollutants.[128] Ships commonly use "residual fuels" which are high in sulfur content. By adopting regulations, the EPA could require ships to use more refined fuels, such as marine diesel oil or marine gas oil, that burn cleaner, as a means of reducing marine shipping vessels' contribution to global climate change emissions. Therefore, the EPA should move expeditiously to adopt such limits and prohibit the use of non-complying fuels.

Residual fuel oil is of low quality. It is used because of its low cost, approximately $385 per metric tonne.[129] Even so, its use is not unproblematic for ship operators. Residual fuels must be heated to about 140°C before being used on board. A proportion of the fuel, the sludge which cannot be put through the engine, must be removed and is regularly burnt on board.[130]

The sulfur content of residual fuels varies according to the crude stock, but globally averages about 2.7 percent.[131] In contrast, cleaner fuels such as marine diesel oil contain 0.5 percent sulfur content, while marine gas oil is composed of 0.1 percent sulfur.[132]

Switching to low-sulfur fuels would reduce emissions of fine particles, including black carbon, as well as carbon dioxide, nitrogen oxides, and nitrous oxides, and enable the use of other emissions control equipment that the sulfur levels in residual fuel would otherwise impede.[133] Marine diesel oil and marine gas oil have shown significant decreases in particulate matter and nitrogen oxides compared to heavy fuel oil.[134] A switch from heavy fuel oil to marine diesel oil would result in a 2.86 percent reduction in carbon dioxide emitted per ton of fuel consumed.[135] The IMO suggests that this switch could reduce carbon dioxide emissions from shipping by 1.6 percent by 2010 and three percent by 2020.[136] This switch would also result in reductions of over 91 percent in nitrous oxide, 63 percent in particulate matter (of which black carbon is a component), and nearly five percent in nitrogen oxide emissions.[137]

---

[128] Regulations setting emissions standards for marine shipping vessel engines based on the levels of sulfur emissions that would result from burning low-sulfur fuels would limit global climate change emissions as well as reduce pollutants regulated under section 213(a)(1) of the Clean Air Act. As noted above, Friends of the Earth's lawsuit to compel EPA to comply with section 213(a)(3) of the Act is thus complementary to this petition. *See* Friends of the Earth v. EPA, No. 07-1572 (D. D.C. filed Sept. 5, 2007).

[129] *See* Bunkerworld.com, Fuel Prices, http://www.bunkerworld.com/markets/prices/, (last visited Oct. 1, 2007).

[130] *Id.*

[131] *Id.* at 41, Table 3-6.

[132] James Winebrake and James Corbett, *Technical Memorandum: Total Fuel Cycle Analysis for Container Ships: A Comparison of Residual Oil, Marine Gas Oil and Marine Diesel Oil*, (2007) at 3. Prepared for FOEI.

[133] ICCT, *supra* note 19, at 11.

[134] Winebrake and Corbett, *supra* note 132, at 4.

[135] IMO, *supra* note 27, at 108 (explaining that switching all ships to marine distillate fuel would reduce CO_2 emissions by approximately 36 million tons per year).

[136] *Id.* at 17, Table 1-5.

[137] Winebrake and Corbett, *supra* note131, at 6.

The switch to clean fuels would also eliminate the need for purifiers, heating of fuel tanks and sludge burning, which will reduce costs for vessel owners and operators. Loss of fuel due to sludge removal would be avoided and the energy used to refine residual oil on board could be put towards powering the ship. As mentioned above, such a switch also would allow for the use of end-of-the-pipe emission controls, enabling considerable additional reductions of greenhouse gases and other air pollutants otherwise not likely to be achieved.

The switch to low sulfur fuels could incur slight lifecycle increases (approximately two to five percent) in carbon dioxide emissions, incurred mainly at the refineries.[138] However, these emissions are more easily addressed at a stationary location rather than on board a vessel. Moreover, they could be offset by other emission reduction mechanisms such as reducing vessel speed. While refineries currently enjoy the benefits of offloading their residual oil at a profit, they are able to refine the residual oil, or if they decide to burn it, are regulated by strict emission standards (unlike the ships that burn it on board).[139] Further, some refineries are extracting the sulfur and using it for other purposes, for example as a source of gypsum.[140]

Experience shows that fuel-switching makes sense. The Danish ship owner Maersk Line voluntarily implemented a fuel switching program for all its ships calling at California ports.[141] More than 60 of the company's ships are participating in the program. The ships switch to distillate fuel in their main engines 24 nautical miles from port. A Maersk spokesperson explained that, "The fuel switch can be implemented very quickly, without the need for capital investment or additional equipment."[142] According to reports this program has reduced overall emissions by approximately 400 tons per year, including an 80 percent reduction in particulate matter and a 17 percent reduction in nitrogen oxides.[143]

It has been suggested that, since sulfur emissions from ships have an overall cooling effect on the atmosphere, moving to cleaner fuel is an unacceptable response to global climate change. But, sulfur emissions are associated with health risks in humans, such as respiratory disease.[144] Thus, any sensible analysis of the net benefit of the remedies proposed in this petition as opposed to the status quo would conclude that the benefits of reducing overall global climate change emissions and human health threats outweigh the incidental cost of forgoing the cooling effect of sulfur emissions.

---

[138] *Id.* at 5.

[139] Isensee and Bertram, *supra* note 116, at 47.

[140] *Id.*

[141] Guy Wilson-Roberts, *Maersk Fuel Switching 'Very Successful'*, SUSTAINABLESHIPPING.COM, July 10, 2007, http://www.sustainableshipping.com/news/2007/07/68418.

[142] *Id.*

[143] *Id.*

[144] *See, e.g.*, EPA (2000) *Health and Environmental Impacts of* SO_2, http://www.epa.gov/air/urbanair/so2/hlth1.html (last visited Oct. 1, 2007).

Further, while emitting sulfur into the atmosphere addresses one effect of carbon dioxide pollution, global warming, it fails to address another significant effect, ocean acidification. Sulfur emissions do not remove carbon dioxide from the atmosphere. As the oceans absorb more carbon dioxide from the atmosphere, they become more acidic, having severe consequences for organisms that form shells or structure from calcium carbonate, such as corals and oysters.[145] Sulfur emissions also contribute directly to ocean acidification.[146] Thus, since there are ways of addressing carbon dioxide pollution and its effects that also reduce harmful sulfur emissions, the optimal solution is to confront both problems at once.

4. Other Readily Available Technical and Operational Measures Would Significantly Reduce Global Climate Change Emissions from Marine Shipping Vessels.

Other operational measures could be employed relatively easily and cost-effectively to further reduce emissions. These could include weather routing, improved efficiency of logistics and voyage planning, fuel-economy standards for ships, and optimal ship and engine operations.[147] Other varied technologies and methods can also be used to reduce fuel consumption. For example:

- The use of "cold ironing" at ports, where ships shut off their diesel engines and are connected to shore based power for their electrical needs.[148]
- Improved hull design can achieve reductions in emissions through reduced fuel consumption.[149]
- A bulbous bow can increase a ship's fuel efficiency by reducing its wavemaking resistance.[150] The Inui Bow – a new form of the bulbous bow developed in the late 1950s and early 1960s – is now widely used on large commercial ships, where it typically reduces fuel consumption by about five percent at cruising speeds. The Inui Bow is now also being applied to smaller commercial ships.[151]
- A stern flap, a small plate that extends behind a ship's transom, lengthening the bottom surface of the hull, can reduce a ship's resistance and thus increase fuel efficiency by a few to several percent.[152]

---

[145] See discussion of ocean pH effects on corals in Section I (A)(2) within the Argument section, above.

[146] Doney, et al., *supra* note 35, at 14580.

[147] FOEI, *supra* note 119, at 1.

[148] Pacific L.A. Marine Terminal LLC, Alternative Maritime Power (AMP, cold ironing), Pier 400 Project, http://www.pacificenergypier400.com/index2.php?id=37.

[149] *See* Brian Hayman, et al., *Technologies for Reduced Environmental Impact from Ships – Ship Building, Maintenance and Dismantling Aspects*, at 3, *available at* http://www.iot.ntnu.no/users/fet/Konferanser/2000-Treship-Newcastle.pdf (last visited Oct. 1, 2007) (discussing hull form optimization).

[150] Ronald O'Rourke, *Navy Ship Propulsion Technologies: Options for Reducing Oil Use – Background for Congress* (2006) at 4, CONGRESSIONAL RESEARCH SERVICE, *available at* http://www.fas.org/sgp/crs/weapons/RL33360.pdf.

[151] *Id.*

[152] *Id.* at 6.

- The Department of Defense has recognized that applying special coatings to Navy ship propellers might reduce ship fuel use by four to five percent, while reducing maintenance requirements as well.[153] This practice might therefore pay for itself within about one year.[154]
- Sail or kite-assisted propulsion can provide zero-emissions wind power, and plans are already underway to employ such technologies on new and existing cargo vessels.[155]

5. The Scope of EPA's Regulatory Authority Is Broad Enough to Enable Significant Reductions in Global Climate Change Emissions from Marine Shipping Vessels.

As demonstrated below, EPA has the authority to regulate marine global climate change emissions over a significant amount of ship traffic and over a vast geographic area.

a. EPA Has the Authority to Regulate Global Climate Change Emissions from Both New Ships and Ships with New or Remanufactured Engines.

The Clean Air Act provides a means for EPA to regulate global climate change emissions from existing ships as well as brand new vessels. The Act permits the agency to regulate new marine engines, and because a rebuilt marine engine is functionally the same as a new one, EPA's regulation of remanufactured marine engines can swiftly reduce greenhouse gas and black carbon emissions from shipping.

Section 213(a)(4) of the Clean Air Act calls for the establishment of emission standards that apply to both new nonroad vehicles *and new nonroad engines*. 42 U.S.C. § 7547(a)(4). The statutory text thus ensures that existing ships cannot elude emissions standards by installing new engines. However, as EPA has found, installation of a newly manufactured propulsion engine in an existing commercial vessel is a rare occurrence. The engines used in such ships tend to be integral to the vessel, and because they are very difficult to remove, owners and operators of commercial vessels regularly rebuild existing engines to extend their service lives rather than install a completely new engine. *See* 72 Fed. Reg. 16,032 (Apr. 3, 2007) (explaining that "the engines are typically below deck and replacement requires cutting the hull or the deck").

Although EPA's current emissions standards apply only to marine engines that are new in the sense of being newly manufactured, EPA has proposed to begin applying such standards to marine diesel engines in excess of 800 horsepower as they are remanufactured. *Id.* This approach is eminently reasonable, given that when the remanufacturing process is complete, such marine engines are functionally new. *Id.* ("Marine engine remanufacturing procedures have improved to the point that engine performance for rebuilt engines is equivalent to that of new engines."). Furthermore, it is essential to carry this proposed approach into the regulation of global climate change emissions from new marine engines. Adopting remanufacturing standards

[153] *Id.* at 7.

[154] *Id.*

[155] *Id.* at 21-29.

that take advantage of existing and expected future technologies would significantly accelerate the benefits of EPA's regulatory program.

b. EPA Has the Authority to Apply Measures to Limit Global Climate Change Emissions from Marine Shipping Vessels to Foreign Flagged Vessels.

Foreign-flagged ships account for 90 percent of calls on U.S. ports and 80 percent of emissions in non-port coastal areas.[156] The EPA has acknowledged that "engines on foreign-flagged vessels account for the majority of emissions from Category 3 marine diesel engines impacting U.S. air quality." 68 Fed. Reg. 9750 (Feb. 28, 2003). Failure to regulate global climate change emissions from foreign-flagged vessels would dramatically limit the effectiveness of any program to regulate emissions from ships. Section 213(a)(4) of the Clean Air Act authorizes the EPA to set standards applicable to emissions from those classes or categories of new nonroad engines and new nonroad vehicles which in the Administrator's judgment cause, or contribute to air pollution. 42 U.S.C. § 7547(a)(4). Limiting greenhouse gas and black carbon emissions from foreign as well as domestic vessels is in accord with the unambiguous mandate of the Act and principles of international law.[157]

(i) The Statute Unambiguously Applies to All Vessels, Foreign or Domestic.

Once EPA makes the requisite findings concerning the impact of nonroad engines, section 213 authorizes EPA to set emissions standards for all classes of new nonroad engines that contribute to air pollution. 42 U.S.C. § 7547(a)(4). The statute makes no distinction between foreign or domestic engines, and therefore authorizes regulation of any engines that contribute to air pollution.

A statute regulating marine vessels that does not distinguish between U.S.- and foreign-flagged vessels applies to both. In *Stevens v. Premier Cruises, Inc.*, 215 F.3d 1237 (11th Cir. 2000), the court held that the Americans with Disabilities Act (ADA), which prohibits discrimination in places of public accommodation, applied to foreign-flagged vessels operating in U.S. waters even though the statute did not explicitly state that it applies to such vessels. In reaching its conclusion, the court considered whether there exists any presumption regarding the application to foreign-flagged vessels of statutes that apply generally to ships, but make no distinction between foreign- and U.S.-flagged vessels. Although acknowledging that there exists a general presumption "against the application of [U.S.] law to the internal management and affairs of a foreign-flag ship in United States water," *Stevens*, 215 F.3d at 1242 (internal citations omitted), the court concluded that no such presumption applies when the statute at issue "does not involve the 'internal management and affairs' of a foreign-flag ship." *Id.* at 1242. *See also Mali v. Keeper of the Common Jail of Hudson County, New Jersey* (Wildenhus's Case), 120 U.S. 1, 12 (1887) (under principles of international comity, "all things done on board, *which affect[] only the vessel or those belonging to her*" are to be left to the jurisdiction of the flag nation

[156] *See* EPA, *supra* note 45, at § 3.5.1.3, 3.6.

[157] In a January 2003 rulemaking EPA committed to consider the application of more stringent standards for new nonroad engines installed on foreign-flagged vessels that enter U.S. ports. 68 Fed. Reg. at 9759. Petitioners expect EPA to comply with this commitment.

(emphasis added)). The *Stevens* court found that the accommodation of a "disabled, fare-paying, American passenger" was an interest of the United States, and did not solely involve the foreign vessel's internal affairs. 215 F.3d at 1242. Indeed, because Congress has clearly intended to address harm from cruise ships, and such ships tended to be predominantly foreign-flagged ships, *id.* at 1242-43 (noting U.S. agency statement that "virtually all cruise ships serving U.S. ports are foreign flag vessels"), the court noted that it would be "strange" to conclude that Congress intended the statute to apply only to domestic vessels. *Id.* at 1243.[158]

The *Stevens* court based its conclusion on *Cunard S.S. Co. v. Mellon*, 262 U.S. 100 (1923). *Id.* at 1242. In *Cunard*, the Supreme Court considered whether the National Prohibition Act, which prohibited the possession of alcoholic beverages within territory subject to U.S. jurisdiction, could be applied to foreign-flagged vessels carrying liquor to be sold or dispensed to passengers and crews. 262 U.S. at 119. Because the statute was intended to apply throughout the territorial limits of the United States and did not distinguish between U.S. and foreign-flagged ships, *id.* at 127, the Court concluded that it applied to foreign-flagged vessels in U.S. territorial waters. *Id.* at 128-29.

Pursuant to these principles, Congress's grant of authority to establish emission standards for nonroad engines applies unambiguously to all U.S. vessels and all vessels operating in U.S. waters, whether foreign- or U.S.-flagged.[159] The statute requires emissions standards for all new nonroad engines or vehicles that contribute to air pollution, making no distinction between foreign or domestic engines or vehicles. 42 U.S.C. § 7547(a)(3), (4). Emissions from foreign vessels that contribute to pollution of the air of the United States are plainly not a matter solely concerning the internal management and affairs of the foreign vessels.[160] Moreover, in light of EPA's findings concerning the significance of foreign Category 3 engines' role in pollution in the United States, *see* 68 Fed. Reg. 9750, it would be "strange" to think that excluding such engines would be consistent with the statutory purpose of the CAA. *See Stevens,* 215 F.3d at 1243. The statute thus unambiguously requires EPA to establish emissions standards applicable to both foreign and domestic vessels operating in U.S. waters.

(ii) International Law Protects the Right of the United States to Limit Global Climate Change Emissions from Foreign Vessels Operating in U.S. Waters.

---

[158] The court in *Stevens* held that the ADA applies to the foreign vessel while recognizing that such application could require significant structural modification of the ship, which would clearly affect the ship's internal affairs. 215 F.3d at 1238-39 (noting that the complaint alleged ADA violations arising from the failure of the ship to "modify numerous interior and exterior doors" and to "modify and provide requisite cabins accessible for persons with disabilities").

[159] While the U.S. jurisdiction extends to foreign-flagged vessels only when those vessels are in U.S. waters (including, under some circumstances, the Exclusive Economic Zone (EEZ)), the United States has jurisdiction over U.S. flagged vessels in all waters, including foreign waters and the high seas. *See* Restatement (Third) of Foreign Relations Law § 402(h) (1986). The U.S. should exercise its jurisdiction to the full extent available under domestic and international law.

[160] *See* Erik Japp Molenaar, *Coastal State Jurisdiction over Vessel-Source Pollution*, 102 (Kluwer Law International) (1998) (ship pollution not considered a matter of internal concern to the vessel).

EPA has the authority to regulate global climate change emissions from U.S.- and foreign-flagged vessels operating in U.S. waters under international law. International law grants nations different levels of authority to regulate, depending on whether the regulated activity takes place in the nation's ports, in its territorial sea, typically out to 12 miles from shore, or in the nation's Exclusive Economic Zone ("EEZ"), 200 miles from shore in most places. The EPA has authority to regulate global climate change emissions from ships in both the territorial sea and the EEZ.

The United States has complete authority to regulate foreign vessels in its ports and other internal waters[161] in any manner, even to the extent of excluding such vessels completely.[162] The right to regulate in ports and other internal waters includes the right to prevent pollution. The United Nations Convention on the Law of the Sea (UNCLOS), the relevant provisions of which the United States has accepted as a binding expression of international law,[163] explicitly permits each nation to establish "particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into

---

[161] Under international law, internal waters include "waters on the landward side of" the low water line on the coast. United Nations Convention on the Law of the Sea (UNCLOS), Dec. 10, 1982, 1833 U.N.T.S. 397, art. 5 & 8. This includes bays whose mouths are no more than 24 miles wide. *Id.* art. 10(4). Ports are considered equivalent to land territory. *Id.* art. 11.

[162] *See, e.g.*, *Benz v. Compania Naviera Hidalgo*, 353 U.S. 138, 142 (1957) ("It is beyond question that a ship voluntarily entering the territorial limits of another country subjects itself to the laws and jurisdiction of that country."); *Cunard*, 262 U.S. at 124 ("The merchant ship of one country voluntarily entering the territorial limits of another subjects herself to the jurisdiction of the latter. The jurisdiction attaches in virtue of her presence, just as with other objects within those limits. During her stay she is entitled to the protection of the laws of that place and correlatively is bound to yield obedience to them."); *Patterson v. Bark Eudora*, 190 U.S. 169, 178 (1903) ("[T]he implied consent to permit [foreign merchant ships] to enter our harbors may be withdrawn, and if this implied consent may be wholly withdrawn, it may be extended upon such terms and conditions as the government sees fit to impose."). *See also* Restatement § 511, cmt. e ("Under international law, a coastal state's sovereignty over its land territory extends to its internal waters, including bays ... [and] seaports."); Molenaar, *supra* note 160, at 101 (International law permits a port nation "not only to deny in principle access [to ports] but also to prescribe non-discriminatory laws and regulations that determine conditions for the entry into its ports."); *id.* at 186 (international law permits national standards in internal waters).

The Convention on the Territorial Sea and the Contiguous Zone, to which the United States is a party, authorizes the United States to impose conditions on the entry of ships to its internal waters. Art. 16(2), Apr. 29, 1958, 15 U.S.T. 1606, 516 U.N.T.S. 206 (entered into force Sept. 10, 1964) (Nations "have the right to take the necessary steps to prevent any breach of the conditions to which admission [of ships proceeding to internal waters] is subject.").

[163] Proclamation No. 5928, 54 Fed. Reg. 777 (Dec. 27, 1988) (UNCLOS reflects international law concerning territorial sea, including that "coastal nations may exercise sovereignty and jurisdiction over their territorial seas"); Proclamation No. 7219, 64 Fed. Reg. 48701 (Aug. 2, 1999) (UNCLOS reflects international law). UNCLOS's environmental provisions are recognized as an expression of customary international law, making them binding on the United States whether or not it is a party to the convention. *See* Restatement (Third), Part VI (Law of the Environment), Introductory Note at 102 ("Most of the provisions of [UNCLOS] concerning the protection of the marine environment reflect customary international law."); *id.* Part V (Law of the Sea), Introductory Note at 5 ("[B]y express or tacit agreement accompanied by consistent practice, the United States, and states generally, have accepted the substantive provisions of the Convention, other than those addressing deep sea-bed mining, as statements of customary law binding upon them apart from the Convention.").

their ports or internal waters," UNCLOS, art. 211(3), subject only to the condition that they publicize those requirements internationally. *Id.*[164]

The authority to regulate to prevent pollution extends to the entire territorial sea. In the territorial sea, UNCLOS permits nations to "adopt laws and regulations for the prevention, reduction and control of marine pollution from foreign vessels," including vessels that are only passing through U.S. territorial waters. UNCLOS., art. 211(4). Moreover, the rules delineating the right of innocent passage through the territorial sea[165] explicitly permit such passage to be regulated for "the preservation of the environment of the coastal State and the prevention, reduction and control of pollution thereof," again subject to the condition that such regulations be published. *Id.* art. 21(1)(f), (3).

The United States and other countries have repeatedly exercised their authority to regulate shipping in ports and the territorial sea. In the Deepwater Port Act of 1974, the United States prohibited foreign vessels from using U.S. deepwater ports if the flag nation had objected to the application of U.S. jurisdiction to all vessels in such ports. 33 U.S.C. § 1518(c)(2). The statute further required the promulgation of regulations governing the use of such ports. *Id.* § 1509. Such regulations include requirements about the design and construction of ships using the ports, and the equipment with which they must be fitted. *See, e.g.,* 33 C.F.R. § 149.

In the Ports and Waterways Safety Act of 1972, the United States prohibited any vessels that failed to comply with U.S. ship regulations from operating in the U.S. territorial sea or internal waters. 33 U.S.C. § 1228(a).[166] Such regulations include requirements that ships have fixed containers or enclosed deck areas to contain oil and hazardous material cargo discharges. 33 C.F.R. § 155.310.

Pursuant to a statutory mandate to assure the protection of national park resources and "leave them unimpaired for the enjoyment of future generations," 16 U.S.C. §1, the United States established standards limiting air emissions from cruise ships in Glacier Bay National Park. 36 C.F.R. § 13.65(b)(4). In developing this regulation, the National Park Service noted that "all of the cruise ships and some of the tour boats operating in [the park] are foreign-flagged vessels." 61 Fed. Reg. 27008, 27011 (May 30, 1996). The EPA has issued citations to foreign cruise ships for air emissions reported while the ships were in port in Juneau, Alaska.[167] Other nations also regulate foreign vessels in their territorial waters. For example, Canadian law

---

[164] Although UNCLOS article 212 specifically addresses air pollution, scholars interpret that provision as *requiring* states to establish *minimum* air pollution standards without disturbing the right of port states, recognized in articles 25(2) and 211(3), to establish other regulations to prevent air pollution. *See* Molenaar, *supra* note 160, at 500-01 (1998). UNCLOS's provisions concerning the "marine environment" are intended to apply to the atmosphere as well as the sea. *See id.* at 499.

[165] The right of innocent passage does not include a right to enter ports or internal waters. *See id.* art. 18.

[166] The statute prohibits these operations in "the navigable waters of the United States," 33 U.S.C. § 1228(1), which include "all waters of the territorial sea of the United States." 33 U.S.C. § 1222(5).

[167] *Federal Regulators Say Cruise Ships Apparently Violated Pollution Rules*, ASSOCIATED PRESS NEWSWIRE, June 22, 2000 (also noting that state and federal officials are drafting "plans for monitoring water and air emissions from the fleet of foreign-flagged vessels").

permits the establishment of air emissions standards and design standards for ships operating on Canadian waters. Canada Shipping Act, R.S.C., ch. S-9, § 657 (1985) (Can.). Similarly, the Canada Shipping Act explicitly recognizes that the pollution regulations of a foreign country apply to Canadian ships operating in foreign waters. *Id.* § 655(4). Pursuant to this statute, Canada has established air emission standards for ships operating within one mile of its coast. Air Pollution Regulations, C.R.C. 1404, (1978) (Can.). Canada has also established design and construction standards applicable to all vessels operating within 100 nautical miles of its northern coast. Arctic Waters Pollution Prevention Act, R.S.C., ch. 2, § 12(1)(a) (1985 & Supp. 1989) (Can.); Arctic Waters Pollution Prevention Regulations, C.R.C. 354 (1978).

International organizations also recognize nations' right to impose pollution-prevention standards in territorial waters. In 1990, the Helsinki Commission, the governing body for the Convention on the Protection of the Marine Environment of the Baltic Sea Area, a convention ratified by nine countries and the European Community, recommended that the parties to the Convention implement sewage discharge regulations "with respect to ships, *irrespective of nationality*, sailing in their national waters." [168]

The United States also has authority to regulate both U.S.- and foreign-flagged vessels in the EEZ. Under international law, states have jurisdiction to regulate in the EEZ for the prevention, reduction and control of marine pollution, as long as such regulation conforms to and gives effect to generally accepted international rules and standards. UNCLOS art. 211(5). In addition, states have the authority to regulate pollution from or through the atmosphere, applicable to the air space under their sovereignty, taking into account internationally agreed rules, standards, and recommended practices and procedures. *Id.* art. 212. The United States has a specific authority to regulate the emission of pollutants from marine vessels that contribute to global climate change under the United Nations Framework Convention on Climate Change. ("UNFCCC"). [169] Thus, regulating global climate change emissions from large marine vessels in the EEZ would give effect to the commitments undertaken in the UNFCCC.

U.S. law makes clear that the United States retains the authority to regulate shipping in the U.S. EEZ. The Oil Pollution Act of 1990 (OPA) requires vessels carrying oil to "be equipped with a double hull ... when operating on the waters subject to the jurisdiction of the United States, including the Exclusive Economic Zone." 46 U.S.C. § 3703a(a). Other

---

[168] Helsinki Comm'n (HELCOM), Rec. 11/9, (Feb. 14, 1990), *available at* http://www.helcom.fi/Recommendations/en_GB/rec11_9/ (emphasis added).

[169] The "ultimate objective" of the UNFCCC is to "achieve ... stabilization of [GHG] concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system ... within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." United Nations Framework Convention on Climate Change (UNFCCC), art. 2, March 21, 1994, 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992). In order to meet this objective, parties to the UNFCCC are bound to certain "commitments" including the commitment to "implement ... national ... programs containing measures to mitigate climate change by addressing anthropogenic emissions by sources ... of all GHGs," *id.* art. 4(1), and to "adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of [GHGs with] the aim of returning individually or jointly to 1990 levels" of GHG emissions.

regulations implemented pursuant to the OPA requires ships operating in U.S. waters to have segregated ballast tanks, crude oil washing systems, dedicated ballast tanks, fixed pumping systems, and oil residue tanks. *See generally* 33 C.F.R. Part 157. These requirements exceeded the international standard in effect at the time the OPA was enacted.[170] The OPA also imposed on ship owners nearly unlimited liability for oil spills, 33 U.S.C. § 2702(a), (b), 2704(a), a significantly greater liability than was imposed under two international conventions that the United States had signed but not ratified.[171]

The practice of the United States and other nations regulating foreign vessels operating in national waters supports the conclusion that international law protects the right of the United States to limit global climate change emissions from foreign-flagged vessels operating in U.S. waters. In light of this authority and the unambiguous application of the CAA to all vessels, domestic and foreign, EPA should limit global climate change emissions from both U.S.- and foreign-flagged vessels.

c. Coast Guard Regulation of Ship Traffic Under the Ports and Waterways Safety Act Is No Barrier to EPA Regulation of Marine Shipping Vessel Speeds.

Although EPA has not historically regulated the speed of ships, this fact is no bar to the agency adopting such restrictions to control global climate change emissions from ships. Nor does the fact that regulation of vessel speed has historically been the province of the Coast Guard prevent EPA from promulgating such regulations. The Supreme Court's decision in *Massachusetts v. EPA* settles this issue.

The United States Coast Guard regulates vessel speeds under the Ports and Waterways Safety Act. 33 U.S.C. §§ 1221-1250. Under this Act, the Coast Guard "may control vessel traffic in areas subject to the jurisdiction of the United States which are "hazardous, or under conditions of reduced visibility, adverse weather, vessel congestion, or other hazardous circumstances, by . . . (C) establishing vessel size, speed, draft limitations and vessel operating conditions." *Id.* § 1223 (a)(4).

In *Massachusetts v. EPA*, the EPA asserted that it could not regulate carbon dioxide emissions from motor vehicles because Congress had already assigned the job of regulating

[170] International Convention on the Prevention of Pollution from Ships, as Modified by the Protocol of 1978 Relating Thereto (MARPOL), Annex I, Regulation 13, required segregated ballast tanks for new tankers and either segregated ballast tanks or a crude oil washing system for existing tankers. International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), Feb. 17, 1978, 1340 U.N.T.S. 61 & 1341 U.N.T.S. 3, reprinted in 17 I.L.M. 546.

[171] Protocol to the International Convention on Civil Liability for Oil Pollution Damage, Nov. 19, 1976, 16 I.L.M. 617; Protocol of 1984 to Amend the International Convention on Civil Liability for Oil Pollution Damage, 1969, May 25, 1984 (not in force), IMO Doc. LEG/CONF. 6/66; Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage, 1969, IMO Doc. LEG/CONF. 9/15, Nov. 27, 1992; Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, Nov. 19, 1976, 16 I.L.M. 621 (1977); Protocol of 1984 to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971, IMO Doc. LEG/CONF.6/67, May 25, 1984 (not in force); Protocol of 1992 to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971, IMO Doc. LEG/CONF.9/16, Nov. 27, 1992.

automobile fuel efficiency to the Department of Transportation. 127 S.Ct. at 1461-62. The Supreme Court flatly rejected this argument:

> [T]hat DOT sets mileage standards in no way licenses EPA to shirk its environmental responsibilities. EPA has been charged with protecting the public's "health" and "welfare," 42 U.S.C. § 7521(a)(1), a statutory obligation wholly independent of DOT's mandate to promote energy efficiency. *See* Energy Policy and Conservation Act, § 2(5), 89 Stat. 874, 42 U.S.C. § 6201(5). The two obligations may overlap, but there is no reason to think the two agencies cannot both administer their obligations and yet avoid inconsistency.

Id. at 1462. Similarly, that Congress has empowered the Coast Guard to regulate vessel speed does not absolve the EPA of its obligation to protect public health and welfare from the damaging effects of carbon dioxide and other pollutants emitted by ships through regulations limiting the speed at which these vehicles are permitted to travel. Moreover, there is no reason to believe that EPA and the Coast Guard cannot both administer their obligations while avoiding inconsistency.

Finally, it is worth noting that the current Administration has already signaled its recognition of the need to coordinate action among multiple federal agencies to develop effective regulatory scheme limiting global climate change emissions from mobile sources. Exec. Order No. 13432, Cooperation Among Agencies in Protecting the Environment with Respect to Greenhouse Gas Emissions From Motor Vehicles, Nonroad Vehicles, and Nonroad Engines, 72 Fed. Reg. 27717 (May 14, 2007).

II. EPA SHOULD REGULATE THE COMPOSITION OF FUEL TO CONTROL GLOBAL CLIMATE CHANGE RELATED EMISSIONS FROM MARINE SHIPPING VESSELS.

The following sections demonstrate not only that EPA has the legal authority to regulate the content of the fuel manufactured or sold for use in ships, but also that exercising this authority will substantially reduce global climate change emissions. Therefore, EPA should act swiftly to eliminate the use of "residual fuels" which are high in sulfur content, and require ships to use more refined and cleaner-burning fuels, such as marine diesel oil or marine gas oil.

A. EPA Has the Authority to Prohibit the Manufacture and Sale of Fuels Used in Marine Shipping Vessels.

Section 211 of the Clean Air Act grants broad discretion to the EPA to regulate the content of fuels manufactured or sold for use in nonroad vehicles and engines, allowing the Administrator to promulgate such regulations as he "may deem appropriate." 42 U.S.C. § 7545(c)(1).[172] The Act allows the EPA to control or ban the manufacture or sale of fuels whose

[172] Section 211 provides:

> (c) Offending fuels and fuel additives; control; prohibition

emission products cause or contribute to air pollution which may reasonably be anticipated to endanger the public health or welfare. 42 U.S.C. § 7545(c)(1). Global climate change emissions from ships satisfy this statutory test.

1. Emission Products of the Fuels Used in Marine Shipping Vessels Cause or Contribute to Global Climate Change.

Emission products of the fuels used in ships cause or contribute to global climate change. While the Clean Air Act does not define the term "emission product," by any reasonable definition of the term, global climate change emissions such as carbon dioxide, nitrous oxide, and black carbon are certainly emission products of the low quality, high sulfur content fuels used in ships, since they are produced when such fuel is combusted. Moreover, as discussed above, these pollutants all contribute to global climate change.

2. Global Climate Change May Reasonably Be Anticipated to Endanger Public Health or Welfare.

For the reasons stated in section I (A)(2) within the Argument section of this petition, above, global climate change may be reasonably anticipated to endanger public health or welfare.

B. EPA Should Exercise Its Authority To Promulgate Regulations Requiring the Manufacture and Sale of Cleaner Fuels for Use in Marine Shipping Vessels.

For the reasons stated in section I (C)(3) within the Argument section of this petition, above, adopting regulations requiring the manufacture and sale of cleaner fuels would result in global climate change emissions reduction benefits.

CONCLUSION

Based on the foregoing, Petitioners respectfully request that EPA:

(1) Make a finding that carbon dioxide, nitrous oxide, and black carbon emissions from new marine engines and vehicles significantly contribute to air pollution which may reasonably be anticipated to endanger public health and welfare;

> (1) The Administrator may, from time to time . . . , by regulation, control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel or fuel additive for use in a motor vehicle, motor vehicle engine, or nonroad engine or nonroad vehicle (A) if in the judgment of the Administrator any emission product of such fuel or fuel additive causes, or contributes, to air pollution which may reasonably be anticipated to endanger the public health or welfare . . . .

42 U.S.C. § 7545(c)(1).

(2) Promulgate emission standards for carbon dioxide, nitrous oxide, and black carbon emissions from marine engines and vehicles pursuant to Section 213(a)(4) of the Clean Air Act, 42 U.S.C. § 7547(a)(4);

(3) Make a finding that climate change related pollutants are emission products of the fuels used in marine engines and vehicles, and that these emission products contribute to air pollution which may reasonably be anticipated to endanger public health and welfare;

(4) Promulgate regulations limiting the maximum sulfur content of marine diesel fuels, and prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel with a sulfur concentration in excess of such limits for use in any marine engine or vehicle.

Sincerely,

Timothy Ballo
Sarah Burt
Earthjustice
426 17th Street, 6th Floor
Oakland, CA 94612
(510) 550-6700

Attorneys for Petitioners Oceana, Friends of the Earth, and the Center for Biological Diversity

From:	Reid Harvey
To:	Jim Ketcham-Colwill
Cc:	Sarah Dunham; Paul Gunning; Suzanne Kocchi
Subject:	framework piece
Date:	10/01/2012 03:46 PM
Attachments:	Framework for Climate Opportunities Moving Forward.docx Sep 7 RTP visit slides_FINAL.pptx Title VI Opportunities FINAL 9-27-12_CLEAN.pptx

---

Jim:

As we discussed, I'm attaching three things to discuss at 4:30 today:

1. The framework piece (which can readily be converted to PPT as needed)

2. A PPT on GHG opportunities, focusing on stationary sources

3. A PPT on Title VI opportunities

Talk to you soon.

Reid

From:	Paul Gunning
To:	Bill Irving
Subject:	Fw: 4 Farm Bill conservation program rules for review by 1/8!
Date:	01/09/2009 06:48 AM
Attachments:	Air quality cite for 4 USDA rules.doc NRCS_TSP_InterimFinalRule__12-24-08clean[1].doc TSP_BCAnalysis 12-24-08[1].doc GRP_Interim_Final_Rule_120408 2[1].doc GRP_BCanalysis-12 04 08[1].doc GRP Final EA 10-21-08[1].doc FRPP_Interim_Final_Rule_12-10-08 with_EPT and Chief[1].doc FRPP_BCanalysis_12 18 08[1].doc FRPP FINAL EA 10-08-08[1].doc WHIP_BCA_12-05-08 - Revised Version[1].doc NRCS_WHIP_InterimFinalRule_121908_clean2.doc

---

Bill,

Any interest in commenting on this?

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 01/09/2009 06:49 AM -----

From:	Larry Elmore/RTP/USEPA/US
To:	Paul Argyropoulos/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA
Cc:	dunkins.robin@epa.gov
Date:	01/08/2009 10:08 AM
Subject:	Fw: 4 Farm Bill conservation program rules for review by 1/8!

Paul & Paul:

USDA has 4 rules they want to have signed/published before the administration changes and OMB has given us a VERY limited amount of time to review these rules (we have to have our comments to Roberta Parry by COB today. OAQPS will be compiling all of the comments for OAR and Robin Dunkins wanted to provide OTAQ and OAP with an opportunity to review/comment on these rules. To facilitate our review of these documents, I did a word search on "air" to determine when, if at all, air or air quality was mentioned/addressed in each document. (see attached file). Each rule has an Interim Final Rule and a Benefit Cost Analysis. In addition, two of the rules (Grassland and Reserve Program and the Farm and Ranch Land Protection Program) have environmental assessments that have specific "Air Quality" chapters that address topics such as ambient air quality, NAAQS, Regional Haze and SIP, etc.

Sorry for the short notice and please let me know if you plan to have any comments.

Air quality cite for 4 USDA rules.doc

Thanks!!!
Larry Elmore, USEPA

telephone: 919/541-5433
fax: 919/541-3470
e-mail: elmore.larry@epa.gov

----- Forwarded by Ginah Mortensen/R7/USEPA/US on 01/06/2009 12:19 PM -----

Roberta Parry/DC/USEPA/US

01/06/2009 09:19 AM

To: Alan Banwart/R7/USEPA/US@EPA, Allison Wiedeman/DC/USEPA/US@EPA, Carol Galloway/R7/USEPA/US@EPA, Denise Tennessee/R4/USEPA/US@EPA, flahive.katie@epa.gov, Ginah Mortensen/R7/USEPA/US@EPA, hurld.kathy@epa.gov, Hank Zygmunt/R3/USEPA/US@EPA, James Werntz/R10/USEPA/US@EPA, Jovita Pajarillo/R9/USEPA/US@EPA, Katherine Taylor/R9/USEPA/US@EPA, Mike Muse/DC/USEPA/US@EPA, Pat Cimino/DC/USEPA/US@EPA, Paul Shriner/DC/USEPA/US@EPA, Richard Colbert/DC/USEPA/US@EPA, Robert Koethe/R1/USEPA/US@EPA, Robin Dunkins/RTP/USEPA/US@EPA, somboonlakana.donna@epa.gov, Sally Shaver/RTP/USEPA/US@EPA, Suzanne Stevenson/RA/R8/USEPA/US@EPA, Sylvia Malm/DC/USEPA/US@EPA, Thomas Davenport/R5/USEPA/US@EPA, wall.tom@epa.gov, Van Kozak/R6/USEPA/US@EPA, weitman.dov@epa.gov

cc: George Utting/DC/USEPA/US@EPA

Subject: 4 Farm Bill conservation program rules for review by 1/8!

I will be sending you a series of four Farm Bill conservation program rules for review in subsequent e-mails: Technical Service Provider Assistance, Grassland Reserve Program, Farm and Ranchland Protection Program, Wildlife Habitat Incentive Program. OMB has asked for comments by this Friday, January 9th. They are trying to get the rules out before the administration changes. I assume that one of our comments will be that we need at least another week or two for review, but we may not get it. **Therefore, if you have comments, I need them by COB Thursday, January 8th.**

PLEASE keep these draft regulations close and DO NOT discuss them with outside EPA. NRCS HQ has not shared these drafts with USDA/NRCS state/field offices. We got a bit of a tongue lashing when NRCS HQ was informed that EPA had been discussing the EQIP draft with state NRCS folks in one region.

Thank you for your cooperation and understanding.

Roberta Parry
U.S. EPA
1200 Pennsylvania Ave., NW
Mail Code 4102M
Washington, D.C. 20460

Phone: (202) 564-0508

----- Forwarded by Ginah Mortensen/R7/USEPA/US on 01/06/2009 12:19 PM -----

Roberta Parry/DC/USEPA/US

01/06/2009 09:21 AM

To: Alan Banwart/R7/USEPA/US@EPA, Allison Wiedeman/DC/USEPA/US@EPA, Carol Galloway/R7/USEPA/US@EPA, Denise Tennessee/R4/USEPA/US@EPA, flahive.katie@epa.gov, Ginah Mortensen/R7/USEPA/US@EPA, hurld.kathy@epa.gov, Hank Zygmunt/R3/USEPA/US@EPA, James Werntz/R10/USEPA/US@EPA, Jovita Pajarillo/R9/USEPA/US@EPA, Katherine Taylor/R9/USEPA/US@EPA, Mike Muse/DC/USEPA/US@EPA, Pat Cimino/DC/USEPA/US@EPA, Paul Shriner/DC/USEPA/US@EPA, Richard Colbert/DC/USEPA/US@EPA, Robert Koethe/R1/USEPA/US@EPA, Robin Dunkins/RTP/USEPA/US@EPA, somboonlakana.donna@epa.gov, Sally Shaver/RTP/USEPA/US@EPA, Suzanne Stevenson/RA/R8/USEPA/US@EPA, Sylvia Malm/DC/USEPA/US@EPA, Thomas Davenport/R5/USEPA/US@EPA, wall.tom@epa.gov, Van Kozak/R6/USEPA/US@EPA, weitman.dov@epa.gov

cc:

Subject: USDA/NRCS Interim Final Rule: Technical Service Provider Assistance

Comments due to me by COB Thursday, January 8th.

NRCS_TSP_InterimFinalRule_ 12-24-08clean[1].doc TSP_BCAnalysis 12-24-08[1].doc

Roberta Parry
U.S. EPA
1200 Pennsylvania Ave., NW
Mail Code 4102M
Washington, D.C. 20460

Phone: (202) 564-0508

----- Forwarded by Ginah Mortensen/R7/USEPA/US on 01/06/2009 12:19 PM -----

Roberta Parry/DC/USEPA/US

01/06/2009 09:23 AM

To: Alan Banwart/R7/USEPA/US@EPA, Allison Wiedeman/DC/USEPA/US@EPA, Carol Galloway/R7/USEPA/US@EPA, Denise Tennessee/R4/USEPA/US@EPA, flahive.katie@epa.gov, Ginah Mortensen/R7/USEPA/US@EPA,

hurld.kathy@epa.gov, Hank Zygmunt/R3/USEPA/US@EPA, James Werntz/R10/USEPA/US@EPA, Jovita Pajarillo/R9/USEPA/US@EPA, Katherine Taylor/R9/USEPA/US@EPA, Mike Muse/DC/USEPA/US@EPA, Pat Cimino/DC/USEPA/US@EPA, Paul Shriner/DC/USEPA/US@EPA, Richard Colbert/DC/USEPA/US@EPA, Robert Koethe/R1/USEPA/US@EPA, Robin Dunkins/RTP/USEPA/US@EPA, somboonlakana.donna@epa.gov, Sally Shaver/RTP/USEPA/US@EPA, Suzanne Stevenson/RA/R8/USEPA/US@EPA, Sylvia Malm/DC/USEPA/US@EPA, Thomas Davenport/R5/USEPA/US@EPA, wall.tom@epa.gov, Van Kozak/R6/USEPA/US@EPA, weitman.dov@epa.gov

cc

Subject USDA/NRCS Interim Final Rule: Grassland Reserve Program

Comments due to me by COB Thursday, January 8th.

GRP__Interim__Final__Rule__120408 2[1].doc GRP__BCanalysis-12 04 08[1].doc GRP Final EA 10-21-08[1].doc

Please let me know if you have any questions.

Roberta Parry
U.S. EPA
1200 Pennsylvania Ave., NW
Mail Code 4102M
Washington, D.C. 20460

Phone: (202) 564-0508

----- Forwarded by Ginah Mortensen/R7/USEPA/US on 01/06/2009 12:19 PM -----

Roberta Parry/DC/USEPA/US

01/06/2009 09:24 AM

To Alan Banwart/R7/USEPA/US@EPA, Allison Wiedeman/DC/USEPA/US@EPA, Carol Galloway/R7/USEPA/US@EPA, Denise Tennessee/R4/USEPA/US@EPA, flahive.katie@epa.gov, Ginah Mortensen/R7/USEPA/US@EPA, hurld.kathy@epa.gov, Hank Zygmunt/R3/USEPA/US@EPA, James Werntz/R10/USEPA/US@EPA, Jovita Pajarillo/R9/USEPA/US@EPA, Katherine Taylor/R9/USEPA/US@EPA, Mike Muse/DC/USEPA/US@EPA, Pat Cimino/DC/USEPA/US@EPA, Paul Shriner/DC/USEPA/US@EPA, Richard Colbert/DC/USEPA/US@EPA, Robert Koethe/R1/USEPA/US@EPA, Robin Dunkins/RTP/USEPA/US@EPA,

somboonlakana.donna@epa.gov, Sally Shaver/RTP/USEPA/US@EPA, Suzanne Stevenson/RA/R8/USEPA/US@EPA, Sylvia Malm/DC/USEPA/US@EPA, Thomas Davenport/R5/USEPA/US@EPA, wall.tom@epa.gov, Van Kozak/R6/USEPA/US@EPA, weitman.dov@epa.gov

cc

Subject Fw: USDA/NRCS Interim Final Rule: Farm and Ranchlands Protection Program

Comments due to me by COB Thursday, January 8th.

Please let me know if you have any questions.

FRPP__Interim__Final__Rule__12-10-08 with__EPT and Chief[1].doc

FRPP__BCanalysis__12 18 08[1].doc

FRPP FINAL EA 10-08-08[1].doc

Roberta Parry
U.S. EPA
1200 Pennsylvania Ave., NW
Mail Code 4102M
Washington, D.C. 20460

Phone: (202) 564-0508

----- Forwarded by Ginah Mortensen/R7/USEPA/US on 01/06/2009 12:19 PM -----

Roberta Parry/DC/USEPA/US

01/06/2009 09:26 AM

To Alan Banwart/R7/USEPA/US@EPA, Allison Wiedeman/DC/USEPA/US@EPA, Carol Galloway/R7/USEPA/US@EPA, Denise Tennessee/R4/USEPA/US@EPA, flahive.katie@epa.gov, Ginah Mortensen/R7/USEPA/US@EPA, hurld.kathy@epa.gov, Hank Zygmunt/R3/USEPA/US@EPA, James Werntz/R10/USEPA/US@EPA, Jovita Pajarillo/R9/USEPA/US@EPA, Katherine Taylor/R9/USEPA/US@EPA, Mike Muse/DC/USEPA/US@EPA, Pat Cimino/DC/USEPA/US@EPA, Paul Shriner/DC/USEPA/US@EPA, Richard Colbert/DC/USEPA/US@EPA, Robert Koethe/R1/USEPA/US@EPA, Robin Dunkins/RTP/USEPA/US@EPA, somboonlakana.donna@epa.gov, Sally Shaver/RTP/USEPA/US@EPA, Suzanne Stevenson/RA/R8/USEPA/US@EPA, Sylvia Malm/DC/USEPA/US@EPA, Thomas Davenport/R5/USEPA/US@EPA, wall.tom@epa.gov,

Van Kozak/R6/USEPA/US@EPA, weitman.dov@epa.gov

cc

Subject USDA/NRCS Interim Final Rule: Wildlife Habitat Incentive Program

Comments due to me by Thursday, January 8th.

Please let me know if you have any questions.

WHIP__BCA__12-05-08 - Revised Version[1].doc NRCS__WHIP__InterimFinalRule__121908__clean2.doc

Roberta Parry
U.S. EPA
1200 Pennsylvania Ave., NW
Mail Code 4102M
Washington, D.C. 20460

Phone: (202) 564-0508

From: Susan Bromm
To: Paul Gunning
Subject: Fw: CEQ Land Use Climate Change Draft Guidance (never publicly released)
Date: 12/19/2012 03:29 PM
Attachments: Draft preamble and guidance 07 21 2011 2 pm to OIRA.docx
8-28REDLINE.docx

----- Forwarded by Susan Bromm/DC/USEPA/US on 12/19/2012 03:29 PM -----

From: JamesG Gavin/DC/USEPA/US
To: Susan Bromm/DC/USEPA/US@EPA
Date: 12/19/2012 03:23 PM
Subject: CEQ Land Use Climate Change Draft Guidance

Attached are the last version that I can find that was distributed by CEQ and, for reference, a redline version of the consolidated suggested changes we responded with

James

From:	Paul Gunning
To:	Sarah Dunham
Cc:	Rona Birnbaum
Subject:	Fw: draft Adaptation Plan for OAP clearance
Date:	05/01/2012 09:44 PM
Attachments:	EPA Adaptation Plan -- Clearance Draft.docx Adaptation plan backgrounder.docx

---

Sarah,

Per Rona's email below, attached is the draft EPA Adaptation Plan (along with a one page backgrounder) for your clearance. We will bring a hard copy of the draft Plan and the 1-pager to the off-site meeting tomorrow.

Please note that:

1) OP made all the changes we requested and
2) We drafted the backgrounder for Gina and hopefully have addressed issue of timing adequately - it states what the requested timeframe (OP is looking for clearance on Monday, May 7) but does not box her in (hopefully).
Paul

-----Forwarded by Paul Gunning/DC/USEPA/US on 05/01/2012 09:32PM -----

> To: Paul Gunning/DC/USEPA/US@EPA
> From: Rona Birnbaum/DC/USEPA/US
> Date: 05/01/2012 05:08PM
> Cc: Bill Perkins/DC/USEPA/US@EPA
> Subject: draft Adaptation Plan for OAP clearance
>
> Paul, can you please forward on to Sarah? Thanks! Rona
>
> Enclosed is the draft EPA Adaptation Plan for Office Director clearance, along with a 1-page background document. All of our comments have been addressed, and the document is clean. Ideally, this can receive clearance so that it can be forwarded on to Gina on Thursday to give her as much time as possible for review. The other OAR Office Directors are also receiving this through their workgroup members for review/clearance.
>
> As the lead for OAR, all offices agree that OAP will forward on to Gina, when ready.
>
> Bill and I are available to answer any questions as needed.
>
> *(See attached file: EPA Adaptation Plan -- Clearance Draft.docx)(See attached file: Adaptation plan backgrounder.docx)*

From:	Bill Irving
To:	Paul Gunning
Cc:	Kimberly Klunich
Subject:	Fw: draft presentation for WRI workshop tomorrow
Date:	04/27/2009 04:03 PM
Attachments:	WRI briefing_4.27draft_PIB_CEB.ppt

Paul - Not sure where it ended with Dina on this, but just in case here is the presentation that Kim and Melissa prepared. If you end up giving it, one of them could likely join you and answer questions.

----- Forwarded by Bill Irving/DC/USEPA/US on 04/27/2009 04:04 PM -----

From:	Kimberly Klunich/DC/USEPA/US
To:	Isabel DeLuca/DC/USEPA/US@EPA
Cc:	Bill Irving/DC/USEPA/US@EPA, Melissa Weitz/DC/USEPA/US@EPA, Adam Daigneault/DC/USEPA/US@EPA
Date:	04/27/2009 11:19 AM
Subject:	draft presentation for WRI workshop tomorrow

Hi Isabel,

Here is a draft briefing for Dina's review (thanks to all). As I mentioned, many of these briefing slides came from a presentation Bill gave on the Hill during a Pew Center briefing, with additions on the W-M draft. Let us know if Dina has any comments/suggestions and we will revise as needed.

Thanks,
Kim

Kimberly Todd
Environmental Protection Specialist
Climate Change Division
U.S. Environmental Protection Agency
klunich.kimberly@epa.gov
Phone: (202) 343-9833
Fax: (202) 343-2358

WRI briefing_4.27draft_PIB_CEB.ppt

From: Paul Gunning
To: birnbaum.rona@epa.gov
Subject: Fw: Draft World Bank report on SLCP integration
Date: 01/30/2013 12:41 PM
Attachments: G8 SLCP Draft_MDM_121220.pdf
USG comments WB report 1-27-2013.docx

Just looping you in as well.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 01/30/2013 12:40 PM -----

From: Maurice LeFranc/DC/USEPA/US
To: Jackie Krieger/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA, Drusilla Hufford/DC/USEPA/US@EPA, Cindy Newberg/DC/USEPA/US@EPA, Erika Sasser/RTP/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Joseph Somers/AA/USEPA/US@EPA, Terry Keating/DC/USEPA/US@EPA, Paul Almodovar/RTP/USEPA/US@EPA, Reid Harvey/DC/USEPA/US@EPA, Dale Evarts/RTP/USEPA/US@EPA, Ken Adler/DC/USEPA/US@EPA, Brenda Doroski/DC/USEPA/US@EPA, Bill Harnett/RTP/USEPA/US@EPA, Sara Terry/RTP/USEPA/US@EPA, Maurice LeFranc/DC/USEPA/US@EPA, Michael Geller/DC/USEPA/US@EPA, Monica Shimamura/DC/USEPA/US@EPA, Pamela Franklin/DC/USEPA/US@EPA, Henry Ferland/DC/USEPA/US@EPA, Sarah Dunham/DC/USEPA/US@EPA, Mike Flynn/DC/USEPA/US@EPA, Steve Page/RTP/USEPA/US@EPA, Susan Anenberg/RTP/USEPA/US@EPA, Dave Godwin/DC/USEPA/US@EPA, Joel Beauvais/DC/USEPA/US@EPA, Karen Orehowsky/DC/USEPA/US@EPA, Buddy Polovick/AA/USEPA/US@EPA, Jim Blubaugh/DC/USEPA/US@EPA, Cheryl Bynum/AA/USEPA/US@EPA, John Mitchell/DC/USEPA/US@EPA
Date: 01/30/2013 11:24 AM
Subject: Fw: Draft World Bank report on SLCP integration

Please see email below. Sorry for short turn around from State. I can compile comments on this - should be focused and substantive. I will need comments by Friday noon in order to get to State by COB Friday. Let me know if you have questions.

Maurice N. LeFranc, Jr.
Senior Advisor on International Climate Change

U.S. Environmental Protection Agency /Office of Air and Radiation
Ariel Rios Building / MC 6101-A
1200 Pennsylvania Avenue
Washington, DC 20460

Phone: (202) 564-1813
Mobile: (202) 450-7863

----- Forwarded by Maurice LeFranc/DC/USEPA/US on 01/30/2013 11:22 AM -----

From: "McGlynn, Emily F" <McGlynnEF@state.gov>
To: Maurice LeFranc/DC/USEPA/US@EPA, Pamela Franklin/DC/USEPA/US@EPA
Cc: "Thompson, John E" <ThompsonJE2@state.gov>, "Lattimer, Timothy P" <LattimerTP@state.gov>, "Eil, Andrew G" <EilAG@state.gov>, "Turk, David M" <TurkDM@state.gov>, "Anenberg, Susan" <AnenbergS@state.gov>
Date: 01/29/2013 04:07 PM
Subject: Draft World Bank report on SLCP integration

Hi Maurice and Pamela – We've been delayed on circulating this, but see attached for the first draft of the World Bank's report on how they can integrate SLCP considerations into their activities. This was a tasking from the G8 last summer and they will be finalizing it over the coming month. We have the ability to provide feedback on this version, they're lookin g f or input by the end of this week – sorry for the tight turnaround. We've put together the attached initial comments, feel free to add onto this. You can share with the EPA CCAC team too. State CCAC team, same for you. Overall, it looks like they're planning to do some really good things, hopefully we'll see some of this come to fruition.

Let us know if you have any questions on this.

Emily

Emily McGlynn
Senior Adviser
Climate and Clean Air Coalition
Office of the Special Envoy for Climate Change
U.S. Department of State
Tel: (202) 647-9818
Fax: (202) 647-9973
Email: mcglynnEF@state.gov

From: Reid Harvey
To: Paul Gunning
Subject: Fw: EPA OAR Comments on the IDR
Date: 07/12/2012 04:16 PM
Attachments: EPA Responses to IDR draft v2 OAR Final Comments.docx

---

----- Forwarded by Reid Harvey/DC/USEPA/US on 07/12/2012 04:16 PM -----

From: Jameel Alsalam/DC/USEPA/US
To: Leif Hockstad/DC/USEPA/US@EPA, Sara Ohrel/DC/USEPA/US@EPA, Jim Ketcham-Colwill/DC/USEPA/US@EPA
Cc: Reid Harvey/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA
Date: 07/12/2012 04:13 PM
Subject: Fw: EPA OAR Comments on the IDR

FYI

Jameel Alsalam
Economist, Climate Economics Branch
U.S. Environmental Protection Agency
voice: 202-343-9807
fax: 202-343-2202
alsalam.jameel@epa.gov

----- Forwarded by Jameel Alsalam/DC/USEPA/US on 07/12/2012 04:10 PM -----

From: Maurice LeFranc/DC/USEPA/US
To: "Larsen, Kate M (OES)" <LarsenKM@state.gov>, "Maltzer, Eric J" <MaltzerEJ@state.gov>, Jameel Alsalam/DC/USEPA/US@EPA
Cc: Susan Wickwire/DC/USEPA/US@EPA, Joel Beauvais
Date: 07/12/2012 04:04 PM
Subject: EPA OAR Comments on the IDR

Kate/Eric:

Here are EPA comments on the IDR. Unfortunately, when we compiled comments we were responding to Kate's email and neglected to use the spreadsheet provided. Hopefully, our comments are clear enough to be plugged into your format. Please let me, Jameel or Susan know if you have comments or questions.

Jameel:

Please circulate to those who provided input from OAR - and thanks for coordinating.

Maurice

Maurice N. LeFranc, Jr.
Senior Advisor on International Climate Change

U.S. Environmental Protection Agency /Office of Air and Radiation

Ariel Rios Building / MC 6101-A
1200 Pennsylvania Avenue
Washington, DC 20460

Phone: (202) 564-1813
Mobile: (202) 450-7863

From: Ben DeAngelo
To: Beth Craig; Paul Gunning
Subject: Fw: Final endangerment brief as filed
Date: 08/18/2011 04:17 PM
Attachments: ENV_DEFENSE-#548261-v1-GHGFINAL_August_18_Response_Brief_As_Filed_.PDF

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 08/18/2011 04:16 PM -----

From: Carol Holmes/DC/USEPA/US
To: Rona Birnbaum/DC/USEPA/US@EPA, Ben DeAngelo/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Jeremy Martinich/DC/USEPA/US@EPA
Cc: John Hannon/DC/USEPA/US
Date: 08/18/2011 04:12 PM
Subject: Fw: Final endangerment brief as filed

WOOOOOOOOOO HOOOOOOOOOOOOOOOOO

Confidential communication for internal deliberations only, Attorney-client, attorney work product and/or enforcement privilege, Do not distribute outside EPA or DOJ

Carol S. Holmes
Senior Counsel
Office of Civil Enforcement (MC 2241A)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave, NW
Washington, DC 20460
Phone (202) 564-8709

----- Forwarded by Carol Holmes/DC/USEPA/US on 08/18/2011 04:12 PM -----

From: "Purdy, Angeline (ENRD)" <Angeline.Purdy@usdoj.gov>
To: Carol Holmes/DC/USEPA/US@EPA, John Hannon/DC/USEPA/US@EPA
Cc: "Lipshultz, Jon (ENRD)" <Jon.Lipshultz@usdoj.gov>
Date: 08/18/2011 04:00 PM
Subject: Final endangerment brief as filed

I'll let you circulate this to all and sundry – we'll get hard copies over within a day or two. Thanks so much to everyone who worked so hard on this!

****

Angeline Purdy
U.S. Department of Justice
ENRD/EDS
P.O. Box 23986
Washington, D.C. 20026
(202) 514-0996

This message, including any attachments, is an attorney-client communication and/or attorney work product intended only for review and use by its designated recipients. Therefore, it is privileged and confidential. If you have received this message in error, please immediately notify the sender by reply e-mail and destroy the message and any attachments.

From: Paul Gunning
To: Kurt Roos; Christopher Voell
Cc: Erin Birgfeld
Subject: Fw: FY 2010 - HAC Committee Action
Date: 06/22/2009 10:50 AM
Attachments: House approps bill.pdf

FYI.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 06/22/2009 10:49 AM -----

From: Dina Kruger/DC/USEPA/US
To: Reid Harvey/DC/USEPA/US@EPA, Bill Irving/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Rona Birnbaum/DC/USEPA/US@EPA, Anhar Karimjee/DC/USEPA/US@EPA
Date: 06/22/2009 09:46 AM
Subject: Fw: FY 2010 - HAC Committee Action

FYI, in case you haven't seen this yet.

-----Forwarded by Isabel DeLuca/DC/USEPA/US on 06/22/2009 09:43AM -----

To: Brian Mclean/DC/USEPA/US@EPA, Dina Kruger/DC/USEPA/US@EPA
From: Ed Callahan/DC/USEPA/US
Date: 06/22/2009 09:10AM
Subject: FY 2010 - HAC Committee Action

For your information, in the attached FY 2010 House Appropriations Committee Bill, there is the following provision on Page 119:

> "SEC. 427. Notwithstanding any other provision of law, none of the funds made available in this or any other Act may be used to promulgate or implement any regulation requiring the issuance of permits under title V of the Clean Air Act for carbon dioxide, nitrous oxide, water vapor, or methane emissions resulting from biological processes associated with livestock production."

Thanks

Ed

House approps bill.pdf

From: Paul Gunning
To: Pamela Franklin; Henry Ferland; Monica Shimamura
Subject: Fw: Methane mitigation paper
Date: 02/22/2012 04:20 PM
Attachments: MethaneScenMort-Final.pdf

JUST FYI

----- Forwarded by Paul Gunning/DC/USEPA/US on 02/22/2012 04:20 PM -----

From: Ben DeAngelo/DC/USEPA/US
To: Reid Harvey/DC/USEPA/US@EPA, Paul Gunning/DC/USEPA/US@EPA, Marcus Sarofim/DC/USEPA/US@EPA, Shaun Ragnauth/DC/USEPA/US@EPA
Date: 02/16/2012 06:32 PM
Subject: Fw: Methane mitigation paper

Timely. New paper from Jason West using EPA's previous methane emissions and mitigation analysis.

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 02/16/2012 06:30 PM -----

From: Jason West <jjwest@email.unc.edu>
To: Ellen Baum <ebaum@catf.us>, joe100@gwi.net, David McCabe <dmccabe@catf.us>, Shiri Avnery <savnery@Princeton.EDU>, Dale Whittington <dwhittin@email.unc.edu>, Ben DeAngelo/DC/USEPA/US@EPA, john_alic@earthlink.net
Cc: Arlene Fiore <amfiore@ldeo.columbia.edu>, "Larry W. Horowitz" <Larry.Horowitz@noaa.gov>
Date: 02/13/2012 12:55 PM
Subject: Methane mitigation paper

All

I'm pleased to say that the paper attached has been accepted for publication in Climatic Change. This was a long time coming. Thanks to all of you for your help and interest in this paper.

Jason West

J. Jason West
Assistant Professor
Department of Environmental Sciences & Engineering
University of North Carolina
146B Rosenau Hall
CB #7431
Chapel Hill, NC 27599
919-843-3928
919-966-7911 (fax)
www.unc.edu/~jjwest

From: Ben DeAngelo
To: Reid Harvey; Paul Gunning; Marcus Sarofim; Shaun Ragnauth
Subject: Fw: Methane mitigation paper
Date: 02/16/2012 06:32 PM
Attachments: MethaneScenMort-Final.pdf

Timely. New paper from Jason West using EPA's previous methane emissions and mitigation analysis.

----- Forwarded by Ben DeAngelo/DC/USEPA/US on 02/16/2012 06:30 PM -----

From: Jason West <jjwest@email.unc.edu>
To: Ellen Baum <ebaum@catf.us>, joe100@gwi.net, David McCabe <dmccabe@catf.us>, Shiri Avnery <savnery@Princeton.EDU>, Dale Whittington <dwhittin@email.unc.edu>, Ben DeAngelo/DC/USEPA/US@EPA, john_alic@earthlink.net
Cc: Arlene Fiore <amfiore@ldeo.columbia.edu>, "Larry W. Horowitz" <Larry.Horowitz@noaa.gov>
Date: 02/13/2012 12:55 PM
Subject: Methane mitigation paper

All

I'm pleased to say that the paper attached has been accepted for publication in Climatic Change. This was a long time coming. Thanks to all of you for your help and interest in this paper.

Jason West

J. Jason West
Assistant Professor
Department of Environmental Sciences & Engineering
University of North Carolina
146B Rosenau Hall
CB #7431
Chapel Hill, NC 27599
919-843-3928
919-966-7911 (fax)
www.unc.edu/~jjwest

From: Paul Gunning
To: Bill Irving
Subject: Fw: New CRS Report - Nitrous Oxide from Agricultural Sources
Date: 10/27/2009 04:30 PM
Attachments: R40874.pdf

FYI.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 10/27/2009 04:30 PM -----

From: "Kelsi Bracmort" <KBRACMORT@crs.loc.gov>
To:
Cc: Paul Gunning/DC/USEPA/US@EPA, Tom Wirth/DC/USEPA/US@EPA, <A.R.Ravishankara@noaa.gov>
Date: 10/27/2009 04:28 PM
Subject: New CRS Report - Nitrous Oxide from Agricultural Sources

---

Greetings,

FYI - CRS issued a new Report *Nitrous Oxide from Agricultural Sources: Potential Role in Greenhouse Gas Emission Reduction and Ozone Recovery* (see attached report).

Thank you for your assistance in responding to requests concerning nitrous oxide. Please contact me if you have any questions or comments (202-707-7283; kbracmort@crs.loc.gov).

Kelsi

Kelsi Bracmort, Ph.D.
Analyst, Agricultural Conservation and Natural Resources Policy
Congressional Research Service
Library of Congress
Phone: 202-707-7283
Fax: 202-707-7289
Email: kbracmort@crs.loc.gov

This information is intended only for the congressional addressee or other individual to whom it is addressed and may contain confidential and/or privileged material. Any review, retransmission, dissemination or other use of this information is only at the discretion of the intended recipient. If you received this in error, please contact the sender and delete the material from any computer.

The foregoing has not been cleared by CRS review and is not for attribution. This response is provided to help in time limited situations. R40874.pdf

From: Paul Gunning
To: Cindy Newberg
Subject: Fw: New CRS Report - Nitrous Oxide from Agricultural Sources
Date: 10/28/2009 01:08 PM
Attachments: R40874.pdf

Cindy - FYI.....

----- Forwarded by Paul Gunning/DC/USEPA/US on 10/28/2009 01:08 PM -----

From: "Kelsi Bracmort" <KBRACMORT@crs.loc.gov>
To:
Cc: Paul Gunning/DC/USEPA/US@EPA, Tom Wirth/DC/USEPA/US@EPA, <A.R.Ravishankara@noaa.gov>
Date: 10/27/2009 04:28 PM
Subject: New CRS Report - Nitrous Oxide from Agricultural Sources

---

Greetings,

FYI - CRS issued a new Report *Nitrous Oxide from Agricultural Sources: Potential Role in Greenhouse Gas Emission Reduction and Ozone Recovery* (see attached report).

Thank you for your assistance in responding to requests concerning nitrous oxide. Please contact me if you have any questions or comments (202-707-7283; kbracmort@crs.loc.gov).

Kelsi

Kelsi Bracmort, Ph.D.
Analyst, Agricultural Conservation and Natural Resources Policy
Congressional Research Service
Library of Congress
Phone: 202-707-7283
Fax: 202-707-7289
Email: kbracmort@crs.loc.gov

This information is intended only for the congressional addressee or other individual to whom it is addressed and may contain confidential and/or privileged material. Any review, retransmission, dissemination or other use of this information is only at the discretion of the intended recipient. If you received this in error, please contact the sender and delete the material from any computer.

The foregoing has not been cleared by CRS review and is not for attribution. This response is provided to help in time limited situations. R40874.pdf

From:	Reid Harvey
To:	paul gunning; Suzanne Kocchi
Subject:	Fw: next version of NCA draft chapters
Date:	09/07/2012 02:39 PM
Attachments:	NCA draft Mitigation Chapter_Sept5.pdf NCA Report Comments form.docx NCA draft chapter Biogeochemical Cycles_Sept5.pdf

---

▼ Lesley Jantarasami

----- Original Message -----
From: Lesley Jantarasami
Sent: 09/07/2012 01:54 PM EDT
To: Rona Birnbaum; Ben DeAngelo; Reid Harvey; Bill Irving
Subject: next version of NCA draft chapters

Hello,

The USGCRP has given us access to the next version of the draft NCA for a showstopper review. I have all the chapters, but am just attaching a few here. Please let me know if you'd like to see any others.

Mitigation Chapter
From my quick read, I don't think they had time to process or respond to our comments on the previous version. Please let me know which of our comments you think rise to the level of showstoppers and that you think we should send again. USGCRP is providing a form to fill out this time instead of accepting line-by-line text edits.

Carbon Sink discussion at end of Biogeochemical Cycles Chapter
USGCRP specifically asked us to take a look at the text box on Carbon Sinks at the end of the Biogeochemical cycles chapter. I noticed that it cites numbers derived from the U.S. GHG Inventory, so Bill's branch will probably want to double check the numbers used.

Comment Due Date
There are a series of webinars next week and the first week in October (see list on page 2 of comment form). If Andy plans to participate, he could raise our concerns during the webinars. USGCRP is also accepting emailed comments through October 9th, so we should go through Andy to email a consolidated set of EPA comments.

Thanks,

Lesley Jantarasami
US EPA, Climate Change Division

Climate Science & Impacts Branch
202.343.9929 or 202.297.3891
Jantarasami.Lesley@epa.gov

From:	Bruce Moore
To:	Peter Tsirigotis; Lydia Wegman
Cc:	Eric Ginsburg; Lisa Conner; Bill Schrock; Paul Gunning
Subject:	Fw: Non-CO2 Team -- Draft OD Presentation
Date:	11/07/2008 11:42 AM
Signed by:	CN=Bruce Moore/OU=RTP/O=USEPA/C=US
Attachments:	OAR Process - NonCO2 Team OD Briefing - DRAFT - 11-7-08.ppt

---

Peter and Lydia,

Attached is the draft Non-CO2 team briefing for the ODs for Wednesday 11/12. The team is reviewing it now. Paul and I are both at work today, and I will be at work on Monday. We tried to incorporate the suggestions you had at our meeting on 10/27. The only thing I can think of that we do not have that you had suggested is a prioritization scheme and criteria for ranking the sectors at issue, but we may be able to address that in the "full" presentation for the transition team. Please let me know if you have comments.

Bruce

Bruce Moore
Consumer & Commercial Products Sector Team Leader
Office of Air Quality Planning and Standards
US Environmental Protection Agency (E143-03)
Research Triangle Park, NC 27711
Phone (919) 541-5460 Fax (919) 541-3470
"moore.bruce@epa.gov"

----- Forwarded by Bruce Moore/RTP/USEPA/US on 11/07/2008 11:33 AM -----

Bruce Moore/RTP/USEPA/US	To	Non CO2 Core Team, Non-CO2 Experts
	cc	
11/07/2008 10:55 AM	Subject	Non-CO2 Team -- Draft OD Presentation for review by COB Friday 11/7/08

Team,

Attached is a draft of the presentation that we plan to give to the Office Directors on Wednesday, 11/12. Paul pulled this together from the materials our team has developed along with other materials, and has addressed the suggestions conveyed by the Steering Committee. We need you to look it over today and let us know of any comments you may have. One thing in particular that we want to add, based on Steering Committee input, is a slide identifying any **options that may be available for putting into place within the first 100 days or first year of the new administration.** Please put on your thinking cap and let us know today.

We apologize for the short fuse, but with the upcoming holiday right before the briefing, we need to finalize this today. It needs to go to the SC to pass on to the ODs on Monday morning, in preparation for the 9:00 Wednesday briefing.

I've also posted this file to the TeamRoom, but I wanted to get this directly to each of you as soon as possible. Send any comments to Paul and me directly.

Thanks,
Bruce

OAR Process - NonCO2 Team OD Briefing - DRAFT - 11-7-08.ppt

Bruce Moore
Consumer & Commercial Products Sector Team Leader
Office of Air Quality Planning and Standards
US Environmental Protection Agency (E143-03)
Research Triangle Park, NC 27711
Phone (919) 541-5460 Fax (919) 541-3470
"moore.bruce@epa.gov"

From:	Ed Callahan
To:	Beth Craig; Drusilla Hufford; Jackie Krieger; Paul Gunning; Richard Haeuber; Sarah Dunham
Cc:	Gloria DeBolt; Larry Kertcher; Pamela Bullard
Subject:	House Appropriations Subcommittee Report on the FY 2013 Appropriations Bill
Date:	06/26/2012 01:35 PM
Attachments:	House-Subcommittee-Report.pdf

Attached is the House Appropriations Subcommittee report on the FY 2013 Appropriations Bill for the Department of the Interior, the Environmental Protection Agency, and Related Agencies. The attached report DOES NOT contain any riders that may be considered in full committee.

The following are "highlights" that I have extracted from the report:

CLIMATE CHANGE

The Committee remains skeptical of the Administration's efforts to re-package existing programs and fund new ones in the name of climate change. That the climate is changing is not in dispute. However, recent rapid increases in funding and the number of new and seemingly duplicative programs are potentially wasteful. In this bill alone, between 2008 and 2011, climate change funding grew from $192 million to $372 million—a staggering 93 percent increase. There must be a significant improvement in the level of coordination and communication of climate change activities, budgets, and accomplishments across the Federal agencies funded in this bill and across the entire Federal government if there is to be further investment by this Committee. That level of coordination and communication continues to be lacking, which is why the fiscal year 2012 Interior, Environment, and Related Agencies conference report included a seven percent cut to climate change spending. The Committee has proposed cutting climate change spending an additional 29 percent in this bill, terminating six programs and denying two new starts requested by the Administration.

S&T

Clean Air and Climate.—The Committee recommends $115,819,000, which is $8,559,000 below the fiscal year 2012 enacted level and $11,289,000 below the budget request. The Committee has not provided the requested increase to implement the Cross-State Air Pollution rule, and maintains funding for Federal Vehicle and Fuels standards at the fiscal year 2012 enacted level.

EPM

For the Climate Protection Program, the Committee provides $84,919,000, which is $14,562,000 below the fiscal year 2012 enacted level and $23,072,000 below the budget request. The Committee provides the following program amounts from within this total: (1) $48,063,000 for the Energy Star program; (2) $6,400,000 for the Greenhouse Gas Registry; and (3) $25,529,000 for voluntary climate protection programs which divert funds away from EPA's core mission responsibilities and often lack a statutory mandate.

Personnel and Full Time Equivalents.—The Committee remains concerned about the distribution of regional FTE to headquarters and the Agency is directed to bring the headquarters FTE in line with

the regional FTE. EPA is also directed to cap its FTE level at no more than the fiscal year 2010 level of 16,594, which is consistent with the direction provided in the fiscal year 2012 Interior, Environment, and Related Agencies conference report. The Committee believes EPA can achieve this reduction of 515 FTE from the budget request with the funding provided.

TITLE IV—GENERAL PROVISIONS

Section 421 continues a provision prohibiting the use of funds to implement any provision in a rule if that provision requires mandatory reporting of greenhouse gas emissions from manure management systems.

112TH CONGRESS
2d Session
HOUSE OF REPRESENTATIVES
REPORT
112–

DEPARTMENT OF THE INTERIOR, ENVIRONMENT, AND RELATED AGENCIES APPROPRIATION BILL, 2013

_____ , 2012.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. SIMPSON, from the Committee on Appropriations, submitted the following

R E P O R T

[To accompany H.R.]

The Committee on Appropriations submits the following report in explanation of the accompanying bill making appropriations for the Department of the Interior, the Environmental Protection Agency, and Related Agencies for the fiscal year ending September 30, 2013. The bill provides regular annual appropriations for the Department of the Interior (except the Bureau of Reclamation and the Central Utah Project), the Environmental Protection Agency, and for other related agencies, including the Forest Service, the Indian Health Service, the Smithsonian Institution, and the National Foundation on the Arts and the Humanities.

CONTENTS

	Page number Bill	Report
Title I—Department of the Interior:		
Bureau of Land Management	2	12
United States Fish and Wildlife Service	8	18
National Park Service	14	24
United States Geological Survey	17	30
Bureau of Ocean Energy Management	20	31
Bureau of Safety and Environmental Enforcement	21	32
Office of Surface Mining Reclamation and Enforcement	23	33
Bureau of Indian Affairs and Bureau of Indian Education	26	34
Office of the Secretary	34	37
Insular Affairs	36	38
Office of the Solicitor	39	40
Office of Inspector General	39	40
Office of the Special Trustee for American Indians	40	40

74–246

	Page number Bill	Report
Department-wide Programs:		
Wildland Fire Management, Interior Department	41	41
FLAME Wildfire Suppression Reserve Fund, Interior Department	45	42
Central Hazardous Materials Fund	45	42
Natural Resource Damage Assessment and Restoration	46	43
Working Capital Fund	46	43
General Provisions, Department of the Interior	48	44
Title II—Environmental Protection Agency:		
Science and Technology	58	46
Environmental Programs and Management	58	49
Office of Inspector General	59	58
Buildings and Facilities	59	59
Hazardous Substance Superfund	60	59
Leaking Underground Storage Tank Program	60	61
Inland Oil Spill Program	61	62
State and Tribal Assistance Grants	61	62
Administrative Provisions	66	65
Title III—Related Agencies:		
Forest Service, U.S. Department of Agriculture	68	66
Forest Service, Wildland Fire Management	73	76
FLAME Wildfire Suppression Reserve Fund, Forest Service	76	77
Indian Health Service, DHHS	84	78
National Institute of Environmental Health Sciences	92	81
Agency for Toxic Substances and Disease Registry	92	82
Other Related Agencies:		
Council on Environmental Quality and Office of Environmental Quality	94	82
Chemical Safety and Hazard Investigation Board	94	83
Office of Navajo and Hopi Indian Relocation	95	83
Institute of American Indian and Alaska Native Culture and Arts Development	96	84
Smithsonian Institution	96	84
National Gallery of Art	98	86
John F. Kennedy Center for the Performing Arts	100	86
Woodrow Wilson International Center for Scholars	100	87
National Endowment for the Arts	100	88
National Endowment for the Humanities	101	89
Commission of Fine Arts	102	90
National Capital Arts and Cultural Affairs	103	91
Advisory Council on Historic Preservation	103	91
National Capital Planning Commission	103	92
United States Holocaust Memorial Museum	104	92
Presidio Trust	N/A	93
Dwight D. Eisenhower Memorial Commission	N/A	93
Title IV—General Provisions	104	94

INTRODUCTION

The fiscal year 2013 bill has been developed following careful consideration of the facts and details available to the Committee. The Committee recommends $28,000,000,000 to fund the Department of the Interior, the Environmental Protection Agency, the U.S. Forest Service, the Indian Health Service, the Smithsonian Institution, and 18 other related agencies.

This amount reflects a $1,174,992,000 reduction in spending from the fiscal year 2012 enacted level and a $1,667,096,000 reduction from the budget request. Overall spending is reduced by four percent from fiscal year 2012 and six percent below the budget request.

The amounts in the accompanying bill are reflected by title in the table below. In addition, a detailed table providing the recommended amounts for each agency/bureau, account, or program funded through this bill is included at the end of this report.

BUDGET AUTHORITY RECOMMENDED IN BILL BY TITLE

DISCRETIONARY BUDGET AUTHORITY RECOMMENDED IN BILL BY TITLE

Act vity	Budget estimates, fiscal year 2013	Committee bill, fiscal year 2013	Committee bill compared with budget estimates
Title I, Department of the Interior:			
New budget authority	$10,379,617	$10,300,498,000	$79,119,000
Title II, Environmental Protection Agency:			
New budget authority	8,344,480,000	7,055,041,000	1,289,439,000
Title III, Related Agencies:			
New budget authority	10,942,999,000	10,644,461,000	298,538,000
Title IV, General Provisions:			
New budget authority	0	0	0
Total, New budget authority	29,667,096,000	28,000,000,000	1,667,096,000

BILL SUMMARY

FOCUSING ON PROVEN, CORE PROGRAMS

The fiscal challenges facing our country today are evident in record Federal budget deficits and our staggering national debt. Today, the Federal government borrows over 40 cents for each dollar that it spends. While our country's fiscal challenges can't be addressed with cuts to discretionary programs, alone, the Committee has an obligation to reverse unsustainable patterns of spending growth. The fiscal year 2013 Interior, Environment, and Related Agencies appropriations bill is a step forward in that direction.

The Subcommittee has made difficult choices in fashioning its budget recommendations. Members of Congress provided considerable input into the content of this measure. In total, 246 Members submitted over 2,100 programmatic requests relating to funding levels for multiple agencies and programs.

History has shown that bigger budgets don't necessarily produce better results. Each agency under the Subcommittee's jurisdiction is strongly encouraged to carefully evaluate how it conducts its work during these constrained fiscal times and focus on proven, cost-effective programs and on better management of resources.

OVERSIGHT AND BUDGETING FOR RESULTS

The Interior, Environment, and Related Agencies Subcommittee takes seriously its oversight responsibility and has conducted 16 budget hearings this year (including five hearings involving the public and American Indians) to carefully review the programs and budgets under its jurisdiction. Over the course of these hearings, Subcommittee Members engaged in a rigorous process to determine the best use of funds to meet the substantial needs and priorities outlined in this report. The Subcommittee held the following oversight hearings over a two-month period:

Department of the Interior FY13 budget oversight hearing—February 16, 2012

U.S. Forest Service FY13 budget oversight hearing—February 17, 2012

Indian Health Service FY13 budget oversight hearing—February 28, 2012

Bureau of Indian Affairs FY13 budget oversight hearing—February 28, 2012

EPA FY13 budget oversight hearing—February 29, 2012

Fish and Wildlife Service FY13 budget oversight hearing—March 1, 2012

Bureau of Land Management FY13 budget oversight hearing—March 6, 2012

U.S. Geological Survey FY13 budget oversight hearing—March 6, 2012

Bureau of Ocean Energy Management/Bureau of Safety and Environmental Enforcement FY 13 budget oversight hearing—March 7, 2012

Smithsonian Institution FY13 budget oversight hearing—March 20, 2012

National Park Service FY13 budget oversight hearing—March 20, 2012

Public Witnesses—March 21, 2012

Public Witnesses—March 22, 2012

American Indian/Alaska Native Public Witnesses—March 27, 2012 (morning)

American Indian/Alaska Native Public Witnesses—March 27, 2012 (afternoon)

American Indian/Alaska Native Public Witnesses—March 28, 2012 (morning)

In total, 139 individuals representing the Executive Branch, the U.S. Congress, State and local governments, the public, and American Indians/Alaska Natives testified before the Subcommittee. The perspectives shared on a wide-range of issues were essential to the Subcommittee as it conducted a thorough review of the budget request.

In addition to those who testified personally, over 150 individuals and organizations have provided written testimony for the permanent hearing record. These hearings are contained in eight published volumes totaling nearly 10,000 pages which are publicly available online.

Inherent in the Committee's oversight function is the responsibility to determine not only appropriate funding levels for the next fiscal year but also what levels of funding remain from past years. In furtherance of its oversight responsibility, the Committee included in the fiscal year 2012 Interior, Environment, and Related Agencies conference report a requirement that the Department of the Interior, EPA, Forest Service, and the Indian Health Service report to the Committee on a quarterly basis on the status of balances of appropriations including all uncommitted, committed, and unobligated funds in each program and activity. This bill language within Title IV General Provisions is continued in the fiscal year 2013 bill. The Committee directs that agency reports show the status of balances at the appropriation account level, as well as at budget activity or other lower levels where such levels are reflected in the Committee's report accompanying an appropriation act.

Oversight of Federal agencies extends beyond dollars and cents. During this time of record budget deficits, the Committee is not only carefully scrutinizing how each taxpayer dollar is spent but ensuring that agencies are meeting Congressional mandates and achieving measurable results.

The Committee recognizes that the traditional approach to budgeting tends toward stove-piping and can distract both Congress and Federal agencies from setting and accomplishing measurable goals. Ideally, agencies should apply expertise in setting and meeting goals to carry out their overall mission and be held accountable to Congress and the taxpayer. The Committee believes that such a process would result in greater transparency and accountability, more efficient use of taxpayer dollars, and, ultimately, better government for the American people.

In light of this goal, the Committee has continued an approach begun last year by funding the Forest Service's Integrated Resource Restoration (IRR) initiative on a proof of concept pilot basis. The Committee applauds the agency's efforts to focus the budgeting process on achieving overall goals in its multiple-use mandate and recognizes that IRR provides more flexibility to meet big-picture goals. The Committee will continue carefully evaluating whether the IRR pilot program helps the Service to better set, accomplish, and report management goals and enhance transparency and accountability, as well as whether a similar budget structure might provide better results for other agencies as well.

ENVIRONMENTAL PROTECTION AGENCY FUNDING

The Environmental Protection Agency (EPA) continues to play an important role in protecting public and environmental health. Our country has made great strides in cleaning up pollution in the air, water, and soil over the past four decades. However, the Committee remains concerned about the efforts of the EPA to expand its regulatory authority beyond what Congress intended by legislating via regulation. The Committee is concerned about the economic uncertainty created by the proliferation of new regulations proposed by the agency. The impact of the EPA's regulatory agenda on our national economy—from the tremendous burdens it places on small businesses and large industries to the impacts felt in small towns and rural communities across America to lost jobs and lost economic production—is staggering.

The Committee notes that the EPA's overall budget has grown significantly in recent years. In calendar year 2009, the agency received over $25 billion in combined stimulus funding and regular appropriations. Between 2009 and 2010 EPA's budget increased by $2.65 billion, a 35 percent increase in that calendar year. Therefore, even with targeted reductions to the Agency's budget in fiscal years 2011 and 2012, EPA's proposed budget for 2013, if enacted, would be its fifth highest budget ever.

The Committee has proposed a $1.4 billion, or 17 percent, reduction in this bill from the fiscal year 2012 enacted level. These cuts restore a needed balance to the EPA's budget, in light of previous increases and the severe fiscal challenges facing our country.

The Committee notes that $866 million of this reduction comes from the Clean Water and Safe Drinking Water State Revolving Funds (SRFs). The recommended funding level for the SRFs in fis-

cal year 2013 is consistent with the Committee's recommendation in the fiscal year 2012 bill. While the Committee recognizes the importance of the SRFs as a key component of the nation's infrastructure investment, these accounts received $6 billion in the American Recovery and Reinvestment Act (ARRA) of 2009 and a 130 percent increase in funding in fiscal year 2010. This funding served as the equivalent of six years' worth of appropriations in one calendar year.

The EPA and the States should continue to focus on fully allocating and spending previously appropriated funds. In addition, funding these accounts through regular appropriations is simply unsustainable given ever growing needs. The Committee continues to encourage the appropriate authorizing committees to examine alternative funding mechanisms for the SRFs that are sustainable in the long-term.

COST OF LITIGATION AND LACK OF TRANSPARENCY

The Committee continues to be concerned that many of the legitimate goals of the Forest Service, the Department of the Interior, and other agencies under the Committee's jurisdiction—as well as the work of this Committee—are undermined by litigation filed in an effort to shift land management decisions from the agencies tasked by Congress with those responsibilities to the courts, regardless of merit. As litigation costs siphon funding away from critical priority programs, agencies are forced to divert budgets intended for effective land management away from carrying out activities associated with their congressionally-directed missions.

In response to concerns about the cost of litigation and agencies' inability to account for them, the Committee took a number of steps in the fiscal year 2012 Interior, Environment, and Related Agencies conference report to increase transparency and ensure greater accountability of taxpayer dollars. This included directing the Department of the Interior, the EPA, and the Forest Service to make publicly available detailed Equal Access to Justice Act (EAJA) fee information as well as legal fees and costs resulting from settlements on other statutes. The Committee expressed concern that, in most cases, agencies did not track this information and could not account for dollars appropriated or otherwise spent on paying for attorney fees.

A recent GAO report on the issue entitled, "Limited Data Available on USDA and Interior Attorney Fee Claims and Payments" determined that most of the agencies did not have this information readily available and could not determine who received payments or how much of each agency's budget was being used to pay for attorney fees. According to the report, "Most USDA and Interior agencies did not have readily available information on attorney fee claims and payments made under EAJA and other fee-shifting statutes for fiscal years 2000 through 2010. As a result, there was no way to readily determine who made claims, the total amount each department paid or awarded in attorney fees, who received the payments, or the statutes under which the cases were brought for the claims over the 11-year period. Both USDA and Interior officials stated that given the decentralized nature of their departments and the absence of an external requirement to track or report on attorney fee information, decisions such as whether to track attor-

ney fee data and the manner in which to do so are best handled at the agency level."

The Committee notes that a Federal appeals court recently ruled that a judge awarded excessive attorney's fees to an environmental group following a dispute over Federal grazing permits. The San Francisco-based Ninth Circuit Court of Appeals ruled unanimously that EAJA "generally does not allow for the award of fees for administrative proceedings." In its decision, the court concluded, "An award of fees in this case would conflict with Congress's express limitation on fee awards for pre-litigation administrative proceedings involving grazing permit proceedings."

Given continued concern about this issue, the Committee is not only continuing reporting requirements included in last year's conference report, but is also taking additional steps to address the costs of litigation. The Committee again directs the Department of the Interior, the Environmental Protection Agency and the Forest Service to provide to the House and Senate Committees on Appropriations and make publicly available, no later than 60 days after enactment of this Act, and with each agency's annual budget submission thereafter, the following information: detailed reports on the amount of program funds used; the names of the fee recipients; the names of the Federal judges; the disposition of the applications (including any appeal of action taken on the applications); the hourly rates of attorney and expert witnesses stated in the applications that was awarded as a result of litigation; and a brief summary of the case. The Committee also directs the Department of the Interior, Environmental Protection Agency, and Forest Service to report the same information on non-EAJA settlements with litigants. Further, the Committee directs the agency to record the disposition as a win, loss, or settlement based on the case itself, not based on the settlement necessary to determine potential EAJA fees. If the agencies lose a case and negotiate a settlement for EAJA, the disposition should be recorded as a loss.

The Committee is pleased that the Department of the Interior and Environmental Protection Agency made an effort to comply with EAJA reporting but notes that the reports lacked detailed data as directed in the fiscal year 2012 Interior, Environment, and Related Agencies conference report. The Committee is disappointed with the Forest Service's late response to the reporting requirements. Each of the agencies is directed to incorporate the information listed above into fiscal year 2014 budget justifications.

EXPIRED AUTHORIZATIONS

No less than 51 agencies and/or programs under the jurisdiction of the Interior, Environment, and Related Agencies Subcommittee remain unauthorized or have an expired Congressional authorization of appropriations (see "Appropriations Not Authorized by Law" at the back of the report). Together these unauthorized agencies and programs comprise nearly $6 billion of this fiscal year 2013 appropriation bill.

Given the number of unauthorized programs, the Committee reserves the option to limit future funding for unauthorized programs or discontinue funding all together. In the fiscal year 2013 appropriations bill, the Committee has exercised that option by decreasing or terminating funding for fish and wildlife conservation; fund-

ing for USGS science programs; EPA's U.S.-Mexico border grant program; EPA's environmental education program; and others.

The Committee urges the appropriate authorizing committees to expeditiously reauthorize these and other unauthorized agencies and/or programs in a timely fashion and encourages all entities with an interest in these laws to work with those authorizing committees to do so.

AMERICAN INDIAN AND ALASKA NATIVE PROGRAMS

In preparation of the fiscal year 2013 budget, the Subcommittee held two days of hearings and received oral or written testimony from nearly 200 witnesses on a variety of topics pertaining to American Indian and Alaska Native programs. By far the topics of most concern to the witnesses dealt with economic empowerment, self-determination, health care, crime, and education. The Subcommittee heard these concerns and is working to address these issues on a bipartisan basis.

The Committee recognizes that conditions facing American Indians and Alaska Natives are reflected in some of the worst health, education, and crime statistics of any demographic group in the nation. Additional funding alone will not address these challenges, but by continuing to target specific concerns, the Committee is attempting to meaningfully address programs and policies that empower and improve the lives of American Indians and Alaska Natives. Funding increases provided in fiscal year 2013 and prior years are, by design, gradual steps in the implementation of this policy. Future increases will be predicated on the ability of the agencies and American Indian and Alaska Native leaders to continue to demonstrate results.

PAYMENTS IN LIEU OF TAXES (PILT)

The Payments in Lieu of Taxes (PILT) program provides compensation to local governments for the loss of tax revenue resulting from the presence of Federal land in their county or State. In 2011, 49 states, the District of Columbia, Guam, the Commonwealth of Puerto Rico, and the U.S. Virgin Islands received PILT payments.

Mandatory funding for PILT payments is scheduled to expire on September 30, 2012. At the time of the markup of the fiscal year 2013 Interior, Environment, and Related Agencies Appropriations bill, much uncertainty remained over this expiring mandatory authorization being extended. The Subcommittee has included bill language extending by one year the mandatory authorization for full PILT funding for fiscal year 2013.

The Committee urges the authorizing committees to extend mandatory PILT payments by the time House and Senate conferees on the Interior, Environment, and Related Agencies Appropriations bill complete work on the fiscal year 2013 conference report.

LAND AND WATER CONSERVATION FUND (LWCF) PROGRAMS

The Committee recommends $66,000,000 for Land and Water Conservation Fund (LWCF) programs, $256,349,000 below fiscal year 2012 enacted levels and $383,934,000 below the 2012 budget request. The recommended level is consistent with the Committee's recommendation in the fiscal year 2012 appropriation bill. Funding

is provided to continue to oversee projects that were funded in previous years. Non-Federal LWCF programs are minimally funded to allow for a limited number of new acquisitions. No funding is provided for new Federal acquisitions other than for small inholdings and recreational access in national forests and on BLM lands. The Committee directs the Forest Service and the Department of the Interior to develop and implement a standard definition and policy for the use of inholdings funding.

The Committee notes that the Administration's fiscal year 2013 budget request included a new category of Federal funds for large-scale projects that were developed in close coordination between the Forest Service and the Department of the Interior. Despite repeated requests by the Committee, the Administration has failed to submit consolidated, prioritized project lists for each of the four Federal programs. As a result, the Committee thus far has insufficient information to determine which projects would be implemented with limited funds. Until the Administration submits such prioritized lists, updated as needed to reflect changing real estate market conditions, the Committee will not invest in new projects.

CLIMATE CHANGE

The Committee remains skeptical of the Administration's efforts to re-package existing programs and fund new ones in the name of climate change. That the climate is changing is not in dispute. However, recent rapid increases in funding and the number of new and seemingly duplicative programs are potentially wasteful. In this bill alone, between 2008 and 2011, climate change funding grew from $192 million to $372 million—a staggering 93 percent increase.

There must be a significant improvement in the level of coordination and communication of climate change activities, budgets, and accomplishments across the Federal agencies funded in this bill and across the entire Federal government if there is to be further investment by this Committee. That level of coordination and communication continues to be lacking, which is why the fiscal year 2012 Interior, Environment, and Related Agencies conference report included a seven percent cut to climate change spending. The Committee has proposed cutting climate change spending an additional 29 percent in this bill, terminating six programs and denying two new starts requested by the Administration.

INVASIVE SPECIES

Throughout the fiscal year 2013 budget oversight process, the Subcommittee has discussed the dangers of the spread of invasive species in places like the Everglades, the Great Lakes, and western river systems. Invasive snakes, fish, mussels, and plants for example have demonstrated the potential to completely alter ecosystems and inflict hundreds of millions of dollars in economic damages.

The Committee is concerned about the decline in funding for a problem that only continues to grow. For example, the Fish and Wildlife Service supports only two full-time staff to designate injurious species under the authority of the Lacey Act. Further, even after each State and territory developed invasive species plans as mandated under the Nonindigenous Aquatic Nuisance Species Prevention and Control Act, less than $30,000 annually is appro-

priated to each State and territory to implement those plans. Despite deep cuts elsewhere in this bill, the Committee is placing a higher priority on invasive species prevention, containment, and enforcement in fiscal year 2013 by level-funding or, in some cases, increasing funding for on-the-ground implementation programs.

While efforts have been made at various levels to coordinate a Federal response to invasive species, the Committee remains concerned that this coordination is not leading to sufficient resources being spent on the ground where these challenges most frequently occur. The Committee strongly encourages national and regional coordinating bodies, such as the National Invasive Species Council and the Aquatic Nuisance Species Task Force, to increase the proportion of funding for on-the-ground activities in fiscal year 2013. The Committee remains committed to addressing this issue fully and intends to hold oversight hearings with appropriate Federal officials and stakeholders.

NATIONAL OCEAN POLICY

The bill includes within Title IV General Provisions language prohibiting the use of funds for Executive Order 13547 regarding National Ocean Policy; requiring a report to Congress of all Federal expenditures on such Policy during fiscal years 2011 and 2012; and requiring the President's fiscal year 2014 budget submission to account for all proposed National Ocean Policy funding.

The Committee notes with considerable skepticism that the Department of the Interior, for example, submitted an "Oceans" crosscut budget of $931 million for fiscal year 2013 yet has informed the Committee in writing that only $2 million would be spent on National Ocean Policy. Further, none of the other agencies in this bill have been able to identify funding related to National Ocean Policy within their respective budgets. Therefore, the Committee is including the general provision to give the Congress time to ascertain the potentially far-reaching impacts of this new policy, which was established in 2010 without Congressional input, and to direct the Administration to fully account for Federal funding spent to date on the policy's development and implementation.

REPROGRAMMING GUIDELINES

The following are the procedures governing reprogramming actions for programs and activities funded in the Department of the Interior, Environment, and Related Agencies Appropriations Act.

Definitions.—"Reprogramming," as defined in these procedures, includes the reallocation of funds from one budget activity, budget line-item or program area, to another within any appropriation funded in this Act. In cases where either the House or Senate Committee report displays an allocation of an appropriation below those levels, that more detailed level shall be the basis for reprogramming.

For construction, land acquisition, and forest legacy accounts, a reprogramming constitutes the reallocation of funds, including unobligated balances, from one construction, land acquisition, or forest legacy project to another such project.

A reprogramming shall also consist of any significant departure from the program described in the agency's budget justifications. This includes proposed reorganizations, especially those of signifi-

cant national or regional importance, even without a change in funding. Any change to the organization table presented in the budget justification shall be subject to this requirement.

General Guidelines for Reprogramming.—

(a) A reprogramming should be made only when an unforeseen situation arises, and then only if postponement of the project or the activity until the next appropriation year would result in actual loss or damage.

(b) Any project or activity, which may be deferred through reprogramming, shall not later be accomplished by means of further reprogramming, but instead, funds should again be sought for the deferred project or activity through the regular appropriations process.

(c) Except under the most urgent situations, reprogramming should not be employed to initiate new programs or increase allocations specifically denied or limited by Congress, or to decrease allocations specifically increased by the Congress.

(d) Reprogramming proposals submitted to the House and Senate Committees on Appropriations for approval shall be considered approved 30 calendar days after receipt if the Committees have posed no objection. However, agencies will be expected to extend the approval deadline if specifically requested by either Committee.

Criteria and Exceptions.—A reprogramming must be submitted to the Committees in writing prior to implementation if it exceeds $1,000,000 annually or results in an increase or decrease of more than 10 percent annually in affected programs, with the following exceptions:

(a) With regard to the tribal priority allocations of the Bureau of Indian Affairs, there is no restriction on reprogrammings among these programs. However, the Bureau shall report on all reprogrammings made during a given fiscal year no later than 60 days after the end of the fiscal year.

(b) With regard to the Environmental Protection Agency, State and Tribal Assistance Grants account, the Committee does not require reprogramming requests associated with States and Tribes Partnership Grants.

Assessments.—"Assessment" as defined in these procedures shall refer to any charges, reserves, or holdbacks applied to a budget activity or budget line item for costs associated with general agency administrative costs, overhead costs, working capital expenses, or contingencies.

(a) No assessment shall be levied against any program, budget activity, sub-activity, budget line item, or project funded by the Interior, Environment, and Related Agencies Appropriations Act unless such assessment and the basis therefore are presented to the Committees on Appropriations in the budget justifications and are subsequently approved by the Committees. The explanation for any assessment in the budget justification shall show the amount of the assessment, the activities assessed, and the purpose of the funds.

(b) Proposed changes to estimated assessments, as such estimates were presented in annual budget justifications, shall be submitted through the reprogramming process and shall be subject to the same dollar and reporting criteria as any other reprogramming.

(c) The Committees direct that each agency or bureau which utilizes assessments shall submit an annual report to the Committees

which provides details on the use of all funds assessed from any other budget activity, line item, sub-activity, or project.

(d) In no case shall contingency funds or assessments be used to finance projects and activities disapproved or limited by Congress, or to finance programs or activities that could be foreseen and included in the normal budget review process.

(e) New programs requested in the budget should not be initiated before enactment of the bill without notification to, and the approval of, the Committees on Appropriations. This restriction applies to all such actions regardless of whether a formal reprogramming of funds is required to begin the program.

Quarterly Reports.—All reprogrammings between budget activities, budget line-items, program areas, or the more detailed activity levels shown in the Statement of the Managers, including those below the monetary thresholds established above, shall be reported to the Committees within 60 days of the end of each quarter and shall include cumulative totals for each budget activity, budget line item, or construction, land acquisition, or forest legacy project.

Land Acquisitions, Easements, and Forest Legacy.—Lands shall not be acquired for more than the approved appraised value (as addressed in section 301(3) of Public Law 91–646), unless such acquisitions are submitted to the Committees on Appropriations for approval in compliance with these procedures.

Land Exchanges.—Land exchanges, wherein the estimated value of the Federal lands to be exchanged is greater than $1,000,000, shall not be consummated until the Committees have had a 30-day period in which to examine the proposed exchange. In addition, the Committee shall be provided advance notification of exchanges valued between $500,000 and $1,000,000.

Budget Structure.—The budget activity or line item structure for any agency appropriation account shall not be altered without advance approval of the House and Senate Committees on Appropriations.

Report Language.—Any limitation or directive contained in either the House or Senate report which is not contradicted by the other report nor specifically denied in the conference report shall be considered as having been approved by both Houses of Congress.

TITLE I—DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

The Bureau of Land Management (Bureau) is responsible for the multiple use management, protection, and development of a full range of natural resources, including minerals, timber, rangeland, fish and wildlife habitat, and wilderness on about 245 million acres of the Nation's public lands and for management of 700 million additional acres of Federally-owned subsurface mineral rights. In addition, the Bureau has trust responsibilities on 56 million acres of Indian trust lands for mineral operations and cadastral surveys. Surface lands under direct Bureau management make up about 13 percent of the total land surface of the United States and more than 40 percent of all land managed by the Federal government, making the Bureau the nation's largest single land manager. The Bureau is the second largest provider of public outdoor recreation in the Western United States.

In 1812, the General Land Office (GLO) was established to handle the business associated with the sale of public lands for private ownership, transforming wilderness to agricultural use, and generating income for the Federal government. Revenue raised by GLO land sales, mainly homesteads, was initially used to pay war debts. As the successor agency to the original GLO, the Bureau of Land Management was established in 1946 with the merger of the Grazing Service and the GLO.

MANAGEMENT OF LANDS AND RESOURCES

Appropriation enacted, 2012	$960,361,000
Budget estimate, 2013	952,017,000
Recommended, 2013	946,707,000
Comparison:	
Appropriation, 2012	−13,654,000
Budget estimate, 2013	−5,310,000

The Committee recommends $946,707,000 for Management of Lands and Resources, $13,654,000 below the fiscal year 2012 enacted level and $5,310,000 below the budget request.

Land Resources.—The Committee recommends $241,266,000 for Land Resources, $15,744,000 below the fiscal year 2012 enacted level and $855,000 above the budget request.

The Committee does not provide funding for Landscape Conservation Cooperatives and prohibits the Bureau from using any funds for LCCs. The Committee questions the purpose and effectiveness of LCCs and believes agencies can and should coordinate and cooperate without LCCs.

Range Management.—The Committee recommends $90,000,000 for the Range Management program, $2,608,000 above the fiscal year 2012 enacted level and $17,673,000 above the budget request. The Committee rejects the Bureau's proposal to charge one dollar per animal unit month and directs the Bureau to instead report to the Committee on potential cost recovery based on permit administration costs, not animal unit months.

The Committee has increased funding to address numerous challenges including sage grouse conservation, completion of grazing permit renewals, hiring of seasonal employees to ensure timely turn-out of livestock, annual and trend monitoring of grazing allotments, and improving the quality of Bureau work on environmental and other documents related to livestock grazing. The Committee commends the Bureau's range management program for using land stewardship to achieve long-term resource management goals including using grazing as a tool to prevent wildfire for sage grouse habitat.

The Committee is deeply concerned by the drastic reduction of range specialists within the Bureau of Land Management and directs the Bureau to brief the Committee on how it will accomplish work related to range management with so few specialists. Further, with increased funding in fiscal year 2012 and a recommended increase for fiscal year 2013, the Committee believes the Bureau must also increase the number of grazing permits renewed.

The Committee includes bill language addressing range management in Title I General Provisions including: (1) Section 112 permanently requiring would-be litigants to exhaust administrative review before bringing a civil action against the Bureau on grazing

decisions; and, (2) Section 113 exempting the trailing of livestock across public land from the National Environmental Policy Act (NEPA) for fiscal years 2013 and 2014. The Committee includes bill language addressing range management in Title IV General Provisions (applying to both the Bureau and the Forest Service) including: (1) Section 412 which makes permanent the grazing permit renewal general provision allowing permits to be renewed for one year under the same terms and conditions if NEPA review has not yet been completed; and, (2) Section 423 prohibiting the use of funds for reductions in domestic sheep grazing due to bighorn sheep unless management actions are consistent with State wildlife plans.

Forestry Management.—The Committee recommends $9,714,000 for Forestry Management, equal to the fiscal year 2012 enacted level and $3,396,000 above the budget request. The Committee is deeply concerned by the proposed cut in this program and notes that much of the Bureau's public domain forestland is located in areas with high mortality due to bark beetle infestation. Further, the proposed reduction would greatly reduce current efforts to prevent catastrophic wildfires while also supporting small businesses in rural areas that contract with the Bureau to manage forests.

Wild Horse and Burro Management.—The Committee recommends $64,068,000 for Wild Horse and Burro Management, $10,820,000 below the fiscal year 2012 enacted level and $13,000,000 below the budget request. The Committee is again troubled by the increased cost of this program and notes that the Bureau dramatically changed its strategy last year with the promise that it would not request increased funding for fiscal year 2013. To the contrary, the Bureau has requested an additional $3,000,000 above fiscal year 2012 enacted levels for fertility control.

The Committee is very concerned about the health of Bureau rangelands and overgrazing from wild horses and burros now that the agency is no longer managing to maintain Appropriate Management Levels (AML) as required under the Wild Free-Roaming Horses and Burro Act of 1971. The Committee believes it's critical to balance the use of public rangelands for wildlife, livestock and other multiple uses. The Committee also notes that overgrazing from wild horses could degrade sage grouse habitat and contribute to the spread of invasive weeds.

The Committee retains language prohibiting any funds from being used for the slaughter of wild horses and burros in Administrative Provisions and allowing the Bureau to enter into long-term contracts for holding wild horses and burros in Title I General Provisions.

Native Plant Program.—The Committee is supportive of the Bureau of Land Management's existing plant conservation and native plant materials program and expects the Bureau to continue the program through resources provided under various accounts. The Committee directs the threatened and endangered species account to contribute to this program.

Wildlife and Fisheries.—The Committee recommends $65,615,000 for Wildlife and Fisheries, $15,368,000 above the fiscal year 2012 enacted level, as requested. The Committee's recommendation in-

cludes $15,000,000, as requested, for broad-scale sage grouse conservation activities.

Bighorn Sheep Research.—The Bureau of Land Management is directed to work with the Agriculture Research Service (ARS) and the Forest Service to provide any information requested for research and analysis of bighorn sheep and domestic sheep. The Committee addresses at length the management of domestic sheep with regard to bighorn sheep later in the report (Forest Service, Forest and Rangeland Research, Bighorn Sheep Research).

Sage Grouse.—The Committee fully funds the Bureau's proposal for sage grouse conservation and related resource management plan amendments. The Committee also directs the Bureau to provide assistance to States for the implementation of State sage grouse conservation plans to prevent the listing of the bird.

The Committee continues to be concerned about the threat wildfire poses to the sage grouse and directs the agency to use resources made available under the Bureau of Land Management and the Department of the Interior's Wildland Fire Program to reduce and mitigate catastrophic fire.

The Committee is also concerned about the lack of quality data with respect to sage grouse habitat mapping and notes that some places identified as 'core habitat' were recently burned by catastrophic wildfire or have changed in other significant ways. The Committee directs the Bureau to ensure that mapping of habitat is verified on the ground to avoid this problem. Further, the Committee urges the Bureau to coordinate its efforts for sage grouse conservation by improving and protecting habitat in places that will serve as core habitat far into the future rather than areas that may evolve. The Committee also urges the Bureau to encourage map consistency by States as State borders may become difficult areas to manage due to different mapping.

Finally, the Committee is concerned that the Bureau considers sage grouse protection paramount to other objectives, rather than incorporating sage grouse conservation into multiple use as required under the Federal Lands Management and Policy Act.

Threatened and Endangered Species.—The Committee recommends $21,812,000 for Threatened and Endangered Species, as requested, $179,000 above the fiscal year 2012 enacted level.

Recreation Management.—The Committee recommends $60,858,000 for Recreation Management, $6,608,000 below the fiscal year 2012 enacted level and $9,432,000 below the budget request.

Energy and Minerals.—The Committee recommends $130,860,000 for Energy and Minerals, $23,246,000 above the fiscal year 2012 enacted level and $37,950,000 above the budget request. The Committee rejects the budget proposal to impose new inspection fees on onshore oil and gas producers.

The Committee notes that production of oil and gas from Federal lands has decreased despite the overall increase of oil and gas production in the United States from State and private lands. The Committee is concerned that the production of oil and gas on Federal lands has been hurt by the perception of tremendous regulatory uncertainty in operating on Federal lands. The Committee would remind the Bureau that when investment capital moves to

non-Federal lands that the result is a reduction in revenue over time to Federal and State treasuries.

The Committee continues the Oil and Gas Leasing Internet Program through fiscal year 2013 in Title I General Provisions.

Mining Law Administration.—The Committee recommends $39,696,000 for Mining Law Administration, as requested. There continues to be a growing awareness in Congress about the need for a coherent minerals policy to ensure availability of minerals essential to the manufacturing supply chain. Currently, less than half of the mineral needs of U.S. manufacturing are met from domestically mined resources. To ensure access to the minerals that are vital to our national and economic security, the Bureau must address the role that delays in permitting of mining activities, including the Department's overly cumbersome Federal Register clearance process, play in hindering the ability to develop domestic sources.

The Committee is concerned that the Department has delayed the publication of various Land Use Analysis documents and Environmental Impact Statements in the Federal Register associated with Federal mineral lease applications submitted to the Bureau of Land Management. The Committee directs the Secretary of the Interior to provide within 30 days of enactment of this Act a detailed report on all land use analysis or environmental impact statements that have been prepared for review by the Office of Management and Budget but have not yet been published, as well as the anticipated date of publication.

BLM/OSM Proposed Merger.—The Committee remains concerned about the lack of coordination and consultation with Congress on efforts to merge functions of the Bureau of Land Management (BLM) and the Office of Surface Mining Reclamation and Enforcement (OSM). The Committee believes that the proposal offers little administrative savings when attempting to combine functions of two statutorily created agencies, and directs no further funds be spent on studies to merge functions of BLM and OSM.

Northern Arizona Mining Withdrawal.—The Committee is aware that on May 23, 2012 and as a part of its oversight responsibilities, the House Committee on Natural Resources provided the Secretary of the Interior with a detailed request for documents related to the Draft Environmental Impact Statement, the Final Environmental Impact Statement, and the Record of Decision for the Northern Arizona Mineral Withdrawal. The Committee directs the Secretary to fully comply with this document request in an expeditious manner.

The Committee includes within Title IV General Provisions a correction to Section 430, Claim Maintenance Fee Amendments, included in the fiscal year 2012 Interior, Environment, and Related Agencies conference report, that changes claim maintenance fees for placer claims including two or more people, to the same fees required for individual placer claims.

Challenge Cost Share.—The Committee recommends terminating the Challenge Cost Share program.

National Landscape Conservation System.—The Committee recommends $20,000,000 for the National Landscape Conservation System base program, $11,819,000 below the fiscal year 2012 enacted level and $15,115,000 below the budget request. The Com-

mittee retains language prohibiting mineral leasing within national monuments in Title IV General Provisions.

International Border.—The Committee notes that since October, 2011, the Bureau of Land Management has brought additional law enforcement resources to the Sonoran Desert National Monument and the Ironwood Forest National Monument to increase pressure on drug smuggling and illegal immigration. The Committee also notes that the BLM has been installing vehicle barriers in the Sonoran Desert National Monument. These activities simultaneously seek to increase the security of the border region as well as protect the integrity of the desert landscape. The Committee directs the Bureau to brief the Committee within 180 days of enactment of this Act on the Bureau's plans for law enforcement activities in the border area.

Wild Lands.—The Committee retains a prohibition of funds for Secretarial Order Number 3310 in Title I General Provisions.

Hunting and Recreational Shooting.—The Committee includes bill language in Title IV General Provisions prohibiting the use of appropriated funds to close areas open to recreational hunting and shooting as of January 1, 2012.

CONSTRUCTION

Appropriation enacted, 2012	$3,570,000
Budget estimate, 2013	0
Recommended, 2013	0
Comparison:	
Appropriation, 2012	−3,570,000
Budget estimate, 2013	0

The Committee has not provided construction funding, as requested.

LAND ACQUISITION

Appropriation enacted, 2012	$22,344,000
Budget estimate, 2013	33,575,000
Recommended, 2013	6,743,000
Comparison:	
Appropriation, 2012	−15,601,000
Budget estimate, 2013	−26,832,000

The Committee recommends $6,743,000 for Land Acquisition, $15,601,000 below the fiscal year 2012 enacted level and $26,832,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee has included language in the front of the report regarding Land and Water Conservation Fund programs.

OREGON AND CALIFORNIA GRANT LANDS

Appropriation enacted, 2012	$111,864,000
Budget estimate, 2013	112,043,000
Recommended, 2013	110,025,000
Comparison:	
Appropriation, 2012	−1,839,000
Budget estimate, 2013	−2,018,000

The Committee recommends $110,025,000 for the Oregon and California Grant Lands, $1,839,000 below the fiscal year 2012 enacted level and $2,018,000 below the budget request.

The Committee provides no funding for the new Resource Management planning effort for the O&C lands and subsequently funds resource management planning at $3,635,000. No reduction should be taken from other Resource Management subactivities.

The Committee supported the Secretary's Western Oregon strategy pilot projects in fiscal year 2012, but notes that these projects have not resulted in realistic long-term solutions to the management of O&C lands. Contrary to the original purpose of the pilots to ecologically restore thousands of acres, projects have resulted in very few acres treated at a very high cost. The Committee is deeply troubled by new resource management plan initiatives for O&C lands after $18,000,000 was spent over five years to develop the last plan (still legally in effect).

The Committee believes a comprehensive review and change of current policies is necessary to meet the goals of the O&C Lands Act of 1937. The Committee notes that the law directs that these lands be managed "for permanent forest production . . . with the principle of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating stream flow, and contributing to the economic stability of local communities and industries, and providing recreational facilities" (43 USC Sec. 1181a). Based on current information from the Bureau, the Committee is hard pressed to believe the new planning efforts will comply with the O&C Lands Act of 1937.

RANGE IMPROVEMENTS

The Committee recommends an indefinite appropriation of not less than $10,000,000 to be derived from public lands receipts and Bankhead-Jones Farm Tenant Act lands grazing receipts.

SERVICE CHARGES, DEPOSITS, AND FORFEITURES

The Committee recommends an indefinite appropriation estimated to be $31,053,000 for Service Charges, Deposits, and Forfeitures, as requested.

MISCELLANEOUS TRUST FUNDS

The Committee recommends an indefinite appropriation estimated to be $19,700,000, as requested and equal to the fiscal year 2012 enacted level, for Miscellaneous Trust Funds.

ADMINISTRATIVE PROVISIONS, BUREAU OF LAND MANAGEMENT

The Committee recommendation includes the requested Administrative Provisions.

UNITED STATES FISH AND WILDLIFE SERVICE

The mission of the U.S. Fish and Wildlife Service (Service) is to conserve, protect and enhance fish and wildlife and their habitats for the continuing benefit of people. The Service has responsibility for migratory birds, threatened and endangered species, certain marine mammals, and land under Service control. Currently, the Service accomplishes its mission by managing more than 150 million acres of land and ocean, 556 units in the National Wildlife Refuge System, 80 Ecological Services Field Stations, 71 National Fish

Hatcheries, one historical National Fish Hatchery, and numerous waterfowl production areas in 206 counties.

RESOURCE MANAGEMENT

Appropriation enacted, 2012	$1,226,177,000
Budget estimate, 2013	1,247,044,000
Recommended, 2013	1,040,488,000
Comparison:	
Appropriation, 2012	−185,689,000
Budget estimate, 2013	−206,556,000

The Committee recommends $1,040,488,000 for Resource Management, $185,689,000 below the fiscal year 2012 enacted level and $206,556,000 below the budget request. The Committee accepts the proposed transfers for the diversity office but does not accept the proposed land acquisition planning transfer. The Committee accepts the proposed program reductions except as otherwise indicated below. Proposed fixed costs and program increases are not funded. Selected additional changes to the budget request follow. A complete summary of the amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee encourages the Service to consider all line items within a program element when determining how to distribute reductions not specified below.

Within Candidate Conservation, the bill includes no less than $2,000,000 to continue multiple Service initiatives begun in fiscal year 2012 to work with States and private landowners to facilitate and increase the use of conservation agreements related to the Endangered Species Act. The Committee is pleased with the progress made by the coalition of partners of the Northern Rocky Mountain Multispecies Conservation Agreements initiative in particular, as directed by House Report 112–331. The Committee recognizes the monumental task being undertaken and that additional time and resources are needed in order for the partners to continue their work. The partners are directed to continue to report annually to Congress.

Within Listing and Critical Habitat the Committee directs the following reductions: $2,568,000 from listing; $375,000 from international listing; and $375,000 from petitions.

The Committee directs the Service to devote sufficient funds from within Consultation to assure timely Biological Opinions on the northern spotted owl to other Federal land management agencies in addition to technical assistance review and "no take letters" to small landowners seeking approval to implement harvest plans.

Within Recovery, the bill includes a $2,000,000 reduction from State of the Birds. The Committee has provided an increase of $1,000,000 to restore the wolf livestock loss demonstration program. The Committee urges the Administration to fund this program through the Department of Agriculture in future years.

To ensure a timely decision on the Wyoming wolf management plan, the Committee has included language in the bill that provides a date certain for final agency action. The Committee notes that the pending wolf management proposal is the result of cooperative work between the agency and the State without the need for disruptive litigation. If in the future the Service determines that wolves elsewhere in the nation should be considered for delisting, such as in the desert southwest, this Committee will consider simi-

lar bill language until such time as Congress has conducted a thorough review and reauthorization of the ESA.

The Committee supports the requested funding for aplomado falcon and California condor recovery. The Service is encouraged to continue to support these ongoing, successful partnerships.

Within National Wetlands Inventory, the Committee supports continued funding for the digitization of coastal barrier maps.

Within National Fish Hatchery System Operations, the bill includes an increase of $3,394,000. The Committee will continue to reject proposals to reduce funding in the Service's budget for mitigation fish hatcheries until the Administration has secured offsetting reimbursable funds from the responsible Federal agencies.

Within Aquatic Habitat and Species Conservation, the bill includes reductions of $2,000,000 from Habitat Assessment and Restoration and $850,000 from Marine Mammals. Increases include $2,463,000 to implement approved State and interstate aquatic invasive species plans and $1,000,000 for State and Federal prevention, containment, and enforcement activities as prescribed in the February 2010 Quagga-Zebra Mussel Action Plan for Western U.S. Waters. The Committee supports the multi-state collaborative approach taken by the Service in fiscal year 2012, and encourages continued efforts in fiscal year 2013.

The Committee expresses concern regarding the rapid spread of several invasive species of Asian carp into the Upper Mississippi River and Ohio River basins and tributaries, which are threatening ecosystems and billions of dollars of economic activity connected to outdoor recreation in States throughout the Midwest. While Federal efforts have focused on preventing the spread of Asian carp into the Great Lakes, there is growing recognition of the threat these invasive species pose to other ecosystems in the Upper Mississippi and Ohio River basins. The U.S. Fish and Wildlife Service, in coordination with the Army Corps of Engineers, National Park Service, and U.S. Geological Survey, shall lead a multi-agency effort to slow the spread of Asian carp in the Upper Mississippi River and Ohio River basins and tributaries by providing high-level technical assistance, coordination, best practices, and support to State and local government strategies to slow, and eventually eliminate, the threat posed by Asian carp. To the maximum extent practicable, the multi-agency effort shall apply lessons learned and best practices developed under the Asian Carp Control Strategic Framework to efforts in the Upper Mississippi and Ohio River basins.

CONSTRUCTION

Appropriation enacted, 2012	$23,051,000
Budget estimate, 2013	19,136,000
Recommended, 2013	17,755,000
Comparison:	
Appropriation, 2012	−5,296,000
Budget estimate, 2013	−1,381,000

The Committee recommends $17,755,000 for Construction, $5,296,000 below the fiscal year 2012 enacted level and $1,381,000 below the budget request. The reduction below the budget request is from core engineering services. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report.

LAND ACQUISITION

Appropriation enacted, 2012	$54,632,000
Budget estimate, 2013	106,892,000
Recommended, 2013	15,047,000
Comparison:	
Appropriation, 2012	−39,585,000
Budget estimate, 2013	−91,845,000

The Committee recommends $15,047,000 for Land Acquisition, $39,585,000 below the fiscal year 2012 enacted level and $91,845,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee has included language in the front of the report regarding Land and Water Conservation Fund programs.

COOPERATIVE ENDANGERED SPECIES CONSERVATION FUND

The Cooperative Endangered Species Conservation Fund provides grants to States and territories for endangered species recovery actions on non-Federal lands and provides funds for non-Federal land acquisition to facilitate habitat protection. Individual States and territories provide 25 percent of grant project costs. Cost sharing is reduced to 10 percent when two or more States or territories are involved in a project.

Appropriation enacted, 2012	$47,681,000
Budget estimate, 2013	60,000,000
Recommended, 2013	14,129,000
Comparison:	
Appropriation, 2012	−33,552,000
Budget estimate, 2013	−45,871,000

The Committee recommends $14,129,000 for the Cooperative Endangered Species Conservation Fund, $33,552,000 below the fiscal year 2012 enacted level and $45,871,000 below the budget request. The Committee recommendation includes funding for administration of ongoing projects funded in prior years, and limited funding for HCP land acquisition. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee has included language in the front of the report regarding Land and Water Conservation Fund programs.

NATIONAL WILDLIFE REFUGE FUND

This program makes payments in lieu of taxes based on their fair market value to counties in which Service lands are located. Payments to counties are estimated to be $16,857,000 in fiscal year 2013, with $11,958,000 derived from this appropriation and $4,899,000 from the net refuge receipts estimated to be collected in fiscal year 2012.

Appropriation enacted, 2012	$13,958,000
Budget estimate, 2013	0
Recommended, 2013	11,958,000
Comparison:	
Appropriation, 2012	−2,000,000
Budget estimate, 2013	+11,958,000

The Committee recommends $11,958,000 for the National Wildlife Refuge Fund, $2,000,000 below the fiscal year 2012 enacted level and $11,958,000 above the budget request.

NORTH AMERICAN WETLANDS CONSERVATION FUND

The U.S. Fish and Wildlife Service, through the North American Wetlands Conservation Fund, leverages partner contributions for wetlands conservation. Projects to date have been in 50 States, 13 Canadian provinces, 25 Mexican states, the Commonwealth of Puerto Rico, and the U.S. Virgin Islands. In addition to this appropriation, the Service receives funding from fines for violations of the Migratory Bird Treaty Act; interest earned on tax receipts in the Federal Aid in Wildlife Restoration account from taxes on firearms, ammunition, archery equipment, pistols, and revolvers; and from the Sport Fish Restoration account from taxes on fishing tackle and equipment, electric trolling motors and fish finders; and certain marine gasoline taxes. By law, sport fish restoration receipts are used for coastal wetlands in States bordering the Pacific and Atlantic Oceans, States bordering the Great Lakes and Gulf of Mexico, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Commonwealth of the Northern Mariana Islands, the freely associated States in the Pacific, and American Samoa.

Appropriation enacted, 2012	$35,497,000
Budget estimate, 2013	39,425,000
Recommended, 2013	22,333,000
Comparison:	
Appropriation, 2012	−13,164,000
Budget estimate, 2013	−17,092,000

The Committee recommends $22,333,000 for the North American Wetlands Conservation Fund, $13,164,000 below the fiscal year 2012 enacted level and $17,092,000 below the budget request. The Committee notes that the authorization of appropriations for this program expires in fiscal year 2012.

NEOTROPICAL MIGRATORY BIRD CONSERVATION

The Neotropical Migratory Bird Conservation Act of 2000 authorized grants for the conservation of neotropical migratory birds in the United States, Latin America and the Caribbean, with 75 percent of the amounts available to be expended on projects outside the U.S. There is a three to one matching requirement under this program.

Appropriation enacted, 2012	$3,786,000
Budget estimate, 2013	3,786,000
Recommended, 2013	1,893,000
Comparison:	
Appropriation, 2012	−1,893,000
Budget estimate, 2013	−1,893,000

The Committee recommends $1,893,000 for the Neotropical Migratory Bird Conservation program, $1,893,000 below the fiscal year 2012 enacted level and $1,893,000 below the budget request. The Committee notes that the authorization of appropriations for this program expired in fiscal year 2010.

MULTINATIONAL SPECIES CONSERVATION FUND

The Multinational Species Conservation Fund provides technical support and cost-sharing grant assistance to countries to strengthen anti-poaching activities; build community support for conservation near the species' habitats; conduct surveys, monitoring, and applied research; and provide infrastructure and field equipment necessary to conserve habitats. These funds help to leverage work with partners and other collaborators to conserve and protect African and Asian elephants, rhinoceroses, tigers, great apes and marine turtles and their habitats.

Appropriation enacted, 2012	$9,466,000
Budget estimate, 2013	9,980,000
Recommended, 2013	4,735,000
Comparison:	
Appropriation, 2012	−4,731,000
Budget estimate, 2013	−5,245,000

The Committee recommends $4,735,000 for the Multinational Species Conservation Fund, $4,731,000 below the fiscal year 2012 enacted level and $5,245,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee notes that the authorizations of appropriations for the programs within this Fund have expired or will expire in fiscal year 2012.

STATE AND TRIBAL WILDLIFE GRANTS

The State and Tribal Wildlife Grants program provides funds for States to implement their comprehensive wildlife conservation plans for species of greatest conservation need. States are required to provide a 50 percent cost share for grants that implement State Wildlife Action Plans.

Appropriation enacted, 2012	$61,323,000
Budget estimate, 2013	61,323,000
Recommended, 2013	30,662,000
Comparison:	
Appropriation, 2012	−30,661,000
Budget estimate, 2013	−30,661,000

The Committee recommends $30,662,000 for State and Tribal Wildlife Grants, $30,661,000 below the fiscal year 2012 enacted level and $30,661,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report.

The Committee notes that the State and Tribal Wildlife Grants program does not have a stand-alone authorization. The Committee has accordingly recommended a reduction commensurate with reductions for other Fish and Wildlife Service programs with expired authorizations. The Committee strongly encourages the Service and its partners to work with Congressional authorizing committees to seek authorization or to evaluate the feasibility of alternatives under the Federal Aid in Wildlife Restoration Act (16 U.S.C. 669 et seq.).

The Committee encourages the Service and the partners to complete the Wildlife TRACS database so that the program can better

demonstrate its ability to prevent at-risk species from having to be listed under the Endangered Species Act.

Bill Language.—The Committee has included bill language that requires a 50 percent match of all grant funding. Not included is language carried in prior years which allowed unobligated funding to be re-apportioned.

NATIONAL PARK SERVICE

The mission of the National Park Service (Service) is to preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. Established in 1916, the National Park Service has stewardship responsibilities for the protection and preservation of the heritage resources of the national park system. The system, consisting of 397 separate and distinct units, is recognized globally as a leader in park management and resource preservation. The national park system represents much of the finest the Nation has to offer in terms of scenery, historical and archeological relics, and cultural heritage. Through its varied sites, the National Park Service attempts to explain America's history, interpret its culture, preserve examples of its natural ecosystems, and provide recreational and educational opportunities for U.S. citizens and visitors from all over the world. In addition, the National Park Service provides support to tribal, local, and State governments to preserve culturally significant, ecologically important, and public recreational lands.

The National Park Service will be 100 years old in 2016, and the Service has embarked on an historic ten-year effort to enhance the national parks leading up to this historic celebration. The Committee continues to support this effort and the $2,445,198,000 recommended will help the Service prepare for a second century of conservation, environmental stewardship and recreation benefiting millions of visitors from throughout the world. In spite of extraordinary fiscal challenges, the Committee has provided funding sufficient to manage NPS units nationwide without disruptions to operations.

Table of Allocations by Activity.—The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report.

OPERATION OF THE NATIONAL PARK SYSTEM

Appropriation enacted, 2012	$2,236,568,000
Budget estimate, 2013	2,250,050,000
Recommended, 2013	2,229,409,000
Comparison:	
Appropriation, 2012	−7,159,000
Budget estimate, 2013	−20,641,000

The Committee recommends $2,229,409,000 for Operation of the National Park System (ONPS), $7,159,000 below the fiscal year 2012 enacted level and $20,641,000 below the budget request. This account funds the day-to-day operations of individual park units as well as regional and headquarters support operations of the Service. The Committee recommends the following changes to the request:

Resource Stewardship.—The Committee recommends $324,300,000 for Resource Stewardship, $5,542,000 below the fiscal year 2012 enacted level and $9,115,000 below the budget request. The Committee has not included requested funding for climate-change related activities. The Committee has noted throughout this and past reports the critical need for a significant improvement in the level of coordination and communication of climate change activities, budgets, and accomplishments across the bureaus within the Department of the Interior. These improvements have yet to be realized. Lastly, the Committee directs that the Park Service provide no less than $1,000,000 within available funds for quagga and zebra mussel containment, prevention, and enforcement as prescribed in the February 2010 Quagga-Zebra Mussel Action Plan for Western U.S. Waters.

Visitor Services.—The Committee recommends $239,348,000 for Visitor Services, equal to the fiscal year 2012 enacted level and $1,540,000 above the budget request. The Committee has included funding, as requested, to support security and visitor services needs relating to the presidential inauguration in 2013.

Park Protection.—The Committee recommends $360,669,000 for Park Protection, equal to the fiscal year 2012 enacted level and $2,329,000 below the budget request.

Facility Operations and Maintenance.—The Committee recommends $681,807,000 for Facility Operations and Maintenance, as requested, which is $1,583,000 below the fiscal year 2012 enacted level.

Park Support.—The Committee recommends $454,366,000 for Park Support, as requested, which is $34,000 below the fiscal year 2012 enacted level.

External Administrative Costs.—The Committee recommends $168,919,000 for External Administrative Costs, equal to the fiscal year 2012 enacted level and $10,737,000 below the budget request.

Additional Guidance.—The following additional direction and guidance is provided with respect to funding provided within this account:

Park Operations.—Funding to maintain visitor services is a core responsibility of the Service. The Committee believes that funding of park operations ought to remain the highest priority of the Service. The Committee rejects the Administration's proposal to pay for fixed cuts through a reduction in park base operations.

Civil War Sesquicentennial.—The Civil War battlefields, sites and monuments provide vital historic and educational opportunities for the millions of Americans that visit each year. The 150th anniversary presents a significant opportunity for Americans to recall and reflect upon the Civil War and its legacy in a spirit of reconciliation and reflection, through exploration, interpretation, and discussion. In keeping with the Service's continued observance of the Sesquicentennial, the Committee continues to support the efforts of the Director to encourage discussion of the historic, social, legal, racial, cultural and political forces that caused the American Civil War and influenced its course and outcomes at events organized and supported by the Service.

Flight 93 Memorial.—Since the terrorist attacks of September 11, 2001, over 1.6 million people have visited the site of the Flight 93 National Memorial in Shanksville, Pennsylvania. The memorial

honors the 40 men and women who died saving the White House or U.S. Capitol from a potentially catastrophic terrorist attack. Phases 1A and 1C of the permanent memorial were dedicated in September 2011. The current phase, focusing on education and including the construction of a visitor center and learning center, are scheduled to be dedicated on September 11, 2014. The Committee remains firmly committed to the timely completion of this project.

In addition, since 2005, the Service has recorded over 2,000 hours of audio interviews involving nearly 750 individuals including family members of the passengers and crew, eyewitnesses, first responders, and others. The Committee strongly encourages the Service to devote the resources necessary to properly archive, maintain, and preserve these invaluable historical collections.

U.S. Capitol Concerts.—The Committee continues its longstanding support for funding for the National Capitol Area Performing Arts Program and directs the Service to maintain funding for the summer concert series staged on the U.S. Capitol grounds at the fiscal year 2012 enacted level.

National Mall Restoration.—The National Mall is the most visited national park in the nation with 25 million annual visitors. The Committee strongly supports the public-private partnership involved in efforts to restore the National Mall. Integral to this effort is the management and operation of concessions and visitor services on the National Mall. Accordingly, the Committee directs the Service to prepare and submit, within 90 days of enactment of this Act, a multi-year plan for the management and operation of concessions within the National Mall and Memorial Parks.

Everglades Restoration.—The Committee notes the substantial progress made toward restoration of the Everglades ecosystem and continues to fully support this important national program. Funding is provided at the request level for the multi-year effort to preserve one of the great ecological treasures of the United States. The Committee urges the Service to begin planning and design work for the additional authorized bridging along the Tamiami Trail.

Science Education.—The Committee recognizes the importance of promoting STEM education—Science, Technology, Engineering, and Mathematics—to better prepare the Nation's young people for the high technology jobs of tomorrow. The Service is uniquely positioned to play a role in STEM education through the management and preservation of NPS resources. The Committee commends the Director's Call to Action, an initiative intended to prepare the Service and its partners for a second century of stewardship and engagement. In particular, the Committee supports the initiative's goal to engage youth through a variety of scientific educational opportunities. A Call to Action aims to "strengthen the NPS as an education institution," a goal that mirrors national efforts to improve scientific acumen among the nation's students.

Bill Language.—The Committee has included bill language to make permanent the administrative provision carried each year allowing the use of franchise fees for the purpose of reducing liability for possessory or leasehold interest under National Park Service concessions contracts.

The Committee has, since 2006, included bill language authorizing the Secretary of the Interior to acquire or lease property to facilitate the transportation of visitors to and from Ellis, Gov-

ernors, and Liberty Island, NY and NJ. The language was necessitated by the need to establish a screening process for visitors to the Statue of Liberty in the aftermath of the events of September 11, 2011. The Service no longer requires this lease or purchase authority. The Service will continue its robust screening process, but no longer requires this authority to lease or purchase new space. Therefore, with concurrence from the Service, the Committee is dropping this general provision from the bill.

NATIONAL RECREATION AND PRESERVATION

The National Recreation and Preservation account provides for outdoor recreation planning, preservation of cultural and national heritage resources, technical assistance to Federal, State and local agencies, and administration of Historic Preservation Fund grants.

Appropriation enacted, 2012	$59,879,000
Budget estimate, 2013	52,096,000
Recommended, 2013	51,822,000
Comparison:	
Appropriation, 2012	−8,057,000
Budget estimate, 2013	−274,000

The Committee recommends $51,822,000 for National Recreation and Preservation, $8,057,000 below the fiscal year 2012 enacted level and $274,000 below the budget request. The Committee recommends the following changes to the request:

Recreation Programs.—The Committee recommends $584,000 for Recreation Programs, equal to the fiscal year 2012 enacted level and $6,000 below the budget request.

Natural Programs.—The Committee recommends $13,354,000 for Natural Programs, equal to the fiscal year 2012 enacted level and $177,000 below the budget request.

Cultural Programs.—The Committee recommends $24,764,000 for Cultural Programs, equal to the fiscal year 2012 enacted level and $55,000 below the budget request.

International Park Affairs.—The Committee recommends $1,636,000 for International Park Affairs, equal to the fiscal year 2012 enacted level and $12,000 below the budget request.

Environmental and Compliance Review.—The Committee recommends $430,000 for Environmental and Compliance Review, equal to the fiscal year 2012 enacted level and $4,000 below the budget request.

Grant Administration.—The Committee recommends $1,738,000 for Grant Administration, equal to the fiscal year 2012 enacted level and $20,000 below the budget request.

Heritage Partnership Program.—The Committee recommends $9,316,000 for the Heritage Partnership Program (HPP), as requested, $8,057,000 below the fiscal year 2012 enacted level. These funds support grants to local non-profit groups in support of historical and cultural recognition, preservation and tourism activities.

Congress has in recent years expanded from 27 to 49 the number of authorized heritage partnerships, creating additional pressure on available grant funding. The Committee notes that State and local managers of National Heritage Areas continue to rely heavily on Federal funding. Funding for the Heritage Partnership Program was sustained in fiscal year 2012, and additional guidance was provided for participating heritage areas to develop self-sufficiency

plans for long-term sustainability. These plans for long-term sustainability have yet to be realized.

The Committee is aware that the Service is conducting evaluations of National Heritage Areas and has been directed to report back to Congress with its recommendation as to the future of the Service's role with respect to each National Heritage Area, no later than three years before the date on which authority for Federal funding terminates. The Committee is concerned that to date, only three evaluations have been completed, and no reports have been delivered. The Committee encourages the Service to continue to provide grant and technical support to these areas in a manner consistent with current policy whether or not the evaluations have been completed.

The Congressional authorizations for 12 National Heritage Areas are scheduled to expire at the end of the current fiscal year. The Committee maintains that the reauthorization of these heritage areas lies within the jurisdiction and purview of Congressional authorizing committees and, thus, urges proponents of these areas to work closely with the appropriate authorizing committees to ensure, wherever appropriate, that these authorizations are extended.

Native American Graves Protection and Repatriation Grants.—The Committee provides funding for the Native American Graves Protection and Repatriation Grant program at the budget request level of $1,747,000.

Japanese American Confinement Site Grants.—The Committee maintains its support for the Japanese American Confinement Site Grants program at the budget request level of $2,995,000. This program leverages proportional funding through partnerships with local preservation groups to preserve Japanese American World War II confinement sites.

HISTORIC PRESERVATION FUND

The Historic Preservation Fund supports the State historic preservation offices to perform a variety of functions. These include State management and administration of existing grant obligations; review and advice on Federal projects and actions; determinations and nominations to the National Register; Tax Act certifications; and technical preservation services. The States also review properties to develop data for planning use. Funding in this account also supports direct grants to qualifying organizations for individual preservation projects and for activities in support of heritage tourism and local historic preservation.

Appropriation enacted, 2012	$55,910,000
Budget estimate, 2013	55,910,000
Recommended, 2013	49,500,000
Comparison:	
Appropriation, 2012	−6,410,000
Budget estimate, 2013	−6,410,000

The Committee recommends $49,500,000 for historic preservation programs, $6,410,000 below both the fiscal year 2012 enacted level and the budget request. The Committee recommends the following changes to the request:

State and Tribal Historic Preservation Offices.—The Committee supports the longstanding efforts of State and Tribal Historic Preservation Offices to identify and protect irreplaceable historic and

archaeological resources. The Committee recommends $42,500,000 for State Historic Preservation Offices, $4,425,000 below both the fiscal year 2012 enacted level and the budget request. The Committee recommends $7,000,000 for Tribal Historic Preservation Offices, $1,985,000 below both the fiscal year 2012 enacted level and the budget request.

CONSTRUCTION

Appropriation enacted, 2012	$155,366,000
Budget estimate, 2013	131,173,000
Recommended, 2013	131,173,000
Comparison:	
Appropriation, 2012	−24,193,000
Budget estimate, 2013	0

The Committee recommends $131,173,000 for Construction, $24,193,000 below the fiscal year 2012 enacted level and equal to the budget request. These amounts fund major repairs and construction of National Park Service assets. The Committee notes that the budget request for line item construction is at the lowest level since 1997 and does not propose funding any new facility construction in fiscal year 2013.

LAND AND WATER CONSERVATION FUND

RESCISSION

Appropriation enacted, 2012	−$30,000,000
Budget estimate, 2013	−30,000,000
Recommended, 2013	−30,000,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	0

The Committee recommends the rescission of $30,000,000 in the annual contract authority provided by 16 U.S.C. 460l–10a. This authority has not been used in years and there are no plans to use it in fiscal year 2013. The Committee does not agree with the Administration's proposal to permanently cancel the authority.

LAND ACQUISITION AND STATE ASSISTANCE

Appropriation enacted, 2012	$101,897,000
Budget estimate, 2013	119,421,000
Recommended, 2013	13,294,000
Comparison:	
Appropriation, 2012	−88,603,000
Budget estimate, 2013	−106,127,000

The Committee recommends $13,294,000 for Land Acquisition and State Assistance, $88,603,000 below the fiscal year 2012 enacted level and $106,127,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. The Committee has included language in the front of the report regarding Land and Water Conservation Fund programs.

American Battlefield Protection Program.—Given the significance of the 150th Anniversary of the Civil War, the Committee recognizes the importance of the American Battlefield Protection Program which provides funding to protect historically significant battlefields outside of current NPS boundaries. Since fiscal year 1999, more than 17,700 acres of the most historically significant sites

have been preserved from development. The Committee provides $2,000,000 for the program.

UNITED STATES GEOLOGICAL SURVEY

The U.S. Geological Survey (USGS) is the Nation's largest water, Earth, and biological science and civilian mapping agency. Established on March 3, 1879, the USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS programs address increasingly complex societal issues such as the development of alternative and unconventional energy resources, management of critical ecosystems, understanding and adaptation to climate change, and responses to natural and human-induced hazards. For more than a century, the diversity of scientific expertise has enabled the USGS to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, policymakers, and the public.

SURVEYS, INVESTIGATIONS, AND RESEARCH

Appropriation enacted, 2012	$1,068,032,000
Budget estimate, 2013	1,102,492,000
Recommended, 2013	967,000,000
Comparison:	
Appropriation, 2012	−101,032,000
Budget estimate, 2013	−135,492,000

The Committee recommends $967,000,000 for Surveys, Investigations, and Research, $101,032,000 below the fiscal year 2012 enacted level and $135,492,000 below the budget request. The Committee accepts the proposed transfers but does not accept the proposed fixed cost increases. The Committee does not accept the proposed program changes except as otherwise indicated below. The bill includes a number of general reductions to activities within this account that are not shown below. A complete summary of the amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report.

Within Ecosystems, the bill includes the following program increases, as requested: $1,000,000 for white nose syndrome in bats; $2,000,000 for Great Lakes Asian carp control; and $1,000,000 for Upper Mississippi Asian carp control.

Within Climate and Land Use Change, the bill includes the following program changes, as requested: an increase of $500,000 for climate science support on tribal lands; a decrease of $1,750,000 from Land Remote Sensing; and an increase of $750,000 for disaster response.

Within Energy, Minerals, and Environmental Health, the bill includes the following program changes, as requested: an increase of $1,000,000 for rare earth elements research; and a decrease of $250,000 from the minerals external research program. The Committee does not accept the proposed reductions of $500,000 from Contaminant Biology and $2,000,000 from Toxic Substances Hydrology. The Committee supports continuing efforts by the Survey to conduct an in-depth analysis of the extent and sources of endo-

crine-disrupting chemicals impacting fish and wildlife in the Chesapeake Bay Watershed.

Within Natural Hazards, the bill includes the following program decreases, as requested: $300,000 from volcano observatory assessments; and $700,000 from the National Volcano Early Warning System.

Within Water Resources, the bill includes the following program changes: an increase of $2,500,000 for a groundwater network, as requested; a decrease of $459,000 from National Water Quality Assessment instead of the requested $6,049,000 decrease; and an increase of $3,112,000 for disaster response within the National Streamflow Information Program instead of the requested $5,500,000 increase.

Within Core Science Systems, the bill includes the following program decreases, as requested: $700,000 from data management; and $446,000 from data preservation.

Within Administration and Enterprise Information, the bill includes a combined decrease of $3,691,000 from Administrative Services, as requested.

Within Facilities, the bill includes a program decrease of $4,390,000 due to operations and maintenance efficiencies, as requested.

Bill Language.—The bill provides two-year funding authority except for satellite operations and deferred maintenance and capital improvement projects, which are no-year authority. Provisos include a funding limitation on surveys on private property and a cost-share requirement on topographic mapping and water resources activities carried on in cooperation with States and municipalities.

BUREAU OF OCEAN ENERGY MANAGEMENT

The Bureau of Ocean Energy Management is responsible for the environmentally and economically sound development of the Nation's offshore energy and mineral resources. The Bureau's management of these resources helps meet the Nation's energy needs by providing access to—and fair return to the American taxpayer for—offshore energy and mineral resources through strategic planning and resource and economic evaluation. Conventional energy activities include development of the Five-Year Outer Continental Shelf (OCS) Oil and Gas Leasing Program; assessment of mineral resource potential, tracking of inventories of oil and gas reserves, and development of production projections; and economic evaluation to ensure the receipt of fair value through lease sales and lease terms.

OCEAN ENERGY MANAGEMENT

Appropriation enacted, 2012	$59,696,000
Budget estimate, 2013	62,701,000
Recommended, 2013	59,696,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	−3,005,000

The Committee recommends an appropriation of $59,696,000 for Ocean Energy Management, equal to the fiscal year 2012 enacted level and $3,005,000 below the budget request. The collection of off-

setting rental receipts and cost recovery fees total $101,404,000, as requested, $322,000 below the fiscal year 2012 enacted level. The recommendation also continues language in Title I General Provisions originating in the fiscal year 2011 Continuing Resolution allowing the reorganization of the Bureau of Ocean Energy Management and the Bureau of Safety and Environmental Enforcement only in conformance with Committee reprogramming guidelines.

The Committee does not provide funding for National Ocean Policy Coastal and Marine Spatial Planning.

BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT

The Bureau of Safety and Environmental Enforcement is responsible for oversight of exploration, development, and production operations for oil, gas, and other marine minerals on the Outer Continental Shelf (OCS). Leases in Federal waters off the shores of California, Alaska, and the Gulf of Mexico provide about 25 percent of the Nation's oil production and more than 10 percent of domestic natural gas production. The Bureau facilitates the safe and environmentally responsible development of oil and gas and the conservation of offshore resources. The Bureau's safety and environmental compliance activities include oil and gas permitting; facility inspections, regulations and standards development; safety and oil spill research; field operations; environmental compliance and enforcement; review of operator oil spill response plans; production and development; and operation of a national training center for inspectors and engineers.

OFFSHORE SAFETY AND ENVIRONMENTAL ENFORCEMENT

Appropriation enacted, 2012	$61,375,000
Budget estimate, 2013	81,399,000
Recommended, 2013	61,375,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	−20,024,000

The Committee recommends an appropriation of $61,375,000 for Offshore Safety and Environmental Enforcement, equal to the fiscal year 2012 enacted level and $20,024,000 below the budget request. The collection of offsetting rental receipts, cost recovery fees and inspection fees totals $125,881,000, as requested, $4,800,000 below the fiscal year 2012 enacted level.

The Committee continues to be concerned with the Bureau's stated intentions for the expansion of regulatory authority over nonlease holders under the Outer Continental Shelf Lands Act (OCSLA). The authority and need for this action has not been explained or justified to the Committee, nor how this diversion of limited resources would impact the Bureau's current mission and objectives identified in the fiscal year 2013 budget request. The agency is directed to use all the resources provided toward the regulatory efforts presented in the fiscal year 2013 budget request (with the exception of the National Ocean Policy and Marine Spatial Planning). Further, the Committee directs that no funds be expended for other purposes until the agency has fully explained its authority, intentions, and objectives to the Committee and the public.

OIL SPILL RESEARCH

Appropriation enacted, 2012	$14,899,000
Budget estimate, 2013	14,899,000
Recommended, 2013	14,899,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	0

The Committee recommends $14,899,000 for Oil Spill Research, as requested, equal to the fiscal year 2012 enacted level. This funding is derived from the Oil Spill Liability Trust Fund to conduct oil spill research and financial responsibility and inspection activities associated with the Oil Pollution Act of 1990, Public Law 101–380.

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

The Office of Surface Mining Reclamation and Enforcement (OSM), through its regulation and technology account, regulates surface coal mining operations to ensure that the environment is reclaimed once mining is completed. The OSM accomplishes this mission by providing grants and technical assistance to those States that maintain their own regulatory and reclamation programs and by conducting oversight of State programs. Further, the OSM administers the regulatory programs in the States that do not have their own programs and on Federal and tribal lands. Through its Abandoned Mine Land (AML) reclamation program, the OSM provides funding for environmental restoration at abandoned coal mines based on fees collected from current coal production operations. In their un-reclaimed condition these abandoned sites endanger public health and safety, and prevent the beneficial use of land and water resources. Mandatory appropriations provide funding for the abandoned coal mine sites as required under the 2006 amendments to the Surface Mining Control and Reclamation Act.

The amounts recommended by the Committee for each Office of Surface Mining Reclamation and Enforcement appropriation account, compared with the budget estimates by activity, are shown in the table at the end of this report.

REGULATION AND TECHNOLOGY

Appropriation enacted, 2012	$122,713,000
Budget estimate, 2013	113,053,000
Recommended, 2013	122,713,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	+9,660,000

The Committee recommends $122,713,000 for Regulation and Technology, equal to the fiscal year 2012 enacted level and $9,660,000 above the budget request. The Committee funds regulatory grants at $68,700,000, equal to the fiscal year 2012 enacted level. The Committee directs OSM and the Administration to discontinue efforts to push States to raise fees on industry as the bill provides the funds necessary for States to run their regulatory programs. Federal regulatory grants to primacy States results in the highest benefit and the lowest cost to taxpayers, and if a State were to relinquish primacy, OSM would have to hire and train sufficient numbers and types of Federal employees. The cost to imple-

ment the Federal program would be significantly higher and as such the Committee summarily rejects the proposal.

The Committee similarly rejects the proposal to increase inspections and enhanced Federal oversight of State regulatory programs. Delegation of the authority to the States is the cornerstone of the surface mining regulatory program, and State regulatory programs do not need enhanced Federal oversight to ensure continued implementation of a protective regulatory framework. Accordingly, the Committee has not provided the $3,994,000 and 25 FTE increase requested for those activities within the Regulation and Technology account.

OSM/BLM Merger.—The Committee remains concerned about the lack of coordination and consultation with Congress on efforts to merge functions of the Bureau of Land Management (BLM) and the Office of Surface Mining Reclamation and Enforcement (OSM). The Committee believes that the proposal offers little administrative savings when attempting to combine functions of two statutorily created agencies, and directs no further funds be spent on studies to merge functions of BLM and OSM.

ABANDONED MINE RECLAMATION FUND

Appropriation enacted, 2012	$27,399,000
Budget estimate, 2013	27,548,000
Recommended, 2013	27,366,000
Comparison:	
Appropriation, 2012	−33,000
Budget estimate, 2013	−182,000

The Committee recommends $27,366,000 for the Abandoned Mine Reclamation Fund, $33,000 below the fiscal year 2012 enacted level and $182,000 below the budget request.

BUREAU OF INDIAN AFFAIRS AND BUREAU OF INDIAN EDUCATION

The Bureau of Indian Affairs and Bureau of Indian Education (Bureau) were founded in 1824 to establish a government-to-government relationship and trust responsibility that results from treaties with Native groups. The Bureau delivers services to over 1.7 million American Indians and Alaska Natives. In addition, the Bureau provides education programs to American Indians through the operation of 169 schools and 14 dormitories. The Bureau administers more than 56 million acres of land held in trust status. Over 10 million of these acres belong to individuals and 46 million acres are held in trust for Tribes.

OPERATION OF INDIAN PROGRAMS

(INCLUDING TRANSFER OF FUNDS)

Appropriation enacted, 2012	$2,367,738,000
Budget estimate, 2013	2,379,431,000
Recommended, 2013	2,404,672,000
Comparison:	
Appropriation, 2012	+36,934,000
Budget estimate, 2013	+25,241,000

The Committee recommends $2,404,672,000 for the Operation of Indian Programs, $36,934,000 above the fiscal year 2012 enacted level and $25,241,000 above the budget request. The amounts recommended by the Committee compared with the budget estimates

by activity are shown in the table at the end of this report. Changes to the budget request follow.

Within Tribal Government, the bill includes an increase of $2,250,000 for road maintenance.

The Committee directs the Bureau to work with Tribes and tribal organizations to explore options for improving the transparency of current year contract support cost information, and to report back to the Committee within 90 days of enactment of this Act.

Within Education, the bill includes the following increases: $12,991,000 to make up half of the projected shortfall in administrative cost grants, which the Committee notes are also contract support costs; and $1,000,000 for the Johnson-O'Malley (JOM) program.

The Committee is disappointed that the Bureau failed to update its count of students eligible for JOM program funding and to report back to the Committee as directed in House Report 112–331. The Committee directs the Bureau, in coordination with the Department of Education, and in consultation with the Tribes, to update its count of students eligible for the Johnson-O'Malley Program funding and to report the results to this Committee within 180 days of enactment of this Act. In addition, the Committee directs the Bureau to reestablish the full-time permanent Johnson-O'Malley coordinator position that was terminated in 2005.

Within Public Safety and Justice, the bill includes the following increases: $7,443,000 for law enforcement; and $557,000 for tribal courts.

For the purpose of addressing the needs of American Indian youth in custody at tribal detention centers operated or administered by the BIA, the Committee considers educational and health-related services to juveniles in custody to be allowable costs for detention/corrections program funding.

Within Community and Economic Development, the bill includes an increase of $1,000,000 for minerals and mining management. The Committee directs the Department to work with Tribes to develop a pilot program to accelerate conventional energy and mineral development on lands held in trust for American Indians. The Committee notes that not all Federal lands are public lands; that conventional energy and mineral development on Tribal trust lands is lagging behind State and private lands; that energy and mineral development on Tribal trust lands can have tremendous economic benefits for people who, as a group, suffer from some of the worst economic conditions in the country; that the Department has an obligation to act in their best interests to the greatest extent allowable by law; and that it must be Tribes themselves who determine what is in their best interests, particularly on lands held in trust specifically for them. The Committee took testimony this year from several witnesses who highlighted a number of concerns with the current energy and mineral development approval process, including permit fees, the need for additional Federal and Tribal personnel and training, and fair distribution of personnel around the country. The Committee directs the Department to use the pilot program to make a good faith effort, using existing authorities, to address these concerns and others identified by Tribes.

The Committee remains concerned that efforts to implement new administrative policies for P.L. 102–477 funds have the potential to

add additional costs to Tribes, thereby diverting funds from the important services that this program provides. The Committee notes that there has been no evidence of misuse of these funds since the program's inception 20 years ago. The Committee recognizes the significant progress made by the P.L. 102–477 Tribal Work Group and the Administration to resolve the issues surrounding these policies, as directed by House Report 112–331, and feels strongly that these joint efforts should continue in pursuit of a permanent resolution. In particular, the parties are urged to resolve the financial reporting issues in a way that meets the goals of administrative flexibility and fiscal accountability without impeding the end outcome goals of the "477" program.

CONSTRUCTION

(INCLUDING TRANSFER OF FUNDS)

Appropriation enacted, 2012	$123,630,000
Budget estimate, 2013	105,910,000
Recommended, 2013	117,110,000
Comparison:	
Appropriation, 2012	−6,520,000
Budget estimate, 2013	+11,200,000

The Committee recommends $117,110,000 for Construction, $6,520,000 below the fiscal year 2012 enacted level and $11,200,000 above the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. Changes to the budget request follow.

Within Education, the bill includes an increase of $9,200,000 for replacement school construction, which should complete the next project on the 2004 priority list. The Committee continues to urge the Bureau to move with all deliberate speed to publish a new replacement school construction priority list and to request funding in fiscal year 2014 to implement projects on the list.

The Committee notes the conditions of the Bug O Nay Ge Shig School of the Leech Lake Band of Ojibwe as an example of the significant safety and health hazards that have not received due attention by this Administration. The Committee urges the Bureau to continue to work with the Leech Lake Band of Ojibwe and other Tribes to replace and repair their school facilities.

The Committee commends the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation for their initiative in addressing their law enforcement needs by constructing a justice center to house their adult and juvenile detention and rehabilitation center, tribal courts, and police department. The Committee also commends the Bureau of Indian Affairs in its efforts to assist the Shoshone-Bannock Tribes in ensuring that the Center continues to operate effectively. Knowing that work must be done in consultation with Tribes, the Committee continues to encourage the Bureau to consider establishing regional detention centers at new or existing facilities, such as the Shoshone-Bannock Tribes' Justice Center, as it works to combat the crime problem in Indian Country.

Within General Administration, the bill includes an increase of $2,000,000 for Construction Program Management.

INDIAN LAND AND WATER CLAIM SETTLEMENTS AND MISCELLANEOUS PAYMENTS TO INDIANS

Appropriation enacted, 2012	$32,802,000
Budget estimate, 2013	36,293,000
Recommended, 2013	36,293,000
Comparison:	
Appropriation, 2012	+3,491,000
Budget estimate, 2013	0

The Committee recommends $36,293,000 for Indian Land and Water Claim Settlements and Miscellaneous Payments to Indians, as requested, $3,491,000 above the fiscal year 2012 enacted level.

INDIAN GUARANTEED LOAN PROGRAM ACCOUNT

Appropriation enacted, 2012	$7,103,000
Budget estimate, 2013	5,000,000
Recommended, 2013	10,000,000
Comparison:	
Appropriation, 2012	+2,897,000
Budget estimate, 2013	+5,000,000

The Committee recommends $10,000,000 for the Indian Guaranteed Loan Program Account, $2,897,000 above the fiscal year 2012 enacted level and $5,000,000 above the budget request.

DEPARTMENTAL OFFICES

OFFICE OF THE SECRETARY

The Office of the Secretary supports a wide-range of Departmental business, policy, and oversight functions. In September 2010, Secretarial Order 3306 established the Office of Natural Resources Revenue as part of the reorganization of the former Minerals Management Service (MMS). This revenue collection and compliance function is now managed within the Office of the Secretary.

DEPARTMENTAL OPERATIONS

Appropriation enacted, 2012	$261,897,000
Budget estimate, 2013	261,631,000
Recommended, 2013	247,777,000
Comparison:	
Appropriation, 2012	−14,120,000
Budget estimate, 2013	−13,854,000

The Committee recommends $247,777,000 for Departmental Operations, $14,120,000 below the fiscal year 2012 enacted level and $13,854,000 below the budget request. The detailed allocation of funding by program is included in the table at the end of this report.

Leadership and Administration.—The Committee recommends $120,160,000 for Leadership and Administration, equal to the fiscal year 2012 enacted level and $1,551,000 below the budget request.

Management Services.—The Committee recommends $8,199,000 for Management Services, $14,120,000 below the fiscal year 2012 enacted level and $12,112,000 below the budget request. The reduction below the request is to the Office of Valuation Services.

Office of Natural Resources Revenue.—The Committee recommends $119,418,000 for the Office of Natural Resources Rev-

enue, equal to the fiscal year 2012 enacted level and $191,000 below the budget request.

Additional Guidance.—National Monument Designations.—The Department is directed to work collaboratively with interested parties, including the Congress, States, local communities, tribal governments and others prior to planning, implementing, or making national monument designations.

Technical Assistance.—The Committee understands and values the technical expertise and depth of knowledge that Federal land managers and researchers possess, and sees the potential value in providing volunteer opportunities for senior agency leaders to share their expertise and technical assistance to supporting national parks and forests in other countries. The Committee encourages the Secretary of the Interior and the Chief of the Forest Service to connect willing former and current senior employees with non-governmental organizations seeking to assist other countries in building the capacity to manage natural resources and public lands.

Aerial Monitoring.—The Department has indicated that it utilizes unmanned aircraft on loan from the Department of Defense to develop an "operational capability strategy" to support DOI's natural resource missions. According to the Department, operations are limited to Federal (Interior) lands and are vetted with interagency partners such as the FAA. Each operation undergoes an approval process including DOI Solicitor review which is intended to mitigate risk of misuse. These aircraft are centrally managed by the Department's Office of Aircraft Services which maintains inventory control. The Committee directs the Department to submit a report to the House and Senate Committees on Appropriations within 180 days of enactment of this Act that identifies by fiscal year: the specific location and nature of work being performed by unmanned aerial vehicles; the amount of funding spent to contract for aerial over-flights; the contractor performing the work; and the number of flights performed. The report shall include expenditures for each fiscal year up through fiscal year 2012.

Bill Language.—The Committee has continued to include bill language that deducts two percent of State royalties to help cover Federal administrative costs.

The Committee has eliminated bill language from prior years relating to a limitation on personal services. Based on various existing statutory prohibitions imposing limits on the use of funds, the provision is redundant and no longer necessary.

The Committee has included bill language extending mandatory funding of the Payments in Lieu of Taxes (PILT) Program for fiscal year 2013.

INSULAR AFFAIRS

ASSISTANCE TO TERRITORIES

The Office of Insular Affairs (OIA) was established on August 4, 1995, through Secretarial Order No. 3191, which also abolished the former Office of Territorial and International Affairs. The OIA has important responsibilities to help the United States government fulfill its responsibilities to the four U.S. territories of Guam, American Samoa (AS), U.S. Virgin Islands (USVI) and the Com-

monwealth of the Northern Mariana Islands (CNMI) and also the three freely associated States: the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI) and the Republic of Palau. The permanent and trust fund payments to the territories and the compact nations provide substantial financial resources to these governments. During fiscal year 2004, financial arrangements for the Compacts of Free Association with the FSM and the RMI were implemented. These also included mandatory payments for certain activities previously provided in discretionary appropriations as well as Compact impact payments of $30,000,000 per year split among Guam, CNMI, AS, and Hawaii. During fiscal year 2013 permanent funding of $487,254,000 will be made available to these governments in addition to the discretionary funding discussed below.

Appropriation enacted, 2012	$87,901,000
Budget estimate, 2013	84,946,000
Recommended, 2013	79,946,000
Comparison:	
Appropriation, 2012	−7,955,000
Budget estimate, 2013	−5,000,000

The amounts recommended by the Committee for the Office of Insular Affairs appropriations accounts compared with the budget estimates by activity are shown in the table at the end of this report. The Committee recommends $79,946,000 for Assistance to Territories, $7,955,000 below the fiscal year 2012 enacted level and $5,000,000 below the budget request.

COMPACT OF FREE ASSOCIATION

Appropriation enacted, 2012	$17,313,000
Budget estimate, 2013	3,054,000
Recommended, 2013	3,313,000
Comparison:	
Appropriation, 2012	−14,000,000
Budget estimate, 2013	+259,000

The Committee recommends $3,313,000 for the Compact of Free Association, $14,000,000 below the fiscal year 2012 enacted level and $259,000 above the budget request. The Committee expects the Compact will be renegotiated and therefore the discretionary stopgap funding will not be necessary in fiscal year 2013. Further, the Committee finds insufficient justification to reduce funding for the Enewetak program and maintains funding at the fiscal year 2012 enacted level.

ADMINISTRATIVE PROVISIONS, INSULAR AFFAIRS

Bill language has been included to provide the Secretary with authority to redistribute capital improvement funds in fiscal year 2013 based upon expenditure rates in the territories.

OFFICE OF THE SOLICITOR

SALARIES AND EXPENSES

Appropriation enacted, 2012	$66,190,000
Budget estimate, 2013	64,939,000
Recommended, 2013	64,654,000
Comparison:	
Appropriation, 2012	−1,536,000
Budget estimate, 2013	−285,000

The Committee recommends $64,654,000 for Salaries and Expenses of the Office of the Solicitor, $1,536,000 below the fiscal year 2012 enacted level and $285,000 below the budget request. The detailed allocation of funding by program is included in the table at the end of this report.

Bill Language.—The bill includes modified language in Title I General Provisions addressing the trailing of livestock across public lands. The language modification is necessitated by the Office of the Solicitor providing information on bill language to the Committee on Appropriations during development of the fiscal year 2012 Interior, Environment, and Related Agencies Appropriations conference report and subsequently changing its legal interpretation of the language following the bill's enactment.

OFFICE OF INSPECTOR GENERAL

SALARIES AND EXPENSES

Appropriation enacted, 2012	$49,392,000
Budget estimate, 2013	48,493,000
Recommended, 2013	48,493,000
Comparison:	
Appropriation, 2012	−899,000
Budget estimate, 2013	0

The Committee recommends $48,493,000 for Salaries and Expenses of the Office of Inspector General, $899,000 below the fiscal year 2012 enacted level and equal to the budget request. The detailed allocation of funding by program is included in the table at the end of this report.

OFFICE OF THE SPECIAL TRUSTEE FOR AMERICAN INDIANS

FEDERAL TRUST PROGRAMS

(INCLUDING TRANSFER OF FUNDS)

The Office of the Special Trustee for American Indians was established by the American Indian Trust Fund Management Reform Act of 1994 (Public Law 103–412). The Department of the Interior is responsible for managing 55 million surface acres and 57 million acres of subsurface mineral interests for over 300,000 Individual Indian Money (IIM) accounts and over 2,900 trust accounts (over 250 Tribes). On these lands, the Department of the Interior manages over 100,000 leases for individual Indians and Tribes. The Department received approximately $401,000,000 in fiscal year 2011 from leases, permits, land sale revenues, royalties from mineral resources, settlements and judgments, and investment income for Individual Indian Money accounts, and approximately $609,000,000 for Tribal accounts.

Appropriation enacted, 2012	$152,075,000
Budget estimate, 2013	146,000,000
Recommended, 2013	146,000,000
Comparison:	
Appropriation, 2012	−6,075,000
Budget estimate, 2013	0

The Committee recommends $146,000,000 for Federal Trust Programs, as requested, $6,075,000 below the fiscal year 2012 enacted level. The detailed allocation of funding by program is included in the table at the end of this report.

DEPARTMENT-WIDE PROGRAMS

WILDLAND FIRE MANAGEMENT

(INCLUDING TRANSFERS OF FUNDS)

The Department's Wildland Fire Management and FLAME wildfire suppression reserve accounts support fire activities for the Bureau of Land Management, the National Park Service, the Fish and Wildlife Service, and the Bureau of Indian Affairs.

Appropriation enacted, 2012	$483,589,000
Budget estimate, 2013	726,473,000
Recommended, 2013	746,473,000
Comparison:	
Appropriation, 2012	+262,884,000
Budget estimate, 2013	+20,000,000

The Committee recommends $746,473,000 for Wildland Fire Management at the Department of the Interior, $262,884,000 above the fiscal year 2012 enacted level and $20,000,000 above the budget request. The Committee's recommendation, combined with $92,000,000 recommended in the FLAME wildfire suppression reserve account, fully funds the 10-year fire suppression average expenditures. The Committee notes that the dramatic increase in appropriations compared to fiscal year 2012 is due to: (1) an increase in the 10-year fire suppression average expenditures for the Department of the Interior; and (2) the use of $189,577,000 in emergency carry-over suppression dollars in fiscal year 2012 to offset appropriations.

Wildfire Preparedness.—The Committee recommends $279,508,000 for Wildfire Preparedness, as requested, $2,986,000 above the fiscal year 2012 enacted level. The Committee believes that the Department and the Forest Service must work together, along with States and other partners, to maintain sufficient readiness within the preparedness program. The Department should immediately notify the Committees on Appropriations if it appears that funding shortfalls may limit needed firefighting capacity.

Wildfire Suppression Operations.—The Committee recommends $276,508,000, as requested, for Wildfire Suppression Operations, $6,027,000 above the fiscal year 2012 enacted level. The Committee recommendation, including the FLAME wildfire suppression reserve fund, fully funds the 10-year fire suppression average expenditures.

Hazardous Fuels.—The Committee recommends $167,315,000 for the Hazardous Fuels program, $15,706,000 below the fiscal year 2012 enacted level and $22,000,000 above the budget request.

As stated in the fiscal year 2012 Interior, Environment, and Related Agencies conference report, the Committee is aware of the duplication that exists in the Department of the Interior's wildland fire programs (multiple parallel organizations in four bureaus with multiple levels to manage multiple fire activities). The Committee is deeply concerned about the growth of the Department's Office of Wildland Fire Coordination in Boise, Idaho, especially with few or no FTE reductions in other areas. The Committee notes that FTE's for the Boise office are expected to increase dramatically in fiscal year 2013 with no identifiable benefit.

The Committee awaits the report required on the Department's wildland fire programs per the fiscal year 2012 Interior, Environment, and Related Agencies conference report. Until this report is received, and its recommendations are approved by the Committee, the Department is directed to maintain the Office of Wildland Fire Coordination at current levels.

The Committee again directs the Department to continue funding hazardous fuels reduction on the highest priority projects in the highest priority areas rather than spending funds based on percentages of acres treated in the wildland urban interface.

The Committee directs the Department to better coordinate hazardous fuels funding with Department agencies and States to protect core sage grouse habitat from catastrophic wildfires using both hazardous fuels dollars to prevent wildfires and preparedness/suppression dollars to suppress fires. Further, the Committee expects Department agencies to devote a higher portion of funds on these efforts.

FLAME Wildfire Suppression Reserve Fund

(INCLUDING TRANSFER OF FUNDS)

Appropriation enacted, 2012	$91,853,000
Budget estimate, 2013	92,000,000
Recommended, 2013	92,000,000
Comparison:	
Appropriation, 2012	+147,000
Budget estimate, 2013	0

The Committee recommends $92,000,000 for the FLAME Wildfire Suppression Reserve Fund, as requested, $147,000 above the fiscal year 2012 enacted level. As discussed above under the Wildland Fire Management account, the Committee fully funds the 10-year average expenditure for wildfire suppression.

Central Hazardous Materials Fund

Appropriation enacted, 2012	$10,133,000
Budget estimate, 2013	9,598,000
Recommended, 2013	9,133,000
Comparison:	
Appropriation, 2012	−1,000,000
Budget estimate, 2013	−465,000

The Committee recommends $9,133,000 for the Central Hazardous Materials Fund, $1,000,000 below the fiscal year 2012 enacted level and $465,000 below the budget request.

NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION

NATURAL RESOURCE DAMAGE ASSESSMENT FUND

Appropriation enacted, 2012	$6,253,000
Budget estimate, 2013	6,263,000
Recommended, 2013	6,000,000
Comparison:	
Appropriation, 2012	−253,000
Budget estimate, 2013	−263,000

The Committee recommends $6,000,000 for the Natural Resource Damage Assessment Fund, $253,000 below the fiscal year 2012 enacted level and $263,000 below the budget request. The detailed allocation of funding by program is included in the table at the end of this report.

WORKING CAPITAL FUND

Appropriation enacted, 2012	$61,920,000
Budget estimate, 2013	70,647,000
Recommended, 2013	56,936,000
Comparison:	
Appropriation, 2012	−4,984,000
Budget estimate, 2013	−13,711,000

The Committee recommends $56,936,000 for the Working Capital Fund, $4,984,000 below the fiscal year 2012 enacted level and $13,711,000 below the budget request.

The Committee recommends $56,936,000 for the Financial and Business Management System (FBMS), equal to the fiscal year 2012 enacted level and $10,211,000 below the budget request. The Committee has not included the requested increase of $3,500,000 for Cultural and Scientific Collections.

Bill Language.—The Committee has included bill language from prior years continuing the Department of the Interior's prohibition on establishing reserves in the appropriated Working Capital Fund other than for accrued annual leave and depreciation of equipment without the prior approval of the House and Senate Committees on Appropriations.

The Committee has continued language from prior years relating to the Department's ability to recover its costs for leasing space and providing for training, professional services and equipment to State, local and tribal government employees at the National Indian Program Training Center in Albuquerque, New Mexico. The National Indian Training Center's mission is to establish partnerships with State, local and tribal governments for providing educational opportunities in support of the Department's trust responsibilities to American Indians. Any funds recovered shall only be available to the National Indian Program Training Center.

The Committee has also included language, as requested, providing authority to enter into grants and cooperative agreements associated with ONRR's minerals revenue collection and management functions including the State and Tribal Audit Program. ONNR had such authority under the former Bureau of Ocean Energy, Management, Regulation and Enforcement prior to its transfer to the Office of the Secretary.

The Committee has included an Administrative Provision governing the acquisition of certain aircraft but has not included the requested authority for the acquisition of 250 unmanned aircraft.

The Committee believes the use of certain unmanned aerial vehicles may be beneficial in supporting a variety of the Department's natural resource missions. Because of a number of questions and concerns raised about the aerial monitoring of public lands, the Committee has requested a report detailing the specific nature of this work.

GENERAL PROVISIONS, DEPARTMENT OF THE INTERIOR (INCLUDING TRANSFERS OF FUNDS)

Section 101 continues a provision providing for emergency transfer authority (intra-bureau) with the approval of the Secretary.

Section 102 continues a provision providing for emergency transfer authority (Department-wide) with the approval of the Secretary.

Section 103 continues a provision providing for the use of appropriations for certain services.

Section 104 continues a provision permitting the transfer of funds between the Bureau of Indian Affairs and the Office of the Special Trustee for American Indians.

Section 105 continues a provision allowing the Secretary to pay private attorney fees for employees and former employees in connection with Cobell v. Salazar.

Section 106 continues a provision allowing Outer Continental Shelf inspection fees to be collected by the Secretary of the Interior.

Section 107 continues a provision authorizing the Bureau of Land Management to implement an oil and gas Internet leasing program.

Section 108 continues a provision allowing for the reorganization of the Bureau of Ocean Energy Management, Regulation and Enforcement only in conformance with Committee reprogramming guidelines.

Section 109 continues a provision allowing the Bureau of Indian Education to utilize funds recovered from grants or ISDA contracts to Tribes upon re-assumption of school operations by the Bureau.

Section 110 continues a provision allowing the Bureau of Land Management to enter into long-term cooperative agreements for long-term care and maintenance of excess wild horses and burros on private land.

Section 111 continues a provision dealing with the U.S. Fish and Wildlife Service's responsibilities for mass marking of salmonid stocks.

Section 112 modifies a provision addressing BLM actions regarding grazing on public lands.

Section 113 modifies a provision providing for the trailing of livestock across public lands through fiscal year 2014.

Section 114 continues a provision prohibiting funds to implement, administer or enforce Secretarial Order 3310 issued by the Secretary of the Interior on December 22, 2010.

Section 115 makes corrections on claim maintenance fee amendments.

Section 116 extends by one year the reporting deadline for the Indian Law and Order Commission to complete its report to Congress. The Commission's work was delayed by a year due to a lack of Federal funds.

Section 117 requires the Secretary to make a timely decision on the matter of a proposal to delist gray wolves.

TITLE II—ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) was created by Reorganization Plan No. 3 of 1970, which consolidated nine programs from five different agencies and departments. Major EPA programs include air and water quality, drinking water, hazardous waste, research, pesticides, radiation, toxic substances, enforcement and compliance assurance, pollution prevention, Inland oil spill, Superfund, Brownfields, and the Leaking Underground Storage Tank program. In addition, EPA provides Federal assistance for wastewater treatment, sewer overflow control, drinking water facilities, other water infrastructure projects, and diesel emission reduction projects. The Agency is responsible for conducting research and development, establishing environmental standards through the use of risk assessment and cost-benefit, monitoring pollution conditions, seeking compliance through enforcement actions, managing audits and investigations, and providing technical assistance and grant support to States and Tribes, which are delegated authority for much of the program implementation. Under existing statutory authority, the Agency contributes to specific homeland security efforts and may participate in international environmental activities.

Among the statutes for which the Environmental Protection Agency has sole or significant oversight responsibilities are:

National Environmental Policy Act of 1969, as amended.

Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

Toxic Substances Control Act, as amended.

Clean Water Act [Federal Water Pollution Control Act], as amended.

Federal Food, Drug and Cosmetic Act, as amended.

Ocean Dumping Act [Marine Protection, Research, and Sanctuaries Act of 1972], as amended.

Oil Pollution Act of 1990.

Safe Drinking Water Act [Public Health Service Act (Title XIV)], as amended.

Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act.

Clean Air Act, as amended.

Great Lakes Legacy Act of 2002.

Bioterrorism Preparedness and Response Act of 2002.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended.

Small Business Liability Relief and Brownfields Revitalization Act of 2002 (amending CERCLA).

Emergency Planning and Community Right-to-Know Act of 1986.

Pollution Prevention Act of 1990.

Pollution Prosecution Act of 1990.

Pesticide Registration Improvement Act of 2003.

Energy Policy Act of 2005.

Energy Independence and Security Act of 2007.

For fiscal year 2013, the Committee recommends $7,055,041,000 for the Environmental Protection Agency, $1,394,344,000 below the fiscal year 2012 enacted level and $1,289,439,000 below the budget request. The amounts recommended by the Committee are changes to the request. Comparison to the budget request and 2012 enacted

levels are shown by account, program area and selected activity in the table at the end of the report.

Reprogramming.—The Agency is held to the reprogramming limitation of $1,000,000. This limitation will be applied to each program area in every account at the levels provided in the detailed table at the end of this report. This will allow the Agency the flexibility to reprogram funds within a set program area. However, where the Committee has cited funding levels for certain program projects or activities within a program area, the reprogramming limitation continues to apply to those funding levels. Further, the Agency may not use any amount of deobligated funds to initiate a new program, office, or initiative, without the prior approval of the Committee. The other guidelines laid out in the "Reprogramming Guidelines" section of this report continue to be in effect.

Congressional Budget Justification.—The Committee directs the Agency to include in future Justifications the following items: (1) a comprehensive index of programs and activities within the program projects; (2) the requested bill language, with changes from the enacted language highlighted, at the beginning of each account section; (3) a justification for every program/project, including those proposed for elimination; (4) a comprehensive, detailed explanation of all changes within a program project; (5) a table showing consolidations, realignments or other transfers of resources and personnel from one program project to another such that the outgoing and receiving program projects offset and clearly illustrate a transfer of resources; and, (6) a table listing the budgets and FTE by major office within each National Program Management area with pay/non-pay breakouts. The Committee notes that the Congressional Justification includes the bill language for each account. The Committee directs the Agency to highlight and explain any changes to the proposed bill language in the Congressional Justification.

SCIENCE AND TECHNOLOGY

The Science and Technology (S&T) account funds all Environmental Protection Agency research (including Superfund research activities paid with funds moved into this account from the Hazardous Substance Superfund account). This account includes programs carried out through grants, contracts, and cooperative agreements, cooperative research and development agreements, and interagency agreements, with other Federal agencies, States, universities, nonprofit organizations, and private business, as well as in-house research. It also funds personnel compensation and benefits, travel, supplies and operating expenses, including rent, utilities and security, for all Agency research. Research addresses a wide range of environmental and health concerns across all environmental media and encompasses both long-term basic and near-term applied research to provide the scientific knowledge and technologies necessary for preventing, regulating, and abating pollution, and to anticipate emerging environmental issues.

Appropriation enacted, 2012	$793,728,000
Budget estimate, 2013	807,257,000
Recommended, 2013	738,357,000
Comparison:	
Appropriation, 2012	−55,371,000
Budget estimate, 2013	−68,900,000

The Committee recommends $738,357,000 for Science and Technology, $55,371,000 below the fiscal year 2012 enacted level and $68,900,000 below the budget request. The Committee recommends that $22,979,000 be paid to this account from the Hazardous Substance Superfund account for ongoing research activities. The changes to the request, as recommended by the Committee, appear in the table at the end of this report. The Committee provides the following additional detail by program area.

Clean Air and Climate.—The Committee recommends $115,819,000, which is $8,559,000 below the fiscal year 2012 enacted level and $11,289,000 below the budget request. The Committee has not provided the requested increase to implement the Cross-State Air Pollution rule, and maintains funding for Federal Vehicle and Fuels standards at the fiscal year 2012 enacted level.

Enforcement.—Funding for forensics support has been maintained at the 2012 enacted level of $15,269,000, which is $324,000 below the budget request.

IT/Data Management.—Funding has been maintained at the fiscal year 2012 enacted level of $3,652,000, which is $395,000 below the budget request.

Operations and Administration.—The Committee recommends $68,970,000 for Facilities Infrastructure and Operations, $3,049,000 below the fiscal year 2012 enacted level and $6,515,000 below the budget request. The Committee continues to support plans to reduce energy utilization rates in order to mitigate rising utility costs.

Pesticide Licensing.—Funding has been maintained at the fiscal year 2012 enacted level of $6,563,000 which is $535,000 below the budget request.

Research: Air, Climate and Energy.—The Committee recommends $95,043,000, which is $3,802,000 below the fiscal year 2012 enacted level and $10,851,000 below the budget request. From within this amount, $77,195,000 is for Research: Clean Air and $15,805,000 is for Research: Global Change.

Research: Chemical Safety and Sustainability.—The Committee recommends $123,047,000, which is $8,241,000 below the fiscal year 2012 enacted level and $11,699,000 below the budget request.

Research: National Priorities.—The bill provides $5,000,000 which shall be used for extramural research grants, independent of the STAR grant program, to fund high-priority water quality and availability research by not-for-profit organizations who often partner with the Agency. Funds shall be awarded competitively with priority given to partners proposing research of national scope and who provide a 25 percent match. The Agency is directed to allocate funds to grantees within 180 days of enactment of this Act.

Research: Safe and Sustainable Water Resources.—The Committee recommends $101,921,000, which is $11,555,000 below the fiscal year 2012 enacted level and $19,269,000 below the budget request. Within the funds provided, the Committee supports the requested increase for research to reduce combined sewer overflow impacts. The Committee has not provided the requested $4,250,000 increase for additional hydraulic fracturing research, or the $2,000,000 increase for the new Southern New England Program. Further, the Committee rejects the proposed $2,326,000 cut to the innovative research on small drinking water systems.

Research: Sustainable and Healthy Communities.—The Committee recommends $152,707,000, which is $18,034,000 below the fiscal year 2012 enacted level and $13,023,000 below the budget request.

Additional Guidance.—The Committee has included the following additional guidance with respect to funding provided under this account.

Endocrine Disruptor Research.—The Committee has longstanding interest in EPA's effort in determining possible health and environmental effects of chemicals. To improve analysis of chemicals, EPA needs to improve its scientific understanding of chemical properties in order to better inform the Agency's Contaminant Candidate List as required by the Safe Drinking Water Act; Air Toxics Strategy as required under the Clean Air Act; and all required activities under the Toxic Substances Control Act. EPA is directed to provide a report to the Committee that details its current and future efforts to develop approaches to understand the toxicity of chemicals in terms of molecular "groups" or "families" based on the chemical's intrinsic properties. In addition, as part of EPA's overall efforts to modernize risk assessment protocols, the Committee encourages EPA to incorporate the various recommendations of the National Academy of Sciences report, "Science and Decisions," and develop a report on the latest scientific literature on low-dose toxicity and non-monotonic dose response curves.

Hydraulic Fracturing.—In 2010, the Committee urged EPA to research whether there is a relationship between hydraulic fracturing and drinking water. The Committee understands EPA has incorporated a review of environmental justice impacts into this study, which the Committee finds to be outside the scope of the 2010 language and an inappropriate use of funds. No funds have been provided in the bill to research environmental justice impacts related to hydraulic fracturing, and EPA shall discontinue the use of any resources that may have been diverted to this subactivity. The Committee directs the Agency to release the study's findings with respect to whether there is a relationship between hydraulic fracturing and drinking water following appropriate public comment as directed in House Report 112–151 and peer review.

Integrated Risk Information System (IRIS).—The Committee strongly supports the goals of EPA's IRIS Program and believes a transparent, robust, and reproducible approach for synthesizing scientific information is an important element of influential Federal scientific assessment programs. However, it has become increasingly clear that fundamental improvements in the policies and practices of the IRIS program are necessary to ensure that the assessments developed are firmly based on up-to-date scientific knowledge, meet the highest of standards of scientific inquiry, and are evaluated in accordance with acceptable scientific approaches. Therefore, building from the directives in the fiscal year 2012 Interior, Environment, and Related Agencies conference report, the Committee directs the Agency to take the following actions:

(a) For draft and final IRIS assessments released in fiscal year 2013, the Agency shall include documentation describing how the Chapter 7 recommendations of the National Academy of Sciences (NAS) have been implemented or addressed, including an explanation for why certain recommendations were not incorporated.

(b) The Agency shall issue a progress report to the House and Senate Committees on Appropriations and relevant Congressional authorizing committees no later than March 1, 2013, describing the IRIS Program's implementation of the National Research Council's Chapter 7 recommendations.

(c) Accordingly, the Committee directs EPA to re-evaluate, using acrylonitrile and other relevant assessments as case studies, the methods previously used to evaluate and interpret the body of available scientific data, including the weight-of-evidence approach, and include in the report called for in section (b) a chapter on whether there are scientifically more appropriate methods to assess, synthesize and draw conclusions regarding likely human health effects associated with likely exposures to the substances.

Laboratory Workforce Planning.—In July 2011, the GAO found that EPA needs a more coordinated approach to managing its laboratories. Of particular concern to the Committee, the GAO's findings reiterated that the Agency has failed to comprehensively plan for managing its workforce across its laboratories. The Committee is pleased that the Agency has identified a number of science-related positions as mission critical occupations. However, EPA should develop a comprehensive workforce planning process for all laboratories that is based on reliable workforce data in order to identify future needs across all Agency laboratories.

Title 42 Hiring Authority.—The Committee has increased the authorized cap for Title 42 slots from 30 to 50 in the Administrative Provisions section. While the Committee recognizes the world class talent that currently resides within the Agency, EPA should identify where critical talent gaps exist and actively recruit accredited scientists with the knowledge and expertise needed by the Agency. As such, the Committee continues to direct EPA to use Title 42 authority to recruit external talent to the Agency.

ToxCast.— The Committee supports EPA's leadership role in the creation of a new paradigm for chemical risk assessment based on the incorporation of advanced molecular biological and computational methods in lieu of animal toxicity tests. The Committee encourages EPA to continue to expand its support for the use of human biology-based experimental and computational approaches in health research to further define toxicity and disease pathways and develop tools for their integration into evaluation strategies. Funding should be made available for the evaluation of the relevance and reliability of Tox21 methods and prediction tools to assure readiness and utility for regulatory purposes, including pilot studies of pathway-based risk assessments. The Committee directs that EPA provide a report on associated funding in fiscal year 2013 for the aforementioned activities and a progress report of Tox21 activities in the fiscal year 2014 Congressional justification, featuring a five-year plan for projected budgets for the development of Tox21 methods, and including prediction models and activities specifically focused on establishing scientific confidence in them for regulatory applications.

ENVIRONMENTAL PROGRAMS AND MANAGEMENT

The Environmental Programs and Management account encompasses a broad range of abatement, prevention, enforcement, and compliance activities, and personnel compensation, benefits, travel,

and expenses for all programs of the Agency except Science and Technology, Hazardous Substance Superfund, Leaking Underground Storage Tank Trust Fund, Inland Oil Spill Programs, and the Office of Inspector General.

Abatement, prevention, and compliance activities include setting environmental standards, issuing permits, monitoring emissions and ambient conditions and providing technical and legal assistance toward enforcement, compliance, and oversight. In most cases, the States are directly responsible for actual operation of the various environmental programs, and the Agency's activities include oversight and assistance.

In addition to program costs, this account funds administrative costs associated with the operating programs of the Agency, including support for executive direction, policy oversight, resources management, general office and building services for program operations, and direct implementation of Agency environmental programs for headquarters, the ten EPA regional offices, and all nonresearch field operations.

Appropriation enacted, 2012	$2,678,222,000
Budget estimate, 2013	2,817,179,000
Recommended, 2013	2,479,081,000
Comparison:	
Appropriation, 2012	−199,141,000
Budget estimate, 2013	−338,098,000

The Committee recommends $2,479,081,000 for Environmental Programs and Management, $199,141,000 below the fiscal year 2012 enacted level and $338,098,000 below the budget request. The changes to the request, as recommended by the Committee, appear in the table at the end of this report. The Committee provides the following additional detail by program area:

Brownfields.—The Committee recommends $23,642,000, equal to the fiscal year 2012 enacted level and $2,043,000 below the budget request. The Committee has not provided funding for the Smart Growth program, a voluntary interagency partnership established in 2009 without a Congressional mandate. The Committee maintains the FTE at the fiscal year 2012 enacted level as grants in the STAG account have been reduced.

Clean Air and Climate.—The Committee recommends $256,709,000, $29,399,000 below the fiscal year 2012 enacted level and $56,486,000 below the budget request. Within the amount provided, the Committee directs the following changes to the request:

For the Climate Protection Program, the Committee provides $84,919,000, which is $14,562,000 below the fiscal year 2012 enacted level and $23,072,000 below the budget request. The Committee provides the following program amounts from within this total: (1) $48,063,000 for the Energy Star program; (2) $6,400,000 for the Greenhouse Gas Registry; and (3) $25,529,000 for voluntary climate protection programs which divert funds away from EPA's core mission responsibilities and often lack a statutory mandate.

For Federal Stationary Source Regulations, the Committee provides $20,590,000, which is $6,708,000 below the fiscal year 2012 enacted level and $13,552,000 below the budget request. This amount provided does not include funding for the greenhouse gas New Source Performance Standards. Further, EPA's justification identifies 70 air toxics rules that need to be under development by

fiscal year 2013. EPA's regulatory agenda is out of control and it must be tempered. Further, the committee disagrees with the proposal to add 24 new Federal regulators for stationary sources.

For Federal Support for Air Quality Management, the Committee provides $115,270,000, which is $8,199,000 below the fiscal year 2012 enacted level and $19,571,000 below the budget request. The recommended level includes a $3,100,000 reduction from the budget request to fund EPA's greenhouse gas stationary source permitting programs at the fiscal year 2011 enacted level.

Compliance.—The Committee provides $106,707,000, equal to the fiscal year 2012 enacted level and $18,502,000 below the budget request.

Enforcement.—The Committee recommends $226,555,000, which is $23,004,000 below the fiscal year 2012 enacted level and $38,887,000 below the budget request. For fiscal year 2013, EPA continues to propose increases for the enforcement budget despite reductions in the FTE levels.

Environmental Protection: National Priorities.—The bill provides $15,000,000 for a competitive grant program to provide rural and urban communities with technical assistance to improve water quality and provide safe drinking water. Of the amount provided, $13,000,000 shall be for grants to qualified not-for-profits providing training and technical assistance on a national level, or multi-state regional basis, and $2,000,000 shall be for grants to qualified not-for-profits to provide technical assistance to private drinking water well owners. EPA shall award grants to not-for-profit organizations that provide at least a 10 percent match, including in-kind contributions. EPA shall give priority to those organizations that are supported by a majority of small community water systems or currently provide assistance to private well owners. The Agency is directed to allocate funds to grantees within 180 days of enactment of this Act.

Geographic Programs.—The Committee recommends $346,261,000, which is $63,458,000 below the fiscal year 2012 enacted level and $65,441,000 below the budget request. The Committee has provided funding for programs that support restoration and protection of our nation's most important water bodies, as protection of these resources continues to be a priority for the Committee. From within the amount provided, the Committee directs the following changes to the request:

Great Lakes Restoration Initiative.—The Committee recommends $250,000,000 for the Great Lakes Restoration Initiative (GLRI), $49,520,000 below the fiscal year 2012 enacted level and $50,000,000 below the budget request. The GLRI continues to be the largest single recipient of funds within Geographic Programs, and restoration of the Great Lakes continues to be a key priority for the Committee. EPA may distribute the funds provided among the five focus areas but shall not spend less than the fiscal year 2012 enacted level for Toxic Substances and Areas of Concern and for the Invasive Species focus areas. The Committee directs the Agency to provide a revised spending plan for the Great Lakes program that includes funding levels for the five focus areas at the same time the Agency submits its Operating Plan. Once submitted, changes to the funding amounts for the focus areas are subject to a reprogramming threshold of $5,000,000. The Agency is further di-

rected to report quarterly to the Committees on Appropriations on changes below the threshold.

The Committee is pleased with EPA's recent announcement establishing a non-governmental advisory board to solicit stakeholder input in a structured manner. The Committee reminds EPA and its Federal agency partners that funds for this initiative are to supplement rather than supplant those funds already being spent on Great Lakes programs by the agencies prior to the establishment of the initiative. The Committee urges the Agency to review the size and scope of its grants to allow for increased dollar levels for individual projects that would address the areas of greatest challenge to the long-term health of the ecosystem even if these projects would result in an unbalanced distribution of funds throughout the Great Lakes States.

Lastly, the Committee directs EPA and the other Federal partners to prioritize action oriented projects in lieu of additional studies, monitoring and evaluations. Sound science should continue to serve as the backbone for all decisions in the Great Lakes; however, the Committee expects to see measurable results from the large increases provided over the last few fiscal years.

Chesapeake Bay.—The Committee recommends $50,000,000 for the Chesapeake Bay Program, $7,299,000 below the fiscal year 2012 enacted level and $22,618,000 below the budget request.

Puget Sound.—The Committee provides $29,952,000, equal to the fiscal year 2012 enacted level and $10,663,000 above the budget request. Funds shall be allocated in the same manner as directed in House Report 112–331. The Committee directs EPA to expeditiously obligate funds, in a manner consistent with the authority and responsibilities under Section 320 and the National Estuary Program.

Community Action for a Renewed Environment (CARE).—Consistent with fiscal year 2012 levels, the Committee provides no funding for the CARE program in fiscal year 2013.

Other geographic activities.—The Committee has not provided funding for the Northwest Forest program as it lacks demonstrable results.

Information Exchange/Outreach.—The Committee recommends $115,793,000, which is $14,899,000 below the fiscal year 2012 enacted level and $23,611,000 below the budget request. The recommendation provides $43,638,000 for Congressional, Intergovernmental, and External Relations. From within this amount, $2,200,000 has been provided for the Administrator's Immediate Office. The bill provides $4,235,000 for the Office of Congressional and Intergovernmental Relations, which is $4,000,000 below the budget request. The Committee is acutely aware that a backlog of responses to Congressional letters, informal questions, and questions for the record exists as Member offices have requested the Committee's assistance to obtain answers. The consistent lack of responsiveness to Congressional inquiries has been a pervasive concern raised at oversight hearings throughout the year and the pattern suggests a systematic approach to hindering Congressional oversight.

International Programs.—The Committee recommends $17,604,000, equal to the fiscal year 2012 enacted level and $1,530,000 below the budget request. Similarly, all program areas

have within the amounts provided been maintained at the fiscal year 2012 enacted level.

IT/Data Management/Security.—The Committee recommends $93,689,000, which is $1,036,000 below the fiscal year 2012 enacted level and $2,072,000 below the budget request.

Legal/Science/Regulatory/Economic Review.—The Committee recommends $89,234,000, which is $21,518,000 below the fiscal year 2012 enacted level and $43,218,000 below the budget request. The Committee has not included funding for the Smart Growth Program and the Promoting a Greener Economy Initiative in fiscal year 2013. On average, EPA produces 150 new regulations per year and the process for the regulatory development is overseen by the Office of Regulatory Policy and Management. EPA's regulatory agenda has had a chilling effect on infrastructure investments and the reductions come not only at a critical time for reducing spending but also at a time to reduce the pace of new regulations.

Operations and Administration.—The Committee recommends $473,695,000, which is $13,388,000 below the fiscal year 2012 enacted level and $37,503,000 below the budget request. EPA has the flexibility to redirect any funds from rent or utility savings in order to meet other identified needs within the recommended level.

Pesticides Licensing.—The Committee recommends $110,348,000, equal to the fiscal year 2012 enacted level and $659,000 below the budget request.

Resource Conservation and Recovery Act.—The Committee recommends $112,469,000, equal to the fiscal year 2012 enacted level and $4,829,000 below the budget request. The Committee has not provided the $2,000,000 request to develop the e-manifest system. The Committee strongly supports efforts to build a cost-effective IT system to manage manifest transactions electronically along with efforts to provide EPA with the authority to collect user fees to offset the cost to the taxpayer.

Toxics Risk Review Prevention.—The Committee recommends $97,678,000, which is $2,293,000 below the fiscal year 2012 enacted level and $11,529,000 below the budget request. The endocrine disruptor program is funded at the requested level of $7,238,000.

Water: Ecosystems.—The Committee recommends $48,174,000, equal to the fiscal year 2012 enacted level and $6,815,000 below the budget request. Funding for the National Estuary Program/Coastal Waterways and the Wetlands programs has been maintained at the fiscal year 2012 level. Considering the October 6, 2011 decision by the Federal District Court for the District of Columbia in *NMA v. Jackson* which affirmed a "statutory ceiling" for EPA's involvement in the issuance of Section 404 Clean Water Act permits, the Committee remains concerned with the backlog of mining permits that still need to be approved, particularly in Appalachia. The Committee also remains concerned about the EPA's development of comprehensive guidance for permitting reviews under the CWA and Surface Mining Control and Reclamation Act, which has not only circumvented Congressional prerogatives but also unduly hampered States' statutory role in implementing federally approved permitting programs and caused further delays and hardships in obtaining CWA and SMCRA permits. The Committee therefore expects EPA will use the funds provided to accelerate the processing of these mining permits with the Corps of Engineers.

Further, the Committee directs EPA, in consultation with the Corps of Engineers, to report quarterly on the number of Section 404 permits under review including: the date received, the number of days each permit has been under review, the "DA number", the permittee, the project name, the permit type, geographical information (county and State), and where action was taken on a permit the report should include disposition of each permit, and the date issued or remanded.

Water: Human Health Protection.—The Committee recommends $96,315,000, which is $4,784,000 below the fiscal year 2012 enacted level and $9,000,000 below the budget request.

Water Quality Protection.—The Committee recommends $192,188,000, which is $24,566,000 below the fiscal year 2012 enacted level and $30,973,000 below the budget request.

Additional Guidance.—The Committee has included the following additional guidance with respect to funding provided under this account.

Administrator Priorities.—The Committee notes that EPA has failed to submit the report on Administrator Priorities as directed in the fiscal year 2012 Interior, Environment, and Related Agencies conference report. The lack of transparency in budgeting is troubling particularly for these funds that lack known performance metrics. As such, no funds have been provided in the bill, and EPA is directed to submit a report within 90 days of enactment of this Act that identifies how any fiscal year 2011 and 2012 funding was used, by account, program area, and program project. Each activity funded should include a justification for the effort and any anticipated results.

Aerial Compliance Monitoring.—EPA has indicated that the Agency and States have used aerial over-flights as a cost-effective tool to verify compliance with environmental laws in impaired watersheds for nearly a decade. The Committee directs EPA to submit a report to the House and Senate Committees on Appropriations within 180 days of enactment of this Act that identifies by fiscal year: the amount of funding spent to contract for aerial over-flights, the contractor performing the work, the number of flights performed, and geographical areas (county and State) that the contracted flights surveyed. The report shall include expenditures from fiscal year 2003 to fiscal year 2012. The report shall also include data that identifies by fiscal year the number of enforcement actions where aerial survey information was utilized as contributing evidence, and the outcome of each action.

Bed bugs.—The Committee is pleased that EPA has initiated a process establishing efficacy standards for conventional pesticides that claim to kill or control bed bugs. However, the Committee is concerned that EPA has decided not to apply these standards to products that fall under Section 25(b) of the Federal Insecticide, Fungicide and Rodenticide Act, where the greatest abuse of consumers is occurring. These products have proliferated in the marketplace and many either only kill bed bugs on contact, or do not work at all, and do not control bed bug infestations. The Committee encourages EPA to apply any efficacy standards that it develops for products that claim to kill or control bed bug infestations to all products that claim to do so.

Brown Marmorated Stink Bug.—The Committee continues to encourage EPA's Office of Chemical Safety and Pollution Prevention to work collaboratively with the U.S. Department of Agriculture, including the Agricultural Research Service, the National Institute of Food and Agriculture, and the Animal and Plant Health Inspection Service, and State partners to expeditiously approve a control program for the brown marmorated stink bug as soon as the appropriate agents are evaluated for release.

Confidential Business Information.—Fundamental improvements to the policies and practices of the Office of Pollution Prevention's review and evaluation of confidential business information (CBI) claims are necessary to ensure that: legitimate claims for trade secrets and CBI are protected from disclosure; structurally-descriptive generic names are provided in lieu of confidential chemical identity; and appropriate health and safety information is still made available to the public. The Committee directs that no fiscal year 2013 funds shall be used to propose or issue any final rules removing existing regulatory provisions addressing claims of confidentiality for chemical identity in health and safety studies under the Toxic Substances Control Act. Further, the Committee strongly urges EPA to enhance and update its current guidance on the use and development of structurally-descriptive generic names to be used in lieu of confidential chemical identity.

Drinking Water Treatment Compliance Flexibility.—The Committee recognizes that EPA's Long Term 2 Enhanced Water Treatment Rule presents significant costs and technical challenges for systems serving fewer than 100,000 persons. When setting the compliance schedule, the Committee understands EPA has provided as much flexibility as it could statutorily offer under the Clean Water Act. Nonetheless, the current timeframes present significant challenges for communities seeking to annualize the capital investment required to implement a number of EPA rulemakings. The Committee directs EPA and the States to work as partners with municipalities who are progressing in good faith toward complying with the rule and simply need additional time to minimize volatility in water utility rates for rate payers. The Committee directs EPA to convene a working group of Federal, State, and local stakeholders to discuss options for compliance schedules and report to the Committee within 180 days of enactment of this Act about interim options for ensuring protection of human health and the environment under the rule without the use of an enforcement action or an administrative order.

Emissions Control Area Pilot.—The Committee has included bill language in Title IV General Provisions establishing a pilot program for vessels to demonstrate alternative methods to comply with international emissions standards. The participating vessel owners will report to EPA utilizing simple averaging and weighted averaging methodologies to be agreed upon, and including utilization of shore power where available.

The EPA Administrator will report to the Committees on Appropriations on the effectiveness of the equivalent methods of compliance, the results of the modeling and atmospheric testing, the availability of low sulfur fuel, and recommended modifications to the next phase of implementation in order to ensure achievement of the human health objectives of the International Convention for

the Prevention of Pollution from Ships, 1973/78 (MARPOL), Annex VI, Regulation 4 in as cost-effective manner as possible.

Exceptional Events.—The Committee is aware that on May 2, 2011 EPA released its *Draft Guidance on the Implementation of the Exceptional Rule* in order to "clarify key provisions of the 2007 Exceptional Events Rule to respond to questions and issues that have arisen since the rule was promulgated." After receiving comments, EPA has not revised its guidance or proposed revisions to a new Exceptional Events Rule. The Committee directs EPA to take the necessary steps to implement an approach to exclude from air quality data exceedences of air quality standards caused by so-called exceptional events, or events that are not reasonably controllable or preventable, that maximizes transparency and predictability for States, Tribes, and local governments and minimizes the regulatory and cost burdens States, Tribes, and local governments bear. Further, EPA is directed to provide a report within 180 days of enactment of this Act that includes by Region the annual number of submitted exceptional event demonstrations as well as the number approved, disapproved, and withdrawn from March 2007 through May 2011.

Endocrine Disruptors.—The Committee recognizes that EPA is continuing to extend existing long-term reproduction studies in birds, fish, and other species to two- or multi-generation tests for the Endocrine Disruptor Screening Program (EDSP). The Committee is also aware that EPA is considering replacing the two-generation mammalian study with an extended one-generation test on the basis of an international review of rat reproduction studies that shows the lack of utility of a second generation. The Committee directs EPA to maximize the efficiency of each protocol and minimize unnecessary costs and animal use by assessing the utility (including sensitivity, specificity and value of information added relative to the assessment of endocrine disruption) of each endpoint in the study, including specifically the need to produce more than one generation of offspring in the bird, fish, and amphibian EDSP Tier 2 tests and issue a public report on its findings for comment. The Committee also directs EPA to determine what information the Agency requires to assess and manage potential risks to human health and the environment in regards to endocrine disruption, to minimize unnecessary endocrine screening and testing, and to use existing scientific data in lieu of requiring new data, when possible. The Committee understands that EPA is currently working with OECD to develop and modify EDSP methods. EPA should work within the framework and timing of the OECD Test Guideline work plan to minimize duplicative efforts.

Navajo Generating Station.—The Committee is aware that, in 2009, EPA announced its intention to issue a rule for controlling emissions from Northern Arizona's Navajo Generating Station (NGS) that could affect visibility in Class I Areas under the Clean Air Act (CAA). Since then, EPA has collected information on the five statutory factors the CAA requires for determining which technologies constitute the Best Available Retrofit Technology (BART) for NGS. EPA previously indicated promulgation of a rule to determine what control technology constitutes BART for NGS was imminent and would be issued early in 2012. Yet, the Administrator testified at the fiscal year 2013 budget hearing that a proposal could

be expected in "late summer" of 2012. The economic impacts of the options being considered could have dramatic impacts on tribal stakeholders, the State's economy, and Arizona water users, with even the timing of the proposal being influential to the on-going operation of the Station itself. Given the duration of this process and the recent completion of the National Renewable Energy Laboratory study, the Committee urges EPA to issue a proposed rule as soon as possible.

Personnel and Full Time Equivalents.—The Committee remains concerned about the distribution of regional FTE to headquarters and the Agency is directed to bring the headquarters FTE in line with the regional FTE. EPA is also directed to cap its FTE level at no more than the fiscal year 2010 level of 16,594, which is consistent with the direction provided in the fiscal year 2012 Interior, Environment, and Related Agencies conference report. The Committee believes EPA can achieve this reduction of 515 FTE from the budget request with the funding provided.

Regional Haze.—The Committee appreciates EPA's recent work with States to identify cost-effective solutions to address regional haze issues. However, concerns remain about which modeling tools and cost estimates are the most appropriate. The Committee believes the process for reviewing State implementation plans would be well-served if EPA, States and industry agreed on a singular version of the CALPUFF or other modeling tools, as well as a uniform set of cost estimates. The Committee finds that an update of EPA's Air Pollution Control Cost Manual may be in order since the Manual was last published in 2002. The Committee directs EPA to establish a working group with State and industry stakeholders to identify opportunities to improve the Agency's cost estimates and reach an agreement on which version of the CALPUFF model may be most appropriate. EPA is directed within 180 days of enactment of this Act to provide the House and Senate Committees on Appropriations with a report on the working group's findings and recommendations. The report should also include the working group's analysis for whether there is merit in establishing set intervals for routine reviews of both the cost manual and the universe of modeling tools, and include recommendations.

Reporting of Official Time.—The Committee notes that official time authorized by the Agency for labor unions that are the exclusive representative of Agency employees has steadily increased from fiscal year 2009 through fiscal year 2011. In light of resource constraints, the Committee expects that both official time and the associated support are properly managed and efficiently used. The Agency shall provide a consolidated report on union official time which includes: time and attendance data; salaries and expenses; cost estimates for dedicated office space, equipment, information technology services, travel and Per Diem for fiscal year 2012 within 90 days of the end of the fiscal year. In addition, the Agency will provide consolidated information concerning the deduction of dues and the allotment of those dues to the exclusive representative. Further, the report will reflect information on any authorized full-time union positions.

Risk Management Plans.—The Committee is troubled by the EPA announcement that it intends to make risk management plans publicly available via its website, reversing a longstanding

practice of making those documents available only upon request or as a hard copy. The Committee directs EPA to maintain its practice of only releasing all Risk Management Plan information pursuant to a FOIA request or in EPA reading rooms.

Rodenticides.—The Committee is aware the proposed cancellation of consumer uses of second-generation anticoagulant rodenticides could lead to a significant loss in the effectiveness of rodent control. Moreover, the Scientific Advisory Panel that raised the aforementioned concerns has also commented that EPA failed to appropriately address the social benefits of these more effective rodenticides and the loss therein of these benefits if EPA were to cancel the consumer use of second generation anticoagulants. Before taking further cancellation actions, the Committee expects EPA will respond to the comments of the Scientific Advisory Panel, address relevant concerns with the risk assessment, and more appropriately consider the potential impacts of rodent resistance in the United States, the economic and public health consequences of the proposed cancellation, and the benefits of having second generation rodenticides available for consumer use as allowable under FIFRA. The Committee urges EPA to discontinue the proposed cancellation if the Agency is unable to demonstrate how the risk of consumer use of second-generation anticoagulant rodenticides exceeds the benefits.

Sanitation Infrastructure in Indian Country.—The Committee is concerned about the lack of sanitation infrastructure in Indian country and Alaska Native Villages. In collaboration with the Indian Health Service and the Bureau of Indian Affairs, the Environmental Protection Agency is directed to report to the Committee on a unified strategy across the relevant government agencies to correct these sanitation deficiencies over a 10-year period. EPA shall provide this report within six months of enactment of this Act.

TSCA Self-Certification.—The Committee directs the Administrator, in consultation with the Secretary of Transportation, to review the TSCA self-certification process to ensure vessel owners are not abusing the process to avoid the costs associated with responsible vessel recycling, and report findings to the Committee within 180 days of enactment of this Act.

OFFICE OF INSPECTOR GENERAL

The Office of Inspector General (OIG) provides audit, evaluation, and investigation products and advisory services to improve the performance and integrity of EPA programs and operations. The Inspector General (IG) will continue to perform the function of IG for the Chemical Safety and Hazard Investigation Board. This account funds personnel compensation and benefits, travel, and expenses (excluding rent, utilities, and security costs) for the Office of Inspector General. In addition to the funds provided under this heading, this account receives funds from the Hazardous Substance Superfund account.

Appropriation enacted, 2012	$41,933,000
Budget estimate, 2013	48,273,000
Recommended, 2013	41,933,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	−6,340,000

The Committee recommends $41,933,000, equal to the fiscal year 2012 level and $6,340,000 below the budget request. In addition, the Committee recommends $9,939,000 as a payment to this account from the Hazardous Substance Superfund account, equal to the fiscal year 2012 enacted level.

The IG is directed to continue to submit quarterly staffing reports to Congress until such time as the Committee informs the Inspector General that the quarterly staffing reports are no longer required.

The Committee has again included authorization for the EPA IG to serve as the IG for the Chemical Safety and Hazard Investigation Board.

BUILDINGS AND FACILITIES

The Buildings and Facilities account provides for the design and construction of EPA-owned facilities as well as for the repair, extension, alteration, and improvement of facilities used by the Agency. The funds are used to correct unsafe conditions, protect health and safety of employees and Agency visitors, and prevent deterioration of structures and equipment.

Appropriation enacted, 2012	$36,370,000
Budget estimate, 2013	41,969,000
Recommended, 2013	36,370,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	−5,599,000

The Committee recommends $36,370,000, equal to the fiscal year 2012 enacted level and $5,599,000 below the budget request. The Committee supports the proposed projects that will reduce Agency operational and rent costs. EPA should prioritize projects based on anticipated cost savings and allocate funds accordingly.

HAZARDOUS SUBSTANCE SUPERFUND

The Hazardous Substance Superfund (Superfund) program was established in 1980 by the Comprehensive Environmental Response, Compensation, and Liability Act to clean up emergency hazardous materials, spills, and dangerous, uncontrolled, and/or abandoned hazardous waste sites. The Superfund Amendments and Reauthorization Act (SARA) expanded the program substantially in 1986, authorizing approximately $8,500,000,000 in revenues over five years. In 1990, the Omnibus Budget Reconciliation Act extended the program's authorization through 1994 for $5,100,000,000 with taxing authority through calendar year 1995.

The Superfund program is operated by EPA subject to annual appropriations from a dedicated trust fund and from general revenues. Enforcement activities are used to identify and induce parties responsible for hazardous waste problems to undertake cleanup actions and pay for EPA oversight of those actions. In addition, responsible parties have been required to cover the cost of fund-financed removal and remedial actions undertaken at spills and waste sites by Federal and State agencies. Funds are paid from this account to the Office of Inspector General and Science and Technology accounts for Superfund related activities.

Appropriation enacted, 2012	$1,213,808,000
Budget estimate, 2013	1,176,431,000
Recommended, 2013	1,164,917,000
Comparison:	
Appropriation, 2012	−48,891,000
Budget estimate, 2013	−11,514,000

The Committee recommends $1,164,917,000 for the Hazardous Substance Superfund program, $48,891,000 below the fiscal year 2012 enacted level and $11,514,000 below the budget request. The changes to the request, as recommended by the Committee, appear in the table at the end of this report. The Committee provides the following additional detail by program area.

Audits, Evaluations, and Investigations.—The Committee recommends $9,939,000, equal to the fiscal year 2012 enacted level and $925,000 below the budget request.

Compliance.—The Committee recommends $1,221,000, equal to the fiscal year 2012 enacted level and $2,000 below the budget request.

Enforcement.—The Committee has provided $169,408,000, which is $17,327,000 below the fiscal year 2012 enacted level and $15,000,000 below the budget request.

Indoor Air and Radiation.—The Committee recommends $2,468,000, equal to the fiscal year 2012 enacted level and $169,000 below the budget request.

Legal/Science/Regulatory/Economic Review.—The Committee recommends $1,526,000, equal to the fiscal year 2012 enacted level and $106,000 below the budget request.

Operations and Administration.—The Committee recommends $130,758,000, which is $5,000,000 below the fiscal year 2012 enacted level and $9,623,000 below the budget request.

Superfund Cleanup.—The Committee has provided $769,649,000, which is $26,231,000 below the fiscal year 2012 enacted level and $14,434,000 above the budget request. Within this amount the Committee has provided $546,771,000 for the Remedial program, $15,000,000 above the budget request. The Committee is disappointed that the President's budget requested deep cuts for the Remedial program while proposing marginal reductions or increases for other Superfund line items. The Committee finds this to be the wrong distribution of funds for the Superfund account. Similarly, the President's budget proposes to reduce four of the six performance metrics for the program including reductions in the number of annual "construction completes" and "sites ready for anticipated reuse." The Committee finds this to be the wrong policy for addressing the nation's most contaminated hazardous waste sites.

Bill Language.—Bill language authorizing transfers to the Science and Technology account, and the Office of Inspector General account, has not been included. Such transfer authority is not essential to ensuring funding will be allocated for Superfund research and Inspector General reviews. As shown in the table at the end of this report, the bill has maintained funding for both Superfund research and for Superfund audits, evaluations, and investigations at the fiscal year 2012 enacted levels.

Additional Guidance.—The Committee has included the following additional guidance with respect to funding provided under this account:

Superfund Special Accounts.—The Committee is encouraged by the steps EPA has taken toward the effective centralized management of Superfund special accounts. However, the Committee remains concerned about the pace at which the $1.8 billion in balances residing in Special Accounts is spent. The Committee directs EPA to report to the Committees on Appropriations within 120 days of enactment of this Act on the practical and legal implications of re-prioritizing funds planned for future-year activities (such as five year reviews) to cleanup activities addressing human health and environmental concerns in the near-term. The report should evaluate alternative uses for these funds, including short-term activities to reduce or eliminate human exposures and groundwater migration.

In addition, the Committee is concerned the special exhibit found in Appendix A of the Congressional justification does not provide information on the multi-year availability or the geographic use of the funds. The Committee directs EPA to incorporate the Superfund special accounts exhibit into the Superfund section of the Congressional justification, add a new table to the exhibit showing the available balance at the beginning and end of year, receipts, interest, obligations, reclassifications, and transfers to the Trust fund for the prior year, current year, and budget year. EPA should also include a separate table that breaks out the prior year data outlined above by EPA region.

Superfund Alternative Sites.—The Committee continues to direct the Agency to report annually, by Region, on the sites using the Superfund Alternative Approach Agreements, including intramural and extramural costs.

LEAKING UNDERGROUND STORAGE TANK TRUST FUND PROGRAM

Subtitle I of the Solid Waste Disposal Act, as amended by the Superfund Amendments and Reauthorization Act, authorized the establishment of a response program for cleanup of releases from leaking underground storage tanks. Owners and operators of facilities with underground tanks must demonstrate financial responsibility and bear initial responsibility for cleanup. The Federal trust fund is funded through the imposition of a motor fuel tax of one-tenth of a cent per gallon.

In addition to State resources, the Leaking Underground Storage Tanks (LUST) Trust Fund provides funding to clean up sites, enforces necessary corrective actions and recovers costs expended from the Fund for cleanup activities. The underground storage tank response program is designed to operate primarily through cooperative agreements with States. Funds are also used for grants to non-State entities, including Indian Tribes, under Section 8001 of the Resource Conservation and Recovery Act. The Energy Policy Act of 2005 expanded the authorized activities of the Fund to include the underground storage tank program. In 2006, Congress amended section 9508 of the Internal Revenue Code to authorize expenditures from the trust fund for prevention and inspection activities.

Appropriation enacted, 2012	$104,142,000
Budget estimate, 2013	104,117,000
Recommended, 2013	104,117,000
Comparison:	
Appropriation, 2012	−25,000
Budget estimate, 2013	0

The Committee recommends $104,117,000 for the Leaking Underground Storage Tank (LUST) Trust Fund Program, $25,000 below the fiscal year 2012 enacted level and equal to the budget request.

INLAND OIL SPILL PROGRAMS

This appropriation, authorized by the Federal Water Pollution Control Act, as amended by the Oil Pollution Act of 1990, provides funds to prepare for and prevent releases of oil and other petroleum products in navigable waterways. In addition, EPA is reimbursed for incident specific response costs through the Oil Spill Liability Trust Fund managed by the United States Coast Guard.

EPA is responsible for directing all cleanup and removal activities posing a threat to public health and the environment; conducting site inspections; providing a means to achieve cleanup activities by private parties; reviewing containment plans at facilities; reviewing area contingency plans; pursuing cost recovery of fund-financed cleanups; and conducting research of oil cleanup techniques. Funds for this appropriation are provided through the Oil Spill Liability Trust Fund which is composed of fees and collections made through provisions of the Oil Pollution Act of 1990, the Comprehensive Oil Pollution Liability and Compensation Act, the Deepwater Port Act of 1974, the Outer Continental Shelf Lands Act Amendments of 1978, and the Federal Water Pollution Control Act, as amended. Pursuant to law, the Trust Fund is managed by the United States Coast Guard.

Appropriation enacted, 2012	$18,245,000
Budget estimate, 2013	23,531,000
Recommended, 2013	18,223,000
Comparison:	
Appropriation, 2012	−22,000
Budget estimate, 2013	−5,308,000

The Committee recommends $18,223,000 for the Inland Oil Spill program, $22,000 below the fiscal year 2012 enacted level and $5,308,000 below the budget request. The Committee has not provided additional funds and FTE requested for increased facility inspections under the latest SPCC rule, but recognizes these activities will be a priority within base funds.

STATE AND TRIBAL ASSISTANCE GRANTS

The State and Tribal Assistance Grants (STAG) account provides grant funds for programs operated primarily by State, local, tribal and other governmental partners. The account includes two broad types of funds: (1) Infrastructure Assistance, which is used primarily by local governments for projects supporting environmental protection; and, (2) Categorical Grants, which assist State and tribal governments and other environmental partners with the operation of environmental programs. The account also includes specific

program grants such as competitive Brownfields grants and diesel emissions reduction grants.

In the STAG account, EPA provides funding for infrastructure projects through two State Revolving Funds (Clean Water and Drinking Water), geographic specific projects in Alaskan Native Villages and on the United States-Mexico Border, Brownfields revitalization projects, diesel emission reduction grants, and other targeted infrastructure projects.

The State Revolving Funds (SRFs) provide Federal financial assistance to protect the Nation's water resources. The Clean Water SRF helps eliminate municipal discharge of untreated or inadequately treated pollutants and thereby helps maintain or restore the country's water to a swimmable and/or fishable quality. The Clean Water SRF provides resources for municipal, inter-municipal, State, and interstate agencies and tribal governments to plan, design, and construct wastewater facilities and other projects, including non-point source, estuary, stormwater, and sewer overflow projects. The Safe Drinking Water SRF finances improvements to community water systems so that they can achieve compliance with the mandates of the Safe Drinking Water Act and continue to protect public health.

Many of the major Federal environmental statutes include provisions that allow the Federal government, through EPA, to delegate to the States and Tribes the day-to-day management of environmental programs or to approve State and Tribal environmental programs. The Federal statutes were designed to recognize the States as partners and co-regulators, allowing the States to issue and enforce permits, carry out inspections and monitoring, and collect data. To assist the States in this task, the statutes also authorized EPA to provide grants to the States and Tribes. These grants, which cover every major aspect of environmental protection, include those programs authorized by sections 319 and 106 of the Clean Water Act (Federal Water Pollution Control Act, as amended) (for non-point source pollution and the water quality permits programs), sections 105 and 103 of the Clean Air Act (for State and Local air quality management programs), section 128 of CERCLA (for State and tribal response programs), section 1443(a) of the Safe Drinking Water Act (for public water system supervision), and section 3011 of RCRA (for the implementation of State hazardous waste programs).

Appropriation enacted, 2012	$3,612,937,000
Budget estimate, 2013	3,355,723,000
Recommended, 2013	2,602,043,000
Comparison:	
Appropriation, 2012	−1,010,894,000
Budget estimate, 2013	−753,680,000

The Committee recommends $2,602,043,000 for the State and Tribal Assistance Grants account, $1,010,894,000 below the fiscal year 2012 enacted level and $753,680,000 below the budget request. The changes to the request, as recommended by the Committee, appear in the table at the end of this report. The Committee provides the following additional detail by program area:

Infrastructure Assistance.—For infrastructure assistance, the Committee recommends $1,608,000,000, which is $916,124,000

below the fiscal year 2012 enacted level and $545,291,000 below the budget request.

During calendar year 2009, the Committee provided over $11 billion for water and wastewater infrastructure assistance. Since then, the Committee provided an additional $4.87 billion for fiscal years 2011 and 2012. As a result, EPA has $2.4 billion in unobligated SRF balances yet to be transferred to States. In addition, the States have yet to spend nearly $5 billion that the Federal government has allocated for drinking water and wastewater projects. The Committee believes that EPA and the States must aggressively put this $7.4 billion on to projects in order to address the pressing infrastructure needs facing the nation. The bill provides funding at the fiscal year 2008 enacted levels for the Clean Water and Drinking Water State Revolving Funds: $689,000,000 and $829,000,000 respectively.

The Committee continues bill language to allow EPA and the States to provide additional forms of subsidy to those communities which cannot afford the below market rates provided by an SRF loan. These subsidies will apply to 20 to 30 percent of the funds appropriated for the SRFs. The Committee has carried forward this authority recognizing that many small, rural and/or disadvantaged communities do not have the resources to borrow from the SRFs with the responsibility to pay back the loan, even with the lower interest rate. The Committee directs the Agency to submit a report within 180 days of enactment of this Act detailing how EPA and the States have used this authority including information on the number and amounts of loans awarded with additional subsidization, recipient communities, and descriptions of projects funded.

The Committee has not included bill language mandating that States must use SRF grants for green infrastructure projects. While decentralized, alternative infrastructure projects may prove to be an important component in the efforts to improve and restore our waters, it should not be a mandatory function of the State Revolving Funds.

Alaska Native Villages.—The Committee has not included funding for this unauthorized grant program in fiscal year 2013 recognizing that low income and disadvantaged communities may apply for water and wastewater infrastructure funding through the State Revolving Funds. Additional subsidies are available for those communities that may not be able to afford the traditional low-interest SRF loans.

Brownfields Infrastructure Projects.—The Committee has provided $60,000,000 for Brownfields Infrastructure Projects, $34,848,000 below the fiscal year 2012 enacted level and $33,291,000 below the budget request. The Committee supports the continued work of the Brownfields program, but at a reduced rate.

Diesel Emissions Reductions Grants (DERA).—The Committee maintains funding for DERA grants at $30,000,000, which is $48,000 above the fiscal year 2012 enacted level and $15,000,000 above the budget request.

U.S.-Mexico Border.—The Committee has not included funding for these regional water infrastructure project grants given that funding is available for these projects through the Clean and Drinking Water State Revolving funds.

Categorical Grants.—For categorical grants to States and other environmental partners for the implementation of delegated programs, the Committee recommends $994,043,000, which is $94,770,000 below the fiscal year 2012 enacted level and $208,389,000 below the budget request. The changes to the request, as recommended by the Committee, appear in the table at the end of this report. Further, no funds have been provided for greenhouse gas permitting grants, or for the greenhouse gas reporting rule under the State and Local Air Quality Management budget line.

Bill Language.—The Committee recommends the following changes to the proposed STAG bill language:

(1) deletes the green infrastructure requirement for the State Revolving Funds;

(2) deletes the authorization for the United States-Mexico Border infrastructure grants;

(3) deletes the authorization for the Alaska Native Villages infrastructure grants;

(4) sets the additional subsidization requirement for the State Revolving Funds between 20 and 30 percent;

(5) removes a limitation on the amount of Clean Water State Revolving Funds that may be available for additional subsidization; and

(6) deletes the language authorizing additional Section 106 grants for nutrient reductions.

Additional Guidance.—The Committee has included the following additional guidance with respect to funding provided under this account:

Brownfields Technical Assistance Centers.—Within the funds provided for State and Tribal Assistance Grants, $2,000,000 is included for the EPA's Technical Assistance to Brownfields Communities program.

ADMINISTRATIVE PROVISIONS

(INCLUDING TRANSFER AND RESCISSION OF FUNDS)

The Committee recommendation continues the language, carried in prior years, concerning Tribal Cooperative Authority, the collection and obligation of pesticides fees, and additional transfer authorities for the purposes of implementing the Great Lakes Restoration Initiative.

The Committee has not included proposed bill language to allow EPA to use funds to implement the Community Action for a Renewed Environment (CARE) projects. Funding has not been provided for the CARE program in fiscal year 2013.

The Committee has expanded upon the President's proposal to rescind prior year funds. Bill language has been included to rescind $130,000,000 from the STAG and Superfund accounts.

The Committee has included bill language authorizing up to $150,000 to be spent for facility repairs at any one time.

The Committee has increased the authorized cap for Title 42 slots from 30 to 50. Upon receiving the authority in fiscal year 2006, EPA was allocated 30 slots and EPA indicates it will fill all 30 positions by the end of fiscal year 2012. Therefore, the Committee finds that an increase in the cap is warranted.

Bill language authorizing oil spill transfer authority has not been included as the Administration has repeatedly failed to demonstrate why administrative delays in reimbursement from the Oil Spill Liability Trust Fund should be a Congressional issue. The Administration's proposal to eliminate the Congressional reporting requirement further demonstrates that the Administration prefers flexibility rather than a resolution to the problem. As such, the Committee has no desire to entertain the Administration's proposal for a second year.

Bill language has not been included authorizing new Energy STAR user fees.

TITLE III—RELATED AGENCIES

DEPARTMENT OF AGRICULTURE

FOREST SERVICE

The U.S. Forest Service manages 193 million acres of National Forests, Grasslands, and a Tallgrass Prairie, including lands in 44 States and the Commonwealth of Puerto Rico, and cooperates with States, other Federal agencies, Tribes and private landowners to sustain the Nation's forests and grasslands. The Forest Service administers a wide variety of programs, including forest and rangeland research, State and private forestry assistance, cooperative forest health programs, an international program, National Forest System, and wildland fire management. The National Forest System (NFS) includes 155 national forests, 20 National grasslands, 20 National recreation areas, a National Tallgrass prairie, six National monuments, and six land utilization projects. The NFS is managed for multiple uses, beginning with wood, water and forage, and expanded under the Multiple Use Sustained Yield Act to include recreation, grazing, fish and wildlife habitat management. The Forest Service celebrated its centennial in 2005.

Health and vitality of national forests.—The Committee is deeply concerned about the declining health of our national forests and mortality due to insects, disease and catastrophic wildfire. As a result, the Committee has made active forest management the priority in its recommendations. Numerous scientific studies have shown that proactive management results in more resilient forested landscapes that are less susceptible to insects, disease and other threats. The Committee applauds the Forest Service's document, "Increasing the Pace of Restoration and Job Creation on Our National Forests", but notes that the Forest Service must move more expeditiously than outlined in the document to prevent additional, large-scale forest health problems.

USDA Administrative Solutions Services Project.—The Committee is concerned by the lack of transparency surrounding the Department of Agriculture's (USDA) Administrative Solutions Services Project, also referred to as the Blueprint for Stronger Service. The Department has neither consulted with Congress regarding proposed or implemented reorganizations and restructurings nor has the Department submitted appropriate reprogramming requests as required in the report accompanying the fiscal year 2012 Omnibus Appropriations Act. The Committee has received disturbing reports from employees across various USDA

Mission Areas that reveal a lack of analysis of business functions, poor data quality, inconsistent approaches between agencies, and an absence of cost savings or other efficiencies that justify the radical changes proposed. Therefore, within available funds, the Committee directs the Department of Agriculture to award a grant or contract to the National Academy of Public Administration, an independent, nonpartisan organization chartered by Congress, to conduct an in-depth review of this effort as it affects the Forest Service. This review will examine: the basis and case for change; the analysis used to generate recommendations; the standards and benchmarks used to evaluate the current state; and, the criteria used for driving decisions.

Forest Service Washington and regional offices.—The Committee is concerned about the amount of resources devoted to the Forest Service's Washington Office and nine regional offices. The Committee believes that regional offices should carry out the goals of the Forest Service Chief instead of creating new initiatives or policies. Additional resources need to be devoted to much-needed projects and on-the-ground management of national forests. The Committee was extremely dismayed to learn that some national forests did not receive an increased allocation from the region even with a significant funding increase in a program. In light of limited funding, the Committee directs the Forest Service to examine the amount of personnel and resources in these offices to identify duplicative functions. The Forest Service should include these findings and recommendations in its fiscal year 2014 budget request.

FOREST AND RANGELAND RESEARCH

Appropriation enacted, 2012	$295,300,000
Budget estimate, 2013	292,796,000
Recommended, 2013	247,796,000
Comparison:	
Appropriation, 2012	−47,504,000
Budget estimate, 2013	−45,000,000

The Committee recommends $247,796,000 for Forest and Rangeland Research, $47,504,000 below the fiscal year 2012 enacted level and $45,000,000 below the budget request.

The Committee is deeply concerned about the Forest and Rangeland Research program noting that many research stations have fixed costs that exceed 90 percent of their budget with no long-term plan to remedy this problem. The Committee is also concerned that there is a lack of coordination between research stations, the Washington Office, regional offices and national forests.

Forest Inventory and Analysis.—The Committee recommends $71,805,000 for the Forest Inventory and Analysis (FIA) program, $5,000,000 above the budget request. The Committee supports the proposed consolidation of the FIA program into one line item. The Committee finds that State forestry agencies and their cooperators are often able to accomplish critical FIA work with equal quality at lower costs than the Forest Service. The Forest Service is directed to work with State foresters to identify ways to more efficiently deliver the program in all States, including timely inventory updates, and should explore opportunities to work with additional State forestry agencies and their cooperators who can accomplish necessary field work at lower cost.

Localized Needs Research.—The fiscal year 2012 Interior, Environment, and Related Agencies conference report specifically directed the Forest Service to expand its localized needs research in support of project development on national forests, yet the budget request reduces funding of localized needs by $10,000,000. The Committee once again directs the Forest Service to expand its localized needs research beyond the fiscal year 2012 enacted level. Specifically, the Committee encourages the Forest Service to continue and complete research on the effectiveness of Multiple Indicator Monitoring for measuring bank alteration. The Committee also directs additional research on whether Multiple Indicator Monitoring and other bank stability measures are effective in predicting actual harm to fish.

Wolverine Research.—The Committee strongly supports the research conducted on interactions between wolverines and winter recreation use and expects the Forest Service to continue to fund robust research on this issue with resources provided under the Forest and Rangeland Research program.

Bighorn Sheep Research.—The management of domestic sheep within the range of bighorn sheep on national forests and public lands, particularly the possibility of disease transmission and spread within bighorn sheep herds, is of major concern to the Committee.

In fiscal year 2012, the Committee included a one-year moratorium on reductions to domestic sheep grazing due to concerns over potential disease transmission. However, the Committee recognizes that, over the long term, such decisions by either future Congresses or Federal agencies must be guided by the application of sound science, both with respect to the biological factors related to the pathogens for which bighorns seem to be susceptible, but also to the risks of disease transmission between the two species in the wild. Such information is vital to both sound decisions by agency managers and to a greater public acceptance of those decisions.

As referenced in the Consolidated and Further Continuing Appropriations Act of 2012, the Appropriations Subcommittees for Agriculture have directed the Agricultural Research Service (ARS) to increase its involvement in bighorn sheep disease research. Building on these efforts, the Committee directs the Forest Service to work diligently with the ARS in the development of scientifically defensible analyses, specifically on the probability of sufficient contact for pathogen transmission and, if there is transmission, the probability of disease and spread of the disease to the herd in the wild. The Committee is not convinced that this important step was thoroughly addressed in the Payette National Forest's Final Environmental Impact Statement and Record of Decision announced on July 28, 2010 and further directs the Forest Service to cooperate fully with the ARS in a review of the risk analysis and assessment portions in that decision, with the objective of assuring a more defensible and sound basis for future decisions in other parts of the West where there are bighorn and domestic sheep conflicts. The Committee directs the Forest Service to brief the Committee on its progress every six months.

STATE AND PRIVATE FORESTRY

Appropriation enacted, 2012	$252,926,000
Budget estimate, 2013	250,730,000
Recommended, 2013	183,000,000
Comparison:	
Appropriation, 2012	−69,926,000
Budget estimate, 2013	−67,730,000

The Committee recommends $183,000,000 for State and Private Forestry, $69,926,000 below the fiscal year 2012 enacted level and $67,730,000 below the budget request. The reduction compared to the request is largely due to the recommended reduction in the Forest Legacy Program and the shift of cooperative fire protection programs to Wildland Fire Management.

Landscape Scale Restoration.—The Committee is supportive of the new line item and recommends $16,000,000 for Landscape Scale Restoration, $2,000,000 below the budget request. The Committee notes that this line item is simply a consolidation of the competitive funds within State and Private Forestry.

Forest Health Management.—The Committee recommends $112,000,000 for Forest Health Management, as requested, which is $265,000 above the fiscal year 2012 enacted level (including forest health funds under Wildland Fire Management). The Committee is supportive of the transfer of forest health line items from Wildland Fire Management to State and Private Forestry, but expects the funding to be allocated in a manner similar to previous years.

Urban and Community Forestry.—The Committee recommends $25,000,000 for Urban and Community Forestry, $6,327,000 below the fiscal year 2012 enacted level and $3,040,000 below the budget request. The Committee supports the urban forest research program through which the Forest Service assists urban communities in monitoring and caring for their forests. The Committee directs the Forest Service to maintain a vibrant urban forest research program that will assist urban communities in systematically inventorying and assessing the changing conditions and health of urban forests and plan strategic actions to sustainably maintain these urban green spaces.

International Forestry.—The Committee recommends $6,000,000 for International Forestry, $1,987,000 below the fiscal year 2012 enacted level and $2,088,000 above the budget request. International Forestry enables forestry experts from the Federal government to participate in negotiations for trade agreements and assist with forestry work abroad. This program plays a large role in protecting the U.S. forest products industry by improving the sustainability and legality of timber management overseas thereby reducing the amount of underpriced and illegally harvested timber on the world market. Much of the funding for these activities is provided by other departments or agencies, including the Department of State, the United States Trade Representative, and the U.S. Agency for International Development. Though the program is funded at a low level, it leverages roughly three dollars for every dollar it receives from other funding sources.

NATIONAL FOREST SYSTEM

Appropriation enacted, 2012	$1,554,137,000
Budget estimate, 2013	1,623,591,000
Recommended, 2013	1,495,484,000
Comparison:	
Appropriation, 2012	−58,653,000
Budget estimate, 2013	−128,107,000

The Committee recommends $1,495,484,000 for the National Forest System, $58,653,000 below the fiscal year 2012 enacted level and $128,107,000 below the budget request.

The Committee notes that similar to fiscal years 2012 and 2011, the budget request included a major restructuring in which several programs were combined into a new entity, Integrated Resource Restoration (IRR). The Committee has not approved this request but will continue the proof of concept pilot established in the fiscal year 2012 Interior, Environment, and Related Agencies conference report. The Committee is, however, disappointed with the Forest Service's delayed communication on the implementation and progress of IRR. The Committee will only continue the pilot if management efficiencies, tangible accomplishments, and accountability are demonstrated.

Planning.—The Committee provides no funding for Planning, $39,936,000 below the fiscal year 2012 level. The Committee does not accept the proposed merging of the Planning and Inventory and Monitoring line items.

The Committee has significant concerns about the implementation and cost of the new planning rule. The Committee believes the Forest Service has ignored the direction of Congress embodied in the National Forest Management Act. The rule places too many conflicting requirements on forest plans and will likely lead to increased litigation. The new inventory requirements for invertebrates will very likely cost millions upon millions of dollars and are virtually impossible to complete. The Committee could potentially support the rule if the eight proposed pilot forest plan revisions were successfully completed through the 2012 Planning Rule.

The Committee retains language in Title IV General Provisions allowing forest management plans to expire if the Service has made a good faith effort to update plans commensurate with appropriated funds. The Committee modifies this language by allowing forest plans to be completed under the 1982 planning rule and allows these plans to be used in place of revised plans that would be completed under the 2012 Planning Rule.

Inventory and Monitoring.—The Committee recommends $161,721,000 for Inventory and Monitoring, equal to the fiscal year 2012 enacted level. The Committee does not accept the proposed merging of this line item with the planning line item.

The Committee is concerned about the lack of monitoring related to livestock grazing allotments and strongly encourages the Forest Service to increase both annual and trend monitoring on allotments. The Committee directs the Forest Service to allocate a greater portion of monitoring funds for these efforts. The Committee also encourages the Forest Service to work with State agencies, universities, professional societies and other USDA agencies, such as the Natural Resource Conservation Service, to efficiently increase allotment monitoring.

The Committee also encourages the Forest Service to improve and increase its monitoring of grazing permits in allotments where riparian streamside health is a concern for listed or threatened species. The Committee also directs each Forest Service region to increase transparency and reporting on how the limited monitoring resources are used on the ground to satisfy monitoring requirements or for other purposes.

Recreation, Heritage and Wilderness.—The Committee recommends $260,066,000 for Recreation, Heritage and Wilderness, $21,110,000 below fiscal year 2012 enacted funding and $7,000,000 below the budget request.

Travel Management Plans.—The Committee is concerned about travel management plans on some national forests, though it notes that many national forests have completed plans with few problems. The Committee has been informed by several communities that travel management plans did not properly include public and community input and needs. Where communities are dissatisfied with travel management plans, the Committee directs the Forest Service to revise these plans.

Eastern Oregon Travel Management Plans.—The Committee notes that appropriate first steps have been taken to overhaul problematic travel management plans in eastern Oregon but much work remains to be done. The Committee strongly encourages the Forest Service to include community input in the new plan in addition to emphasizing existing uses important to the public.

California Travel Management Plans.—Due to specific concerns related to all travel management plans in the State of California, the Committee includes language in Title IV General Provisions prohibiting the implementation of travel management plans in California until the agency completes additional analysis to include more routes. The language also prevents the agency from designating maintenance level 3 (ML–3) roads as highways. The Committee notes that the California State Patrol has confirmed numerous times that it does not consider ML–3 roads as highways.

Pittsburg Landing.—The Committee is supportive of legislation naming the campground at Pittsburg Landing in the Hells Canyon National Recreation Area the Tracy L. Vallier Campground at Pittsburg Landing. The Committee urges the appropriate authorizing committees to work with the Forest Service to accomplish this goal through an Act of Congress.

Grazing Management.—The Committee recommends $55,356,000 for Grazing Management, equal to the fiscal year 2012 enacted level and $14,976,000 above the budget request. The Committee urges the Forest Service to devote greater resources toward renewing grazing permits and administering allotments to forest plan standards.

Wallow Fire Area Grazing.—The Committee commends the Forest Service for its work following the Wallow Fire to approve the return of approximately seventy percent of permitted livestock to affected allotments. The Committee encourages the Forest Service to continue forage monitoring and infrastructure repair and replacement, including ensuring proper "right of way" clearances to prevent further infrastructure damage related to Wallow Fire impacts, with the goal of returning the remainder of displaced livestock to their proper pasture rotations as soon as possible.

The Committee includes bill language addressing range management in Title IV (applying to both the Bureau and the Forest Service) including: (1) Section 412 which makes permanent the grazing permit renewal general provision allowing permits to be renewed for one year under the same terms and conditions if NEPA review has not yet been completed; and (2) Section 423 prohibiting the use of funds for reductions in domestic sheep grazing due to bighorn sheep unless management actions are consistent with State wildlife plans.

Intent of Congress.—The Committee is concerned by a recent decision in Federal District Court regarding Section 431 in the fiscal year 2012 Omnibus Appropriations Act. The intent of Congress was to place a one-year moratorium on any new restrictions on domestic sheep grazing due to bighorn sheep as domestic sheep grazing existed on July 1, 2011 unless specifically detailed in a State wildlife management plan. Grazing levels, as they existed on July 1, 2011, were to be interpreted regardless of prior records of decision or amendments to land management plans. This intent was clearly stated in Section 431(a) with the language, "Notwithstanding any other provision of law or regulation (other than the Endangered Species Act of 1973) . . ." The date of July 1, 2011 was specifically chosen. The Supplemental Environmental Impact Statement for the Land and Resource Management Plan Amendment to the Southwest Idaho Ecogroup included option P, which essentially stated that certain domestic sheep grazing levels could be sustained and still provide for the viability of bighorn sheep. This level of grazing is commensurate with grazing existing on the Payette National Forest on July 1, 2011. Further, the Committee intended for this provision to apply to national forests nation-wide, including, but not limited to, the Payette National Forest. The Committee has clarified language in Section 423 of Title IV General Provisions to make the intent of Congress clear.

Forest Products.—The Committee recommends $342,211,000 for Forest Products, $6,700,000 above the fiscal year 2012 enacted level.

The Committee has recommended a two percent increase of funding for Forest Products, Vegetation and Watershed Management, and Wildlife and Fish Habitat Management as these programs, in addition to the hazardous fuels program under Wildland Fire Management, provide the largest on-the-ground benefit to national forests. The Committee believes these programs are fundamental to the health and vitality of our national forests and expects the Forest Service to increase its accomplishments in each line item.

The Forest Service is currently removing less than ten percent of the annual net growth on national forests. This, combined with fire suppression policies, has resulted in overcrowded, unhealthy forests susceptible to insects, disease and catastrophic wildfire. To accomplish the monumental amount of work necessary to improve the health of national forests and protect communities from catastrophic wildfires, forest products mills and logging infrastructure, where it still exists, must be maintained. These businesses provide significant living-wage jobs, many of which operate in rural areas with higher levels of unemployment. Further, without this infrastructure, the cost of treating national forests increases dramati-

cally and greatly reduces the amount of acres feasibly treated with appropriated dollars.

The Committee expects the Forest Service to increase vegetative and timber management activities to sell not less than three billion board feet in fiscal year 2013, with the expectation of increasing this target in future fiscal years. This can be accomplished by implementing larger projects and reducing unit costs.

Region 10 Timber Supply.—The Committee notes that over the last ten years the timber supply in Region 10 has been constrained to less than ten percent of the allowable sale quantity in the current land management plan. As a result, numerous mills have closed. In an effort to restore confidence in the timber supply and foster and allow investment in new facilities, the Forest Service pledged to prepare and offer four 10-year timber sales each with a volume of 150–200 million board feet. The agency recently converted the first two timber sales to smaller stewardship projects. These projects will neither restore confidence, nor will they allow investment in new facilities. The Committee directs the Forest Service to prepare and offer, within two years, the four 10-year timber sales as promised.

Vegetation and Watershed Management.—The Committee recommends $187,646,000 for Vegetation and Watershed Management, $3,600,000 above the fiscal year 2012 enacted level.

Wildlife and Fish Habitat Management.—The Committee recommends $142,736,000 for Wildlife and Fish Habitat Management, $2,700,000 above the fiscal year 2012 enacted level. The Committee directs the Service to increase monitoring of threatened and endangered fish and their habitat, especially in grazing allotments, and expects funding from this program to be allocated for this purpose.

Collaborative Forest Landscape Restoration Fund.—The Committee recommends $40,000,000, for the Collaborative Forest Landscape Restoration Fund (CFLR), as requested, $64,000 above the fiscal year 2012 enacted level. The Committee has been supportive of the CFLR program in the past but is concerned about the lengthy time frame to implement projects and achieve positive outcomes. The Committee directs the Forest Service to report to the Committee within 60 days of enactment of this Act on the implementation of CFLR-funded projects and the outcomes of those projects to date. The report should include performance measures as described in the CFLR 2011 Annual Report accomplishment form available on the Forest Service's website.

Bill Language.—The Committee includes language in Title IV General Provisions including: (1) Section 426 extending the Herger-Feinstein Quincy Library Group for one year; (2) Section 427 extending the 'Good Neighbor Cooperative Conservation Authority' to all Western States for five years; (3) Section 428 directing the Forest Service to identify three acres for small communities to build a fire station; (4) Section 429 extending cost recovery authorities for the Forest Service regarding special uses; (5) Section 430 streamlining the administration of interpretative associations by the Forest Service; (6) Section 432 allowing designation by description and prescription for forest management; (7) Section 437 clarifying notice, comment, and appeals for categorical exclusions; and, (8) Section 438 prohibiting the use of appropriated funds to close

areas open to recreational hunting and shooting as of January 1, 2012.

CAPITAL IMPROVEMENT AND MAINTENANCE

(INCLUDING TRANSFER OF FUNDS)

Appropriation enacted, 2012	$394,089,000
Budget estimate, 2013	346,379,000
Recommended, 2013	356,086,000
Comparison:	
Appropriation, 2012	−38,003,000
Budget estimate, 2013	+9,707,000

The Committee recommends $356,086,000 for Capital Improvement and Maintenance, $38,003,000 below the fiscal year 2012 enacted level and $9,707,000 above the budget request.

Facilities Maintenance and Capital Improvement.—The Committee recommends $49,463,000 for Facilities Maintenance and Capital Improvement, $26,201,000 below the fiscal year 2012 enacted level and $50,000,000 below the budget request.

Road Maintenance and Construction.—The Committee recommends $182,525,000 for Road Maintenance and Construction, equal to the fiscal year 2012 enacted level and $24,707,000 above the budget request. Specifically, the Committee recommends $147,812,000 for road maintenance and $34,713,000 for road construction.

The Committee realizes the Forest Service has limited funds compared to its road infrastructure needs and encourages the use of stewardship contracts and other combined projects (for example improving forest health and maintaining or reconstructing roads) to accomplish more work with less funding.

Legacy Road and Trail Remediation.—The Committee recommends $35,000,000 for Legacy Road and Trail Remediation, $9,928,000 below the fiscal year 2012 enacted level.

Bill Language.—The Committee includes language in Title IV General Provisions clarifying the role of forest roads in silvicultural operations as it relates to the Federal Water Pollution Control Act.

LAND ACQUISITION

Appropriation enacted, 2012	$52,521,000
Budget estimate, 2013	57,934,000
Recommended, 2013	16,494,000
Comparison:	
Appropriation, 2012	−36,027,000
Budget estimate, 2013	−41,440,000

The Committee recommends $16,494,000 for Land Acquisition, $36,027,000 below the fiscal year 2012 enacted level and $41,440,000 below the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. Funds for priority recreational access do not have to be cost-shared and are not to be capped at $250,000. The Committee has included language in the front of this report regarding Land and Water Conservation Fund programs.

ACQUISITION OF LANDS FOR NATIONAL FORESTS SPECIAL ACTS

Appropriation enacted, 2012	$953,000
Budget estimate, 2013	955,000
Recommended, 2013	955,000
Comparison:	
Appropriation, 2012	+2,000
Budget estimate, 2013	0

The Committee recommends $955,000 for Acquisition of Lands for National Forests Special Acts, as requested, and $2,000 above the fiscal year 2012 enacted level.

ACQUISITION OF LANDS TO COMPLETE LAND EXCHANGES

Appropriation enacted, 2012	$227,000
Budget estimate, 2013	227,000
Recommended, 2013	227,000
Comparison:	
Appropriation, 2012	0
Budget estimate, 2013	0

The Committee recommends $227,000, as requested, for Acquisition of Lands to Complete Land Exchanges under the Act of December 4, 1967 (16 U.S.C. 484a). Under the Act, deposits made by public school districts or public school authorities to provide for cash equalization of certain land exchanges can be appropriated to acquire similar lands suitable for national forest system purposes in the same State as the national forest lands conveyed in the exchanges.

RANGE BETTERMENT FUND

Appropriation enacted, 2012	$3,257,000
Budget estimate, 2013	2,360,000
Recommended, 2013	2,360,000
Comparison:	
Appropriation, 2012	−897,000
Budget estimate, 2013	0

The Committee recommends $2,360,000, as requested, for the Range Betterment Fund, to be derived from grazing receipts from national forests (Public Law 94–579) and to be used for range rehabilitation, protection, and improvements including seeding, reseeding, fence construction, weed control, water development, and fish and wildlife habitat enhancement in 16 western States.

GIFTS, DONATIONS AND BEQUESTS FOR FOREST AND RANGELAND RESEARCH

Appropriation enacted, 2012	$45,000
Budget estimate, 2013	46,000
Recommended, 2013	46,000
Comparison:	
Appropriation, 2012	+1,000
Budget estimate, 2013	0

The Committee recommends $46,000 for Gifts, Donations and Bequests for Forest and Rangeland Research, as requested, $1,000 above the fiscal year 2012 enacted level.

MANAGEMENT OF NATIONAL FOREST LANDS FOR SUBSISTENCE USES

Appropriation enacted, 2012	$2,573,000
Budget estimate, 2013	0
Recommended, 2013	2,000,000
Comparison:	
Appropriation, 2012	−573,000
Budget estimate, 2013	+2,000,000

The Committee recommends $2,000,000 for the Management of National Forest Lands for Subsistence Uses in Alaska and does not support the proposed transfer of this program to the National Forest System.

WILDLAND FIRE MANAGEMENT

(INCLUDING TRANSFERS OF FUNDS)

Appropriation enacted, 2012	$1,734,851,000
Budget estimate, 2013	1,971,394,000
Recommended, 2013	2,072,799,000
Comparison:	
Appropriation, 2012	+337,948,000
Budget estimate, 2013	+101,405,000

The Committee recommends $2,072,799,000 for Wildland Fire Management, $337,948,000 above the fiscal year 2012 enacted level and $101,405,000 above the budget request. The Committee's recommendation, combined with $315,000,000 recommended in the FLAME wildfire suppression reserve account, fully funds the 10-year fire suppression average expenditures. The Committee notes that the increase in appropriations compared to fiscal year 2012 is due to: (1) the use of $240,000,000 in emergency carry-over suppression dollars in fiscal year 2012 to offset appropriations; and, (2) the fiscal year 2013 request's shift of $76,000,000 from Wildland Fire Management to the National Forest System, which was not approved by the Committee.

Wildfire Preparedness.—The Committee recommends $1,001,513,000 for Wildfire Preparedness, as requested, $2,929,000 below the fiscal year 2012 enacted level.

Wildfire Suppression Operations.—The Committee recommends $616,000,000 for Wildfire Suppression Operations, as requested, $77,758,000 above the fiscal year 2012 enacted level. The Committee recommendation fully meets the 10-year average expenditure on all emergency and discretionary funded suppression actions.

Hazardous Fuels.—The Committee recommends $345,005,000 for hazardous fuels reduction, $27,929,000 above the fiscal year 2012 enacted level and $103,405,000 above the budget request. The recommendation also includes $5,000,000 for biomass utilization grants.

The Committee again directs the Forest Service to focus hazardous fuels reduction dollars based on areas with the greatest need, as determined by land managers, instead of percentages of acres treated in the Wildland Urban Interface.

The Committee also strongly encourages the Forest Service to focus on Fire Regime Condition Class II and III areas. These areas are the most prone to catastrophic fire and many times require mechanical thinning followed by prescribed burns. The Committee realizes much of this work is more expensive than prescribed burning

alone, but encourages the Forest Service to leverage hazardous fuels dollars by combining projects and using tools such as stewardship contracting and timber sales.

State Fire Assistance.—The Committee recommends $72,688,000 for State Fire Assistance, as requested, $13,275,000 below the fiscal year 2012 enacted level (including State Fire Assistance funds under State and Private Forestry). The Committee supports the proposed consolidation of the program under Wildland Fire Management and directs the Forest Service to allocate funds in a way that meets the regional resource needs for hazard mitigation and preparedness as determined in consultation with State foresters.

Volunteer Fire Assistance.—The Committee recommends $11,733,000 for Volunteer Fire Assistance, as requested, $1,292,000 below the fiscal year 2012 enacted level (including Volunteer Fire Assistance funds under State and Private Forestry). The Committee supports the proposed consolidation of the program under Wildland Fire Management and directs the Forest Service to allocate funds in a way that meets the rural firefighting resource needs as determined in consultation with State foresters.

Wildland Firefighting.—The Committee encourages the Forest Service to thoroughly evaluate the impact of crew size on operational efficacies and firefighter safety with respect to wildland firefighting operations. The Forest Service should report its findings to the Committee.

FLAME Wildfire Suppression Reserve Fund

(INCLUDING TRANSFERS OF FUNDS)

Appropriation enacted, 2012	$315,381,000
Budget estimate, 2013	315,000,000
Recommended, 2013	315,000,000
Comparison:	
Appropriation, 2012	−381,000
Budget estimate, 2013	0

The Committee recommends $315,000,000 for the FLAME Wildfire Suppression Reserve Fund, as requested, $381,000 below the fiscal year 2012 enacted level.

ADMINISTRATIVE PROVISIONS, FOREST SERVICE

(INCLUDING TRANSFERS OF FUNDS)

The Committee has continued all administrative provisions included in the fiscal year 2012 Omnibus Appropriations Act.

The Committee has corrected a citation to the Volunteers in the National Forest Act.

The Committee has included new language limiting funds available to the Forest Service for cost pools 1–5.

The Committee has made language regarding the National Forest Foundation and interest earned from Federal funds permanent. This provision was included to clarify the intent of Congress in the fiscal year 2002 Interior, Environment, and Related Agencies Appropriations Act where this provision was made permanent, but subsequently never removed from Administrative Provisions.

Forest Service Cost Pools.—A decade ago, the Committee agreed to the use of cost pools to fund Forest Service administrative activities as a mechanism to facilitate and simplify financial accounting.

At that time, the Committee required that the Service summarize in its annual budget justifications planned indirect expenditures from the cost pools to the region, station, area, and detached unit office (RSA) level. This requirement is found at 16 U.S.C. 579d. Additionally, the Committee has included a general provision annually for each year since fiscal year 2004 requiring disclosure of estimated overhead charges, deductions, reserves and holdbacks from programs, projects, activities and subactivities. The Committee is concerned about non-compliance with these disclosure requirements. While the Service's budget justifications do show the source of the cost pool funds by budget line item, no information is provided on the amounts in each cost pool or the distribution of those funds to the RSA level, as required by law. The budget justifications also lack detailed information explaining how the cost pool amounts were derived or the activities and number of personnel they support.

The Forest Service is directed to include tables in the fiscal year 2014 and future budget justifications that clearly display the source of funding for each cost pool by budget line item, the amount for each cost pool, and direct and indirect expenditures from each cost pool by RSA. The prior, current, and future budget years should be shown for each table. In addition to tabular material, the Forest Service should explain, in detail, the activities and FTEs supported by each cost pool. Changes from the current year to the budget year should be explained in the same level of detail as contained in the appropriation accounts sections of the Forest Service budget justification.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

INDIAN HEALTH SERVICE

The provision of Federal health services to Indians is based on a relationship between Indian Tribes and the U.S. Government first set forth in the 1830s by the U.S. Supreme Court under Chief Justice John Marshall. Numerous treaties, statutes, constitutional provisions, and international law have reconfirmed this relationship. Principal among these is the Snyder Act of 1921, which provides the basic authority for most Indian health services provided by the Federal Government to American Indians and Alaska Natives. The Indian Health Service (IHS) provides direct health care services in 29 hospitals, 66 health centers, two school health centers, and 41 health stations. Tribes and tribal groups, through contracts and compacts with the IHS, operate 16 hospitals, 254 health centers, 4 school health centers, and 74 health stations (including 166 Alaska Native village clinics).

INDIAN HEALTH SERVICES

Appropriation enacted, 2012	$3,866,181,000
Budget estimate, 2013	3,978,974,000
Recommended, 2013	4,049,612,000
Comparison:	
Appropriation, 2012	+183,431,000
Budget estimate, 2013	+70,638,000

The Committee recommends $4,049,612,000 for Indian Health Services, $183,431,000 above the fiscal year 2012 enacted level and

$70,638,000 above the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. Except as otherwise indicated below, the Committee expects the Indian Health Service to implement its fiscal year 2013 budget in accordance with its budget justification.

Staffing costs for new and expanded health care facilities.—The Committee recommends $48,418,000 for staffing costs for new and expanded health care facilities, $3,638,000 above the budget request. Funds are limited to facilities funded through the Health Care Facilities Construction Priority System or the Joint Venture Construction Program that are newly opened in fiscal year 2012 or that open in fiscal year 2013. None of the funds may be allocated to a facility until such facility has achieved beneficial occupancy status.

Hospitals and Health Clinics.—The Committee recommends $1,851,448,000 for Hospitals and Health Clinics, $40,482,000 above the fiscal year 2012 enacted level and $2,138,000 above the budget request. The bill includes a decrease of $1,500,000 below the budget request for health information technology and an increase of $3,638,000 above the budget request for staffing costs for new and expanded health care facilities, as described above.

Dental Health.—The Committee recommends $166,597,000 for Dental Health, $7,157,000 above the fiscal year 2012 enacted level and $300,000 above the budget request. The increase above the budget request is for staffing in support of the Early Childhood Caries initiative.

The Committee supports the Administration's request of $1,000,000 for the electronic dental record system. The continued funding has allowed the Dental Division to complete implementation at 118 of the 230 Federal and Tribal dental sites. The Committee strongly encourages the Service to continue to press forward with this program and, if possible, to accelerate implementation to the remaining dental programs.

The Committee is pleased that dental vacancies have dropped from 140 in fiscal year 2009 to 30 in fiscal year 2012. However, an improving economy could negatively impact recruitment. The Committee, therefore, directs the Indian Health Service to issue a report regarding the use of direct hire authority, and addressing the following questions: (1) how various divisions within the Indian Health Service use this authority and to what extent there is a discrepancy between divisions; and (2) how the Division of Oral Health can have the same direct hire authority as other health disciplines in order to enhance future recruitments.

Contract Health Services.—The Committee recommends that the Service consider proposing a new name for this program in the fiscal year 2014 budget request in order to be more clear and consistent with the program's activities. The Committee directs the Indian Health Service to implement the recommendations of the Government Accountability Office (GAO–12–446) in order to ensure equitable allocation of resources for the Contract Health Services program.

Urban Indian Health.—The Committee recommends $45,488,000 for Urban Indian Health, $2,504,000 above the fiscal year 2012 enacted level and $2,500,000 above the budget request.

Indian Health Professions.—The Committee recommends $41,598,000 for Indian Health Professions, $1,002,000 above the fiscal year 2012 enacted level and $1,000,000 above the budget request. The increase above the budget request is for the loan repayment program.

Direct Operations.—The Committee recommends $67,567,000 for Direct Operations, $4,086,000 below the fiscal year 2012 enacted level and $5,300,000 below the budget request. The decrease below the budget request is from Headquarters operations.

The Committee is aware of the departures of approximately 25 senior staff during the past two years. The continued loss of well-trained and experienced agency leaders represents a serious threat to the agency's corporate knowledge, ongoing ability to manage programs and resources, and ability to be responsive to Tribes and Federal accountability requirements in a timely and credible manner. The Committee directs the Service to provide a report within 30 days of enactment of this Act: (1) detailing the number and position of senior personnel that have left the agency within the past two years and how many of these positions remain unfilled to date; (2) describing whether and how the Service is allocating funds that would have otherwise been spent on the salaries and expenses related to these positions; and (3) describing the steps the agency has taken to identify and address the underlying conditions that created this trend, in order to shore up its public health and administrative infrastructure with highly qualified and experienced replacements.

Contract Support Costs.—The Committee recommends $546,446,000 for Contract Support Costs, $75,009,000 above the fiscal year 2012 enacted level and $70,000,000 above the budget request. With this increase, the Committee is attempting to fund the projected shortfall so the Federal government can meet its contractual obligations. The Committee directs the Service to work with Tribes and tribal organizations to explore options for improving the transparency of current year contract support cost information, and to report back to the Committee within 90 days of enactment of this Act.

Health Research.—The Committee is concerned by the continued disparity of the health status of American Indians and Alaska Natives (AI/ANs) compared to the general U.S. population. The Committee recognizes that identifying successful strategies for reducing these disparities depends on monitoring ongoing health trends. Therefore, the Committee is disappointed that the Service has fallen behind in tracking the health status and treatment needs of AI/ANs. The Service's last *Trends in Indian Health and Regional Difference in Indian Health* report was based on data gathered for the 2002–2003 edition. In addition, supplemental reports targeting specific health issues have been discontinued. The last vision survey was completed in 1994; obstetrics in 1996; and oral health in 1999. Examining the prevalence of emerging issues like the incidence of HIV/AIDS, teen suicide outbreaks, disparities plaguing AI/AN males, and drug overdoses and alcohol abuse are vital for developing policies and programs that ensure adequate health care for all AI/ANs. The Committee strongly urges the Service to reinstate ongoing and timely monitoring of health trends as a means for the

Service and Tribes to better target resources to improve the health status and eliminate the health disparities of AI/ANs.

INDIAN HEALTH FACILITIES

Appropriation enacted, 2012	$440,346,000
Budget estimate, 2013	443,502,000
Recommended, 2013	443,864,000
Comparison:	
Appropriation, 2012	+3,518,000
Budget estimate, 2013	+362,000

The Committee recommends $443,864,000 for Indian Health Facilities, $3,518,000 above the fiscal year 2012 enacted level and $362,000 above the budget request. The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report. Except as otherwise indicated below, the Committee expects the Indian Health Service to implement its fiscal year 2013 budget in accordance with its budget justification.

Facilities and Environmental Health Support.—The Committee recommends $204,741,000 for Facilities and Environmental Health Support, $5,328,000 above the fiscal year 2012 enacted level and $362,000 above the budget request. The increase above the budget request is for staffing costs for new and expanded health care facilities. These funds are subject to the same limitations as described earlier in this report under the Indian Health Services account.

NATIONAL INSTITUTES OF HEALTH

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

The National Institute of Environmental Health Sciences (NIEHS), an agency within the National Institutes of Health, was authorized in section 311(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and in section 126(g) of the Superfund Amendments and Reauthorization Act of 1986 to conduct certain research and worker training activities associated with the nation's Hazardous Substance Superfund program.

Appropriation enacted, 2012	$78,928,000
Budget estimate, 2013	78,928,000
Recommended, 2013	74,928,000
Comparison:	
Appropriation, 2012	−4,000,000
Budget estimate, 2013	−4,000,000

The Committee recommends $74,928,000 for the National Institute of Environmental Health Sciences, $4,000,000 below both the fiscal year 2012 enacted level and the budget request. The Committee remains highly supportive of NIEHS' worker training program and notes the program trained 143,000 workers last year, teaching those participants how to reduce the risks of exposure to hazardous materials. This program has been offered to workers for years at no charge wherein many other governmental training programs include a course fee. The Committee directs NIEHS to explore the feasibility of incorporating a nominal fee to recoup administrative or other costs associated with the worker training pro-

gram. NIEHS should include a report that summarizes findings and recommendations with the fiscal year 2014 budget request.

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

TOXIC SUBSTANCES AND ENVIRONMENTAL PUBLIC HEALTH

The Agency for Toxic Substances and Disease Registry (ATSDR), an agency in the Department of Health and Human Services, was created in section 104(i) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The Agency's mission is to serve the public through responsive public health actions to promote healthy and safe environments and prevent harmful toxic exposures. ATSDR assesses hazardous exposures in communities near toxic waste sites and advises the Environmental Protection Agency (EPA) and other government agencies, community groups and industry partners on actions needed to protect people's health. In addition, ATSDR conducts toxicological and applied research to support environmental assessments, supports health surveillance systems and registries, develops and disseminates information on hazardous substances, provides education and training on hazardous exposures, and responds to environmental emergencies. Through a national network of scientists and public health practitioners in State health departments, regional EPA offices and headquarters, ATSDR has been in the front ranks in protecting people from acute toxic exposures that occur from hazardous leaks and spills, environment-related poisonings, and natural and terrorism-related disasters.

Appropriation enacted, 2012	$76,215,000
Budget estimate, 2013	76,300,000
Recommended, 2013	74,039,000
Comparison:	
Appropriation, 2012	−2,176,000
Budget estimate, 2013	−2,261,000

The Committee recommends $74,039,000 for the Agency for Toxic Substances and Disease Registry (ATSDR), $2,176,000 below the fiscal year 2012 enacted level and $2,261,000 below the budget request.

Within the funds provided, $2,000,000 has been included to continue the important epidemiological studies of health conditions caused by exposures to uranium released from mining and milling operations in the Navajo Nation.

OTHER RELATED AGENCIES

EXECUTIVE OFFICE OF THE PRESIDENT

COUNCIL ON ENVIRONMENTAL QUALITY AND OFFICE OF ENVIRONMENTAL QUALITY

The Council on Environmental Quality (CEQ) was established by Congress under the National Environmental Policy Act of 1969 (NEPA). The Office of Environmental Quality (OEQ), which provides professional and administrative staff for the Council, was established in the Environmental Quality Improvement Act of 1970. The Council on Environmental Quality has statutory responsibility for overseeing Federal agency implementation of the requirements

of NEPA. CEQ also assists in coordinating environmental programs among the Federal agencies in the Executive Branch.

Appropriation enacted, 2012	$3,148,000
Budget estimate, 2013	3,106,000
Recommended, 2013	2,661,000
Comparison:	
Appropriation, 2012	−487,000
Budget estimate, 2013	−445,000

The Committee recommends $2,661,000 for the Council on Environmental Quality and Office of Environmental Quality, $487,000 below the fiscal year 2012 enacted level and $445,000 below the budget request. Commensurate with the appropriation, the authorized level for CEQ FTE is capped at 19, equivalent to the fiscal year 2006 utilization level.

CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

SALARIES AND EXPENSES

Appropriation enacted, 2012	$11,129,000
Budget estimate, 2013	11,403,000
Recommended, 2013	10,000,000
Comparison:	
Appropriation, 2012	−1,129,000
Budget estimate, 2013	−1,403,000

The Committee recommends $10,000,000 for Salaries and Expenses of the Chemical Safety and Hazard Investigation Board (the Board), which is $1,129,000 below the fiscal year 2012 enacted level and $1,403,000 below the budget request.

Bill Language.—The Committee continues to carry language, as in prior years, authorizing the EPA Inspector General to act as the Inspector General for the Board. The Committee has not provided funds to be transferred to the EPA IG who reports sufficient existing funding to cover these responsibilities.

OFFICE OF NAVAJO AND HOPI INDIAN RELOCATION

SALARIES AND EXPENSES

The Office of Navajo and Hopi Indian Relocation was established by Public Law 93–531 to plan and conduct relocation activities associated with the settlement of a land dispute between the Navajo Nation and the Hopi Tribe.

Appropriation enacted, 2012	$7,738,000
Budget estimate, 2013	8,400,000
Recommended, 2013	7,600,000
Comparison:	
Appropriation, 2012	−138,000
Budget estimate, 2013	−800,000

The Committee recommends $7,600,000 for Salaries and Expenses of the Office of Navajo and Hopi Indian Relocation, $138,000 below the fiscal year 2012 enacted level and $800,000 below the budget request.

INSTITUTE OF AMERICAN INDIAN AND ALASKA NATIVE CULTURE AND ARTS DEVELOPMENT

PAYMENT TO THE INSTITUTE

Appropriation enacted, 2012	$8,519,000
Budget estimate, 2013	9,369,000
Recommended, 2013	8,348,000
Comparison:	
Appropriation, 2012	−171,000
Budget estimate, 2013	−1,021,000

The Committee recommends $8,348,000 for the Institute of American Indian and Alaska Native Culture and Arts Development, $171,000 below the fiscal year 2012 enacted level and $1,021,000 below the budget request.

SMITHSONIAN INSTITUTION

The Smithsonian Institution is the world's largest museum and research complex, with 19 museums and galleries, numerous research centers, a library, archives, and the National Zoological Park. Funded by both private and Federal sources, the Smithsonian is unique in the Federal establishment. Created by an Act of Congress in 1846 to carry out the trust included in James Smithson's will, it has been engaged for 165 years in the "increase and diffusion of knowledge." In 2011, the Smithsonian attracted nearly 30 million visitors to its museums, galleries, and zoological park. Additional millions also view Smithsonian traveling exhibitions and participate in the annual Folklife Festival on the National Mall. As custodian of the National Collections, the Smithsonian is responsible for more than 137 million art objects, natural history specimens, and artifacts. These scientific and cultural collections are a vital resource for global research and conservation efforts. The collections are displayed for the enjoyment and education of visitors and are available for research by the staff of the Institution and by thousands of visiting students, scientists, and historians each year.

The amounts recommended by the Committee for the Smithsonian Institution, compared with the budget estimates by activity, are shown in the table at the end of this report.

SALARIES AND EXPENSES

Appropriation enacted, 2012	$635,512,000
Budget estimate, 2013	660,333,000
Recommended, 2013	643,634,000
Comparison:	
Appropriation, 2012	+8,122,000
Budget estimate, 2013	−16,699,000

The Committee recommends $643,634,000 for Salaries and Expenses of the Smithsonian Institution, $8,122,000 above the fiscal year 2012 enacted level and $16,699,000 below the budget request.

Additional Guidance.—The following additional direction and guidance is provided with respect to funding provided within this account:

Collections Care.—The Committee maintains its longstanding commitment to the preservation of Smithsonian Institution collections and has included, as requested, $1,400,000 for the Collections Care Initiative. The Committee urges the Smithsonian to continue

placing a high priority on the preservation of these priceless, irreplaceable historical collections.

Exhibit Maintenance.—The Committee has provided requested funding for exhibit maintenance and critical collections needs at the National Air and Space Museum ($100,000), the National Museum of Natural History ($130,000), and the National Museum of American History ($100,000) which remain among the most highly visited Smithsonian sites.

National Museum of African American History and Culture.—The Committee maintains its support for the National Museum of African American History and Culture (NMAAHC) and has included $5,550,000 to facilitate collections acquisitions, development of exhibitions, and strengthen and expand the museum's capital campaign which is responsible for raising matching funds for the construction of the NMAAHC. Federal dollars for the construction of the NMAAHC are being matched on a 1:1 basis.

Joint Venture.—The Committee maintains its support for the joint venture between the Library of Congress and the Smithsonian Institution creating a comprehensive compilation of audio and video recordings of personal histories and testimonials of individuals who participated in the Civil Rights movement.

FACILITIES CAPITAL

Appropriation enacted, 2012	$174,720,000
Budget estimate, 2013	196,500,000
Recommended, 2013	145,544,000
Comparison:	
Appropriation, 2012	−29,176,000
Budget estimate, 2013	−50,956,000

The Committee recommends $145,544,000 for Facilities Capital, $29,176,000 below the fiscal year 2012 enacted level and $50,956,000 below the budget request.

The Committee supports revitalization of Smithsonian Institution facilities and the planning and design of future projects. The Committee also supports and remains committed to the construction of the Congressionally authorized National Museum of African American History and Culture. Accordingly, the Committee recommends $50,000,000 for ongoing construction of the National Museum of African American History and Culture. These funds, which will ensure that construction continues, complement $45,000,000 provided by the Committee in prior years for pre-construction planning and design and $74,880,000 provided in fiscal year 2012 to complete design and begin construction. Federal funds for the construction of the NMAAHC are being matched on a 1:1 basis.

The Committee has provided funding, as requested, to address critical repairs at the National Air and Space Museum and structural and seismic upgrades at the Museum Support Center.

The Committee further directs that the balance of Facilities Capital funding be devoted to the highest and best use for revitalization efforts of Smithsonian Institution assets on a priority basis. A growing number of projects necessitate the need for the Smithsonian Institution to set clear priorities within the Facilities Capital account. The Committee urges the Smithsonian to establish, and present in priority order in future annual budget justifications, all Facilities Capital program activities.

NATIONAL GALLERY OF ART

The National Gallery of Art is one of the world's great galleries. Its magnificent works of art, displayed for the benefit of millions of visitors annually, and its two iconic buildings and sculpture garden, serve as an example of a successful cooperative endeavor between private individuals and institutions and the Federal Government. With the special exhibitions shown in the Gallery, and through the many exhibitions which travel across the country, the Gallery brings great art treasures to Washington, DC, and to the Nation. Through its educational and teacher training programs and its website, the Gallery provides art history materials, rich online educational materials, direct loans, and broadcast programs to millions of Americans in every State.

Table of Allocations by Activity.—The amounts recommended by the Committee compared with the budget estimates by activity are shown in the table at the end of this report.

SALARIES AND EXPENSES

Appropriation enacted, 2012	$113,883,000
Budget estimate, 2013	120,000,000
Recommended, 2013	113,121,000
Comparison:	
Appropriation, 2012	−762,000
Budget estimate, 2013	−6,879,000

The Committee recommends $113,121,000 for Salaries and Expenses of the National Gallery of Art, $762,000 below the fiscal year 2012 enacted level and $6,879,000 below the budget request. Within the amount provided, the Committee includes $3,518,000, as requested, for the Gallery's Special Exhibition program.

Bill Language.—The Committee has included bill language, as requested, specifying the amount provided for Special Exhibitions.

REPAIR, RESTORATION AND RENOVATION OF BUILDINGS

Appropriation enacted, 2012	$14,493,000
Budget estimate, 2013	23,000,000
Recommended, 2013	12,679,000
Comparison:	
Appropriation, 2012	−1,814,000
Budget estimate, 2013	−10,321,000

The Committee recommends $12,679,000 for Repair, Restoration and Renovation of buildings at the National Gallery of Art, $1,814,000 below the fiscal year 2012 enacted level and $10,321,000 below the budget request. Reductions from the request are to defer Master Facilities Plan work.

Bill Language.—The Committee has included bill language, as requested, relating to lease agreements of no more than 10 years that addresses space needs created by ongoing renovations in the Master Facilities Plan.

JOHN F. KENNEDY CENTER FOR THE PERFORMING ARTS

The John F. Kennedy Center for the Performing Arts is a living memorial to the late President Kennedy and is the National Center for the Performing Arts. The Center houses nine stages and seven theaters which have a total of more than 7,300 seats. The Center consists of over 1.5 million square feet of usable floor space with

visitation averaging 8,000 on a daily basis. The support systems in the building often operate at capacity 18 hours a day, seven days a week, 365 days a year.

OPERATIONS AND MAINTENANCE

Appropriation enacted, 2012	$23,163,000
Budget estimate, 2013	22,379,000
Recommended, 2013	22,379,000
Comparison:	
Appropriation, 2012	−784,000
Budget estimate, 2013	0

The Committee recommends $22,379,000 for Operations and Maintenance, as requested, $784,000 below the fiscal year 2012 enacted level.

CAPITAL REPAIR AND RESTORATION

Appropriation enacted, 2012	$13,628,000
Budget estimate, 2013	13,588,000
Recommended, 2013	13,588,000
Comparison:	
Appropriation, 2012	−40,000
Budget estimate, 2013	0

The Committee recommends $13,588,000 for Capital Repair and Restoration, as requested, $40,000 below the fiscal year 2012 enacted level.

WOODROW WILSON INTERNATIONAL CENTER FOR SCHOLARS

SALARIES AND EXPENSES

The Woodrow Wilson International Center for Scholars is a unique institution with a special mission to serve as a living memorial to President Woodrow Wilson. The Center performs this mandate through its role as an international institute promoting policy-relevant research and dialogue to increase understanding and enhance the capabilities and knowledge of leaders, citizens, and institutions worldwide. The Woodrow Wilson Center hosts scholars and policy makers to do their own advanced study, research and writing and facilitates debate and discussions among scholars, public officials, journalists and business leaders from across the country on relevant, major long-term issues facing this Nation and the world.

Appropriation enacted, 2012	$10,987,000
Budget estimate, 2013	10,492,000
Recommended, 2013	10,492,000
Comparison:	
Appropriation, 2012	−495,000
Budget estimate, 2013	0

The Committee recommends $10,492,000 for Salaries and Expenses of the Woodrow Wilson International Center for Scholars, as requested, $495,000 below the fiscal year 2012 enacted level.

NATIONAL FOUNDATION ON THE ARTS AND THE HUMANITIES

NATIONAL ENDOWMENT FOR THE ARTS

GRANTS AND ADMINISTRATION

Appropriation enacted, 2012	$146,021,000
Budget estimate, 2013	154,255,000
Recommended, 2013	132,000,000
Comparison:	
Appropriation, 2012	−14,021,000
Budget estimate, 2013	−22,255,000

The Committee recommends $132,000,000 for the National Endowment for the Arts (NEA), $14,021,000 below the fiscal year 2012 enacted level and $22,255,000 below the budget request.

The Committee values greatly the longstanding collaborative relationship between the NEA and the States. State Arts Agencies (SSAs) support the arts for communities at the grassroots level regardless of their geographic location, providing much of their funding to smaller organizations, community groups, and schools rather than well-established arts organizations. The Committee supports the continuation of this effective partnership and urges the NEA to work constructively with States in developing and implementing arts education programs and policies.

The Committee remains committed to supporting proven national initiatives with broad geographic reach. The Big Read, Challenge America, and Shakespeare in American Communities are among the cost-effective grant programs with broad, bipartisan Congressional support that meet these criteria, supporting the NEA's goal of extending the arts to underserved populations in both urban and rural communities across the United States.

The National Council on the Arts has historically played a substantive role in directing the development and direction of the NEA's programs. The Committee is concerned that the Council is playing a diminishing role and urges the NEA to fully engage the Council in its statutorily mandated advisory role in the decision-making process relating to the NEA's grant-making policies and programmatic initiatives, in addition to the Council's traditional advisory role in the awarding of NEA grants.

The Committee has not provided $3,000,000 in requested funding for expenses associated with an anticipated relocation of the NEA from its current location at the Old Post Office Building. At the time of the markup of this bill, a detailed justification, including specific relocation costs, had not been presented to the Committee for consideration. The Committee would be negligent in its oversight responsibilities by providing funding for relocation without this level of detail. Therefore, the Committee directs the NEA to work with the General Services Administration (GSA) to identify cost-effective options and submit to the Committee at the earliest possible date a detailed justification for the relocation of the NEA.

The Committee notes that the NEA's Congressional authorization expired in 1993 and, therefore, urges the NEA to work with the appropriate authorizing committees on expeditiously renewing its Congressional authorization.

Bill Language.—Each year, the Committee provides in bill language specific guidelines under which the Endowment is directed to distribute taxpayer dollars in support of the arts. With the ex-

ception of established honorific programs, grant funding to individual artists is strictly prohibited. The Committee directs that priority be given to providing services or grant funding for projects, productions, or programs that encourage public knowledge, education, understanding, and appreciation of the arts. Any reduction in support to the States for arts education should be no more than proportional to other funding decreases taken in other NEA programs.

Reforms originally instituted by the Committee in P.L. 108–447 relating to grant guidelines and program priorities are fully restated in Sections 415 and 416 of the bill. The Committee expects the NEA to adhere to them fully. These reforms maintain broad bipartisan support and continue to serve well both the NEA and the public interest.

Further, the Committee has included bill language addressing grant award matching requirements and waiver procedures. This language is the result of extensive collaboration and consultation between the NEA and State Arts Agencies as directed in the fiscal year 2012 Interior, Environment, and Related Agencies conference report.

The allocation of funding among NEA activities is shown in the table at the end of this report.

NATIONAL ENDOWMENT FOR THE HUMANITIES

GRANTS AND ADMINISTRATION (INCLUDING MATCHING GRANTS)

Appropriation enacted, 2012	$146,021,000
Budget estimate, 2013	154,255,000
Recommended, 2013	132,000,000
Comparison:	
Appropriation, 2012	−14,021,000
Budget estimate, 2013	−22,255,000

The Committee recommends a total of $132,000,000 for the National Endowment for the Humanities (NEH), $14,021,000 below the fiscal year 2012 enacted level and $22,255,000 below the budget request.

The Committee commends the NEH Federal/State Partnership for its ongoing, successful collaboration with State humanities councils in each of the 50 states as well as Washington, D.C., the Commonwealth of Puerto Rico, the U.S. Virgin Islands, Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa. Every NEH dollar received by a council is matched by a local contribution. In recent years, the proportion of NEH program funds supporting the work of State humanities councils has grown to nearly 40 percent. The Committee urges the NEH to sustain program funding to support the critical work of State humanities councils consistent with the guidance provided in the fiscal year 2012 Interior, Environment, and Related Agencies conference report.

The Committee does not support the budget request proposal to discontinue the *We the People* program. A similar proposal made last year was rejected. *We the People* was initiated on Constitution Day—September 17, 2002—and should remain a core NEH grant program designed to promote the teaching, study, and understanding of American history, culture, and democratic principles. Grants awarded through the *We the People* program have histori-

cally leveraged millions of non-Federal dollars supporting enrichment and educational materials provided to thousands of educators, schools, community colleges, and libraries nationwide. *We the People* is a proven, cost-effective national grant program with broad geographic reach and bipartisan Congressional support. The Committee, therefore, directs that it be sustained as an individual initiative at no less than $3,500,000 in fiscal year 2013.

The Committee has not provided $3,000,000 in requested funding for expenses associated with an anticipated relocation of the NEH from its current location at the Old Post Office Building. At the time of the markup of this bill, a detailed justification, including specific relocation costs, had not been presented to the Committee for consideration. The Committee would be negligent in its oversight responsibilities by providing funding for relocation without this level of detail. Therefore, the Committee directs the NEH to work with the General Services Administration (GSA) to identify cost-effective options and submit to the Committee at the earliest possible date a detailed justification for the relocation of the NEH.

The Committee notes that the NEH's Congressional authorization expired in 1993 and, therefore, urges the NEH to work with the appropriate authorizing committees on expeditiously renewing its Congressional authorization.

The allocation of funding among NEH activities is shown in the table at the end of this report.

COMMISSION OF FINE ARTS

The Commission of Fine Arts was established in 1910 to advise the government on matters pertaining to the design of national symbols, and particularly to guide the architectural development of Washington, D.C. The Commission's work includes advice on designs for parks, public buildings, public art, as well as the design of national monuments, coins and medals, and overseas American military cemeteries. In addition, the Commission conducts design reviews of semipublic and private structures within the Old Georgetown Historic District and within certain areas of the National Capital that are adjacent to areas of Federal interest. The Commission reviews more than 600 projects annually. The Commission also administers the National Capital Arts and Cultural Affairs program.

SALARIES AND EXPENSES

Appropriation enacted, 2012	$2,396,000
Budget estimate, 2013	2,175,000
Recommended, 2013	2,175,000
Comparison:	
Appropriation, 2012	−221,000
Budget estimate, 2013	0

The Committee recommends $2,175,000 for Salaries and Expenses of the Commission of Fine Arts, as requested, $221,000 below the fiscal year 2012 enacted level.

NATIONAL CAPITAL ARTS AND CULTURAL AFFAIRS

Appropriation enacted, 2012	$1,997,000
Budget estimate, 2013	0
Recommended, 2013	1,950,000
Comparison:	
Appropriation, 2012	−47,000
Budget estimate, 2013	+1,950,000

The National Capital Arts and Cultural Affairs program was established in Public Law 99–190 to support organizations that perform, exhibit, and/or present the arts in the Nation's Capital. The Committee recommends $1,950,000, which is $47,000 below the fiscal year 2012 enacted level and $1,950,000 above the budget request.

ADVISORY COUNCIL ON HISTORIC PRESERVATION

SALARIES AND EXPENSES

The National Historic Preservation Act of 1966 established the Advisory Council on Historic Preservation. The ACHP was granted permanent authorization as part of the National Historic Preservation Act Amendments of 2006 (Public Law 109–453). The ACHP promotes the preservation, enhancement, and productive use of our nation's historic resources and advises the President and Congress on national historic preservation policy.

Appropriation enacted, 2012	$6,098,000
Budget estimate, 2013	7,023,000
Recommended, 2013	5,723,000
Comparison:	
Appropriation, 2012	−375,000
Budget estimate, 2013	−1,300,000

The Committee recommends $5,723,000 for Salaries and Expenses of the Advisory Council on Historic Preservation (ACHP), $375,000 below the fiscal year 2012 enacted level and $1,300,000 below the budget request.

The Committee is concerned by the Council's decision to intervene in the review of the proposed Susquehanna-Roseland Transmission line almost two years after the review process was initiated and following the closure of the public comment process on the draft environmental impact statement. This initiative, which is critical to the supply of electricity to 58 million consumers in 13 States and Washington, DC, is one of seven electric transmission lines that has been accelerated through a pilot demonstration to streamline Federal permitting and increase cooperation at the Federal and State level. The Council is directed to work cooperatively with the Department of the Interior to avoid any further delays so that the Department, as directed in the fiscal year 2012 Interior, Environment, and Related Agencies conference report, adheres to its scheduled issuance of a final Record of Decision in October, 2012.

The Committee has not provided $1,300,000 in requested funding for expenses associated with an anticipated relocation of the ACHP from its current location at the Old Post Office Building. At the time of the markup of this bill, a detailed justification, including specific relocation costs, had not been presented to the Committee for consideration. The Committee would be negligent in its over-

sight responsibilities by providing funding for relocation without this level of detail. Therefore, the Committee directs the ACHP to work with the General Services Administration (GSA) to identify cost-effective options and submit to the Committee at the earliest possible date a detailed justification for the relocation of the ACHP.

NATIONAL CAPITAL PLANNING COMMISSION

SALARIES AND EXPENSES

The National Capital Planning Act of 1952 designated the National Capital Planning Commission as the central planning agency for the Federal government in the National Capital Region. The three major functions of the Commission are to prepare and adopt the Federal elements of the National Capital Comprehensive Plan; prepare an annual report on a five-year projection of the Federal Capital Improvement Program; and review plans and proposals submitted to the Commission.

Appropriation enacted, 2012	$8,141,000
Budget estimate, 2013	7,977,000
Recommended, 2013	7,977,000
Comparison:	
Appropriation, 2012	−164,000
Budget estimate, 2013	0

The Committee recommends $7,977,000 for Salaries and Expenses of the National Capital Planning Commission, as requested, $164,000 below the fiscal year 2012 enacted level.

UNITED STATES HOLOCAUST MEMORIAL MUSEUM

HOLOCAUST MEMORIAL MUSEUM

In 1980, Congress passed legislation creating a 65-member Holocaust Memorial Council with the mandate to create and oversee a living memorial/museum to victims of the Holocaust. The museum opened in April 1993. Construction costs for the museum came solely from donated funds raised by the U.S. Holocaust Memorial Museum Campaign, and appropriated funds were used for planning and development of programmatic components, overall administrative support, and annual commemorative observances. Since the opening of the museum, appropriated funds have been provided to pay for the ongoing operating costs of the museum as authorized by Public Law 102–529 and Public Law 106–292. Private funds support educational outreach throughout the United States.

Appropriation enacted, 2012	$50,717,000
Budget estimate, 2013	51,788,000
Recommended, 2013	49,900,000
Comparison:	
Appropriation, 2012	−817,000
Budget estimate, 2013	−1,888,000

The Committee recommends $49,900,000 for the Holocaust Memorial Museum, $817,000 below the fiscal year 2012 enacted level and $1,888,000 below the budget request.

PRESIDIO TRUST

PRESIDIO TRUST FUND

Appropriation enacted, 2012	$11,981,000
Budget estimate, 2013	0
Recommended, 2013	0
Comparison:	
Appropriation, 2012	−11,981,000
Budget estimate, 2013	0

As requested, no funding is proposed for the Presidio Trust in fiscal year 2013. Funds provided in fiscal year 2012 fulfilled the commitment made by Congress to support the transition of the Presidio Army Base to a mixed-use, financially independent facility by the year 2013 as authorized by Public Law 104–333. The Presidio's self-sufficiency plan stipulated that the Presidio Trust receive Federal appropriations through fiscal year 2012, at which time the Trust would become responsible for funding the operations and maintenance of the Presidio in perpetuity.

DWIGHT D. EISENHOWER MEMORIAL COMMISSION

The Dwight D. Eisenhower Memorial Commission was created by Congress in 1999 through Public Law 106–79 for the purpose of establishing a permanent national memorial to Dwight D. Eisenhower, Supreme Commander of the Allied Forces in Europe in World War II and 34th President of the United States. The Commission consists of 12 members, four members of the House of Representatives, four Senators, and four private citizens appointed by the President.

SALARIES AND EXPENSES

Appropriation enacted, 2012	$1,997,000
Budget estimate, 2013	5,600,000
Recommended, 2013	0
Comparison:	
Appropriation, 2012	−1,997,000
Budget estimate, 2013	−5,600,000

The bill does not include funding for the Salaries and Expenses account. The Committee is aware that the design of the Eisenhower Memorial has garnered a significant amount of interest. The Committee notes that an open, public, and transparent process exists for deciding the components of the final design. The process is intended to be collaborative and incorporate multiple perspectives. The Committee urges the Commission to continue working with all constituencies as partners in the planning process including, but not limited to, the National Park Service, the Commission on Fine Arts, and the National Capitol Planning Commission.

Further, in order for the Committee to remain informed as to the status of fund raising efforts the Eisenhower Commission is directed to include a table in its annual Congressional justification that shows the total amount of private (non-Federal) contributions to date, and the total obligations and total expenditures of those funds.

CAPITAL CONSTRUCTION

Appropriation enacted, 2012	$30,940,000
Budget estimate, 2013	54,240,000
Recommended, 2013	0
Comparison:	
Appropriation, 2012	−30,940,000
Budget estimate, 2013	−54,240,000

The bill does not include funding for the Capital Construction account. The Committee provided the Commission a total of $32,937,000 in fiscal year 2012 to finance the initial groundbreaking of the memorial in August 2012. Additional considerations for a number of the design elements required a revision of the schedule. The fiscal year 2013 budget offers an updated schedule with groundbreaking beginning in January 2013. As a result, the Commission will not have spent the construction funds provided for fiscal year 2012. The Committee finds the previously appropriated funds will be sufficient to initiate construction in fiscal year 2013, and thus, has not provided additional funds.

TITLE IV—GENERAL PROVISIONS

Section 401 modifies a provision providing for public availability of information governing the use of consulting services contracts.

Section 402 continues a provision prohibiting activities to promote public support or opposition to legislative proposals.

Section 403 continues a provision providing for annual appropriations unless expressly provided otherwise in this Act.

Section 404 modifies a provision providing for restrictions on departmental assessments unless approved by the Committees on Appropriations.

Section 405 continues a provision preventing the use of funds to sell giant sequoia trees on National Forest or Bureau of Land Management lands in a manner different than such sales were conducted in the past.

Section 406 continues a limitation on accepting and processing applications for patents and on the patenting of Federal lands; permits processing of grandfathered applications; and permits third-party contractors to process grandfathered applications.

Section 407 continues a provision regarding the payment of contract support costs.

Section 408 modifies a provision allowing Forest Service land management plans to be more than 15 years old if the Secretary is acting in good faith to update such plans.

Section 409 continues a provision limiting preleasing, leasing, and related activities within the boundaries of National Monuments.

Section 410 continues a provision which restricts funding for acquisition of land from being used for declarations of taking or complaints in condemnation.

Section 411 continues a provision addressing timber sales involving Alaskan western red cedar.

Section 412 modifies a provision continuing certain authorities to renew grazing permits or leases administered by the Forest Service or Department of the Interior.

Section 413 continues a provision which prohibits no-bid contracts and grants except under certain circumstances.

Section 414 continues a provision which requires public disclosure of certain reports.

Section 415 continues a provision which delineates the grant guidelines for the National Endowment for the Arts.

Section 416 continues a provision which delineates the program priorities for the programs managed by the National Endowment for the Arts.

Section 417 provides guidelines relating to National Endowment for the Arts grant awards to States.

Section 418 continues a provision requiring the Department of the Interior, the EPA, the Forest Service, and the Indian Health Service provide the Committees on Appropriations a quarterly report on the status of balances of appropriations.

Section 419 requires the President to submit a report to the Committees on Appropriations no later than 120 days after the fiscal year 2014 budget is submitted to Congress describing in detail all Federal agency obligations and expenditures for climate change programs and activities in fiscal year 2012.

Section 420 continues a provision prohibiting the use of funds to promulgate or implement any regulation requiring the issuance of permits under title V of the Clean Air Act for carbon dioxide, nitrous oxide, water vapor, or methane emissions.

Section 421 continues a provision prohibiting the use of funds to implement any provision in a rule if that provision requires mandatory reporting of greenhouse gas emissions from manure management systems.

Section 422 clarifies Silvicultural Operations under the Federal Water Pollution Control Act.

Section 423 modifies the management of domestic sheep and bighorn sheep on Federal lands and public lands.

Section 424 continues a provision prohibiting the government from entering into contracts or agreements with any corporation that was convicted of a felony criminal violation under any Federal law within the preceding 24 months.

Section 425 continues a provision prohibiting funds for contracts or agreements with entities with unpaid Federal tax liabilities that have not entered into payment agreements to remedy the liability.

Section 426 extends the Herger-Feinstein Library Group Forestry Recovery Act.

Section 427 extends the Colorado Good Neighbor authority to all western states.

Section 428 requires the Forest Service to identify land for fire stations within National Recreation Areas.

Section 429 extends Forest Service cost recovery for special uses for five years.

Section 430 allows interpretive associations to partner with the Forest Service.

Section 431 extends the maximum authorized term for grazing permits and leases.

Section 432 clarifies the Forest Service may use designation by description and prescription.

Section 433 prohibits the Forest Service in California from implementing the travel management rule without additional analysis and prevents the agency from designating ML–3 roads as highways.

Section 434 prohibits the use of funds to develop, adopt, implement, administer, or enforce a change or supplement to a rule or guidance documents pertaining to the definition of waters under the Federal Water Pollution Control Act.

Section 435 prohibits the use of funds to develop, carry out, implement, or enforce proposed regulations published on June 18, 2010.

Section 436 prohibits the use of funds to expand the stormwater discharge program under section 402(p) of the Federal Water Pollution Control Act until certain criteria are met.

Section 437 clarifies current Appeals Reform Act requirements for Forest Service activities.

Section 438 prohibits the use of funds to limit recreational shooting and hunting on Federal and public lands except for public safety.

Section 439 prohibits the use of funds to develop, propose, finalize, administer, or implement the National Ocean Policy under Executive Order 13547; requires a report identifying all Federal expenditures for the development, administration, or implementation of such Policy in fiscal years 2011 and 2012; and requires that the President's budget submission for fiscal year 2014 identify funding proposed for the implementation of such Policy.

Section 440 establishes a pilot program for vessels to demonstrate alternative methods to comply with emissions control area standards.

Section 441 establishes a Spending Reduction Account as required by Section 3(j) of H. Res. 5.

BILL-WIDE REPORTING REQUIREMENTS

The following items are included in accordance with various requirements of the Rules of the House of Representatives:

FULL COMMITTEE VOTES

Pursuant to the provisions of clause 3(b) of rule XIII of the Rules of the House of Representatives, the results of each roll call vote on an amendment or on the motion to report, together with the names of those voting for and those voting against, are printed below:

[INSERT FULL COMMITTEE VOTES]

STATEMENT OF GENERAL PERFORMANCE GOALS AND OBJECTIVES

Pursuant to clause 3(c)(4) of rule XIII of the Rules of the House of Representatives, the following is a statement of general performance goals and objectives for which this measure authorizes funding:

The Committee on Appropriations considers program performance, including a program's success in developing and attaining outcome-related goals and objectives, in developing funding recommendations.

RESCISSION OF FUNDS

Pursuant to clause 3(f)(2) of rule XIII of the Rules of the House of Representatives, the following table is submitted describing the rescission recommended in the accompanying bill:

Department and activity:

Amounts recommended for rescission:

Department of the Interior: Land and Water Conservation Fund (contract authority) $30,000,000.

Environmental Protection Agency: State and Tribal Assistance Grants $100,000,000.

TRANSFERS OF FUNDS

Pursuant to clause 3(f)(2) of rule XIII of the Rules of the House of Representatives, the following table is submitted describing the transfer of funds in the accompanying bill.

APPROPRIATION TRANSFERS RECOMMENDED IN THE BILL

Account from which transfer is made	Amount 000's)	Account to wh ch transfer is made	Amount 000's)
Department of the Interior, National Park Service.	not specified	Department of Transportation, Federal Highway Administration.	not specified
Department of the Interior, Operation of Indian Programs.	not specified	Indian forest land assistance accounts	not specified
Department of the Interior, Bureau of Indian Affairs Construction.	not specified	Bureau of Reclamation	not specified
Department of the Interior, Office of Insular Affairs.	not specified	Secretary of Agriculture	not specified
Department of the Interior, Office of the Special Trustee for American Indians.	not specified	Department of the Interior, Bureau of Indian Affairs, Office of Indian Programs; Office of the Solicitor, Salaries and Expenses; Office of the Secretary, Salaries and Expenses.	not specified
Department of the Interior, Wildland Fire Management.	not specified	Department of the Interior, for repayment of advances made during emergencies.	not specified
Department of the Interior, Wildland Fire Management.	up to $50,000	Forest Service, Wildland Fire Management.	up to $50,000
Department of the Interior, FLAME Wildfire Suppression Reserve Fund.	not specified	Department of the Interior, Wildland Fire Management.	not specified
Environmental Protection Agency, Hazardous Substance Superfund.	not specified	Other Federal Agencies	not specified
Environmental Protection Agency, Hazardous Substance Superfund.	$9,939	Environmental Protection Agency, Office of Inspector General.	$9,939
Environmental Protection Agency, Hazardous Substance Superfund.	$22,979	Environmental Protection Agency, Science and Technology.	$22,979
Environmental Protection Agency, Environmental Programs and Management.	up to $250,000	Any Federal Department or Agency for Great Lakes Initiative.	up to $250,000
Forest Service, Capital Improvement and Maintenance.	not specified	General Fund of the Treasury	not specified
Forest Service, Capital Improvement and Maintenance.	up to $13,000	Forest Service, National Forest System	up to $13,000
Forest Service, Wildland Fire Management.	not specified	Forest Service, for repayment of advances made during emergencies.	not specified
Forest Service, Wildland Fire Management.	not specified	Forest Service, State and Private Forestry.	not specified
Forest Service, Wildland Fire Management.	not specified	Forest Service, National Forest System	not specified
Forest Service, Wildland Fire Management.	not specified	Forest Service, Forest and Rangeland Research.	not specified
Forest Service, Wildland Fire Management.	up to $50,000	Secretary of the Interior	up to $50,000

Account from which transfer is made	Amount 000's)	Account to wh ch transfer is made	Amount 000's)
Forest Service, Wildland Fire Management.	up to $21,000	Forest Service, National Forest System	up to $21,000
Forest Service, FLAME Wildfire Suppression Reserve Fund.	not specified	Forest Service, Wildland Fire Management.	not specified
Forest Service	not specified	Forest Service, Wildland Fire Management.	not specified
Forest Service	up to $82,000	USDA, Working Capital Fund	up to $82,000
Forest Service	up to $14,500	USDA, Greenbook	up to $14,500

DISCLOSURE OF EARMARKS AND CONGRESSIONALLY DIRECTED SPENDING ITEMS

Neither the bill nor the report contains any Congressional earmarks, limited tax benefits, or limited tariff benefits as defined by clause 9 of rule XXI.

COMPLIANCE WITH RULE XIII, CLAUSE 3(e) (RAMSEYER RULE)

In compliance with clause 3(e) of rule XIII of the Rules of the House of Representatives, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted is enclosed in black brackets, new matter is printed in italic, and existing law in which no change is proposed is shown in roman):

[INSERT FROM LEGISLATIVE COUNSEL]

CHANGES IN APPLICATION OF EXISTING LAW

Pursuant to clause 3(f)(1)(A) of rule XIII of the Rules of the House of Representatives, the following statements are submitted describing the effect of provisions in the accompanying bill, which directly or indirectly change the application of existing law. In most instances these provisions have been included in prior appropriations Acts.

The bill includes the following changes in application of existing law:

OVERALL BILL

Providing that certain appropriations remain available until expended or extends the availability of funds beyond the fiscal year where programs or projects are continuing but for which legislation does not specifically authorize such extended availability. This authority tends to result in savings by preventing the practice of committing funds on low priority projects at the end of the fiscal year to avoid losing the funds.

Limiting, in certain instances, the obligation of funds for particular functions or programs. These limitations include restrictions on the obligation of funds for administrative expenses, travel expenses, the use of consultants, and programmatic areas within the overall jurisdiction of a particular agency.

Limiting official entertainment or reception and representation expenses for selected agencies in the bill.

Continuing ongoing activities of those Federal agencies, which require annual authorization or additional legislation, which has not been enacted.

TITLE I—DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

MANAGEMENT OF LANDS AND RESOURCES

Providing funds to the Bureau for the management of lands and resources.

Providing funds to the National Fish and Wildlife Foundation under certain conditions.

Permitting the use of fees for processing applications for permit to drill.

Permitting the use of fees for conducting oil and gas inspections.

Permitting the use of mining fee collections for program operations.

Permitting the use of fees from communication site rentals.

LAND ACQUISITION

Requiring that funding for the program is derived from the Land and Water Conservation Fund.

OREGON AND CALIFORNIA GRANT LANDS

Providing funds for the Oregon and California Grant Lands.

Authorizing the transfer of certain collections from the Oregon and California Land Grants Fund to the Treasury.

RANGE IMPROVEMENTS

Allowing certain funds to be transferred to the Department of the Interior for range improvements.

SERVICE CHARGES, DEPOSITS, AND FORFEITURES

Allowing the use of certain collected funds for certain administrative costs and operation of termination of certain facilities.

Allowing the use of funds on any damaged public lands.

Authorizing the Secretary to use monies from forfeitures, compromises or settlements for improvement, protection and rehabilitation of public lands under certain conditions.

MISCELLANEOUS TRUST FUNDS

Allowing certain contributed funds to be advanced for administrative costs and other activities of the Bureau.

ADMINISTRATIVE PROVISIONS

Permitting the Bureau to enter into agreements with public and private entities, including States.

Permitting the Bureau to manage improvements to which the United States has title.

Permitting the payment of rewards for information on violations of law on Bureau lands.

Providing for cost-sharing arrangements for printing services.

Permitting the Bureau to conduct certain projects for State governments on a reimbursable basis.

Prohibiting the use of funds for the destruction of wild horses and burros.

UNITED STATES FISH AND WILDLIFE SERVICE

RESOURCE MANAGEMENT

Limiting funding for certain Endangered Species Act programs.

LAND ACQUISITION

Requiring that funding for the program is derived from the Land and Water Conservation Fund.

Prohibiting the use of funds for administrative overhead, planning or other management costs.

COOPERATIVE ENDANGERED SPECIES CONSERVATION FUND

Requiring that portions of funding for the program are derived from the Cooperative Endangered Species Conservation Fund and the Land and Water Conservation Fund.

STATE AND TRIBAL WILDLIFE GRANTS

Specifying the State and tribal wildlife grants distribution formula, the planning and cost-sharing requirements, and limiting administrative costs.

ADMINISTRATIVE PROVISIONS

Providing that programs may be carried out by direct expenditure, contracts, grants, cooperative agreements and reimbursable agreements with public and private entities.

Providing for repair of damage to public roads.

Providing options for the purchase of land not to exceed $1.

Permitting cost-shared arrangements for printing services.

Permitting the acceptance of donated aircraft.

NATIONAL PARK SERVICE

OPERATION OF THE NATIONAL PARK SYSTEM

Designating funds for Everglades restoration.

Providing for repair, rehabilitation and maintenance of National Park Service assets.

NATIONAL RECREATION AND PRESERVATION

Providing for expenses not otherwise provided for.

HISTORIC PRESERVATION

Providing for expenses derived from the Historic Preservation Fund.

CONSTRUCTION

Providing funds for construction, improvements, repair or replacement of physical facilities including modified water deliveries to Everglades National Park with certain restrictions.

LAND AND WATER CONSERVATION FUND

Rescinding $30,000,000 in Land and Water Conservation Fund contract authority.

LAND ACQUISITION AND STATE ASSISTANCE

Requiring that funding for the program is derived from the Land and Water Conservation Fund.

ADMINISTRATIVE PROVISIONS

Allowing certain franchise fees to be available for expenditure without further appropriation to extinguish or reduce liability for certain possessory interests.

Providing for the retention of administrative costs under certain Land and Water Conservation Fund programs.

Allows National Park Service funds to be transferred to the Federal Lands Highway Administration for purposes authorized under 23 U.S.C. 204 for reasonable administrative support costs.

UNITED STATES GEOLOGICAL SURVEY

SURVEYS, INVESTIGATIONS, AND RESEARCH

Providing funds to perform surveys, investigations, and research covering topography, geology, hydrology, biology, and the mineral and water resources.

Providing funds to classify lands as to their mineral and water resources.

Funding engineering supervision to power permittees and Federal Energy Regulatory Commission licensees.

Funding the administration of the minerals exploration program (30 U.S.C. 641) to conduct inquiries into the economic conditions affecting mining and materials processing industries.

Prohibiting the conduct of new surveys on private property without permission.

Requiring cost sharing for cooperative topographic mapping and water resource data collection activities.

ADMINISTRATIVE PROVISIONS

Allowing funds to be used for certain contracting, technical services, construction, maintenance, acquisition, and representation expenses.

Permitting the use of certain contracts, grants, and cooperative agreements.

Recognizing students and recent graduates as Federal employees for the purposes of travel and work injury compensation.

BUREAU OF OCEAN ENERGY MANAGEMENT

Permitting funds for mineral leasing and environmental study; enforcing laws and contracts; and for matching grants.

Provides that funds may be used which shall be derived from non-refundable cost recovery fees collected in 2013.

Permitting the use of certain excess receipts from Outer Continental Shelf leasing activities.

Providing for reasonable expenses related to volunteer beach and marine cleanup activities.

BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT

Permitting funds for mineral leasing and environmental study; enforcing laws and contracts; and for matching grants.

Provides that funds may be used which shall be derived from non-refundable cost recovery fees collected in 2013.

Permitting the use of certain excess receipts from Outer Continental Shelf leasing activities.

Permitting the use of funds derived from non-refundable inspection fees collecting in 2013.

Requiring that not less than 50 percent of inspection fees expended be used on personnel, expanding capacity and reviewing applications for permit to drill.

OIL SPILL RESEARCH

Providing that funds shall be derived from the Oil Spill Liability Trust Fund.

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

REGULATION AND TECHNOLOGY

Permitting payment to State and tribal personnel for travel and per diem expenses for training.

ABANDONED MINE RECLAMATION FUND

Allowing the use of debt recovery to pay for debt collection.

Allowing that certain funds made available under title IV of Public Law 95–87 may be used for any required non-Federal share of the cost of certain projects.

Allowing funds to be used for travel expenses of State and tribal personnel while attending certain OSM training.

ADMINISTRATIVE PROVISION

Permits the Secretary to transfer title for computer equipment to States and Tribes hereafter.

BUREAU OF INDIAN AFFAIRS AND BUREAU OF INDIAN EDUCATION

OPERATION OF INDIAN PROGRAMS

Allowing the use of certain funds for official reception and representation expenses.

Limiting funds for welfare assistance payments, except for disaster relief.

Limiting funds for contract support costs.

Limiting the use of funds for school operations of Bureau-funded schools and other education programs.

Permitting the use of tribal priority allocations for general assistance payments to individuals, for contract support costs, and school operations costs.

Providing for an Indian self-determination fund.

Limiting funds for administrative cost grants under certain circumstances.

Allowing the transfer of certain forestry funds.

Allows the use of funds to purchase uniforms or other identifying articles of clothing for personnel if it enhances the safety of Bureau field employees.

CONSTRUCTION

Providing for the transfer of Navajo irrigation project funds to the Bureau of Reclamation.

Providing that six percent of Federal Highway Trust Fund contract authority may be used for construction management costs.

Providing Safety of Dams funds on a non-reimbursable basis.

Requiring the use of administrative and cost accounting principles for certain school construction projects and exempting such projects from certain requirements.

Requiring conformance with building codes and health and safety standards.

Specifying the procedure for dispute resolution.

Limiting the control of construction projects when certain time frames have not been met.

Allowing reimbursement of construction costs from the Office of Special Trustee.

INDIAN GUARANTEED LOAN PROGRAM ACCOUNT

Limiting funds for administrative expenses and for subsidizing total loan principal.

ADMINISTRATIVE PROVISIONS

Allowing the use of funds for direct expenditure, contracts, cooperative agreements, compacts, and grants.

Allowing contracting for the San Carlos Irrigation Project.

Limiting the use of funds for certain contracts, grants and cooperative agreements.

Allowing Tribes to return appropriated funds.

Prohibiting funding of Alaska schools.

Limiting the number of schools and the expansion of grade levels in individual schools.

Specifying distribution of indirect and administrative costs for certain Tribes.

DEPARTMENTAL OFFICES

OFFICE OF THE SECRETARY, SALARIES AND EXPENSES

Allowing the use of certain funds for official reception and representation expenses.

Permitting payments to former Bureau of Mines workers.

Allowing certain refunds of overpayments in connection with certain Indian leases.

Providing two percent deduction of State royalties to help cover Federal administrative costs.

Designating funds for mineral revenue management activities.

Extending mandatory funding for Payment in Lieu of Taxes.

Allowing certain payments authorized for the Payments in Lieu of Taxes Program to be retained for administrative expenses.

Providing that no Payments in Lieu of Taxes Program payment be made to otherwise eligible units of local government if the computed amount of the payment is less than $100.

Providing that a payment made to a unit of general local government for fiscal year 2013 may be reduced by the Secretary to correct overpayments, and increased by the Secretary to correct underpayments, to such unit of local government for the previous fiscal year.

Providing that to the extent that the aggregate increases in payment required in the preceding proviso exceed the aggregate reductions in payment under such proviso, the amount necessary to cover any remaining underpayment shall be taken as a prorated reduction to all payments.

INSULAR AFFAIRS

ASSISTANCE TO TERRITORIES

Designating funds for various programs and for salaries and expenses of the Office of Insular Affairs and providing until expended for the former.

Allowing audits of the financial transactions of the Territorial and Insular governments by the GAO.

Providing grant funding under certain terms of the Agreement of the Special Representatives on Future United States Financial Assistance for the Northern Mariana Islands.

Providing for capital infrastructure in various Territories.

Allowing appropriations for disaster assistance to be used as non-Federal matching funds for hazard mitigation grants.

COMPACT OF FREE ASSOCIATION

Providing grants to Palau, the Marshall Islands, and Micronesia.

ADMINISTRATIVE PROVISIONS, INSULAR AFFAIRS

Allowing, at the request of the Governor of Guam, for certain discretionary and mandatory funds to be used to assist securing certain rural electrification loans through the U.S. Department of Agriculture.

Allowing the Secretary to redistribute capital improvement funds in the territories based on expenditure rates.

OFFICE OF SPECIAL TRUSTEE FOR AMERICAN INDIANS

FEDERAL TRUST PROGRAMS

Limiting the amount of funding available for the historical accounting of Indian trust fund accounts.

Allowing transfers to other Department of the Interior accounts.

Providing no-year funding for certain Indian Self Determination Act grants.

Specifying that the statute of limitations shall not commence on any claim resulting from trust funds losses.

Exempting quarterly statements for Indian trust accounts $15 or less.

Requiring annual statements and records maintenance for Indian trust accounts.

Limiting use of funds to correct administrative errors in Indian trust accounts.

Permitting the use of recoveries from erroneous payments pursuant to Indian trust accounts.

DEPARTMENT-WIDE PROGRAMS

WILDLAND FIRE MANAGEMENT

Providing funds for wildland fire management.

Limiting funds for renovation or construction of fire facilities.

Permitting the repayments of funds transferred from other accounts for firefighting.

Permitting the use of funds for lodging and subsistence of firefighters.

Permitting the use of grants, contracts and cooperative agreements for hazardous fuels reduction, including cost-sharing and local assistance.

Permitting cost-sharing of cooperative agreements with non-Federal entities under certain circumstances.

Permitting reimbursement to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for consultation activities under the Endangered Species Act.

Providing certain terms for leases of real property with local governments.

Providing for the transfer of funds between the Department of the Interior and the Department of Agriculture for wildland fire management.

Providing funds for support of Federal emergency response actions.

FLAME WILDFIRE SUPPRESSION RESERVE FUND

Providing funds for the FLAME fund.

CENTRAL HAZARDOUS MATERIALS FUND

Providing funds for response action, including associated activities, performed pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act.

NATURAL RESOURCE DAMAGE ASSESSMENT FUND

Providing funds for activities to carry out the Comprehensive Environmental Response, Compensation, and Liability Act, the Federal Water Pollution Control Act, the Oil Pollution Act of 1990, and Public Law 101–337.

WORKING CAPITAL FUND

Allowing funds for the financial and business management system and information technology improvement.

Prohibiting use of funds to establish reserves in the working capital fund with exceptions.

Allowing assessments for reasonable charges for training services at the National Indian Program Center and use of these funds hereafter under certain conditions.

Providing that the Secretary may enter into grants and cooperative agreements to support the Office of Natural Resource Revenue's collection and disbursement of royalties, fees, and other mineral revenue proceeds, as authorized by law.

ADMINISTRATIVE PROVISIONS

Allowing acquisition of certain aircraft.

Allowing the sale of existing aircraft with proceeds used to offset the purchase price of replacement aircraft.

Allowing for the transfer of certain aircraft and providing that such aircraft shall revert back to the Department of the Interior in the future is such aircraft is no longer needed.

GENERAL PROVISIONS, DEPARTMENT OF THE INTERIOR

Allowing transfer of funds for certain reconstruction of facilities, aircraft or utilities in emergency situations.

Allowing transfer of funds in certain emergency situations, including wildfires and oil spill response, if other funds provided in other accounts will be exhausted within 30 days and a supplemental appropriation is requested as promptly as possible.

Permitting the Department to use limited funding for certain services.

Permitting the transfer of funds between the Bureau of Indian Affairs and the Office of Special Trustee for American Indians and limiting amounts for historical accounting activities.

Allowing payment of attorney fees for Federal employees related to the Cobell v. Salazar litigation.

Providing the authority for the Secretary to collect nonrefundable inspection fees.

Providing the authority for the Secretary to implement an oil and gas leasing Internet program.

Permitting the reorganization of the Bureau of Ocean Energy Management, Enforcement and Regulation.

Authorizing the use of Indian education funds to benefit schools re-assumed by the Bureau of Indian Education.

Permitting the Secretary of the Interior to enter into long-term agreements for wild horse and burro holding facilities.

Requiring the U.S. Fish and Wildlife Service to mark hatchery salmon.

Requiring the exhaustion of administrative review before litigants may file in Federal court.

Providing an exemption for trailing livestock in fiscal years 2013 and 2014.

Prohibiting the use of funds to implement, administer or enforce Secretarial Order 3310.

Making corrections on claim maintenance fee amendments.

Extending the deadline for the Indian Law and Order Commission to report to Congress.

Requiring the Secretary of the Interior to issue a final rule pursuant to the Endangered Species Act.

TITLE II—ENVIRONMENTAL PROTECTION AGENCY

SCIENCE AND TECHNOLOGY

Providing for operating expenses in support of research and development.

Designating funding for National Priorities research as specified in the explanatory statement to this Act.

ENVIRONMENTAL PROGRAMS AND MANAGEMENT

Allowing hire and maintenance of passenger motor vehicles and operation of aircraft and purchase of reprints and library memberships in societies or associations which issue publications to members only or at a price to members lower than to subscribers who are not members.

Limiting amounts for official representation and reception expenses.

Providing two-year funding availability for administrative costs of Brownfields program.

Designating funding for specific Geographic Programs as specified in the explanatory statement to this Act.

Designating funding for National Priorities as specified in the explanatory statement to this Act.

HAZARDOUS SUBSTANCE SUPERFUND

Allowing distribution of funds to purchase services from other agencies under certain circumstances.

Providing for the transfer of funds within certain agency accounts.

LEAKING UNDERGROUND STORAGE TANK PROGRAM

Providing for grants to Federally-recognized Indian Tribes.

STATE AND TRIBAL ASSISTANCE GRANTS

Limiting funding amounts for certain programs.

Specifies funding for capitalization grants for the Clean Water and Drinking Water State Revolving Funds and allows certain amounts for additional subsidies.

Designating funds for specific sections of law.

Limits the amount of funds for section 104(k) for certain activities.

Providing certain grants under authority of section 103, Clean Air Act.

Providing funding for environmental information exchange network initiatives grants, statistical surveys of water resources and enhancements to State monitoring programs, tribal grants, and underground storage tank projects.

Providing waivers for certain uses of Clean Water and Drinking Water State Revolving Funds for State administrative costs for grants to Federally-recognized Indian Tribes and grants to specific Territories and Freely Associated States.

Requiring that not less than 20 percent but not more that 30 percent of Clean Water and Drinking Water funds shall be used by States for forgiveness of principal or negative interest loans.

Prohibiting the use of funds for jurisdictions that permit development or construction of additional colonia areas.

ADMINISTRATIVE PROVISIONS

Allowing awards of grants to Federally-recognized Indian Tribes.

Authorizing the collection and obligation of pesticide registration service fees.

Allowing the transfer of funds from the "Environmental Programs and Management" account to support the Great Lakes Restoration Initiative and provides for certain interagency agreements and grants to various entities in support of this effort.

Providing amounts for construction, alteration, repair, rehabilitation, and renovation of facilities.

Authorizing additional persons that may be hired under certain authorities.

TITLE III—RELATED AGENCIES

FOREST SERVICE

FOREST AND RANGELAND RESEARCH

Providing funds for forest and rangeland research.

Designating funds for the forest inventory and analysis program.

STATE AND PRIVATE FORESTRY

Providing for forest health management, including treatments of certain pests or invasive plants, and for restoring damaged forests, and for cooperative forestry, education and land conservation activities, and conducting an international program.

Deriving forest legacy funding from the Land and Water Conservation Fund.

NATIONAL FOREST SYSTEM

Providing funds for the National Forest System.

Designating funds for forest products.

Depositing funds in the Collaborative Forest Landscape Restoration Fund.

Designating funds in the Integrated Resource Restoration pilot program.

CAPITAL IMPROVEMENT AND MAINTENANCE

Providing funds for construction, reconstruction, and maintenance and acquisition of buildings and other facilities and infrastructure; and for construction, capital improvement, decommissioning, and maintenance of forest roads and trails.

Designating funds for the Legacy Road and Trail Remediation program.

Requiring that funds becoming available in fiscal year 2012 for the road and trails fund (16 U.S.C. 501) shall be transferred to the Treasury.

Transferring funds to the Integrated Resource Restoration pilot program.

LAND ACQUISITION

Deriving funding from the Land and Water Conservation Fund.

RANGE BETTERMENT FUND

Providing that six percent of range betterment funds may be used for administrative expenses.

WILDLAND FIRE MANAGEMENT

Permitting the use of funds for emergency rehabilitation and restoration and hazardous fuels reduction to support emergency response and wildfire suppression.

Allowing the use of wildland fire funds to repay advances from other accounts.

Allowing reimbursement of States for certain wildfire emergency activities.

Designating funds for the Joint Fire Sciences Program and extending research authorities to the program.

Allowing funds to be available for emergency rehabilitation, hazardous fuels reduction and emergency response.

Designating funds for hazardous fuels reduction and national fire plan research.

Designating funds for State fire assistance, volunteer fire assistance and forest health on Federal and State and private lands.

Allowing the transfer of funds to other Forest Service accounts.

Providing for cost-shared cooperative agreements.

Providing for the transfer of funds for training and monitoring associated with hazardous fuels reduction as prescribed in a community wildfire protection plan.

Allowing funds available for Community Forest Restoration Act to be used on non-federal land.

Limiting the transfer of wildland fire management funds between the Department of the Interior and the Department of Agriculture.

Providing for the use of hazardous fuels reduction funds for biomass grants.

Limiting the assessment for cost pools from the FLAME Wildfire Suppression Reserve Fund.

Permitting the transfer of funds for the Integrated Resources Restoration pilot.

FLAME WILDFIRE SUPPRESSION RESERVE FUND

Providing fund for the FLAME fund.

ADMINISTRATIVE PROVISIONS

Permitting the purchase of passenger motor vehicles and proceeds from the sale of aircraft may be used to purchase replacement aircraft.

Allowing funds for certain employment contracts.

Allowing funds to be used for purchase and alteration of buildings.

Allowing for acquisition of certain lands and interests.

Allowing expenses for certain volunteer activities.

Providing for the cost of uniforms.

Providing for debt collections on certain contracts.

Allowing transfer of funds in certain emergency situations if all other funds provided for wildfire suppression will be obligated within 30 days and the Secretary notifies the Committees.

Allowing funds to be used through the Agency for International Development for work in foreign countries and to support other forestry activities outside of the United States.

Allowing the Forest Service, acting for the International Program, to sign certain funding agreements with foreign governments and institutions as well as with certain domestic agencies.

Prohibiting the transfer of funds under the Department of Agriculture transfer authority under certain conditions and preventing reprogramming without advance approval of the Appropriations Committees.

Limiting funds available for cost pools.

Limiting the transfer of funds for the Working Capital Fund and Department Reimbursable Program (also known as Greenbook charges).

Limiting funds to support the Youth Conservation Corps and Public Lands Corps.

Limiting the use of funds for official reception and representation expenses.

Providing for matching funds for the National Forest Foundation.

Providing for matching funds for the National Fish and Wildlife Foundation.

Allowing funds to be used for technical assistance for certain rural communities.

Allowing funds for payments to counties in the Columbia River Gorge National Scenic Area.

Allowing funds to be used for the Older American Act.

Permitting funding assessments for facilities maintenance, rent, utilities, and other support services.

Limiting funds to reimburse the Office of General Counsel at the Department of Agriculture.

Permitting eligible employees to be considered a Federal Employee.

INDIAN HEALTH SERVICE

INDIAN HEALTH SERVICES

Providing that tribal contract and grant funding is deemed obligated at the time of grant or contract award and remains available until expended.

Providing no-year funds for contract medical care including the Indian Catastrophic Health Emergency Fund.

Providing for certain funding to be allocated at the discretion of the Director.

Providing for loan repayment under sections 104 and 108 of the Indian Health Care Improvement Act with certain conditions and making the funds available for certain other purposes.

Providing funding and allocation direction for the methamphetamine, domestic violence, and substance abuse programs.

Providing that certain contracts and grants may be performed in two fiscal years.

Providing for use of collections and reporting of collections under Title IV of the Indian Health Care Improvement Act.

Providing no-year funding for scholarship funds.

Exempting certain tribal funding from fiscal year constraints.

Limiting contract support cost spending.

Providing for the collection of individually identifiable health information relating to the Americans with Disabilities Act by the Bureau of Indian Affairs.

Permitting the use of Indian Health Care Improvement Fund monies for facilities improvement and providing no-year funding availability.

INDIAN HEALTH FACILITIES

Providing that facilities funds may be used to purchase land, modular buildings and trailers.

Providing for TRANSAM equipment to be purchased from the Department of Defense.

Prohibiting the use of funds for sanitation facilities for new homes funded by the Department of Housing and Urban Development.

Allowing for the purchase of ambulances.

Providing for a demolition fund.

ADMINISTRATIVE PROVISIONS

Providing for per diem expenses for senior level positions.

Providing for payments for telephone service in private residences in the field, purchase of motor vehicles, aircraft and reprints.

Providing for purchase and erection of modular buildings.

Providing funds for uniforms.

Allowing funding to be used for attendance at professional meetings.

Providing that health care may be extended to non-Indians at Indian Health Service facilities, subject to charges, and for the expenditure of collected funds.

Providing for transfers of funds from the Department of Housing and Urban Development to the Indian Health Service.

Prohibiting limitations on certain Federal travel and transportation expenses.

Limiting the use of funds for assessments or charges by the Department of Health and Human Services except under certain conditions.

Allowing de-obligation and re-obligation of funds applied to self-governance funding agreements.

Prohibiting the expenditure of funds to implement new eligibility regulations.

Permitting certain reimbursements for goods and services provided to Tribes.

Providing that reimbursements for training, technical assistance, or services include total costs.

Prohibiting changing the appropriations structure without approval of the Appropriations Committees.

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

TOXIC SUBSTANCES AND ENVIRONMENTAL PUBLIC HEALTH

Providing for the conduct of health studies, testing, and monitoring.

Designating funds for Individual Learning Accounts and providing no-year funding.

Providing deadlines for health assessments and studies.

Limiting use of funds for administrative costs.

Limiting the number of toxicological profiles.

EXECUTIVE OFFICE OF THE PRESIDENT

COUNCIL ON ENVIRONMENTAL QUALITY AND OFFICE OF ENVIRONMENTAL QUALITY

Limiting the use of funds for official reception and representation expenses.

Designating the appointment and duties of the chairman.

CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

Permitting use of funds for hire of passenger vehicles, uniforms or allowances, and limiting the use of funds for per diem expenses and the number of senior level positions.

Providing for the appointment of the EPA, Inspector General to serve as Inspector General for the Board.

OFFICE OF NAVAJO AND HOPI INDIAN RELOCATION

SALARIES AND EXPENSES

Defining eligible relocatees.

Prohibiting movement of any single Navajo or Navajo family unless a new or replacement home is available.

Limiting re-locatees to one new or replacement home.

Establishing a priority for relocation of Navajos to those certified eligible who have selected and received homesites on the Navajo reservation or selected a replacement residence off the Navajo reservation.

SMITHSONIAN INSTITUTION

SALARIES AND EXPENSES

Limiting certain lease terms.

Providing for purchase of passenger vehicles and certain rental, repair and cleaning of uniforms.

Designating funds for certain programs including the National Museum of African American History and Culture and providing no-year funds.

Providing that funds may be used to support American overseas research centers.

Allowing for advance payments to independent contractors performing research services or participating in official Smithsonian presentations.

FACILITIES CAPITAL

Designating funds for maintenance, repair, rehabilitation, and construction and for consultant services.

Providing funding to continue construction of the National Museum of African American History and Culture.

NATIONAL GALLERY OF ART

SALARIES AND EXPENSES

Allowing payment in advance for membership in library, museum, and art associations or societies.

Allowing for purchase, repair, and cleaning of uniforms for guards and employees and allowances therefor.

Allowing purchase or rental of devices for protecting buildings and contents thereof, and maintenance, alteration, improvement, and repair of buildings, approaches, and grounds.

Providing for restoration and repair of works of art by contract under certain circumstances.

Providing no-year funds for special exhibitions.

REPAIR, RESTORATION, AND RENOVATION OF BUILDINGS

Providing lease agreements of no more than 10 years addressing space needs created by renovations under the Master Facilities Plan.

Permitting the Gallery to perform work by contract under certain circumstances.

JOHN F. KENNEDY CENTER FOR THE PERFORMING ARTS

OPERATIONS AND MAINTENANCE

Providing funds to the John F. Kennedy Center for the Performing Arts Kennedy Center for operational and maintenance costs.

CAPITAL REPAIR AND RESTORATION

Providing funds to the John F. Kennedy Center for the Performing Arts Kennedy Center for facility repair.

WOODROW WILSON INTERNATIONAL CENTER FOR SCHOLARS

SALARIES AND EXPENSES

Providing funds to the Woodrow Wilson Center for Scholars.

NATIONAL ENDOWMENT FOR THE ARTS

GRANTS AND ADMINISTRATION

Provides funds for the support of projects and productions in the arts, including arts education and public outreach activities.

NATIONAL ENDOWMENT FOR THE HUMANITIES

GRANTS AND ADMINISTRATION

Specifies funds to carry out the matching grants program.

Allowing obligation of National Endowment for the Humanities current and prior year funds from gifts, bequests, and devises of money for which equal amounts have not previously been appropriated.

ADMINISTRATIVE PROVISIONS, NATIONAL FOUNDATION ON THE ARTS AND THE HUMANITIES

Prohibiting the use of funds for grants and contracts which do not include the text of 18 U.S.C. 1913.

Prohibiting the use of appropriated funds and permitting the use of non-appropriated funds for reception expenses.

Allowing the chairperson of the National Endowment for the Arts to approve small grants under certain circumstances.

COMMISSION OF FINE ARTS

SALARIES AND EXPENSES

Permitting the charging and use of fees for its publications and accepting gifts related to the history of the Nation's Capital.

NATIONAL CAPITAL ARTS AND CULTURAL AFFAIRS

Providing funding for the National Capital Arts and Cultural Affairs.

NATIONAL CAPITAL PLANNING COMMISSION

Providing funding for the National Capital Planning Commission.

Providing that one-quarter of one percent may be used for official reception and representational expenses.

UNITED STATES HOLOCAUST MEMORIAL MUSEUM

Designating funds for equipment replacement and for repair, rehabilitation and for exhibition design and production and providing no year availability for these funds.

TITLE IV—GENERAL PROVISIONS

Providing for public availability of information on consulting services contracts.

Prohibiting the use of funds to promote or oppose legislative proposals on which Congressional action is incomplete.

Providing for annual appropriations unless expressly provided otherwise in this Act.

Requiring assessments against programs in this bill to be presented to the Committee for approval.

Limiting funds for sale of giant sequoia trees in a manner different from the past.

Continuing a limitation on accepting and processing applications for patents and on the patenting of Federal lands; permitting processing of grandfathered applications; and permitting third-party contractors to process grandfathered applications.

Limiting the use of funds for contract support costs on Indian contracts.

Limiting funds for completing or issuing the five-year program under the Forest and Rangeland Renewable Resources Planning Act.

Limiting leasing and preleasing activities within National Monuments.

Limiting takings for acquisition of lands except under certain conditions.

Modifying a provision addressing timber sales involving Alaskan Red Cedar.

Modifying a provision continuing certain authorities to renew grazing permits or leases administered by the Forest Service or Department of the Interior.

Prohibiting funds to enter into certain no-bid contracts except under certain conditions.

Requiring reports to Congress to be posted on public agency websites.

Continuing a provision that delineates grant guidelines for the National Endowment for the Arts.

Continuing a provision that delineates program priorities for the programs managed by the National Endowment for the Arts.

Providing guidance on matching grant awards and waive-of-match provisions to States.

Requiring that the Department of the Interior, the EPA, the Forest Service, and the Indian Health Service provide the Committees on Appropriations a quarterly report on the status of balances of appropriations.

Requiring a government-wide report regarding expenditures on climate change.

Continuing a provision prohibiting the use of funds to promulgate or implement any regulation requiring the issuance of permits under title V of the Clean Air Act for carbon dioxide, nitrous oxide, water vapor, or methane emissions.

Continuing a provision prohibiting the use of funds to implement any provision in a rule if that provision requires mandatory reporting of greenhouse gas emissions from manure management systems.

Clarifying Silvicultural Operations under the Federal Water Pollution Control Act.

Maintaining current management of domestic sheep as it relates to bighorn sheep for the Forest Service and Bureau of Land Management unless otherwise prescribed in a State wildlife management plan.

Prohibiting the government from entering into contracts or agreements with any corporation that was convicted of a felony criminal violation under any Federal law within the preceding 24 months.

Prohibiting funds for contracts or agreements with entities with unpaid Federal tax liabilities that have not entered into payment agreements to remedy the liability.

Extending the Herger-Feinstein Quincy Library Group Forestry Recovery Act.

Extending the Good Neighbor Cooperative Conservation Authority to 16 western states.

Requiring the Forest Service to identify land for fire stations within National Recreation Areas.

Extending Forest Service cost recovery for special uses for five years.

Allowing interpretive associations to partner with the Forest Service.

Extending the authorized term for grazing permits and leases.

Clarifying that the Forest Service may use designation by description and prescription.

Prohibiting implementation of travel management rules in Region 5 of the Forest Service.

Prohibiting the use of funds to develop, adopt, implement, administer, or enforce a change or supplement to a rule or guidance documents pertaining to the definition of waters under the Federal Water Pollution Control Act.

Prohibiting the use of funds to develop, carry out, implement, or enforce proposed regulations published on June 18, 2010.

Prohibiting the use of funds to expand the stormwater discharge program under section 402(p) of the Federal Water Pollution Control Act until certain criteria are met.

Clarifying the current Appeals Reform Act requirements for Forest Service Activities.

Prohibiting the use of funds to limit recreational shooting and hunting on Federal and public lands except for public safety.

Prohibiting the use of funds to implement the National Ocean Policy under Executive Order 13547 and requiring a report identifying Federal expenditures for the development, administration, and implementation of such Policy.

Establishing a pilot program for vessels to demonstrate alternative methods to comply with emissions control area standards.

Establishing a spending reduction account.

APPROPRIATIONS NOT AUTHORIZED BY LAW

Pursuant to clause 3(f)(1)(B) of rule XIII of the Rules of the House of Representatives, the following table lists the appropriations in the accompanying bill which are not authorized by law:

Dollars in thousands]

	Last year of authorizat on	Authorizat on level	App opriat ons in last year of authorization	Appropriations in this bill
Bureau of Land Management:				
All discretionary programs	2002	Such sums...	1,681,437	1,076,678
U.S. Fish and Wildlife Service:				
Endangered Species Act (16 U.S.C. 1531 et seq.)	1992	41,500	42,373	132,017
Partners for Fish and Wildlife Act (16 U.S.C. 3771 et seq.)	2011	75,000	60,134	41,156
National Wildlife Refuge Volunteer Act (16 U.S.C. 742f note)	2009	2,000	2,000	1,705
Coastal Barrier Resources Act (16 U.S.C. 3501 et seq.)	2010	2,000	2,000	N/A
Junior Duck Stamp Conservation and Design Program Act	2010	350	250	250
Nonindigenous Aquatic Nuisance Species Prevention and Control Act (16 U.S.C. 4701 et seq.)	2002	6,000	6,000	N/A
Marine Mammal Protection Act (16 U.S.C. 1361 et seq.)	1999	14,768	2,008	4,972
National Fish and Wildlife Foundation Establishment Act (16 U.S.C. 3701 et seq.)	2010	25,000	7,537	7,525
North American Wetlands Conservation Act (16 U.S.C. 4401 et seq.)	2012	75,000	35,497	22,333

Dollars in thousands]

	Last year of authorizat on	Authorizat on level	App opriat ons in last year of authorization	Appropriations in this bill
Neotropical Migratory Bird Conservation Act (16 U.S.C. 6101 et seq.)	2010	6,500	5,000	1,893
African Elephant Conservation Act (16 U.S.C. 4201 et seq.)	2012	5,000	1,645	823
Rhinoceros and Tiger Conservation Act (16 U.S.C. 5301 et seq.)	2012	10,000	2,471	1,236
Asian Elephant Conservation Act (16 U.S.C. 4201 et seq.)	2012	5,000	1,645	823
Great Ape Conservation Act (16 U.S.C. 6301 et seq.)	2010	5,000	2,500	1,030
Marine Turtle Conservation Act (16 U.S.C. 6601)	2009	5,000	2,000	823
U.S. Geological Survey				
National Earthquake Hazards Reduction Program Reauthorization Act (42 U.S.C. 7701 et seq.)	2009	88,900	88,900	44,125
Water Resources Research Act (42 U.S.C. 10301 et seq.)	2011	80,000	6,490	6,490
Energy Independence and Security Act (Carbon Sequestration Program) (42 U.S.C. 17271)	2012	30,000	8,986	7,186
Energy Independence and Security Act (Geothermal Energy Resources Program) (42 U.S.C. 17271)	2012	75,000	1,495	1,495
Bureau of Indian Affairs				
The No Child Left Behind Act (20 U.S.C. 7401 et seq.)	2007	Such sums...	549,293	671,662
Environmental Protection Agency:				
Hazardous Substance Superfund	1994	5,100,000	1,480,853	1,164,917
Clean Air Act	1997	Such sums...	450,000	583,979
Clean Water Act	1990	135,000	.....	336,677
National Estuary Program	2010	35,000	33,000	27,014
Great Lakes	2008	79,000	60,000	250,000
Lake Champlain Basin	2008	11,000	3,000	1,399
Long Island Sound Restoration	2010	40,000	7,000	2,962
Lake Pontchartrain	2011	20,000	1,000	955
Chesapeake Bay Restoration	2005	40,000	23,000	50,000
FIFRA	1991	95,000	112,000	110,348
Toxic Substances Control Act	1983	62,000	69,000	97,678
Resource Conservation Act—General Authorization	1988	80,000	75,000	112,469
Environmental Education	1996	9,000	9,000	0
State and Tribal Assistance Grants:				
Alaska Native Villages	2000	15,000	Not available	0
BEACH Act	2005	30,000	9,920	0
Brownfields Projects	2006	200,000	89,000	60,000
Clean Water SRF	1992	1,800,000	2,400,000	689,000
CERCLA/Brownfields Cat Grant	2006	50,000	49,000	47,752
Drinking Water SRF	2003	1,000,000	963,000	829,000
Grants for State Public Water	2003	100,000	93,000	105,320
Lead Containment Control Act of 1988	1992	Such sums...	Not available	14,572
Non-Point Source Management Program	1991	130,000	51,000	150,505
Pollution Prevention Act	1993	8,000	6,800	4,922
Radon Abatement Act	1991	10,000	9,000	8,045
State Hazardous Waste Program Grants	1988	60,000	67,000	102,974
Toxic Substances Control Act	1983	1,500	5,100	5,081
Underground Injection Control Grants	2003	15,000	11,000	10,852
USDA Forest Service, National Forest Foundation	1997	Such sums...	2,000	3,000
National Endowment for the Arts	1993	Such sums...	174,460	132,000
National Endowment for the Humanities	1993	Such sums...	177,403	132,000

COMPARISON WITH BUDGET RESOLUTION

Section 308(a)(1)(A) of the Congressional Budget and Impoundment Control Act of 1974 (Public Law 93–344), as amended, requires that the report accompanying a bill providing new budget authority contain a statement detailing how the authority compares with the reports submitted under section 302 of the Act for

the most recently agreed to concurrent resolution on the budget for the fiscal year. This information follows:

[INSERT COMPARISION WITH BUDGET RESOLUTION TABLE]

Five-Year Outlay Projections

In compliance with section 308(a)(1)(B) of the Congressional Budget Act of 1974 (Public Law 93–344), as amended, the following table contains five-year projections associated with the budget authority provided in the accompanying bill:

[INSERT FIVE-YEAR OUTLAY PROJECTIONS TABLE]

ASSISTANCE TO STATE AND LOCAL GOVERNMENTS

In accordance with section 308(a)(1)(C) of the Congressional Budget Act of 1974 (Public Law 93–344), as amended, the financial assistance to State and local governments is as follows:

[INSERT ASSISTANCE TO STATE AND LOCAL GOVERNMENTS TABLE]

[In millions of dollars]

CONSTITUTIONAL AUTHORITY

Pursuant to section 6(e) of the rules of the Committee on Appropriations, the following statement is submitted regarding the specific powers granted to Congress in the Constitution to enact the accompanying bill:

The principal constitutional authority for this legislation is clause 7 of section 9 of article I of the Constitution of the United States which States "No money shall be drawn from the Treasury, but in Consequence of Appropriations made by Law. . . ." Appropriations contained in this Act are made pursuant to this specific power granted by the Constitution.

DETAILED TABLE OF FUNDING RECOMMENDATIONS

The following table provides the amounts recommended by the Committee compared with the budget estimates by activity and sub-activity. The reprogramming guidelines apply to levels outlined below.

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
TITLE I - DEPARTMENT OF THE INTERIOR					
BUREAU OF LAND MANAGEMENT					
Management of Lands and Resources					
Land Resources:					
Soil, water and air management	46,229	44,477	40,477	-5,752	-4,000
Range management	87,392	72,327	90,000	+2,608	+17,673
Grazing permit administration fee	---	6,500	---	---	-6,500
Grazing permit offsetting collections	---	-6,500	---	---	+6,500
Forestry management	9,714	6,318	9,714	---	+3,396
Riparian management	22,682	22,896	22,682	---	-214
Cultural resources management	16,105	17,325	14,325	-1,780	-3,000
Wild horse and burro management	74,888	77,068	64,068	-10,820	-13,000
Subtotal	257,010	240,411	241,266	-15,744	+855
Wildlife and Fisheries:					
Wildlife management	36,914	52,175	52,175	+15,261	---
Fisheries management	13,333	13,440	13,440	+107	---
Subtotal	50,247	65,615	65,615	+15,368	---
Threatened and endangered species	21,633	21,812	21,812	+179	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Recreation Management:					
Wilderness management	18,392	18,568	14,784	-3,608	-3,784
Recreation resources management	49,074	51,722	46,074	-3,000	-5,648
Subtotal	67,466	70,290	60,858	-6,608	-9,432
Energy and Minerals:					
Oil and gas	72,466	46,055	94,005	+21,539	+47,950
Oil and gas permit processing fund	32,500	32,500	32,500	---	---
(Pilot offices, Sec. 365, permit processing fund)	(20,973)	---	(20,973)	---	(+20,973)
Oil and gas inspection fees	---	47,950	---	---	-47,950
Subtotal, Oil and gas/permit processing fund	104,966	126,505	126,505	+21,539	---
Oil and gas offsetting permit processing fees	-32,500	-32,500	-32,500	---	---
Inspection offsetting collection	---	-47,950	---	---	+47,950
Subtotal	72,466	46,055	94,005	+21,539	+47,950
Coal management	7,043	9,529	9,529	+2,486	---
Other mineral resources	8,402	10,502	10,502	+2,100	---
Renewable energy	19,703	26,824	16,824	-2,879	-10,000
Subtotal, Energy and minerals	107,614	92,910	130,860	+23,246	+37,950

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Realty and Ownership Management:					
Alaska conveyance	29,061	16,741	16,741	-12,320	---
Cadastral survey	11,996	12,105	11,105	-891	-1,000
Land and realty management	32,605	35,902	30,902	-1,703	-5,000
Subtotal	73,662	64,748	58,748	-14,914	-6,000
Resource Protection and Maintenance:					
Resource management planning	38,060	42,748	42,748	+4,688	---
Abandoned mine lands	19,819	17,903	17,903	-1,916	---
Resource protection and law enforcement	27,024	27,181	27,024	---	-157
Hazardous materials management	16,641	16,758	16,641	---	-117
Subtotal	101,544	104,590	104,316	+2,772	-274
Transportation and Facilities Maintenance:					
Annual maintenance	41,160	41,479	40,479	-681	-1,000
Deferred maintenance	29,960	31,066	30,066	+106	-1,000
Subtotal	71,120	72,545	70,545	-575	-2,000
Land and resources information systems	15,827	---	---	-15,827	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Workforce and Organizational Support:					
Information systems operations	14,673	---	---	-14,673	---
Administrative support	49,130	49,526	48,526	-604	-1,000
Bureauwide fixed costs	91,161	99,325	96,513	+5,352	-2,812
Information technology management	---	27,648	27,648	+27,648	---
Subtotal	154,964	176,499	172,687	+17,723	-3,812
Challenge cost share	7,455	7,482	---	-7,455	-7,482
National landscape conservation system, base program	31,819	35,115	20,000	-11,819	-15,115
Communication site management	2,000	2,000	2,000	---	---
Offsetting collections	-2,000	-2,000	-2,000	---	---
Subtotal, Management of lands and resources	960,361	952,017	946,707	-13,654	-5,310
Mining Law Administration:					
Administration	39,696	39,696	39,696	---	---
Offsetting collections	-54,000	-59,000	-59,000	-5,000	---
Subtotal, Mining Law Administration	-14,304	-19,304	-19,304	-5,000	---
Total, Management of lands and resources	946,057	932,713	927,403	-18,654	-5,310
Construction					
Appropriation	3,570	---	---	-3,570	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Land Acquisition					
Land Acquisition	18,969	26,577	---	-18,969	-26,577
Inholding, emergency, and hardship	1,498	1,498	2,366	+868	+868
Acquisition management	1,877	3,000	1,877	---	-1,123
Hunter and angler access	---	2,500	2,500	+2,500	---
Total, Land acquisition	22,344	33,575	6,743	-15,601	-26,832
Oregon and California Grant Lands					
Western Oregon resources management	97,899	99,003	97,003	-896	-2,000
Western Oregon information and resource data systems	1,923	1,941	1,923	---	-18
Western Oregon transportation & facilities maintenance	10,984	10,030	10,030	-954	---
Western Oregon construction and acquisition	310	313	313	+3	---
Western Oregon national monument	748	756	756	+8	---
Total, Oregon and California grant lands	111,864	112,043	110,025	-1,839	-2,018
Range Improvements					
Improvements to public lands	7,873	7,873	7,873	---	---
Farm Tenant Act lands	1,527	1,527	1,527	---	---
Administrative expenses	600	600	600	---	---
Total, Range improvements	10,000	10,000	10,000	---	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Service Charges, Deposits, and Forfeitures					
Rights-of-way processing	16,400	16,400	16,400	---	---
Energy and minerals cost recovery	7,300	2,900	2,900	-4,400	---
Recreation cost recovery	1,500	1,500	1,500	---	---
Adopt-a-horse program	450	450	450	---	---
Repair of damaged lands	3,100	2,633	2,633	-467	---
Cost recoverable realty cases	900	900	900	---	---
Timber purchaser expenses	50	20	20	-30	---
Commercial film and photography fees	200	165	165	-35	---
Copy fees	1,100	2,085	2,085	+985	---
Trans Alaska pipeline	1,125	4,000	4,000	+2,875	---
Subtotal (gross)	32,125	31,053	31,053	-1,072	---
Offsetting fees	-32,125	-31,053	-31,053	+1,072	---
Total, Service Charges, Deposits & Forfeitures	---	---	---	---	---
Miscellaneous Trust Funds and Permanent Operating Funds					
Current appropriations	19,700	19,700	19,700	---	---
TOTAL, BUREAU OF LAND MANAGEMENT	1,113,535	1,108,031	1,073,871	-39,664	-34,160
(Mandatory)	(29,700)	(29,700)	(29,700)	---	---
(Discretionary)	(1,083,835)	(1,078,331)	(1,044,171)	(-39,664)	(-34,160)

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
UNITED STATES FISH AND WILDLIFE SERVICE					
Resource Management					
Ecological Services:					
Endangered species:					
Candidate conservation	11,337	11,463	10,554	-783	-909
Listing and critical habitat	20,869	22,431	14,564	-6,305	-7,867
Consultation and HCPs	60,943	64,095	45,865	-15,078	-18,230
Recovery	82,806	81,709	63,034	-19,772	-18,675
Subtotal, Endangered species	175,955	179,698	134,017	-41,938	-45,681
Habitat conservation:					
Partners for fish and wildlife	54,768	55,857	41,156	-13,612	-14,701
Conservation planning assistance	35,780	36,695	30,555	-5,225	-6,140
Coastal programs	14,870	14,149	12,657	-2,213	-1,492
National wetlands inventory	5,219	5,741	5,211	-8	-530
Subtotal, Habitat conservation	110,637	112,442	89,579	-21,058	-22,863
Environmental contaminants	13,128	14,393	11,189	-1,939	-3,204
Subtotal, Ecological services	299,720	306,533	234,785	-64,935	-71,748

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
National Wildlife Refuge System:					
Wildlife and habitat management	223,439	233,664	189,294	-34,145	-44,370
Visitor services	74,225	74,777	67,715	-6,510	-7,062
Refuge law enforcement	37,373	38,611	31,802	-5,571	-6,809
Conservation planning	11,704	8,515	9,972	-1,732	+1,457
Refuge maintenance	138,950	139,263	138,659	-291	-604
Subtotal	485,691	494,830	437,442	-48,249	-57,388
Migratory Birds, Law Enforcement & International Conservation:					
Migratory bird management	51,453	51,063	43,316	-8,137	-7,747
Law enforcement	62,143	63,901	52,707	-9,436	-11,194
International affairs	12,971	13,054	10,993	-1,978	-2,061
Subtotal	126,567	128,018	107,016	-19,551	-21,002
Fisheries and Aquatic Resource Conservation:					
National fish hatchery system operations	46,075	43,189	46,075	---	+2,886
Maintenance and equipment	18,031	17,997	17,997	-34	---
Aquatic habitat and species conservation	71,211	70,421	63,098	-8,113	-7,323
Subtotal	135,317	131,607	127,170	-8,147	-4,437
Cooperative landscape conservation & adaptive science:					
Cooperative landscape conservation	15,475	15,541	1,489	-13,986	-14,052
Adaptive science	16,723	17,513	1,500	-15,223	-16,013
Subtotal	32,198	33,054	2,989	-29,209	-30,065

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
General Operations:					
Central office operations	38,605	41,846	33,002	-5,603	-8,844
Regional office operations	40,951	42,626	34,973	-5,978	-7,653
Servicewide bill paying	36,039	37,325	35,575	-464	-1,750
National Fish and Wildlife Foundation	7,525	7,525	7,525	---	---
National Conservation Training Center	23,564	23,680	20,011	-3,553	-3,669
Subtotal	146,684	153,002	131,086	-15,598	-21,916
Total, Resource Management	1,226,177	1,247,044	1,040,488	-185,689	-206,556
Construction					
Construction and rehabilitation:					
Line item construction projects	12,129	8,195	8,195	-3,934	---
Bridge and dam safety programs	1,852	1,852	1,852	---	---
Nationwide engineering service	9,070	9,089	7,708	-1,362	-1,381
Total, Construction	23,051	19,136	17,755	-5,296	-1,381
Land Acquisition					
Acquisitions	30,117	83,741	---	-30,117	-83,741
Highlands Conservation Act	4,992	---	4,000	-992	+4,000
Inholdings/emergencies and hardships	4,492	4,980	3,000	-1,492	-1,980
Exchanges	2,496	1,995	---	-2,496	-1,995
Acquisition management	10,538	10,739	6,570	-3,968	-4,169
User pay cost share	1,997	2,003	1,477	-520	-526

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Refuge land protection planning	---	3,434	---	---	-3,434
Total, Land acquisition	54,632	106,892	15,047	-39,585	-91,845
Cooperative Endangered Species Conservation Fund					
Grants and administration:					
Conservation grants	10,529	12,601	---	-10,529	-12,601
HCP assistance grants	9,485	7,000	---	-9,485	-7,000
Administration	2,707	2,974	2,707	---	-267
Subtotal, Grants and administration	22,721	22,575	2,707	-20,014	-19,868
Land acquisition:					
Species recovery land acquisition	9,984	15,487	---	-9,984	-15,487
HCP land acquisition grants to states	14,976	21,938	11,422	-3,554	-10,516
Subtotal, Land acquisition	24,960	37,425	11,422	-13,538	-26,003
Total, Cooperative Endangered Species Conservation Fund	47,681	60,000	14,129	-33,552	-45,871
National Wildlife Refuge Fund					
Payments in lieu of taxes	13,958	---	11,958	-2,000	+11,958
North American Wetlands Conservation Fund					
North American Wetlands Conservation Fund	35,497	39,425	22,333	-13,164	-17,092

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Neotropical Migratory Bird Conservation					
Migratory bird grants	3,786	3,786	1,893	-1,893	-1,893
Multinational Species Conservation Fund					
African elephant conservation fund	1,645	1,697	823	-822	-874
Rhinoceros and tiger conservation fund	2,471	2,695	1,236	-1,235	-1,459
Asian elephant conservation fund	1,645	1,697	823	-822	-874
Great ape conservation fund	2,059	2,194	1,030	-1,029	-1,164
Marine turtle conservation fund	1,646	1,697	823	-823	-874
Total, Multinational Species Conservation Fund	9,466	9,980	4,735	-4,731	-5,245
State and Tribal Wildlife Grants					
State wildlife grants (formula)	51,323	44,055	25,662	-25,661	-18,393
State wildlife grants (competitive)	5,732	13,000	2,866	-2,866	-10,134
Tribal wildlife grants	4,268	4,268	2,134	-2,134	-2,134
Total, State and tribal wildlife grants	61,323	61,323	30,662	-30,661	-30,661
Subtotal, U.S. Fish and Wildlife Service	1,475,571	1,547,586	1,159,000	-316,571	-388,586
Coastal impact assistance (rescission)	---	-200,000	---	---	+200,000
TOTAL, U.S. FISH AND WILDLIFE SERVICE	1,475,571	1,347,586	1,159,000	-316,571	-188,586

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
NATIONAL PARK SERVICE					
Operation of the National Park System					
Park Management:					
Resource stewardship	329,842	333,415	324,300	-5,542	-9,115
Visitor services	239,348	237,808	239,348	---	+1,540
Park protection	360,669	362,998	360,669	---	-2,329
Facility operations and maintenance	683,390	681,807	681,807	-1,583	---
Park support	454,400	454,366	454,366	-34	---
Subtotal	2,067,649	2,070,394	2,060,490	-7,159	-9,904
External administrative costs	168,919	179,656	168,919	---	-10,737
Total, Operation of the National Park System	2,236,568	2,250,050	2,229,409	-7,159	-20,641
National Recreation and Preservation					
Recreation programs	584	590	584	---	-6
Natural programs	13,354	13,531	13,354	---	-177
Cultural programs	24,764	24,819	24,764	---	-55
International park affairs	1,636	1,648	1,636	---	-12
Environmental and compliance review	430	434	430	---	-4
Grant administration	1,738	1,758	1,738	---	-20
Heritage Partnership Programs	17,373	9,316	9,316	-8,057	---
Total, National Recreation and Preservation	59,879	52,096	51,822	-8,057	-274

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Historic Preservation Fund					
State historic preservation offices	46,925	46,925	42,500	-4,425	-4,425
Tribal grants	8,985	8,985	7,000	-1,985	-1,985
Total, Historic Preservation Fund	55,910	55,910	49,500	-6,410	-6,410
Construction					
General Program:					
Line item construction and maintenance	77,722	52,420	52,420	-25,302	---
Emergency and unscheduled	3,855	3,855	3,855	---	---
Housing	2,960	2,200	2,200	-760	---
Dam safety	1,248	1,248	1,248	---	---
Equipment replacement	13,728	13,500	13,500	-228	---
Planning, construction	7,700	7,260	7,260	-440	---
Construction program management	37,530	37,049	37,049	-481	---
General management plans	14,623	13,641	13,641	-982	---
Rescission of prior year balances	-4,000	---	---	+4,000	---
Total, Construction	155,366	131,173	131,173	-24,193	---
Land and Water Conservation Fund (rescission of contract authority)	-30,000	-30,000	-30,000	---	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Land Acquisition and State Assistance					
Assistance to States:					
State conservation grants (formula)	42,138	36,500	---	-42,138	-36,500
State conservation grants (competitive)	---	20,000	---	---	-20,000
Administrative expenses	2,790	3,500	2,794	+4	-706
Subtotal	44,928	60,000	2,794	-42,134	-57,206
National Park Service:					
Acquisitions	30,511	31,502	---	-30,511	-31,502
American Battlefield Protection Program	8,986	8,986	2,000	-6,986	-6,986
Emergencies and hardships	2,995	3,069	1,250	-1,745	-1,819
Acquisition management	9,485	9,500	7,250	-2,235	-2,250
Inholdings, donations, and exchanges	4,992	6,364	---	-4,992	-6,364
Subtotal	56,969	59,421	10,500	-46,469	-48,921
Total, Land Acquisition and State Assistance	101,897	119,421	13,294	-88,603	-106,127
TOTAL, NATIONAL PARK SERVICE	2,579,620	2,578,650	2,445,198	-134,422	-133,452

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
UNITED STATES GEOLOGICAL SURVEY					
Surveys, Investigations, and Research					
Ecosystems:					
Status and trends	21,999	22,170	17,599	-4,400	-4,571
Fisheries: Aquatic and endangered resources	22,576	27,111	17,976	-4,600	-9,135
Wildlife: Terrestrial and endangered resources	48,169	49,414	39,669	-8,500	-9,745
Terrestrial, Freshwater and marine environments	36,735	42,561	29,235	-7,500	-13,326
Invasive species	13,043	17,675	13,043	---	-4,632
Cooperative research units	18,756	18,921	15,006	-3,750	-3,915
Total, Ecosystems	161,278	177,852	132,528	-28,750	-45,324
Climate and Land Use Change:					
Climate variability:					
Climate science centers	25,490	26,150	24,740	-750	-1,410
Climate research and development	22,049	23,248	17,549	-4,500	-5,699
Carbon sequestration	8,986	9,384	7,186	-1,800	-2,198
Science support for DOI bureaus	2,396	8,959	2,396	---	-6,563
Subtotal	58,921	67,741	51,871	-7,050	-15,870

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Land Use Change:					
Land remote sensing	73,699	72,131	66,449	-7,250	-5,682
Geographic analysis and monitoring	11,470	13,877	9,970	-1,500	-3,907
Subtotal	85,169	86,008	76,419	-8,750	-9,589
Total, Climate and Land Use Change	144,090	153,749	128,290	-15,800	-25,459
Energy, Minerals, and Environmental Health:					
Minerals resources	49,231	45,271	46,786	-2,445	+1,515
Energy resources	27,292	30,492	21,792	-5,500	-8,700
Contaminant biology	9,062	9,900	9,062	---	-838
Toxic substances hydrology	10,628	11,464	10,628	---	-836
Total, Energy, Minerals, and Env Health	96,213	97,127	88,268	-7,945	-8,859
Natural Hazards:					
Earthquake hazards	55,125	58,917	44,125	-11,000	-14,792
Volcano hazards	24,770	24,968	19,770	-5,000	-5,198
Landslide hazards	3,266	3,908	2,616	-650	-1,292
Global seismographic network	5,312	5,451	4,262	-1,050	-1,189
Geomagnetism	2,066	2,205	1,666	-400	-539
Coastal and marine geology	43,941	49,329	34,941	-9,000	-14,388
Total, Natural Hazards	134,480	144,778	107,380	-27,100	-37,398

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Water Resources:					
Groundwater resources	8,916	11,657	11,416	+2,500	-241
National water quality assessment	62,909	62,178	62,450	-459	+272
National streamflow information program	29,358	32,470	32,470	+3,112	---
Hydrologic research and development	11,665	15,493	11,665	---	-3,828
Hydrologic networks and analysis	31,329	28,730	31,329	---	+2,599
Cooperative Water Program	63,985	59,300	63,985	---	+4,685
Water Resources Research Act Program	6,490	---	6,490	---	+6,490
Total, Water Resources	214,652	209,828	219,805	+5,153	+9,977
Core Science Systems:					
Biological information management and delivery	15,052	26,325	20,643	+5,591	-5,682
Nat'l Geological & Geophysical Data Pres Program	996	---	996	---	+996
National cooperative geological mapping	26,300	27,991	26,300	---	-1,691
National Geospatial Program	64,330	66,074	64,330	---	-1,744
Total, Core Science Systems	106,678	120,390	112,269	+5,591	-8,121
Administration and Enterprise Information:					
Science support	73,427	75,756	62,906	-10,521	-12,850
Security and technology	20,991	23,295	19,523	-1,468	-3,772
Information resources	15,802	---	---	-15,802	---
Total, Admin and Enterprise Information	110,220	99,051	82,429	-27,791	-16,622

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Facilities:					
Rental payments and operations & maintenance	93,141	92,437	88,751	-4,390	-3,686
Deferred maintenance and capital improvement	7,280	7,280	7,280	---	---
Total, Facilities	100,421	99,717	96,031	-4,390	-3,686
Total, Surveys, Investigations, and Research	1,068,032	1,102,492	967,000	-101,032	-135,492
TOTAL, UNITED STATES GEOLOGICAL SURVEY	1,068,032	1,102,492	967,000	-101,032	-135,492
BUREAU OF OCEAN ENERGY MANAGEMENT					
Ocean Energy Management					
Renewable energy	22,685	24,046	22,685	---	-1,361
Conventional energy	47,245	47,612	47,567	+322	-45
Environmental assessment	62,016	62,938	62,016	---	-922
General support services	12,785	13,345	12,785	---	-560
Executive direction	16,047	16,164	16,047	---	-117
Subtotal	160,778	164,105	161,100	+322	-3,005

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Offsetting rental receipts	-98,993	-98,791	-98,791	+202	---
Cost recovery fees	-2,089	-2,613	-2,613	-524	---
TOTAL, BUREAU OF OCEAN ENERGY MANAGEMENT	59,696	62,701	59,696	---	-3,005
BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT					
Offshore Safety and Environmental Enforcement					
Environmental enforcement	4,108	8,303	4,108	---	-4,195
Operations, safety and regulation	132,079	146,740	136,879	+4,800	-9,861
Administrative operations	15,545	20,975	15,545	---	-5,430
General support services	12,607	13,037	12,607	---	-430
Executive direction	18,117	18,225	18,117	---	-108
Subtotal	182,456	207,280	187,256	+4,800	-20,024
Offsetting rental receipts	-52,587	-52,479	-52,479	+108	---
Inspection fees	-62,000	-65,000	-65,000	-3,000	---
Cost recovery fees	-6,494	-8,402	-8,402	-1,908	---
Total, Offshore Safety and Environmental Enforcement	61,375	81,399	61,375	---	-20,024

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Oil Spill Research					
Oil spill research	14,899	14,899	14,899	---	---
TOTAL, BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT	76,274	96,298	76,274	---	-20,024
OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT					
Regulation and Technology					
Environmental protection	91,832	81,855	91,832	---	+9,977
Permit fees	40	3,400	40	---	-3,360
Offsetting collections	-40	-3,400	-40	---	+3,360
Technology development and transfer	14,455	14,584	14,455	---	-129
Financial management	505	505	505	---	---
Executive direction	15,921	16,109	15,921	---	-188
Civil penalties (indefinite)	100	100	100	---	---
Civil penalties (offsetting collections)	-100	-100	-100	---	---
Total, Regulation and Technology	122,713	113,053	122,713	---	+9,660
Abandoned Mine Reclamation Fund					
Environmental restoration	9,480	9,447	9,447	-33	---
Technology development and transfer	3,544	3,571	3,544	---	-27

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Financial management	6,396	6,455	6,396	---	-59
Executive direction	7,979	8,075	7,979	---	-96
Total, Abandoned Mine Reclamation Fund	27,399	27,548	27,366	-33	-182
TOTAL, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT	150,112	140,601	150,079	-33	+9,478
BUREAU OF INDIAN AFFAIRS					
Operation of Indian Programs					
Tribal Government:					
Aid to tribal government	30,492	28,441	28,441	-2,051	---
Consolidated tribal government program	76,398	77,283	77,283	+885	---
Self governance compacts	154,836	158,038	158,038	+3,202	---
Contract support	219,209	228,000	228,000	+8,791	---
Indian self determination fund	1,997	2,000	2,000	+3	---
New tribes	314	320	320	+6	---
Small and needy tribes	1,947	1,947	1,947	---	---
Road maintenance	25,390	25,155	27,405	+2,015	+2,250
Tribal government program oversight	8,748	7,974	7,974	-774	---
Subtotal	519,331	529,158	531,408	+12,077	+2,250

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Human Services:					
Social services	34,324	33,776	33,776	-548	---
Welfare assistance	74,791	74,791	74,791	---	---
Indian child welfare act	10,850	10,533	10,533	-317	---
Housing improvement program	12,599	12,602	12,602	+3	---
Human services tribal design	429	437	437	+8	---
Human services program oversight	3,367	3,012	3,012	-355	---
Subtotal	136,360	135,151	135,151	-1,209	---
Trust - Natural Resources Management:					
Natural resources, general	5,116	5,057	5,057	-59	---
Irrigation operations and maintenance	11,920	11,945	11,945	+25	---
Rights protection implementation	28,976	32,645	32,645	+3,669	---
Tribal management/development program	7,705	9,723	9,723	+2,018	---
Endangered species	1,245	1,234	1,234	-11	---
Integrated resource information program	2,106	2,106	2,106	---	---
Cooperative landscape conservation	200	999	999	+799	---
Agriculture and range	28,836	28,609	28,609	-227	---
Forestry	43,574	42,701	42,701	-873	---
Water resources	10,134	10,113	10,113	-21	---
Fish, wildlife and parks	11,322	11,366	11,366	+44	---
Resource management program oversight	6,111	5,611	5,611	-500	---
Subtotal	157,245	162,109	162,109	+4,864	---
Trust - Real Estate Services	126,759	127,813	127,813	+1,054	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Education:					
Elementary and secondary programs (forward funded)..	522,247	523,026	536,017	+13,770	+12,991
(Tribal grant support costs)	(46,253)	(48,253)	(61,244)	(+14,991)	(+12,991)
Post secondary programs (forward funded).....	67,293	69,793	69,793	+2,500	---
Subtotal, forward funded education.....	589,540	592,819	605,810	+16,270	+12,991
Elementary and secondary programs.....	122,534	122,828	123,828	+1,294	+1,000
Post secondary programs.....	61,435	62,052	62,052	+617	---
Education management.....	21,971	18,434	18,434	-3,537	---
Subtotal, Education.....	795,480	796,133	810,124	+14,644	+13,991
Public Safety and Justice:					
Law enforcement.....	321,944	328,444	335,887	+13,943	+7,443
Tribal courts.....	23,407	24,567	25,124	+1,717	+557
Fire protection.....	872	871	871	-1	---
Subtotal.....	346,223	353,882	361,882	+15,659	+8,000
Community and economic development.....	34,810	34,333	35,333	+523	+1,000
Executive direction and administrative services.....	251,530	239,573	239,573	-11,957	---
(housing improvement, road maint, etc. in bill lang)..	(48,049)	(49,224)	(51,474)	(+3,425)	(+2,250)
Indian Arts and Crafts Board.....	---	1,279	1,279	+1,279	---
Total, Operation of Indian Programs.....	2,367,738	2,379,431	2,404,672	+36,934	+25,241

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Construction					
Education	70,826	52,866	62,066	-8,760	+9,200
Public safety and justice	11,311	11,306	11,306	-5	---
Resources management	32,959	32,733	32,733	-226	---
General administration	2,032	2,027	2,027	-5	---
Construction management	6,502	6,978	8,978	+2,476	+2,000
Total, Construction	123,630	105,910	117,110	-6,520	+11,200
Indian Land and Water Claim Settlements and Miscellaneous Payments to Indians					
White Earth Land Settlement Act (Admin)	624	625	625	+1	---
Hoopa-Yurok settlement fund	250	250	250	---	---
Pyramid Lake water rights settlement	142	142	142	---	---
Nez Perce/Snake River	9,435	9,450	9,450	+15	---
Navajo Water Resources Development Trust Fund	5,990	6,000	6,000	+10	---
Navajo Gallup Water Settlement	4,381	7,826	7,826	+3,445	---
Duck Valley Water Rights Settlement	11,980	12,000	12,000	+20	---
Total, Indian Land and Water Claim Settlements and Miscellaneous Payments to Indians	32,802	36,293	36,293	+3,491	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Indian Guaranteed Loan Program Account					
Indian guaranteed loan program account	7,103	5,000	10,000	+2,897	+5,000
TOTAL, BUREAU OF INDIAN AFFAIRS	2,531,273	2,526,634	2,568,075	+36,802	+41,441
DEPARTMENTAL OFFICES					
Office of the Secretary, Departmental Operations					
Leadership and administration	120,160	121,711	120,160	---	-1,551
Management services	22,319	20,311	8,199	-14,120	-12,112
Office of Natural Resources Revenue	119,418	119,609	119,418	---	-191
Total, Office of the Secretary, Departmental Operations	261,897	261,631	247,777	-14,120	-13,854
Extension of mandatory payments to local governments (PILT)	---	---	398,000	+398,000	+398,000
Total, Office of the Secretary (including PILT)	261,897	261,631	645,777	+383,880	+384,146

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Insular Affairs					
Assistance to Territories					
Territorial Assistance					
Office of Insular Affairs	9,465	9,262	9,262	-203	---
Technical assistance	18,774	12,500	12,500	-6,274	---
Maintenance assistance fund	2,237	741	741	-1,496	---
Brown tree snake	2,995	3,000	3,000	+5	---
Coral reef initiative	998	1,000	1,000	+2	---
Water and wastewater projects	790	---	---	-790	---
Empowering Insular Communities	2,205	2,971	2,971	+766	---
Compact impact	---	5,000	---	---	-5,000
Subtotal, Territorial Assistance	37,464	34,474	29,474	-7,990	-5,000
American Samoa operations grants	22,717	22,752	22,752	+35	---
Northern Marianas covenant grants	27,720	27,720	27,720	---	---
Total, Assistance to Territories	87,901	84,946	79,946	-7,955	-5,000

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Compact of Free Association					
Compact of Free Association - Federal services	2,814	2,818	2,814	---	-4
Enewetak support	499	236	499	---	+263
Compact payments, Palau (section 122)	14,000	---	---	-14,000	---
Total, Compact of Free Association	17,313	3,054	3,313	-14,000	+259
Total, Insular Affairs	105,214	88,000	83,259	-21,955	-4,741
Office of the Solicitor					
Legal services	47,434	47,719	47,434	---	-285
General administration	16,218	15,518	15,518	-700	---
Ethics	2,538	1,702	1,702	-836	---
Total, Office of the Solicitor	66,190	64,939	64,654	-1,536	-285
Office of Inspector General					
Audit and investigations	39,140	35,826	35,826	-3,314	---
Administrative services and information management	10,252	12,667	12,667	+2,415	---
Total, Office of Inspector General	49,392	48,493	48,493	-899	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Office of Special Trustee for American Indians					
Federal Trust Programs					
Program operations, support, and improvements	149,863	143,033	143,033	-6,830	---
(Office of Historical Accounting)	(31,172)	(26,839)	(26,839)	(-4,333)	---
Executive direction	2,212	2,967	2,967	+755	---
Total, Office of Special Trustee for American Indians	152,075	146,000	146,000	-6,075	---
TOTAL, DEPARTMENTAL OFFICES	634,768	609,063	988,183	+353,415	+379,120
(Mandatory)	(27,720)	(27,720)	(27,720)	---	---
(Discretionary)	(607,048)	(581,343)	(960,463)	(+353,415)	(+379,120)
DEPARTMENT-WIDE PROGRAMS					
Wildland Fire Management					
Fire Operations:					
Preparedness	276,522	279,508	279,508	+2,986	---
Fire suppression operations	270,481	276,508	276,508	+6,027	---
Subtotal, Fire operations	547,003	556,016	556,016	+9,013	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Other Operations:					
Hazardous fuels reduction	183,021	145,315	167,315	-15,706	+22,000
Burned area rehabilitation	13,025	13,025	13,025	---	---
Fire facilities	6,127	6,127	4,127	-2,000	-2,000
Joint fire science	5,990	5,990	5,990	---	---
Rural fire assistance	---	---	---	---	---
Subtotal, Other operations	208,163	170,457	190,457	-17,706	+20,000
Subtotal, Wildland fire management	755,166	726,473	746,473	-8,693	+20,000
Rescission of unobligated balances	-82,000	---	---	+82,000	---
Use of emergency suppression funds	-189,577	---	---	+189,577	---
Total, Wildland fire management	483,589	726,473	746,473	+262,884	+20,000
FLAME Wildfire Suppression Reserve Account					
FLAME wildfire suppression reserve account	91,853	92,000	92,000	+147	---
Total, all wildland fire accounts	575,442	818,473	838,473	+263,031	+20,000
Central Hazardous Materials Fund					
Central hazardous materials fund	10,133	9,598	9,133	-1,000	-465

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Natural Resource Damage Assessment Fund					
Damage assessments	3,737	3,699	3,587	-150	-112
Program management	1,903	1,949	1,826	-77	-123
Restoration support	613	615	587	-26	-28
Total, Natural Resource Damage Assessment Fund	6,253	6,263	6,000	-253	-263
Working Capital Fund	61,920	70,647	56,936	-4,984	-13,711
TOTAL, DEPARTMENT-WIDE PROGRAMS	653,748	904,981	910,542	+256,794	+5,561
GENERAL PROVISIONS					
State royalty administrative cost deduction	-42,000	-40,000	-40,000	+2,000	---
TOTAL, GENERAL PROVISIONS	-42,000	-40,000	-40,000	+2,000	---
TOTAL, TITLE I, DEPARTMENT OF THE INTERIOR	10,300,629	10,437,037	10,357,918	+57,289	-79,119
Appropriations	(10,416,629)	(10,667,037)	(10,387,918)	(-28,711)	(-279,119)
Rescissions	(-116,000)	(-230,000)	(-30,000)	(+86,000)	(+200,000)
(Mandatory)	(57,420)	(57,420)	(57,420)	---	---
(Discretionary)	(10,243,209)	(10,379,617)	(10,300,498)	(+57,289)	(-79,119)

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
TITLE II - ENVIRONMENTAL PROTECTION AGENCY					
Science and Technology					
Clean Air and Climate	124,378	127,108	115,819	-8,559	-11,289
(Climate protection program)	(16,319)	(7,760)	(7,760)	(-8,559)	---
Enforcement	15,269	15,593	15,269	---	-324
Homeland security	41,973	40,066	40,066	-1,907	---
Indoor air and Radiation	6,750	6,661	6,661	-89	---
IT / Data management / Security	3,652	4,047	3,652	---	-395
Operations and administration	72,019	75,485	68,970	-3,049	-6,515
(Rent)	(35,605)	(34,899)	(32,556)	(-3,049)	(-2,343)
(Utilities)	(20,162)	(20,202)	(20,162)	---	(-40)
(Security)	(10,696)	(11,066)	(10,696)	---	(-370)
Pesticide licensing	6,563	7,098	6,563	---	-535
Research: Air, climate and energy	98,845	105,894	95,043	-3,802	-10,851
Research: Chemical safety and sustainability	131,288	134,746	123,047	-8,241	-11,699
(Research: Computational toxicology)	(21,177)	(21,267)	(21,267)	(+90)	---
(Research: Endocrine disruptor)	(16,861)	(16,253)	(16,253)	(-608)	---
Research: National priorities	4,992	---	5,000	+8	+5,000
Research: Safe and sustainable water resources	113,476	121,190	101,921	-11,555	-19,269

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Research Sustainable and healthy communities	170,741	165,730	152,707	-18,034	-13,023
Water: Human health protection	3,782	3,639	3,639	-143	---
Total, Science and Technology	793,728	807,257	738,357	-55,371	-68,900
(transfer from Superfund)	(22,979)	(23,225)	(22,979)	---	(-246)
Environmental Programs and Management					
Brownfields	23,642	25,685	23,642	---	-2,043
Clean air and climate	286,108	313,195	256,709	-29,399	-56,486
(Climate protection program)	(99,481)	(107,991)	(84,919)	(-14,562)	(-23,072)
Compliance	106,707	125,209	106,707	---	-18,502
Enforcement	249,559	265,442	226,555	-23,004	-38,887
(Environmental justice)	(6,848)	(7,161)	(6,848)	---	(-313)
Environmental protection: National priorities	14,975	---	15,000	+25	+15,000
Geographic programs:					
Great Lakes Restoration Initiative	299,520	300,000	250,000	-49,520	-50,000
Chesapeake Bay	57,299	72,618	50,000	-7,299	-22,618
San Franciso Bay	5,838	4,857	4,857	-981	---
Puget Sound	29,952	19,289	29,952	---	+10,663
Long Island Sound	3,956	2,962	2,962	-994	---
Gulf of Mexico	5,455	4,436	4,436	-1,019	---
South Florida	2,058	1,700	1,700	-358	---
Lake Champlain	2,395	1,399	1,399	-996	---
Lake Pontchartrain	1,952	955	955	-997	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
CARE(Community Action for a Renewed Environment)....	---	2,069	---	---	-2,069
Other geographic activities.....	1,294	1,417	---	-1,294	-1,417
Subtotal.....	409,719	411,702	346,261	-63,458	-65,441
Homeland security.....	11,278	12,303	12,303	+1,025	---
Indoor air and radiation.....	33,717	32,434	32,434	-1,283	---
Information exchange / Outreach.....	130,692	139,404	115,793	-14,899	-23,611
(Children and other sensitive populations: Agency coordination).....	(7,481)	(10,923)	(7,481)	---	(-3,442)
(Environmental education).....	(9,699)	---	---	(-9,699)	---
International programs.....	17,604	19,134	17,604	---	-1,530
IT / Data management / Security.....	94,725	95,761	93,689	-1,036	-2,072
Legal/science/regulatory/economic review.....	110,752	132,452	89,234	-21,518	-43,218
Operations and administration.....	487,083	511,198	473,695	-13,388	-37,503
(Rent).....	(170,529)	(171,152)	(170,529)	---	(-623)
(Utilities).....	(11,205)	(10,660)	(10,660)	(-545)	---
(Security).....	(29,216)	(31,486)	(31,486)	(+2,270)	---
Pesticide licensing.....	110,348	111,007	110,348	---	-659
Resource Conservation and Recovery Act (RCRA).....	112,469	117,298	112,469	---	-4,829
Toxics risk review and prevention.....	99,971	109,207	97,678	-2,293	-11,529
(Endocrine disruptors).....	(8,255)	(7,238)	(7,238)	(-1,017)	---
Underground storage tanks (LUST / UST).....	12,846	12,283	12,283	-563	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Water: Ecosystems					
National estuary program / Coastal waterways	27,014	27,304	27,014	---	-290
Wetlands	21,160	27,685	21,160	---	-6,525
Subtotal	48,174	54,989	48,174	---	-6,815
Water: Human health protection	101,099	105,315	96,315	-4,784	-9,000
Water quality protection	216,754	223,161	192,188	-24,566	-30,973
Total, Environmental Programs and Management	2,678,222	2,817,179	2,479,081	-199,141	-338,098
Office of Inspector General					
Audits, evaluations, and investigations	41,933	48,273	41,933	---	-6,340
(transfer from Superfund)	(9,939)	(10,864)	(9,939)	---	(-925)
Buildings and Facilities					
Homeland security: Protection of EPA personnel and infrastructure	7,044	8,038	7,044	---	-994
Operations and administration	29,326	33,931	29,326	---	-4,605
Total, Buildings and Facilities	36,370	41,969	36,370	---	-5,599
Hazardous Substance Superfund					
Audits, evaluations, and investigations	9,939	10,864	9,939	---	-925
Compliance	1,221	1,223	1,221	---	-2
Enforcement	186,735	184,408	169,408	-17,327	-15,000

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Homeland security	41,769	41,941	41,941	+172	---
Indoor air and radiation	2,468	2,637	2,468	---	-169
Information exchange / Outreach	1,431	1,433	1,431	---	-2
IT /data management/security	16,067	15,583	15,583	-484	---
Legal/science/regulatory/economic review	1,526	1,632	1,526	---	-106
Operations and administration	135,758	140,381	130,758	-5,000	-9,623
(Rent)	(47,032)	(46,005)	(46,005)	(-1,027)	---
(Utilities)	(3,760)	(3,455)	(3,455)	(-305)	---
(Security)	(8,269)	(8,594)	(8,594)	(+325)	---
Research: Chemical safety and sustainability*	3,337	3,316	3,316	-21	---
Research: Sustainable communities**	17,677	17,798	17,677	---	-121
Superfund cleanup:					
Superfund: Emergency response and removal	189,590	188,500	188,500	-1,090	---
Superfund: Emergency preparedness	9,244	8,179	8,179	-1,065	---
Superfund: Federal facilities	26,199	26,765	26,199	---	-566
Superfund: Remedial	564,998	531,771	546,771	-18,227	+15,000
Superfund: Support to other Federal agencies	5,849	---	---	-5,849	---
Subtotal	795,880	755,215	769,649	-26,231	+14,434
Total, Hazardous Substance Superfund	1,213,808	1,176,431	1,164,917	-48,891	-11,514
(transfer to Inspector General)	(-9,939)	(-10,864)	(-9,939)	---	(+925)
(transfer to Science and Technology)	(-22,979)	(-23,225)	(-22,979)	---	(+246)

* Formerly Research: Human health and ecosystems
** Formerly Research: Land protection

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Leaking Underground Storage Tank Trust Fund (LUST)					
Enforcement	789	792	792	+3	---
Operations and administration	1,590	1,513	1,513	-77	---
Research: Sustainable communities*	396	490	490	+94	---
Underground storage tanks (LUST / UST)	101,367	101,322	101,322	-45	---
(LUST/UST)	(11,962)	(11,490)	(11,490)	(-472)	---
(LUST cooperative agreements)	(58,956)	(57,402)	(57,402)	(-1,554)	---
(Energy Policy Act grants)	(30,449)	(32,430)	(32,430)	(+1,981)	---
Total, Leaking Underground Storage Tank Trust Fund	104,142	104,117	104,117	-25	---

* Formerly Research: Land protection

Inland Oil Spill Program (formerly Oil Spill Response)					
Compliance	138	142	138	---	-4
Enforcement	2,286	2,968	2,286	---	-682
Oil	14,673	19,290	14,673	---	-4,617
Operations and administration	535	513	513	-22	---
Research: Sustainable communities*	613	618	613	---	-5
Total, Inland Oil Spill Program	18,245	23,531	18,223	-22	-5,308

* Formerly Research: Land protection

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
State and Tribal Assistance Grants (STAG)					
Alaska Native villages	9,984	10,000	---	-9,984	-10,000
Brownfields projects	94,848	93,291	60,000	-34,848	-33,291
Clean water state revolving fund (SRF)	1,466,456	1,175,000	689,000	-777,456	-486,000
Diesel emissions grants	29,952	15,000	30,000	+48	+15,000
Drinking water state revolving fund (SRF)	917,892	850,000	829,000	-88,892	-21,000
Mexico border	4,992	10,000	---	-4,992	-10,000
Subtotal, Infrastructure assistance grants	2,524,124	2,153,291	1,608,000	-916,124	-545,291
Categorical grants:					
Beaches protection	9,864	---	---	-9,864	---
Brownfields	49,317	47,572	47,572	-1,745	---
Environmental information	9,964	15,200	9,964	---	-5,236
Hazardous waste financial assistance	102,974	103,412	102,974	---	-438
Lead	14,512	14,855	14,512	---	-343
Nonpoint source (Sec. 319)	164,493	164,757	150,505	-13,988	-14,252
Pesticides enforcement	18,644	19,085	18,644	---	-441
Pesticides program implementation	13,119	13,140	13,119	---	-21
Pollution control (Sec. 106)	238,403	265,264	204,264	-34,139	-61,000
(Water quality monitoring)	(18,433)	(18,500)	(11,300)	(-7,133)	(-7,200)
Pollution prevention	4,922	5,039	4,922	---	-117
Public water system supervision	105,320	109,700	105,320	---	-4,380
Radon	8,045	---	8,045	---	+8,045
State and local air quality management	235,729	301,500	200,729	-35,000	-100,771
Toxics substances compliance	5,081	5,201	5,081	---	-120
Tribal air quality management	13,252	13,566	13,252	---	-314
Tribal general assistance program	67,631	96,375	67,631	---	-28,744

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Underground injection control (UIC)	10,852	11,109	10,852	---	-257
Underground storage tanks	1,548	1,490	1,490	-58	---
Wetlands program development	15,143	15,167	15,167	+24	---
Subtotal, Categorical grants	1,088,813	1,202,432	994,043	-94,770	-208,389
Total, State and Tribal Assistance Grants	3,612,937	3,355,723	2,602,043	-1,010,894	-753,680
Subtotal, ENVIRONMENTAL PROTECTION AGENCY	8,499,385	8,374,480	7,185,041	-1,314,344	-1,189,439
Rescission	-50,000	-30,000	-130,000	-80,000	-100,000
TOTAL, TITLE II, ENVIRONMENTAL PROTECTION AGENCY	8,449,385	8,344,480	7,055,041	-1,394,344	-1,289,439
Appropriations	(8,499,385)	(8,374,480)	(7,185,041)	(-1,314,344)	(-1,189,439)
Rescissions	(-50,000)	(-30,000)	(-130,000)	(-80,000)	(-100,000)
TITLE III - RELATED AGENCIES					
DEPARTMENT OF AGRICULTURE					
FOREST SERVICE					
Forest and Rangeland Research					
Forest inventory and analysis	64,269	66,805	71,805	+7,536	+5,000
Research and development programs	231,031	225,991	175,991	-55,040	-50,000
Total, Forest and rangeland research	295,300	292,796	247,796	-47,504	-45,000

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
State and Private Forestry					
Landscape scale restoration	---	18,000	16,000	+16,000	-2,000
Forest Health Management:					
Federal lands forest health management	47,425	63,000	63,000	+15,575	---
Cooperative lands forest health management	39,999	49,000	49,000	+9,001	---
Subtotal	87,424	112,000	112,000	+24,576	---
Cooperative Fire Protection:					
State fire assistance	30,488	---	---	-30,488	---
Volunteer fire assistance	6,669	---	---	-6,669	---
Subtotal	37,157	---	---	-37,157	---
Cooperative Forestry:					
Forest stewardship	28,814	24,778	20,000	-8,814	-4,778
Forest legacy	53,303	60,000	3,000	-50,303	-57,000
Community forest and open space conservation	1,997	4,000	1,000	-997	-3,000
Urban and community forestry	31,327	28,040	25,000	-6,327	-3,040
Forest resource information and analysis	4,917	---	---	-4,917	---
Subtotal, Cooperative Forestry	120,358	116,818	49,000	-71,358	-67,818
International forestry	7,987	3,912	6,000	-1,987	+2,088
Total, State and Private Forestry	252,926	250,730	183,000	-69,926	-67,730

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
National Forest System					
Integrated resource restoration	---	793,124	---	---	-793,124
Land management planning	39,936	---	---	-39,936	---
Inventory and monitoring	161,721	---	161,721	---	+161,721
Land management planning, assessment and monitoring	---	188,774	---	---	-188,774
Recreation, heritage and wilderness	281,176	267,066	260,066	-21,110	-7,000
Grazing management	55,356	40,380	55,356	---	+14,976
Forest products	335,511	---	342,211	+6,700	+342,211
Vegetation and watershed management	184,046	---	187,646	+3,600	+187,646
Wildlife and fish habitat management	140,036	---	142,736	+2,700	+142,736
Collaborative Forest Landscape Restoration Fund	39,936	40,000	40,000	+64	---
Minerals and geology management	83,426	73,351	83,426	---	+10,075
Landownership management	85,738	78,855	78,855	-6,883	---
Law enforcement operations	143,829	140,041	140,041	-3,788	---
Valles Caldera National Preserve	3,426	---	3,426	---	+3,426
Subsistence management	---	2,000	---	---	-2,000
Total, National Forest System	1,554,137	1,623,591	1,495,484	-58,653	-128,107
Capital Improvement and Maintenance					
Facilities:					
Maintenance	62,561	81,189	49,463	-13,098	-31,726
Construction	13,103	18,274	---	-13,103	-18,274
Subtotal	75,664	99,463	49,463	-26,201	-50,000

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Roads:					
Maintenance	155,242	123,105	147,812	-7,430	+24,707
Construction	27,283	34,713	34,713	+7,430	---
Subtotal	182,525	157,818	182,525	---	+24,707
Trails:					
Maintenance	63,321	63,224	63,224	-97	---
Construction	18,530	18,761	18,761	+231	---
Subtotal	81,851	81,985	81,985	+134	---
Deferred maintenance	9,121	7,113	7,113	-2,008	---
Legacy road and trail remediation	44,928	---	35,000	-9,928	+35,000
Subtotal, Capital improvement and maintenance	394,089	346,379	356,086	-38,003	+9,707
Deferral of road and trail fund payment	-12,000	-12,000	-12,000	---	---
Total, Capital improvement and maintenance	382,089	334,379	344,086	-38,003	+9,707
Land Acquisition					
Acquisitions	41,539	44,434	---	-41,539	-44,434
Acquisition management	7,488	7,500	7,000	-488	-500
Cash equalization	---	1,000	---	---	-1,000
Critical Inholdings/Cash Equalization	3,494	---	4,494	+1,000	+4,494

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Priority recreational access	---	5,000	5,000	+5,000	---
Total, Land Acquisition	52,521	57,934	16,494	-36,027	-41,440
Acquisition of land for national forests, special acts	953	955	955	+2	---
Acquisition of lands to complete land exchanges	227	227	227	---	---
Range betterment fund	3,257	2,360	2,360	-897	---
Gifts, donations and bequests for forest and rangeland research	45	46	46	+1	---
Management of national forest lands for subsistence uses	2,573	---	2,000	-573	+2,000
Wildland Fire Management					
Fire operations:					
Wildland fire preparedness	1,004,442	1,001,513	1,001,513	-2,929	---
Wildland fire suppression operations	538,242	616,000	616,000	+77,758	---
Subtotal, Fire operations	1,542,684	1,617,513	1,617,513	+74,829	---
Other operations:					
Hazardous fuels	317,076	241,600	345,005	+27,929	+103,405
(Hazardous Fuels Base Program)*	(312,084)	(236,600)	(340,005)	(+27,921)	(+103,405)
(Biomass Grants)	(4,992)	(5,000)	(5,000)	(+8)	---
Fire plan research and development	21,699	20,634	20,634	-1,065	---
Joint fire sciences program	7,250	7,226	5,226	-2,024	-2,000
Forest health management (federal lands)	15,958	---	---	-15,958	---
Forest health management (co-op lands)	8,353	---	---	-8,353	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
State fire assistance	55,475	72,688	72,688	+17,213	---
Volunteer fire assistance	6,356	11,733	11,733	+5,377	---
Subtotal, Other operations	432,167	353,881	455,286	+23,119	+101,405
Subtotal, Wildland fire management	1,974,851	1,971,394	2,072,799	+97,948	+101,405
Use of emergency suppression funds	-240,000	---	---	+240,000	---
Total, Wildland fire management	1,734,851	1,971,394	2,072,799	+337,948	+101,405
FLAME Wildfire Suppression Reserve Account					
FLAME wildfire suppression reserve account	315,381	315,000	315,000	-381	---
Total, all wildland fire accounts	2,050,232	2,286,394	2,387,799	+337,567	+101,405
Total, Forest Service without Wildland fire	2,544,028	2,563,018	2,292,448	-251,580	-270,570
TOTAL, FOREST SERVICE	4,594,260	4,849,412	4,680,247	+85,987	-169,165

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
DEPARTMENT OF HEALTH AND HUMAN SERVICES					
INDIAN HEALTH SERVICE					
Indian Health Services					
Clinical Services:					
Hospital and health clinics	1,810,966	1,849,310	1,851,448	+40,482	+2,138
Dental health	159,440	166,297	166,597	+7,157	+300
Mental health	75,589	78,131	78,131	+2,542	---
Alcohol and substance abuse	194,297	195,378	195,378	+1,081	---
Contract health services	843,575	897,562	897,562	+53,987	---
(Catastrophic health emergency fund)	(51,418)	(51,500)	(51,500)	(+82)	---
Subtotal	3,083,867	3,186,678	3,189,116	+105,249	+2,438
Preventive Health:					
Public health nursing	66,632	69,868	69,868	+3,236	---
Health education	17,057	17,450	17,450	+393	---
Community health representatives	61,407	61,531	61,531	+124	---
Immunization (Alaska)	1,927	1,927	1,927	---	---
Subtotal	147,023	150,776	150,776	+3,753	---
Other services:					
Urban Indian health	42,984	42,988	45,488	+2,504	+2,500
Indian health professions	40,596	40,598	41,598	+1,002	+1,000
Tribal management grant program	2,577	2,577	2,577	---	---
Direct operations	71,653	72,867	67,567	-4,086	-5,300

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Self-governance	6,044	6,044	6,044	---	---
Contract support costs	471,437	476,446	546,446	+75,009	+70,000
Subtotal	635,291	641,520	709,720	+74,429	+68,200
Total, Indian Health Services	3,866,181	3,978,974	4,049,612	+183,431	+70,638
Indian Health Facilities					
Maintenance and improvement	53,721	55,470	55,470	+1,749	---
Sanitation facilities construction	79,582	79,582	79,582	---	---
Health care facilities construction	85,048	81,489	81,489	-3,559	---
Facilities and environmental health support	199,413	204,379	204,741	+5,328	+362
Equipment	22,582	22,582	22,582	---	---
Total, Indian Health Facilities	440,346	443,502	443,864	+3,518	+362
TOTAL, INDIAN HEALTH SERVICE	4,306,527	4,422,476	4,493,476	+186,949	+71,000
NATIONAL INSTITUTES OF HEALTH					
National Institute of Environmental Health Sciences	78,928	78,928	74,928	-4,000	-4,000

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY					
Toxic substances and environmental public health.....	76,215	76,300	74,039	-2,176	-2,261
TOTAL, DEPARTMENT OF HEALTH AND HUMAN SERVICES..	4,461,670	4,577,704	4,642,443	+180,773	+64,739
OTHER RELATED AGENCIES					
EXECUTIVE OFFICE OF THE PRESIDENT					
Council on Environmental Quality and Office of Environmental Quality.....	3,148	3,106	2,661	-487	-445
CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD					
Salaries and expenses.....	11,129	11,403	10,000	-1,129	-1,403
OFFICE OF NAVAJO AND HOPI INDIAN RELOCATION					
Salaries and expenses.....	7,738	8,400	7,600	-138	-800
INSTITUTE OF AMERICAN INDIAN AND ALASKA NATIVE CULTURE AND ARTS DEVELOPMENT					
Payment to the Institute.....	8,519	9,369	8,348	-171	-1,021

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
SMITHSONIAN INSTITUTION					
Salaries and Expenses					
Museum and Research Institutes:					
National Air and Space Museum	18,217	18,417	18,317	+100	-100
Smithsonian Astrophysical Observatory	23,997	24,101	23,997	---	-104
Major scientific instrumentation	3,816	3,822	3,816	---	-6
Universe Center	300	300	300	---	---
National Museum of Natural History	48,086	48,466	48,216	+130	-250
National Zoological Park	23,315	24,339	24,157	+842	-182
Smithsonian Environmental Research Center	3,767	3,867	3,767	---	-100
Smithsonian Tropical Research Institute	12,469	13,109	12,469	---	-640
Biodiversity Center	1,847	1,853	1,847	---	-6
Arthur M. Sackler Gallery/Freer Gallery of Art	6,125	6,155	6,125	---	-30
Center for Folklife and Cultural Heritage	2,330	2,448	2,330	---	-118
Cooper-Hewitt, National Design Museum	4,207	4,240	4,207	---	-33
Hirshhorn Museum and Sculpture Garden	4,349	4,370	4,349	---	-21
National Museum of African Art	4,284	4,303	4,284	---	-19
World Cultures Center	300	300	300	---	---
Anacostia Community Museum	2,060	2,070	2,060	---	-10
Archives of American Art	1,877	1,887	1,877	---	-10
National Museum of African American History and Culture	13,415	26,496	18,965	+5,550	-7,531

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
National Museum of American History	22,600	22,822	22,700	+100	-122
National Museum of the American Indian	31,849	31,998	31,849	---	-149
National Portrait Gallery	5,989	6,021	5,989	---	-32
Smithsonian American Art Museum	9,328	9,378	9,328	---	-50
American Experience Center	799	801	799	---	-2
Subtotal, Museums and Research Institutes	245,326	261,563	252,048	+6,722	-9,515
Mission enabling:					
Program support and outreach:					
Outreach	9,277	9,315	9,277	---	-38
Communications	2,740	2,753	2,740	---	-13
Institution-wide programs	10,910	12,328	12,310	+1,400	-18
Office of Exhibits Central	3,007	3,024	3,007	---	-17
Museum Support Center	1,871	1,881	1,871	---	-10
Museum Conservation Institute	3,231	3,247	3,231	---	-16
Smithsonian Institution Archives	2,189	2,201	2,189	---	-12
Smithsonian Institution Libraries	9,967	10,165	9,967	---	-198
Subtotal, Program support and outreach	43,192	44,914	44,592	+1,400	-322
Office of Chief Information Officer	45,920	48,545	45,920	---	-2,625
Administration	34,054	35,129	34,054	---	-1,075
Inspector General	2,645	2,909	2,645	---	-264

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Facilities services:					
Facilities maintenance	70,690	71,618	70,690	---	-928
Facilities operations, security and support	193,685	195,655	193,685	---	-1,970
Subtotal, Facilities services	264,375	267,273	264,375	---	-2,898
Subtotal, Mission enabling	390,186	398,770	391,586	+1,400	-7,184
Total, Salaries and expenses	635,512	660,333	643,634	+8,122	-16,699
Facilities Capital					
Revitalization	84,694	100,650	84,694	---	-15,956
Facilities planning and design	15,146	10,850	10,850	-4,296	---
Construction	74,880	85,000	50,000	-24,880	-35,000
Total, Facilities Capital	174,720	196,500	145,544	-29,176	-50,956
TOTAL, SMITHSONIAN INSTITUTION	810,232	856,833	789,178	-21,054	-67,655
NATIONAL GALLERY OF ART					
Salaries and Expenses					
Care and utilization of art collections	36,649	39,212	36,649	---	-2,563
Operation and maintenance of buildings and grounds	32,237	34,005	32,237	---	-1,768

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Protection of buildings, grounds and contents	23,471	22,709	22,709	-762	---
General administration	21,526	24,074	21,526	---	-2,548
Total, Salaries and Expenses	113,883	120,000	113,121	-762	-6,879
Repair, Restoration and Renovation of Buildings					
Base program	14,493	23,000	12,679	-1,814	-10,321
TOTAL, NATIONAL GALLERY OF ART	128,376	143,000	125,800	-2,576	-17,200
JOHN F. KENNEDY CENTER FOR THE PERFORMING ARTS					
Operations and maintenance	23,163	22,379	22,379	-784	---
Capital repair and restoration	13,628	13,588	13,588	-40	---
TOTAL, JOHN F. KENNEDY CENTER FOR THE PERFORMING ARTS	36,791	35,967	35,967	-824	---
WOODROW WILSON INTERNATIONAL CENTER FOR SCHOLARS					
Salaries and expenses	10,987	10,492	10,492	-495	---

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
NATIONAL FOUNDATION ON THE ARTS AND THE HUMANITIES					
National Endowment for the Arts					
Grants and Administration					
Grants:					
Direct grants	56,118	55,143	52,500	-3,618	-2,643
Challenge America grants	7,987	8,000	6,000	-1,987	-2,000
Our Town	4,992	10,000	2,500	-2,492	-7,500
Subtotal	69,097	73,143	61,000	-8,097	-12,143
State partnerships:					
State and regional	36,253	38,376	35,500	-753	-2,876
Underserved set-aside	9,812	10,386	9,000	-812	-1,386
Subtotal	46,065	48,762	44,500	-1,565	-4,262
Subtotal, Grants	115,162	121,905	105,500	-9,662	-16,405
Program support	2,841	2,250	1,500	-1,341	-750
Administration	28,018	27,100	25,000	-3,018	-2,100
Relocation expenses	---	3,000	---	---	-3,000
Total, Arts	146,021	154,255	132,000	-14,021	-22,255

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
National Endowment for the Humanities					
Grants and Administration					
Grants:					
Bridging cultures	3,494	9,000	2,500	-994	-6,500
Federal/State partnership	40,435	40,350	38,000	-2,435	-2,350
Preservation and access	15,176	15,700	12,750	-2,426	-2,950
Public programs	13,404	13,900	12,000	-1,404	-1,900
Research programs	14,502	15,255	12,250	-2,252	-3,005
Education programs	13,179	13,550	12,000	-1,179	-1,550
Program development	499	500	500	+1	---
We The People Initiative grants	2,995	---	3,500	+505	+3,500
Digital humanities initiatives	4,143	4,250	3,500	-643	-750
Subtotal, Grants	107,827	112,505	97,000	-10,827	-15,505
Matching Grants:					
Treasury funds	2,381	2,750	2,000	-381	-750
Challenge grants	8,357	8,750	8,000	-357	-750
Subtotal, Matching grants	10,738	11,500	10,000	-738	-1,500
Administration	27,456	27,250	25,000	-2,456	-2,250

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
Relocation expenses	---	3,000	---	---	-3,000
Total, Humanities	146,021	154,255	132,000	-14,021	-22,255
TOTAL, NATIONAL FOUNDATION ON THE ARTS AND THE HUMANITIES	292,042	308,510	264,000	-28,042	-44,510
COMMISSION OF FINE ARTS					
Salaries and expenses	2,396	2,175	2,175	-221	---
NATIONAL CAPITAL ARTS AND CULTURAL AFFAIRS					
Grants	1,997	---	1,950	-47	+1,950
ADVISORY COUNCIL ON HISTORIC PRESERVATION					
Salaries and expenses	6,098	7,023	5,723	-375	-1,300
NATIONAL CAPITAL PLANNING COMMISSION					
Salaries and expenses	8,141	7,977	7,977	-164	---
UNITED STATES HOLOCAUST MEMORIAL MUSEUM					
Holocaust Memorial Museum	50,717	51,788	49,900	-817	-1,888

COMPARATIVE STATEMENT OF NEW BUDGET (OBLIGATIONAL) AUTHORITY FOR 2012
AND BUDGET REQUESTS AND AMOUNTS RECOMMENDED IN THE BILL FOR 2013
(Amounts in thousands)

	FY 2012 Enacted	FY 2013 Request	Bill	Bill vs. Enacted	Bill vs. Request
PRESIDIO TRUST					
Operations	11,981	---	---	-11,981	---
DWIGHT D. EISENHOWER MEMORIAL COMMISSION					
Salaries and expenses	1,997	5,600	---	-1,997	-5,600
Capital construction	30,940	54,240	---	-30,940	-54,240
Total, DWIGHT D. EISENHOWER MEMORIAL COMMISSION	32,937	59,840	---	-32,937	-59,840
TOTAL, TITLE III, RELATED AGENCIES	10,479,159	10,942,999	10,644,461	+165,302	-298,538
TITLE IV - GENERAL PROVISIONS					
Across-the-board cut (.16%)	239	---	---	-239	---
GRAND TOTAL	29,229,412	29,724,516	28,057,420	-1,171,992	-1,667,096
Appropriations	(29,395,412)	(29,984,516)	(28,217,420)	(-1,177,992)	(-1,767,096)
Rescissions	(-166,000)	(-260,000)	(-160,000)	(+6,000)	(+100,000)
Discretionary total	29,174,992	29,667,096	28,000,000	-1,174,992	-1,667,096

BEFORE THE ADMINISTRATOR OF THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

INTERNATIONAL CENTER FOR TECHNOLOGY ASSESSMENT, CENTER FOR FOOD SAFETY, FRIENDS OF THE EARTH,

Petitioners,

v.

HONORABLE STEPHEN JOHNSON,
In his official capacity as Administrator, United States Environmental Protection Agency,

Respondent.

PETITION FOR RULEMAKING SEEKING THE REGULATION OF GREENHOUSE GAS EMISSIONS FROM NONROAD VEHICLES AND ENGINES

INTRODUCTION

Pursuant to the Clean Air Act (CAA), 42 U.S.C. § 7400, *et seq.* and the Administrative Procedure Act, 5 U.S.C. § 551 et seq, International Center for Technology Assessment and Center for Food Safety hereby petition the Administrator of the Environmental Protection Agency (EPA) to undertake a rulemaking procedure leading to the adoption of emissions standards, expressed either as emissions limitations, work practices or other requirements, to control and limit greenhouse gas (GHG) emissions from new nonroad vehicles and engines and rebuilt heavy-duty engines, excluding aircraft and vessels.[1] Nonroad vehicles and engines are used in the agricultural, construction, commercial, industrial, lawn and garden, recreational, and logging sectors.[2] These vehicles and engines substantially contribute to atmospheric GHG concentrations. EPA has authority to adopt such standards pursuant to CAA § 202, 42 U.S.C. § 7521, and CAA § 213(a)(4), 42 U.S.C. § 7547(a)(4). Petitioners have a procedural right to petition EPA to undertake the requested rulemaking. 5 U.S.C. § 553(e); *Massachusetts v. EPA*, 127 S.Ct. 1438, 1459 (2007). Petitioners request that EPA act in the shortest possible time, in light of the risk of severe to calamitous climate disruption that threatens public health and welfare.

Petitioner, the International Center for Technology Assessment (ICTA), is located at 660 Pennsylvania Ave., S.E., Suite 302, Washington, D.C. 20003. Formed in 1994, ICTA seeks to assist the public and policy makers in better understanding how technology affects society. ICTA is a non-profit organization devoted to analyzing the economic, environmental, ethical,

[1] Nonroad engines and nonroad vehicles are defined, respectively, at CAA § 216(10) and (11), 42 U.S.C. § 7550(10) (11).

[2] Requests for rulemaking leading to GHG emissions limits for aircraft and vessels are the subject of separate requests recently made by the State of California and Friends of the Earth.

political, and social impacts that can result from the application of technology or technological systems.

Petitioner, Center for Food Safety (CFS), is located at 660 Pennsylvania Ave, SE, Suite 302, Washington, D.C. 20003, and 2601 Mission Street, Suite 803, San Francisco, CA 94110. CFS is a nonprofit organization that works to protect human health and the environment by curbing the proliferation of harmful food production technologies and by promoting organic and other forms of sustainable agriculture.

Petitioner, Friends of the Earth (FOE), is headquartered at 1717 Massachusetts Avenue, NW, Suite 600, Washington, D.C. 20036-2002. FOE is a public interest, non-profit advocacy organization whose mission is to defend the environment and champion a just and healthy world by, among other efforts, working to change the current model of economic and corporate globalization and to reduce dependence on fossil fuels.

I. CLIMATE CHANGE IS OCCURRING, THREATENS SEVERE ENVIRONMENTAL AND SOCIAL DISRUPTION, BUT MAY BE MITIGATED BY EFFECTIVE, RAPID ACTION

The International Panel on Climate Change (IPCC) concluded recently that warming of the global climate system is now "unequivocal," based on observations of the widespread melting of snow and ice, rising sea levels, and increases in average global air and ocean temperatures.[3] International Panel on Climate Change (IPCC), Synthesis Report of the IPCC Fourth Assessment Summary for Policymakers, 1 (Nov. 16, 2007), www.ipcc\ch (visited Nov. 18, 2007).[4] The IPCC is highly confident that global warming is affecting both terrestrial ecosystems ("earlier timing of spring events and poleward and upward shifts in plant and animal ranges") and marine and freshwater systems ("shifts in ranges and changes in algal, plankton and fish abundance . . . associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation."). *Id*. at 2.[5] The warming is attributable to increasing GHG concentrations, *id*. at 3, with concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) having increased "markedly as a result of human activities since

[3] The IPCC report follows statements by virtually all major U.S. scientific bodies concluding that human activities are heating the planet's climate system. *See* Naomi Oreskes, *The Scientific Consensus on Climate Change*, 306 Science 1686 (Dec. 3, 2004).

[4] The IPCC analysis released in 2007 fails to account for peer reviewed scientific information released in late 2006 and all of 2007, much of which provides reason for additional concern. Accordingly, the analysis by IPCC summarized here likely understates the degree to which human generated GHG emissions have pressed the global climate system to a crisis point. *See* publications cited by the National Environmental Trust, *Indications that Climate Is Changing Faster than Anticipated: A Sample of Peer Reviewed Studies From 2007*, at www.net.org/warming/docs/recent science factsheet.pdf (visited Nov. 23, 2007).

[5] Scientists express medium confidence that climate change has already impacted agricultural practices, altered forest disturbance regimes, impacted aspects of human health, "such as heat related mortality in Europe, changes in infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid latitudes," and disrupted "human activities in the Arctic (e.g. hunting and travel over snow and ice) and in lower elevation alpine areas (such as mountain sports)." *Id*. at 3 4.

1750." *Id*. at 4. GHG concentrations have climbed most rapidly in recent years, with global emissions increasing 70% between 1970 and 2004. *Id*. Emissions of CO_2 the most important GHG grew by 80% in that period, resulting in atmospheric CO_2 concentrations that presently exceed "by far the natural range over the last 650,000 years." *Id*.[6]

The IPCC states with very high confidence that the "net effect of human activities since 1750 has been one of warming," *id*., noting that most of the increase in global temperatures since the mid-20th century is due to increases in GHG concentrations resulting from human activity. *Id.* at 5. Furthermore, absent human activity, simulations taking into account only "natural forcings" from solar and volcanic activity show the past 50 years would have been a cooling period. *Id*.

Human produced, GHG-induced, atmospheric warming and sea-level thermal expansion will likely continue for centuries even if GHG concentrations were to stabilize at present levels, due to the feedback effects of the climate-carbon cycle and the long timescales required for removal of CO_2 from the atmosphere. *Id*. at 6-7, 13.[7] If GHG emissions continue at or above present rates, induced changes in the global climate system during the 21st century "would very likely be larger than those observed during the 20th century." *Id*. at 10. These likely will include a sea-level rise up to 0.59 meters, even without taking into account the full impacts possible from changes in ice sheet flow.[8] *Id*. at 7-8.

Significant public health consequences from climate change are projected this century, including increased mortality, morbidity, and injuries attributable to the increasing frequency of heat waves, greater intensity of hurricanes and cyclones and associated flooding, and risks of food and water shortages. *Id*. at 12. Climate change induced impacts on natural ecosystems are projected to be predominately negative, *id*. at 7-8, with an estimated species extinction of 20-30% associated with a warming of 1.5-2.5 ºC above 1980-1999 levels, and "significant extinction" of 40-70% of species with a temperature increase exceeding 3.5ºC. *Id*. at 13. Polar, island, and high mountain communities and ecosystems are among the most vulnerable to climate change induced impacts, while the IPCC notes "increasing evidence of greater vulnerability of specific groups such as the poor and elderly" in both developing and developed countries." *Id*. at 20.

---

[6] See also *Mass. v. EPA*, 127 S.Ct. 1438, 1447, n. 10 (Citing data recorded at the National Oceanic & Atmospheric Administration's Mauna Loa observatory, the court noted that "[i]n 2006 carbon dioxide levels reached 382 parts per million."). In May 2007, the CO_2 concentration at Mauna Loa reached 386 ppm. *See* www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2 mm mlo.dat (visited Nov. 20, 2007). *See also*, World Meteorological Organization, Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Using Global Observations through 2006 (November 23, 2007) at www.wmo.ch/pages/prog/arep/gaw/ghg/documents/ghg bulletin 3.pdf (visited Nov. 23, 2007).

[7] *See also*, IPCC, Climate Change 2007 The Physical Science Basis, Chapter 10 Global Climate Projections, 824 (2007), at www.ipcc.ch/pdf/assessment report/ar4/wg1/ar4 wg1 chapter10.pdf (visited Nov. 20, 2007).

[8] IPCC notes that the added sea level rise from Greenland ice sheet disintegration could be "several metres, and larger than from thermal expansion, should warming in excess of 1.9 4.6˚C above pre industrial be sustained over many centuries." *Id*. at 21.

According to IPCC projections, climate change likely will impact the United States in several ways. First, all of North America is very likely to experience warming this century, more so than the planet as a whole. IPCC, Climate Change 2007: The Physical Science Basis, Chapter 10 Global Climate Projections (887) at www.ipcc.ch/ipccreports/ar4-wg1.htm (visited Dec. 5, 2007). In Northern Regions, including in Alaska, "warming is likely to be largest in winter, and in the southwest USA largest in summer." *Id*. Warming may also be larger in winter over elevated areas "as a result of snow-albedo feedback." *Id*. at 889. In Western Mountain Regions, warming will lead to decreased snowpack and produce greater winter flooding, reduced summer flows, and "exacerbated competition for over-allocated water resources." IPCC, Climate Change 2007: Synthesis Report, Summary for Policymakers, 10 at www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf (visited Nov. 30, 2007). In agricultural regions, climate change may at first increase yields of rain-fed crops, but major challenges are projected "for crops that are near the warm end of their suitable range or which depend on highly utilized water resources." *Id*. In cities, heat waves are anticipated this century to become more numerous, more intense, and more protracted. *Id*. Coastal communities and habitats "will be increasingly stressed by climate change impacts interacting with development and pollution." *Id*.

The United States previously committed itself, in conjunction with other nations, to achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." United Nations Framework Convention on Climate Change, Art. 2 (1992). Unfortunately, we are now at that level.[9] Further GHG emissions beyond the earth's capacity to remove them from the atmosphere may lead to widespread ice sheet melting and "imply metres of sea level rise, major changes in coastlines and inundation of low-lying areas." *Id*. at 13.[10]

Concerted and quick action to cap and reduce GHG emissions may still allow stabilization of CO_2 concentrations at a level below that which renders severe climate change inevitable. The IPCC notes that "[m]any impacts can be reduced, delayed or avoided by mitigation." *Id*. at 20. On the other hand, delayed emission reductions "significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts." *Id*.

---

[9] *See* IPCC, Climate Change 2007 Mitigation of Climate Change, Contribution of Working Group III to the Fourth Assessment Report, Chapter 1 Introduction, 99 100, at http://www.ipcc.ch/pdf/assessment report/ar4/wg3/ar4 wg3 chapter1.pdf (visitied Nov. 23, 2007).

[10] *See also* Hansen, et al, "Dangerous Human made Interference with Climate: A GISS ModelE Study," *Atmos. Chem, Phys.*, 7, 2287, 2299 (2007); University of Melbourne Climate Adaptation Science and Policy Initiative, Evidence of Accelerated Climate Change (November 2007) at www.climateinstitute.org.au.

II. GHG EMISSIONS FROM NONROAD VEHICLES AND ENGINES

In 2007, non-transportation mobile vehicles and equipment were responsible for approximately 220 million tons of CO_2 emissions.[11] In 2005, the most recent year for which sector-by-sector comparisons were available, non-transportation mobile vehicles and equipment were responsible for approximately 192 Tg of CO_2-equivalent emissions. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, Annex 3:123-127.[12] This amount exceeds the total GHG emissions generated by aircraft. *Id*. It exceeds, as well, the combined emissions from boats and ships, rail and pipelines. *Id*. GHG emissions from the nonroad sector increased 49% between 1990 and 2005 a significantly higher rate of emissions increase over the same period than for on-road vehicles (32%), aircraft (3%), boats and ships (36%) and rail (32%). *Id*. at A-126 to 127.

Extrapolating from a simple linear regression of historical data, the EPA projected average annual growth rates through 2010 for nonroad engines ranging from 2.3% annual average growth for construction vehicles and engines to 4.5% for logging equipment. EPA, Nonroad Engine Growth Estimates, NR-008c (April 2004).[13] For certain recreational engines, EPA projected growth rates within or above that range: 4.3% for snowmobiles, 5.4% for off-highway motorcycles, and 7.5% for all-terrain vehicles.[14] Based on these projections, GHG emissions for the nonroad sector likely will continue to grow and become increasingly greater contributors to severe climate change, unless effective limitations are imposed.

Greenhouse gas emissions from mobile sources are dominated by CO_2 emissions. Data derived from EPA's Nonroad Emissions model for 2007 show nearly a third of such emissions stem from the construction and mining sector, while a fifth are from agriculture. Figure 1. Within the agricultural, construction, and industrial sectors, the greatest CO_2 emissions are produced by diesel-burning vehicles. Within agriculture, diesel tractors emit 37.7 million (37M) tons of CO_2. Within the construction sector, diesel tire loaders, excavators and crawler tractor/dozers each emit over 9.5M tons. Liquified Petroleum Gas (LPG) forklifts are responsible for the most emissions (14M tons) in the industrial sector. Gasoline-powered four-stroke commercial turf equipment is responsible for the highest CO_2 emissions (6.7M tons) from the lawn and garden sector, while gas-powered four-stroke residential law and garden tractors (5M tons) run a close second. Two-stroke, gasoline-powered outboard engines (6.5M tons) are responsible for the most emissions from marine pleasure craft engines, while from recreational equipment sources two stroke

[11] Non road CO_2 emissions in 2007 based on Western Environmental Law Center calculations using EPA's nonroad emissions model. See Figure 1, *infra* for details.

[12] One Tg is equivalent to 10^{12} grams, 10^9 kg, and 1 million metric tons.

[13] EPA projected average annual growth for engines in construction equipment was 2.3%; farm equipment: 2.6%; industrial: 2.7%; lawn & garden: 2.4%; light commercial: 4.0%; logging: 4.5%; railway: 3.4%. For recreational equipment other than for off road motorcycles, ATVs, or snowmobiles, the project growth rate was 0.7%.

[14] Calculations of annual growth rates are based on 1996 and 2010 data from Nonroad Engine Growth Estimates, Tables 2 4.

gasoline snowmobiles (4.6M tons) and four stroke gasoline ATVs (3M tons) emitted the most CO_2.[15]

2007 Emissions: Non-road Sector	CO_2 tons	Percent Total
Construction and Mining Equipment	70,413,126	32.00%
Agricultural Equipment	43,627,556	19.80%
Industrial Equipment	30,645,516	13.90%
Lawn and Garden Equipment	26,212,514	11.90%
Commercial Equipment	18,046,747	8.20%
Pleasure Craft	17,399,940	7.90%
Recreational Equipment	10,347,620	4.70%
Logging Equipment	2,117,651	1.00%
Airport Equipment	1,068,325	0.50%
Railroad Equipment	266,237	0.10%
Total: All Categories	**220,145,231**	**100%**

Figure 1: Non-road CO2 emissions in 2007. Calculations by Western Environmental Law Center using EPA's nonroad emissions model.

III. LEGAL BASIS FOR ACTION BY EPA

A. The CAA Authorizes EPA Regulation of Greenhouse Gas Emissions from Nonroad Vehicles and Engines.

CAA § 213(a)(1) requires EPA to "conduct a study of emissions from nonroad engines and nonroad vehicles…to determine if such emissions cause, or significantly contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." CAA § 213(a)(2) requires EPA, based on the results of that study, to determine if carbon monoxide (CO), oxides of nitrogen (NO_X) or volatile organic compound (VOC) emissions from nonroad vehicle and engine emissions are significant contributors to non-attainment for ozone (O_3) or CO air quality standards in at least two regions. If so, EPA was required to promulgate regulations limiting such emissions. CAA § 213(a)(3).

EPA completed the CAA § 213-required study in 1991.[16] On the basis of that study, EPA determined that nonroad vehicle and engine emissions significantly contribute to O_3 or CO levels in more than one non-attainment area. 59 Fed. Reg. 31306, 31307 (June 17, 1994). EPA proceeded to adopt standards for criteria pollutant emissions from compression-ignition vehicles and engines in 1994, 1998, and 2004,[17] and from spark-ignition engines in 2002.[18]

---

[15] Other significant sources from the recreational sector include gasoline golf carts (0.97M tons of CO2) and off road gasoline motorcycles (0.83M tons).

[16] EPA, "Nonroad Engine and Vehicle Emission Study," No. 460/3 91 02 (Nov. 1991) at 116.

[17] EPA, "EPA Diesel Milestones Since the Clear Air Amendments of 1990," No. 420 F 04 034 (May 2004).

[18] 67 Fed. Reg. 68242 (Nov. 8, 2002).

The CAA further provides that if, after making its endangerment determination as to criteria pollutants, EPA assesses that pollutants other than NO_X, CO, or VOCs also cause or contribute to air pollution that endangers health or welfare, then EPA is authorized to regulate such other emissions. CAA § 213(1)(4).

The Supreme Court has established that vehicle GHG emissions are air pollutants that may be regulated under the Clean Air Act. *Mass. v. EPA*, 127 S.Ct. at 1462. In light of recent scientific reports, it is even more apparent than at the time of the Court's decision in *Mass. v. EPA* that continued GHG emissions endanger public health. It has become clear, as well, that climate change induced by anthropogenic GHG emissions threatens impairment of virtually every facet of human "welfare," as Congress defined the term in the statute, including "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants." CAA § 302(h), 42 U.S.C. § 7602(h); *Mass. v. EPA* at 1447.[19]

GHG emissions from nonroad vehicles and engines endanger health and welfare in the same way as emissions from other vehicles and engines; accordingly, EPA retains authority to render the relevant determination of endangerment and adopt regulations to effectively limit such emissions and reduce the danger.

Accordingly EPA should render the determination sought by this petition that GHG pollutants emitted by nonroad vehicles and engines endanger health or welfare and proceed to issue regulations limiting such emissions. CAA § 213(1)(4).

B. EPA's Discretion under CAA Section 213(a)(4) Should be Interpreted in Light of the Supreme Court's Decision in *Mass. v. EPA*, the Structure and Purpose of the CAA, and EPA's Fundamental Responsibilities as a Guardian of the Public Trust.

In *Mass. v. EPA*, the Supreme Court stressed that CAA § 202 requires the EPA to regulate GHG emissions from motor vehicles[20] if it determines that such emissions endanger public health or welfare. 127 S.Ct. at 1459-1461. EPA's authority under CAA § 213(a)(4) to regulate GHG emissions from nonroad vehicles and engines in relevant respects closely tracks the language of CAA § 202. Specifically, both sections grant authority to the Administrator to regulate emissions upon his or her determination that the emissions "may reasonably be anticipated to endanger

[19] EPA previously determined that nonroad vehicle and engine emissions "significantly contribute to regional haze and visibility impairment in Federal Class I areas and where people live, work and recreate." 67 Fed. Reg. 68242, 68243. That determination and consequent regulation of nonroad large spark ignition and recreational engines illustrates that EPA rightly interprets CAA § 213(a)(4) to authorize regulation for purposes other than attainment of national ambient air quality standards.

[20] § 202 (a) authorizes the Administrator to regulate emissions from motor vehicles and "motor vehicle" is defined to mean "any self propelled vehicle designed for transporting persons or property on a street or highway." CAA §216(2); 42 U.S.C. § 7550 (2).

public health or welfare."[21] The Court's reasoning that GHG emissions constitute air pollutants that may be regulated under CAA § 202 therefore applies with equal force to EPA action under CAA § 213. In particular, the Court's holdings that GHG emissions are air pollutants is valid without respect to whether those emissions flow through the tailpipe of passenger automobiles and light trucks, or from heavy duty off-road trucks or all-terrain vehicles. *Id.*; CAA § 302(g); 42 U.S.C. § 7602(g).

Sections 202 and 213(a)(4) differ in one important respect. In the event that EPA makes an endangerment determination with respect to certain pollutants, CAA § 213 establishes that the Administrator "*may* promulgate" standards applicable to such emissions from new nonroad vehicles and engines, whereas CAA § 202(a)(1) establishes that EPA "*shall*" prescribe regulations to limit such emissions from new cars and light trucks. (Emphases added.) *See also* CAA § 202 (a)(3)(B) ("Administrator *may* promulgate regulations …revising any standards...[for] heavy-duty vehicles or engines."). However, the varying level of discretion that these terms imply are relevant only to the question whether regulations must issue following the determination, not to the question whether an endangerment determination is required. As to that, EPA must render the determination or else provide an explanation that is reasonable under the terms of the CAA for "why it cannot or will not exercise its discretion to determine whether" GHG emissions contribute to climate change. *Mass. v. EPA*, 127 S.Ct. at 1462.

In light of the remand to EPA in *Mass. v. EPA*, the Agency is readying its decision on (1) a determination whether GHG emissions endanger health or welfare, and (2) whether EPA will commence a rulemaking procedure to limit such emissions from new motor vehicles. In light of the overwhelming evidence of harm to health and welfare caused by emissions of GHGs, a part of which has been summarized above, we anticipate that EPA will render a positive determination as the failure to do so would be arbitrary and capricious. We request that the anticipated positive determination for motor vehicles and engines rendered pursuant to CAA § 202 be deemed also to satisfy the determination required under CAA § 213(a)(4), so as to enable EPA also to undertake, without undue delay, a rulemaking leading to regulations limiting GHG emissions from new nonroad vehicles and engines. We request, as well, that the forthcoming determination also be deemed to satisfy the CAA § 202(a)(3)(D) determination requisite to initiate rulemaking to limit GHG emissions from rebuilt heavy duty engines.

EPA's discretion to not commence rulemaking aimed at regulations on GHG emissions from nonroad vehicles and engines is limited by the relevant statutory considerations. *Mass. v. EPA* at 1462 ("[O]nce EPA has responded to a petition for rulemaking, its reasons for action or inaction must conform to the authorizing statute."). This means that, under CAA § 213(a)(4), EPA can decline to regulate nonroad vehicle and engine emissions only if EPA determines reasonably that such emissions do not endanger public health or welfare, or else that, taking into account factors such as cost, noise, safety and energy, no such regulation would be appropriate.

[21] The two sections, however, are formulated differently with respect to the Administrator's determination, in that § 202 compels the Administrator to render the determination where the Administrator assesses that such emissions "cause or contribute to" such air pollution, *see* §§ 202(a)(1) and (a)(3)(D), while the § 213 formulation requires the determination upon the Administrator's initial determination that such emissions "significantly contribute to" such pollution. This difference does not effect the present petition in light of the manifestly significant GHG emissions from the nonroad vehicle and engine sector.

CAA § 213(a)(4).

EPA's discretion to decline to regulate such emissions is further circumscribed by the structure of the CAA. The statute recognizes that air pollution prevention is the primary responsibility of state and local governments. CAA § 101, 42 U.S.C. § 7401; *see also* CAA § 116, 42 U.S.C. § 7416 (states retain authority to adopt or enforce emissions standards and limits except where expressly preempted). But states' ability to fulfill and acquit themselves of their "primary responsibility" with respect to vehicle emissions including those from nonroad engines has been limited by Congress in favor of federal regulation. In particular, the CAA bars states from limiting emissions from new construction or farm nonroad vehicles and engines under 175 horsepower, while the statute allows state regulation of emissions from other nonroad vehicles and engines in limited circumstances.[22] CAA § 209(e). By restricting states' ability to fulfill their traditional role in regulating pollution from such vehicles, Congress implicitly invested EPA with unique responsibility to act in the states' stead so as to prevent such harmful emissions. In the present context, at the precipice of several tipping points beyond which calamitous climate change will be unstoppable, the failure by EPA to appropriately respond to this petition will countermand Congress's purpose in enacting the CAA, namely to protect "the quality of the Nation's air resources so as to promote the public health and welfare." CAA § 101, 42 U.S.C. § 7401.

Similarly, rendering the endangerment determination and proceeding to rulemaking aimed at limiting GHG emissions from this sector is compelled by EPA's "continuing responsibility" to fulfill its duty "as trustee of the environment for succeeding generations." National Environmental Policy Act § 101(b), 42 U.S.C. § 4331(b). EPA's duty to succeeding generations must be exercised in light of the fact that the CAA limits states' ability to protect those sovereign interests that are "independent of and behind the titles of its citizens, in all the earth and air within its domain." *Georgia v. Tennessee Copper Co.*, 206 U.S. 230, 237 (1907), cited by *Mass. v. EPA* at 1454. Again, the relevant context is that EPA, to date, has declined to impose mandatory limitations on GHG emissions from vehicles, engines and other sources, even in the face of clear evidence that, unabated, these emissions will fundamentally disrupt earth's climate system and render the planet far less hospitable for human civilization and many, perhaps most, animal species. Accordingly, EPA has yet to fulfill its fundamental trust responsibility in this area.[23] Further inaction now would compound and amplify the damage of EPA's prior inaction. To acquit itself of its public trust responsibility, EPA must embrace the discretion it retains to adopt and enforce effective limitations on GHG emissions, including those from the nonroad vehicle and engine sector, as well as from rebuilt heavy-duty engines.

---

[22] States can adopt only the federal standard, if any, or one that California may at its discretion adopt, where such receives EPA approval.

[23] *See* Mary Christins Wood, "Atmospheric Trust Litigation," University of Oregon Law School (2007), at www.law.uoregon.edu/faculty/mwood/publications.php.

IV. TECHNOLOGY IS AVAILABLE TO REDUCE GREENHOUSE GAS EMISSIONS FROM NONROAD VEHICLES AND ENGINES

A wide range of technology is available to reduce GHG emissions from nonroad vehicles and engines.[24] Some of these include physical controls and operational protocols that are directed toward fuel savings, while others aim at limiting certain pollutants that are indirect GHGs. The technologies, controls and protocols may include, but are not limited to:

1. Auxiliary power unit systems to avoid engine use solely to heat or cool the cab or to power ancillary equipment;

2. Auto-therm engine recovery systems for heating the cab, relying on an electric pump instead of the engine's water pump;

3. Tire inflation systems, to ensure vehicle tire pressure is maintained to manufacturer specifications, including remote sensing and automatic tire inflation devices;

4. Minimum tire efficiency standards, including single wide and low-rolling resistance tires;

5. Anti-idling standards, including automatic engine shutdown systems;

6. Diesel to electric conversion or replacement, including for port support, hauling, goods movement, and ground service vehicles and equipment; truck refrigeration; forklifts; tow tractors/ industrial tugs; urban construction equipment; sweepers/scrubbers; burnishers; carts and lawn and garden equipment; agricultural pump stations;

7. Use of standard hybrid or hydraulic-hybrid technology for large trucks;

8. Decreasing weight of vehicles and powering down of engines;

9. Repowering (outright replacement) of older engines;

10. Use of low-carbon fuels, taking account of whole life-cycle GHG emissions;

11. Use of low viscosity lubricants and onboard oil purification systems;

12. Accelerated replacement of older nonroad vehicles and engines and replacement with fuel efficient vehicles and engines;

13. Use of low GHG refrigerants in air conditioning equipment;

---

[24] Some are discussed in California Air Resource Board, Proposed Early Actions to Mitigate Climate Change in California (April 20, 2007) and Expanded List of Early Action Measures to Reduce Greenhouse Gas Emissions in California Recommended for Board Consideration (September 2007, both available at http://www.arb.ca.gov/cc/ccea/ccea.htm (visited Nov. 20, 2007); U.C. Berkeley Transportation Sustainability Research Center, A Low Carbon Fuel Standard for California: Part 1: Technical Analysis, 174 78, (May 29, 2007).

14. Evaporative emission controls to reduce ozone precursor emissions;

15. Exhaust emission controls to reduce black carbon and other particulates;

16. Use of cool paints to reduce cab temperature and thus air conditioning demand; and

17. Adoption of a "not to exceed" standard for cold start emissions.

In addition, as the Supreme Court recognized in *Train v. Natural Resources Defense Council*, 421 U.S. 60 (1975), the CAA is intended to be a technology-forcing statute. EPA can and should establish regulations that substantially limit GHG emissions from nonroad vehicles and engines even where those regulations force the development of new technology. EPA has acknowledged that it has authority to adopt technology-forcing standards under § 213. 70 Fed. Reg. at 69677. Given the diversity of nonroad vehicles and engines, EPA's regulations can promote a wide variety of technological improvements in these sources.

RELIEF REQUESTED

Petitioners Center for International Technology Assessment, et. al. respectfully request that the Administrator:

1. Determine that CO_2 and other GHG emissions from nonroad vehicles and engines, and from rebuilt heavy-duty engines, significantly contribute to air pollution which may reasonably be anticipated to endanger public health and welfare;

2. Propose and adopt regulations specifying emissions standards for CO_2 and other GHG emissions from such vehicles and engines pursuant to CAA § 213(a)(4), 42 U.S.C. § 7547(a)(4), and CAA § 202(a)(3)(D), such standards to take the form either of emissions limitations or of work or operational practices; and

3. Propose and adopt such regulations as are necessary to carry out the emissions limitations adopted pursuant to the requests above.

We request that the Administrator take initial action within six months of receipt of this petition.

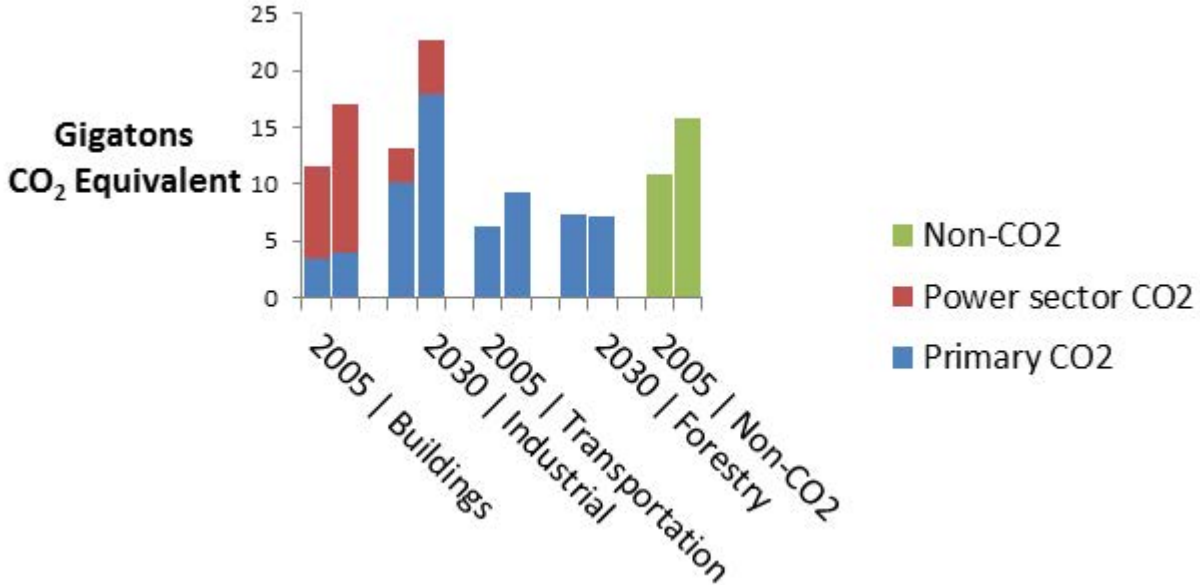
Dated: Jan. 29, 2008

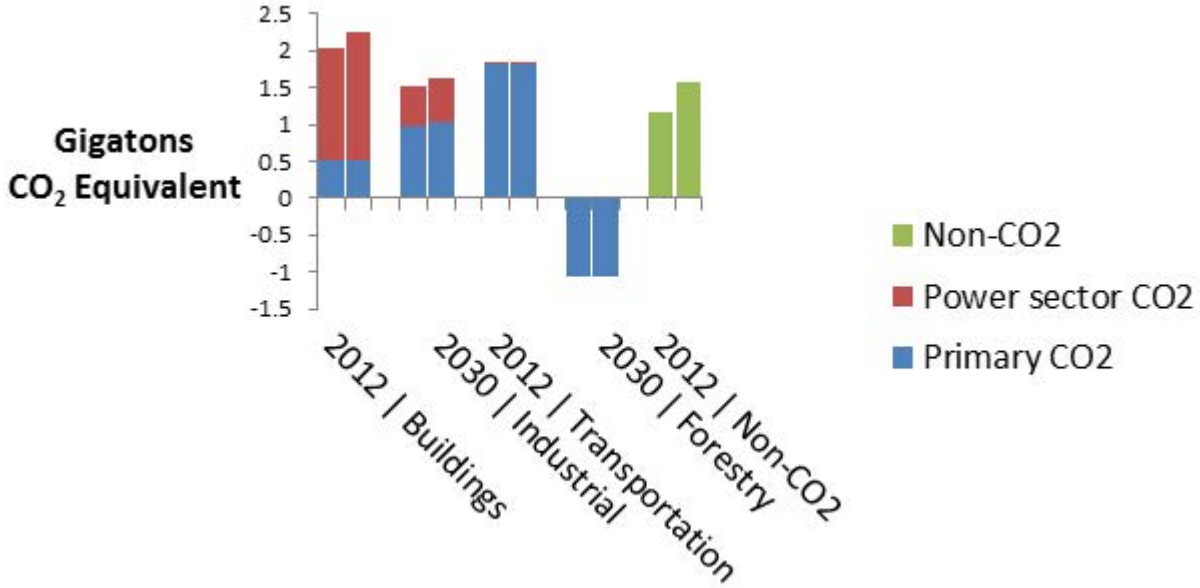
Respectfully submitted,

_____

Daniel M. Galpern
Western Environmental Law Center
Attorney for Petitioners

Joseph Mendelson III
International Center for Technology Assessment
Center for Food Safety
Of Counsel


Gigatons
CO2 Equivalent
25
20
15
10
5
0
2005 | Buildings
2030 | Industrial
2005 | Transportation
2030 | Forestry
2005 | Non-CO2
Non-CO2
Power sector CO2
Primary CO2


Gigatons
CO_2 Equivalent
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
2012 | Buildings
2030 | Industrial
2012 | Transportation
2030 | Forestry
2012 | Non-CO2
Non-CO2
Power sector CO2
Primary CO2

From: Methane to Markets Admin. Support
Reply To: asg@methanetomarkets.org
To: Paul Gunning/DC/USEPA/US@EPA
Subject: International Guidance for Anaerobic Digestion
Date: 07/23/2010 01:50 PM
Attachments: M2M International Guidance for AD_July2010.pdf

---

23 July 2010

Dear Agriculture Subcommittee Members and interested stakeholders:

The Methane to Markets Agriculture Subcommittee has supported the development of an international guidance for quantifying and reporting the performance of anaerobic digestion (AD) systems for livestock manure. The U.S. Environmental Protection Agency prepared a draft guidance document which was reviewed by a panel of international AD experts and discussed at multiple Methane to Markets events, including the Expo in New Delhi, India earlier this year.

We are pleased to present the final *International Guidance for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manure*. The guidance is attached to this email and will soon be made available on the Methane to Markets website. This is an important milestone for the Agriculture Subcommittee and we would like to thank all of you that provided input and assistance with the development of this document.

Best regards,

Ashley King
Director, Administrative Support Group
Methane to Markets Partnership
E-mail: asg@methanetomarkets.org
Phone: +1-202-343-9683
Fax: +1-202-343-2202

From:	Niclas_Nylund@mckinsey.com
To:	mwgrobmyer@aol.com; ebaum@catf.us; KLocklin@eif.com; Paul Gunning/DC/USEPA/US@EPA; Sara Ohrel/DC/USEPA/US@EPA; Smith, Professor Pete; Shaun Ragnauth/DC/USEPA/US@EPA
Cc:	Alissa_Jones@mckinsey.com
Subject:	Invitation for calls about agriculture and waste sectors
Date:	04/12/2010 01:14 PM
Attachments:	758511 Pathways to a lowcarbon economy Version 2 of the global greenhouse gas abatement cost curve.pdf

---

Dear everyone,

I have previously reached out to all of you regarding the work we at McKinsey currently do for ClimateWorks in developing a perspective on global abatement opportunities of non-CO2 climate forcers. I know that most of you have confirmed your interest in taking part in our expert panels on methane/N2O with particular focus on agriculture/waste. (To those of you whom I have not got confirmation from, I send you this email anyway to keep you in the loop since I very much hope for your participation. Please let me know as soon as possible)

The work we have done over the last couple of weeks has primarily been on understanding work that has already been undertaken before, comparisons of different data sources, and establishing the business-as-usual scenarios for the different sectors. Time has now come to continue with new areas that were not previously included in the McKinsey Global Greenhouse Cost Curve v.2.0. This will include diving into the areas of waste water and manure management to quantify appropriate abatement levers, and associated abatement potentials and cost. Before doing this, we would also like to discuss BAU and the levers that have already been modeled to identify any potential areas that might need updating.

Therefore, I send this email to announce two planned teleconferences over the next couple of weeks:

* The first call will primarily be about confirming our baseline and previously developed levers (in the McKinsey Global Cost Curve v.2.0), and also start discussing areas that were not included in the previous McKinsey work, primarily waste water and manure, e.g. aligning on what levers to look into. I plan to set up this call on **Tuesday April 20 at 16:00 CET / 10:00 ET**. I plan to split it into 2x1 hour blocks - one for agriculture and one for waste. You are all of course welcome to join both, but in case you can only join one of the hours, please accept/reject the invitations accordingly.

* I would also like to schedule a second call about two weeks later to follow up on the work on the new levers, and to discuss issues/verify conclusions with you. My proposal is that this call takes place on **Wednesday May 5 at 16:00 CET / 10:00 ET**.

Please notify me as soon as possible in case we need to reschedule any of the calls. If this is OK, I will send out invitations shortly.

I will send out a couple of slides well in advance before the first call to enable everyone to get an understanding of the current status and possibly prepare for the questions we have. Overall though, it would be helpful to start thinking about:

* Has anything changed significantly over the last two years that requires updating anything from the McKinsey v.2.0 work? (attached for those of you who were not directly involved or have not seen it)
* What are the best sources of data to use when digging deeper into abatement levers/potentials for manure management and waste water?

Looking forward to talking to you and hope you can make both calls!

Best regards,
Niclas

Niclas Nylund
McKinsey & Company, Stockholm
Office: +46 8 700 65 36
Mobile: +46 708 17 35 85

+==========+
This email is confidential and may be privileged. If you have received it in error, please notify us immediately and then delete it. Please do not copy it, disclose its contents or use it for any purpose.
+==========+

From: Mimi Brody
To: Paul Gunning/DC/USEPA/US@EPA; Lawrence Elworth/DC/USEPA/US@EPA; John Larmett/DC/USEPA/US@EPA
Cc: Wayne Pacelle; Michael Markarian; Nancy Perry; Jessica Culpepper; Jonathan Lovvorn
Subject: Latham provision in Interior Approps (barring EPA from collecting GHG emission data from largest CAFOs)
Date: 10/29/2009 03:53 PM

Dear Paul, Lawrence, and John,

I'm sure you're as upset as we are about the unexpected outcome on the Latham provision in the Interior Appropriations bill, prohibiting EPA from spending funds in FY10 to collect greenhouse gas emissions data from the largest CAFOs, as envisioned in your reporting rule. We wanted you and your colleagues to know that we swung into gear as soon as we heard about Rep. Simpson's motion to instruct the conferees, and sent an email to every House office urging opposition. We told them we'll count this on our 2009 scorecard and included the group letter we organized that 36 groups co-signed, who all wanted to preserve EPA's authority to collect this important data. A sample of the email we sent is pasted below. I also thought you might want to see Mike Markarian's blog today ("A Free Pass for Factory Farms?") at: http://hslf.typepad.com/political_animal/2009/10/free-pass-for-factory-farms.html.

Take care, and keep on fighting the good fight.

Mimi Brody
HSUS

From: Mimi Brody [mailto:mbrody@hsus.org]
Sent: Tuesday, October 27, 2009 12:57 PM
To: Rose Hacking
Subject: Scorecard vote: NO on Interior Approps Motion to Instruct

Dear Rose,

On behalf of our organization's 20,270 supporters in your district, and the 36 organizations listed below, we urge Rep. Abercrombie to vote against the motion to instruct conferees on the Interior Appropriations bill (H.R. 2996), being offered by Rep. Simpson. IF THIS IS A RECORDED VOTE, THE HUMANE SOCIETY LEGISLATIVE FUND PLANS TO COUNT IT ON THE 2009 HUMANE SCORECARD. Below is a letter demonstrating the broad-based support for this position. Thank you for your prompt attention and consideration.

Mimi Brody
Director of Federal Affairs
The Humane Society of the United States
(202) 955-3667 / mbrody@hsus.org

Adrian Dominican Sisters • American Rivers • Animal Welfare Institute • Center for Biological Diversity • Center for Food Safety • Center for Science in the Public Interest • Center on Race, Poverty & the Environment • Clean Air Task Force • Clean Water Action • Cool Foods Campaign • Dairy Education Alliance • Defenders of Wildlife • Earthjustice • Environmental Integrity Project •

Environmental Working Group • Farm Sanctuary • Food Animal Concerns Trust • Food Democracy Now! • Food & Water Watch • Friends of the Earth • Friends of Family Farmers • Greenpeace USA • Humane Society of the United States • Illinois Citizens for Clean Air & Water • Institute for Agriculture and Trade Policy • Johns Hopkins Center for a Livable Future • National Parks Conservation Association • National Sustainable Agriculture Coalition • National Trust for Historic Preservation • Natural Resources Defense Council • Organic Consumers Association • Republicans for Environmental Protection • Sierra Club • The Wilderness Society • Union of Concerned Scientists • Waterkeeper Alliance

September 30, 2009

RE: No bar on EPA reporting rule for CAFOs/climate change in final Interior Appropriations bill

Dear Chairwoman Feinstein and Chairman Dicks,

As you prepare for conference on the FY10 Interior Appropriations bill, we thank you for your leadership and urge you to ensure that the final bill does not contain the amendment offered by Representative Latham to tie EPA's hands on climate change science and impede the agency's ability to gather critical baseline data on greenhouse gas (GHG) emissions. As you know, his amendment was narrowly approved in the House Appropriations Committee by a 31-27 vote, while a parallel amendment offered by Senator Brownback was defeated in the Senate Appropriations Committee by a vote of 18-12. This amendment would bar EPA from implementing its rule on mandatory reporting of greenhouse gases from manure management systems (CAFOs or "Concentrated Animal Feeding Operations," also known as factory farms). It would directly undermine a statutory requirement, authored by Senators Feinstein and Boxer and enacted as part of the FY08 Consolidated Appropriations Act, directing EPA to issue a final rule providing for "mandatory reporting of greenhouse gas emissions above appropriate thresholds in all sectors of the economy of the United States."

Congress wisely recognized that emissions data on all sectors is needed to craft effective climate change policies. It would make no sense for Congress now to insist that the EPA put up blinders with respect to the very largest industrial animal agriculture facilities – those emitting 25,000 metric tons or more of GHG emissions per year (the threshold that EPA set in its proposed rule for entities in various sectors). The Senate Interior Appropriations bill respects that threshold, containing a 2nd degree amendment offered in committee by Chairwoman Feinstein to limit EPA's data collection from CAFOs to just these largest facilities.

Current data already show that manure management systems in the industrial animal agriculture sector are responsible for a significant amount of GHG; however, there is much to be learned about levels of emissions and how those emissions are affected by different standards and practices. Domestically, manure management and enteric fermentation are responsible for about one-third of all anthropogenic methane emissions, and methane is more than 20 times as potent a GHG as carbon dioxide. In 2007, methane emissions from manure management were 45% higher than in 1990. The EPA notes that "[t]he majority of this increase was from swine and dairy cow manure, where emissions increased 51 and 60 percent, respectively," and that one reason for the increase is the shift toward confining livestock in facilities that use liquid manure management systems. In addition, according to the EPA, the direct and indirect emissions of nitrous oxide – 310 times as potent a GHG as carbon dioxide – from manure management increased 22 percent between 1990 and 2007.

Our organizations strongly oppose any provision that would prevent EPA from conducting a full assessment of the greenhouse gas emissions from the largest industrial animal agriculture facilities.

The agency is committed to using the best available science to learn more about GHG emissions from all sectors. That process must be respected and allowed to proceed. We urge you to oppose the Latham amendment and any other effort to prejudge the science by forcing the agency to ignore GHG emissions that result from waste management at the largest industrial animal agriculture facilities. Such an amendment would undermine sound science and hurt Congress' ability to address climate change effectively.

Thank you again for your leadership and consideration on this important matter.

Sincerely,

Mimi Brody
Director of Federal Affairs
The Humane Society of the United States

Kate McMahon
Energy and Transportation Policy Campaigner Friends of the Earth

Ed Hopkins
Environmental Quality Program Director
Sierra Club

Martha Noble
Senior Policy Associate
National Sustainable Agriculture Coalition

Hannah Connor
Staff Attorney
Waterkeeper Alliance

Wenonah Hauter
Executive Director
Food & Water Watch

Jonathan Lewis
Staff Attorney and Climate Specialist
Clean Air Task Force

Alan Rowsome
Conservation Advocacy Associate
The Wilderness Society

Marty Hayden
Vice President, Policy & Legislation
Earthjustice

Bill Snape
Senior Counsel
Center for Biological Diversity

Dr. Robert Lawrence
Director

Johns Hopkins Center for a Livable Future

David Wallinga, MD
Director Food and Health Program
Institute for Agriculture and Trade Policy

Lynn Thorp
National Campaigns Coordinator
Clean Water Action

Mary Beth Beeham
Director of Legislative Affairs
Defenders of Wildlife

Brise Tencer
Washington Representative for Food & Environment and Doug Gurian-Sherman Senior Scientist
Union of Concerned Scientists

Patrick J. Lally
Director of Congressional Affairs
National Trust for Historic Preservation

Kristen Brengel
Director, Legislative & Government Affairs National Parks Conservation Association

Delcianna Winders
Director of Legal Campaigns
Farm Sanctuary

Damon Moglen
Director, Global Warming Campaign
Greenpeace USA

Jessica M. Werber
Attorney
Environmental Integrity Project

Sarah Jones
Legislative Analyst
Environmental Working Group

Peter Raabe
Policy Director for Budget and Appropriations American Rivers

Franz A. Matzner
Forests and Public Land Program/Acting Legislative Director Natural Resources Defense Council

Paige Tomaselli
Staff Attorney
Center for Food Safety

Andrew Kimbrell
Executive Director

Cool Foods Campaign

Cathy Liss
President
Animal Welfare Institute

Alexis Baden-Mayer
Political Director
Organic Consumers Association

Danielle Diamond
Attorney
Illinois Citizens for Clean Air & Water

Richard Wood
Executive Director
Food Animal Concerns Trust (FACT)

David Jenkins
Vice President for Government and Political Affairs Republicans for Environmental Protection

Michael F. Jacobson, Ph.D.
Executive Director
Center for Science in the Public Interest

Kendra Kimbirauskas
Co-President
Friends of Family Farmers

Brent Newell
Legal Director
Center on Race, Poverty & the Environment

Dave Murphy
Director
Food Democracy Now!

Christopher Matthias
Program Coordinator for Justice and Peace and Corporate Responsibility
Adrian Dominican Sisters

Helen Reddout
Coordinator
Dairy Education Alliance

Final

Methane to Markets
International Guidance for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manures

Prepared for:
The Methane to Markets Partnership

Prepared by:
U.S. Environmental Protection Agency
1200 Pennsylvania Ave. NW (6202J)
Washington, DC 20460

July 2010

PREFACE

This guidance was developed by the U.S. Environmental Protection Agency (EPA) at the request of the Agriculture Subcommittee of the Methane to Markets Partnership. The Methane to Markets Partnership is an initiative to reduce global methane emissions to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse gases. The initiative focuses on cost-effective, near-term methane recovery and use as a clean energy source. The Partnership works internationally through collaboration among developed countries, developing countries, and countries with economies in transition, together with strong participation from the private sector. A separate guidance for quantifying and reporting the performance of anaerobic digestion systems for agro-industrial wastes may be developed in the future.

ACKNOWLEDGEMENTS

The U.S. Environmental Protection Agency (U.S. EPA) would like to acknowledge the contributions of the Methane to Markets Agriculture Subcommittee members. The subcommittee consists of representatives from Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Dominican Republic, Ecuador, Finland, India, Italy, Japan, Mexico, Mongolia, Nigeria, Philippines, Poland, Thailand, United Kingdom, United States, and Vietnam.

In addition, U.S. EPA would like to express gratitude to the team of expert reviewers that provided input and guidance for this document, including:

Dr. Saroch Boonyakitsombut, King Mongkut's University of Technology, Thailand
Dr. Dave Chadwick, North Wyke Research, United Kingdom
Dr. Raymond Deasjardins, Agriculture and Agri-Food, Canada
Dr. Rudiger Grass, University of Kassel, Germany
Dr. Eduardo Groppelli, Universidad Nacional del Litoral, Argentina
Dr. Steffen Gruber, Instituto Nacional de Tecnología Agropecuaria, Argentina
Jorge Hilbert, Instituto Nacional de Tecnología Agropecuaria, Argentina
Claudia Intartaglia, Instituto Nacional de Tecnología Agropecuaria, Argentina
Dr. Li Jingming, Ministry of Agriculture, China
Dr. VVN Kishore, The Energy and Resources Institute, India
Dr. Mahesh Patankar, Indian Institute for Energy Conservation, India
Dr. Heinz-Peter Mang, Society for Sustainable Biogas and Bioenergy Utilization, Germany
Dr. Jae Jak Nam, National Institute of Agricultural Science and Technology, Republic of Korea
Dr. Chavit Ratanatamskul, Chulalongkorn University, Thailand
Dr. Doug Williams, Williams Engineering Associates, United States

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PREREQUISITES FOR PERFORMANCE EVALUATIONS 5

3.0 REQUIRED BACKGROUND INFORMATION 5

4.0 ESTIMATING METHANE EMISSION REDUCTIONS 10
4.1 Manure-Related Reductions 11
4.2 Baseline Emissions From Co-Digested Wastes 13

5.0 BIOGAS PRODUCTION AND UTILIZATION 16
5.1 Biogas Production 16
5.2 Biogas Composition 17
5.3 Biogas Utilization 18
5.4 Data Collection 19
5.5 Reporting 20

6.0 ECONOMIC ANALYSIS 20
6.1 General Approach 21
6.2 Boundary Conditions 21
6.3 Methodology 23
6.3.1 Annual Capital Cost 23
6.3.2 Annual Operation and Maintenance Costs 24
6.3.3 Other Annual Costs 24
6.3.4 Annual Revenue 25
6.3.5 Net Income 26

7.0 PROCESS PERFORMANCE CHARACTERIZATION 26
7.1 Waste Stabilization Parameters 27
7.2 Pathogen Reduction 28
7.3 Sample Collection 29
7.4 Sample Preservation 30
7.5 Analytical Methods 31
7.6 Hydraulic Retention Time and Temperature 31
7.7 Reporting 32

8.0 REPORT FORMAT 32

REFERENCES 34

APPENDIX A A-1
APPENDIX B B-1

1.0 INTRODUCTION

The Methane to Markets Partnership strives to reduce global methane emissions. Methane accounts for 16 percent of all greenhouse gas emissions resulting from human activities (M2M, 2008). Because methane is a potent greenhouse gas and is short-lived in the atmosphere compared to carbon dioxide, achieving significant reductions would have a considerable impact on atmospheric warming, especially in the near term.

The Methane to Markets Agriculture Subcommittee focuses on reducing methane emissions from agriculture. Globally, managed livestock manure contributes more than 230 million metric tons of carbon dioxide equivalents of methane emissions, roughly 4 percent of total anthropogenic methane emissions. To reduce methane emissions from the agricultural sector, the Agriculture Subcommittee promotes anaerobic digestion of manure and agro-industrial wastes.

Anaerobic digestion is a waste stabilization process. The stabilization of livestock manures occurs by the microbially mediated reduction of the carbon in complex organic compounds to methane and carbon dioxide. Because anaerobic digestion occurs under controlled conditions, it provides the opportunity for the capture and combustion of the methane produced. It is the capture and combustion of the methane produced, along with the ability to maximize the degree of waste stabilization, that differentiates anaerobic digestion from anaerobic decomposition, which occurs naturally in lagoons and other livestock manure storage structures and may provide only partial stabilization.

As a unit process in the management of livestock manures, anaerobic digestion can provide the following benefits:

1. Reduction in methane emissions to the atmosphere. Methane is a greenhouse gas with approximately 21 times the global warming capacity of carbon dioxide.

2. Reduction in emissions of noxious odors. Noxious odors associated with livestock manures result from the accumulation of products of incomplete anaerobic decomposition.

3. Reduction in water pollution potential. Oxygen-demanding organic compounds are removed by reduction to methane and carbon dioxide, and densities of enteric pathogenic micro-organisms are reduced with negligible or no energy input.

4. Renewable energy production. The captured mixture of methane and carbon dioxide, known as biogas, can be used as a fuel to produce mechanical power for purposes such as generating electricity, cooking, lighting, and water and space heating.

5. Revenue to offset costs. Revenue can be realized byselling carbon credits and using biogas to generate electricity or displace on-farm fossil fuel use. This energy use will partially offset costs or ideally provide an increase in net income.

Interest in anaerobic digestion as a livestock manure management option has expanded rapidly in recent years as concern about methane emissions and other environmental impacts from livestock wastes has increased, along with recognizing the potential to capture and utilize a renewable energy source. As interest has increased, a number of system design approaches have evolved and been followed by construction of full-scale systems. Many of these design approaches have been accompanied by claims of process superiority. Generally, data supporting these claims have been minimal at best and not collected following a standardized methodology. Thus, the ability to compare different system design approaches with respect to biogas production, waste stabilization, and cost-effectiveness on a uniform basis has been lacking. To address this situation, the Agriculture Subcommittee of the Methane to Markets Partnership determined that an international guidance for evaluating and reporting the performance of anaerobic digestion systems for livestock manure should be developed.

This guidance is intended to establish a uniform set of methods for evaluating and reporting the performance of anaerobic digestion systems for livestock manures developed to reduce methane emissions. It provides guidelines for anaerobic digestion system evaluations. Adherence to the guidance is voluntary and is not a compulsory requirement for countries participating in the Methane to Markets Partnership. The guidance, however, is applicable to all systems across all countries, including those countries not participating in the Partnership.

Initial efforts to develop this guidance included an international search for existing documents that could support its development. A number of documents were identified, most of which

focused on estimating greenhouse gas reductions, reducing greenhouse gas emissions, or safety issues.

Based on this search, a number of relevant documents were identified, including:

1. Intergovernmental Panel on Climate Change (IPCC) *2006 IPPC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006), which includes methods for establishing baseline methane emissions estimates from livestock waste management systems and combustion efficiency, as well as and methane leakage rates and emissions from open and closed flare systems.

2. The United Nations Framework Convention on Climate Change (UNFCCC) methodology for Clean Development Mechanism (CDM) projects for methane recovery in animal manure management systems (UNFCCC, 2010); which includes calculations for estimating methane reductions.

3. *A Protocol for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manure* (AgSTAR, 2007), which provides a method for evaluating the performance of anaerobic digesters in the United States.

These documents and methods were used to develop various elements of this International Guidance document. The U.S. protocol (AgSTAR, 2007) formed the basis of the overall approach, which was expanded in this document to provide flexibility for an array of technologies, scales, and country-specific constraints. This protocol was based on mass-balance characterizations for livestock waste processes and provides guidance for sampling, data analysis, and reporting. These are critical components for evaluating digester systems, as they provide a standardized and credible approach to verify claims of process performance, which are readily applicable in an international context. Specifically, the U.S. protocol:

- Establishes prerequisites for performance evaluations.
- Lists required background information.
- Specifies acceptable methods for data collection and analysis to characterize performance with respect to biogas production and utilization and waste stabilization.
- Details the approach to be used to perform an economic analysis.

All the elements listed above are incorporated in this international guidance. Although it is most desirable to perform a comprehensive performance evaluation, evaluations including all of the

elements listed above may not always be possible due to resource or other constraints. Therefore, , this international guidance provides four levels of performance evaluations, as outlined below:

- **Level I:** Assembly of background information, estimation of methane emission reductions, and measurement of biogas production and composition.
- **Level II:** Level I, plus measurement of biogas utilization for generating electricity or replacing fossil fuels by direct combustion or engine-generator set waste heat recovery, or some combination thereof.
- **Level III:** Level II, plus economic analysis.
- **Level IV:** Level III plus quantification of the degree of waste stabilization.

Adherence to this international guidance will provide an objective and unbiased assessment of individual system performance and provide vendors with the ability to demonstrate the validity of performance claims. Furthermore, it will provide a common basis for comparing the performance of different design approaches. It also will provide a standard for acceptance of performance evaluation reports if a central repository is created in the future and an appropriate basis for developing technology-specific certification programs. Such information should be useful to:

- Allow livestock producers considering construction of anaerobic digestion systems to make informed choices about which technologies to install.
- Provide consultants with the ability to compare various technologies to develop the best possible system or to improve their existing technologies to meet the standards of others.
- Provide policymakers with a basis for considering or developing incentives and public waste-to-energy or rural sanitation education programs.
- Furnish the financial community with information to quantify the benefits of anaerobic digestion projects.

Certification of specific design approaches for the anaerobic digestion of livestock manures by governmental agencies or non-governmental organizations should be based on the peer review of

at least two, and preferably three or more, performance evaluation reports. There should be at least three peer reviews of each report by individuals with the requisite expertise, by virtue of a combination of education and experience. Only those performance evaluation reports judged to be complete and technically sound should be accepted as the basis for certification. All peer reviews should be retained in the permanent records of the certifying agency and be available for public inspection with the names of the peer reviewers deleted. The basis for certification—Level I, II, III, or IV—should be indicated and briefly described. It also is suggested that only Level II, III, or IV should be used as a basis for certification, as the evaluation is based on measured system performance.

2.0 PREREQUISITES FOR PERFORMANCE EVALUATIONS

Performance evaluations under this guidance should be conducted only for full-scale systems that serve commercial livestock operations. The evaluation should be at least 12 months in duration to capture any impact of seasonal ambient temperature variation. In addition, evaluations should be conducted after the startup phase of operation has been completed and the digester is operating under steady-state conditions, as defined below:

1. **Plug-flow and mixed digesters, such as above and below ground tanks:** Continuous operation for a period equal to the sum of at least five hydraulic retention times (HRTs) after startup phase.

2. **Unmixed systems, such as covered lagoons, and standard rate (unheated and unmixed) anaerobic digesters:** Continuous operation for at least 1 year after startup phase.

3. **Unheated or heated attached film and anaerobic sludge blanket digesters:** Continuous operation for at least 3 months after startup phase, with the 3 months of operation being the warmest 3 months of the year for unheated digesters.

3.0 REQUIRED BACKGROUND INFORMATION

The importance of assembling and reporting adequate background information cannot be overemphasized. Such information is critical for evaluating reported results in the proper context. Below are lists of information about the livestock operation (Table 1) and the anaerobic digestion

system (Table 2) that should be assembled. This information should be included in all performance evaluation reports. If the performance of a centralized system is being evaluated, the information specified in Table 1 should be provided for each livestock operation served.

In addition to the background information about the farm, a site- and system-specific plan for data collection should be developed for each evaluation. This plan should identify the sampling locations, the sampling methods to be used, the frequency and number of samples to be collected, and any other data necessary to perform the evaluation described in this guidance.

Table 1. General Information.

1. Name of operation

2. Postal address and other contact information

3. Type of operation (*e.g.*, dairy, swine, layer, *etc.*)

4. If dairy,
    a. Breed (*e.g.*, Holstein, Guernsey, *etc.*)
    b. Average number of lactating cows
    c. Average number of dry cows
    d. Average number of heifers (females more than 6 months old)
    e. Average number of calves (females less than 6 months old)
    f. Respective fractions of manure from lactating cows, dry cows, and replacements collected for digestion
    g. Method(s) of manure collection (*e.g.*, scrape, flush, *etc.*) and frequency of manure collection

5. If swine,
    a. Type of operation (*e.g.*, farrow-to-wean, farrow plus nursery, farrow-to-finish, *etc.*)
    b. Average numbers of sows and pregnant gilts, litters per sow-year, and weaned pigs per litter if applicable
    c. Average number of nursery pigs and number of nursery stage cycles per year
    d. Average number of feeder pigs and number of grow/finish cycles per year
    e. Respective fractions of manure from sows and pregnant gilts, nursery pigs, and feeder pigs collected for digestion
    f. Method(s) of manure collection (*e.g.*, scrape, flush, pull-plug pit, *etc.*) and frequency of manure collection

6. If beef,
    a. Average number of feeder cattle and number of grow/finish cycles per year
    b. Fraction of manure collected for digestion
    c. Method(s) of manure collection (*e.g.*, scrape, flush, pull-plug pit, *etc.*) and frequency of manure collection

7. If layer,
    a. Average number of hens
    b. Method(s) of manure collection (*e.g.*, scrape, flush, pull-plug pit, *etc.*) and frequency of manure collection

8. If other livestock,
    a. Type
    b. Average number of animals
    c. Fraction of manure collected for digestion
    d. Method(s) of manure collection (*e.g.*, scrape, flush, pull-plug pit, *etc.*) and frequency of manure collection

Table 2. Anaerobic Digestion System Information

Biogas Production

1. Type of digester (i.e., plug-flow, mixed, attached film, or covered lagoon)

2. Name of system vendor, postal address, and other contact information

3. Digester design assumptions
   - a. Average manure volume, m^3/day (ft^3/day)
   - b. Average wastewater volume, m^3/day (ft^3/day) (e.g., none, milking center wastewater, confinement facility wash water)
   - c. Other waste volume, m^3/day (ft^3/day) (e.g., none, food processing waste) with physical and chemical characteristics (e.g., concentrations of total solids, total volatile solids, chemical oxygen demand)
   - d. Pretreatment before digestion (e.g., none, gravity settling, screening)
   - e. Volumetric loading rate, m^3 per 1,000 m^3 per day (ft^3 per 1,000 ft^3 per day)
   - f. Organic loading rate, kg total volatile solids per 1,000 m^3 per day (lb per 1,000 ft^3 per day)
   - g. Hydraulic retention time, days
   - h. Operating temperature, °C
   - i. Average monthly ambient temperatures
   - j. Rate of biogas production, m^3 per kg total volatile solids added (ft^3 per lb)
   - k. Presence or absence of monensin or any other antibacterial growth promoters
   - l. Expected methane content, percent
   - m. Compliance (yes or no) with an established engineering design standard (e.g., an applicable U.S. Department of Agriculture Natural Resource Conservation Service Conservation Practice Standard)

4. Physical description
   - a. General description, including types of construction materials (e.g., partially below grade, concrete channel plug-flow with flexible cover)
   - b. Dimensions (length, width, and depth or diameter and depth or height)
   - c. Type(s), location(s), and thickness(s) of insulation when applicable
   - d. Operating volume and ancillary gas storage capacity, if present
   - e. Digester effluent treatment (e.g., none, solids separation, phosphorus precipitation)
   - f. Method of digester effluent storage (e.g., none, earthen pond)

5. Monthly summaries of operational details during the period of evaluation
   - a. Numbers and types of animals
   - b. Other waste volume(s) and physical and chemical characteristics
   - c. Frequency of digester influent addition (e.g., hourly, twice per day, once per day)
   - d. Average daily digester temperature and monthly range
   - e. Use of monensin or any other antibacterial growth promoters
   - f. Any deviation from digester design assumptions (e.g., change in manure volume, addition or deletion of an additional waste stream)

Table 2 (continued). Anaerobic Digestion System Information

Biogas Utilization

1. Biogas utilization (e.g., none; generation of electricity; use on site for cooking or lighting or as a boiler or furnace fuel; sale to a third party).

2. If generation of electricity:
    a. Type of engine-generator set (e.g., internal combustion engine, microturbine, fuel cell) with name of manufacturer, model, and power output rating (MJ or kW) for biogas and nominal voltage
    b. Component integration (i.e., vendor or owner)
    c. Origin of equipment controller (i.e., manufacturer integrated, third-party off shelf, or third-party custom)
    d. System installer with postal address and other contact information
    e. Stand alone capacity (yes or no)
    f. Pretreatment of biogas (e.g., none, condensate trap, dryer, hydrogen sulfide removal) with names of manufacturers and models
    g. Exhaust gas emission regulation (yes or no). If yes, type of control (e.g., none, catalytic converter)
    h. If interconnected to an electric utility:
        i. Name of utility
        ii. Type of contract (i.e., sell all/buy all, surplus sale, or net metering)
        iii. If engine-generator set waste heat utilization:
        iv. Heat source (i.e., cooling system or exhaust gas or both) and heat recovery capacity (kJ/hr or Btu/hr)
        v. Waste heat utilization (e.g., digester heating, potable water heating, space heating)

3. If use on site as a boiler or furnace fuel, description of the boiler or furnace, including manufacturer, model, and rate capacity for biogas (kJ/hr or Btu/hr).

4. If biogas sale to third party, description of method of processing, delivery, and end use.

Cost Information

1. System “as built” cost, excluding site cost.

2. Cost basis (e.g., turnkey by a developer, owner acted as general contractor, constructed with farm labor).

3. An itemized list of component costs (e.g., digester, biogas utilization system).

4.0 ESTIMATING METHANE EMISSION REDUCTIONS

Each performance evaluation must include an estimate of the gross and net reductions in methane emissions resulting from the use of anaerobic digestion for the production, capture, and combustion of biogas. Gross reductions are total reductions, not accounting for any project-related emissions, such as leakage of methane from the digester or biogas handling equipment. Net reductions are total reductions less losses due to leakage and combustion efficiency, among others.

Estimates of gross methane emission reductions should not be based on the mass of methane produced by the digester.This approach would overestimate the emission reduction because digesters are designed to optimize methane production and may produce more methane than the system that it replaced. Therefore, methane reductions should be based on estimated emissions from the manure management system that was in place before anaerobic digestion was added to the manure management system. These emissions are typically referred to as *baseline emissions* as specified in, the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. For example, if the farm had originally used an anaerobic lagoon, as the primary waste management system and added an anaerobic digester, the gross methane reduction would be based on the estimated emissions from the anaerobic lagoon that was in place prior to adding the anaerobic digester.

For new operations, baseline emissions would be based on the manure management system without anaerobic digestion, which is typical for the type of livestock operation in the region, unless an exception can be justified. For example, in some parts of the world, flush-type pig farms typically have anaerobic lagoons in place to provide recycled water for flushing waste from under slatted floors, while in other parts of the world this same pig farm would typically employ manual labor and fresh water for removing waste, which is then sent to a fish pond. When co-digestion with another waste is being practiced, the avoided methane emissions associated with this other waste can be included in the gross reduction estimate. The methods for determining baseline emissions from these sources are the IPCC methods for solid waste disposal, wastewater, land application, and composting.

To estimate net emission reduction, the gross reduction in methane emissions should be adjusted to account for leakage from the system, efficiency of combustion, and any additional fossil fuel used (adapted from the UNFCCC methodology), as follows:

$$EF_P = \left(\sum_{i=1}^{n} EF_M + \sum_{i=1}^{n} EF_W \right) - \left(LK_P + CE_P + FF_P \right) \quad (1)$$

where:
- EF_P = Annual project net methane emission reduction, kg CH_4 per year
- EF_M = Annual gross methane emissions from manure, kg CH_4 per year
- EF_W = Annual gross methane emissions from co-digested waste, kg CH_4 per year
- LK_P = Methane leakage, kg CH_4 per year
- CE_P = Combustion-related emissions, kg CH_4 per year
- FF_P = Fossil fuel-related carbon dioxide emissions on a methane equivalent basis, kg CH_4 per year

The net project methane emissions reduction may be converted to a carbon dioxide equivalent basis by multiplying by 21, which is the global warming potential (GWP) of methane. The GWP of methane represents the ability of methane to trap heat in the atmosphere as compared to carbon dioxide. The estimated carbon dioxide equivalents represent the carbon credits that the project is eligible to claim and market.

4.1 Manure-Related Reductions

At a minimum, the *2006 IPPC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) Tier 2 method for estimating methane emissions should be followed for estimating gross reductions in methane emissions from manure. If possible, the Tier 3 method should be used. It is based on country-specific models or using measurement-based approaches to quantify methane emissions.

Using the Tier 2 method, methane emissions for each livestock category (T) and prior manure management system (S) and climate combination (k) should be estimated as follows:

$$EF_M = \sum_{T,S} \left[\left(VS_T \times H_T \times 365 \right) \times \left(B_{0,T} \times 0.67\ \text{kg/m}^3 \times \frac{MCF_{S.k}}{100} \right) \right] \quad (2)$$

where: EF_M = Annual methane emissions from manure, summed by livestock category (T) and prior manure management system (S), kg CH_4 per year
VS_T = Daily volatile solids excretion rate for livestock category (T), kg VS per animal-day
H_T = Average daily number of animals in livestock category (T)
365 = Basis for calculating annual volatile solids production, days per year
$B_{0,T}$ = Maximum methane production capacity for manure produced by livestock category (T), m^3 CH_4 per kg volatile solids excreted
0.67 = Conversion factor, kg CH_4 per m^3 CH_4
$MCF_{S,k}$ = Methane conversion factor for manure management system (S) for climate (k), percent

The best way to estimate average daily volatile solids excretion rates is from measured digester influent volatile solids concentration and flow rate. Another option is to use country-specific published data or region-specific default values. Default values may be found in Tables 10A-4 through 10A-9 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006). Finally, the following relationship (IPCC, 2006) can be used:

$$VS_T = \left[GE \times \left(1 - \frac{DE\%}{100} \right) + (UE \times GE) \right] \times \left[\frac{1 - Ash}{18.45} \right] \quad (3)$$

where: VS_T = Volatile excretion rate for animal type (T) on a dry matter basis, kg VS per day
GE = Gross energy intake, MJ per day
DE% = Basis for calculating annual volatile solids production, days per year
(UE x GE) = Urinary energy expressed as a fraction of GE. Typically 0.04GE can be considered urinary excretion by most ruminants (reduce to 0.02 for ruminants fed 85% or more grain and for swine). Use country-specific values when available.
Ash = Ash (fixed solids) content of manure calculated as a fraction of dry matter feed intake (e.g., 0.08 for cattle). Use country-specific values when available.
18.45 = Conversion factor for dietary GE per kg of dry matter (MJ per kg). This value is relatively constant across a wide range of forage and grain-based feeds commonly consumed by livestock.

See Section 10.2, Equation 10.16 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) for estimating GE intake and digestibility. The maximum methane production capacity (B_0) of manure varies by species and diet. If available, published country-specific data should be used. Otherwise, see Tables 10A-4 through 10A-9 of the *2006 IPCC*

Guidelines for National Greenhouse Gas Inventories for default values. The same source should be consulted for default MCF values (See Table 10.17).

4.2 Baseline Emissions From Co-Digested Wastes

When another waste is being co-digested with manure, there is an additional reduction in methane emissions if that waste previously was a source of methane emissions. For example, there will be a reduction in methane emissions if the waste being co-digested with manure was previously sent to a landfill or a conventional anaerobic lagoon. Conversely, there will be no reduction if the waste was previously treated using an aerobic process such as activated sludge or land application. These processes may also increase nitrous oxide emissions, which are not addressed in this guideline. Equation 4 should be used for estimating the reduction in methane emissions for each waste being co-digested with manure.

$$EF_W = (VS_W \times 365) \times \left(B_{0,W} \times 0.67\ \text{kg/m}^3 \times \frac{MCF_{S,k}}{100} \right) \qquad (4)$$

where: EF_W = Annual methane emissions from waste (W), kg CH_4 per year
VS_W = Mass of waste (W) digester influent volatile solids, kg dry matter per day
$B_{0,W}$ = Maximum methane production capacity waste (W), m^3 CH_4 per kg influent volatile solids
$MCF_{S,k}$ = Methane conversion factor for waste management system (S) for climate (k), percent

If a country-specific and verifiable published value for the maximum methane production capacity (B_o) of the waste is not available, this value must be determined experimentally using replicated long-term, bench-scale batch studies to be conducted at the operating temperature of the digester being evaluated to estimate the readily biodegradable and refractory fractions of VS. Such studies should be conducted for no less than 30 days and with the refractory fraction at infinity (VS_∞/VS_0) determined by plotting VS_t/VS_0 versus ($1/VS_0$*t), where t equals zero at the beginning of the study. The y-axis intercept should be determined using linear regression analysis.

4.3 Leakage and Combustion Emissions.

Very little information is available regarding methane leakage from anaerobic digestion systems. However, some leakage probably occurs from most systems and should be incorporated into estimates of net methane emission reductions from anaerobic digestion systems. The IPCC (2006) provides no guidance. Therefore, this guidance recommends using the default value for projects covered under the UNFCCC CDM, which is 10 percent of the B_0 of the manure fed into the management system, as follows (adapted from UNFCCC, 2010):

$$LK_P = 0.10 \times 0.67 \times \sum_{S,T} B_{0,T} \times N_T \times VS_T \times MS\%_S \times 365 \quad (5)$$

where:
- LK_P = Methane leakage, kg CH_4 per year
- 0.10 = Assumed amount of leakage
- 0.67 = Conversion factor, kg CH_4 per m^3 CH_4
- $B_{0,T}$ = Maximum methane production capacity for manure produced by livestock category (T), m^3 CH_4 per kg volatile solids excreted
- N_T = Number of animals in livestock category (T)
- VS_T = Daily volatile solids excretion rate for livestock category (T), kg VS per animal-day
- $MS\%_S$ = Fraction of manure handled in baseline manure management system (S)
- 365 = Basis for calculating annual volatile solids production, days per year

Because no combustion process is 100 percent efficient, and all captured methane should be disposed of by combustion, combustion-related methane emissions also should be accounted for in estimating a project's net methane emission reduction. For open and enclosed flares, methane emissions should be based on the measured volume of methane combusted and calculated as follows:

$$CE_P = \left[CH_{4_{comb}} \times \left(1 - C_{eff}\right)\right] \times 0.67 \quad (6)$$

where:
- CE_P = Combustion-related emissions, kg CH_4 per year
- $CH_{4,\,comb}$ = Measured methane sent to flare, m^3 CH_4 per year
- C_{eff} = Combustion efficiency, decimal
- 0.67 = Conversion factor, kg CH_4 per m^3 CH_4

Unless higher combustion efficiency values can be justified by supporting documentation, the UNFCCC CDM default values listed in Table 3 should be used.

Table 3. Default Values for Methane Flare Combustion Efficiencies, Decimal

Combustion Process		Default Value, Decimal (C_{eff})
Open flare	Continually operational	0.50
	Not continually operational	0
Enclosed flare	Continuous monitoring of compliance with manufacturer's specifications* or continuous monitoring of methane destruction	0.90

*In any hour when there is noncompliance with the manufacturer's specifications, a 0.50 default value should be used for that hour.

Methane emissions associated with combustion in lean and rich burn internal combustion engines and boilers and furnaces also should be based on the measured amount of methane combusted and calculated using Equation 6, unless the IPCC default values listed in Table 4 are being used. In that case, methane emissions should be calculated as follows:

$$CE_P = CH_{4comb} \times 35{,}755{,}188\ J/m^3 \times CH_{4emitted} / 1 \times 10^{12}\ J \qquad (7)$$

where: CE_P = Combustion related emissions, kg CH_4 per year
$CH_{4,\ comb}$ = Measured methane sent to combustion device, m^3 CH_4 per year
$CH_{4,\ emitted}$ = Methane emissions from combustion in lean burn and rich burn internal combustion engines and boilers and furnaces, kg CH_4 per TJ

Table 4. Default Values for Methane Emissions from Combustion in Lean Burn and Rich Burn Internal Combustion Engines and Boilers and Furnaces (IPCC, 2006)

Combustion Process	Default Value, kg CH_4/TJ ($CH_{4,\ emitted}$)
Lean burn internal combustion engine	597
Rich burn internal combustion engine	110
Boiler/furnace	1

4.4 Fossil Fuel Use Related Emissions

An anaerobic digestion project may result in increased fossil fuel use, such as use of gasoline or diesel fuel for manure transport to a centralized anaerobic digestion facility, transport of another waste to the facility for co-digestion, or use of compressors and other equipment required to process the biogas for use. The resulting increase in carbon dioxide emissions also should be accounted for using the default emission factors for fossil fuel use, as shown in Table 5.

Table 5. Default Values for Carbon Dioxide Emissions from Gasoline and Diesel Fuel Use (derived from values in IPCC, 2006)

Fuel	Default Value, kg CO_2/L (C_{factor})
Gasoline	2.4
Diesel	2.7

The values in Table 5 should be used with Equation 8 to estimate the carbon dioxide emissions resulting from increased fossil fuel use due to transportation and stationary fuel combustion.

$$FF_P = \frac{(FF_{use} \times C_{factor})}{21} \tag{8}$$

where: FF_P = Fossil fuel-related carbon dioxide emissions on a methane equivalent basis, kg CH_4 per year
FF_{Use} = Additional fossil fuel use, L per year
C_{factor} = Conversion factor, kg CO_2 per L
21 = GWP of methane as compared to carbon dioxide, kg CO_2/kg CH_4

5.0 Biogas Production and Utilization

This guidance requires measurement of total biogas production and composition for all evaluations. Level II, III, and IV evaluations also require measurements related to biogas utilization for generating electricity or replacing fossil fuels by direct combustion or engine-generator set waste heat recovery.

5.1 Biogas Production

Total biogas production should be measured in all performance evaluations. The measurements

must account for all biogas produced, including biogas used in an energy recovery device and all biogas that is flared (e.g., when biogas production exceeds engine capacity or when biogas is flared during periods of engine maintenance). Biogas production will need to be measured using an appropriate meter. Top inlet mechanical meters designed to measure corrosive gas flow are suitable for this measurement. Other types of gas flow meters, such as thermal mass flow meters, also are acceptable. Meters should be temperature- and pressure-compensated. Evidence of the verification of the precision and accuracy of all meters used to measure biogas production is required. All biogas production reporting should be under standard conditions (0°C, 1 atm) to allow direct comparisons of production among different systems.

5.2 Biogas Composition

The concentration of carbon dioxide by volume should be determined at least monthly using the detection tube appropriate for the expected concentration. Monthly determination of the biogas hydrogen sulfide concentration also is desirable. The concentration should be based on the average of at least three replicate measurements during each sampling episode. In addition, laboratory biogas analysis to determine methane, carbon dioxide, hydrogen sulfide, and ammonia content by volume should be performed at least quarterly to confirm the accuracy of the gas detection tube measurements. Each sample should be collected in a Tedlar™ gas collection bag and analyzed to determine methane, carbon dioxide, hydrogen sulfide, and ammonia composition by volume using gas chromatography ASTM Method D 1945-03 (ASTM International, 2009) for methane and carbon dioxide, ASTM Method D 5504-01 (ASTM International, 2009) for hydrogen sulfide, and EPA Method 350.1 for ammonia, or equivalent analytical methods. Results of samples containing more than 10 percent of unidentified gases, typically nitrogen and oxygen, should be discarded due to an unacceptable degree of atmospheric contamination reflecting a poor sample collection technique. Real-time electronic gas analysis (using continuous gas analyzers) is a requirement for CDM projects and is also an acceptable method for this evaluation, with evidence of precision and accuracy.

5.3 Biogas Utilization

Biogas utilization should be measured and recorded using the same type of meter used to determine total biogas production. When biogas is used to generate electricity, the electricity generated (MJ or kWh) also should be measured and recorded using a permanently installed utility-type meter or a comparable substitute. With these data and the biogas composition, the thermal efficiency of the conversion of biogas energy to electrical energy using the lower heating value (LHV) for methane should be calculated for reporting as follows:

$$TCE = \left[\left(\frac{MJ_E}{Biogas \times CH_4 \times LVH}\right)\right] \times 100 \qquad (9a)$$

where:

TCE	=	Thermal conversion efficiency, percent
MJ_E	=	Rate of electricity generation, MJ per unit time
Biogas	=	Rate of biogas combustion, m^3/unit time
CH_4	=	Biogas methane content, decimal
LHV	=	Lower heating value of methane, MJ/m^3

or

$$TCE = \left[\left(\frac{kWh \times 3{,}412}{Biogas \times CH_4 \times LHV}\right)\right] \times 100 \qquad (9b)$$

where:

TCE	=	Thermal conversion efficiency, percent
kWh	=	Rate of electricity generation, kWh per unit time
3,412	=	Btu/kWh
Biogas	=	Rate of biogas combustion, ft^3/unit time
CH_4	=	Biogas methane content, decimal
LHV	=	Lower heating value of methane, Btu/ft^3

The LHV of methane is the heat of combustion less the heat of vaporization of the water formed as a product of combustion. The LHV of methane should be used in this calculation because condensation of any water with an engine-generator set is unlikely. The LHV of methane under standard conditions (0°C, 1 atm) is 960 Btu per ft^3 or 35,770 kJ per m^3 (Mark's Standard Handbook for Mechanical Engineers, 1978). However, the LHV of methane varies with temperature and pressure in accordance with the universal gas law, and the LHV of methane

used to calculate thermal efficiency should be determined for the temperature and pressure at which biogas production is being measured. When reporting thermal conversion efficiency, the assumed heating value should be stated along with the time period involved.

Engine-generator set operating hours also should be measured and recorded at least monthly to calculate and report monthly and annual engine-generator set online efficiency, as shown in Equation 10.

$$\text{Online efficiency, \%} = \frac{\text{Engine - generator set hr per unit time}}{\text{hr per unit time}} \times 100 \tag{10}$$

Average output should also be calculated as shown in Equation 11a or 11b.

$$\text{Average generator set output, kW} = \frac{\text{kWh per unit time}}{\text{Engine - generator set hr per unit time}} \tag{11a}$$

or

$$\text{Average generator set output, MJ} = \frac{\text{MJ per unit time}}{\text{Engine - generator set hr per unit time}} \tag{11b}$$

Capacity utilization efficiency should be calculated as shown in Equation 12a or 12b.

$$\text{Average capacity utilization efficiency, \%} = \frac{\text{Average generator set output, kW}}{\text{Rated maximum output for biogas, kW}} \times 100 \tag{12a}$$

or

$$\text{Average capacity utilization efficiency, \%} = \frac{\text{Average generator set output, MJ}}{\text{Rated maximum output for biogas, MJ}} \times 100 \tag{12b}$$

When there is utilization of engine-generator water jacket or exhaust heat for water or space heating , the heat energy (in Btu or kJ) beneficially used should be measured and recorded using appropriate meters. In addition, determination of any heat energy that is utilized for digester heating is recommended.

5.4 Data Collection

All meters used to measure biogas production and utilization, electricity generated, engine-generator set hours, and waste heat beneficially utilized should be calibrated by the manufacturer immediately prior to the beginning of each performance evaluation. In addition, each meter

should have a totalizer that is not manually resettable to avoid accidental data loss, and all meter readings should be recorded during every sampling episode (or more often) with the date and time of the meter reading noted. Also, a copy of the digester operator records should be obtained monthly.

5.5 Reporting

If co-digestion of livestock manure and another waste or feedstock is being practiced, reporting biogas and methane produced and electricity generated on a per head basis is not applicable. This practice, which has been employed in the past, is misleading and will not be acceptable in submitted reports. When the performance of systems co-digesting manure and another waste or feedstock is being evaluated, biogas and methane produced and electricity generated should be reported as a function of the average daily loading of VS and COD over the duration of the study. In addition, the average daily loadings of VS and COD for manure and other wastes should be reported concurrently.

6.0 ECONOMIC ANALYSIS

It is generally accepted that the anaerobic stabilization of livestock manure under controlled conditions can significantly reduce the potential impacts of these wastes on air and water quality, while also recovering a substantial amount of usable energy. However, the decision to construct and operate an aerobic digestion system depends ultimately on the anticipated ability to at least recover any internally derived capital investment with a reasonable rate of return, and to service any debt financing over the life of the system. Therefore, all comprehensive system performance evaluations should include a financial analysis performed in accordance with the general principles of engineering economics, as outlined by Grant *et al.* (1976) and others.

In the past, several approaches have been used for assessing the economic attractiveness of these systems. One is the simple determination of the time required to recover the internally derived and borrowed capital investment from the revenue generated. This payback period approach is simple but does not consider the time value of money. Calculation of present worth or net

present value is another approach in which the value of future revenue is discounted to present worth and compared to the required capital investment. The problem with this approach is that the result obtained is dependent on the assumption of a single discount rate over the life of the system. In addition, it does not account for annual net income or loss from the biogas production and utilization effort. Therefore, this guidance requires a cash flow approach, described below, in which total annual cost and annual revenue are calculated and compared to determine the annual net income or loss. However, results of payback period and present worth calculations also can be conveyed in performance evaluation reports if desired.

6.1 General Approach

Economic analysis of anaerobic digestion systems for Level III and IV performance evaluations should be performed from the perspective that the system is an independent enterprise, with annual net income or loss for the system being the single metric used to characterize financial viability. When the digester system is part of a livestock operation, as opposed to a centralized system, the biogas energy used by other parts of the operation is treated as a source of income for the biogas enterprise, along with payments received for any biogas energy sold to a third party.

6.2 Boundary Conditions

Because anaerobic digestion is an optional component of manure management systems, appropriate boundary conditions that exclude costs and revenue sources that are not dependent on the biogas enterprise must be defined. Only costs for system components that are required for the anaerobic digester should be included.

For example, costs associated with manure storage following anaerobic digestion should not be included as components of either biogas system capital or annual operation and maintenance costs, because biogas production and utilization does not require subsequent manure storage. Costs associated with manure storage are costs of an independent decision to store manure to minimize environmental impacts associated with current land application practices or to maximize manure value as a source of plant nutrients for crop production. However, when

another waste that is not a byproduct of the farm enterprise is being co-digested with manure, the additional cost for storing and disposing the additional effluent should be included.

Another example of an inappropriate cost component would be including the cost of a pump to transfer manure to an anaerobic digester when a pump is required without digestion to transfer manure to a storage structure. However, if the anaerobic digester effluent cannot be transferred to the storage structure by gravity and a pump is needed to operate the anaerobic digester, then the cost of the pump should be included in the estimate.

With respect to complementary operations, such as the separation of coarse solids from anaerobically digested dairy or pig manure, there has been debate about the handling of costs and revenue. Commonly, the capital and operating costs of solids separation have been considered as part of the biogas production and utilization system total cost, and the sale or an onsite use of the separated solids (e.g., as bedding or soil amendment) is considered a source of revenue. However, this activity is not necessary for biogas production and utilization because separation of coarse solids from dairy manure can be accomplished without prior anaerobic digestion. Thus, solids separation should be considered as a separate enterprise in this context, with the caveat that any reduction in the final stabilization cost for the solids used on site or sold represents revenue to the biogas enterprise.

Similarly, the cost of separating coarse solids from dairy manure entering a covered lagoon digester should not be considered as part of the cost of biogas production and utilization, because removal of these solids is necessary for the satisfactory performance of conventional anaerobic lagoons, and the cost is the same. In addition, the revenue derived from the separated solids with and without biogas production will be the same.

This guidance recognizes that variation among biogas production and utilization systems and site-specific conditions may justify different boundary conditions for financial analysis, based on best professional judgment. When the rationale for the specified boundary conditions is not entirely clear, a brief explanation of the underlying logic should be included with the results of the economic analysis. In all cases, the report presenting the results of the performance

evaluation must include a schematic that identifies the boundary conditions assumed for the economic analysis.

6.3 Methodology

This section describes the methodology to estimate annual capital cost, annual operating and maintenance cost, other annual costs, annual revenue, and net income.

6.3.1 Annual Capital Cost

The first step in determining annual net income or loss from biogas production is the calculation of the annual capital cost of the system using the annual cash flow approach. To do so, three initial assumptions are necessary. The first assumption is that the total capital cost is comprised of internally derived capital (e.g., monetary investment by the operator) and borrowed capital, not just the borrowed capital. The second assumption is that the retirement of total capital cost will occur by a uniform series of annual payments over the useful life of the system, or a shorter period if desired. The third assumption is an estimate of the useful life of the system. Although a useful life of 20 years generally is standard for structural components, it clearly is unrealistically long for some system components. Flexible covers generally have a useful life of about 10 years, and mechanical equipment has a useful life of 7 years. However, all system components can be considered to have a useful life of 20 years if the reconditioning or replacement costs for components having a useful life of less than 20 years are accounted for in the annual operation and maintenance costs. This assumption allows for simplicity and standardization. A more detailed approach is acceptable if reconditioning and replacement costs are not included in the estimate of annual operation and maintenance cost, as will the less conservative assumption of capital recovery over 10 instead of 20 years.

Generally, anaerobic digestion systems are financed with a combination of internally derived and borrowed capital. In some instances, projects may receive cost-sharing assistance in the form of a grant or a below-market interest rate loan. One of the objectives of this guidance is to establish a basis that allows the comparison of different types of anaerobic digestion systems and of similar

systems in different geographical locations. Therefore, all determinations of the annual capital cost for individual systems should be based on the final total cost, not the net cost to the owner.

In calculating the annual capital cost of the system, it is recommended for simplicity that the rate of interest being paid for borrowed capital is a reasonable rate of return to the internally derived capital invested. Therefore, the annual capital cost is calculated simply by multiplying the turnkey cost of the system by the capital recovery factor for a uniform series of payments over 20 years, or 10 years if desired, at the interest rate being paid for borrowed capital.

6.3.2 Annual Operation and Maintenance Costs

One of the more uncertain aspects of the economic analysis of anaerobic digestion systems has been the ability to realistically estimate annual operation and maintenance costs. This lack of information is due, in part, to two factors. First, system owners generally do not maintain a detailed record of operation and maintenance costs during performance evaluations. Second, most performance evaluations will be for relatively new systems and it is unrealistic to assume that the operation and maintenance costs incurred during a 12-month performance evaluation will be representative of the average annual operation and maintenance costs over the life of the system, given that maintenance costs tend to increase with age. Therefore, the standard assumption that the average annual operation and maintenance costs will be 3 percent of the total capital costs should be used unless better information is available. However, management and labor requirements for routine system operation should be recorded and reported as part of all performance evaluations in an effort to delineate more clearly the cost of biogas system operation and maintenance.

6.3.3 Other Annual Costs

The construction of an anaerobic digestion system may increase the assessed value of a livestock operation and therefore increase annual real estate taxes. It also may increase the annual cost of insurance on structures and equipment and possibly the cost of liability insurance. In addition, other costs may increase, plus new costs may occur. For example, the cost of manure collection

may increase if collection frequency increases. Also, an operating permit with an annual fee may be required. The magnitude of these increases should be determined and added to the estimated annual capital and operation and maintenance costs to determine the total annual cost of operating the system. Similarly, other annual costs in addition to operation and maintenance costs (e.g., insurance, real estate taxes, salaries, fringe benefits, transportation) will be incurred for centralized systems. All of these costs should be identified and included in the economic analyses of anaerobic digestion systems when possible, or their absence should be noted.

6.3.4 Annual Revenue

For some anaerobic digestion systems, the sale of carbon credits may be the sole source of revenue. However, electricity generated will be the primary source of revenue for many systems when it is financially attractive to reduce purchases of electricity from, and possibly sell electricity to, the local electric utility. For systems with sell all/buy all utility contracts, the annual revenue generated by the system simply will be the annual sum of payments received from the utility. The estimation of annual revenue from electricity generation for operations with surplus sale or net metering utility contracts is more difficult due to the problem of placing a value of the biogas-generated electricity being used on site. Because of the way rate schedules for electricity generally are structured, the average cost per kWh decreases as the amount of electricity purchased increases. Therefore, reducing the amount of electricity purchased can increase its unit cost. In addition, onsite use of biogas-generated electricity may either increase or decrease demand charges and may result in the addition of a stand-by charge. If there is no onsite use of biogas-generated electricity, assuming that the average value of biogas electricity is equal to the average cost per kWh of electricity purchased from the utility may result in either an over- or underestimate of the annual revenue from onsite biogas-generated electricity use.

The recommended approach for dealing with this issue is to compare the total amount of electricity purchased from the local utility for the 12 months prior to startup of the anaerobic digestion system with the total amount for the 12 months of the performance evaluation. The difference multiplied by the utility rate during the performance evaluation is the revenue generated by onsite use. If, however, the livestock operation is a new operation or there were

significant changes, such as expansion when biogas production began, the cost of electricity without biogas production should be estimated. This should be done from the record of onsite biogas electricity consumption and purchases from the local utility for the 12 months of the performance evaluation. In all cases, the validity of the estimate should be confirmed by evidence that the period of the performance assessment is reasonably typical with respect to ambient temperature.

For combined heat and power systems where engine-generator set waste heat is being recovered for beneficial use, the revenue being derived from waste heat utilization should be calculated based on the cost per unit of energy for the conventional fuel being replaced and the waste heat energy being utilized. The same approach should be used to estimate revenue when using biogas as a boiler or furnace fuel. Costs of the conventional fuels most likely to be replaced (liquefied petroleum gas or No. 2 fuel oil) vary seasonally and therefore, the impact of seasonal variation in biogas use and value must be incorporated into revenue estimates.

6.3.5 Net Income

After calculations of total annual costs and annual revenue are made, calculate net income from the biogas enterprise before income taxes. An attempt to estimate net income after income taxes should not be made because income from the biogas system will be a component of total income only from the livestock operation, and livestock income may vary significantly over the life of the biogas system. In addition, the use of confidential business information will be avoided.

7.0 PROCESS PERFORMANCE CHARACTERIZATION

This section presents a summary of process performance characterization information, including waste stabilization parameters, pathogen reduction, sample collection, sample preservation, analytical methods, hydraulic retention time and temperature, and reporting.

7.1 Waste Stabilization Parameters

Level IV evaluations of the performance of anaerobic digestion systems include quantifying the degree of waste stabilization being realized by the anaerobic digestion process. For mixed, plug-flow, and attached film digesters, the degree of waste stabilization claimed should be based on differences—when statistically significant—between mean influent and effluent concentrations of the following parameters:

- Total solids (TS)
- Volatile solids (VS)
- Chemical oxygen demand (COD)
- Total volatile acids (TVA)

In addition, it must be demonstrated that the observed changes in concentrations of these parameters are due to microbial processes rather than settling of particulate matter by showing that there is no statistically significant difference ($P<0.05$) between influent and effluent fixed solids and preferably, total phosphorus (TP) concentrations as well. Ideally, changes in concentrations of the following chemicals should be determined but are not required:

- Total Kjeldahl nitrogen (TKN)
- Organic nitrogen (ON)
- Ammonia nitrogen (NH_4-N)
- Total phosphorus (TP)
- Total sulfur (S)

Mean influent and effluent pH values must be reported in conjunction with the other parameters listed above.

For covered lagoons, differences between influent and effluent concentrations for those parameters present in both particulate and soluble forms (i.e., TS, VS, and COD) represent changes due to the combination of microbial processes and settling and are not valid indicators of the degree of waste stabilization being achieved. Although these differences have value in characterizing effluent water pollution potential and should be reported, quantification of the degree of waste stabilization should be based on the difference between influent and effluent TVA concentrations and COD reduction, which are estimated based on methane production.

Stoichiometrically, 0.3496 m^3 of methane is produced per kg COD destroyed (5.60 ft^3 of methane is produced per lb of COD destroyed) under standard conditions (0°C and 1 atm) (Madigan et al., 1997). The assumed quantity of methane produced per unit COD destroyed under other than standard conditions must be adjusted to standard conditions using the universal gas law (See Metcalf and Eddy, Inc., 2003 and Appendix B). It is recommended that this approach for estimating COD reduction also be used in evaluating other types of digesters and comparing it to COD reduction estimates based on the difference between mean influent and effluent concentrations (see Appendix A for a discussion of the construction of materials balances).

Although methane production also can be expressed as a function of VS destruction, the nature of this relationship is variable depending on the chemical composition of the VS destroyed. The variation in chemical composition among different types of livestock manure as well as the impact of different feeding programs and possibly other variables within the different animal sectors, suggests that there is no single, generally applicable conversion factor as with COD. For example, the generally accepted degree of variation in total biogas production during the anaerobic digestion of domestic wastewater biosolids can vary from 0.7492 to 1.124 m^3 per kg VS destroyed (12 to 18 ft^3 per lb of VS destroyed) (Metcalf and Eddy, Inc., 2003). A defensible basis for estimating VS destruction during the anaerobic digestion of livestock manures based on methane production seems to be lacking at this time but may emerge in the future.

Finally, it is recommended that long-term, bench-scale batch studies be conducted at the operating temperature of the digester being evaluated to estimate the readily biodegradable and refractory fractions of VS. Such studies should be for no less than 30 days and with the refractory fraction at infinity (VS_∞/VS_0), determined by plotting VS_t/VS_0 versus ($1/VS_0$*t), where t equals zero at the beginning of the study, and determining the y-axis intercept using linear regression analysis.

7.2 Pathogen Reduction

Under this guidance, estimating pathogen reduction is optional. At a minimum, all claims of

pathogen reduction potential must be supported by results of the analyses of the digester or covered lagoon influent and effluent samples collected and analyzed for the waste stabilization parameters previously listed. Claims of pathogen reduction potential may be based solely on reductions in the densities of the total coliform and fecal streptococcus groups of indicator organisms. It should be clearly explained that reductions in these groups of microorganisms are only indicative of the potential for pathogen reduction. If the demonstration of reduction of a specific pathogen is desired, preference should be given to *Mycobacterium avium paratuberculosis* in dairy manure and *Salmonella spp* in swine and poultry manures.

7.3 Sample Collection

Given the inherent variability in animal manures, care should be taken to ensure that all influent and effluent samples are collected under conditions that are representative of the average daily flow. While the most desirable approach would be to collect 24-hour flow-composite samples, this approach generally is impractical for collection of livestock manure samples. Thus, the following alternatives are recommended.

1. With influent and effluent lift stations, a series of at least five grab samples should be collected at different depths when the lift station is at maximum capacity and then combined into a single composite sample. When possible, the contents of the lift station should be mixed before sample collection.

2. When samples have to be collected from a continuously or periodically flowing influent or effluent stream, a series of at least six grab samples should be collected over a period of no less than 1 hour and combined into a single composite sample.

Composite samples should be no less than 20 L, and subsamples withdrawn for analysis should be no less than 1 L. To ensure that samples collected are representative, there should be an ongoing review of analytical results to determine if the degree of variability is reasonable. If not reasonable, a modification of the sample collection protocol is necessary.

Because of inherent variability over time, all claims with respect to waste stabilization must be based on the results of the analysis of a minimum of 12 monthly influent and effluent samples, with the following caveat: if the coefficient of variation for influent or effluent TS concentrations

exceeds 25 percent, or there is more than one extreme observation that is statistically determined to be an outlier, more frequent sample collection and analysis may be necessary, with at least 24 semimonthly sampling episodes recommended.

With co-digestion of livestock manure and another waste or combination of other wastes or another feedstock, a sampling plan must be devised that will characterize the digester influent and effluent to accurately delineate the degree of waste stabilization being realized, as well as the relationship between waste stabilization and biogas production. If the same waste or combination of wastes or another feedstock is being combined with manure continually and at a constant rate, periodic sampling, as described above, should be sufficient. If, however, different wastes are being combined with manures at different times, or co-digestion is intermittent, adequate evidence must be provided that the mean values of the physical and chemical characteristics of the digester influent and effluent are representative.

An additional requirement for all performance evaluations involving co-digestion is that a record be maintained of all additions of other wastes for a period equal to at least five HRTs prior to and through the 12-month duration of the performance evaluation. This record must be included in the report of the performance evaluation and include at least the following information:

1. Type and source of the waste(s) or other feedstocks.
2. Date(s) of addition.
3. Volume added.
4. TS, VS, COD, and TVA concentrations and pH, using the same analytical protocols being used for determining digester influent and effluent physical and chemical characteristics.

7.4 Sample Preservation

All anaerobic digester influent and effluent samples should be collected, immediately iced or refrigerated, and delivered for analysis within 24 hours . Given the high concentrations of organic matter, subsamples should not be acidified for preservation.

7.5 Analytical Methods

Only analytical methods described in Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (U.S. Environmental Protection Agency, 1983) or Standard Methods for the Examination of Water and Wastewater, 21st edition (American Public Health Association, 2005), or equivalent methods having the same degree of precision and accuracy should be used. Particular analytical methods are not specified because there may be more than one suitable option for a parameter. Influent and effluent samples should be analyed by a laboratory with appropriate certification to perform analyses of wastewater and with an ongoing quality assurance/quality control (QA/QC) program. In the event that an analytical laboratory without the appropriate certification, such as a university research laboratory, is used, that laboratory must have a QA/QC program that is comparable to such programs required for certification. The laboratory used should have previous experience in analyzing samples with high solids concentrations, and duplicate, or preferably triplicate, analyses of individual samples should be performed for all parameters.

The multiple-tube fermentation techniques described in Standard Methods for the Examination of Water and Wastewater, 21st edition (American Public Health Association, 2005) should be used to estimate fecal coliform, fecal streptococcus, and *Salmonella spp.* densities. For estimation of *M. avium paratuberculosis* densities, either the NADC or the Cornell Method (Stabel, 1997) is acceptable.

7.6 Hydraulic Retention Time and Temperature

Because the degree of waste stabilization will vary with HRT, and actual HRT might differ from the design value, the determination of actual digester or covered lagoon influent or effluent flow rate to calculate actual HRT is also a requirement of this guidance. Because of differences among digesters, no specific flow measurement techniques arespecified. However, the method used, as well as the underlying rationale, must be fully described in the performance evaluation report.

In addition, digester or covered lagoon operating temperature must be determined and recorded during each sampling episode. The concurrent measurement of influent and effluent temperatures

is desirable, but not required. At least monthly, the accuracy of all thermometers and other temperature measuring devices should be checked using a precision thermometer with certification traceable to the National Institute of Standards and Technology (NIST) or a similar national standards organization. For covered anaerobic lagoons, the average daily ambient temperature over the duration of the performance evaluation also should be measured and recorded or obtained from the nearest official weather observation station.

7.7 Reporting

All reductions must be shown to be statistically significant at least at the $P<0.05$ level using the Student t test (Snedecor and Cochran, 1980.). Any suspected outliers in datasets should be tested at $P<0.05$ using Dixon's method (Snedecor and Cochran, 1980). For covered lagoons, claims of VS and COD reductions will have to be estimated based on observed biogas production. All densities of indicator organisms and pathogens should be reported and compared statistically on a $\log_{10}$ colony-forming unit (CFU) per 100 ml basis. If a reduction is claimed, it also must be statistically significant at least at $P<0.05$. When differences are found to be statistically significant, 95 percent confidence interval estimates should be reported.

8.0 REPORT FORMAT

Reports presenting results of performance evaluations of anaerobic digestion systems for livestock manures should contain the following sections:

- Summary and Conclusions—A brief overview of the performance evaluation and presentation of the major findings.
- Introduction— Descriptions of the location of the performance evaluation and the biogas system evaluated followed by the objectives of the evaluation.
- Methods and Materials—A description of methods and materials employed in the performance evaluation.
- Results—Summaries of the results obtained.

- Discussion—A discussion of the results obtained, especially with respect to similarities to and differences from previously reported results.

- References—A list of literature cited, following the format used in this document.

- Appendices
    - A copy of the QA/QC plan for the laboratory that performed digester influent and effluent sample analyses, when applicable.
    - A record of tests of the accuracies of meters and temperature measuring devices used.
    - All data collected in tabular form.

REFERENCES

AgSTAR Program. 2007. A Protocol for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manures. In: Proceedings of the American Society of Agricultural and Biological Engineers International Symposium on Air Quality and Waste Management for Agriculture, American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

American Public Health Association. 2005. Standard Methods for the Examination of Water and Wastewater, 21st Ed. A.D. Eaton, L.S. Clesceri, E.W. Rice, and A.E. Greenberg (Eds). American Public Health Association, Washington, DC.

ASTM International. 2009. Standard Test Method for Analysis of Natural Gas by Gas Chromatography, ASTM D 1945-03. In: Book of Standards Vol. 5.06. ASTM International, West Conshohocken, PA.

ASTM International. 2009. Standard Test Method for Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Chemiluminescence, ASTM D 5504-01. In: Book of Standards Vol. 5.06. ASTM International, West Conshohocken, PA.

Grant, E.L., W.G. Ireson, and R.S. Leavenworth. 1976. Principles of Engineering Economy, 6th Ed. John Wiley and Sons, New York, New York.

Intergovernmental Panel on Climate Change. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, S. Eggleston, C. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds). Institute of Global Strategies, Japan.

Madigan, M.T., J.M. Martinko, and J. Parker. 1997. Brock Biology of Microorganisms, 8th Ed. Prentice-Hall, Upper Saddle River, New Jersey.

Mark's Standard Handbook for Mechanical Engineers. 1976. 8th Ed. T. Baumeister, E. Avallone, and T. Baumeiset III (eds). McGraw-Hill Book Company, New York, New York.

Metcalf and Eddy, Inc. 2003. Wastewater Engineering, Treatment, and Reuse, 4th Ed. Revised by G. Tchobanoglas, F.L. Burton, and H.D. Stensel. McGraw-Hill, New York, New York.

Methane to Markets Partnership. 2008. *Methane to Markets Partnership Factsheet.* Available online at: http://www.methanetomarkets.org/m2m2009/documents/partnership_fs_eng.pdf.

Regional Greenhouse Gas Initiative, Inc. 2007. Regional Greenhouse Gas Initiative, Draft Model Rule. Regional Greenhouse Gas Initiative, Inc., New York, New York.

Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods, 7th Ed. The Iowa State University Press, Ames, Iowa.

Stabel, J.R. 1997. An Improved Method for Cultivation of *Mycobacterium paratuberculosis* from Bovine Fecal Samples and Comparison with Three Other Methods. *J. Veterinary Diagnostic Investigations*, 9:375-380.

United Nations Framework Convention on Climate Change/Clean Development Mechanism (UNFCCC/CDM). 2010. Methodology for methane recovery in animal manure management systems, Version 16. (Available at: http://cdm.unfccc.int/methodologies/DB/ZODCONSVY9D2ONIJKJMUZEKRE56T71/view.html).

UNFCCC/CDM. 2008. Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion, v2. EB 41 Meeting Report, Annex11. (Available at: http://unfccc.int/kyoto_protocol/mecanisms/clean_development_mechanism/items/2718.php).

UNFCCC/CDM. No date. Tool to Determine Project Emissions from Flaring Gases Containing Methane, v1. EB 28 Meeting Report, Annex13. (Available at: http://unfccc.int/kyoto_protocol/mecanisms/clean_development_mechanism/items/2718.php).

U.S. Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. (Available at http://nepis.epa.gov/titleORD.htm or from the National Technical Information Service—Publication No. PB84-128677).

APPENDIX A

Material Balances

A material balance (or inventory) is a simple accounting of any material in a system, which may be a single unit, a collection of units, or an entire system, and generally may be stated as:

Input (enters through the system boundary) +
Generation (produced within the system) –
Output (leaves through the system boundary) – (A-1)
Consumption (consumed within the system) =
Accumulation (buildup within the system boundary)

If there is no generation or consumption within the system boundary, as is the case with fixed solids (FS) and total phosphorus (TP) in an anaerobic digestion reactor, Equation A-1 reduces to:

Input (enters through the system boundary) –
Output (leaves through the system boundary) = (A-2)
Accumulation (buildup within the system boundary)

In the analysis of the performance of livestock and other waste treatment or stabilization processes, it generally assumed that no accumulation of any substance due to settling is occurring if the input of FS, and preferably also TP, is equal to the output. Therefore, any difference between input and output must be due to generation or consumption, and Equation A-1 reduces to:

Input (enters through the system boundary) +
Generation (produced within the system) = (A-3)
Output (leaves through the system boundary) –
Consumption (consumed within the system) +

If generation is zero or negligible in comparison to consumption, Equation A-3 reduces to:

Input (enters through the system boundary) –
Output (leaves through the system boundary) = (A-4)
Consumption (consumed within the system)

and treatment or stabilization efficiency is calculated as follows:

Treatment or stabilization efficiency, % = (A-5)
*(Consumption/Input) * 100*

The basis for material balances for continuous steady-state processes such as anaerobic digestion usually is mass flow rates (e.g., kg per hr). However, material balances to estimate treatment or stabilization efficiency also can be constructed using concentrations (e.g., mg per L) when volumetric flow rates (e.g., L per hr) are equal. Although, there is some reduction in volume

during anaerobic digestion due to the saturation of the biogas leaving the reactor with water vapor, the reduction in volume is negligible and can be ignored.

For estimating chemical oxygen demand (COD) reduction in covered lagoons based on methane production under standard conditions, the relationship is:

$$COD_{reduction}, \text{ kg/unit time} = (\text{Methane production, } m^3\ CH_4 \text{ /unit time})/(0.3496\ m^3\ CH_4/\text{kg } COD_{destroyed}) \quad \text{(A-6a)}$$

$$COD_{reduction}, \text{ lb/unit time} = (\text{Methane production, } ft^3\ CH_4 \text{ /unit time})/(5.60\ ft^3\ CH_4/\text{lb } COD_{destroyed}) \quad \text{(A-6b)}$$

For nonstandard conditions, the universal gas equation should be used to determine the volume occupied by one mole of methane and the methane equivalent of COD converted under anaerobic conditions, assuming 64 g COD per mole of methane.

APPENDIX B

Biogas Production

To determine biogas production under digester operating conditions from COD destruction based on the stoichiometrically based estimate that 5.60 ft^3 of methane are produced per lb of COD destroyed (0.3496 m^3 per kg COD destroyed) under standard conditions (0°C and 1 atm), or to correct non-temperature- or pressure-compensated biogas production measurements to standard conditions, the following relationship (the general gas law) should be used:

$$V_2 = V_1 * (T_2/T_1) * (P_1/P_2) \qquad \text{(B-1)}$$

where: V_1 = gas volume (m^3) at temperature T_1 (°K) and pressure P_1 (mm Hg)
V_2 = gas volume (m^3) at temperature T_2 (°K) and pressure P_2 (mm Hg)

From: Paul Gunning
To: gunning.paul@epa.gov
Subject:
Date: 10/31/2011 04:22 PM
Attachments: Non-CO2 - Amserdam Presentation.pptx

Scenarios of methane emission reductions to 2030: abatement costs and co-benefits to ozone air quality and human mortality

J. Jason West[1], Arlene M. Fiore[2], Larry W. Horowitz[2]

[1] *Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill, CB#7431, Chapel Hill, NC, 27599, USA*

[2] *Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, 201 Forrestal Road, Princeton, NJ, 08540, USA*

Corresponding author:
J. Jason West

jasonwest@unc.edu

phone: 919-843-3928

fax: 919-966-7911

Abstract

Methane emissions contribute to global baseline surface ozone concentrations; therefore reducing methane to address climate change has significant co-benefits for air quality and human health. We analyze the costs of reducing methane from 2005 to 2030, as might be motivated to reduce climate forcing, and the resulting benefits from lower surface ozone to 2060. We construct three plausible scenarios of methane emission reductions, relative to a base scenario, ranging from 75 to 180 Mton CH_4 yr^{-1} decreased in 2030. Using compilations of the global availability of methane emission reductions, the least aggressive scenario (A) does not incur any positive marginal costs to 2030, while the most aggressive (C) requires discovery of new methane abatement technologies. The present value of implementation costs for Scenario B are nearly equal to Scenario A, as it implements cost-saving options more quickly, even though it adopts positive cost measures. We estimate the avoided premature human mortalities due to surface ozone decreases by combining transient full-chemistry simulations of these scenarios in a global atmospheric chemical transport model, with concentration-mortality relationships from a short-term epidemiologic study and projected global population. An estimated 38,000 premature mortalities are avoided globally in 2030 under Scenario B. As benefits of methane reduction are positive but costs are negative for Scenario A, it is justified regardless of how avoided mortalities are valued. The incremental benefits of Scenario B also far outweigh the incremental costs. Scenario C has incremental costs that roughly equal benefits, only when technological learning is assumed. Benefits within industrialized nations alone also exceed costs in Scenarios A and B, assuming that the lowest-cost emission reductions, including those in developing nations, are implemented. Monetized co-benefits of methane mitigation for human health are estimated to be $13-17 per ton CO_2eq, with a wider range possible under alternative assumptions. Methane mitigation can be a cost-effective means of long-term and international air quality management, with concurrent benefits for climate.

Keywords: co-benefits of greenhouse gas abatement, ozone air pollution, methane, air pollution mortality, cost-benefit analysis

1. Introduction

Emissions of methane (CH_4) related to human activities have caused global atmospheric methane concentrations to more than double since the preindustrial period, causing a positive radiative climate forcing that is second only to CO_2 (Forster et al., 2007). In addition to being a greenhouse gas, methane also reacts in the atmosphere to produce ozone (Crutzen, 1973). Since methane is long-lived in the atmosphere (a perturbation lifetime of 12 years, Forster et al., 2007), it affects global baseline (i.e., not affected by local sources) concentrations of ozone (Wang and Jacob, 1998). In fact, methane is the dominant anthropogenic volatile organic compound (VOC)

contributing to ozone formation in the global troposphere (Fiore et al., 2002). Anthropogenic increases in emissions of methane and nitrogen oxides (NO_x) have been identified as the most important causes for the historic increases in background ozone concentrations since preindustrial times (Wang and Jacob, 1998; Lelieveld and Dentener, 2000).

Reductions in methane emissions to address climate change therefore have significant co-benefits for improving air quality and human health globally, regardless of where those reductions occur (Hansen et al., 2000; Fiore et al., 2002). These co-benefits, however, have received little attention (West et al., 2006). In contrast, the co-benefits of mitigating CO_2 emissions for air quality and human health have been analyzed extensively, with the majority of these studies finding that air pollution co-benefits are significant in comparison with the costs of mitigation or monetized benefits of slowing climate change (Ekins, 1996; WGPHFFC, 1997; OECD, 2000; Cifuentes et al., 2001a,b; Syri et al., 2001; Hourcade et al., 2001; Burtraw et al., 2003; Aunan et al., 2003, 2004; Vennemo et al., 2006; van Vuuren et al., 2006; Barker et al., 2007). Co-benefits of CO_2 mitigation are realized via reductions in air pollutants co-emitted with CO_2. In contrast, co-benefits of methane mitigation are realized through reactions that methane participates in directly. In addition, methane emissions are expected to grow, particularly from developing nations, and several measures are known to reduce methane emissions at low cost (Nakicenovic et al., 2000; IEA, 2003; EPA, 2006a; EPA, 20006b; Moss et al., 2010). Including methane reductions in has been shown to reduce overall costs of multi-gas GHG reduction programs (Reilly et al., 1999; Weyant et al., 2006; van Vuuren et al., 2006). Consequently, methane mitigation has increasingly been included in discussions of long-term planning for ozone management (EMEP, 2005; Royal Society, 2008; HTAP, 2010), in addition to its role as an important forcing agent with a short lifetime (Jackson, 2009; UNEP, 2011).

We previously analyzed the potential for reducing global baseline ozone as a function of the costs of identified methane controls, and presented the strengths and weaknesses of managing ozone through methane reductions relative to more traditional ozone precursors – NO_x, VOCs, and carbon monoxide (West and Fiore, 2005). We also showed that among reductions in these four ozone precursors to improve ozone air quality, reducing methane best decreases climate forcing (West et al., 2007a). Finally, we simulated an immediate 20% global reduction of anthropogenic methane emissions and showed that the monetized co-benefits of avoided premature mortalities from reduced ozone are comparable to previous estimates of co-benefits for CO_2, and can exceed the costs of methane control, suggesting that this reduction could be justified for ozone air quality purposes alone (West et al., 2006).

In this study, we reevaluate the costs and benefits of reducing methane emissions, using realistic future scenarios of methane abatement. We present here three plausible scenarios of global methane emissions abatement relative to a base scenario to 2030, which are based on compilations of the global potential for methane abatement. These scenarios were modeled by Fiore et al. (2008) in fully transient 25-year simulations using the MOZART-2 model of global atmospheric chemistry and transport, to assess future concentrations of methane and ozone, and as a bounding case, we also consider a complete removal of anthropogenic methane emissions in 2030. The changes in surface ozone concentrations from these simulations are used here to estimate the global avoided premature mortalities, and these benefits are compared with the estimated costs of methane emission control.

2. Base methane emissions and abatement scenarios

Anthropogenic emissions of methane derive from many source categories, including energy production and distribution (in the coal, oil, and natural gas sectors), landfills, and wastewater treatment. Agricultural operations also contribute substantially to current anthropogenic emissions, mainly in the production of rice and ruminant animals (mainly cows) (Denman et al., 2007). Because methane is the main component of natural gas, several actions that capture methane for energy use involve a net cost-savings or small positive cost. While these cost-saving actions have increasingly been adopted in industrialized countries, causing emissions from these countries to decrease since 1990 (EPA, 2006a), they are much less widespread elsewhere, and recent estimates suggest that roughly 10% of current global anthropogenic emissions can be reduced at a net cost-savings using presently available technology (IEA, 2003; EPA, 2006b).

Here we construct three plausible and illustrative scenarios of future methane emissions abatement over the period 2005 to 2030, relative to a base scenario, the IIASA Current Legislation (CLE) scenario (Dentener et al., 2005; Cofala et al., 2007). The CLE scenario projects global anthropogenic methane emissions to increase by 40% between 2000 and 2030, an increase that falls in the middle of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) scenarios (Nakicenovic et al., 2000).

Relative to this base scenario, three scenarios of methane emission reductions are developed beginning in 2005. These scenarios use as benchmarks studies of the global availability of methane emission reductions using current technologies by 2030: the IIASA Maximum Feasible Reduction (MFR) scenario (Dentener et al., 2005; Cofala et al., 2007), and compilations of the global availability of methane emission reductions as a function of cost by the International Energy Agency (IEA, 2003) and the US Environmental Protection Agency (EPA, 2006b). The IEA (2003) and EPA (2006b) report the technical costs of implementation, including capital costs, operation and maintenance, and avoided costs from the recovery of methane, but omit transaction costs, such as the costs to administer a methane reduction strategy. They created marginal abatement cost curves for annualized costs under assumptions of a discount rate (10% per year), future energy prices, and for the EPA, a tax rate that applies to corporations considering methane reductions (40%). For our purpose of comparing social costs and benefits, we apply a more appropriate social discount rate of 5% per year and no tax rate, and adjust cost estimates accordingly. Both the IEA (2003) and EPA (2006b) report costs in US dollars for the year 2000, and we use these units here.

Figure 1 shows global methane abatement in the three benchmark studies and the three methane reduction scenarios developed here. The MFR scenario is intended to be an aggressive scenario which immediately deploys all currently-available methane reduction technologies, even though some are costly, but assumes no future discovery of new abatement technologies (Dentener et al., 2005). Methane reductions under IEA and EPA are shown in 2030 for marginal costs of $15 per ton of CO_2 equivalent (CO_2eq) reduced, as this is roughly the monetized benefit of reducing

methane estimated in previous studies of benefits for human mortality (West et al., 2006) and other benefits to health, agriculture, and forestry (West and Fiore, 2005). Throughout this paper, we use a 100-year global warming potential for methane of 21, the value currently used in emission trading markets, such that 1 ton of CH_4 equals 21 tons of CO_2eq.

The IEA (2003) reported base results as the global availability of methane reductions in 2010 at a 10% discount rate, using current technologies in five sectors: coal, oil, gas, wastewater, and landfills. We use their sensitivity case for 2020, and adjust the cost curve by multiplying by the ratio of available reductions in other reported sensitivity cases (relative to the base) for a 5% discount rate and twice the base energy price. Because these reported sensitivity cases are based on original data on the time profile of costs for each abatement measure, the error in our extrapolation is low. We then add global abatement opportunities in agricultural sources (manure management, enteric fermentation, and rice cultivation) as reported by DeAngelo et al. (2006) and EPA (2006b) for 2020. Finally, we extrapolate these results to 2030 proportionally to the growth in base scenario methane emissions. Accounting for these changes gives a global availability of about 79 Mton CH_4 yr^{-1} in 2030 at a negative marginal cost, and 122 Mton CH_4 yr^{-1} in 2030 at <$15 per ton CO_2eq (Figure 1a).

The EPA (2006b) reports global methane reductions available for four industrial sectors (coal, oil, natural gas, and landfills), and three agricultural sectors (manure management, enteric fermentation, and rice cultivation), in 2020, which we extrapolate to 2030 as for IEA (2003). The EPA (2006b) reports generally lower availability of methane reductions than does IEA (2003). The reductions from agriculture for EPA (2006b) are the same that we added to the results from IEA (2003); consequently, the major difference is that EPA (2006b) does not include possible reductions in wastewater treatment, which is a large source of cost-effective reductions for IEA (2003). The EPA (2006b) does not report the sensitivity of their results at a 5% discount rate, 0% tax rate, or at a higher energy price, but clearly, changing these assumptions in line with our assumptions above for IEA would increase the availability of methane reductions at a given cost. Because of these inconsistencies, we do not use EPA (2006b) estimates in forthcoming sections.

In Figure 1, Scenario A is constructed such that it clearly can be achieved for less than $15 per ton CO_2eq marginal cost, and is well within the reductions considered possible in the MFR scenario. Under Scenario B, the 2030 reduction roughly equals the global available reduction at <$15 per ton CO_2eq of IEA (2003), after modifying the IEA (2003) marginal cost curves as described above. Scenario B is also possible according to the MFR scenario, but exceeds the available reductions of EPA (2006b). Scenario C cannot be achieved using only the technologies included in the MFR, IEA, or EPA datasets, requiring development of new technologies before 2030.

These three scenarios span a range of methane emission reductions, with totals of 75, 125 and 180 Mton yr^{-1} in 2030 from Scenarios A, B, and C, respectively, which are 18%, 29% and 42% of global anthropogenic CLE emissions in 2030. Total anthropogenic methane emissions (Figure 1b) would stabilize under Scenario A at slightly more than 2005 emissions, while Scenarios B and C would decrease emissions relative to 2005. These scenarios are also compared with the new Representative Concentration Pathway scenarios (Moss et al., 2010),

which show a wider range of 2030 emissions, with the no-policy scenario (RCP8.5) growing faster than CLE, and the aggressive policy scenario (RCP2.6) reaching lower emissions than Scenario C.

The marginal costs of each of these scenarios are shown in Figure 2, based on IEA (2003) data, modified as described above, and assuming that measures are applied strictly from the least costly alternatives to the most costly. Estimating the true time profile of costs is not entirely possible, as the IEA (2003) and EPA (2006b) report annualized costs. In many cases, these projects involve large capital costs at the beginning of the project. Since it is not possible to reconstruct the actual cost history, we report the annual costs (as if the investment were financed with a loan) over the lifetime of the technology, but this approach will tend to underestimate the actual costs early in the period analyzed. The lifetimes of these technologies range from 5 to 30 years (IEA, 2003; EPA, 2006b) and we assume that each technology can be replaced at the end of its lifetime with another at the same annual cost, as would generally be expected.

In Figure 2, we project the marginal cost in each year assuming no technological learning through 2030. This assumption is conservative, as we expect the costs of individual technologies to decrease through time and new technologies make greater emission reductions possible. Scenario A has a 2030 marginal cost of $0 per ton CH_4, assuming no technological learning. Likewise, under Scenario B, marginal costs remain less than or equal to $0 until 2017. Scenario C incurs very high marginal costs in 2021 and 2022 (>$1500 per ton), incorporating the most costly measures in IEA (2003), and becomes infeasible in 2023 when available technologies are exhausted.

Scenario C could be possible with an increase in methane abatement opportunities through technological innovation. The existing literature on innovation, including for emission controls, has focused on a single type of technology and the reduction in marginal cost as that technology matures (Dutton et al., 1984; Grubb et al., 2002; Taylor et al., 2003; Rubin et al., 2004; Riahi et al., 2004; EPA, 2006b). Here we are more interested in how innovation will increase the availability of emission reductions from a suite of many possible technologies through time, rather than the decrease in cost of one technology, especially as Scenario C is not possible using identified technologies at any cost. Experience has shown that after beginning to control emissions of a pollutant, innovation both decreases the costs per ton reduced and increases the emission reductions possible below a given marginal cost. However, the current literature does not provide a good basis for quantifying the growth in emission reduction potential through time from an expanding suite of technologies.

Methane abatement costs are therefore presented both without and with technological learning. Lacking historical evidence on which to base our assumptions for learning, we consider the rate of growth in emission reduction potential that would be required to make Scenario C possible. We define emission reduction potential as the available emission reduction from all known technologies at or less than a given marginal cost; in a future year, it is the available reductions plus those reductions that have been implemented between the present and the future year. We therefore assume a growth rate of emission reduction potential that applies to reductions at each marginal cost; in doing so, we expand the reductions available at each cost, but conservatively ignore the likelihood that the marginal costs of each individual technology will decrease through

time (shifting the cost curve right, but not down). We find that a 1% per year growth rate in the emission reduction potential is more than sufficient to make Scenario C possible; this growth rate is not unreasonable should aggressive policies for methane mitigation be instituted. In Figure 2, assuming technological learning decreases the marginal costs of Scenarios A and B, particularly in the 2020s, and Scenario C becomes feasible with a 2030 marginal cost of \$859 per ton CH_4 (\$40.9 per ton CO_2eq). Many projections of future emissions over the next century must assume technological innovation, and our assumption of Scenario C in 2030 is in line with global methane emissions in recent scenarios with aggressive climate policies (e.g., for RCP2.6 in Figure 1; Clarke et al., 2006; Moss et al., 2010).

Because of the long atmospheric lifetime of methane, the benefits of reduced ozone are realized over decades. Accordingly, we evaluate scenarios to 2060 in order to fully account for the costs and benefits of all implemented actions. Here we assume that annual costs of implementation in 2030 are constant to 2060, assuming that the same technologies continue to be applied, and with no further innovation beyond 2030 in the case of technological learning.

3. Changes in surface ozone concentrations due to methane abatement

The CLE base scenario and these three methane abatement scenarios were simulated by Fiore et al. (2008) using MOZART-2 in fully transient simulations to 2030, with emissions of all other species following the CLE scenario (Dentener et al., 2005; Cofala et al., 2007). Fiore et al. (2008) report the difference in surface ozone concentrations between CLE and the three methane reduction scenarios, as well as the radiative climate forcing. Here we present the changes in population-weighted ozone concentration in several world regions, as these indicators are more directly relevant for human health.

Figure 3 shows the decreases in the global annual average population-weighted 8-hr. daily maximum ozone under the three methane reduction scenarios. Relative to the base scenario, ozone concentration decreases smoothly in each scenario, reaching global average reductions of 0.7, 1.3, and 2.0 ppb in 2030 for Scenarios A, B, and C, respectively. In Table 1, the changes in ozone are shown for individual world regions defined in Figure S1. Table 1 shows the population-weighted ozone concentrations in the base simulation, as averages annually and in the "ozone season" in each region, which is defined as the three-month period with the greatest average population-weighted 8-hr. daily maximum ozone concentration in 2030. In 2005, the Western Pacific region has the highest population-weighted annual average 8-hr. ozone, followed by South Asia and the Middle East. From 2005 to 2030, ozone in the base scenario increases markedly in South Asia, such that it is the region with highest ozone in 2030, as well as in Southeast Asia and the Middle East. The ozone growth in these regions is consistent with other models that analyzed the CLE scenario (Dentener et al., 2006), and is due to large projected increases in emissions in these regions and the large sensitivity to changes in emissions in tropical regions (West et al., 2009a). Industrialized nations show much less growth in ozone as a result of planned emission reductions included in CLE.

Reducing methane (Table 2) causes the greatest decrease in surface ozone in the Middle East, in agreement with previous results (West and Fiore, 2005; West et al., 2006; Fiore et al., 2008). The Western Pacific, South Asia, and Europe also see ozone decreases greater than the global average. We find that the regional pattern of the response to changes in methane emissions is nearly the same in the three scenarios (Fiore et al., 2008). The global average ozone change in Scenario A is 52% of that in Scenario B, and the results in each individual region and season are also very nearly 52% of those in Scenario B. Likewise, changes in ozone in Scenario C are very nearly 152% that in Scenario B in all regions and seasons.

Fiore et al. (2008) also present the steady-state change in ozone where anthropogenic emissions are eliminated (by fixing methane globally to the preindustrial concentration of 700 ppb). The global population-weighted annual average 8-hr. daily maximum ozone decreases by 5.6 ppb, which would be the greatest ozone reduction possible by reducing methane emissions. If we assume that anthropogenic emissions of methane are eliminated starting in 2006, methane would not have reached the preindustrial concentration by 2030, nor would ozone have reached steady state. Using the perturbation lifetime of methane of 11.3 years diagnosed for MOZART-2 (Fiore et al., 2008), 89% of this steady state change would be achieved by 2030, giving a reduction in the global population-weighted annual average 8-hr. daily maximum ozone of 5.0 ppb, and we estimate ozone changes between 2005 and 2030 similarly. The spatial pattern of the surface ozone change does not differ substantially with the other scenarios, as the change in ozone in 2030 from eliminating anthropogenic methane emissions is roughly 3.75 times that in Scenario B. These relationships between methane and surface ozone concentrations are consistent with others in the literature (Fiore et al., 2008). A multimodel study finds that responses of surface ozone to changes in methane vary among 18 models by a coefficient of variation (σ/μ) of 20%, and that MOZART-2 is not an outlier (Fiore et al., 2009).

We evaluate changes in ozone beyond these simulations until 2060, assuming no further changes in emissions of methane or other species, so that benefits can be fully evaluated. Here we calculate the steady-state methane calculation corresponding to the methane emissions in 2030 in each scenario, and have methane approach this steady state exponentially according to its perturbation lifetime. Changes in ozone are then calculated in each year, grid cell, and day by scaling to the changes in ozone between a present-day simulation (1760 ppb methane) and a methane perturbation simulation (1460 ppb) (Fiore et al., 2008). Scaling to these steady-state simulations is justified, irrespective of changes in base scenario methane and other emissions, as ozone is very nearly linear with methane changes (Fiore et al., 2008).

4. Avoided premature mortalities associated with ozone reductions

Ozone has been associated with premature mortality in a large number of daily time-series epidemiological studies (Levy et al., 2001, 2005, Thurston and Ito, 2001; Gryparis et al., 2004; Bell et al., 2004, 2005; Ito et al., 2005; Bell and Dominici, 2006; NAS, 2008). The global

avoided premature mortalities associated with modeled ozone reductions are assessed using the general methods of West et al. (2006; 2007b; 2009b) and Anenberg et al. (2009; 2010), which are supported by the US National Academy of Sciences (NAS, 2008). The relationship between changes in ozone concentration and daily mortalities is derived from a daily time-series study of 95 United States cities (Bell et al., 2004), and we use their results for 8-hr. daily maximum ozone. Bell et al. (2004) show a smaller relationship between ozone and mortality than meta-analyses (Bell et al., 2005; Ito et al., 2005; Levy et al., 2005), but we select this study because it is not subject to a possible publication bias (the tendency to selectively publish studies showing stronger relationships). In addition to these results for short-term ozone mortality, Jerrett et al. (2009) find evidence for a relationship between ozone and long-term (chronic) mortality; as there are few other studies to support long-term ozone mortality, we conservatively limit our estimates to short-term mortality, but note that mortality impacts may be greater had we estimated long-term mortality. While the majority of epidemiologic evidence is derived from studies in the US and Europe, available studies from elsewhere are not inconsistent (HEI Scientific Oversight Committee, 2004), and we apply this relationship globally.

Global atmospheric models are now commonly used to drive air pollution health impact assessments (West et al., 2006; 2007b; 2009b; Corbett et al., 2007; Jacobson, 2008; Liu et al., 2009; Anenberg et al., 2009; 2010; Barrett et al., 2010). These studies have important uncertainties due to the coarse resolution of global models. For the present case, these uncertainties are expected to be small, as methane affects the global ozone background and is not expected to play a major role in ozone formation in polluted urban plumes. Nonetheless, the possible effects of methane on ozone on finer scales, including urban areas (see Fiore et al., 2008), and the uncertainties of coarse grid resolution for health impact analysis, should be investigated more fully.

Population is projected annually into the future in each of four world regions based on the IPCC SRES B2 scenario, in which the global population increases to 8.37 billion in 2030, selected because B2 is near the center of the SRES scenarios (Nakicenovic et al., 2000). The spatial distribution of population is from the LandScan database (Oak Ridge, 2005) for the global 2003 population, which is then mapped onto the grid used for atmospheric modeling (1.9ºx1.9º). Baseline mortality rates are taken as the "non-accident" baseline mortality in each of fourteen world regions from WHO (2004). Avoided premature mortalities are calculated using the change in 8-hr. daily maximum ozone concentration between the methane reduction scenario and the base scenario, in each grid cell on each day to 2060. We apply a low-concentration threshold of 25 ppb, below which changes in ozone concentration are not assumed to affect mortality, and compare to results with no threshold.

In Figure 4, the time profile of avoided premature mortalities roughly follows that for ozone (Figure 2), but also reflects the growth in population, with avoided mortalities in 2030 of about 19,500, 37,800, and 57,200, in Scenarios A, B, and C, respectively. Accumulated over the period 2005-2030, 187,000 premature mortalities are avoided in Scenario A, 411,000 in Scenario B, and 644,000 in Scenario C. These results are for a low-concentration ozone threshold of 25 ppb; results with no threshold are ~5% higher (Figure 4). Beyond 2030, avoided mortalities continue to rise, but less slowly, as methane approaches a steady state change and as population continues to grow. We previously showed that ozone mortality has little sensitivity to changes in

threshold below about 30 ppb, but that higher thresholds substantially reduce the avoided mortalities (West et al., 2006; West et al., 2007b). In the scenario where methane emissions are eliminated (not shown) 140,000 mortalities are avoided in 2030 with 2.19 million avoided mortalities between 2005 and 2030, assuming a 25 ppb threshold. As expected, annual avoided mortalities are small compared to the total annual premature mortalities attributed to ozone (~700,000) and fine particulate matter (~3.7 million) (Anenberg et al., 2010). Across all scenarios, changes in mortality scale roughly proportionally to the changes in ozone concentration, and since the change in ozone is proportional to the methane reduction, mortalities roughly scale with methane.

In Scenario B in 2030, the greatest numbers of avoided premature mortalities are observed to occur in Africa, South Asia, and East Asia (Figure 5 and Table 3), as these regions are projected to have the greatest population in 2030 (Table 1). The avoided mortalities per million people are greatest in Africa, as Africa has the highest baseline mortality rates in the world and experiences a high change in ozone (Table 2). High numbers of avoided premature mortalities per million people are also seen in South Asia, Europe, the Former Soviet Union, Western Pacific, and the Middle East due to large changes in ozone and/or high baseline mortality.

As a sensitivity analysis, we also consider the avoided cardiovascular and respiratory (C&R) mortalities. Because the proximate causes of death differ between the US and Europe (where most epidemiological studies are performed) and elsewhere, there is likely error in applying these ozone-mortality relationships elsewhere. Estimating only C&R mortalities reduces this error by controlling for differences in the causes of death, but may underestimate the total mortalities. We use the C&R ozone-mortality relationship from Bell et al. (2004) and baseline C&R mortality rates. The results (Table 3) show that Scenario B causes 21,000 avoided premature C&R mortalities in 2030, with the greatest number of avoided premature C&R mortalities in South Asia, followed by East Asia and Africa, as a smaller fraction of the population dies of C&R causes in Africa. The avoided C&R mortalities per million people is greatest in the Former Soviet Union and Europe, as these regions have an older population, in which a greater fraction dies of C&R causes.

The sensitivity to the choice of total mortalities versus C&R mortalities highlights the uncertainty in the results overall. While we do not estimate uncertainty explicitly, it is explored more fully for similar applications elsewhere (West et al., 2006, 2007b; Anenberg et al., 2009, 2010). The uncertainty in the ozone-mortality relationships of Bell et al. (2004) is roughly ±50% (95% posterior interval), while uncertainty is greater if the diversity among studies is taken into account. This uncertainty would combine with the uncertainty in the response of ozone to changes in methane of ±20% (one standard deviation), based on the range of several models (Fiore et al., 2009).

5. Comparison of costs and benefits of methane abatement

Costs of methane reductions and avoided mortality benefits of the three scenarios are shown in Figure 6. Here, total annual costs are the sum of the annual costs of all measures in Figure 2 less

than a given marginal cost, as all measures are assumed to remain in effect through 2060 (replacing at the same marginal cost after its useful lifetime). In Scenarios A and B, the costs borne in each year remain negative through 2060. For Scenario B, this annual cost starts to increase in 2016, as measures with positive marginal costs are added. Scenario C becomes infeasible in 2023 using only known technologies, but is feasible with technological learning, as described earlier, with positive annual costs after 2021.

We monetize benefits using a value of a statistical life (VSL) of $1 million per avoided premature mortality in 2005, applied globally, as this value has been suggested to be a reasonable global average VSL (Markandaya et al., 2001), and calculate benefits for both the total avoided mortalities and for C&R mortalities only. Although different VSLs have been applied for analyses focused on particular nations – the US Environmental Protection Agency currently uses $6.9 million for domestic decisions involving air pollution mortality, while much lower values are applied in developing nations – here we evaluate the effects of a global reduction in methane affecting citizens of all nations, for which a common global VSL is more justifiable. We assume that the VSL grows in the future, proportionally with world GDP, based on the GDP growth in the IPCC SRES B2 scenario (Nakicenovic et al., 2000), to $2.7 million in 2060. These estimates of benefits can be scaled simply to other choices of a global average 2005 VSL.

For all scenarios, the benefits are positive and increase through time as methane reductions are phased in, as ozone responds to the long lifetime of methane, and as population grows. For Scenario C, the benefits exceed the costs with technological learning in each year of the analysis. As mentioned earlier, Figure 6 is not an accurate reflection of when the actual costs would be borne, since we use annualized costs, but we accurately report the present value (PV) since a common discount rate (5%) is used throughout.

The PV of costs and monetized benefits are summarized in Table 4. Here we analyze the costs and benefits for each scenario incrementally – *e.g.*, for the reductions in Scenario B additional to those in A. We use these incremental results as proxies for the marginal costs and benefits of each scenario, providing a basis for determining if the additional emissions controls are justified. For Scenario A, the net costs are negative, and any positive benefits would be expected to outweigh the costs and justify the actions. Scenario B has very small positive costs of implementation beyond the negative costs of measures included in Scenario A; although Scenario B adopts some positive cost measures, it also implements the cost-saving measures sooner, such that these cost savings are then discounted less. These small positive costs are easily outweighed by the monetized health benefits. The additional reductions for Scenario C with technological learning, beyond those in B, come at a large positive cost, as measures with positive cost begin to be implemented in 2012.

While the total benefits of Scenario C outweigh the costs in Figure 6, Table 4 shows that the incremental costs of Scenario C (beyond the reductions in Scenario B) are roughly equal to the benefits. As Scenario C is not feasible without technological learning, we conclude that Scenario C is possibly cost-effective, but that this conclusion would depend heavily on the rate of technological learning and other key assumptions in this study, including the concentration-response function and discount rate.

We also show the monetized benefit per ton of methane reduced, which is comparable for the three scenarios, differing mainly in discounting, and range from $269 to $353 per ton CH_4 ($12.8 to $16.8 per ton CO_2eq). This range reflects the concentration-response function for total mortality and a VSL of $1 million; use of alternative assumptions would result in a much larger range for the co-benefit. This monetized benefit is comparable to the $12 per ton CO_2eq estimated by West et al. (2006) despite differences in study design – particularly the use of scenarios that are gradually phased in here compared to immediate implementation. This monetized benefit can be taken as the point at which measures with lower annual marginal costs would be justified, but more expensive measures would not be, suggesting that the least costly measures in Scenario C would have benefits exceeding costs, but the most costly would not be justified.

6. Comparing costs and benefits for Annex 1 nations

Were the costs of international methane reductions to be borne entirely by wealthy nations, there may be interest in seeing whether the benefits of avoided mortalities within these nations would justify the cost, apart from additional benefits in developing nations. In Table 4, we show the PV of mortality benefits realized within only Annex 1 nations of the United Nations Framework Convention on Climate Change. Rather than the $1 million applied globally, a higher VSL would likely be appropriate for Annex 1 nations, and we choose $5 million for illustration. This VSL then grows with GDPs in wealthy nations at a rate that is slower than the global GDP growth, to $8.3 million in 2060. Even though avoided mortalities in Annex 1 are ~15% of the global, using the higher VSL makes the total Annex 1 monetized benefits ~60% of the global.

These benefits can be compared against the global costs of methane reductions in Table 4, if we assume that Annex 1 nations can invest in the least expensive methane reductions globally. Doing so, the comparison between costs and benefits is similar to that for global benefits (Section 5) but with Scenario C appearing less attractive. We also analyze the case where methane is only reduced in Annex 1 nations, based on the locations of available methane reductions reported by IEA (2003), DeAngelo et al. (2006), and EPA (2006b), and using assumptions consistent with those in Section 2. We find that the maximum methane reduction available in Annex 1 nations in 2030, assuming no technological learning, is about 70 Mton CH_4 yr^{-1}, which would make all three scenarios impossible using only current technologies. The costs of a large methane reduction program would therefore be expected to be much higher if low-cost opportunities are not employed globally.

7. Conclusions

Mitigation of methane emissions for climate purposes provides an important co-benefit for ozone air quality and human health. We find that the benefits of improved global ozone air quality,

evaluated as avoided premature mortalities, outweigh the costs of an aggressive global methane control scenario (Scenario B), without considering benefits of reduced climate impacts. Two compilations of the costs of reducing global methane emissions used here (IEA (2003) and EPA (2006b)) both show that a substantial fraction (~10%) of global anthropogenic methane emissions can be reduced at a net cost-savings due to the value of the captured methane as an energy resource. Consequently, Scenario A can be justified simply because the costs of implementation are negative while costs are positive. We find that the additional reductions in Scenario B (beyond those in Scenario A) come at very low cost, despite adopting positive cost measures, because it implements cost-saving measures more quickly than Scenario A. Scenario B also has nearly twice the monetized benefits of Scenario A, and those benefits easily exceed the costs. This would suggest that policies that aggressively take advantage of cost-saving methane mitigation opportunities in the near term would best increase social welfare. Scenario C requires technological learning in order to be feasible, and we estimate that Scenario C with technological learning has benefits roughly equal to costs, and is therefore strongly dependent on choices of the VSL, the rate of learning, and the other uncertainties in this study. As benefits exceed costs in several scenarios, methane mitigation is a cost-effective means of improving ozone air quality.

We estimate the monetized co-benefits of reduced mortalities to be \$13-\$17 per ton CO_2eq, under base assumptions, but with a wider range of values possible under alternative assumptions (*e.g.*, the VSL and concentration-response factor). This co-benefit is comparable to the \$12 per ton CO_2eq estimated by West et al. (2006), but differs from that of West et al. (2006) because we have simulated realistic emission control scenarios through time, which distributes benefits such that they are discounted more. On the other hand, the present study accounts for the costs and benefits of scenarios beyond 2030, and allows VSLs to increase in the future as incomes rise, and these improvements tend to make abatement more attractive. Consequently, many of the reductions in Scenario C would likely be justified, but the most expensive may not be.

The benefits of reduced methane for human health have large uncertainties associated with the surface ozone response to methane, and the global health response to ozone. Understanding the effects of changes in the global ozone background on mortality can be improved through further studies in developing nations and over a range of concentrations. In particular, while we emphasize short-term mortalities, estimated benefits may increase if evidence for chronic mortalities (Jerrett et al., 2009) is supported in future studies. The effects of methane on ozone in urban regions, and the importance of grid cell resolution for health impact analysis should be investigated further. Future research should also investigate the effects of ozone on several morbidity outcomes globally, as inclusion of morbidity would likely increase benefits, and should consider valuation of benefits based on disability-adjusted life years. Further, a wide range of VSLs may be considered to be appropriate for this global analysis, and the estimated benefits would scale with different 2005 VSLs.

Costs are also uncertain as new technologies for reducing emissions are developed and improved. Here we consider the costs of implementing technologies, and ignore the transaction costs or costs of administrating large national or international emission reduction policies. These costs would be relatively small for industrial sources, as a smaller number of companies would be involved, and current actions to reduce methane target these sectors. Widespread

implementation would likely be more difficult and costly for agricultural emissions, due to the large number of entities involved globally. Significant progress has been made in reducing industrial emissions from industrialized nations, and since methane emissions are projected to grow in developing nations (EPA, 2006a; Moss et al., 2010), effectively transferring technologies to developing nations can make significant reductions tractable and affordable. Future work should further analyze the rates at which methane reductions are plausible, and identify barriers to rapid implementation.

In addition to the benefits evaluated here, methane mitigation would also have important benefits for slowing global climate change, which would manifest in a variety of avoided impacts, including sea level rise, agriculture, water resources, and human health (IPCC, 2007). Reduced ozone concentrations would also provide benefits in avoided morbidity impacts on human health and agricultural productivity (West and Fiore, 2005), ecosystems and the global carbon cycle (Felzer et al., 2005; Sitch et al., 2007), and materials. This research suggests that while methane mitigation is important for global climate change, as methane is a dominant short-lived forcing agent, the co-benefits of methane mitigation for air quality and human health are substantial. Methane mitigation deserves consideration as a cost-effective tool for long-term management of global baseline ozone. Both air quality and climate goals should be accounted for as methane mitigation is evaluated, and methane should play a key role in coordinating actions to address both problems simultaneously.

Acknowledgments

We thank Joe Chaisson, Ellen Baum, Ben DeAngelo, Dale Whittington, John Alic, and three anonymous referees for their helpful input. This research was supported by the National Oceanographic and Atmospheric Administration and by the Merck Foundation.

References

Anenberg SC, Horowitz LW, Tong DQ, West JJ (2010) An Estimate of the Global Burden of Anthropogenic Ozone and Fine Particulate Matter on Premature Human Mortality Using Atmospheric Modeling. Environ Health Perspect 118 (9):1189-1195

Anenberg SC, West JJ, Fiore AM, Jaffe DA, Prather MJ, Bergmann D, Cuvelier C, Dentener FJ, Gauss M, Hess P, Jonson JE, Lupu A, MacKenzie IA, Marmer E, Park RJ, Sanderson M, Schultz M, Shindell DT, Szopa S, Vivanco MG, Wild O, Zeng G (2009) Intercontinental Impacts of Ozone Pollution on Human Mortality. Environ Sci Technol 43:6482-6487

Aunan K, Jinghua Fang, Heidi Elizabeth Staff Mestl, D. O'Connor, Hans Martin Seip, Haakon Vennemo, Zhai F (2003) Co-benefits of CO2-reducing policies in China - a matter of scale? Intl J Global Environ Issues 3 (3):287-304

Aunan K, Fang JH, Vennemo H, Oye K, Seip HM (2004) Co-benefits of climate policy - lessons learned from a study in Shanxi, China. Energy Policy 32 (4):567-581

Barker T, Bashmakov I, Alharthi A, Amann M, Cifuentes L, Drexhage J, Duan M, Edenhofer O, Flannery B, Grubb M, Hoogwijk M, Ibitoye FI, Jepma CJ, Pizer WA, Yamaji K (2007) Mitigation from a cross-sectoral perspective. In: Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds) Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge,

Barrett SRH, Britter RE, Waitz IA (2010) Global Mortality Attributable to Aircraft Cruise Emissions. Environmental Science & Technology 44 (19):7736-7742

Bell M, Dominici F (2006) Analysis of threshold effects for short-term exposure to ozone and increased risk of mortality. Epidemiology 17 (6):S223-S223

Bell ML, Dominici F, Samet JM (2005) A meta-analysis of time-series studies of ozone and mortality with comparison to the National Morbidity, Mortality, and Air Pollution Study. Epidemiology 16 (4):436-445

Bell ML, McDermott A, Zeger SL, Samet JM, Dominici F (2004) Ozone and short-term mortality in 95 US urban communities, 1987-2000. JAMA 292 (19):2372-2378

Burtraw D, Krupnick A, Palmer K, Paul A, Toman M, Bloyd C (2003) Ancillary benefits of reduced air pollution in the US from moderate greenhouse gas mitigation policies in the electricity sector. J Environ Econ Manage 45 (3):650-673

Cifuentes L, Borja-Aburto VH, Gouveia N, Thurston G, Davis DL (2001) Climate change: Hidden health benefits of greenhouse gas mitigation. Science 293 (5533):1257-1259

Cifuentes L, Borja-Aburto VH, Gouveia N, Thurston G, Davis DL (2001) Assessing the health benefits of urban air pollution reductions associated with climate change mitigation (2000-2020): Santiago, Sao Paulo, Mexico City, and New York City. Environ Health Perspect 109:419-425

Clarke LE, Wise M, Placet M, Izaurralde RC, Lurz JP, Kim SH, Smith SJ, Thomson AM (2006) Climate Change Mitigation: An Analysis of Advanced Technology Scenarios. Pacific Northwest National Laboratory,

Cofala J, Amann M, Klimont Z, Kupiainen K, Hoglund-Isaksson L (2007) Scenarios of global anthropogenic emissions of air pollutants and methane until 2030. Atmos Environ 41 (38):8486-8499

Corbett JJ, Winebrake JJ, Green EH, Kasibhatla P, Eyring V, Lauer A (2007) Mortality from ship emissions: A global assessment. Environmental Science & Technology 41 (24):8512-8518

Crutzen P (1973) A discussion of the chemistry of some minor constituents in the stratosphere and troposphere. Pure Appl Geophys 106-108:1385-1399

DeAngelo BJ, de la Chesnaye FC, Beach RH, Sommer A, Murray BC (2006) Methane and nitrous oxide mitigation in agriculture. Energy J:89-108

Denman KL, Brasseur G, Chidthaisong A, Ciais P, Cox PM, Dickinson RE, Hauglustaine D, Heinze C, Holland E, Jacob D, Lohmann U, Ramachandran S, da Silva Dias PL, Wofsy SC, Zhang X (2007) Couplings Between Changes in the Climate System and Biogeochemistry. In: Solomon S, Qin D, Manning M et al. (eds) Climate Change 2007: The Physcial Science Basis. Cambridge University Press, New York,

Dentener F, Stevenson D, Cofala J, Mechler R, Amann M, Bergamaschi P, Raes F, Derwent R (2005) The impact of air pollutant and methane emission controls on tropospheric ozone and radiative forcing: CTM calculations for the period 1990-2030. Atmos Chem Phys 5:1731-1755

Dentener F, Stevenson D, Ellingsen K, van Noije T, Schultz M, Amann M, Atherton C, Bell N, Bergmann D, Bey I, Bouwman L, Butler T, Cofala J, Collins B, Drevet J, Doherty R, Eickhout B, Eskes H, Fiore A, Gauss M, Hauglustaine D, Horowitz L, Isaksen ISA, Josse B, Lawrence M, Krol M, Lamarque JF, Montanaro V, Muller JF, Peuch VH, Pitari G, Pyle J, Rast S, Rodriguez J, Sanderson M, Savage NH, Shindell D, Strahan S, Szopa S, Sudo K, Van Dingenen R, Wild O, Zeng G (2006) The global atmospheric environment for the next generation. Environmental Science & Technology 40 (11):3586-3594

Dutton JM, Thomas A, Butler JE (1984) The History of Progress Functions as a Managerial Technology. Business History Review 58:204-233

Ekins P (1996) The secondary benefits of CO2 abatement: How much emission reduction do they justify? Ecological Economics 16 (1):13-24

EMEP (2005) The development of European surface ozone: Implications for a revised abatement policy.

Environmental Protection Agency (2006a) Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2020. Washington, DC

Environmental Protection Agency (2006b) Global Mitigation of Non-CO_2 Greenhouse Gases. Washington, DC

Felzer B, Reilly J, Melillo J, Kicklighter D, Sarofim M, Wang C, Prinn R, Zhuang Q (2005) Future effects of ozone on carbon sequestration and climate change policy using a global biogeochemical model. Climatic Change 73 (3):345-373

Fiore AM, Dentener FJ, Wild O, Cuvelier C, Schultz MG, Hess P, Textor C, Schulz M, Doherty RM, Horowitz LW, MacKenzie IA, Sanderson MG, Shindell DT, Stevenson DS, Szopa S, Van Dingenen R, Zeng G, Atherton C, Bergmann D, Bey I, Carmichael G, Collins WJ, Duncan BN, Faluvegi G, Folberth G, Gauss M, Gong S, Hauglustaine D, Holloway T, Isaksen ISA, Jacob DJ, Jonson JE, Kaminski JW, Keating TJ, Lupu A, Marmer E, Montanaro V, Park RJ, Pitari G, Pringle KJ, Pyle JA, Schroeder S, Vivanco MG, Wind P, Wojcik G, Wu S, Zuber A (2009) Multimodel estimates of intercontinental source-receptor relationships for ozone pollution. J Geophys Res 114:D04301

Fiore AM, Jacob DJ, Field BD, Streets DG, Fernandes SD, Jang C (2002) Linking ozone pollution and climate change: The case for controlling methane. Geophys Res Lett 29 (19):1919

Fiore AM, West JJ, Horowitz LW, Naik V, Schwarzkopf MD (2008) Characterizing the tropospheric ozone response to methane emission controls and the benefits to climate and air quality. J Geophys Res 113 (D8):D08307

Forster P, Ramaswamy V, Artaxo P, Berntsen T, Betts R, Fahey DW, Haywood J, Lean J, Lowe DC, Myhre G, Nganga J, Prinn R, Raga G, Schulz M, R. Van Dorland (2007) Changes in Atmospheric Constituents and in Radiative Forcing. In: Solomon S, Qin D, Manning M et al. (eds) Climate Change 2007: The Physcial Science Basis. Cambridge University Press, New York,

Grubb M, Kohler J, Anderson D (2002) Induced technical change in energy and environmental modeling: Analytic approaches and policy implications. Ann Rev Energy Environ 27:271-308

Gryparis A, Forsberg B, Katsouyanni K, Analitis A, Touloumi G, Schwartz J, Samoli E, Medina S, Anderson HR, Niciu EM, Wichmann HE, Kriz B, Kosnik M, Skorkovsky J, Vonk JM, Dortbudak Z (2004) Acute effects of ozone on mortality from the "Air pollution and health: A European approach" project. Am J Respir Crit Care Med 170 (10):1080-1087

Hansen J, Sato M, Ruedy R, Lacis A, Oinas V (2000) Global warming in the twenty-first century: An alternative scenario. Proc Natl Acad Sci U S A 97 (18):9875-9880

HEI International Scientific Oversight Committee (2004) Health Effects of Outdoor Air Pollution in Developing Countries of Asia: A Literature Review. Health Effects Institute, Boston

Hemistpheric Transport of Air Pollution Working Group (HTAP) (2010) *Hemispheric Transport of Air Pollution: Part A, Ozone and Particulate Matter*, Eds. F. Dentener, T. Keating, H. Akimoto, UN Economic Commission for Europe, Geneva, www.htap.org.

Intergovernmental Panel on Climate Change (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II tot he Fourth Assessment Report of the Interngovernmental Panel on Climate Change. Cambridge Universtiy Press, Cambridge

International Energy Agency Greenhouse Gas R & D Programme (2003) Building the cost curves for the industrial sources of non-CO_2 greenhouse gases.

Ito K, De Leon SF, Lippman M (2005) Associations between ozone and daily mortality. Epidemiology 16 (4):446-457

Jacobson MZ (2008) On the causal link between carbon dioxide and air pollution mortality. Geophys Res Lett 35 (3):L03809

Lelieveld J, Dentener FJ (2000) What controls tropospheric ozone? J Geophys Res 105 (D3):3531-3551

Jackson SC (2009) Parallel Pursuit of Near-Term and Long-Term Climate Mitigation. Science 326 (5952):526-527

Levy JI, Carrothers TJ, Tuomisto JT, Hammitt JK, Evans JS (2001) Assessing the public health benefits of reduced ozone concentrations. Environ Health Perspect 109 (12):1215-1226

Levy JI, Chemerynski SM, Sarnat JA (2005) Ozone exposure and mortality: an empiric Bayes metaregression analysis. Epidemiology 16 (4):458-468

Liu JF, Mauzerall DL, Horowitz LW (2009) Evaluating inter-continental transport of fine aerosols:(2) Global health impact. Atmos Environ 43 (28):4339-4347

Markandaya A, Halsnaes K, Lanza A, Matsuoka Y, Maya S, Pan J, Shogren J, Seroa de Motta R, Zhang T (2001) Costing Methodologies. In: Metz B, Davidson O, Swart R, Pan J (eds) Climate Change 2001: Mitigation. Cambridge Univ. Press, Cambridge, pp 451-498

Moss RH, Edmonds JA, Hibbard KA, Manning MR, Rose SK, van Vuuren DP, Carter TR, Emori S, Kainuma M, Kram T, Meehl GA, Mitchell JFB, Nakicenovic N, Riahi K, Smith SJ, Stouffer RJ, Thomson AM, Weyant JP, Wilbanks TJ (2010) The next generation of scenarios for climate change research and assessment. Nature 463 (7282):747-756

Nakicenovic N, Alcamo J, Davis G, de Vries B, Fenhann J, Gaffin S, Gregory K, Grubler A, Jung TY, Kram T, La Revere EL, Michaelis L, Mori S, Morita T, Pepper W, Pitcher H, Price L, Riahi K, Roehrl A, Rogner H-H,

Sankovski A, Schlesinger M, Shukla P, Smith S, Swart R, van Rooijen S, Victor N, Dadi Z (2000) Special Report on Emissions Scenarios. Cambridge University Press, Cambridge

National Research Council (2008) Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution. National Academy Press, Washington, DC

Land Scan 2003 (2005) http://www.ornl.gov/sci/gist/landscan/landscan2003/. Accessed January, 2005

OECD (2000) Ancillary Benefits and Costs of Greenhouse Gas Mitigation, vol 592. OECD, Paris

Reilly J, Prinn R, Harnisch J, Fitzmaurice J, Jacoby H, Kicklighter D, Melillo J, Stone P, Sokolov A, Wang C (1999) Multi-gas assessment of the Kyoto Protocol. Nature 401 (6753):549-555

Riahi K, Rubin ES, Taylor MR, Schrattenholzer L, Hounshell D (2004) Technological learning for carbon capture and sequestration technologies. Energy Economics 26 (4):539-564

Royal Society (2008) Ground-level ozone in the 21st century: future trends, impacts, and policy implications. London

Rubin ES, Taylor MR, Yeh S, Hounshell DA (2004) Learning curves for environmental technology and their importance for climate policy analysis. Energy 29 (9-10):1551-1559

Sitch S, Cox PM, Collins WJ, Huntingford C (2007) Indirect radiative forcing of climate change through ozone effects on the land-carbon sink. Nature 448 (7155):791-U794

Taylor MR, Rubin ES, Hounshell DA (2003) Effect of government actions on technological innovation for SO2 control. Environmental Science & Technology 37 (20):4527-4534

Thurston GD, Ito K (2001) Epidemiological studies of acute ozone exposures and mortality. J Expo Anal Environ Epidemiol 11 (4):286-294

United Nations Environment Program (2011) *Integrated Assessment of Black Carbon and Tropospheric Ozone*.

van Vuuren DP, Cofala J, Eerens HE, Oostenrijk R, Heyes C, Klimont Z, Elzen MGJd, Amann M (2006) Exploring the ancillary benefits of the Kyoto Protocol for air pollution in Europe. Energy Policy 34:444-460

van Vuuren DP, Weyant J, de la Chesnaye F (2006) Multi-gas scenarios to stabilize radiative forcing. Energy Economics:28:102-120.

Vennemo H, Aunan K, Fang JH, Holtedahl P, Tao H, Seip HM (2006) Domestic environmental benefits of China's energy-related CDM potential. Clim Change 75 (1-2):215-239

Wang YH, Jacob DJ (1998) Anthropogenic forcing on tropospheric ozone and OH since preindustrial times. J Geophys Res 103 (D23):31123-31135

West JJ, Fiore AM (2005) Management of tropospheric ozone by reducing methane emissions. Environ Sci Technol 39 (13):4685-4691

West JJ, Fiore AM, Horowitz LW, Mauzerall DL (2006) Global health benefits of mitigating ozone pollution with methane emission controls. Proc Natl Acad Sci U S A 103 (11):3988-3993

West JJ, Fiore AM, Naik V, Horowitz LW, Schwarzkopf MD, Mauzerall DL (2007a) Ozone air quality and radiative forcing consequences of changes in ozone precursor emissions. Geophys Res Lett 34 (6):L06806

West JJ, Naik V, Horowitz LW, Fiore AM (2009a) Effect of regional precursor emission controls on long-range ozone transport - Part 1: Short.term changes in ozone air quality. Atmos Chem Phys 9:6077-6093

West JJ, Naik V, Horowitz LW, Fiore AM (2009b) Effect of regional precursor emission controls on long-range ozone transport - Part 2: Steady-state changes in ozone air quality and effects on human mortality. Atmos Chem Phys 9:6095-6107

West JJ, Szopa S, Hauglustaine DA (2007b) Human mortality effects of future concentrations of tropospheric ozone. Comptes Rendus Geoscience 339 (11-12):775-783

Weyant J, de la Chesnaye FC, Blanford GJ (2006) Overview of EMF-21: Multigas mitigation and climate policy. Energy Journal 3:1-32

Working Group on Public Health and Fossil Fuel Combustion (1997) Short-term improvements in public health from global climate policies on fossil fuel combustion: an interim report. Lancet 350:1341-1349

World Health Organization (2004) The World Health Report 2004: Changing History. World Health Organization, Geneva

Figure Legends

Figure 1 – a) Methane emissions reductions relative to the base CLE scenario, and b) total anthropogenic emissions, for the CLE base and MFR scenarios, available reductions at <$15 per ton CO_2 equivalent for the IEA and EPA compilations of global methane abatement opportunities (extended to 2030 and modified as described in the text), three scenarios defined in this study, and the RCP scenarios.

Figure 2 – Marginal cost of methane emission reduction scenarios to 2030, based on the marginal costs reported by IEA (2003) and modified as described in the text, for no technological learning (solid), and learning to expand the emission reductions possible at each marginal cost by 1% per year (dashed). These costs can be divided by the global warming potential of methane, to obtain costs per ton CO_2eq.

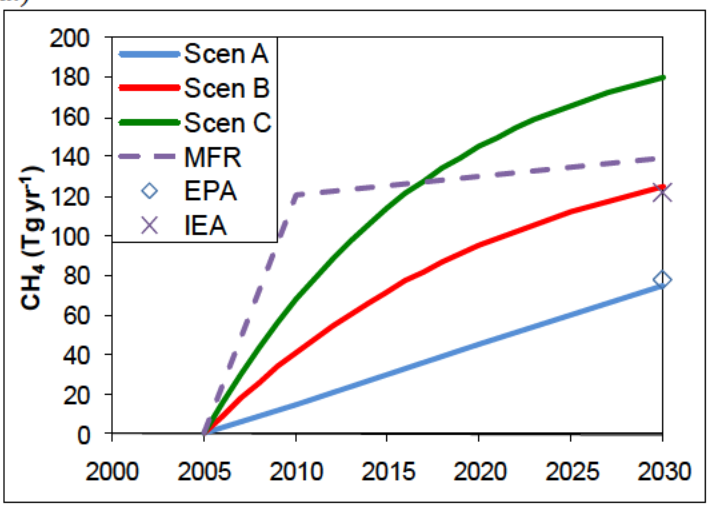
Figure 3 – Change in global annual average population-weighted 8-hr. ozone, in the three methane reduction scenarios relative to the CLE baseline.

Figure 4 – Global annual avoided premature mortalities due to ozone, under the three methane emissions abatement scenarios, for total avoided mortalities with a low-concentration threshold of 25 ppb (solid lines), total mortalities with no low-concentration threshold (dotted lines), and cardiovascular and respiratory mortalities with a 25 ppb threshold (dashed lines).

Figure 5 – Annual avoided premature mortalities in 2030 under scenario B relative to CLE (assuming a low-concentration threshold of 25 ppb), shown for a.) total avoided premature mortalities, and b.) avoided mortalities per million people.

Figure 6 – The annual costs and monetized benefits of avoided total and cardiovascular and respiratory (C&R) mortalities (evaluated at $1 million per mortality) realized in a.) Scenario A, b.) B, and c.) C. Costs are based on presently available methane mitigation technologies (no technological learning) and with technological learning to increase the availability of controls at each marginal cost by 1% per year. Benefits scale simply to other choices of the VSL.

a.)



b.)

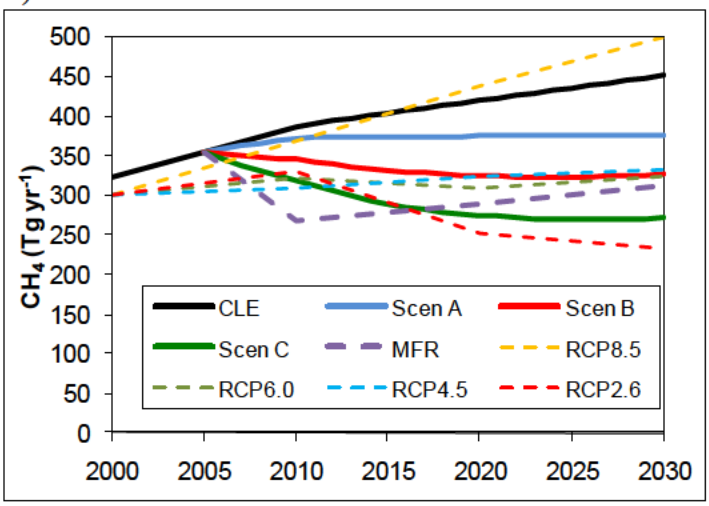


Figure 1 – a) Methane emissions reductions relative to the base CLE scenario, and b) total anthropogenic emissions, for the CLE base and MFR scenarios, three scenarios defined in this study, and the RCP scenarios. Panel a) also shows available reductions at <$15 per ton CO_2 equivalent for the IEA and EPA compilations of global methane abatement opportunities (extended to 2030 and modified as described in the text).

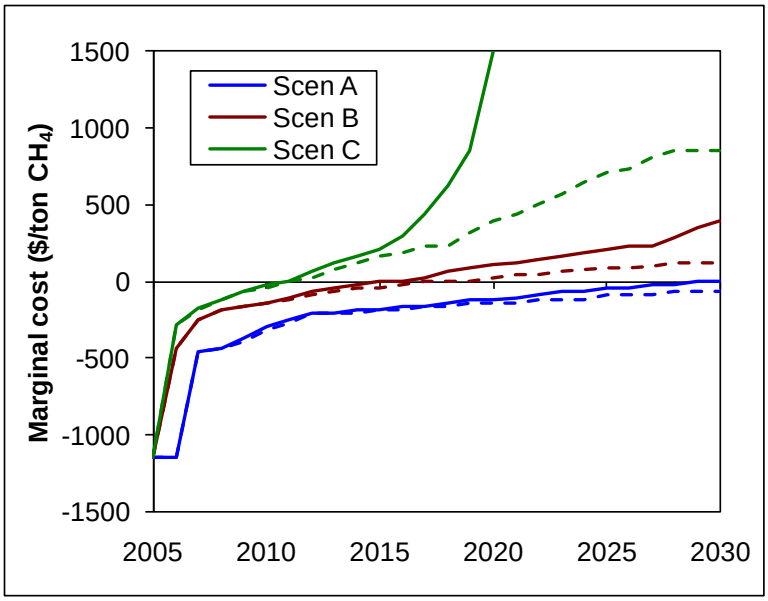


Figure 2 – Marginal cost of methane emission reduction scenarios to 2030, based on the marginal costs reported by IEA (2003) and modified as described in the text, for no technological learning (solid), and learning to expand the emission reductions possible at each marginal cost by 1% per year (dashed). These costs can be divided by the global warming potential of methane, to obtain costs per ton CO_2eq. Beyond 2030, the marginal costs are assumed to be constant at the 2030 value.

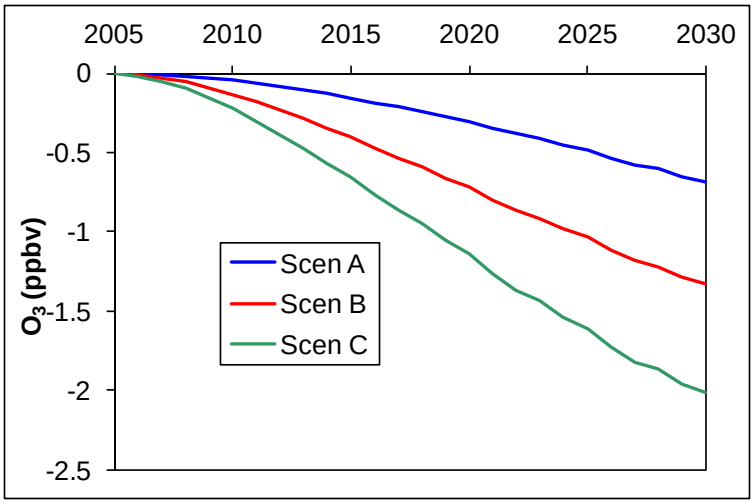


Figure 3 – Change in global annual average population-weighted 8-hr. ozone, in the three methane reduction scenarios relative to the CLE baseline.

Table 1 – Population and surface ozone concentrations (in ppb) in the base simulation, in each of 11 world regions and globally.

Region	2005 Population (million)	2030 Population (million)	2005 pop-weighted annual average 8-hr O_3[a]	2030 pop-weighted annual average 8-hr O_3[a]	2030 average 3-month pop-weighted 8-hr O_3	Three-month period with highest average pop-weighted 8-hr O_3 in 2030
Africa	908.9	1431.5	43.1	46.4	51.3	DJF
Middle East	426.1	585.2	53.5	59.2	65.6	JJA
South Asia	1288.9	1614.4	58.9	69.8	78.2	FMA
Southeast Asia	584.5	732.1	39.1	45.0	51.1	FMA
East Asia	1368.0	1710.8	49.3	50.8	62.1	MJJ
Western Pacific	176.4	196.9	61.2	61.7	78.8	MJJ
Australia	23.9	25.5	30.0	29.9	34.6	ASO
Former Soviet Union	281.0	281.0	39.0	41.0	52.3	JJA
Europe	515.9	541.1	45.1	47.3	56.2	AMJ
North America	326.3	347.2	51.7	52.9	70.5	JJA
Latin America	574.7	905.2	37.8	39.0	42.2	ASO
Global	6474.8	8371.0	48.3	52.3		

[a] The 2005 and 2030 results differ in the spatial distribution of population, as well as ozone concentrations. If we use the 2030 population distribution in 2005, the global population-weighted annual average 8-hr O_3 is 48.0 ppb.

Table 2 – Decreases in the population-weighted 8-hr. ozone concentrations (ppb) in 2030 in Scenario B relative to the CLE scenario, for the annual average and average in the three-month period with highest ozone. Changes in ozone for Scenarios A and C follow the same pattern, scaling simply to results for Scenario B (see text).

Region	Annual average ΔO_3	Three-month ΔO_3
Africa	1.33	1.32
Middle East	1.67	1.98
South Asia	1.48	1.63
Southeast Asia	1.16	1.20
East Asia	1.34	1.47
Western Pacific	1.54	1.77
Australia	0.89	0.86
Former Soviet Union	1.08	1.34
Europe	1.36	1.57
North America	1.26	1.38
Latin America	0.99	1.01
Global	1.33	

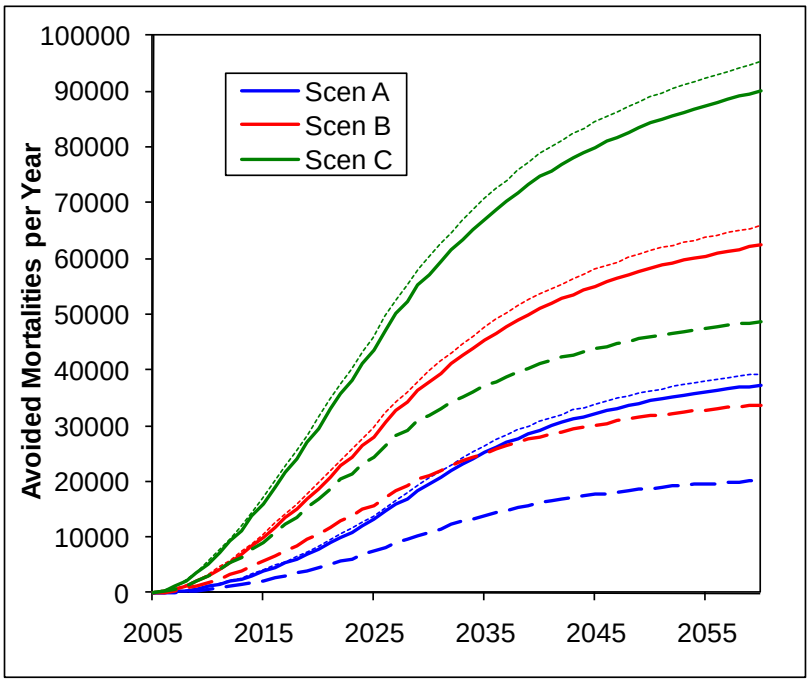


Figure 4 – Global annual avoided premature mortalities due to ozone, under the three methane emissions abatement scenarios, for total avoided mortalities with a low-concentration threshold of 25 ppb (solid lines), total mortalities with no low-concentration threshold (dotted lines), and cardiovascular and respiratory mortalities with a 25 ppb threshold (dashed lines).

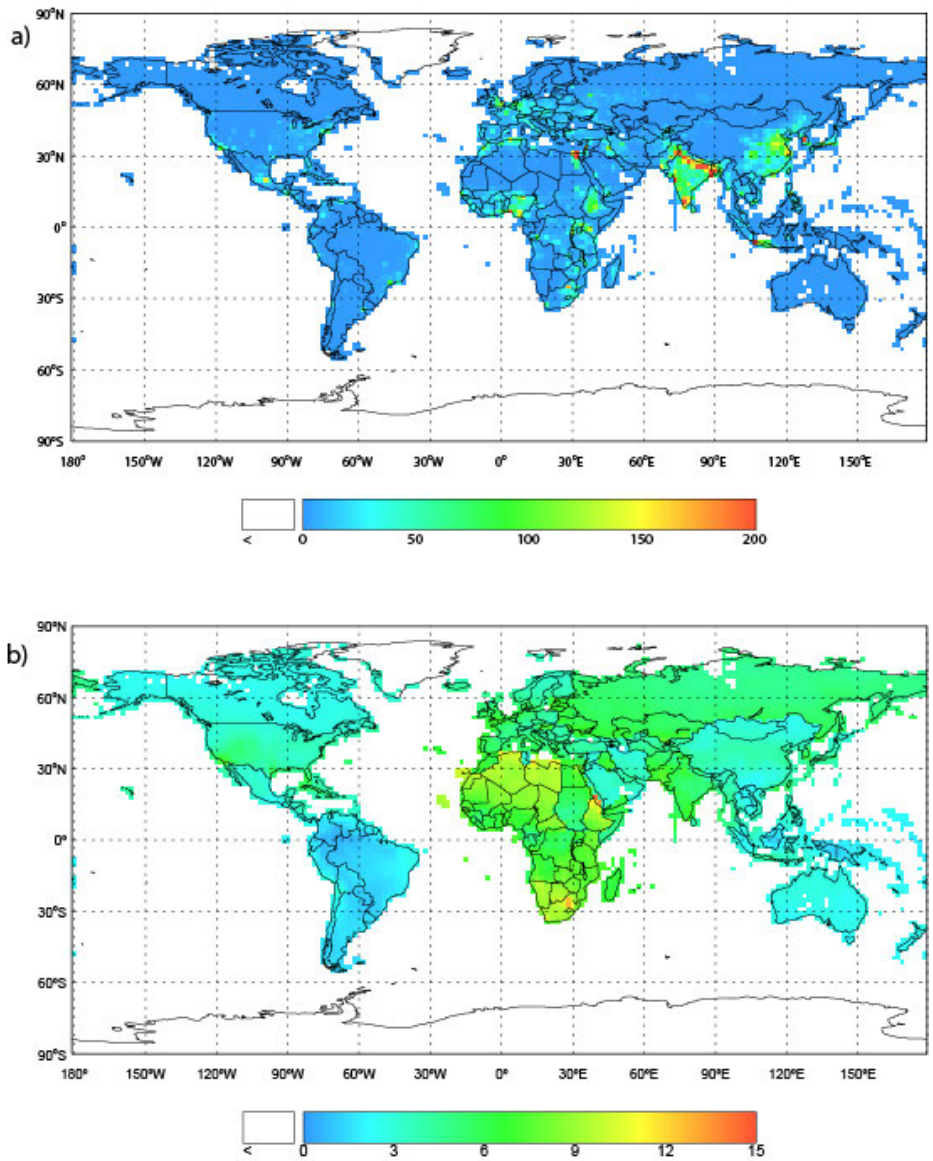


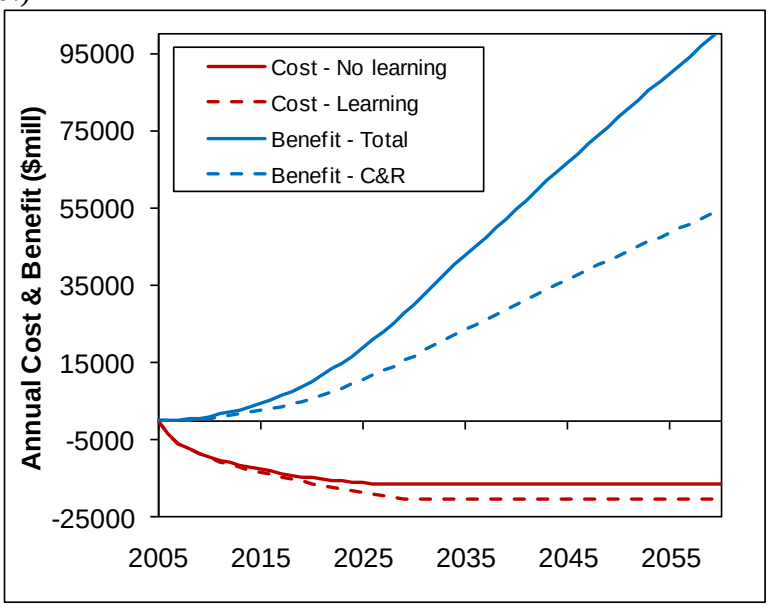
Figure 5 – Annual avoided premature mortalities in 2030 under scenario B relative to CLE (assuming a low-concentration threshold of 25 ppb), shown for a.) total avoided premature mortalities, and b.) avoided mortalities per million people.

Table 3 – Avoided total premature and cardiovascular and respiratory (C&R) mortalities per year in 2030, under scenario B relative to the base scenario, using a low-concentration threshold of 25 ppb.

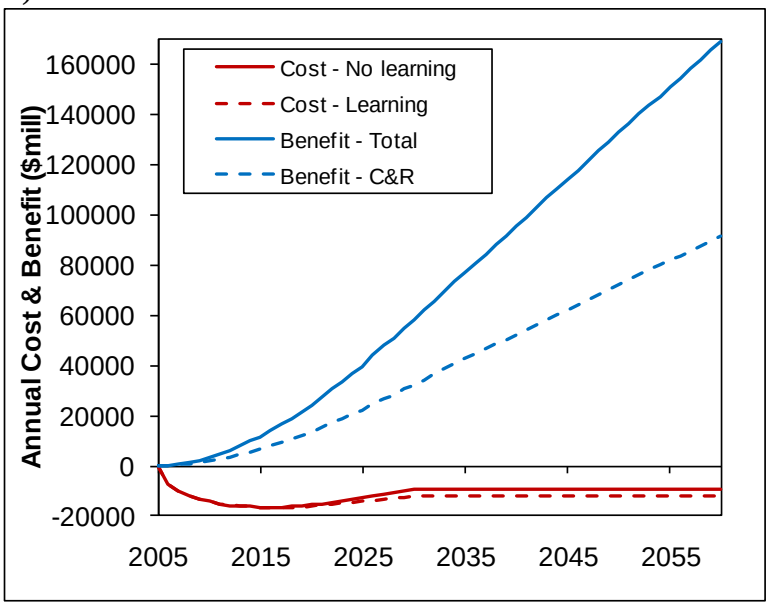
Region	Total [a]	C&R [a]	Total per million people	C&R per million people
Africa	9860	3320	6.89	2.32
Middle East	2800	1640	4.79	2.81
South Asia	8820	5190	5.46	3.21
Southeast Asia	2280	1370	3.12	1.88
East Asia	5660	3890	3.31	2.28
Western Pacific	940	570	4.78	2.91
Australia	50	30	2.01	1.24
Former Soviet Union	1390	1240	4.95	4.41
Europe	2700	1870	5.00	3.46
North America	1340	840	3.86	2.43
Latin America	1890	1030	2.09	1.14
Global	37800	21000	4.51	2.51
Annex 1 nations [b]	5840	4130	4.59	3.24

[a] Regional totals are rounded to the nearest ten mortalities, global totals to the nearest 100.
[b] The nations listed in Annex 1 of the United Nations Framework Convention on Climate Change.

a.)


Annual Cost & Benefit ($mill)
95000
75000
55000
35000
15000
-5000
-25000
2005
2015
2025
2035
2045
2055
Cost - No learning
Cost - Learning
Benefit - Total
Benefit - C&R

b.)


Annual Cost & Benefit ($mill)
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
2005
2015
2025
2035
2045
2055
Cost - No learning
Cost - Learning
Benefit - Total
Benefit - C&R

c.)

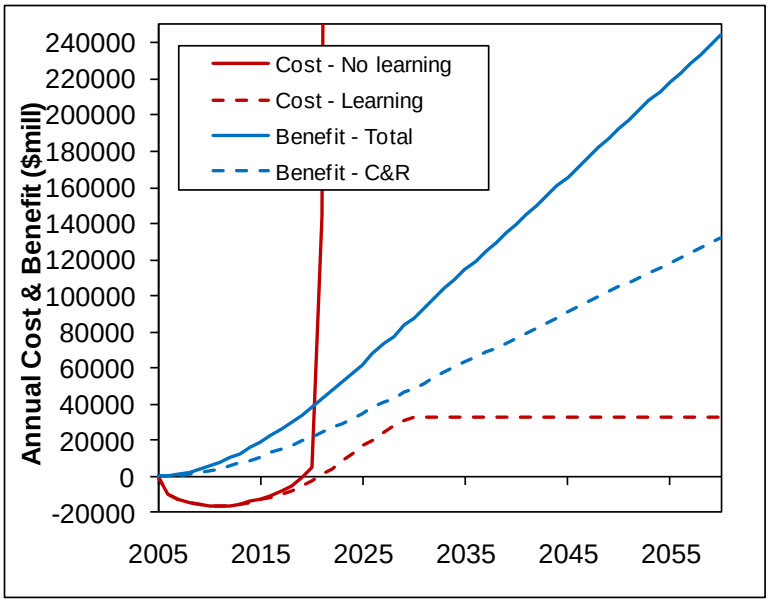


Figure 6 – The annual costs and monetized benefits of avoided total and cardiovascular and respiratory (C&R) mortalities (evaluated at $1 million per mortality) realized in a.) Scenario A, b.) B, and c.) C. Costs are based on presently available methane mitigation technologies (no technological learning) and with technological learning to increase the availability of controls at each marginal cost by 1% per year. Benefits scale simply to other choices of the VSL.

Table 4 – Costs and monetized avoided mortality benefits under the three scenarios. Total costs and benefits are shown as incremental costs for Scenario A with respect to the Base, Scenario B with respect to A, and C with respect to B. Costs are based on the IEA dataset, modified as discussed in the text. Monetized benefits use results with a low-concentration threshold of 25 ppb, and are based on a VSL of $1 million per avoided mortality for global benefits, and $5 million when only mortalities in Annex 1 nations are evaluated. Costs and benefits are discounted to present values using a discount rate of 5% per year.

	No technological learning			Technological learning			PV of Benefits			
Scenario	Marginal cost in 2030 ($/ton CH_4) ($/ton CO_2eq in parenthesis)	PV of costs ($ billion)	Average cost per avoided mortality[a] ($ thousands)	Marginal cost in 2030 ($/ton CH_4) ($/ton CO_2eq in parenthesis)	PV of costs ($ billion)	Average cost per avoided mortality[a] ($ thousands)	Total mortalities globally ($ billion)	Benefit per ton[b] ($/ton CH_4) ($/ton CO_2eq in parenthesis)	C&R mortalities globally ($ billion)	Total mortalities in Annex 1 nations ($ billion)
A (wrt base)	$0 ($0)	-$238	-$212	-$69 (-$3.2)	-$271	-$241	$375	$269 ($12.8)	$207	$220
B (wrt A)	$161 ($7.7)	$4	$4	$115 ($5.5)	$18	$20	$329	$353 ($16.8)	$183	$203
C (wrt B)	infeasible	infeasible	infeasible	$859 ($40.9)	$333	$342	$351	$343 ($16.3)	$195	$216

[a] the present value of implementation costs divided by the total global avoided mortalities (2005-2060), for Scenario A with respect to the Base, B with respect to A, and C with respect to B.

[b] the annualized present value of benefits for total mortalities globally divided by the total methane emissions reduced (in 2030), for Scenario A with respect to the Base, B with respect to A, and C with respect to B.

Supporting information

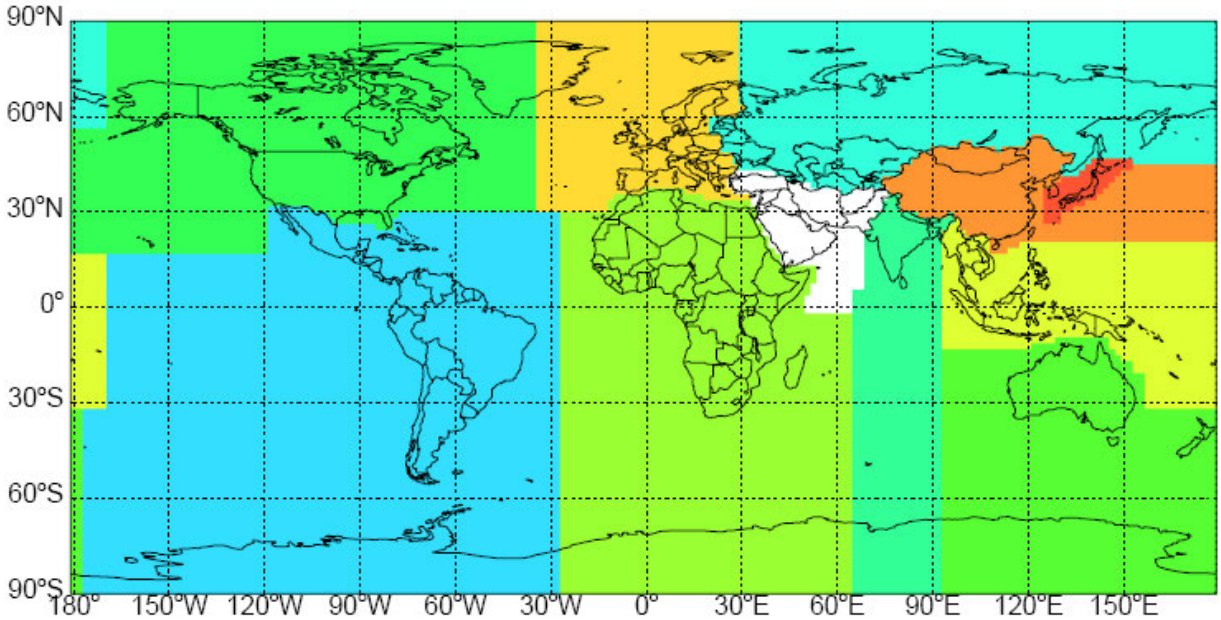


Figure S1 – Eleven world regions for assessing changes in population-weighted ozone and mortalities.

Table S1 – Annual and accumulated methane emission reductions in Scenarios A, B, and C (in Tg CH_4 yr^{-1}). Accumulated reductions between 2006 and 2030 total 975 Tg CH_4 for Scenario A, 1991.6 Tg CH_4 for Scenario B, and 3033.2 Tg CH_4 for Scenario C.

Year	Annual		
	A	B	C
2006	3.0	9.2	15.8
2007	6.0	17.9	30.5
2008	9.0	26.2	44.0
2009	12.0	33.9	56.5
2010	15.0	41.2	68.1
2011	18.0	48.1	78.8
2012	21.0	54.6	88.6
2013	24.0	60.8	97.8
2014	27.0	66.5	106.2
2015	30.0	72.0	114.0
2016	33.0	77.2	121.2
2017	36.0	82.0	127.9
2018	39.0	86.6	134.0
2019	42.0	90.9	139.7
2020	45.0	95.0	145.0
2021	48.0	98.8	149.9
2022	51.0	102.5	154.4
2023	54.0	105.9	158.5
2024	57.0	109.1	162.3
2025	60.0	112.2	165.9
2026	63.0	115.0	169.2
2027	66.0	117.8	172.2
2028	69.0	120.3	175.0
2029	72.0	122.7	177.6
2030	75.0	125.0	180.0

From:	Paul Gunning
To:	Dale Evarts
Subject:	N2O
Date:	02/06/2008 04:21 PM
Attachments:	tor2005-442.pdf CCTP-StratPlan-Ch07-Sep-2006.pdf tor2005-421.pdf tor2005-441.pdf

---

Dale,

Here is some info. on N2O. This comes from our work on the Climate Change Technology Program. Let me know if you have any questions or need additional info.

Hope all is well.

Paul

tor2005-442.pdf CCTP-StratPlan-Ch07-Sep-2006.pdf tor2005-421.pdf tor2005-441.pdf

Paul M. Gunning
Chief, Non-CO2 Programs Branch
Climate Change Division
U.S. EPA (6207J)
1200 Pennsylvania Avenue
Washington, DC 20460
(202) 343-9736
Fax (202) 343-2202
Cell (202) 251-1436

Office Address - Overnight Mail
US EPA
1310 L Street, NW
Washington, DC 20005

From:	Kelsi Bracmort
To:	
Cc:	Paul Gunning/DC/USEPA/US@EPA; Tom Wirth/DC/USEPA/US@EPA; A.R.Ravishankara@noaa.gov
Subject:	New CRS Report - Nitrous Oxide from Agricultural Sources
Date:	10/27/2009 04:28 PM
Attachments:	R40874.pdf

Greetings,

FYI - CRS issued a new Report *Nitrous Oxide from Agricultural Sources: Potential Role in Greenhouse Gas Emission Reduction and Ozone Recovery* (see attached report).

Thank you for your assistance in responding to requests concerning nitrous oxide. Please contact me if you have any questions or comments (202-707-7283; kbracmort@crs.loc.gov).

Kelsi

Kelsi Bracmort, Ph.D.
Analyst, Agricultural Conservation and Natural Resources Policy
Congressional Research Service
Library of Congress
Phone: 202-707-7283
Fax: 202-707-7289
Email: kbracmort@crs.loc.gov

This information is intended only for the congressional addressee or other individual to whom it is addressed and may contain confidential and/or privileged material. Any review, retransmission, dissemination or other use of this information is only at the discretion of the intended recipient. If you received this in error, please contact the sender and delete the material from any computer.
The foregoing has not been cleared by CRS review and is not for attribution. This response is provided to help in time limited situations.

Reducing Emission of Non-CO2 Climate Forcers - Opportunities to Achieve Near-Term Climate Benefits

Paul M. Gunning, Climate Change Division
Office of Air and Radiation
US Environmental Protection Agency
November 3, 2011

Overview

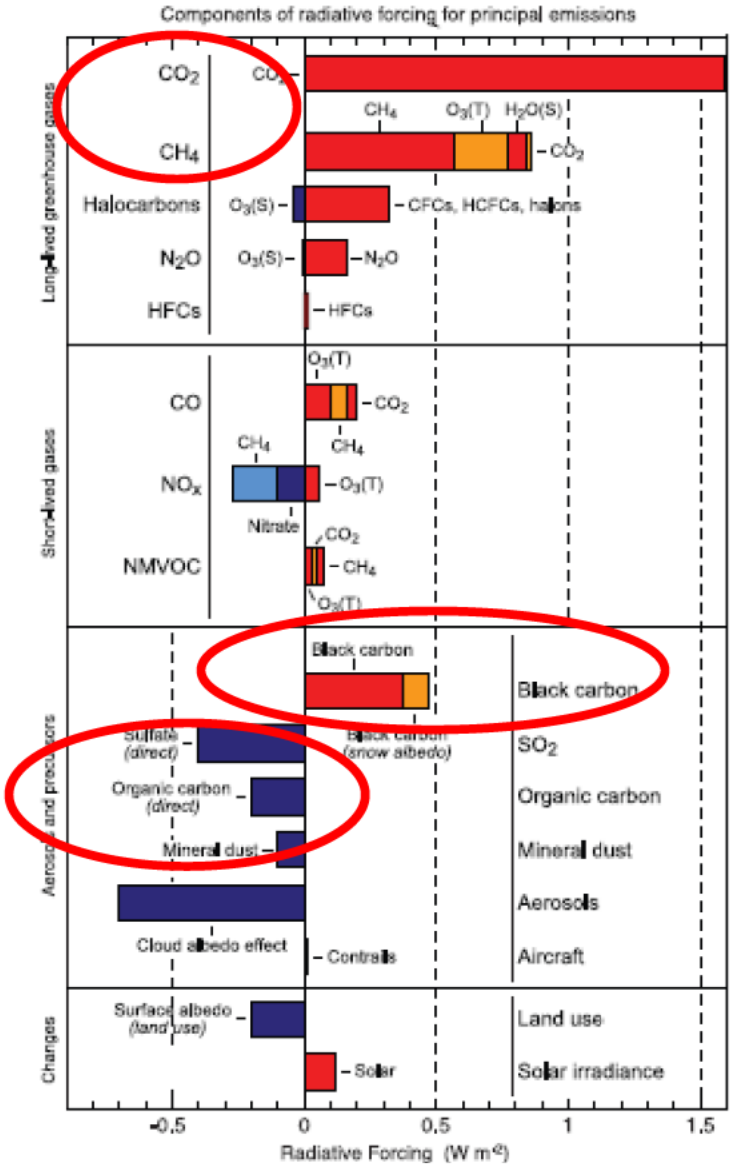
- Importance of Non-CO2 Climate Forcers
- Growing Interest in Short-lived Climate Forcers (SLCFs) – Understanding the Opportunity
  - Methane
  - Black Carbon
  - HFCs
- Possible International Coordination
- US Perspective
- Conclusion

What Are the "Other Gases"

Greenhouse Gases and Black Carbon	Atmospheric Lifetime (years)	100-Year GWP	Key Sources
Methane	12	23	Landfills, coal mines, natural gas and oil systems, enteric fermentation, livestock waste management, rice cultivation, wastewater treatment
Nitrous Oxide	120	310	Agricultural soils, livestock waste management, stationary and mobile source combustion, industrial acid production
HFCs	1.5 – 264	140 – 11,700	HCFC-22 production, substitute for Ozone Depleting Substances
PFCs	2,600 – 50,000	6,500-9,200	Primary aluminum smelting, substitute for Ozone Depleting Substances, electronics manufacturing
SF_6	3,200	23,900	Magnesium production and casting, electric utility switchgear, electronics manufacturing
NF_3	740	10,970	Electronics manufacturing
Ozone Precursors: NO_X, CO, NMVOCs	Days - months	N/A	Fossil fuel combustion, solvents. Currently being addressed under the CAA - methane is also an ozone precursor
Aerosols Sulfates Carbonaceous (BC)	Days - months	Sulfates - cooling BC –warming	Fossil fuel combustion, solvents. Currently being addressed under the CAA

Non-CO_2 Forcers Play an Important Role

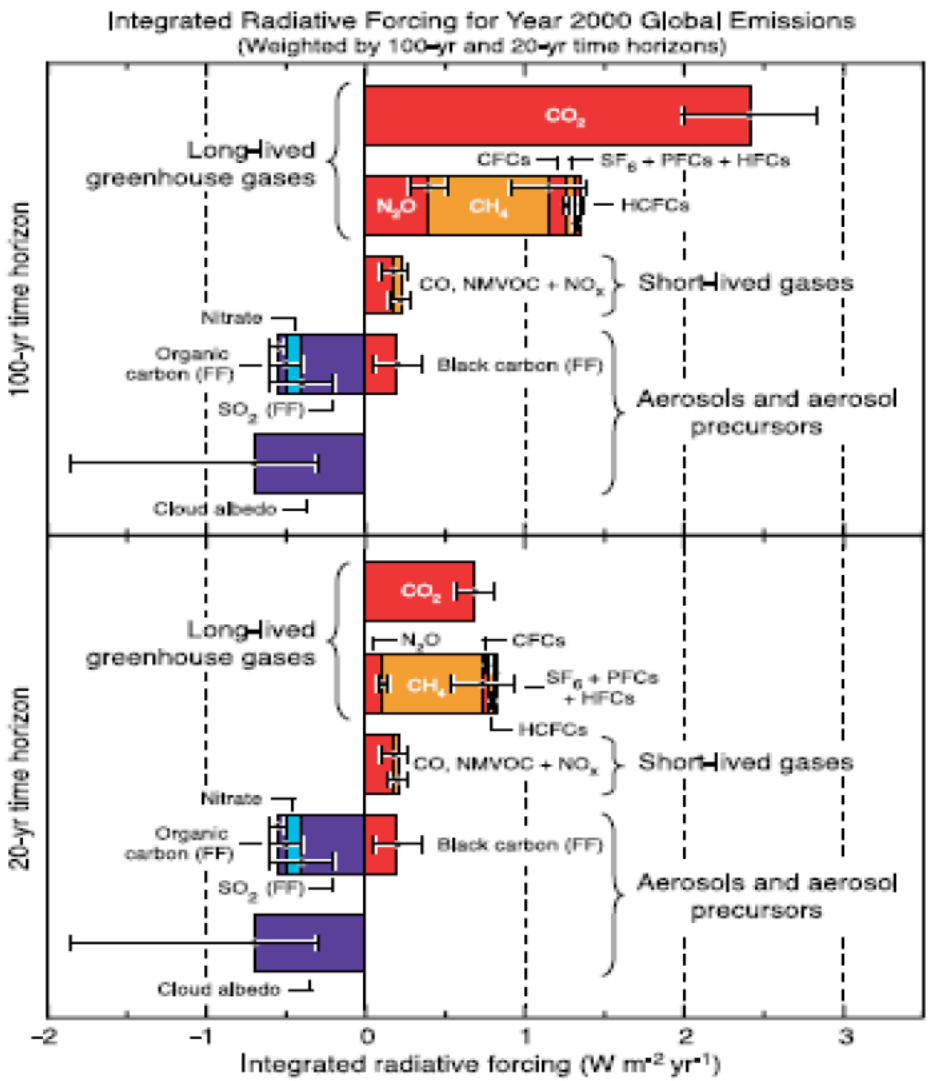
- Anthropogenic emissions of Non-CO_2 gases have been important contributors to climate change - contributing to about 40 percent of observed radiative forcing
- Direct BC warming is large at the global (and regional) scale
  - BC deposition on snow has a strong warming effect
- Co-emissions of sulfur dioxide and/or organic carbon partially offset BC warming – aerosols together have a net cooling effect
- Over the long-term, warming by CO_2 and other long-lived GHGs dominates
  - One-third of CO2 emitted will still be in the atmosphere after 100 years



Source: IPCC AR4 WG1 2007

The Role of Time Horizon

- Consideration of Longer vs. Shorter Timeframes Affects the Relative Importance of Different Gases and Aerosols
- Significant near term climate benefits with mitigation of CH4, BC, some HFCs and O3 are possible due to short atmospheric lifetimes
  - For example, potential to slow near-term Arctic warming and sea ice loss



Source: IPCC AR4 WG1 2007

Short-Lived Climate Forcers

"Short-lived climate forcers" (SLCFs) refers to gases and aerosols that have a strong impact on climate forcing, but that are not long-lived in the atmosphere compared to carbon dioxide (CO_2).

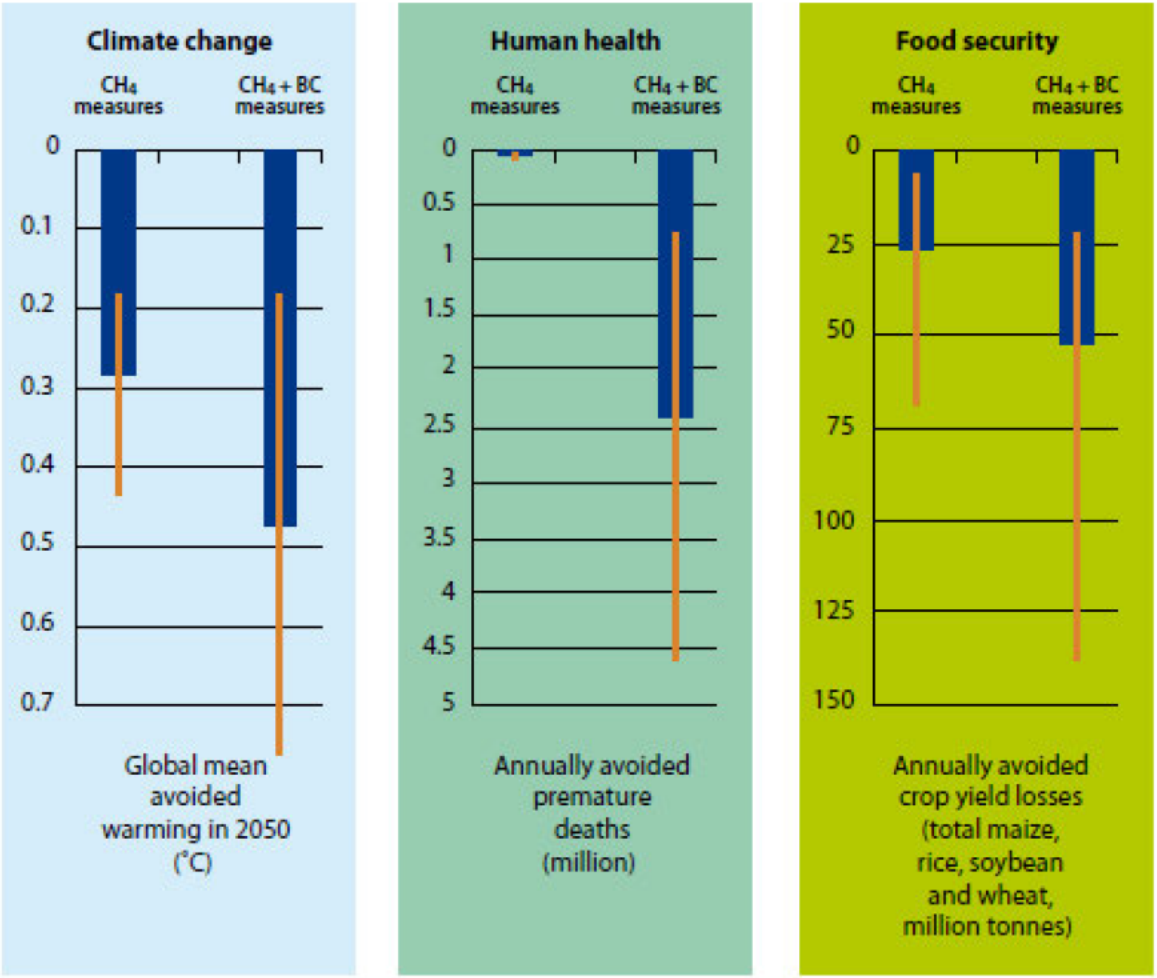
- **Methane**: Anthropogenic and natural emissions sources.
  - Atmospheric lifetime of ~ 12 years; relatively well-mixed in the atmosphere, so emissions reductions anywhere are important.
  - Very potent greenhouse gas (25 times CO_2)
  - Significant co-benefits: air and water quality, safety, energy
- **Black carbon**: particulates; major component of soot.
  - Not a GHG; rather, warms the atmosphere by absorbing sunlight.
  - Produced from incomplete combustion of fossil fuels, wood, and biomass.
  - Atmospheric lifetime is days to weeks; not well-mixed in the atmosphere.
  - Important health impacts.
- **HFCs**: Growth in use of HFCs (e.g., refrigerants and air conditioning) are a direct result of phasing out of ozone-depleting substances.
  - Majority of commercial HFCs have short atmospheric lifetimes (~ 1 to 29 years) but are very potent GHGs (hundreds of times more potent than CO_2).

UNEP, WMO *Integrated Assessment on Black Carbon and Tropospheric Ozone*

- Black carbon and tropospheric ozone are harmful air pollutants with substantial regional and global climate impacts.
- Black carbon's darkening of snow and ice surfaces increases their absorption of sunlight, which along with atmospheric heating exacerbates melting of snow and ice around the world, including the Arctic, the Himalayas, and other glaciated, snow-covered regions.
- Reducing black carbon and tropospheric ozone now will slow the rate of climate change within the first half of the century. Climate benefits are achieved by reducing emissions of methane (an ozone precursor) which is also a powerful greenhouse gas.
- The identified emissions reducing measures complement but do not replace anticipated CO_2 reduction measures.

Source: UNEP and WMO (2011): *Integrated Assessment of Black Carbon and Tropospheric Ozone – Summary for Decisionmakers*

Global Benefits from implementation of Black Carbon, methane measures (2030)



Source: UNEP and WMO (2011): *Integrated Assessment of Black Carbon and Tropospheric Ozone – Summary for Decisionmakers*

Methane: Mitigation Opportunities

Source	Key Technologies
Landfills	Methane recovery and combustion (i.e., power generation, industrial uses, flaring)
Coal Mines	Methane recovery and combustion, flaring, ventilation air use
Gas/Oil Systems	Use of low-bleed equipment, and better management practices
Livestock Waste	Methane collection from anaerobic digestors and combustion (power, flaring)
Wastewater Treatment	Methane collection from anaerobic digestors and combustion (power, flaring)
Ruminant Livestock	Improved production efficiency through better nutrition and management
Rice Production	Water management, organic supplements

Methane Reduction Efforts

- National Approaches
  - Voluntary Programs (technical assistance, capacity building)
  - Regulation (i.e., EU-US landfills)
  - Financial Incentives (i.e. tax credits)
- International Efforts
  - Global Methane Initiative
  - UNFCCC (CDM and JI mechanisms)

Methane: Global Methane Initiative (GMI)

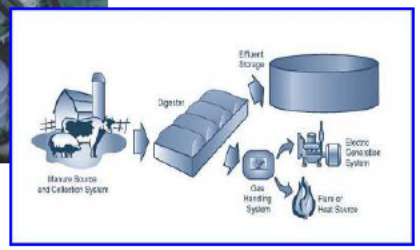
- **Multilateral public-private partnership that aims to reduce methane emissions and to advance the abatement, recovery and use of methane as a clean energy source.**
- **Targets:** Agriculture, Coal Mines, Landfills, Municipal Wastewater, Oil & Gas Systems

Global Participation: Partnership of Country Partners and the Project Network members committed to cost-effect methane emission reduction opportunities.

- Country Partners:
  - 40 Partner Countries and the EU
- Project Network
  - Consists of private sector entities, financial and multilateral institutions, local governments, and NGOs
  - 1000+ public and private organizations

Methane: GMI's Partnership Approach to Project Development

- **Strategic Focus**
  - Conduct capacity building and outreach efforts with all Partner countries in relevant sectors
  - Develop sector and country specific strategies to identify and overcome barriers to projects
  - Leverage relationship with project network to advance projects



- **Key Activities**
  - Technical Assistance and Project Identification
    - Data collection, assessment reports, pre-feasibility studies
  - Tool Development and Technology Transfer
    - LFG generation model, CMM and Landfill database
  - Training and Capacity Building
    - Clearing houses, training workshops, study tours, peer matching

Methane: GMI Achievements

- GMI spends approximately US$9.5 million annually on capacity building, technical support, feasibility studies, workshops, etc.
  - Through this seed money, GMI leverages US$66 million annually through in-kind support, project developers, technology providers, etc.

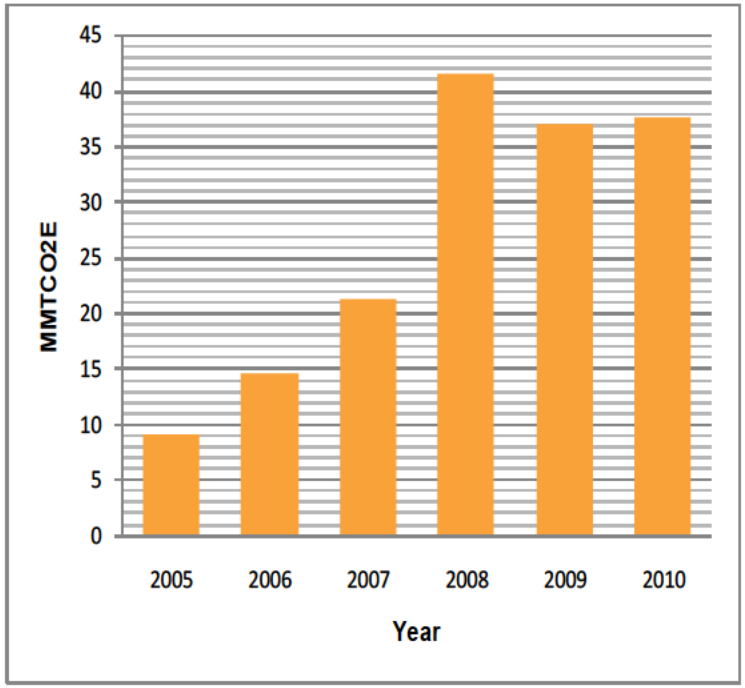
GMI investments resulted in:

- Supporting work at over 600 sites
  - Total annual reductions of ~38 $MMTCO_2e$ in 2010

Key Directions Moving Forward:

- Krakow All-Partnership Meeting Oct12-14, 2011
- Hosted by Poland, included Steering meeting, and technical and policy sessions
- Key Outcomes – Wastewater Subcommittee, Partner Action Plans, Next Methane Expo – 2013 in Canada
- Meeting Info and all GMI materials at: **www.globalmethane.org**

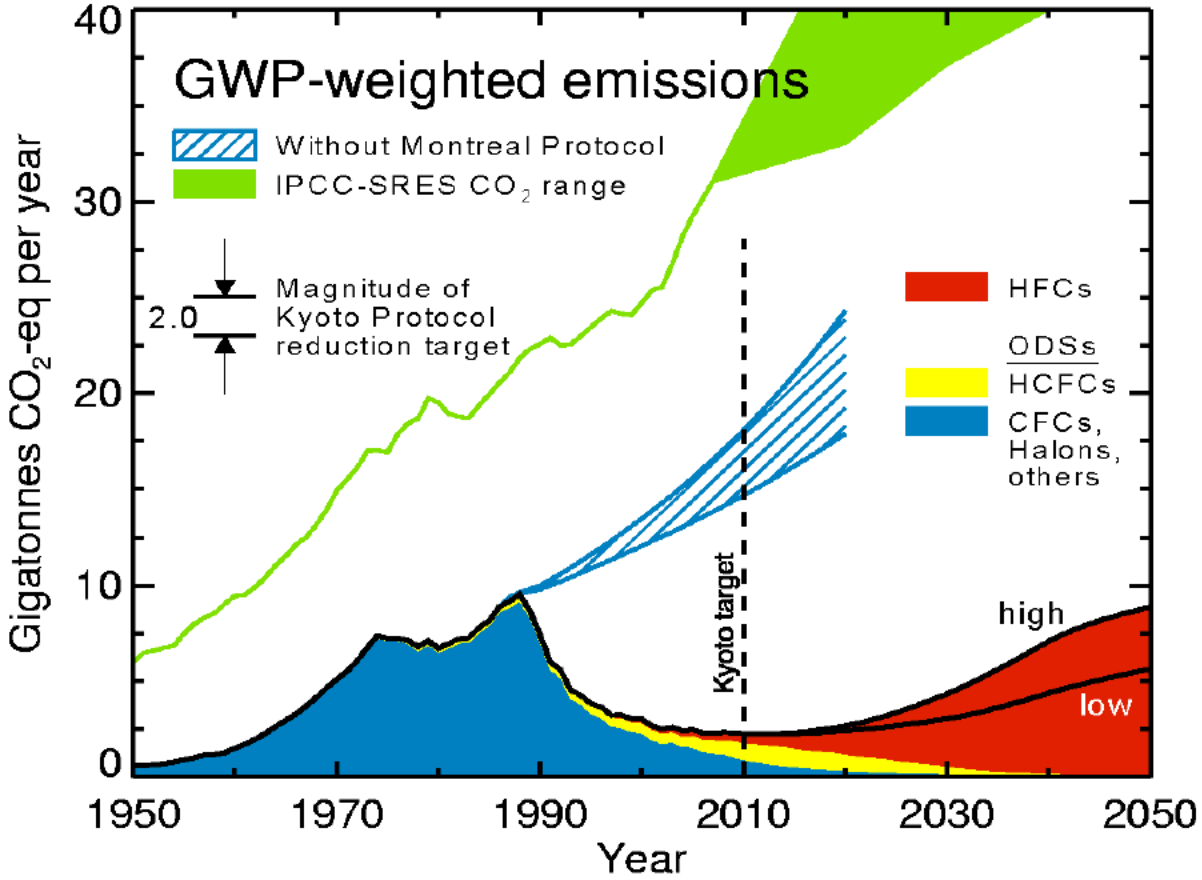
Methane Emission Reductions from 2005 to 2010



Global Methane Initiative

HFCs: Potential Growth, If Unmitigated

- HFC growth directly linked to the Montreal Protocol's ODS phaseout and expanding availability of refrigeration and air conditioning
- HFC emissions could reach 19% of projected global CO_2 emissions by 2050 if left unchecked



HFCs: Ongoing Activities

National and Regional Approaches

- European F-Gas regulations (e.g., limits motor vehicle air conditioners to refrigerants with less than 150 GWP)
- U.S. Significant New Alternatives Policy (SNAP) Program lists 400+ substitute alternatives with lower overall risks considering:
  - ODP & GWP, Flammability, Toxicity, Local Air Quality, Ecosystem Effects, Occupational Health & Safety
  - Next generation substitutes are alternatives for both ODS & HFCs
- U.S. regulations prohibit intentional venting of HFCs and require specific servicing practices for motor vehicles

Bilateral Approaches

- U.S.-Indo Task Force seeks to provide industry & government dialogue
  - Report on the suite of available alternatives to HFCs
  - Domestic and international action to phasedown use

Multilateral Approaches

- Montreal Protocol

HFCs: 2011 North American Proposal

Proposed amendment would:

- Control HFC Production and Consumption
- Phase*down*, not Phase*out* of HFCs
- Control By-Product Emissions of HFC-23 excluding CDM projects
- Complements but Leaves Unchanged UNFCCC Obligations
  - Supports Global Efforts to Reduce GHGs
  - Leaves HFC Emissions in UNFCCC Basket

Why the Montreal Protocol?

- More Than 20 Years Experience With These Sectors
  - Air-conditioning, refrigeration, solvents, foams, aerosols, adhesives, coatings & inks, and fire suppression
- Multilateral Fund, Technology and Economic Assessment Panel (TEAP), Scientific Assessment Panel (SAP), Environmental Effects Assessment Panel

Black Carbon Initiatives

- **International Maritime Organization (IMO)**
  - Investigating appropriate control measures to reduce the impact of Black Carbon emissions from international shipping
- **Global Alliance for Clean Cookstoves**
  - New $250 million 10-year public-private partnership led by UN Foundation to save lives, improve livelihoods, empower women, and combat climate change by creating a thriving global market for clean and efficient household cooking solutions
- **Heavy Duty Diesel**
  - U.S. National Clean Diesel Campaign sets stringent diesel PM standards for new diesel engines: on-highway trucks as of 2007, nonroad equipment as of 2011, and new locomotive and marine diesel engines as of 2015
  - Projected to reduce black carbon emissions by 90% or more through use of diesel particulate filters
- **Other initiatives such as work under Arctic Council can greatly contribute to reducing black carbon emissions**

International Coordination on SLCFs

- On August 29-30, the United States hosted a working-level brainstorming discussion on the need to address SLCFs and possible paths forward
  - 12 countries & UNEP participated, broadly agreed that action is a priority
- On September 12, Mexico and Sweden hosted a Ministerial meeting in Mexico City to discuss potential international cooperation on SLCFs.
  - The Ministerial meeting was preceded by two days of technical discussions about methane, black carbon, and HFCs.
  - 23 countries participated, with Minister-level participation from Bangladesh, Canada, Mexico, Sweden, and the United States.
- **Key outcomes**:
  - Participants acknowledged that any effort on SLCFs mitigation must be done in tandem with long-term mitigation efforts, including CO_2.
  - Strong support was expressed for a strengthened, concerted approach for national and regional measures and for an action-oriented initiative at the global level that engages the private sector and civil society.
  - Actions on SLCFs should be complementary to work under the UNFCCC, particularly long-term mitigation.

U.S. supports broader international initiative on SLCFs

- At the conclusion of discussions at the Mexico Ministerial meeting, Todd Stern, the U.S. Special Envoy for Climate Change and the head of the U.S. delegation, expressed strong US support for an initiative on short-lived climate forcers.

- **"It is clear to the U.S. that the issue of near-term climate change merits its own initiative**."
  - The need to reduce emissions of short-lived climate forcers is clear and it is urgent.
  - There is no existing forum that addresses this need systematically or strategically.
  - There are mitigation options available that can be accelerated and incentivized though coordinated action.

EPA United States Environmental Protection Agency

U.S.-proposed guiding principles

- **First,** we need to be explicit and specific about the relationship between a new short-lived climate forcers initiative and existing efforts.

- **Second**, efforts to reduce short-term forcers produce benefits on multiple fronts – on climate, but also health, food security, and energy security. It is important to highlight both climate and other co-benefits.

- **Third:** the initiative should be light on its feet. It should draw in private sector participation, and bed able to launch new initiatives where there are gaps, but we don't need a large institution.

- **Fourth:** A new initiative should be inclusive, but not at the price of ambitious actions. It should be open to anyone who wants to engage, but should not be encumbered by having to be all things to all people or to engage in endless political debate.

- **Fifth:** Most importantly, any initiative will require resources. Partnership in strategy and political message can go a long way, but partnership with funds—funds to enhance existing efforts and funds to fill gaps where we find them—will go a lot further.

Key Points on a Potential SLCF Initiative: U.S. Perspective

- Efforts on near-term warming are complementary to and supportive of our shared commitment to action on carbon dioxide.
  - The UNEP-WHO integrated assessment vividly illustrates the importance of a close link between the scientific community and policymakers.
- Defining the mandate and terms of international SLCF cooperation in a way that demonstrates support for the goals of the UNFCCC while avoiding any competition with the UNFCCC scope of work.
- Establishing a mutually beneficial relationship with existing technical institutions.
  - The new partnership should strive to elevate the profile of those organizations, such as GMI, not to compete with them or to dictate to them.
- The United States looks forward to working with all interested countries to bring to fruition an initiative that raises the profile of the benefits of SLCF mitigation, and incentivizes and accelerates international action.

Conclusions: Near Term Opportunities

Action on SLCFs can be taken now and will have significant climate benefits

- Methane:
  - Enhanced global cooperation through the GMI can have dramatic impact on methane mitigation efforts
  - Financing alone is not enough, significant need for training, technology transfer, and capacity building to establish a “pipeline” of projects
- HFCs:
  - Montreal Protocol optimum vehicle for HFC phasedown , sector experience, existing financial mechanism, tied to ODS phaseout, potential 98 gigatons
  - National and regional actions offer significant opportunities for transition – key is to act now to prevent growth
- Black Carbon:
  - Global Alliance for Clean Cookstoves offers significant opportunity for large-scale replacements, addressing public health and climate challenges
  - Other global, regional and national initiatives e.g., IMO, Arctic Council and domestic actions provide opportunities
- Co-benefits: SLCFs offer co-benefits for human health, improved air and water air quality, and better energy efficiency

United States Environmental Protection Agency

APPENDIX

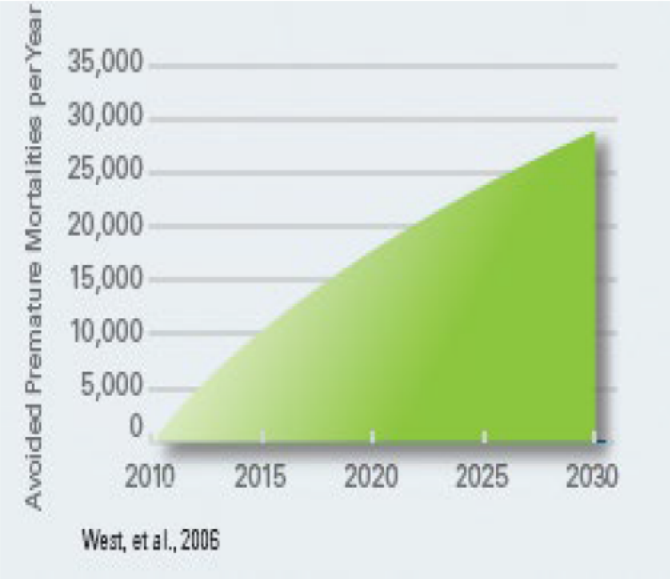
Co-Benefits: Health Effects of Black Carbon

- Black Carbon is part of fine particles ($PM_{2.5}$), which are strongly associated with adverse effects on cardiovascular and respiratory systems
  - **Ambient** $PM_{2.5}$ exposures linked to premature death, heart attacks, strokes, hospital and emergency room visits, bronchitis, asthma, and cancer
    - In the U.S.$PM_{2.5}$ associated with 130,000-320,000 premature deaths in 2005 (5.4% of all deaths nationwide)
    - According to WHO, urban $PM_{2.5}$ linked to 800,000 premature deaths annually; more recent health studies suggest estimates likely significantly higher, linking total $PM_{2.5}$ (urban and rural) to ~3.7 million premature deaths
  - **Indoor** $PM_{2.5}$ exposures associated with respiratory impacts, e.g., acute lower respiratory infections (ALRI) in children, chronic obstructive pulmonary disease (COPD) in women, cardiovascular impacts i.e., high blood pressure
    - WHO estimates indoor smoke from cookstoves leads to 2 million premature deaths annually, ~64% occur in low-income countries
- Hundreds of thousands of premature deaths, millions of illnesses can be prevented annually through SLCF mitigation efforts reducing indoor and outdoor pollution

Co-Benefits: Methane Mitigation

- **Air Quality Improvement**
  - Methane contributes to ground-level ozone: reducing methane emissions by 20% could avoid 370,000 premature deaths over 20 years
  - Reduction of local emissions of VOCs and HAPs from landfills, agriculture, and oil and gas systems
  - Odor reductions for landfill and agriculture
- **New Sources of Clean Energy**
  - Methane is primary component of natural gas
  - Mitigation makes methane available for energy

Reducing Methane Emissions can Avoid Ozone – Associated Mortalities



- **Water Quality Benefits**
  - Local water quality improvements due to improved management of agricultural wastes & leachate in landfills
- **Industrial Safety**
  - Reducing methane, an explosive gas, improves worker safety in coal mining, oil & gas

HFCs: Climate Benefits and Co-Benefits

Cumulative HFC Reductions ($MMTCO_2eq$) 2014-2050	
Developed Countries	42,600
Developing Countries	44,500
World**	87,200
Byproduct Controls	11,600
World* Total	98,800
*World total may not sum due to rounding	Analysis by U.S. EPA

- Cumulative HFC emission reductions over 98 gigatons through 2050
- Co-benefits from transitioning away from HFCs:
  - Improved energy efficiency by upgrading equipment designs, using better materials
  - Reduction in overall electricity needs – particularly important where demand outpaces capacity

From:	Sara Ohrel
To:	Paul Gunning; Suzanne Kocchi
Subject:	peer review documents
Date:	12/20/2012 11:32 AM
Attachments:	FASOM Peer Review Panel Final Report Revised 20110512.docx FASOM Peer Review Response FINAL.docx

---

Hi Paul,
As requested, the peer review and peer review response documents

Sara Bushey Ohrel
Climate Economics Branch
U.S. Environmental Protection Agency
Phone: (202) 343-9712
Cell/telework: (202) 341-6748

Hydrocarbon Emissions Characterization in the Colorado Front Range – A Pilot Study

Gabrielle Pétron[1,2], Gregory Frost[1,2], Benjamin R. Miller[1,2], Adam I. Hirsch[1,3], Stephen A. Montzka[2], Anna Karion[1,2], Michael Trainer[2], Colm Sweeney[1,2], Arlyn E. Andrews[2], Lloyd Miller[5], Jonathan Kofler[1,2], Amnon Bar-Ilan[4], Ed J. Dlugokencky[2], Laura Patrick[1,2], Charles T. (Tom) Moore Jr.[6], Thomas B. Ryerson[2], Carolina Siso[1,2], William Kolodzey[7], Patricia M. Lang[2], Thomas Conway[2], Paul Novelli[2], Kenneth Masarie[2], Bradley Hall[2], Douglas Guenther[1,2], Duane Kitzis[1,2], John Miller[1,2], David Welsh[2], Dan Wolfe[2], William Neff[2], and Pieter Tans[2]

[1] *Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, USA*

[2] *National Oceanic and Atmospheric Administration, Earth System Research Laboratory, Boulder, Colorado, USA*

[3] *now at the National Renewable Energy Laboratory, Golden, Colorado, USA*

[4] *ENVIRON International Corporation, Novato, California, USA*

[5] *formerly with Science and Technology Corporation, Boulder, Colorado, USA*

[6]*Western Governors' Association, Fort Collins, Colorado, USA*

[7]*NOAA Hollings Scholar now at Clemson University*

Abstract

The multi-species analysis of daily air samples collected at the NOAA Boulder Atmospheric Observatory (BAO) in Weld County in northeastern Colorado since 2007 shows highly correlated alkane enhancements caused by a regionally distributed mix of sources in the Denver-Julesburg Basin. To further characterize the emissions of methane and non-methane hydrocarbons (propane, n-butane, i-pentane, n-pentane and benzene) around BAO, a pilot study involving automobile-based surveys was carried out during the summer of 2008. A mix of venting emissions (leaks) of raw natural gas and flashing emissions from condensate storage tanks can explain the alkane ratios we observe in air masses impacted by oil and gas operations in northeastern Colorado. Using the WRAP Phase III inventory of total volatile organic compound (VOC) emissions from oil and gas exploration, production and processing, together with flashing and venting emission speciation profiles provided by State agencies or the oil and gas industry, we derive a range of bottom-up speciated emissions for Weld County in 2008. We use the observed ambient molar ratios and flashing and venting emissions data to calculate top-down scenarios for the amount of natural gas leaked to the atmosphere and the associated methane and non-methane emissions. Our analysis suggests that the emissions of the species we measured are most likely underestimated in current inventories and that the uncertainties attached to these estimates can be as high as a factor of two.

1) Introduction

Since 2004, the National Oceanic and Atmospheric Administration Earth System Research Laboratory (NOAA ESRL) has increased its measurement network density over

North America, with continuous carbon dioxide (CO_2) and carbon monoxide (CO) measurements and daily collection of discrete air samples at a network of tall towers [Andrews et al., in preparation] and bi-weekly discrete air sampling along vertical aircraft profiles [Sweeney et al., in preparation]. Close to 60 chemical species or isotopes are measured in the discrete air samples, including long-lived greenhouse gases (GHGs) such as CO_2, methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF_6), tropospheric ozone precursors such as CO and several volatile organic compounds (VOCs), and stratospheric-ozone-depleting substances. The NOAA multi-species regional data set provides unique information on how important atmospheric trace gases vary in space and time over the continent, and it can be used to quantify how different processes contribute to GHG burdens and/or affect regional air quality.

In this study we focus our analysis on a very strong alkane atmospheric signature observed downwind of the Denver-Julesburg Fossil Fuel Basin (DJB) in the Colorado Northern Front Range (Figures 1 and 1S). In 2008, the DJB was home to over 20,000 active natural gas and condensate wells. Over 90% of the production in 2008 came from tight gas formations.

A few recent studies have looked at the impact of oil and gas operations on air composition at the local and regional scales in North America. Katzenstein et al. [2003] reported results of two intensive surface air discrete sampling efforts over the Anadarko Fossil Fuel Basin in the southwestern United States in 2002. Their analysis revealed substantial regional atmospheric CH_4 and non-methane hydrocarbon (NMHC) pollution over parts of Texas, Oklahoma, and Kansas, which they attributed to emissions from the oil and gas industry operations. More recently, Schnell et al. [2009] observed very high

wintertime ozone levels in the vicinity of the Jonah-Pinedale Anticline natural gas field in western Wyoming. Ryerson et al. [2003], Wert et al. [2003], de Gouw et al. [2009] and Mellqvist et al. [2009] reported elevated emissions of alkenes from petrochemical plants and refineries in the Houston area and studied their contribution to ozone formation. Simpson et al. [2010] present an extensive analysis of atmospheric mixing ratios for a long list of trace gases over oil sands mining operations in Alberta during one flight of the 2008 Arctic Research of the Composition of the Troposphere from Aircraft and Satellites campaign. Our study distinguishes itself from previous ones by the fact that it relies substantially on the analysis of daily air samples collected at a single tall-tower monitoring site between August 2007 and April 2010.

Colorado has a long history of fossil fuel extraction [Scamehorn, 2002]. Colorado natural gas production has been increasing since the 1980s, and its share of national production jumped from 3% in 2000 to 5.4% in 2008. 1.3% of the nationally produced oil in 2008 also came from Colorado, primarily from the DJB in northeastern Colorado and from the Piceance Basin in western Colorado. As of 2004, Colorado also contained 43 natural gas processing plants, representing 3.5% of the conterminous US processing capacity [EIA, 2006], and two oil refineries, located in Commerce City, in Adams County just north of Denver.

Emissions management requirements for both air quality and climate-relevant gases have led the state of Colorado to build detailed baseline emissions inventories for ozone precursors, including volatile organic compounds (VOCs), and for GHGs. Since 2004, a large fraction of the Colorado Northern Front Range, including Weld County and the Denver metropolitan area, has been in violation of the 8-hour ozone national ambient

air quality standard [CDPHE, 2008a]. In December 2007, the Denver and Colorado Northern Front Range (DNFR) region was officially designated as a Federal Non-Attainment Area (NAA) for repeated violation in the summertime of the ozone National Ambient Air Quality Standard (see area encompassed by golden boundary in Figure 1). At the end of 2007, Colorado also adopted a Climate Action Plan, which sets greenhouse gas emissions reduction targets for the state [Ritter, 2007].

Methane, a strong greenhouse gas with a global warming potential (GWP) of 25 over a 100 yr time horizon [IPCC, 2007], accounts for a significant fraction of Colorado GHG emissions, estimated at 14% in 2005 ([Strait et al., 2007] and Table 1S; note that in this report, the oil and gas industry CH_4 emission estimates were calculated with the EPA State Greenhouse Gas Inventory Tool). The natural gas industry (including exploration, production, processing, transmission and distribution) is the single largest source of CH_4 in the state of Colorado (estimated at 238 Gg/yr or ktonnes/yr), followed closely by coal mining (233 Gg/yr); note that all operating surface and underground coal mines are now in western Colorado. Emission estimates for oil production operations in the state were much lower, at 9.5 Gg/yr, than those from gas production. In 2005, Weld County represented 16.5% of the state's natural gas production and 51% of the state crude oil/ natural gas condensate production (Table 2S). Scaling the state's total CH_4 emission estimates from Strait et al. [2007], rough estimates for the 2005 CH_4 source from natural gas production and processing operations and from natural gas condensate/oil production in Weld County are 19.6 Gg and 4.8 Gg, respectively. It is important to stress here that there are large uncertainties associated with these inventory-derived estimates.

Other important sources of CH_4 in the state include large open-air cattle feedlots, landfills, wastewater treatment facilities, forest fires, and agriculture waste burning, which are all difficult to quantify. 2005 state total CH_4 emissions from enteric fermentation and manure management were estimated at 143 and 48 Gg/yr, respectively [Strait et al., 2007]; this combined source is of comparable magnitude to the estimate from natural gas systems. On-road transportation is not a substantial source of methane [Nam et al., 2004].

In 2006, forty percent of the DNFR NAA's total anthropogenic VOC emissions were estimated to be due to oil and gas operations [CDPHE, 2008b]. Over the past few years, the State of Colorado has adopted more stringent VOC emission controls for oil and gas exploration and processing activities. In 2007, the Independent Petroleum Association of Mountain States (IPAMS, now Western Energy Alliance), in conjunction with the Western Regional Air Partnership (WRAP), funded a working group to build a state-of-the-knowledge process-based inventory of total VOC and NOx sources involved in oil and gas exploration, production and gathering activities for the western United State's fossil fuel basins, hereafter referred to as the WRAP Phase III effort (http://www.wrapair.org/forums/ogwg/index.html). Most of the oil and gas production in the DJB is concentrated in Weld County. Large and small condensate storage tanks in the County are estimated to be the largest VOC fossil fuel production source category (59% and 9% respectively), followed by pneumatic devices (valve controllers) and unpermitted fugitives emissions (13% and 9% respectively). A detailed breakdown of the WRAP oil and gas source contributions is shown in Figure 2S for 2006 emissions and projected 2010 emissions [Bar-Ilan et al., 2008a,b]). The EPA NEI 2005 for Weld County, used

until recently by most air quality modelers, did not include VOC sources from oil and natural gas operations (Table 3S).

Benzene (C_6H_6) is a known human carcinogen and it is one of the 188 hazardous air pollutants (HAPs) tracked by the EPA National Air Toxics Assessment (NATA). Benzene, like VOCs and CH_4, can be released at many different stages of oil and gas production and processing. Natural gas itself can contain varying amounts of aromatic hydrocarbons, including C_6H_6 [EPA, 1998]. Natural gas associated with oil production (such sources are located in several places around the DJB) usually has higher C_6H_6 levels [Burns et al., 1999] than non-associated natural gas. Glycol dehydrators used at wells and processing facilities to remove water from pumped natural gas can vent large amounts of C_6H_6 to the atmosphere when the glycol undergoes regeneration [EPA, 1998]. Condensate tanks, venting and flaring at the well-heads, compressors, processing plants, and engine exhaust are also known sources of C_6H_6 [EPA, 1998]. C_6H_6 can also be present in the liquids used for fracturing wells [EPA, 2004].

In this paper, we focus on describing and interpreting the measured variability in CH_4 and $C_{3\text{-}5}$ alkanes observed in the Colorado Northern Front Range. We use data from daily air samples collected at a NOAA tall tower located in Weld County as well as continuous CH_4 observations and discrete targeted samples from an intensive mobile sampling campaign in the Colorado Northern Front Range. These atmospheric measurements are then used together with other emissions data sets to provide an independent view of methane and non-methane hydrocarbon emissions inventory results.

The paper is organized as follows. Section 2 describes the study design and sampling methods. Section 3 presents results from the tall tower and the Mobile Lab

surveys, in particular the strong correlation among the various alkanes measured. Based on the multi-species analysis in the discrete air samples, we were able to identify two major sources of C_6H_6 in Weld County. In section 4.1 we discuss the results and in section 4.2 we compare the observed ambient molar ratios with other relevant data sets, including raw natural gas composition data from 77 gas wells in the DJB. The last discussion section, 4.3, is an attempt to shed new light on methane and VOC emission estimates from oil and gas operations in Weld County. We first describe how we derived speciated bottom-up emission estimates based on the WRAP Phase III total VOC emission inventories for counties in the DJB. We then used 1) an average ambient propane-to-methane molar ratio, 2) a set of bottom-up estimates of propane and methane flashing emissions in Weld County and 3) three different estimates of the propane-to-methane molar ratio for the raw gas leaks to build top-down methane and propane emission scenarios for venting sources in the county. We also scaled the top-down propane (C_3H_8) estimates with the observed ambient alkane ratios to calculate top-down emission estimates for n-butane (n-C_4H_{10}), i- and n-pentane (i-C_5H_{12}, n-C_5H_{12}), and benzene. We summarize our main conclusions in section 5.

2) The Front Range Emissions Study: Sampling Strategy, Instrumentation, and Sample Analysis

2.1. Overall Experimental Design

The Colorado Northern Front Range study was a pilot project to design and test a new measurement strategy to characterize GHG emissions at the regional level. The anchor of the study was a 300-m tall tower located in Weld County, 25 km east-northeast of Boulder and 35 km north of Denver, called the Boulder Atmospheric Observatory

(BAO) [40.05^{o}N, 105.01^{o}W; base of tower at 1584 m above sea level] (Figure 1). The BAO is situated on the southwestern edge of the DJB. A large landfill and a wastewater treatment plant are located a few kilometers southwest of BAO. Interstate 25, a major highway going through Denver, runs in a north-south direction 2 km east of the site. Both continuous and discrete air sampling have been conducted at BAO since 2007.

To put the BAO air samples into a larger regional context and to better understand the sources that impacted the discrete air samples, we made automobile-based on-road air sampling surveys around the Colorado Northern Front Range in June and July 2008 with an instrumented "Mobile Lab" and the same discrete sampling apparatus used at all the NOAA towers and aircraft sampling sites.

2.2. BAO and other NOAA cooperative Tall Towers

The BAO tall tower has been used as a research facility of boundary layer dynamics since the 1970s [Kaimal and Gaynor, 1983]. The BAO tower was instrumented by the NOAA ESRL Global Monitoring Division (GMD) in Boulder in April 2007, with sampling by a quasi-continuous CO_2 non-dispersive infrared sensor and a CO Gas Filter Correlation instrument, both oscillating between three intake levels (22, 100 and 300 m above ground level) [Andrews et al., in preparation]. Two continuous ozone UV-absorption instruments have also been deployed to monitor ozone at the surface and at the 300-m level.

The tower is equipped to collect discrete air samples from the 300-m level using a programmable compressor package (PCP) and a programmable flasks package (PFP) described later in section 2.4. Since August 2007 one or two air samples have been taken approximately daily in glass flasks using PFPs and a PCP. The air samples are brought

back to GMD for analysis on three different systems to measure a series of compounds, including methane (CH_4 , also referred to as C_1), CO, propane (C_3H_8, also referred to as C_3), n-butane (n-C_4H_{10}, nC_4), isopentane (i-C_5H_{12}, iC_5), n-pentane (n-C_5H_{12}, nC_5), acetylene (C_2H_2), benzene, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Ethane and i-butane were not measured.

In this study, we use the results from the NOAA GMD multi-species analysis of air samples collected midday at the 300-m level together with 30- second wind speed and direction measured at 300-m. 30-minute averages of the wind speed and direction prior to the collection time of each flask are used to separate samples of air masses coming from three different geographic sectors: the North and East (NE sector), where the majority of the DJB oil and gas wells are located; the South (S sector), mostly influenced by the Denver metropolitan area; and the West (W sector), with relatively cleaner air.

In 2008, NOAA and its collaborators were operating a regional air sampling network of eight towers and 18 aircraft profiling sites located across the continental US employing in-situ measurements (most towers) and flask sampling protocols (towers and aircraft sites) that were similar to those used at BAO. Median mixing ratios for several alkanes, benzene, acetylene, and carbon monoxide from BAO and a subset of five other NOAA towers and from one aircraft site are presented in the Results (Section 3). Table 1 provides the three letter codes used for each sampling site, their locations and sampling heights. STR is located in San Francisco. WGC is located 34 km south of downtown Sacramento in California's Central Valley where agriculture is the main economic sector. Irrigated crop fields and feedlots contribute to the higher CH_4 observed at WGC. The LEF tower in northern Wisconsin is in the middle of the Chequamegon National Forest

which is a mix of temperate/boreal forest and lowlands/wetlands [Werner et al., 2003]. Air samples from NWF (surface elevation 3050m), in the Colorado Rocky Mountains, mostly reflect relatively unpolluted air from the free troposphere. The 457m tall Texas tower (WKT) is located between Dallas/Fort Worth and Austin. It often samples air masses from the surrounding metropolitan areas. In summer especially, it also detects air masses with cleaner background levels arriving from the Gulf of Mexico. The SGP NOAA aircraft sampling site [Sweeney et al., in preparation; http://www.esrl.noaa.gov/gmd/ccgg/aircraft/] in northern Oklahoma is also used in the comparison study. At each aircraft site, twelve discrete air samples are collected at specified altitudes on a weekly or biweekly basis. Oklahoma is the fourth largest state for natural gas production in the USA [EIA, 2008] and one would expect to observe signatures of oil and gas drilling operations at both SGP and BAO. Additional information on the tower and aircraft programs is available at http://www.esrl.noaa.gov/gmd/ccgg/. Median summer mixing ratios for several alkanes, C_2H_2, C_6H_6 and CO are presented in the Results section.

2.3. Mobile Sampling

Two mobile sampling strategies were employed during this study. The first, the Mobile Lab, consisted of a fast response CO_2 and CH_4 analyzer (Picarro, Inc.), a CO gas-filter correlation instrument from Thermo Environmental, Inc., an O_3 UV-absorption analyzer from 2B Technologies and a Global Positioning System (GPS) unit. All were installed onboard a vehicle. A set of 3 parallel inlets attached to a rack on top of the vehicle brought in outside air from a few meters above the ground to the instruments. Another simpler sampling strategy was to drive around and collect flask samples at

predetermined locations in the Front Range region. A summary of the on-road surveys is given in Table 2.

The Mobile Lab's Picarro Envirosense CO_2/CH_4/H_2O analyzer (model G1301, unit CFADS09) employs Wavelength-Scanned Cavity Ring-Down Spectroscopy (WS-CRDS), a time-based measurement utilizing a near-infrared laser to measure a spectral signature of the molecule. CO_2, CH_4, and water vapor were measured at a 5-second sampling rate (0.2 Hz), with a standard deviation of 0.09 ppm in CO_2 and 0.7 ppb for CH_4. The sample was not dried prior to analysis, and the CO_2 and CH_4 mole fractions were corrected for water vapor after the experiment based on laboratory tests. For water mole fractions between 1% and 2.5%, the relative magnitude of the CH_4 correction was quasi-linear, with values between 1 and 2.6%. CO_2 and CH_4 mole fractions were assigned against a reference gas tied to the relevant World Meteorological Organization (WMO) calibration scale. Total measurement uncertainties were 0.1 ppm for CO_2 and 2 ppb for CH_4 [Sweeney et al., in preparation]. The CO and ozone data from the Mobile Lab are not discussed here. GPS data were also collected in the Mobile Lab at 1 Hz, to allow data from the continuous analyzers to be merged with the location of the vehicle.

The excursions with the flask sampler (PFP) focused on characterizing the concentrations of trace gases in Boulder (June 4 and 11, 2008), the northeastern Front Range (June 19), Denver (July 1) and around oil and gas wells and feedlots in Weld County south of Greeley (July 14) (see Table 2). Up to 24 sampling locations away from direct vehicle emissions were chosen before each drive.

Each Mobile Lab drive lasted from four to six hours, after a ~30 min warm-up on the NOAA campus for the continuous analyzer before switching to battery mode. The

first two Mobile Lab drives, which did not include discrete air sampling, were surveys around Denver (July 9) and between Boulder and Greeley (July 15). The last two drives with the Mobile Lab (July 25 and 31) combined in-situ measurements with discrete flask sampling to target emissions from specific sources: the quasi-real-time display of the data from the continuous CO_2/CH_4 analyzer was used to collect targeted flask samples at strong CH_4 point sources in the vicinity of BAO. Discrete air samples were always collected upwind of the surveying vehicle and when possible away from major road traffic.

2.4. Chemical Analyses of Flask Samples

Discrete air samples were collected at BAO and during the road surveys with a two-component collection apparatus. One (PCP) includes pumps and batteries, along with an onboard microprocessor to control air sampling. Air was drawn through Teflon tubing attached to an expandable 3-m long fishing pole. The second package (PFP) contained a sampling manifold and twelve cylindrical, 0.7L, glass flasks of flow-through design, fitted with Teflon O-ring on both stopcocks. Before deployment, manifold and flasks were leak-checked then flushed and pressurized to ~1.4 atm with synthetic dry zero-air containing approximately 330 ppm of CO_2 and no detectable CH_4. During sampling, the manifold and flasks were flushed sequentially, at ~5 L min^{-1} for about 1 min and 10 L min^{-1} for about 3 minutes respectively, before the flasks were pressurized to 2.7 atm. Upon returning to the NOAA lab, the PFP manifold was leak-checked and meta-data recorded by the PFP during the flushing and sampling procedures were read to verify the integrity of each air sample collected. In case of detected inadequate flushing or filling, the affected air sample is not analyzed.

Samples collected in flasks were analyzed for close to 60 compounds by NOAA GMD (http://www.esrl.noaa.gov/gmd/ccgg/aircraft/analysis.html). In this paper, we focus on eight species: 5 alkanes (CH_4, C_3H_8, n-C_4H_{10}, i-C_5H_{12}, n-C_5H_{12}) as well as CO, C_2H_2 and C_6H_6. CH_4 and CO in each flask were first quantified on one of two nearly identical automated analytical systems (MAGICC 1 & 2). These systems consist of a custom-made gas inlet system, gas-specific analyzers, and system-control software. Our gas inlet systems use a series of stream selection valves to select an air sample or standard gas, pass it through a trap for drying maintained at ~-80°C, and then to an analyzer.

CH_4 was measured by gas chromatography (GC) with flame ionization detection (±1.2 ppb = average repeatability determined as 1 s.d. of ~20 aliquots of natural air measured from a cylinder) [Dlugokencky et al., 1994]. We use the following abbreviations for measured mole fractions: ppm = µmol mol^{-1}, ppb = nmol mol^{-1}, and ppt = pmol mol^{-1}. CO was measured directly by resonance fluorescence at ~150 nm (±0.2 ppb) [Gerbig et al., 1999; Novelli et al., 1998]. All measurements are reported as dry air mole fractions relative to internally consistent calibration scales maintained at NOAA (http://www.esrl.noaa.gov/gmd/ccl/scales.html).

Gas chromatography/mass spectrometric (GC/MS) measurements were also performed on ~200 mL aliquots taken from the flask samples and pre-concentrated with a cryogenic trap at near liquid nitrogen temperatures [Montzka et al., 1993]. Analytes desorbed at ~110°C were then separated by a temperature-programmed GC column (combination 25 m x 0.25 mm DB5 and 30 m x 0.25 mm Gaspro), followed by detection with mass spectrometry by monitoring compound-specific ion mass-to-charge ratios. Flask sample responses were calibrated versus whole air working reference gases which,

in turn, are calibrated with respect to gravimetric primary standards (NOAA scales: benzene on NOAA-2006 and all other hydrocarbons (besides CH_4) on NOAA-2008). We used a provisional calibration for n-butane based on a diluted Scott Specialty Gas standard. Total uncertainties for analyses from the GC/MS reported here are <5% (accuracy) for all species except n-C_4H_{10} and C_2H_2, for which the total uncertainty at the time of this study was of the order of 15-20%. Measurement precision as repeatability is generally less than 2% for compounds present at mixing ratios above 10 ppt.

To access the storage stability of the compounds of interest in the PFPs, we conducted storage tests of typically 30 days duration, which is greater than the actual storage time of the samples used in this study. Results for C_2H_2 and C_3H_8 show no statistically significant enhancement or degradation with respect to our "control" (the original test gas tank results) within our analytical uncertainty. For the remaining species, enhancements or losses average less than 3% for the 30 day tests. More information on the quality control of the flask analysis data is available at http://www.esrl.noaa.gov/gmd/ccgg/aircraft/qc.html.

The flask samples were first sent to the GC/MS instrument for hydrocarbons, CFCs, and HFCs before being analyzed for major GHGs. This first step was meant to screen highly polluted samples that could potentially damage the greenhouse gas MAGICC analysis line with concentrations well above “background” levels. The time interval between flask collection and flask analysis spanned between 1 to 11 days for the GC/MS analysis and 3 to 12 days for MAGICC analysis.

3) Results

3.1 BAO tall tower: long-term sampling platform for regional emissions

3.1.1 Comparing BAO with other sampling sites in the US

Air samples collected at BAO tower have a distinct chemical signature (Figure 2), showing enhanced levels of most alkanes (C_3H_8, nC_4H_{10}, iC_5H_{12} and nC_5H_{12}) in comparison to results from other NOAA cooperative tall towers (see summary of site locations in Table 1 and data time series in Figure 1S). The midday summer time median mixing ratios for C_3H_8 and n-C_4H_{10} at BAO were at least 6 times higher than those observed at most other tall tower sites. For i-C_5H_{12} and n-C_5H_{12}, the summertime median mixing ratios at BAO were at least 3 times higher than at the other tall towers.

In Figure 2, we show nighttime measurements at the Niwot Ridge Forest tower (NWF) located at a high elevation site on the eastern slopes of the Rocky Mountains, 50 km west of BAO. During the summer nighttime, downslope flow brings clean air to the tower [Roberts et al., 1984]. The median summer mixing ratios at NWF for all the species shown in Figure 2 are much lower than at BAO, as would be expected given the site's remote location.

Similarly to BAO, the northern Oklahoma aircraft site, SGP, exhibits high alkane levels in the boundary layer and the highest methane summer median mixing ratio of all sites shown in Figure 2 (1889 ppb at SGP vs. 1867 ppb at BAO). As for BAO, SGP is located in an oil- and gas-producing region. Oklahoma, the fourth largest state in terms of natural gas production in the US, has a much denser network of interstate and intrastate natural gas pipelines compared to Colorado. Katzenstein et al. [2003] documented the spatial extent of alkane plumes around the gas fields of the Anadarko Basin in Texas,

Oklahoma, and Kansas during two sampling intensives. The authors estimated that methane emissions from the oil and gas industry in that entire region could be as high as 4-6 Tg CH_4/yr, which is 13-20% of the US total methane emission estimate for year 2005 reported in the latest EPA US GHG Inventory [EPA, 2011a].

Enhancements of CH_4 at BAO are not as striking in comparison to other sites. CH_4 is a long-lived gas destroyed predominantly by its reaction with OH radicals. CH_4 has a background level that varies depending on the location and season [Dlugokencky et al., 1994], making it more difficult to interpret differences in median summer CH_4 mixing ratios at the suite of towers. Since we do not have continuous measurements of CH_4 at any of the towers except WGC, we cannot clearly separate CH_4 enhancements from background variability in samples with levels between 1800 and 1900 ppb if we only look at CH_4 mixing ratios by themselves (see more on this in the next section).

3.1.2 Influence of different sources at BAO

3.1.2.1. Median mixing ratios in the three wind sectors

To better separate the various sources influencing air sampled at BAO, Figure 3 shows the observed median mixing ratios of several species as a function of prevailing wind direction. For this calculation, we only used samples for which the associated 30-minute average wind speed (prior to collection time) was larger than 2.5 m/s. We separated the data into three wind sectors: NE, including winds from the north, northeast and east (wind directions between 345° and 120°); S, including south winds (120° to 240°); and W, including winds from the west (240° to 345°).

For the NE sector, we can further separate summer (June to August) and winter (November to April) data. For the other two wind sectors, only the winter months have

enough data points. The species shown in Figure 3 have different photochemical lifetimes [Parrish et al., 1998], and all are shorter-lived in the summer season. This fact, combined with enhanced vertical mixing in the summer, leads to lower mixing ratios in summer than in winter.

Air masses from the NE sector pass over the oil and gas wells in the DJB and exhibit large alkane enhancements. In winter, median mole fractions of C_3-C_5 alkanes are 8 to 11 times higher in air samples from the NE compared to the samples from the W sector, while the median CH_4 value is 76 ppb higher. The NE wind sector also shows the highest median values of C_6H_6, but not CO and C_2H_2.

C_3H_8, n-C_4H_{10} and the C_5H_{12} isomers in air samples from the NE wind sector are much higher than in air samples coming from the Denver metropolitan area in the South wind sector. Besides being influenced by Denver, southern air masses may pass over two operating landfills, the Commerce City oil refineries, and some oil and gas wells (Figure 1). The S sector BAO CO and C_2H_2 mixing ratios are higher than for the other wind sectors, consistent with the higher density of vehicular emission sources [Harley et al., 1992; Warneke et al., 2007; Baker et al., 2008] south of BAO. There are also occasional spikes in CFC-11 and CFC-12 mixing ratios in the S sector (not shown). These are most probably due to leaks from CFC-containing items in the landfills. Air parcels at BAO coming from the east pass over Interstate Highway 25, which could explain some of the high mole fractions observed for vehicle combustion tracers such as CO, C_2H_2, and C_6H_6 in the NE sector data (see more discussion on C_6H_6 and CO in section 4.4 & Figure 4).

The W wind sector has the lowest median mole fractions for all anthropogenic tracers, consistent with a lower density of emission sources west of BAO compared to the

other wind sectors. However, the S and W wind sectors do have some data points with high alkane values, and these data will be discussed further below.

3.1.2.2. Strong alkane source signature

To detect if the air sampled at BAO has specific chemical signatures from various sources, we looked at correlation plots for the species shown in Figure 3. Table 3 summarizes the statistics for various tracer correlations for the three different wind sectors. Figure 4 (left column) shows correlation plots of some of these BAO species for summer data in the NE wind sector.

Even though BAO data from the NE winds show the largest alkane mixing ratios (Figure 3), all three sectors exhibit strong correlations between C_3H_8, n-C_4H_{10} and the C_5H_{12} isomers (Table 3). The r^2 values for the correlations between C_3H_8 and n- C_4H_{10} or the C_5H_{12} isomers are over 0.9 for the NE and W sectors. CH_4 is also well correlated with C_3H_8 in the NE wind sector for both seasons. For the NE wind sector BAO summertime data, a min/max range for the C_3H_8/CH_4 slope is 0.099 to 0.109 ppb/ppb.

The tight correlations between the alkanes suggest a common source located in the vicinity of BAO. Since large alkane enhancements are more frequent in the NE wind sector, this common source probably has larger emissions north and east of the tower. This NE wind sector encompasses Interstate Highway 25 and most of the DJB oil and gas wells. The C_3-C_5 alkane mole fractions do not always correlate well with combustion tracers such as C_2H_2 and CO for the BAO NE wind sector ($C_{3\text{-}5}$/CO and $C_{3\text{-}5}/C_2H_2$: $r^2 <$ 0.3 for 50 summer samples; $C_{3\text{-}5}$/CO: r^2 <0.4 and $C_{3\text{-}5}/C_2H_2$: r^2 ~0.6 for 115 winter samples). These results indicate that the source responsible for the elevated alkanes at BAO is not the major source of CO or C_2H_2, which argues against vehicle combustion

exhaust as being responsible. Northeastern Colorado is mostly rural with no big cities. The only operating oil refineries in Colorado are in the northern part of the Denver metropolitan area, south of BAO. The main industrial operations in the northeastern Front Range are oil and natural gas exploration and production and natural gas processing and transmission. We therefore hypothesize here that the oil and gas operations in the DJB, as noted earlier in Section 2, are a potentially substantial source of alkanes in the region.

3.1.2.3. At least two sources of benzene in BAO vicinity

The median winter C_6H_6 mixing ratio at BAO is higher for the NE wind sector compared to the South wind sector, which comprises the Denver metropolitan area. The C_6H_6-to-CO winter correlation is highest for the S and W wind sectors BAO samples (r^2=0.85 and 0.83 respectively) compared to the NE wind sector data (r^2=0.69). The C_6H_6-to-CO correlation slope is substantially higher for the NE wind sector data compared to the other two wind sectors, suggesting that there may be a source of benzene in the NE that is not a significant source of CO. The C_6H_6-to-C_2H_2 correlation slope is slightly higher for the NE wind sector data compared to the other two wind sectors. C_6H_6 in the BAO data from the NE wind sector correlates more strongly with C_3H_8 than with CO. The C_6H_6-to-C_3H_8 summer correlation slope for the NE wind sector is 10.1 ±1.2 ppt/ppb (r^2=0.67).

For the S and W wind sectors BAO data, the C_6H_6-to-C_2H_2 (0.27 - 0.32 ppt/ppt) and C_6H_6-to-CO (1.57 - 1.81 ppt/ppb) slopes are larger than observed emissions ratios for the Boston/New York City area in 2004: 0.171 ppt/ppt for C_6H_6-to-C_2H_2 ratio and 0.617 ppt/ppb for C_6H_6-to-CO ratio [Warneke et al., 2007]. Baker et al. [2008] report an atmospheric molar C_6H_6-to-CO ratio of 0.9 ppt/ppb for Denver in summer 2004, which is

in between the Boston/NYC emissions ratio value reported by Warneke et al. [2007] and the BAO S and W wind sectors correlation slopes.

The analysis of the BAO C_6H_6 data suggests the existence of at least two distinct C_6H_6 sources in the vicinity of BAO: an urban source related mainly to mobile emissions, and a common source of alkanes and C_6H_6 concentrated in northeastern Colorado. We discuss C_6H_6 correlations and sources in more detail in section 4.4.

3.2. On-road surveys: tracking point and area source chemical signatures

Road surveys with flask sampling and the Mobile Lab with the fast-response CH_4 analyzer were carried out in June-July 2008 (Table 2). The extensive chemical analysis of air samples collected in the Front Range provides a snapshot of a broader chemical composition of the regional boundary layer during the time of the study. The Mobile Lab surveys around the Front Range using the in situ CH_4 analyzer allowed us to detect large-scale plumes with long-lasting enhancements of CH_4 mixing ratios as well as small-scale plumes associated with local CH_4 point sources. In the last two Mobile Lab surveys (surveys 8 and 9), we combined the monitoring of the continuous CH_4 analyzer with targeted flask sampling, using the CH_4 data to decide when to collect flask samples in and out of plumes.

The regional background CH_4 mixing ratio at the surface (interpreted here as the lowest methane level sustained for ~10 minutes or more) was between 1800 ppb and 1840 ppb for most surveys. Some of the highest “instantaneous” CH_4 mixing ratios measured during the Mobile Lab surveys were: 3166 ppb at a wastewater treatment plant, 2329 ppb at a landfill, 2825 ppb at a feedlot near Dacono, over 7000 ppb close to a

feedlot waste pond near Greeley, and 4709 ppb at a large natural gas processing and propane plant in Fort Lupton (Figure 1).

The analysis of the summer 2008 intensive data suggests that regional scale mixing ratio enhancements of CH_4 and other alkanes are not rare events in the Colorado Northern Front Range airshed. Their occurrence and extent depends on both emissions and surface wind conditions, which are quite variable and difficult to predict in this area. During the Mobile Lab road surveys, the high-frequency measurements of CO_2 and CH_4 did not exhibit any correlation. Unlike CO_2, the CH_4 enhancements were not related to on-road emissions. Below we present two examples of regional enhancements of CH_4 observed during the Front Range Mobile Lab surveys.

3.2.1. Survey 9: $C_{3\text{-}5}$ alkane levels follow large-scale changes in methane

Figure 5 shows a time series of the continuous CH_4 mixing ratio data and alkane mixing ratios measured in twelve flask samples collected during the Front Range Mobile Lab survey on 31 July 2008 (flasks #1 to 12, sampled sequentially as shown in Figure 6). The wind direction on that day was from the ENE or E at the NCAR Foothills Lab and BAO tower. The Mobile Lab left the NOAA campus in Boulder around 11:40 am and measured increasing CH_4 levels going east towards the BAO tower (Figure 6). An air sample was collected close to the peak of the CH_4 broad enhancement centered around 11:55 am. The CH_4 mixing ratio then decreased over the next 25 minutes and reached a local minimum close to 1875 ppb. The CH_4 level stayed around 1875 ppb for over one hour and then decreased again, more slowly this time, to ~ 1830 ppb over the next two hours.

Flasks # 1 to 3 were collected before, at the peak, and immediately after the broad CH_4 feature between 11:40 and 12:15. Flasks # 4 & 5 were sampled close to a wastewater treatment plant and flasks # 7 to 8 were sampled in a landfill. The in situ measurements showed that CH_4 was still elevated above background as these samples were collected. After a 90-minute stop at BAO to recharge the Mobile Lab UPS batteries, flasks # 9 to 11 were collected in a corn field while the in situ measurements showed lower CH_4 levels. The last flask sample was collected on the NOAA campus just before 17:00 MDT, about 5.5 hours after the first flask sample was collected. The flask samples were always collected upwind of the Mobile Lab car exhaust.

Sharp spikes in the continuous CH_4 data reflect local point sources (wastewater treatment plant, landfill). The highly variable signals in both the continuous and discrete CH_4 close to these sources are driven by the spatial heterogeneity of the CH_4 emissions and variations in wind speed and direction. Broader enhancements in the continuous CH_4 data reflect larger (regional) plumes. The last flask (#12) sampled at NOAA has much higher levels of combustion tracers (CO, C_2H_2, C_6H_6) than the other samples.

Figure 7 shows correlation plots for C_3H_8 versus CH_4 and n-C_4H_{10} versus C_3H_8 in the 12 flasks taken on 31 July. Air samples not directly influenced by identified point sources (flasks #1-3, 6-7, 9-12) show a very strong correlation between the various measured alkanes. Using the data from the air samples not directly influenced by identified point sources (flasks #1-3, 6-7, 9-12), we derive a C_3H_8-to-CH_4 (C_3/C_1) mixing ratio slope of 0.097± 0.005 ppb/ppb (Figure 7A). This slope is very similar to the one observed for the summertime NE wind sector data at BAO (0.104± 0.005; Table 3). Three air samples collected downwind of the waste water treatment plant and the landfill

(flasks # 4-5 and 8) are off the C_3H_8-to-CH_4 correlation line and have higher CH_4 than air samples collected nearby but not under the influence of these local CH_4 sources (flasks 3 and 6). Flask # 8 also has elevated CFC-11 (310 ppt) compared to the other samples collected that day (< 255 ppt), probably related to leaks from old appliances buried in the landfill.

The C_3-C_5 alkane mixing ratios in samples collected on 31 July are tightly correlated for flasks # 1 to 11 with $r^2 > 0.95$ (Figure 7B). As concluded for the BAO alkane mixing ratio enhancements earlier, this tight correlation suggests that the non-methane alkanes measured during the surveys are coming from the same source types. The nC_4/C_3 correlation slope on 31 July (0.47 ppb/ppb; flasks # 1-11) is similar to the summer slope in the BAO NE samples (0.45 ppb/ppb), while the 31 July iC_5/C_3 and nC_5/C_3 slopes are slightly higher (0.17 and 0.17 ppb/ppb, respectively) than for BAO (0.14 and 0.15 ppb/ppb, respectively).

3.2.2. Survey 6: Alkane enhancements in the Denver-Julesburg oil and gas production zone and cattle feedlot contributions to methane

The flask-sampling-only mobile survey on 14 July 2008 focused on the agricultural and oil and gas drilling region south of Greeley. Eleven of the twelve air samples collected on 14 July were taken over the Denver-Julesburg Basin (flasks# 2-12 in Figure 3S in Supplementary Material). Figure 8A shows a correlation plot of C_3H_8 versus CH_4 mixing ratios in these air samples. Flasks collected NE of BAO and not near feedlots (# 4, 6-8, and 10-12) fall on a line: $y=0.114(x-1830)$ ($r^2=0.99$). This slope and the correlation slope calculated for the BAO NE wind sector data are indistinguishable (within the 1-σ uncertainties in the slopes). Four samples collected in the vicinity of four

different cattle feedlots (flasks # 2, 3, 5, and 9) exhibit a lower C_3H_8-to-CH_4 correlation slope (0.083 ppb/ppb, r^2=0.93). The r^2 for the C_3H_8-to-CH_4 correlation using all the flasks is 0.91.

The n-C_4H_{10} versus C_3H_8 correlation plot and its slope, along with the n-C_4H_{10}–to-C_3H_8 and C_5H_{12}–to-C_3H_8 correlation slopes for air samples not collected downwind of feedlots are shown in Figure 8B. The r^2 for the n-C_4H_{10}-to-C_3H_8 correlation using all the flasks is 0.98, which is slightly higher than the r^2 for the C_3H_8-to-CH_4 correlation using all flasks (0.91). The r^2 for the i-C_5H_{12}-to-n-C_4H_{10} and n-C_5H_{12}-to-n-C_4H_{10} correlations using all the flasks are 0.96 ppb/ppb and 0.99 ppb/ppb, respectively. These results suggest that cattle feedlots have no substantial impact on n-C_4H_{10} and the C_5H_{12} levels.

The strong correlation observed between the various alkane mixing ratios for air samples not collected downwind of feedlots once again suggests that a common source contributes to most of the observed alkanes enhancements. It is possible that some of the C_3H_8 enhancements seen near the feedlots are due to leaks of propane fuel used for farm operations [Ronald Klusman, personal communication]. Two flask samples were collected downwind of a cattle feedlot near Dacono during Mobile Lab survey #8, on 25 July 2008. The analysis of these samples revealed large CH_4 enhancements (1946 and 2335 ppb), but no enhancement in C_3H_8 (~ 1ppb), n-C_4H_{10} (<300ppt), the C_5H_{12} (< 130ppt) or C_6H_6 (< 30ppt).

For survey #6, the n-C_4H_{10}-to-C_3H_8 correlation slope (0.56 ppb/ppb) is 16% higher than the summer slope observed at BAO for the NE wind sector data, while the 14 July i-C_5H_{12}-to-C_3H_8 and n-C_5H_{12}-to-C_3H_8 correlation slopes (0.24 and 0.23 ppb/ppb, respectively) are 76% and 53% higher, respectively, than the summer NE BAO data.

These slopes are higher than for flasks from survey #9. The difference in the C_5/C_3 slopes between the various Mobile Lab surveys data and the BAO NE summer data may reflect the spatial variability in the alkane source molar composition.

3.2.3. Benzene source signatures

To look at the C_6H_6 correlations with other tracers, the 88 Mobile Lab flask samples have been divided into two subsets, none of which includes the three samples collected downwind of the natural gas and propane processing plant near Dacono, CO. In the summer, the lifetimes of C_6H_6 and C_3H_8 at 800 mbar and 40^oN are close to 3 or 4 days and the lifetime of CO is about 10 days [Finlayson-Pitts and Pitts, 2000; Spivakovsky et al., 2000].

The first subset of 39 samples has C_3H_8 mixing ratios smaller than 3 ppb and it includes flasks collected mostly during surveys #2, 3 and 4. For this subset influenced mostly by urban and mobile emissions, C_6H_6 correlates well with CO (slope=1.82 ppt/ppb, r^2=0.89) and C_2H_2 (slope=0.37 ppt/ppt, r^2=0.75) but not with C_3H_8 (r^2<0.3). The C_6H_6-to-CO correlation slope for this subset is similar to the correlation slopes for the BAO S and W wind sector winter samples.

The second subset of 46 samples corresponds to flasks with a C_3H_8 mixing ratio larger than 3ppb. These flasks were collected mostly during surveys #1, 6, 8 and 9. For this second subset influenced mostly by emissions from the DJB, C_6H_6 correlates well with C_3H_8 (slope=17.9 ppt/ppb, r^2=0.95) but not with CO or C_2H_2 (r^2<0.3). The C_6H_6-to-C_3H_8 slope for these samples is almost twice as big as the slope calculated for the BAO NE wind sector data (10.1 ppt/ppb) (Table 3).

4) Discussion

4.1. Comparing the alkane enhancements in the BAO and Mobile Lab data sets

In the previous section we showed two examples of enhanced alkanes in northeast Colorado using mobile sampling (surveys 6 and 9 on 14 and 31 July 2008, respectively). With lifetimes against OH removal on the order of 3.5, 1.7 and 1.0 days in the summer at 40°N [Finlayson-Pitts and Pitts, 2000; Spivakovsky et al., 2000] respectively, C_3H_8, n-C_4H_{10} and the C_5H_{12} isomers do not accumulate over the continent. Instead their atmospheric mixing ratios and the slopes of correlations between different alkanes reflect mostly local or regional sources within a few days of atmospheric transport.

The source responsible for the alkane enhancements observed at BAO and in multiple surveys during the Front Range Study appears to be located in the northeastern part of the Front Range region within the Denver-Julesburg Basin, so we call it the DJB source. The small differences in alkane correlation slopes for the BAO and Mobile Lab samples likely reflect differences in the emitted alkane molar ratios across this distributed source, as well as the mix of chemical ages for the air samples collected at a variety of locations and on different days.

In Table 3 and Figure 4, we compare the alkane correlation slopes in the Mobile Lab flask data set with the correlation slopes in the BAO data set. To calculate the DJB source C_3H_8-to-CH_4 correlation slope from the Mobile Lab data set, we have removed air samples collected downwind of feedlots, the wastewater treatment plant, and the natural gas and propane processing plant (Figure 1). The Mobile Lab flasks C_3H_8-to-CH_4 correlation slope is 0.095±0.007 ppb/ppb (R^2=0.76, 77 samples), similar to the slope

calculated for the BAO NE wind sector data. Samples collected downwind of the natural gas processing plant exhibit variable chemical signatures, reflecting a complex mix of contributions from leaks of gas and combustion exhaust from flaring units and compressor engines.

To calculate the DJB source n-C_4H_{10}-to-C_3H_8, i-C_5H_{12}-to-C_3H_8 and n-C_5H_{12}-to-C_3H_8 correlation slopes from the Mobile Lab data set, we have removed the three air samples collected downwind of the natural gas and propane processing plant (Figure 1). The C_4/C_3, i-C_5/C_3 and n-C_5/C_3 correlation slopes in the Mobile Lab data are 0.49, 0.19 and 0.19 ppb/ppb, respectively (r^2> 0.8, 85 samples). The i-C_5/C_3 and n-C_5/C_3 correlation slopes are 40% and 30% higher, respectively, than the BAO NE sector summer slopes. If we remove the 11 data points from survey #6 samples collected in the middle of the DJB, the C_5H_{12}-to-C_3H_8 ratios are only 15% higher than calculated for the NE sector at BAO.

High correlations among various alkanes were reported in this region by Goldan et al. [1995]. In that study, hourly air samples were analyzed with an in-situ gas chromatograph deployed on a mesa at the western edge of Boulder for two weeks in February 1991. CH_4 was not measured during that study. The correlation coefficient (r^2) between C_3H_8, n-C_4H_{10}, and the C_5H_{12} isomers was around 0.86, with a clear minimum slope for the abundance ratios (see Figure 4 in Goldan et al. [1995]). The authors proposed that the C_4-C_6 alkanes shared one common source with propane (called the "C_3 source" in the next section and in Figure 9), with additional emissions contributing to some C_4-C_6 alkane enhancements.

4.2. Comparing the Front Range observed alkane signatures with VOC emissions profiles for oil and gas operations in the Denver-Julesburg Basin

In this section we compare the alkane ratios calculated from the BAO NE wind sector and the Mobile Lab samples to emissions profiles from the DJB oil and gas exploration and production sector. Most of these profiles were provided by the WRAP Phase III inventory team, who developed total VOC and NOx emission inventories for oil and gas production and processing operation in the DJB for 2006 [Bar-Ilan et al., 2008a]. Emissions and activity data were extrapolated by the WRAP Phase III inventory team to derive emission estimates for 2010 based on projected production numbers and on state and federal emissions control regulations put in place in early 2008 for oil and gas permitted activities in the DNFR NAA [Bar-Ilan et al., 2008b]. The VOCs included in the inventories are: C_3H_8, i,n-C_4H_{10}, i,n-C_5H_{12} and higher alkanes, C_6H_6, toluene, ethyl-benzene, xylenes and 224-trimethylpentane. The WRAP Phase III inventories for 2006 and 2010 were only provided as total VOC and NOx emitted at the county level for all the counties in the Colorado part of the DJB. The emission estimates are based on various activity data (including the number of new wells (spuds), the total number of wells, estimates of oil, condensate and gas production, and equipment counts) and measured/reported or estimated VOC speciation profiles for the different source categories. Supplementary Figure 2S and Bar-Ilan et al. [2008a,b] present more details on how the inventory emission estimates are derived.

We focus primarily on flashing and venting sources here, since the WRAP Phase III inventory indicates that these two sources are responsible for 95% of the total VOC

emissions from oil and gas exploration and production operations in Weld County and in the NAA [Bar-Ilan et al., 2008a,b] (see Figure 2S). In 2006, all the oil produced in the DJB was from condensate wells. Condensate tanks at well pads or processing plants store a mostly-liquid mix of hydrocarbons and aromatics separated from the lighter gases in the raw natural gas. Flash losses or emissions happen for example when the liquid condensate is exposed to decreasing atmospheric pressure: gases dissolved in the liquid are released and some of the heavier compounds may be entrained with these gases. Flashing emissions from condensate storage tanks are the largest source of VOCs from oil and gas operations in the DJB. In the DNFR NAA, operators of large condensate tanks have to control and report emission estimates to the Colorado Department of Public Health and the Environment (CDPHE). In 2006 and 2010 flashing emissions represented 69% and 65% respectively of the total VOC source from oil and gas exploration, production and processing operations, for the nine counties in the NAA (see supplementary Figure 2S and Bar-Ilan et al. [2008a] for more details on how the estimates are derived).

Venting emissions are related to loss of raw natural gas when a new oil or gas well is drilled or when an existing well is vented (blowdown), repaired or restimulated (recompletion). Equipment at active well sites (e.g. well head, glycol dehydrators and pumps) or in the midstream network of compressors and pipelines gathering the raw natural gas can also leak significant amounts of natural gas. In the WRAP Phase III inventory, venting emissions represented 27% and 21% respectively of the total VOC estimated source from the NAA oil and gas operations in 2006 and 2010 ([Bar-Ilan et al., 2008a,b], Figure 2S).

The molar compositions of venting and flashing emissions are quite different (see supplementary Figure 4S). Emissions from flash losses are enriched in C_{2+} alkanes compared to the raw natural gas emissions. To convert the total VOC bottom-up source into speciated emission ratio estimates, we use molar ratio profiles for both flashing and venting emissions reported in three data sets:

- Bar-Ilan et al. [2008a]: mean venting profile used for the 2006 DJB inventory, also called the "Venting-WRAP" profile;
- Colorado Oil and Gas Conservation Commission [COGCC, 2007]: composition of 77 samples of raw natural gas collected at different wells in the Greater Wattenberg Area in December 2006, also called "Venting-GWA" profiles. Note that C_6H_6 was not reported in this data set;
- Colorado Department of Public Health and the Environment (CDPHE, personal communication): flashing emissions profiles based on condensate composition data from 16 different storage tanks in the DJB and EPA TANK2.0 (flashing emissions model) runs.

Figure 9 shows a comparison of the alkane molar ratios for the raw natural gas and flash emissions data sets with the correlation slopes derived for the Mobile Lab 2008 samples and for air samples collected at BAO in the summer months only (between August 2007 and April 2010) for the NE wind sector (cf. Table 4S to get the plotted values). The alkane correlation slopes observed at BAO and across the Northern Front Range with the Mobile Lab are all within the range of ratios reported for flashing and/or venting emissions. The C_{3-5} alkane ratios for both flashing and venting emissions are too similar for their atmospheric ratios to be useful in distinguishing between the two source

processes. The ambient C_3H_8-to-CH_4 and n-C_4H_{10}-to-CH_4 molar ratios are lower than what could be expected from condensate tank flashing emissions alone, indicating that most of the CH_4 observed came from the venting of raw natural gas. In the next section, we will describe how we derive bottom-up emission estimates for CH_4 and C_3H_8 as well as three top-down emissions scenarios consistent with the observed atmospheric slopes.

Figure 9 also shows the correlation slopes calculated by Goldan et al. [1995] for the 1991 Boulder study. These slopes compare very well with the BAO and Mobile Lab results and the oil and gas venting and flashing emissions ratios. Goldan et al. [1995] compared the measured C_4/C_3 and C_5/C_3 ratios for the Boulder C_3 source (see definition in Section 4.1) with the ratios reported in the locally distributed pipeline-quality natural gas for February 1991, and concluded that the common C_3H_8 and higher alkane source was not linked with the local distribution system of processed natural gas. However, the composition of the raw natural gas at the extraction well is quite different from the purified pipeline-quality natural gas distributed to end-users. Processed pipeline-quality natural gas delivered throughout the USA is almost pure CH_4 [Gas Research Institute, 1992]. Since Goldan et al. [1995] did not measure CH_4 in their 1991 study, they could not determine if the atmospheric C_{3+}/C_1 alkane ratios were higher than expected in processed natural gas.

4.3. Estimation of the alkane source in Weld County

Bottom-up speciated emission estimates

In this section, we derive bottom-up and top-down estimates of alkane emissions from the DJB source for Weld County. We have averaged the 2006 and 2010 WRAP

Phase III total VOC emissions data [Bar-Ilan et al., 2008ab] to get bottom-up estimates for the year 2008, resulting in 41.3 Gg/yr for flashing emissions and 16.8 Gg/yr for venting emissions. There are no uncertainty estimates provided in the WRAP Phase III inventory. 2006 total VOC flashing emission estimates in Weld County are based on reported emissions for controlled large condensate tanks (34.8 Gg/yr) and calculated emissions for uncontrolled small condensate tanks (5.4 Gg/yr) (see [Bar-Ilan et al., 2008] for more details). Uncertainties attached to these estimates may be due to inaccurate emissions factors (number of pounds of VOC flashed per tons of condensate produced) and/or inaccurate estimate of the effectiveness of emission control systems.

The WRAP Phase III total VOC emission from venting sources for Weld County was calculated by averaging industry estimates of the volume of natural gas vented or leaked to the atmosphere by various processes shown in Figure 2S (well blowdown, well completion, pneumatic devices…). A basin-wide average of gas composition analyses provided by oil and gas producers was then used to compute a bottom-up estimate of the total mass of VOC vented to the atmosphere by oil and gas exploration, production and processing operations. Uncertainties attached to the venting source can be related to uncertainties in leak rates or intensity of out-gassing events, as well to the variability in the composition of raw natural gas, none of which were quantitatively taken into account in the WRAP Phase III inventory.

Next we describe the calculations, summarized in Figure 5S, to derive bottom-up estimates of venting and flashing emissions for the various trace gases we measured using information from the WRAP Phase III inventory and the COGCC GWA raw natural gas composition data set (Table 4 and supplementary Figure 6S). From the total

annual vented VOC source and the average vented emission profile provided by Bar-Ilan et al. [2008a] (Table 2S), we derived an estimate of the volume of natural gas that we assumed is vented to the atmosphere by the oil and gas production and processing operations in Weld County. Following Bar-Ilan et al. inventory data and assumptions [2008a], we used the weight fraction of total VOC in the vented gas (18.74%), the molar mass of the vented gas (21.5g/mol) and standard pressure and temperature with the ideal gas law to assume that 1 mole of raw natural gas occupies a volume 22.4 L (as was done in the WRAP Phase III inventory). The total volume of vented gas we calculate for Weld County in 2008 is 3.36 billion cubic feet (Bcf), or the equivalent of 1.68% of the total natural gas produced in the county in 2008 (202.1 Bcf). We then use the estimate of the volume of vented gas and the molar composition profiles for the 77 raw natural gas samples reported in the COGCC GWA study to compute average, minimum, and maximum emissions for CH_4, each of the C_{3-5} alkanes we measured, and C_6H_6. Using this procedure, 2008 Weld County average venting CH_4 and C_3H_8 bottom-up source estimates are 53.1 Gg/yr and 7.8 Gg/yr, respectively (Table 4).

For flashing emissions, we distributed the WRAP 2008 total annual VOC source estimate (41.3 Gg/yr) using the modeled flash loss composition profiles for 16 different condensate tanks provided by the CDPHE. Average CH_4 and C_3H_8 emissions as well as the minimum and maximum estimates are reported in Table 4. The 2008 average flashing CH_4 and C_3H_8 bottom-up emission estimates are 11.2 Gg/yr and 18.3 Gg/yr, respectively (Table 4). The total flashing + venting CH_4 and C_3H_8 bottom-up estimates range from 46 to 86 Gg/yr and from 15 to 52 Gg/yr, respectively.

Top-Down emissions scenarios

Finally, we use our atmospheric measurements to bring new independent constraints for the estimation of venting and flashing emissions in Weld County in 2008. The exercise consists in calculating three top-down venting emission scenarios for CH_4 and C_3H_8 (x_m, x_p: mass of methane and propane vented respectively) consistent with a mean observed CH_4-to-C_3H_8 atmospheric molar ratio of 10 ppb/ppb (Table 4) in the DJB. We assume, as done earlier in the bottom-up calculations, that the observed C_3H_8-to-CH_4 ratio in the DJB results from a combination of flashing and venting emissions. The bottom-up information used here is (1) the set of speciated flashing emissions derived earlier for the 16 condensate tanks provided by CDPHE for CH_4 and C_3H_8 $(y_m, y_p)_{\text{tank=1,16}}$, and (2) three scenarios for the basin-average raw (vented) natural gas CH_4-to-C_3H_8 molar ratio, denoted $v_{m/p}$. The three values used for basin-average vented gas CH_4-to-C_3H_8 molar ratio are: 18.75, which is the WRAP Phase III inventory assumption (scenario 1); 15.43, which is the median of the molar ratios for the COGCC GWA 77 gas samples (scenario 2); and 24.83, which is the mean of the molar ratios for the COGCC GWA 77 gas samples (scenario 3). For each vented gas profile scenario, we use the set of 16 flash emission estimates to calculate an ensemble of venting emission estimates for CH_4 (x_m) and C_3H_8 (x_p) following the two equations below.

The first equation formalizes the assumption for CH_4-to-C_3H_8 molar ratio of the vented raw natural gas, with M_m (16g/mol) and M_p (44g/mol) being the molar masses of CH_4 and C_3H_8 respectively.:

$$v_{m/p} = \frac{M_p}{M_m} \times \frac{x_m}{x_p} \qquad (1)$$

In the second equation, the mean observed atmospheric CH_4-to-C_3H_8 molar ratio ($a_{m/p}$=10 ppb/ppb) constrains the overall ratio of methane versus propane emitted by both flashing

and venting sources. Therefore, for each set of 16 bottom-up flashed emission estimates (y_m, y_p), we have:

$$\frac{M_p\left(x_m + y_m\right)}{M_m\left(x_p + y_p\right)} = a_{m/p} \qquad (2)$$

The analytical solutions to this set of equations are given by:

$$\begin{aligned} x_p &= \frac{1}{\left(v_{m/p} - a_{m/p}\right)} \times \left(a_{m/p} \times y_p - \frac{M_p}{M_m} y_m\right) \\ x_m &= v_{m/p} \times \frac{M_m}{M_p} \times x_p \end{aligned} \qquad (3)$$

The average, minimum and maximum venting emission estimates, x_m and x_p, are reported for the three vented gas profile scenarios in Table 4 and Figure 10.

The first goal of this top-down estimation exercise is to highlight the many assumptions required to build the bottom-up and top-down emission estimates. The choices made for the WRAP Phase III inventory or our top-down calculations are all reasonable, and the uncertainty attached to the values chosen (if available) should be propagated to calculate total uncertainty estimates for the final emission products. When the error propagation is done conservatively, the emission uncertainty is close to a factor of 2 for both CH_4 and C_3H_8. This number is much higher than the 30% uncertainty reported by the EPA for the 2009 national CH_4 source estimate from natural gas systems [EPA, 2011c].

The scenario 1 mean top-down vented CH_4 source (118.4 Gg/yr) is twice as large as the bottom-up estimate of 53.1 Gg/yr (Table 4). If we assume that 77% (by volume) of the raw gas is CH_4, an average estimate of 118.4 Gg/yr of CH_4 vented would mean that the equivalent of 4% of the 2008 natural gas gross production in Weld County was

vented. It is important to note that the top-down scenarios cover a large range (67-229 Gg/yr), corresponding to between 2.3% and 7.7% of the annual production being lost to the atmosphere through venting (Table 4). The lowest estimate is, however, larger than what we derived from the WRAP Phase III bottom-up inventory (1.68%). If instead of using the EIA [EIA, 2004] convention for the molar volume of gas (23.6 L/mol), we used the standard molar volume used by WRAP (22.4 L/mol), our top-down calculations of the volume of gas vented would be 5% lower than reported in Table 4.

Emissions for the other alkanes measured are all derived from the C3H8 total sources scaled with the atmospheric molar ratios observed in the BAO NE summer samples and the Mobile Lab samples. Figure 10 shows a comparison of the bottom-up estimates and the top-down emission scenarios (mean of scenario 1 and overall minimum and maximum of the three scenarios).

The main result of this exercise is that for each of the three top-down total emissions scenarios, the mean estimates for CH_4, n-C_4H_{10} and the C_5H_{12} isomers are at least 60% higher than the bottom-up mean estimates. The minimum top-down emissions scenarios are lower than (in the case of C_3H_8) or higher than (for CH_4, nC_4H_{10}, i-C_5H_{12}, n-C_5H_{12}) the bottom-up mean estimates.

To put the top-down CH_4 source estimate from oil and gas exploration, production and processing operations in perspective, we compare it with an estimate of the passive "geological" CH_4 flux over the entire DJB. Klusman and Jakel [1998] reported an average flux of 0.57 mg CH_4/m^2/day in the DJB due to natural microseepage of light alkanes. Multiplied by a rough upper boundary estimate of the DJB surface area (Figure 1), the estimated annual natural flux is 0.66 Gg CH_4 /yr, or less than 1% of the

top-down venting source estimated for active exploration and production of natural gas in Weld County.

4.4. Benzene sources in the Northern Front Range

On-road vehicles are estimated to be the largest source of C_6H_6 in the US [EPA, 2009a]. Emissions from on-road and off-road vehicles and from large point sources (including chemical plants and refineries) have been regulated by the EPA for over thirty years [Fortin et al., 2005; Harley et al., 2006]. When motor vehicle combustion dominates emissions, such as in the BAO S and W wind sectors, C_6H_6 correlates well with CO and C_2H_2.

Crude oil and natural gas production and processing emitted an estimated 8333 tonnes of benzene nationally in 2005, which represented 2% of the national total C_6H_6 source [EPA, 2009a]. C_6H_6 and C_3H_8 have similar photochemical lifetimes (~ 3-4 days in the summer), so the observed atmospheric ratios we report in Table 3 should be close to their emission ratio if they are emitted by a common source. The strong correlation between C_6H_6 and C_3H_8 (Figure 4, Table 3) for the BAO NE wind sector and in the DJB Mobile Lab air samples suggests that oil and gas operations could also be a non-negligible source of C_6H_6 in the Northern Colorado Front Range.

The C_6H_6-to-C_3H_8 molar ratios in the flash losses from 16 condensate tanks simulated with the EPA TANK model are between 0.4 to 5.6 ppt/ppb. The C_6H_6-to-C_3H_8 molar ratio reported for vented emissions in the WRAP Phase III inventory is 5.3 ppt/ppb, based on regionally averaged raw gas speciation profiles provided by local companies [Bar-Ilan et al., 2008a] (only an average profile was provided, other data is

proprietary). These emission ratios are at least a factor of two lower than the atmospheric ratios measured in the Front Range air samples influenced by the DJB source (Table 3).

If we use the mean C_3H_8 emission estimate for scenario 1 described in Section 4.3 (35.7 Gg/yr), together with the C_6H_6-to-C_3H_8 correlation slope for the summer BAO NE wind sector data and that from the Mobile Lab samples (10.1 ppt/ppb and 17.9 ppt/ppb respectively), we derive a C_6H_6 emission estimate for the DJB source in Weld County in 2008 of 639 tonnes/yr (min/max range: 478/883 tonnes/yr) and 1145 tonnes/yr (min/max range: 847/1564 tonnes/yr), respectively. As expected, these numbers are much higher than what we derived for the bottom-up flashing and venting emissions (total of 139 tonnes/yr, min/max range of 49-229 tonnes/yr). For comparison, C_6H_6 emissions from facilities in Colorado reporting to the US EPA for the Toxics Release Inventory amounted to a total of 3.9 tonnes in 2008 [EPA, 2009b] and on–road emissions in Weld County were estimated at 95.4 tonnes/yr in 2008 [CDPHE, personal communication]. Based on our analysis, oil and gas operations in the DJB could be the largest source of C_6H_6 in Weld County.

More measurements are needed to further evaluate the various potential sources associated with oil and gas operations (for example, glycol dehydrators and condensate tank flash emissions). The past two iterations of the C_6H_6 emissions inventory developed by the State of Colorado for the National Emissions Inventory and compiled by the EPA do not show much consistency from one year to another. The 2008 and 2005 NEI reported very different C_6H_6 emission estimates for condensate tanks in Weld County (21.5 Mg/yr versus 1120 Mg/yr, respectively; see also Table 3S). Estimates in the 2008 NEI are much closer to estimates provided by CDPHE (personal communication) for

2008 (21.3 Mg/yr), suggesting the 2005 NEI estimate may be flawed, even though it is in the range of our top-down estimation. We conclude that the current level of understanding of emissions of C_6H_6 from oil and gas operations cannot explain the top-down range of estimates we derive in our study, suggesting that, once again, more field measurements are needed to understand and quantify oil and gas operation sources.

5) Conclusion

This study provides a regional overview of the processes impacting ambient alkane and benzene levels in northeastern Colorado in the late 2000s. We report atmospheric observations collected by two sampling platforms: a 300-m tall tower located in the SW corner of Weld County (samples from 2007 to 2010), and road surveys by a Mobile Lab equipped with a continuous methane analyzer and discrete canister sampling (June-July 2008). The analysis of the tower data filtered by wind sector reveals a strong alkane and benzene signature in air masses coming from northeastern Colorado, where the main activity producing these compounds is related to oil and gas operations over the Denver–Julesburg Fossil Fuel Basin. Using the Mobile Lab platform, we sampled air directly downwind of different methane sources (oil and gas wells, a landfill, feedlots, and a waste water treatment plant) and collected targeted air samples in and out of plumes. The tall tower and Mobile Lab data both revealed a common source for air masses with enhanced alkanes. In the data from both platforms, the alkane mixing ratios were strongly correlated, with slight variations in the correlation slopes depending on the location and day of sampling. The alkanes did not correlate with combustion tracers such as carbon monoxide and acetylene. We hypothesize that the observed alkanes were emitted by the same source located over the Denver-Julesburg Basin, "the DJB source".

The second part of the study brings in information on VOC emissions from oil and gas activities in the DJB from the detailed bottom-up WRAP Phase III inventory [Bar Ilan et al., 2008a,b]. We have used the total VOC emission inventory and associated emissions data for DJB condensate and gas production and processing operations to calculate annual emission estimates for CH_4, C_3H_8, n-C_4H_{10}, i-C_5H_{12}, n-C_5H_{12} and C_6H_6 in Weld County. The main findings are summarized below:

- The emissions profiles for flashing and venting losses are in good agreement with the atmospheric alkane enhancement ratios observed during this study and by Goldan et al. [1995] in Boulder in 1991. This is consistent with the hypothesis that the observed alkane atmospheric signature is due to oil and gas operations in the DJB.
- The three top-down emission scenarios for oil and gas operations in Weld County in 2008 give a rather large range of potential emissions for CH_4 (71.6-251.9 Gg/yr) and the higher alkanes. Except for propane, the lowest top-down alkanes emission estimates are always larger than the inventory-based mean estimate we derived based on the WRAP Phase III inventory data and the COGCC GWA raw gas composition data set.
- There are notable inconsistencies between our results and state and national regulatory inventories. In 2008 gas wells in Weld County represented 15% of the state's production. Based on our top-down analysis, Weld County methane emissions from oil and gas production and processing represent at least 30% of the state total methane source from natural gas systems derived by Strait et al. [2007] using the EPA State Inventory Tool. The methane source from natural gas

systems in Colorado is most likely underestimated by at least a factor of two. Oil and gas operations are the largest source of alkanes in Weld County. They were included as a source of "total VOC" in the 2008 EPA NEI for Weld County but not in the 2005 NEI.

- There are at least two main sources of C_6H_6 in the region: one related to combustion processes, which also emit CO and C_2H_2 (engines and mobile vehicles), and one related to the DJB alkane source. The C_6H_6 source we derived based on flashing and venting VOC emissions in the WRAP inventory (143 Mg/yr) most likely underestimates the actual total source of C_6H_6 from oil and gas operations. Our top-down source estimates for C_6H_6 from oil and gas operations in Weld County cover a large range: 385-2056 Mg/yr. Again, the lowest figure is much higher than reported in the 2008 CDPHE inventory for Weld County oil and gas total point sources (61.8 Mg/yr).
- Samples collected at the BAO tall tower or while driving around the Front Range reflect the emissions from a complex mix of sources distributed over a large area. Using a multi-species analysis including both climate and air quality relevant gases, we can start unraveling the contributions of different source types. Daily multi-species measurements from the NOAA collaborative network of tall towers in the US provide a unique opportunity to understand source chemical signatures in different airsheds and how these emissions may change over time.
- More targeted multi-species well-calibrated atmospheric measurements are needed to evaluate current and future bottom-up inventory emissions calculations

for the fossil fuel energy sector and to reduce uncertainties on absolute flux estimates for climate and air quality relevant trace gases.

Acknowledgements

The authors thank John Grant (ENVIRON) and Kathleen Sgamma (Western Energy Alliance) for their expertise and support in interpreting the WRAP Phase III inventory public data. Special thanks are extended to the NOAA personnel and collaborators responsible for flask preparation, sample collection and sample analysis, data quality control and database management.

References

Andrews, A.E., J. Kofler, P.S. Bakwin, C. Zhao, P. Tans (2009), Carbon Dioxide and Carbon Monoxide Dry Air Mole Fractions from the NOAA ESRL Tall Tower Network, 1992-2009, Version: 2009-05-12, Path: ftp://ftp.cmdl.noaa.gov/ccg/towers/.

Baker A. K., A. J. Beyersdorf , L. A. Doezema, A. Katzenstein, S. Meinardi , I. Simpson, D. R. Blake, F. S. Rowland, (2008), Measurements of nonmethane hydrocarbons in 28 United States cities, Atmospheric Environment, 42, 170-182.

Bakwin, P.S, P.P. Tans, C. Zhao, W. Ussler III, and E. Quesnell (1995), Measurements of carbon dioxide on a very tall tower, Tellus. 47B, 535-549.

Bar-Ilan A. et al. (2008a), Development of baseline 2006 emissions from oil and gas activity in the Denver-Julesburg Basin, WRAP Phase III report, 34p, available at http://www.wrapair.org/forums/ogwg/PhaseIII_Inventory.html.

Bar-Ilan A. et al. (2008b), Development of the 2010 oil and gas emissions projections for the Denver-Julesburg Basin, WRAP Phase III report, 26p, available at http://www.wrapair.org/forums/ogwg/PhaseIII_Inventory.html.

Burns, D., (1999), Minimizing benzene emissions from glycol dehydrators, presented at the Benzene Emissions Conference on January 27, 1999 in Calgary, Alberta, available at http://www.gasliquids.com/papers/benzene99.pdf.

CDPHE (2008a), 8-hour Ozone Nonattainment Fact Sheet, available at http://www.cdphe.state.co.us/ap/ozone/ozonefactsheet.pdf.

CDPHE (2008b), Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan - Emissions Inventory, available at http://www.colorado.gov/airquality/documents/deno308/Emission_Inventory_TSD_Draft Final.pdf.

CDPHE (2009), State of Colorado Technical Support Document For Recommended 8-Hour Ozone Designations, available at http://www.cdphe.state.co.us/ap/ozone/OZDesignations.pdf

Colorado Oil and Gas Conservation Commission (2007), Greater Wattenberg area baseline study, report available in the Library section at http://cogcc.state.co.us/.

Conway, T., P. Tans, L. Waterman, K. Thoning, D. Kitzis, K. Masarie, and N. Zhang (1994), Evidence for interannual variability of the carbon cycle from the National Oceanic and Atmospheric Administration;Climate Monitoring and Diagnostics Laboratory Global Air Sampling Network, J. Geophys. Res., 99(D11), 22831-22855.

de Gouw, J.A. et al. (2009), Airborne measurements of ethene from industrial sources using laser photo-acoustic spectroscopy, Environ. Sci. Technol., 43, 2437-2442.

Dlugokencky, E., L. Steele, P. Lang, and K. Masarie (1994), The growth rate and distribution of atmospheric methane, J. Geophys. Res., 99(D8), 17021-17043.

EIA (2004), How EIA Estimates Natural Gas Production, 50p, available at ftp://ftp.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngprod/ngprod.pdf.

EIA (2006), Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market, Office of Oil and Gas, 11p, available at http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2006/ngprocess/ngprocess.pdf.

EIA (2008), Natural Gas Navigator, http://tonto.eia.doe.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm.

EPA (1998), Locating and Estimating Air Toxic Emissions from Sources of benzene, report, available at http://www.epa.gov/ttn/chief/le/.

EPA (2004), Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs, EPA 816-R-04-003, 424 pages.

EPA (2008), 2005 National Emissions Inventory Data & Documentation, http://www.epa.gov/ttn/chief/net/2005inventory.html

EPA (2009a), 2008 Report On the Environment, www.epa.gov/roe.

EPA (2009b), Toxics Release Inventory program, data available at http://www.epa.gov/triexplorer/chemical.htm.

EPA (2011a), Inventory of U.S. Greenhouse Gas emissions and Sinks: 1990-2009, available at http://www.epa.gov/climatechange/emissions/.

EPA (2011b), 2008 National Emissions Inventory Data, Sector summaries, available at http://www.epa.gov/ttnchie1/net/2008inventory.html.

EPA (2011c), Inventory of U.S. Greenhouse Gas emissions and Sinks: 1990-2009, Annex 7, available at http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Annex-7.pdf.

Finlayson-Pitts B. and J. N. Pitts (2000), Chemistry of the Upper and Lower Atmosphere, Academic Press Title, 969 pages.

Fortin, T. J.; B. J. Howard, D. D. Parrish, P. D. Goldan, W. C. Kuster, E. L. Atlas, R. A. Harley (2005), Temporal changes in U.S. benzene emissions inferred from atmospheric measurements. Environ. Sci. Technol., 39, 1403-1408.

Gas Research Institute (1992), Variability of Natural Gas Composition in Select Major Metropolitan Areas of the United States, Report GRI-92/0123.

Goldan, P. D., M. Trainer, W. C. Kuster, D. D. Parrish, J. Carpenter, J. M. Roberts, J. E. Yee, and F. C. Fehsenfeld (1995), Measurements of hydrocarbons, oxygenated hydrocarbons, carbon monoxide, and nitrogen oxides in an urban basin in Colorado: Implications for Emission Inventories, *J. Geophys. Res.*, 100(D11), 22,771–22,783.

Harley, R. A., D. S. Hooper, A. J. Kean, T. W. Kirchstetter, J. M. Hesson, N. T. Balberan, E. D. Stevenson, and G. R. Kendall (2006), Effects of reformulated gasoline and motor vehicle fleet turnover on emissions and ambient concentrations of benzene, Environ. Sci. Technol., 40, 5084–5088.

IPCC (2007), Fourth Assessment Report: Climate Change 2007.

Kaimal J. C. and J. E. Gaynor (1983), The Boulder Atmospheric Observatory, J. Climate Appl. Meteor., 22, 863-880.

Katzenstein, A. S., L. A. Doezema, I. J. Simpson, D. R. Blake and F. S. Rowland (2003), Extensive Regional Atmospheric Hydrocarbon Pollution in the Southwestern United States, PNAS, Vol. 100, No. 21, 11975-11979.

Mellqvist J., J. Samuelsson, J. Johansson, C. Rivera, B. Lefer and S. Alvarez (2009), Measurements of industrial emissions of alkenes in Texas using the Solar Occultation Flux method, J. Geophys. Res., 115, D00F17, doi:10.1029/2008JD011682.

Montzka, S., R. Myers, J. Butler, J. Elkins, and S. Cummings (1993), Global Tropospheric Distribution and Calibration Scale of HCFC-22, Geophys. Res. Lett., 20(8), 703-706.

Nam, E. K., T. E. Jensen, and T. J. Wallington (2004), Methane Emissions from Vehicles, Environ. Sci. Technol., 38 (7), pp 2005–2010, DOI: 10.1021/es034837g.

Novelli, P.C., V.S. Connors, H.G. Reichle, Jr., B.E. Anderson, C.A.M. Brenninkmeijer, E.G. Brunke, B.G. Doddridge, V.W.J.H. Kirchhoff, K.S. Lam, K.A. Masarie, T. Matsuo, D.D. Parrish, H.E. Scheel, and L.P. Steele (1998), An internally consistent set of globally distributed atmospheric carbon monoxide mixing ratios developed using results from an intercomparison of measurements, Journal of Geophysical Research, Vol.103, No. D15, p. 19,285-19,293.

Parrish, D. D., et al. (1998), Internal consistency tests for evaluation of measurements of anthropogenic hydrocarbons in the troposphere, J. Geophys. Res., 103(D17), 22,339–22,359.

Ritter Governor B. (2007), Colorado Climate Action Plan: A Strategy to Address Global Warming, available at: http://www.pewclimate.org/docUploads/COClimatePlan.pdf, 35p.

Roberts J. et al. (1984), Measurements of aromatic hydrocarbon ratios and NO_x concentrations in the rural troposphere: Observation of air mass photochemical aging and NO_x removal, Atmospheric Environment, Volume 18, Issue 11, Pages 2421-2432.

Ryerson, T. B., et al. (2003), Effect of petrochemical industrial emissions of reactive alkenes and NO_x on tropospheric ozone formation in Houston, Texas , *J. Geophys. Res.* , 108 , 4249, doi:10.1029/2002JD003070.

Scamehorn, (2002), High Altitude Energy: A History of Fossil Fuel in Colorado, University Press of Colorado, 244p.

Schnell, R. C., S. J. Oltmans; R. R. Neely; M. S. Endres; J. V. Molenar; A. B. White (2009), Rapid photochemical production of ozone at high concentrations in a rural site during winter, Nature Geosci. 2, 120–122.

Simpson, I.J., N. J. Blake, B. Barletta, G. S. Diskin, H. E. Fuelberg, K. Gorham, L. G. Huey, S. Meinardi, F. S. Rowland, S. A. Vay, A. J. Weinheimer, M. Yang, and D. R. Blake (2010), Characterization of trace gases measured over Alberta oil sands mining operations: 76 speciated C_2–C_{10} volatile organic compounds (VOCs), CO_2, CH_4, CO, NO, NO_2, NO_y, O_3 and SO_2, Atmos. Chem. Phys., 10, 11931-11954.

Speight J.G. (1999), The chemistry and technology of petroleum, third Edition, Published by Marcel Dekker, ISBN 0824702174, 9780824702175, 918 pages

Spivakovsky, C. M., J. A. Logan, S. A. Montzka, Y.J. Balkanski, M. Foreman-Fowler, D. B. A. Jones, L. W. Horowitz, A. C. Fusco, C. A. M. Brenninkmeijer, M. J. Prather, S. C. Wofsy, and M. B. McElroy (2000), Three-dimensional climatological distribution of tropospheric OH: Update and evaluation, J. Geophys. Res., 105, 8931–8980.

Strait R., S. Roe, A. Bailie, H. Lindquist, A. Jamison (2007), Colorado Greenhouse Gas Inventory and Reference Case Projections 1990-2020, Center for Climate Strategies report for the Colorado Department of Public Health and Environment (CDPHE) under contract to the Western Regional Air Partnership (WRAP), 99p, available at http://www.cdphe.state.co.us/ap/studiesreports.html.

Warneke, C., et al. (2007), Determination of urban volatile organic compound emission ratios and comparison with an emissions database, *J. Geophys. Res.*, 112, D10S47, doi:10.1029/2006JD007930.

Werner C., K. Davis, P. Bakwin, C. Yi, D. Hursts and L. Lock (2003), Regional-scale measurements of CH_4 exchange from a tall tower over a mixed temperate/boreal lowland and wetland forest, Global Change Biology, 9, 1251-1261.

Wert, B. P., et al. (2003), Signatures of terminal alkene oxidation in airborne formaldehyde measurements during TexAQS 2000 , *J. Geophys. Res.* , 108 , 4104, doi:10.1029/2002JD002502.

List of Figures

Figure 1: Map of the study area centered on the Boulder Atmospheric Observatory (BAO), located 25 km east-northeast of Boulder. Overlaid on this map are the locations of active oil and gas wells (light purple dots) as of April 2008 (data courtesy of SkyTruth, http://blog.skytruth.org/2008/06/colorado-all-natural-gas-and-oil-wells.html, based on COGCC well data). Also shown are the locations of landmarks used in the study,

including selected point sources (NGP Plant = natural gas processing plant, WWT Plant = Lafayette wastewater treatment plant).

Figure 2: Observed median mixing ratios for several species measured in air samples taken at various sites at midday during June-August (2007-2010). The sites are described in Table 1. Only nighttime samples are shown for NWF to capture background air with predominantly down-slope winds. Notice the different units with all columns and the different scaling applied to methane, propane and n-butane.

Figure 3: Summertime and wintertime median mixing ratios of several species measured in air samples from the 300-meter level at the BAO tower for three wind sectors: North and East (NE) where the density of gas drilling operations is highest, South (S) with Denver 35 km away, and West (W) with mostly clean air. The time span of the data is from August 2007 to April 2010. Summer includes data from June to August and winter includes data from November to April. Due to the small number of data points (<15), we do not show summer values for the S and W wind sectors. Data outside of the 11am-3pm local time window were not used. Notice the different scales used for methane, propane and n-butane. The minimum number of data points used for each wind sector is: NE summer 33, NE winter 89, S winter 65 and W winter 111.

Figure 4: Correlation plots for various species measured in the BAO summertime NE wind sector flask samples (left column) and summer 2008 Mobile Lab (right column) samples. Data at BAO were filtered to keep only midday air samples collected between

June and August over the time period spanning August 2007 to August 2009. See also Table 3.

Figure 5: (Top panel) Time series of the continuous methane measurements from Mobile Lab Survey # 9 on July 31, 2008. Also shown are the mixing ratio data for the 12 flask samples collected during the road survey. The GC/MS had a faulty high energy dynode cable when these samples were analyzed, resulting in more noisy data for the alkanes and the CFCs (σ < 10% instead of 5%). However, the amplitudes of the C_{3-5} alkane signals are much larger than the noise here. The methane mixing ratio scale is shown on the left hand vertical axis. For all other alkanes, refer to the right hand vertical axis.

(Bottom panel) Time series of wind directions at the NCAR Foothills and Mesa Laboratories in Boulder (see Figure 6 for locations) and from the 300-m level at the BAO on July 31, 2008.

Figure 6: Continuous methane observations (colored squares) and flask (circles) samples collected during the July 31, 2008 Mobile Lab Survey #9 in Boulder and Weld County. The size of the symbols (and the symbol color for the continuous methane data) represents the mixing ratio of continuous/flask methane (squares, green circles) and flask propane (blue circles). The labels indicate the flask sample number (also shown in the time series in Figure 5). NCAR = National Center for Atmospheric Research, FL = NCAR Foothills Laboratory, ML = NCAR Mesa Laboratory, WWT Plant = Lafayette wastewater treatment plant.

Figure 7: A) Propane versus methane mixing ratios for air samples collected during Survey #9 on July 31, 2008. B) n-butane versus propane mixing ratios in the same air samples. The black line in plot A shows the correlation line for samples not impacted by

local sources of methane (all flasks except #4, 5, 8, and 12). The black line in plot B shows the correlation line for all samples except flask 12. The flask sample number is shown next to each data point. The twelve samples were filled sequentially (see Figure 6).

Figure 8: A) Propane versus methane mixing ratios for air samples collected during Survey #6 on July 14, 2008. B) n-butane versus propane mixing ratios in the same air samples. The black line in plot A shows the correlation line for samples not impacted by local sources of methane (all flasks except 1-3, 5, and 9). The black line in plot B shows the correlation line for samples not impacted by local sources of propane.

Figure 9: Alkane correlation slopes in air samples collected at BAO (NE wind sector, summer samples only, blue) and over the Denver-Julesburg Basin (red) during the Front Range Study (June-July 2008) are compared with VOC emissions molar ratios for flashing (green) and venting (grey) sources used by Bar-Ilan et al. [2008a] for the DJB WRAP Phase III emissions inventory. The error bars indicate the min and max values for the flashing emissions molar ratios. Also shown are the mean, min and max molar ratios derived from the composition analysis of gas samples collected in 2006 at 77 different gas wells in the Great Wattenberg Area (yellow, [Colorado Oil and Gas Conservation Commission, 2007]). Goldan et al. [1995] data are from a two week measurement campaign in the Foothills, west of Boulder, in February 1991 (light purple). Goldan et al. identified a “local” propane source (lower limit for correlation slope) with clear $C_{4\text{-}5}$ alkane ratios to propane (dark propane, see also text). The error bars on the observed

atmospheric molar ratios are the 2-sigma calculated for the ratios with linmix_err.pro (http://idlastro.gsfc.nasa.gov/ftp/pro/math/linmix_err.pro).

Figure 10: Bottom-up (inventory-derived) emission estimates and top-down emission scenarios for CH_4, C_3H_8, n-C_4H_{10} , i-C_5H_{12}, n-C_5H_{12} and C_6H_6 in Weld County. The vertical bars show scenario 1 average values and the error bars indicate the minimum and maximum values for the three scenarios described in Table 4.

Tables

Table 1: Locations of a subset of the NOAA ESRL Towers and Aircraft Profile Sites used in this study. STR and WGC in Northern California are collaborations with Department of Energy Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (PI: Marc Fischer). The last column gives the altitudes of the quasi-daily flask air samples used in this study. We use midday data for all sites, but at Niwot Ridge Forest we used night time data to capture background air from summertime downslope flow. We also show the location information of SGP, a NOAA ESRL aircraft site in north central Oklahoma, for which we used samples taken below 650 meters altitude.

Site Code	City	State	Latitude ^{o}North	Longitude ^{o}East	Elevation (meters above sea level)	Sampling Height (meters above ground)
BAO	Erie	Colorado	40.05	105.01	1584	300
LEF	Park Falls	Wisconsin	45.93	90.27	472	396
NWF	Niwot Ridge	Colorado	40.03	105.55	3050	23
STR	San Francisco	California	37.7553	122.45	254	232

WGC	Walnut Grove	California	38.265	121.49	0	91
WKT	Moody	Texas	31.32	97.33	251	457
SGP*	Southern Great Plains	Oklahoma	36.80	97.50	314	< 650

* aircraft discrete air samples

Table 2: List of the Front Range Mobile Lab measurement and flasks sampling surveys. Some trips (#1, 2, 3, 4, 6) sampled air using the flask only. Surveys # 5 and 7 used only the continuous analyzers on the Mobile Lab with no discrete flask collection. The last two trips targeted flask sampling close to known point or area sources based on the continuous methane measurement display in the Mobile Lab.

Road Survey #	**Road Survey Date**	**Geographical Area / Target sources**	**Measurements/ Sampling Technique**
1	**June 4**	Boulder	12 flasks
2	**June 11**	Boulder + Foothills	12 flasks
3	**June 19**	NOAA-Longmont-Fort Collins-Greeley (Oil and Gas Drilling, Feedlots)	24 flasks
4	**July 1**	NOAA - Denver	12 flasks
5	**July 9**	Around Denver	Picarro
6	**July 14**	NOAA - Greeley	12 flasks
7	**July 15**	NOAA-Greeley	Picarro
8	**July 25**	BAO surroundings Dacono Natural Gas Compressor - Feedlot	Picarro + 8 flasks
9	**July 31**	"Regional" CH_4 enhancements, Landfill, Corn field	Picarro + 12 flasks

Table 3: Correlation slopes and r^2 for various species measured in the BAO tower midday air flask samples for summer (June to August, when more than 25 samples exist) and winter (November to April) over the time period spanning August 2007 to April 2010. The three wind sectors used in Figure 3 are also used here with a 30-min average wind speed threshold of 2.5 m/s. Also shown are the slopes derived from flask samples collected by the Mobile Lab in summer 2008. The slope is in bold when r^2 is higher than 0.7 and the slope is not shown when r^2 is less than 0.4. The number of data points (n) used for the slope and r^2 calculations are provided. All slope units are ppb/ppb, except for C_6H_6/C_3H_8, C_6H_6/CO and C_2H_2/CO, which are in ppt/ppb. We used the IDL routine linmix_err.pro for the calculations with the following random measurement errors: 2ppb for CH_4 and CO and 5% for C_3H_8, n-C_4H_{10}, i-C_5H_{12}, n-C_5H_{12}, C_2H_2, and C_6H_6.

Sector		**BAO North and East**						**BAO South**			**BAO West**			**Mobile Lab**		
Season		**summer**			**winter**			**winter**			**winter**			**summer**		
Molar ratios y/x	**units**	**slope**	r^2	n	**slope**	r^2	n	**slope**	r^2	n	**slope**	r^2	n	**slope**	r^2	n
C_3H_8/ CH_4	ppb/ ppb	**0.104 ±0.005**	0.85	81	**0.105 ±0.004**	0.90	115	0.079 ±0.008	0.53	130	**0.085 ±0.005**	0.73	148	**0.095 ±0.007**	0.76	77
nC_4H_{10}/	ppb/	**0.447**	1.00	81	**0.435**	1.0	120	**0.449**	0.98	131	**0.434**	1.00	151	**0.490**	1.00	85

C_3H_8	ppb	**±0.013**			**±0.005**			**±0.011**			**±0.006**			**±0.011**		
iC_5H_{12}/ C_3H_8	ppb/ ppb	**0.14 1 ±0.004**	1.00	81	**0.134 ±0.004**	0.9 8	120	**0.142 ±0.009**	0.81	121	**0.130 ±0.004**	0.94	151	**0.185 ±0.011**	0.81	85
nC_5H_{12}/ C_3H_8	ppb/ ppb	**0.150 ±0.003**	1.00	81	**0.136 ±0.004**	0.9 8	120	**0.142 ±0.006**	0.90	131	**0.133 ±0.003**	0.91	151	**0.186 ±0.008**	0.92	85
C_6H_6/ C_3H_8	ppt/ ppb	10.1 ±1.2	0.67	49	**8.2 ±0.5**	0.7 9	117	-	0.33	130	-	0.39	150	**17.9 ±1.1**	0.95	46
C_6H_6/ CO	ppt/ ppb	2.89 ±0.40	0.58	53	3.18 ±0.24	0.6 9	112	**1.57 ±0.08**	0.85	123	**1.81 ±0.08**	0.83	148	**1.82 ±0.12**	0.89	39
C_2H_2/ CO	ppt/ ppb	**3.15 ±0.33**	0.85	81	**7.51 ±0.39**	0.8 5	100	**5.03 ±0.17**	0.92	110	**5.85 ±0.25**	0.86	131	**4.32 ±0.28**	0.89	39
C_6H_6/ C_2H_2	ppt/ ppt	0.51 ±0.09	0.55	50	**0.34 ±0.02**	0.9 0	103	**0.27 ±0.02**	0.90	111	**0.32 ±0.02**	0.96	132	**0.37 ±0.04**	0.75	39

Table 4: Bottom-up (inventory-derived) emission estimates and top-down emissions scenarios for CH_4 and C_3H_8 in Weld County.

	Bottom-Up Estimates	**Top-Down Scenarios[e]: Venting**	**Top-Down Scenarios[e]: TOTAL Bottom-Up Flashing + Top-Down Venting**	**Top-Down Scenarios[e]: % of production vented[f]**

Gg/yr	Flashing[b]	Venting[c]	Flashing + venting	% of production vented[d]	1	2	3	1	2	3	1	2	3
methane	**11.2**	53.1	64.3	**1.68%**	118.4	92.5	157	**129.6**	103.7	168.2	**4.0%**	3.1%	5.3%
min[a]	**4**	42	46		86.5	67.6	114.7	90.5	**71.6**	118.7	2.9%	**2.3%**	3.8%
max[a]	**23**	63	86		172.6	134.9	228.9	195.6	157.9	**251.9**	5.8%	4.5%	**7.7%**
propane	**18.3**	7.8	26.1		17.4	10.2	28	**35.7**	28.5	46.3			
min[a]	**14**	1	15		12.7	7.5	20.5	26.7	**21.5**	34.5			
max[a]	**24**	28	52		25.3	14.9	40.8	49.3	38.9	**64.8**			

[a] The minimum and maximum values reported here come from the ensemble of 16 condensate tank emissions speciation profiles provided by CDPHE.

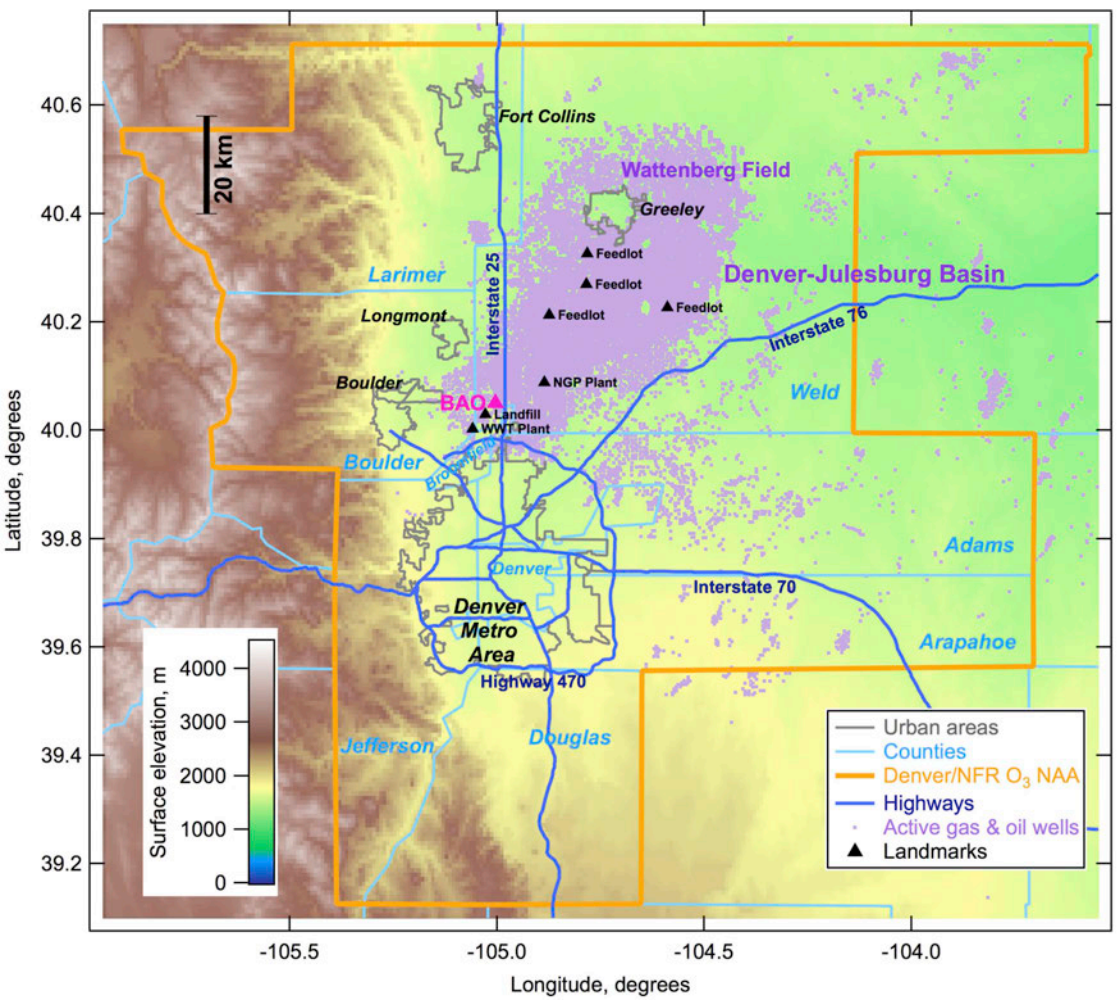
[b] The bottom-up flashing emissions for methane and propane were calculated using the 2008 estimate of total VOC flash emissions derived by averaging the WRAP estimate for 2006 and the projection for 2010 (Cf. section 4.3).

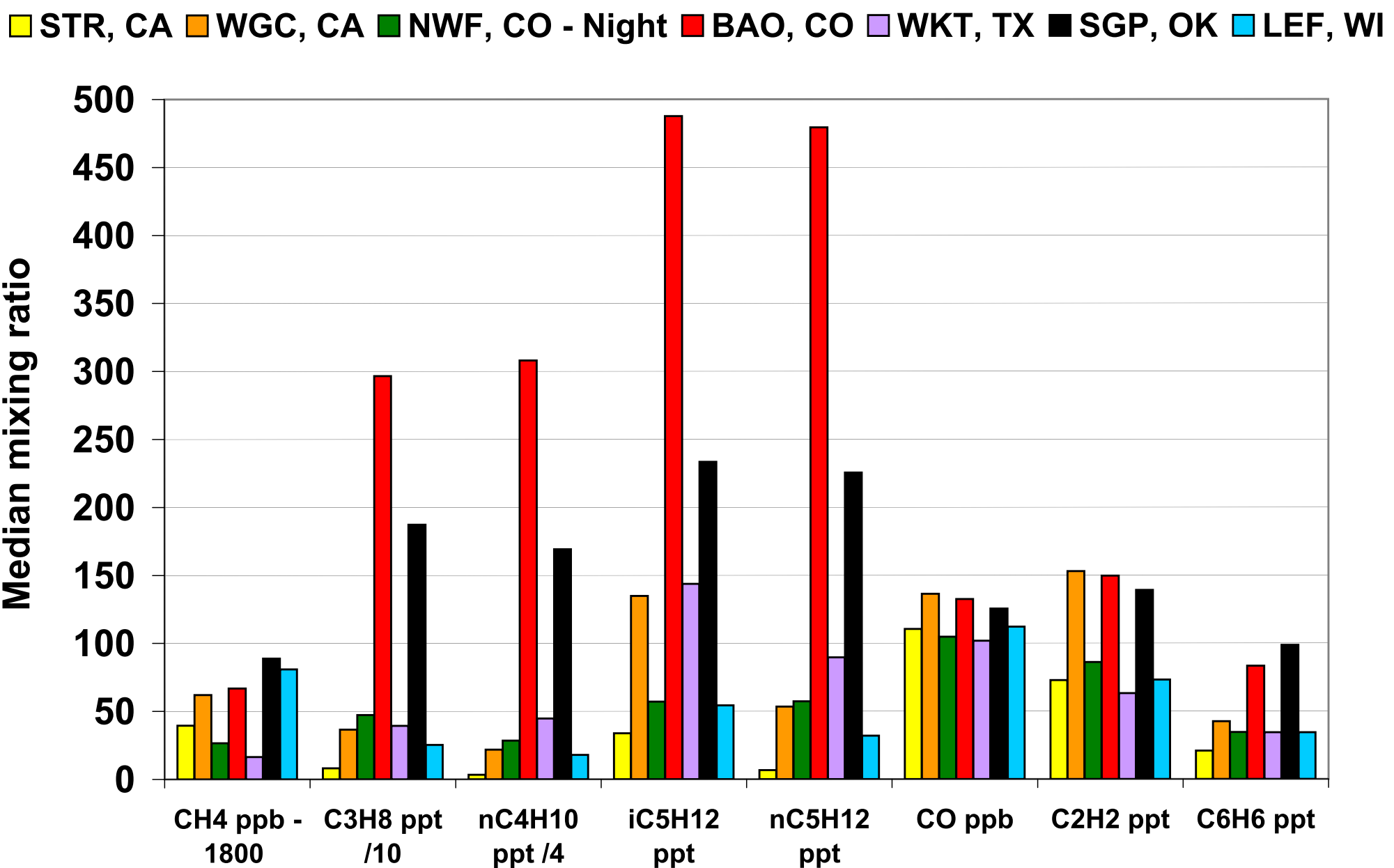
[c] The bottom-up venting emissions for methane and propane were calculated using the WRAP Phase III inventory estimate for the total volume of natural gas vented and the GWA 77 natural gas composition profiles.

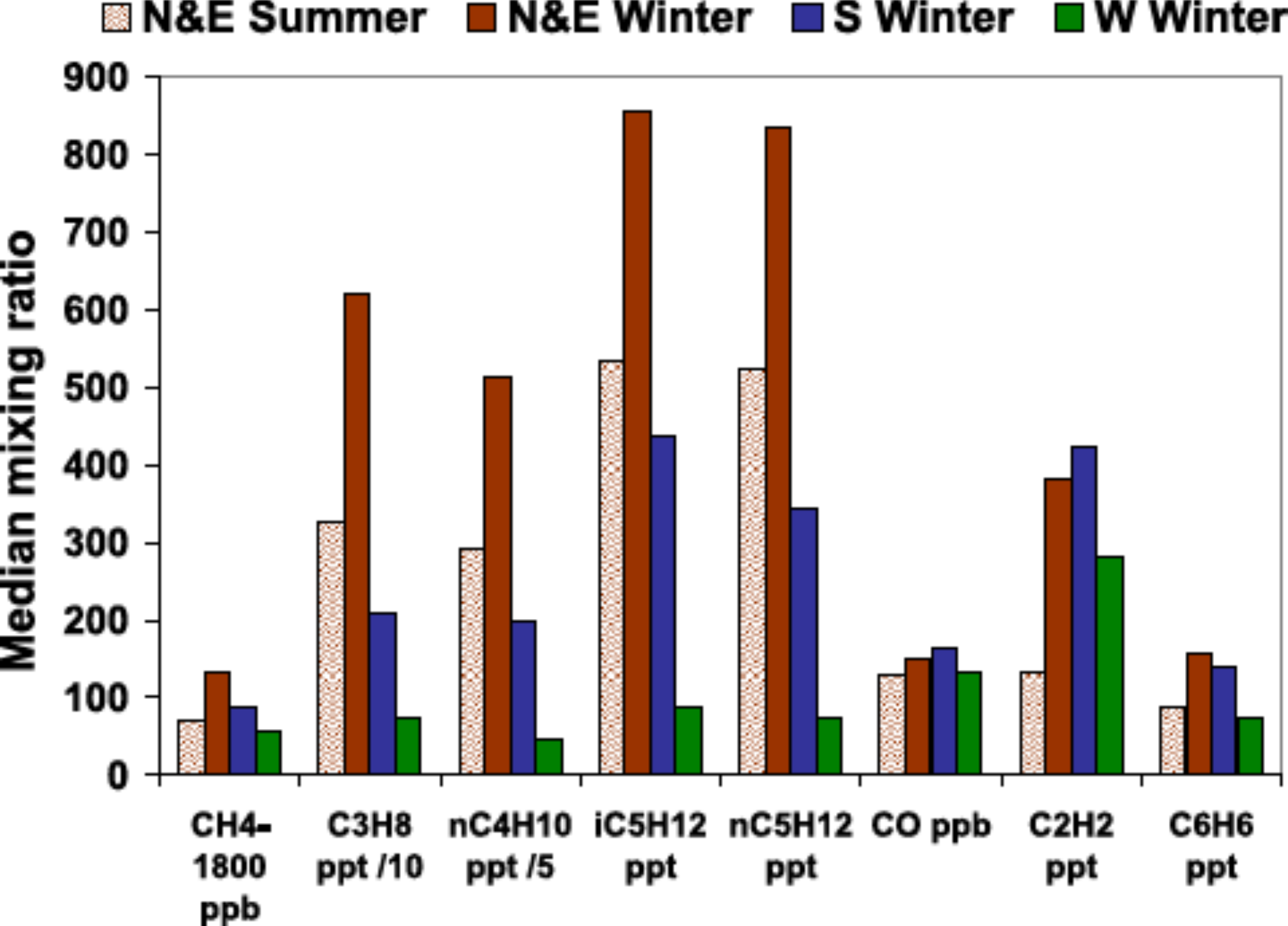
[d] Using the WRAP Phase III inventory data set and assumptions, including a CH_4 mean molar ratio of 77.44% for the vented natural gas and a molar volume for the gas of 22.4 L/mol.

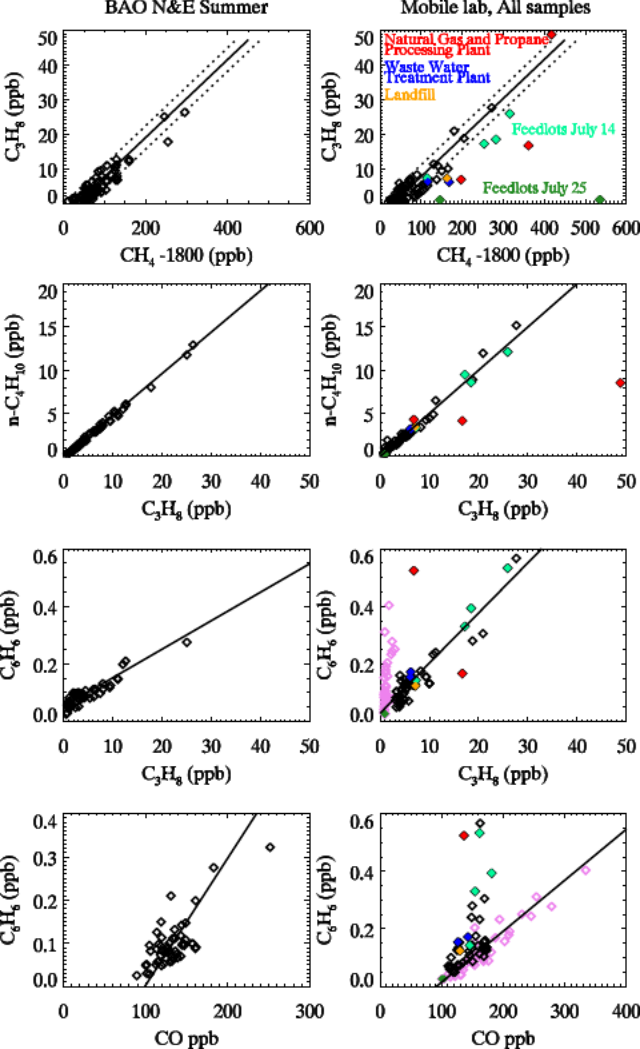
[e] The CH_4-to-C_3H_8 molar ratio for vented natural gas is 18.75 (WRAP report estimate) for scenario 1, 15.43 for scenario 2 (median of molar ratios in GWA data set) and 24.83 for scenario 3 (mean of molar ratios in GWA data set).

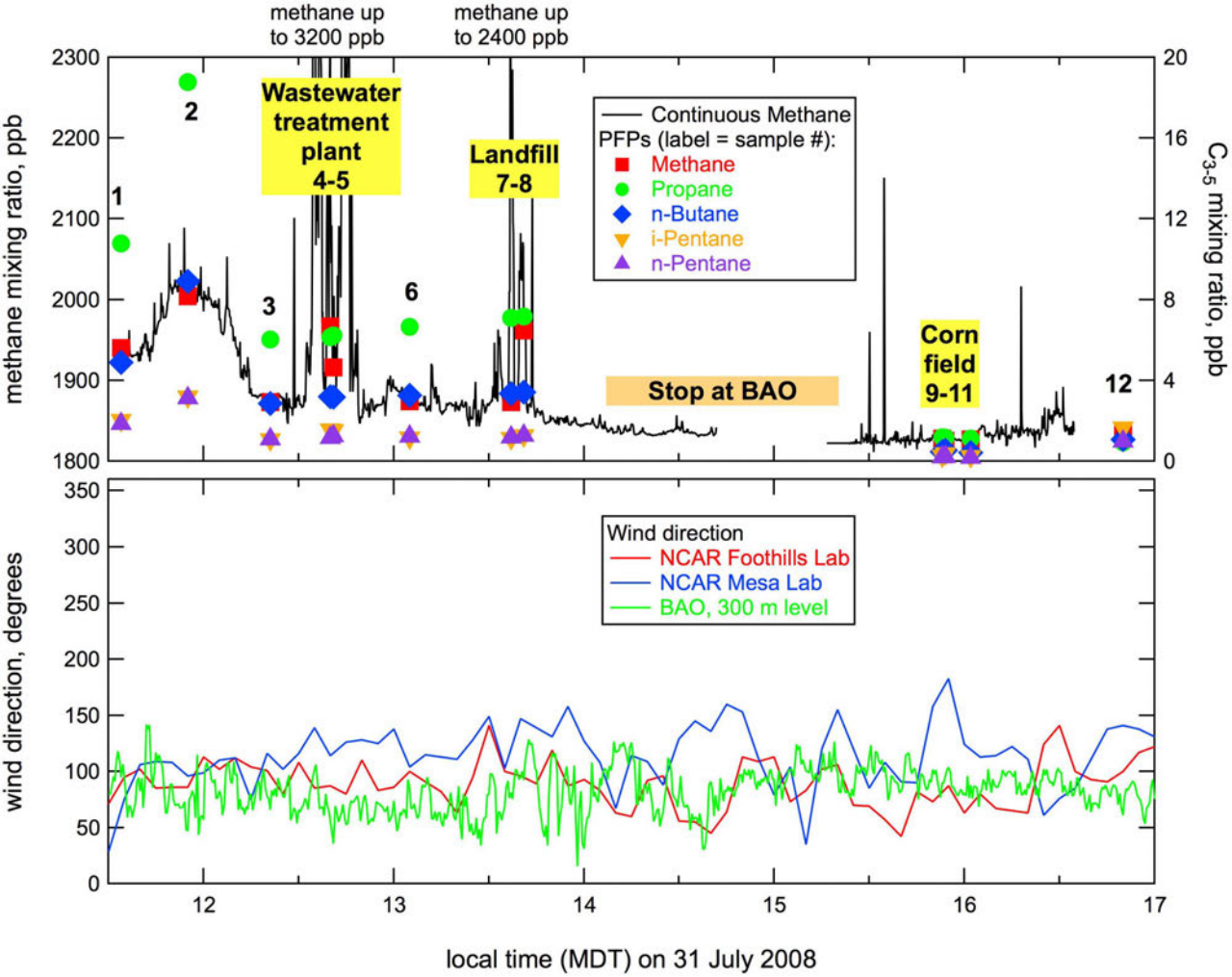
[f] Using the assumptions of a CH_4 molar ratio of 77% for the vented natural gas and a molar volume for the gas of 23.6 L/mol (Pressure= 14.73 pounds per square inch and Temperature= 60°F) as used by the EIA [EIA, 2004].

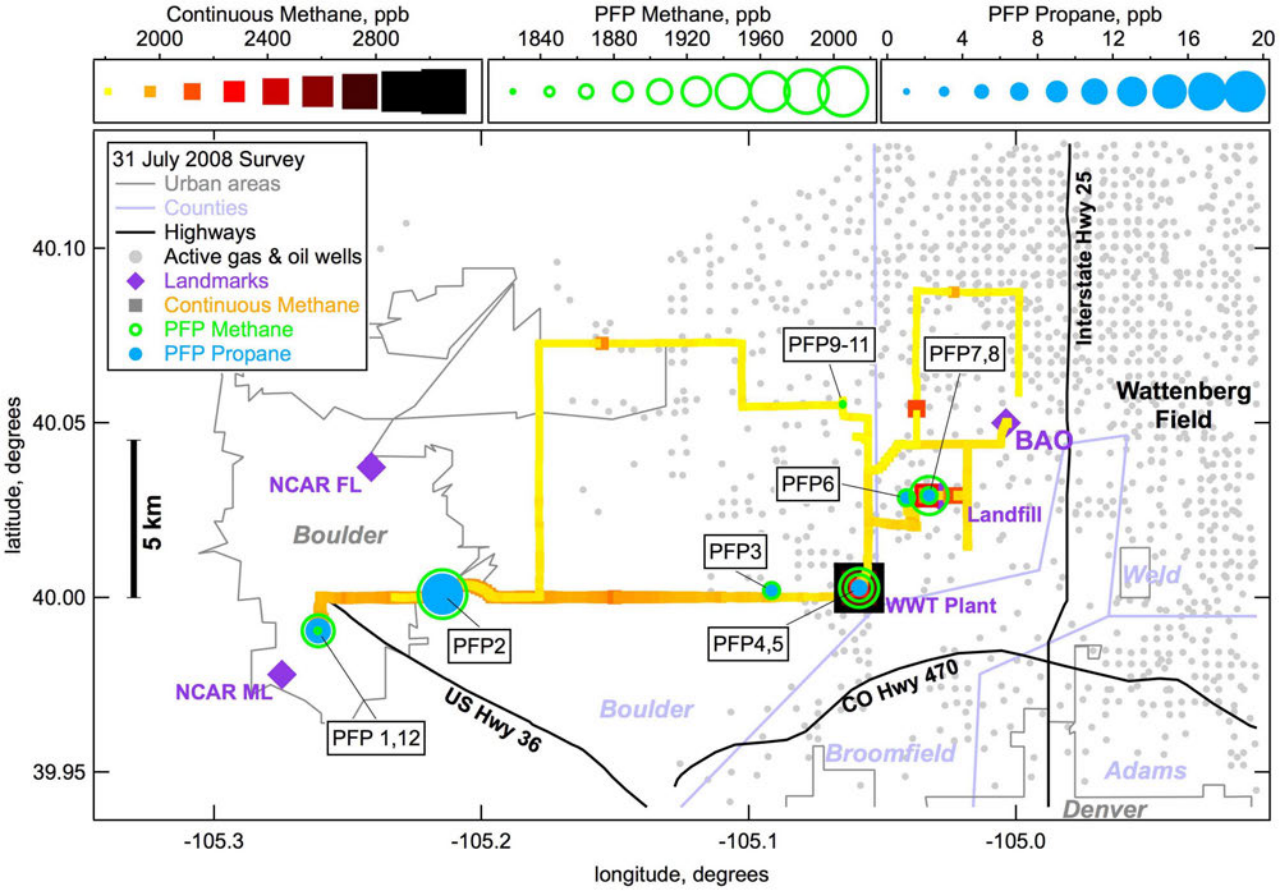

20 km
Fort Collins
Wattenberg Field
Greeley
Feedlot
Feedlot
Feedlot
Feedlot
Larimer
Denver-Julesburg Basin
Longmont
Interstate 25
Interstate 76
Boulder
NGP Plant
BAO
Landfill
WWT Plant
Weld
Boulder
Broomfield
Adams
Denver
Interstate 70
Denver
Metro
Area
Arapahoe
Highway 470
Jefferson
Douglas
Urban areas
Counties
Denver/NFR O_3 NAA
Highways
Active gas & oil wells
Landmarks
Surface elevation, m
4000
3000
2000
1000
0
40.6
40.4
40.2
40.0
39.8
39.6
39.4
39.2
Latitude, degrees
-105.5
-105.0
-104.5
-104.0
Longitude, degrees

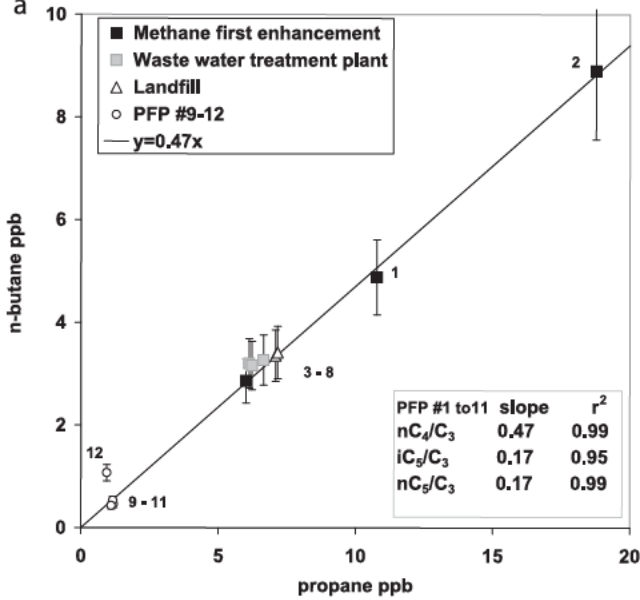

STR, CA
WGC, CA
NWF, CO - Night
BAO, CO
WKT, TX
SGP, OK
LEF, WI
Median mixing ratio
500
450
400
350
300
250
200
150
100
50
0
CH4 ppb - 1800
C3H8 ppt /10
nC4H10 ppt /4
iC5H12 ppt
nC5H12 ppt
CO ppb
C2H2 ppt
C6H6 ppt

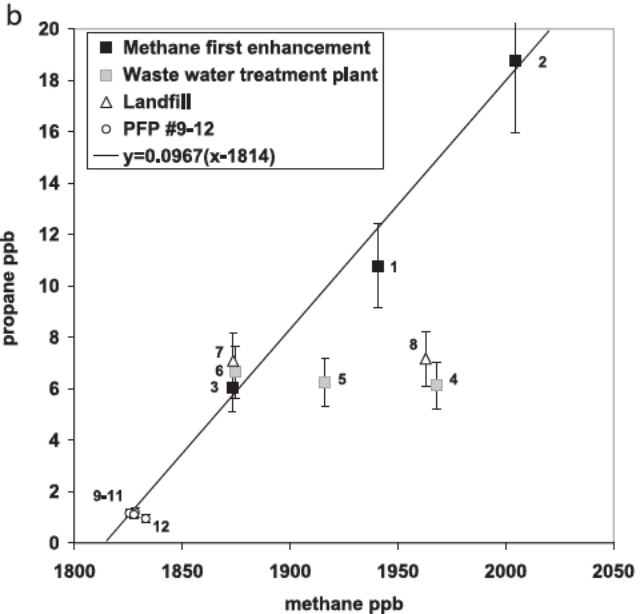

N&E Summer
N&E Winter
S Winter
W Winter
Median mixing ratio
900
800
700
600
500
400
300
200
100
0
CH4- 1800 ppb
C3H8 ppt /10
nC4H10 ppt /5
iC5H12 ppt
nC5H12 ppt
CO ppb
C2H2 ppt
C6H6 ppt


BAO N&E Summer
Mobile lab, All samples
Natural Gas and Propane Processing Plant
Waste Water Treatment Plant
Landfill
Feedlots July 14
Feedlots July 25
C_3H_8 (ppb)
CH_4 -1800 (ppb)
n-C_4H_{10} (ppb)
C_3H_8 (ppb)
C_6H_6 (ppb)
C_3H_8 (ppb)
C_6H_6 (ppb)
CO ppb

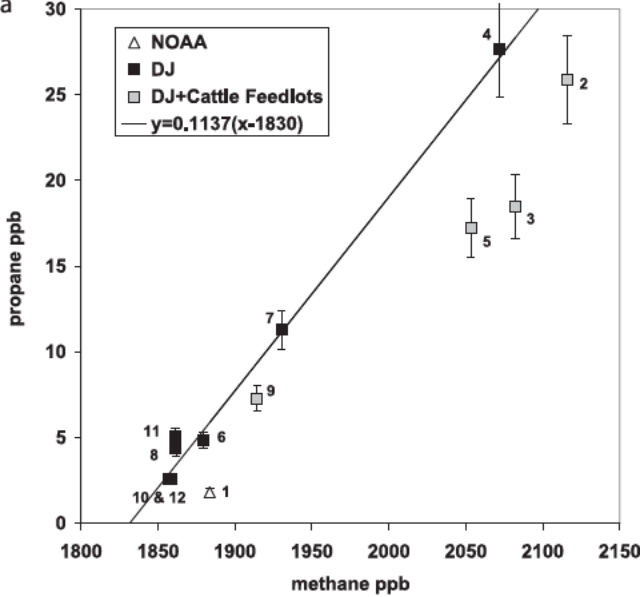

methane up to 3200 ppb
methane up to 2400 ppb
Wastewater treatment plant 4-5
Landfill 7-8
Stop at BAO
Corn field 9-11
1
2
3
6
12
Continuous Methane
PFPs (label = sample #):
Methane
Propane
n-Butane
i-Pentane
n-Pentane
methane mixing ratio, ppb
C_{3-5} mixing ratio, ppb
Wind direction
NCAR Foothills Lab
NCAR Mesa Lab
BAO, 300 m level
wind direction, degrees
local time (MDT) on 31 July 2008


Continuous Methane, ppb
2000
2400
2800
PFP Methane, ppb
1840
1880
1920
1960
2000
PFP Propane, ppb
0
4
8
12
16
20
31 July 2008 Survey
Urban areas
Counties
Highways
Active gas & oil wells
Landmarks
Continuous Methane
PFP Methane
PFP Propane
5 km
NCAR FL
NCAR ML
Boulder
PFP 1,12
PFP2
PFP3
PFP4,5
PFP6
PFP9-11
PFP7,8
WWT Plant
Landfill
BAO
Wattenberg Field
Interstate Hwy 25
US Hwy 36
CO Hwy 470
Boulder
Broomfield
Weld
Adams
Denver
40.10
40.05
40.00
39.95
latitude, degrees
-105.3
-105.2
-105.1
-105.0
longitude, degrees

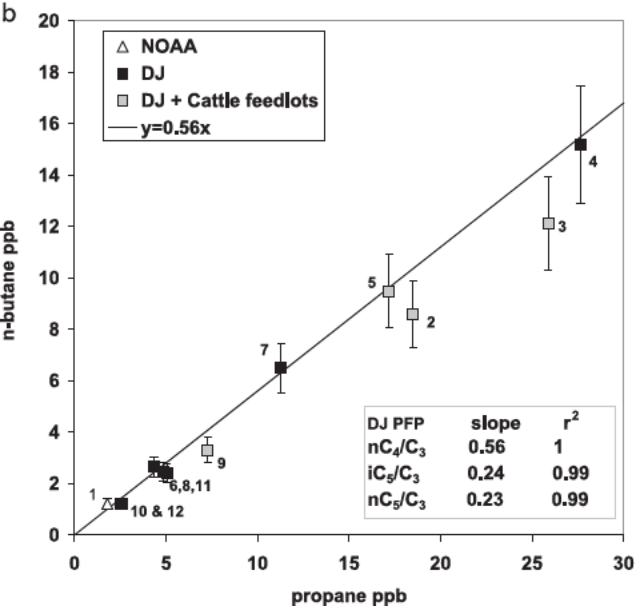

a
Methane first enhancement
Waste water treatment plant
Landfill
PFP #9-12
y=0.47x
n-butane ppb
propane ppb
2
1
3 - 8
12
9 - 11
PFP #1 to11 slope r2
nC4/C3 0.47 0.99
iC5/C3 0.17 0.95
nC5/C3 0.17 0.99

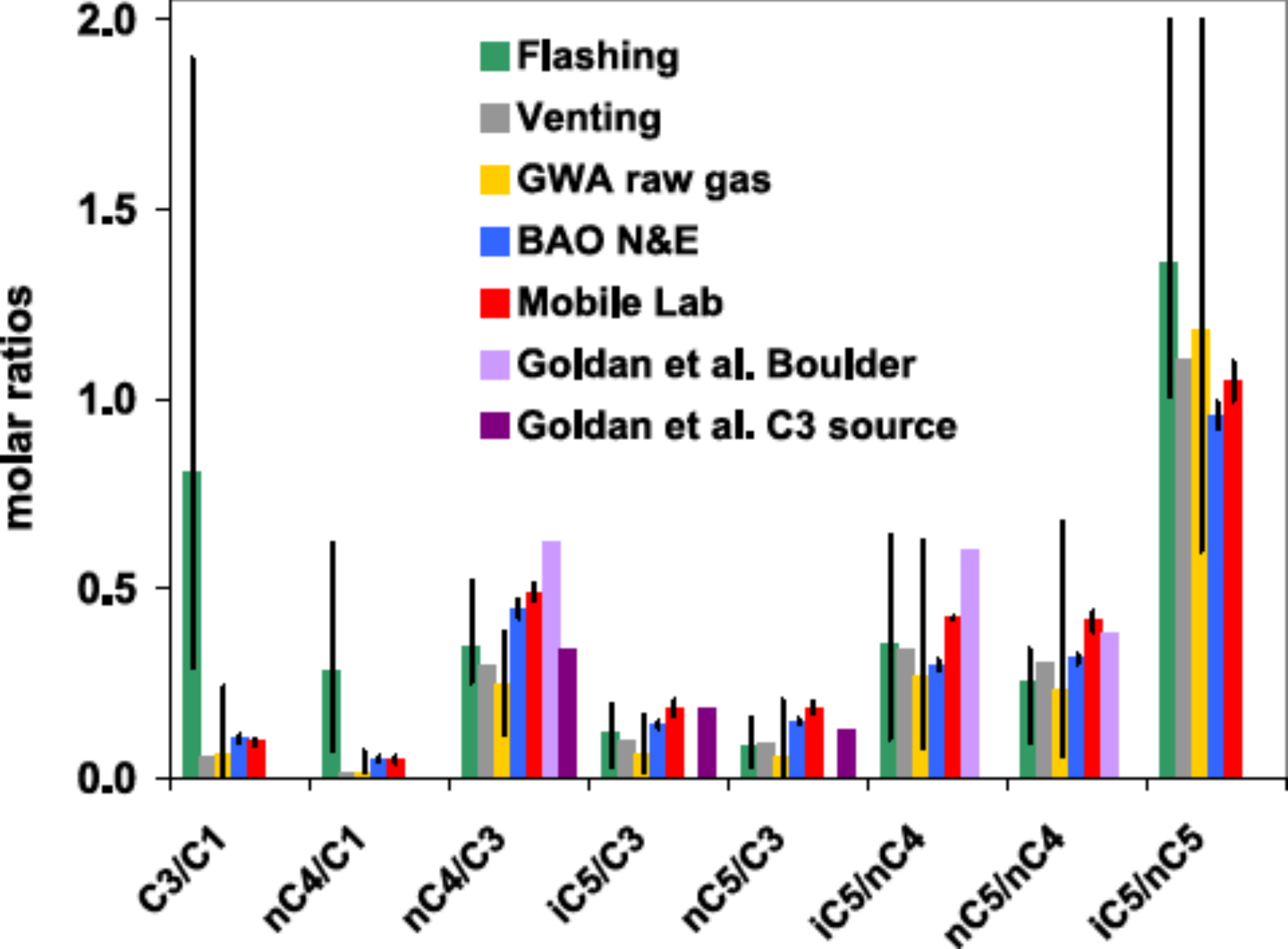

b
Methane first enhancement
Waste water treatment plant
Landfill
PFP #9-12
y=0.0967(x-1814)
propane ppb
methane ppb
2
1
7
6
3
5
8
4
9-11
12

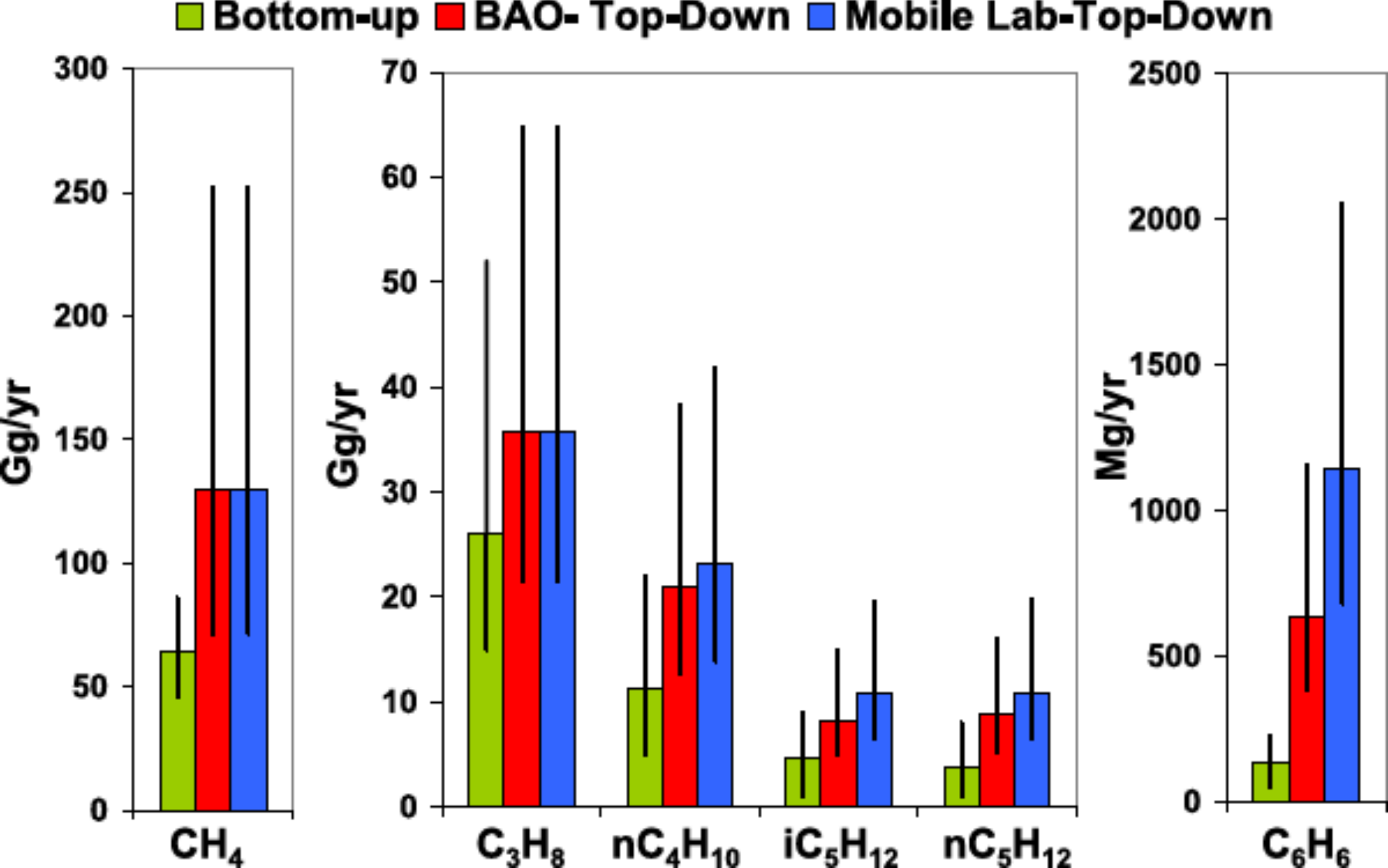
a


NOAA
DJ
DJ+Cattle Feedlots
y=0.1137(x-1830)
propane ppb
methane ppb
0
5
10
15
20
25
30
1800
1850
1900
1950
2000
2050
2100
2150
1
2
3
4
5
6
7
8
9
10 & 12
11

b


NOAA
DJ
DJ + Cattle feedlots
y=0.56x
n-butane ppb
propane ppb
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
1
2
3
4
5
6,8,11
7
9
10 & 12
DJ PFP slope r2
nC4/C3 0.56 1
iC5/C3 0.24 0.99
nC5/C3 0.23 0.99


Flashing
Venting
GWA raw gas
BAO N&E
Mobile Lab
Goldan et al. Boulder
Goldan et al. C3 source
molar ratios
2.0
1.5
1.0
0.5
0.0
C3/C1
nC4/C1
nC4/C3
iC5/C3
nC5/C3
iC5/nC4
nC5/nC4
iC5/nC5


Bottom-up
BAO- Top-Down
Mobile Lab-Top-Down
Gg/yr
300
250
200
150
100
50
0
CH4
Gg/yr
70
60
50
40
30
20
10
0
C3H8
nC4H10
iC5H12
nC5H12
Mg/yr
2500
2000
1500
1000
500
0
C6H6

Congressional Research Service

Nitrous Oxide from Agricultural Sources: Potential Role in Greenhouse Gas Emission Reduction and Ozone Recovery

Kelsi Bracmort
Analyst in Agricultural Conservation and Natural Resources Policy

October 26, 2009

Congressional Research Service
7-5700
www.crs.gov
R40874

CRS Report for Congress
Prepared for Members and Committees of Congress

Summary

Gases other than carbon dioxide accounted for nearly 15% of U.S. greenhouse gas emissions in 2007, yet there has been minimal discussion of these other greenhouse gases in climate and energy legislative initiatives. Reducing emissions from non-carbon dioxide greenhouse gases, such as nitrous oxide (N_2O), could deliver short-term climate change mitigation results as part of a comprehensive policy approach to combat climate change.

Nitrous oxide is 298 times more potent than carbon dioxide in its ability to affect climate change; and moreover, results of a recent scientific study indicate that nitrous oxide is currently the leading ozone-depleting substance. Thus, legislation to restrict nitrous oxide emissions could contribute to both climate change protection and ozone recovery.

The primary human source of nitrous oxide is agricultural soil management, which accounted for two-thirds of the N_2O emissions reported in 2007 (approximately 208 million metric tons CO_2 equivalent). One proposed strategy to lower N_2O emissions is more efficient application of synthetic fertilizers. However, further analysis is needed to determine the economic feasibility of this approach as well as techniques to measure and monitor the adoption rate and impact of N_2O emission reduction practices for agricultural soil management.

As Congress considers legislation that would limit greenhouse gas emissions (both H.R. 2454 and S. 1733 would require that greenhouse gas emissions be reduced by 83% in 2050), among the issues being discussed is how to address emissions of non-CO_2 greenhouse gases. Whether such emissions should be subject to direct regulation, what role EPA should play using its existing Clean Air Act authority, whether the sources of N_2O should be included among the covered entities of a cap-and-trade system, whether N_2O reductions should be considered offsets to be purchased by the covered entities of a cap-and-trade system, and what role USDA should play in any N_2O reduction scheme are among the issues being discussed. How these issues are resolved will have important implications for agriculture, which has taken a keen interest in climate change legislation.

Contents

Introduction 1
Nitrous Oxide: A Primer 2
Sources of N_2O Emissions 3
The Nitrogen Cycle 3
Opportunities and Challenges for Nitrous Oxide Emission Reduction 5
Federal Support for Nitrous Oxide Emission Reduction 7
Policy Options for Nitrous Oxide Emission Reduction 7

Figures

Figure 1. Sources and Pathways of Nitrogen (N) Resulting in N_2O Emissions from Agricultural Soil Management 4
Figure 2. County-Level N_2O Emissions from Major Cropped Soils in 2005 4
Figure 3. The Nitrogen Cycle 5

Tables

Table 1. U.S. Greenhouse Gas Emissions 2
Table 2. Select N_2O Mitigation Alternatives for Agricultural Soil Management 6

Contacts

Author Contact Information 9

Introduction

Policymakers are dedicating considerable attention to climate change mitigation, primarily discussing options for carbon dioxide (CO_2) emission reduction.[1] Less frequently addressed in proposed legislation is emission reduction for non-CO_2 greenhouse gases, such as nitrous oxide (N_2O). However, N_2O reduction efforts have the potential to mitigate climate change. Moreover, N_2O emission sources may be regulated under the existing Clean Air Act as a class I or class II ozone-depleting substance at the discretion of the Environmental Protection Agency (EPA) Administrator. No new legislation needs to be passed to regulate N_2O for climate protection and ozone recovery.

The five non-CO_2 greenhouse gases regularly monitored but not entirely regulated by EPA (methane, nitrous oxide, hydroflourocarbons, perflourocarbons, and sulfur hexaflouride) accounted for nearly 15% of U.S. greenhouse gas (GHG) emissions in 2007, as measured by total tons of CO_2 equivalent.[2] Nitrous oxide—the third most abundant greenhouse gas—was responsible for roughly 4% of total U.S. GHG emissions in 2007 by weight. Although they comprise a smaller portion of GHG emissions, non-CO_2 greenhouse gases, including N_2O, are more potent than CO_2. The gases identified above are 25 to 22,800 times more effective than an equivalent weight of CO_2 at trapping heat in the atmosphere, with N_2O being 298 times more potent by weight.[3]

In addition to being one cause of climate change, N_2O is an ozone-depleting substance (ODS).[4] Indeed, scientific analysis suggests that N_2O is now the leading ODS, as other substances have been reduced significantly owing to regulations enacted in the late 1980s, in the Montreal Protocol on Substances that Deplete the Ozone Layer.[5] N_2O emission reduction could thus play a compelling role in recovery of the ozone layer as well as in climate change remediation.

The agriculture sector is the primary anthropogenic source of nitrous oxide.[6] The bulk of U.S. N_2O emissions stem from fertilizing agricultural soils for crop production. Strategies or

---

[1] For more information on CO_2 emission reduction techniques, see CRS Report RL33801, *Carbon Capture and Sequestration (CCS)*, by Peter Folger. For more information on legislative proposals to address climate change and regulation of greenhouse gases under the Clean Air Act, see CRS Report R40556, *Market-Based Greenhouse Gas Control: Selected Proposals in the 111th Congress*, by Jonathan L. Ramseur, Larry Parker, and Brent D. Yacobucci; and CRS Report R40585, *Climate Change: Potential Regulation of Stationary Greenhouse Gas Sources Under the Clean Air Act*, by Larry Parker and James E. McCarthy.

[2] U.S. Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*, EPA 430-R-09-004, April 2009, http://epa.gov/climatechange/emissions/usinventoryreport html.

[3] The potency of a greenhouse gas is described by its global warming potential (GWP), an estimate of how much a greenhouse gas affects climate change over a quantity of time relative to CO_2, which has a GWP value of 1. Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis* (2007), p. 212.

[4] An ozone-depleting substance is a compound that contributes to stratospheric ozone depletion by releasing chlorine or bromine atoms into the atmosphere when broken down, leading to the destruction of ozone, a substance necessary to prevent harmful UVB rays from reaching Earth.

[5] The Montreal Protocol is an international treaty crafted to protect the stratospheric ozone layer by gradually eliminating a number of ozone-depleting substances.

[6] Also in the agriculture sector, animal digestive systems and manure management account for a large portion of U.S. methane emissions. The Intergovernmental Panel on Climate Change (IPCC) assigns nitrous oxide and methane a global warming potential of 298 and 25, respectively.

technologies designated for N_2O emission reduction are limited.[7] This is partly due to the dispersed nature of N_2O emission sources.

In the agriculture sector, the majority of N_2O is released as a consequence of specific nitrogen cycle processes (nitrification and denitrification) when large amounts of synthetic nitrogen fertilizers are used for crop production. More efficient application of synthetic fertilizers (e.g., precision agriculture, nitrogen inhibitors, nitrogen sensors, controlled-release fertilizer products) is one way to reduce excess amounts of nitrogen available for bacterial processing and eventual release to the atmosphere as N_2O. High costs and difficulty in measuring these products' efficacy, among other deterrents, have hampered widespread adoption of practices to reduce N_2O emissions.

This report focuses on the contributions of N_2O to climate change and ozone depletion. Policy options for N_2O emission reduction, sources of N_2O, and federal support to lower N_2O emissions are discussed.

Nitrous Oxide: A Primer

Nitrous oxide (N_2O), familiar to some as "laughing gas," contributes to climate change and ozone depletion. Once released, N_2O lingers in the atmosphere for decades (its atmospheric lifetime is approximately 114 years) and is 298 times more effective at trapping heat in the atmosphere over a 100-year time frame than carbon dioxide (CO_2).[8] N_2O emission quantity estimates have remained fairly constant over the last few years, hovering around 312 million metric tons carbon dioxide equivalent (CO_2e). See **Table 1**.

Table 1. U.S. Greenhouse Gas Emissions

(million metric tons CO_2e)

Gas / Source	2005	2006	2007	Avg. Contribution[a]
Carbon dioxide (CO_2)	6,090.8	6,014.9	6,103.4	85%
Methane (CH_4)	561.7	582.0	585.3	8%
Nitrous oxide (N_2O)	*315.9*	*312.1*	*311.9*	*4%*
Hydroflourocarbons (HFCs)	116.1	119.1	125.5	1.7%
Perflouruocarbons (PFCs)	6.2	6.0	7.5	<1%
Sulfur hexaflouride (SF_6)	17.9	17.0	16.5	<1%
Total	7,108.6	7,051.1	7,150.1	

Source: Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*.

a. Average contribution to total U.S. greenhouse gas inventory based on data provided for 2005 to 2007.

[7] Strategies and technologies for N_2O emission reduction are limited in comparison to resources expended for methane capture. Methane capture technologies, as well as financial and technical support, for point sources have been available for decades. For more information on methane capture, see CRS Report R40813, *Methane Capture: Options for Greenhouse Gas Emission Reduction*, by Kelsi Bracmort et al.

[8] S. Solomon, D. Qin, and M. Manning et al., *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth*, IPCC, IPCC WG1 AR4 Report, New York, NY, 2007, http://ipcc-wg1.ucar.edu/wg1/wg1-report html. The IPCC assigned N_2O a global warming potential of 298 over a 100-year time horizon.

Sources of N_2O Emissions

Nitrous oxide is emitted from anthropogenic (manmade) and natural sources. Oceans and natural vegetation are the major natural sources of N_2O. Agricultural soil management (e.g. fertilization, application of manure to soils, drainage and cultivation of organic soils) is responsible for two-thirds of anthropogenic U.S. N_2O emissions.[9] In 2007, N_2O emissions from agricultural soil management totaled more than 200 million metric tons of CO_2e.[10] Other anthropogenic sources of N_2O are combustion by mobile sources (cars, trucks, etc.), nitric acid production, and manure management.[11]

Figure 1 depicts the origination and passage of nitrogen (N) that leads to N_2O emissions from agricultural soil management. The amount of N_2O emitted from cropland soils largely depends on the amount of nitrogen applied to a crop, weather, and soil conditions. Corn and soybean crops emit the largest amounts of N_2O, respectively, due to vast planting areas, plentiful synthetic nitrogen fertilizer applications, and, in the case of soybeans, high nitrogen fixation rates (**Figure 2**).[12]

The Nitrogen Cycle

Comprehension of the nitrogen cycle (**Figure 3**) is beneficial when crafting policy to reduce N_2O emissions from anthropogenic sources. Nitrogen, an essential element required by organisms to grow, is found throughout the atmosphere in various forms. The nitrogen cycle portrays the routes in which nitrogen moves through the soil and atmosphere in both organic and inorganic form. Certain processes within the nitrogen cycle convert the nitrogen into a form that can be taken up by plants. Four of the major processes are:

- nitrogen fixation—conversion of nitrogen gas (N_2) to a plant-available form;
- nitrogen mineralization—conversion of organic nitrogen to ammonia (NH_3);
- nitrification—conversion of ammonia (NH_3) to nitrate (NO_3-) via oxidation (that is, by being combined with oxygen); and
- denitrification—conversion of nitrates back to nitrogen gas.

Nitrous oxide is a byproduct of nitrification and denitrification. Both processes occur naturally. Excess application of nitrogen fertilizer can lead to increased nitrification, which can cause nitrate to leach into groundwater or surface runoff (in turn, this causes eutrophication, which can damage aquatic environments).

---

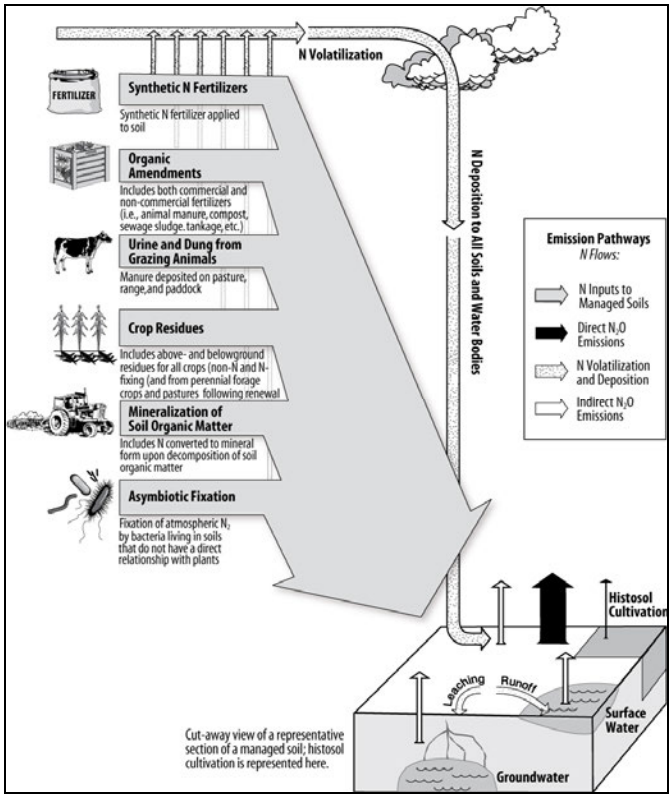
[9] Agricultural soil management includes practices that add to, or create an environment conducive to the release of, mineral nitrogen (N).

[10] U.S. Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*, EPA 430-R-09-004, April 2009, http://epa.gov/climatechange/emissions/usinventoryreport html.

[11] Mobile (fuel) combustion leads to N_2O being emitted as a byproduct. N_2O is released as a byproduct during the oxidation of ammonia for production of nitric acid, a primary component of synthetic fertilizers and some explosives. N_2O emissions are generally released in large amounts from dry manure handling systems (e.g., pasture, solid storage)..

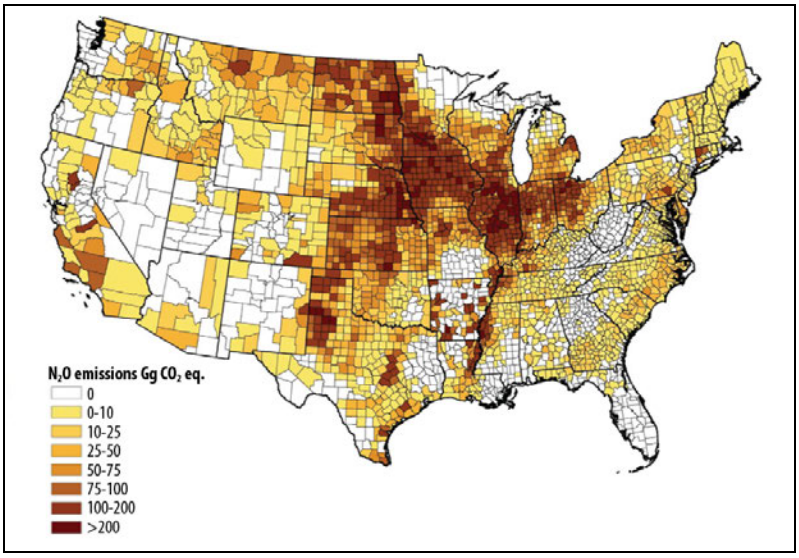
[12] U.S. Department of Agriculture, *U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005* , Technical Bulletin No. 1921, 2008, http://www.usda.gov/oce/global_change/AFGGInventory1990_2005 htm. Nitrogen fixation is the conversion of nitrogen gas to ammonia.

Figure 1. Sources and Pathways of Nitrogen (N) Resulting in N_2O Emissions from Agricultural Soil Management



Source: U.S. Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*, EPA 430-R-09-004, Chapter 6, April 2009. Adapted by CRS.

Figure 2. County-Level N_2O Emissions from Major Cropped Soils in 2005

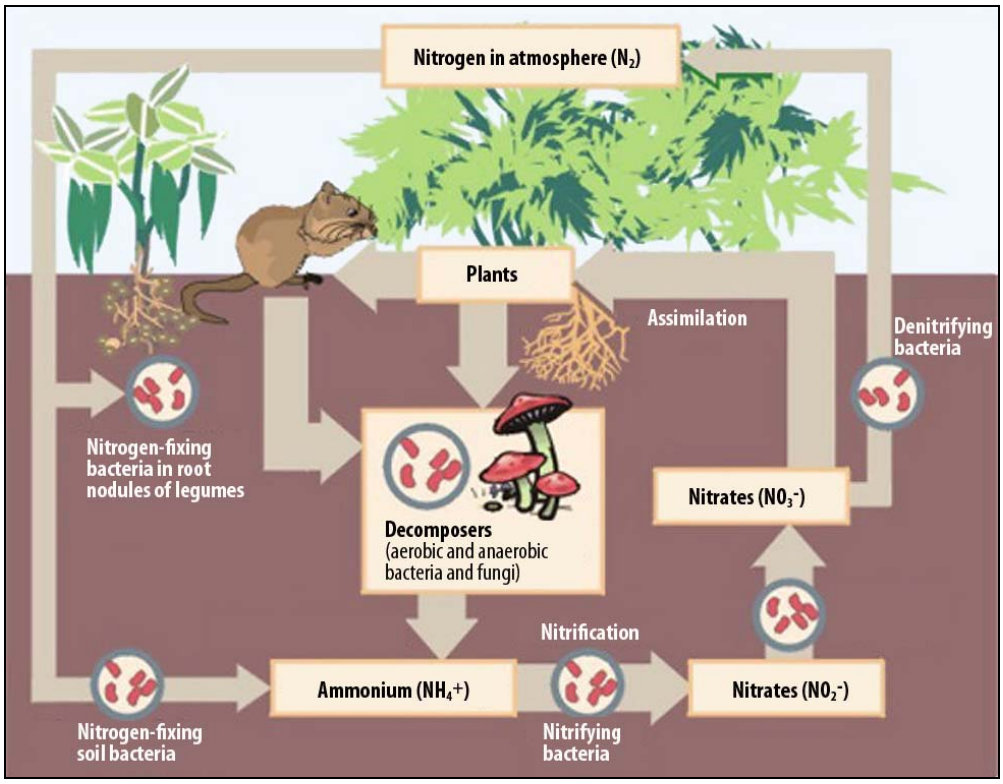


Source: USDA, *U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005*. Adapted by CRS.

a. 1 Gigagram (Gg) is equivalent to 1,000 metric tons.

b. Major crops are defined as corn, soybean, wheat, hay, sorghum, and cotton.

Figure 3. The Nitrogen Cycle



Source: EPA. Adapted by CRS

Opportunities and Challenges for Nitrous Oxide Emission Reduction

N_2O emission mitigation options are available for agricultural soil management and nitric acid production. Nitric acid is a chemical compound used to make synthetic fertilizers. N_2O abatement options for nitric acid production include a high-temperature catalytic reduction method, a low-temperature catalytic reduction method, and nonselective catalytic reduction.[13] The estimated reduction efficiencies (the percentage reduction achieved with adoption of a mitigation option) are 90%, 95%, and 85%, respectively.

Agricultural soil management mitigation options recommended by researchers and technology transfer specialists to discourage excess application of nitrogen fertilizers and soil disturbance (**Table 2**) are not generally being practiced. Fertilizer and soil best management practices aim to provide the crop with the nutrient and soil conditions necessary for crop production, and prevent nutrient and soil loss from the crop field (e.g., erosion, leaching).[14] Some may consider less

[13] U.S. Environmental Protection Agency, *Global Mitigation of Non-CO_2 Greenhouse Gases*, EPA-430-06-005, 2006. Catalytic reduction methods use a catalyst to reduce nitrous oxides in exhaust gas at varying temperatures.

[14] C. S. Snyder, *Fertilizer Nitrogen BMPs to Limit Losses That Contribute to Global Warming* , International Plant Nutrition Institute, Ref. # 08057, June 2008, http://www.ipni net/ipniweb/portal.nsf/0/ 6D54ABC2C92D9AFA8525749B0074FF59.

money spent towards fertilizer use an economic incentive for agricultural producers.[15] Others may be concerned to ensure that crop yields meet expected feed, fiber, and fuel mandates (e.g., for corn ethanol), which may be difficult to attain with less fertilizer use.[16] Monitoring reduced nitrogen fertilization applications on a large scale for climate change mitigation purposes may be difficult; it is not clear how such a program could be managed at a national level.[17] Enforcement options could include voluntary verification, third-party verifiers, or government intervention.

Reporting N_2O emissions from agricultural soil management was not included in the Final Mandatory Reporting of Greenhouse Gases Rule issued by EPA on September 22, 2009.[18] EPA's reasoning behind this decision was that no low-cost or simple direct N_2O measurement methods exist. Additionally, EPA released a proposed rule requiring new or modified facilities that could trigger Prevention of Significant Deterioration (PSD) permitting requirements to apply for a revision to their operating permits to incorporate the best available control technologies and energy efficiency measures to minimize GHG emissions.[19]

Table 2. Select N_2O Mitigation Alternatives for Agricultural Soil Management

Mitigation Alternative	Description
Split fertilization	Application of same amount of nitrogen fertilizer as in baseline but divided into three smaller increments during crop uptake period to better match nitrogen application with crop demand and reduce nitrogen availability for leaching, nitrification, denitrification, and volatilization.
Simple fertilization reduction (10%, 20%, or 30%)	Reduction of nitrogen-based fertilizer from one-time baseline application of 10%, 20%, or 30%.
Nitrification inhibitor	Reduces conversion of ammonium to NO_3-, which slows the immediate availability of nitrate (nitrate is water soluble). The inhibition of nitrification reduces nitrogen loss and increases overall plant uptake.
No-till	Conversion from conventional tillage to no-till, where soils are disturbed less and more crop residue is retained.

Source: EPA, *Global Mitigation of Non-CO_2 Greenhouse Gases*, http://www.epa.gov/climatechange/economics/downloads/GM_SectionV_Agriculture.pdf.

[15] According to the Government Accountability Office, natural gas is the highest-priced factor when producing nitrogen fertilizer. Thus, natural gas prices impact nitrogen fertilizer costs. U.S. General Accounting Office, *Natural Gas: Domestic Nitrogen Fertilizer Production Depends on Natural Gas Availability and Prices*, GAO-03-1148, September 2003, http://www.gao.gov/new.items/d031148.pdf.

[16] For example, the Renewable Fuel Standard (RFS) is a provision established by the Energy Policy Act of 2005 requiring gasoline to contain a minimum amount of fuel produced from renewable biomass (including corn). For more information on the RFS, see CRS Report R40155, *Selected Issues Related to an Expansion of the Renewable Fuel Standard (RFS)*, by Brent D. Yacobucci and Randy Schnepf.

[17] For more information on monitoring carbon in agriculture, see CRS Report RS22964, *Measuring and Monitoring Carbon in the Agricultural and Forestry Sectors*, by Ross W. Gorte and Renée Johnson.

[18] For more information on the agricultural implications of the Mandatory Reporting of Greenhouse Gases Rule, see CRS Report RL32948, *Air Quality Issues and Animal Agriculture: A Primer*, by Claudia Copeland.

[19] For more information on the proposed PSD rule, see CRS Report R40585, *Climate Change: Potential Regulation of Stationary Greenhouse Gas Sources Under the Clean Air Act*, by Larry Parker and James E. McCarthy; and EPA, *Proposed Rule: Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule*, 2009, http://www.epa.gov/NSR/fs20090930action html.

Federal Support for Nitrous Oxide Emission Reduction

USDA provides some financial and technical assistance for nutrient management through its conservation programs.[20] Moreover, USDA's Agricultural Research Service (ARS) is studying the relationship between agricultural management practices and nitrous oxide emissions.[21]

In addition to the agriculture sector, work is being done in the transportation sector to reduce N_2O emissions. Mobile combustion was responsible for nearly 10% of N_2O emissions reported in 2007.[22] One N_2O emission reduction initiative, proposed by EPA and the Department of Transportation, is to cap tailpipe N_2O emissions at 0.010 grams per mile as part of a wider effort to reduce greenhouse gas emissions and improve fuel economy in tandem, via a CO_2 emission standard for light-duty vehicles.[23] EPA has allocated financial resources to quantify N_2O emissions for the greenhouse gas inventory (e.g., DAYCENT model).[24]

Policy Options for Nitrous Oxide Emission Reduction

Congress has begun to investigate the reduction of non-CO_2 greenhouse gas emissions, including N_2O emissions, as one strategy to mitigate climate change. Some contend that N_2O emissions reduction could serve as a short-term response in the larger, long-term scheme of mitigation and adaptation efforts.[25] It may be viewed as a short-term response because N_2O emissions make up a small amount of the GHG inventory compared to CO_2 emissions. Any substantial approach to mitigate climate change is likely at some point to have to address sources that emit CO_2.

---

[20] For more information on agricultural conservation programs, see CRS Report R40763, *Agricultural Conservation: A Guide to Programs* , by Megan Stubbs. For more information on technical assistance for nutrient management, see USDA, Natural Resources Conservation Service, *Conservation Practice Standard—Nutrient Management Code 590*, August 2006, ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/590.pdf.

[21] For more information on the efforts underway at ARS, visit the Air Quality of Agricultural Systems Research Unit website at http://www.ars.usda.gov/main/site_main htm?modecode=36-25-15-15, or the Air Quality National Program website at http://www.ars.usda.gov/research/programs/programs htm?NP_CODE=203.

[22] U.S. Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*, EPA 430-R-09-004, April 2009, http://epa.gov/climatechange/emissions/usinventoryreport html.

[23] U.S. Environmental Protection Agency, *EPA and NHTSA Propose Historic National Program to Reduce Greenhouse Gases and Improve Fuel Economy for Cars and Trucks* , EPA-420-F-09-047, September 2009, http://www.epa.gov/otaq/climate/regulations/420f09047 htm.

[24] EPA uses the DAYCENT ecosystem model for the U.S. greenhouse gas inventory "to estimate direct N_2O emissions from mineral cropland soils that are managed for production of major crops—specifically corn, soybeans, wheat, alfalfa hay, other hay, sorghum, and cotton."

[25] Shilpa Rao and Keywan Riahi, "The Role of Non-CO_2 Greenhouse Gases in Climate Change Mitigation: Long-Term Scenarios for the 21st Century," *Energy Journal*, vol. 27 (2006), pp. 1-26; Mario Molina, Durwood Zaelke, and K. Madhava Sarma et al., "Reducing Abrupt Climate Change Risk Using the Montreal Protocol and Other Regulatory Actions to Complement Cuts in CO_2 Emissions," *Proceedings of the National Academy of Sciences of the United States of America*, October 12, 2009.

Congress could approach N_2O emissions reduction as part of a comprehensive GHG emission strategy offering economically attractive abatement alternatives to discourage actions leading to climate change. For example, a cap or fee on N_2O emissions could spur innovative methods for agricultural producers to limit excess synthetic fertilizer application. Congress could also examine the tools necessary to identify N_2O emission abatement options, assess their cost, and determine their economic impact for full incorporation into climate change legislation.

Besides mitigating climate change, reducing N_2O emissions could lead to ozone recovery. Congress could explore the co-benefits that may arise from restricting N_2O emissions for climate change purposes. N_2O is not regulated as an ODS under the Clean Air Act, Title VI, Stratospheric Ozone Protection (as guided by the Montreal Protocol). As emissions of other ODSs (e.g., chlorofluorocarbon-11, halon-1211) have declined due to regulation, N_2O has emerged as the dominant ODS.[26] The first-ever published ozone depletion potential (ODP) value assigned to N_2O, 0.017, is less than the ODP value of 1.0 for the reference gas chlorofluorocarbon 11 (CFC-11). While some may not see a cause for alarm based on the ODP value alone, the quantity of N_2O emissions and its potency as a GHG can lead to serious harm (see **Table 1**).

The ODP value for N_2O does not allow for its mandatory inclusion as a class I substance for regulation under the Clean Air Act.[27] However, N_2O could be listed as a class II substance at the direction of the EPA Administrator or regulated under Section 615 of the act.[28] Class I substances have an ODP of 0.2 or more and are more harmful to stratospheric ozone molecules than Class II substances, which have an ODP of less than 0.2.

With or without ODP substance listing, Congress may find it useful to incorporate the ozone depletion impacts of N_2O into its climate change policy proposals both to reduce greenhouse gas emissions and to further ozone recovery achievements. Classifying N_2O emission reduction as an eligible offset type, including N_2O as a covered entity within a cap-and-trade program, or directing EPA to use existing authority under the Clean Air Act to regulate N_2O are other available options to reduce N_2O emissions for ozone or climate protection. Any option chosen to reduce N_2O emissions will more than likely require an improvement of N_2O estimation, measurement, and reporting methods and possible financial incentives.

Congress could apply lessons learned from previous international agreements that are intended to abolish harmful compounds. The outcomes of the Montreal Protocol, put into action in the late 1980s, may prove useful to Congress in understanding the long-term implications of certain climate change policy options, specifically cap-and-trade. A number of gases were phased out under the Protocol, which allowed for each country to establish a regulatory framework to monitor and reduce ODSs. Certain ozone-depleting substances, such as N_2O, were not included in the Protocol partly because their threat was not perceived as urgent at the time. However, one unintended consequence of the success of the Protocol reducing targeted ODSs is that N_2O has emerged as the leading ODS.

[26] A. R. Ravishankara, John S. Daniel, and Robert W. Portmann, "Nitrous Oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century," *Science Express*, August 27, 2009.

[27] 42 U.S.C. § 7671a. The EPA Administrator may add to the list of class I substances any substances that the Administrator determines as having an ozone depletion potential of 0.2 or greater.

[28] 42 U.S.C. § 7671n. The EPA Administrator has the authority to promptly promulgate regulations respecting the control of an ODS by submitting notice of the proposal and promulgation of such regulation to the Congress.

Author Contact Information

Kelsi Bracmort
Analyst in Agricultural Conservation and Natural Resources Policy
kbracmort@crs.loc.gov, 7-7283

From: Paul Gunning
To: Kurt Roos
Subject: Re: 3.4.2 Methane and Nitrous Oxide Emissions from Agriculture
Date: 07/26/2007 03:47 PM
Attachments: 3.4.2 Methane and Nitrous Oxide from Ag.doc

Thanks Kurt. I really appreciate you taking the time to look at this.

Paul

▼ Kurt Roos/DC/USEPA/US

Kurt Roos/DC/USEPA/US

07/26/2007 12:48 PM

To: Paul Gunning/DC/USEPA/US@EPA
cc:
Subject: 3.4.2 Methane and Nitrous Oxide Emissions from Agriculture

Paul,

Attached is an editted version of the file Tom W. sent you. I included the Farm Bill stuff we talked about, made a stonger conenction with us and USDA, made some changes on the manure language, and also editted Tom's input as it was rather long winded and meandering. Your call on what you want in or out. Sorry about all the colors and cross outs.

Kurt
Kurt Roos
Team Leader, AgSTAR Program
U.S. EPA
1200 Pennsylvania, Ave., NW
Mail Stop 6202-J
Washington, DC 20460
202 343-9041

www.epa.gov/agstar 3.4.2 Methane and Nitrous Oxide from Ag.doc

From:	Allen Fawcett
To:	Paul Gunning
Cc:	Chris Sherry; irving.bill@epa.gov; Jameel Alsalam; kocchi.suzanne@epa.gov; Leif Hockstad; Jennifer Jenkins; Jia Li
Subject:	Re: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)
Date:	01/09/2013 03:42 PM
Attachments:	Emissions Projections Question from Rick Duke.xlsx

---

Here's an updated version of the table using US inventory numbers for 2010 US CO2, and adding in the non-forest flux from LULUCF.

Allen

US & Global GHG Emissions

Global	2010	2030
CO2	31,305	40,640
Agriculture Non-CO2	5,999	6,945
All Other Non-CO2*	5,388	8,489
Total Non-CO2	11,387	15,434
Total GHG	42,692	56,074
No reliable source for global forestry numbers		

US	2010	2030
CO2	5,706	5,523
Agriculture Non-CO2	428	570
All Other Non-CO2*	687	1,055
Total Non-CO2	1,115	1,625
Total GHG	6,822	7,148
Forestry Including Harvested Wood Products	(922)	(201.7) to 7.3
Non Forest Flux from land use change	(153)	
Total Net CO2 Flux from LULUCF	(1,075)	
Net Emission (Sources and Sinks)	5,747	6,948 to 7,155

Global non-CO2 numbers and 2030 projections from the December 2012 version of the Global Non-CO2 Emisisons Report:
http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html

U.S. 2010 CO2 and non-CO2 numbers from the latest US GHG inventory.

Global CO2 numbers from EIA's 2011 International Energy Outlook. US 2030 CO2 numbers from the 2013 AEO early release.

Please note that global non-co2 projection does not assume Copenhagen pledges or other economy-wide reduction plans, and assumes emissions rates remain the same in the future as they are today. This means that population and economic growth lead to emissions growth.

U.S. Non-CO2 Projections were last published in the Fifth U.S. Climate Action Report (2010), whose projections extended just to 2020. For the purpose of the global report, we relied on CAR5, and then extended the trends outwards. An update to the U.S. non-CO2 projections is currently in the works, for incorporation in the next round. The existing projections are now several years old, and so we are expecting some pretty significant changes with the new set of projections. Nonetheless:

*All other non-CO2 includes non-CO2 from industrial processes, energy and waste.

There is no generally accepted international "authority" that provides consistent estimates for forest CO2 flux at the global scale. Individual research teams have accomplished quite a bit via modeling and satellite imagery, but the estimates created in this way are subject to substantial uncertainty associated with modeling assumptions, data inputs, land use definitions, and image interpretation. Results can vary by orders of magnitude. As a result, it is difficult to provide one estimate for global CO2 flux from forest activities, either in 2010 or in 2030.

2010 LULUCF numbers source: Table 7.1 of the US GHG inventory
http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Chapter-7-LULUCF.pdf

2030 US Forestry numbers source: Table 17 of the US Forest Service 2010 Resources Planning Act Assessment
http://www.fs.fed.us/research/publications/gtr/gtr_wo87.pdf
Note that the source presents a range with no centeral estimate.

▼ Allen Fawcett---01/09/2013 03:22:34 PM---From: Allen Fawcett/DC/USEPA/US To: Paul Gunning/DC/USEPA/US@EPA

From: Allen Fawcett/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Chris Sherry/DC/USEPA/US@EPA, irving.bill@epa.gov, Jameel Alsalam/DC/USEPA/US@EPA, kocchi.suzanne@epa.gov, Leif Hockstad/DC/USEPA/US@EPA, Jennifer Jenkins/DC/USEPA/US@EPA, Jia Li/DC/USEPA/US@EPA
Date: 01/09/2013 03:22 PM
Subject: Re: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

US & Global Non-CO2 Emissions		
Global	**2010**	**2030**
CO2	31,305	40,640
Agriculture non-CO2	5,999	6,945
All Other Non-CO2*	5,388	8,489
Total Non-CO2	11,387	15,434
Total GHG	42,692	56,074
Forestry Including Harvested Wood Products	(922)	(201.7) to 7.3
US	**2010**	**2030**
CO2	5,634	5,523
Agriculture non-CO2	428	570
All Other Non-CO2*	687	1,055
Total Non-CO2	1,116	1,625
Total GHG	6,749	7,148
No reliable source for global forestry numbers		
Global non-CO2 numbers and 2030 projections from the December 2012 version of the Global Non-CO2 Emisisons Report: http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html		
U.S. 2010 numbers from the latest US GHG inventory.		
Please note that this projection does not assume Copenhagen pledges or other economy-wide reduction plans, and assumes emissions rates remain the same in the future as they are today. This means that population and economic growth lead to emissions growth.		
U.S. Non-CO2 Projections were last published in the Fifth U.S. Climate Action Report (2010), whose projections extended just to 2020. For the purpose of the global report, we relied on CAR5, and then extended the trends outwards. An update to the U.S. non-CO2 projections is currently in the works, for incorporation in the next round. The existing projections are now several years old, and so we are expecting some pretty significant changes with the new set of projections. Nonetheless:		
*All other non-CO2 includes non-CO2 from industrial processes, energy and waste.		
Global CO2 numbers from EIA's 2011 International Energy Outlook. US CO2 numbers from the 2013 AEO early release.		
There is no generally accepted international "authority" that provides consistent estimates for forest CO2 flux at the global scale. Individual research teams have accomplished quite a bit via modeling and satellite imagery, but the estimates created in this way are subject to substantial uncertainty associated with modeling assumptions, data inputs, land use definitions, and image interpretation. Results can vary by orders of magnitude. As a result, it is difficult to provide one estimate for global CO2 flux from forest activities, either in 2010 or in 2030.		
2010 US Forestry numbers source: Table 7.1 of the US GHG inventory http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Chapter-7-LULUCF.pdf		
2030 US Forestry numbers source: Table 17 of the US Forest Service 2010 Resources Planning Act Assessment http://www.fs.fed.us/research/publications/gtr/gtr_wo87.pdf		

[attachment "Emissions Projections Question from Rick Duke.xlsx" deleted by Allen Fawcett/DC/USEPA/US]

▼ Allen Fawcett---01/09/2013 03:02:55 PM---Here are the US and global CO2 numbers from EIA's 2011 International Energy Outlook. From: Allen Faw

From: Allen Fawcett/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Chris Sherry/DC/USEPA/US@EPA, irving.bill@epa.gov, Jameel Alsalam/DC/USEPA/US@EPA, kocchi.suzanne@epa.gov, Leif Hockstad/DC/USEPA/US@EPA, Jennifer Jenkins/DC/USEPA/US@EPA, Jia Li/DC/USEPA/US@EPA
Date: 01/09/2013 03:02 PM
Subject: Re: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

Here are the US and global CO2 numbers from EIA's 2011 International Energy Outlook.

World carbon dioxide emissions by region, Reference
(Million metric tons carbon dioxide)

Region/Country	2010	2020	2030
United States	5,644	5,777	6,108
Total World	**31,305**	**35,210**	**40,640**

a/ Includes the 50 States and the District of Columbia.
Notes: The U.S. numbers include emissions from electricity generatio
Sources: History: U.S. Energy Information Administration (EIA), Intern
2011), website www.eia.gov/ies. Projections: EIA, Annual Energy Out
Modeling System, run REF2011.D020911A, website www.eia.gov/aeo,
[attachment "IEO2011-World_carbon_dioxide_emissions_by_region-Reference_case.xls" deleted by Allen Fawcett/DC/USEPA/US]

▼ Allen Fawcett---01/09/2013 02:55:55 PM---Paul, Here is the data for the non-CO2 numbers and the US inventory land use numbers. Still workin

From: Allen Fawcett/DC/USEPA/US
To: Paul Gunning/DC/USEPA/US@EPA
Cc: Chris Sherry/DC/USEPA/US@EPA, irving.bill@epa.gov, Jameel Alsalam/DC/USEPA/US@EPA, kocchi.suzanne@epa.gov, Leif Hockstad/DC/USEPA/US@EPA, Jennifer Jenkins/DC/USEPA/US@EPA, Jia Li/DC/USEPA/US@EPA
Date: 01/09/2013 02:55 PM
Subject: Re: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

Paul,

Here is the data for the non-CO2 numbers and the US inventory land use numbers. Still working on forestry and the global CO2 numbers.

Allen

US and global non-CO2 data from the Global non-CO2 emissions report:

US & Global Non-CO2 Emissions		
Global Non-CO2	**2010**	**2030**
Agriculture	5,999	6,945
All Other Non-CO2*	5,388	8,489
Total Non-CO2	11,387	15,434
US Non-CO2	**2010**	**2030**
Agriculture	428	570
All Other Non-CO2*	687	1,055
Total Non-CO2	1,116	1,625

Global numbers and 2030 projections from the December 2012 version of the Global Non-CO2 Emisisons Report: http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html

U.S. 2010 numbers from the latest US GHG inventory.

Please note that this projection does not assume Copenhagen pledges or other economy-wide reduction plans, and assumes emissions rates remain the same in the future as they are today. This means that population and economic growth lead to emissions growth.

U.S. Non-CO2 Projections were last published in the Fifth U.S. Climate Action Report (2010), whose projections extended just to 2020. For the purpose of the global report, we relied on CAR5, and then extended the trends outwards. An update to the U.S. non-CO2 projections is currently in the works, for incorporation in the next round. The existing projections are now several years old, and so we are expecting some pretty significant changes with the new set of projections. Nonetheless:

*All other non-CO2 includes non-CO2 from industrial processes, energy and waste.

For the purposes of answering this question , the agriculture sector is the sector as defined by the US GHG Inventory and IPCC, and does not include any LULUCF non-CO2 emissions (those I included in the "all other")

Land use tables from the inventory:

Table ES-6, 2-10, and 7-3: Emissions from Land Use, Land-Use Change, and Forestry (Tg CO2 Eq.)

Land-Use Category	1990	2005	2010
CO2	8.1	8.9	9.0
Cropland Remaining Cropland: Liming of Agricultural Soils & Urea Fertilization	7.1	7.9	8.0
Wetlands Remaining Wetlands: Peatlands □ Remaining Peatlands	1.0	1.1	1.0
CH4	2.5	8.1	4.8
Forest Land Remaining Forest Land: □ Forest Fires	2.5	8.1	4.8
N2O	3.1	8.5	5.7
Forest Land Remaining Forest Land: □ Forest Fires	2.1	6.6	4.0
Forest Land Remaining Forest Land: □ Forest Soils	0.1	0.4	0.4
Settlements Remaining Settlements:□ Settlement Soils	1.0	1.5	1.4
Wetlands Remaining Wetlands: Peatlands □ Remaining Peatlands	0.0	0.0	0.0
Total	**13.8**	**25.6**	**19.6**

Note: Parentheses indicate net sequestration. Totals may not sum due to independent rounding.

Tables ES-5, 2-11 and 7-1. Net CO2 Flux from Land Use, Land-Use Change and Forestry (Tg CO2 Ec

Land-Use Category	1990	2005	2010
Forest Land Remaining Forest Land	(701.4)	(940.9)	(921.8)
Cropland Remaining Cropland	(29.4)	(18.3)	(15.6)
Land Converted to Cropland	2.2	5.9	5.9
Grassland Remaining Grassland	(52.2)	(8.9)	(8.3)
Land Converted to Grassland	(19.8)	(24.4)	(23.6)
Settlements Remaining Settlements	(57.1)	(87.8)	(98.0)
Other (Landfilled Yard Trimmings and Food Scraps)	(24.2)	(11.6)	(13.3)
Total	**(881.8)**	**(1085.9)**	**(1074.7)**

Note: Parentheses indicate net sequestration. Totals may not sum due to independent rounding.

[attachment "GER and US inventory land use data.xlsx" deleted by Allen Fawcett/DC/USEPA/US]

▼ Paul Gunning---01/09/2013 01:16:32 PM---Can we pull this data together (see original request from Rick Duke at the bottom). I know we gave

From: Paul Gunning/DC/USEPA/US
To: irving.bill@epa.gov, Leif Hockstad/DC/USEPA/US@EPA, Chris Sherry/DC/USEPA/US@EPA, Jameel Alsalam/DC/USEPA/US@EPA, Allen Fawcett/DC/USEPA/US@EPA
Cc: kocchi.suzanne@epa.gov
Date: 01/09/2013 01:16 PM
Subject: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

Can we pull this data together (see original request from Rick Duke at the bottom). I know we gave global non-co2 but what about co2?

Paul

----- Forwarded by Paul Gunning/DC/USEPA/US on 01/09/2013 01:13 PM -----

From: Joel Beauvais/DC/USEPA/US
To: "Paul Gunning" <gunning.paul@epa.gov>, "William Irving" <irving.bill@epa.gov>, "Jackie Krieger" <Krieger.Jackie@epamail.epa.gov>
Cc: "Maurice LeFranc" <lefranc.maurice@epa.gov>
Date: 01/09/2013 01:09 PM
Subject: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

From: "Reidmiller, David R" [ReidmillerDR@state.gov]
Sent: 01/09/2013 05:42 PM GMT
To: "Duke, Rick" <Richard_Duke@ceq.eop.gov>
Cc: "Talley, Trigg" <TalleyT@state.gov>; "Larsen, Kate M (OES)" <LarsenKM@state.gov>; "Ogden, Peter" <Peter_R_Ogden@who.eop.gov>; Joel Beauvais; "Ali_A_Zaidi@ceq.eop.gov" <Ali_A_Zaidi@ceq.eop.gov>
Subject: RE: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

Rick et al,

My understanding is you were looking for the following data. From the datasets I have seen (the non-CO2 emissions data is exclusively from EPA), the following table shows what I have come across (green, I have; red I have not). Of course, I defer to EPA if there are more recent / caveats to these data.

		Current / 2010	2030
	Forestry		

US			
	Ag		
	Industrial		
	Total non-CO2		
Global	*Forestry*		
	Ag		
	Industrial		
	Total non-CO2		

The three tables below summarize what data I have seen.

From EPA's *Inventory of U.S. GHG Emissions & Sink: 1990-2010* (released Apr 2012)

Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector (Tg CO_2 Eq.)					
Sector/Source	**1990**	**1995**	**2000**	**2005**	**2010**
Industrial Processes	313.9	336.5	349.6	330.1	303.4
Agriculture	387.8	416.3	415.3	424.6	428.4
LULUCF (emissions)	13.8	15.7	31.3	25.6	19.6

From: http://www.epa.gov/climatechange/Downloads/EPAactivities/DataAnnex_EPA_NonCO2_Projections_2011_draft.zip

Non-CO2 emissions, all sectors *(Mt CO2e)*									
Country	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
United States	1,044.6	1,073.8	1,078.6	1,058.2	1,152.0	1,251.3	1,360.1	1,486.6	1,570.7

The table below is also non-CO2 emissions from the hyperlinked zip file above. Green nations are Major Economies; yellow are EU. (The U.S.-only table above is extracted from this larger table below.)

	MtCO2e									
Country	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Afghanistan	12.0	12.5	15.0	16.4	18.3	20.4	22.7	25.4	28.2	
Albania	4.8	3.4	3.5	2.9	2.8	2.8	2.8	2.9	3.0	
Algeria	23.2	24.7	29.6	34.7	39.1	47.0	51.8	56.8	61.1	
Andorra	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	
Angola	129.4	124.3	129.0	155.9	194.1	202.4	199.7	204.3	212.6	

Antigua and Barbuda	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.2	1.5	
Argentina	138.4	147.7	160.0	171.9	181.2	193.8	203.9	215.1	225.8	
Armenia	3.9	3.4	3.4	3.8	4.1	4.5	4.8	5.2	5.5	
Australia	160.4	150.0	172.8	153.1	158.2	168.6	177.2	187.4	197.1	
Austria	16.9	16.4	14.9	13.7	14.0	14.6	15.0	15.5	15.8	
Azerbaijan	17.7	13.2	16.1	20.9	34.1	41.6	44.5	46.5	49.2	
Bahamas	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	
Bahrain	3.3	3.6	3.9	4.4	4.5	5.0	5.4	6.0	6.6	
Bangladesh	49.7	54.7	58.7	63.7	70.8	78.0	86.7	97.1	109.2	
Barbados	1.8	1.9	2.0	2.0	2.0	2.1	2.2	2.2	2.3	
Belarus	27.8	18.6	19.9	23.0	23.9	23.8	23.9	24.0	24.0	
Belgium	20.4	21.3	20.7	17.9	16.7	17.6	18.4	19.5	20.7	
Belize	5.1	5.8	6.6	7.5	8.6	9.4	10.3	11.2	12.0	
Benin	10.2	9.9	10.8	11.0	11.9	12.6	13.3	14.1	15.0	
Bhutan	0.6	0.7	0.9	0.8	0.8	0.9	0.9	1.0	1.1	
Bolivia	42.0	40.2	39.0	53.0	55.0	57.0	58.8	60.8	62.8	
Bosnia and Herzegovina	3.7	3.6	6.7	6.2	5.9	6.1	6.3	6.5	6.8	
Botswana	10.4	9.5	6.5	6.3	6.7	7.1	7.4	7.6	7.9	
Brazil	534.6	558.6	560.2	756.8	715.9	745.8	761.8	779.7	794.5	
Brunei	10.0	10.8	12.0	13.1	12.9	13.9	14.5	14.9	15.8	
Bulgaria	31.5	22.3	19.5	17.1	16.9	16.9	16.9	17.2	17.4	
Burkina Faso	9.5	11.0	13.2	15.9	18.7	20.8	22.7	24.8	27.2	
Burma	162.6	180.4	139.1	144.1	151.6	156.8	162.5	168.8	175.5	
Burundi	1.8	1.7	1.7	1.9	2.3	2.5	2.7	2.9	3.1	
Cambodia	22.7	25.3	24.0	34.0	34.2	35.7	36.0	36.7	37.6	
Cameroon	85.0	83.8	85.4	81.5	81.8	82.9	84.0	85.0	86.1	

Canada	138.7	190.6	162.3	171.4	180.9	199.8	213.5	230.6	244.4	
Cape Verde	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	
Central African Republic	113.1	107.7	85.4	86.1	89.2	91.6	94.1	97.0	100.1	
Chad	21.0	21.4	25.8	33.6	34.7	36.9	38.5	40.4	42.0	
Chile	15.1	21.5	28.0	35.8	37.8	40.2	42.7	45.7	48.7	
China	1,006.0	1,135.6	1,143.9	1,404.7	1,586.5	1,734.8	1,953.7	2,339.6	2,818.3	
Colombia	78.0	85.8	90.4	101.0	107.9	115.7	122.8	129.6	137.7	
Comoros	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Congo (Brazzaville)	9.1	8.3	7.7	8.0	8.1	8.3	8.4	8.6	8.8	
Congo (Kinshasa)	237.0	212.3	176.5	167.2	169.3	171.3	173.5	175.9	178.5	
Cook Islands	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
Costa Rica	3.8	6.1	7.9	9.6	11.4	12.2	13.0	14.0	14.8	
Cote d'Ivoire	37.7	39.7	45.9	45.0	47.6	50.4	53.4	56.7	60.0	
Croatia	8.4	6.1	6.2	7.0	7.3	7.6	7.9	8.4	8.8	
Cuba	30.6	16.3	20.1	23.6	25.8	28.4	30.8	34.1	37.2	
Cyprus	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.7	
Czech Republic	30.6	21.9	20.1	19.7	19.4	19.8	20.2	21.1	21.6	
Denmark	16.3	15.7	14.9	13.4	10.9	11.3	11.4	12.0	12.2	
Djibouti	0.5	0.5	0.6	0.6	0.6	0.7	0.8	1.0	1.1	
Dominica	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Dominican Republic	5.5	7.5	7.8	8.5	9.6	10.5	11.3	12.3	13.3	
Ecuador	12.9	15.0	14.8	15.6	16.1	17.2	18.3	19.7	20.9	
Egypt	35.4	41.1	46.5	53.9	62.2	69.0	76.2	84.8	93.1	
El Salvador	4.7	4.8	5.0	5.6	6.3	6.9	7.4	8.2	8.9	
Equatorial Guinea	0.1	0.3	6.4	14.6	15.0	15.7	16.4	17.6	18.2	
Eritrea	5.1	5.0	5.6	5.2	5.2	5.7	6.1	6.5	7.0	

Estonia	5.1	3.0	3.1	3.0	3.1	3.0	3.1	3.1	3.1	
Ethiopia	73.5	71.3	78.6	95.4	116.2	128.8	139.3	150.2	161.3	
Fiji	0.8	0.9	0.8	0.8	0.9	1.0	1.0	1.1	1.2	
Finland	14.3	13.4	12.6	11.9	12.4	13.1	13.5	13.8	14.1	
France	161.2	158.4	145.8	132.6	135.7	144.6	149.0	153.9	156.7	
Gabon	12.9	16.9	14.7	14.2	14.3	15.2	15.3	15.7	16.1	
Gambia	3.6	4.2	4.9	5.6	6.3	7.1	7.9	8.8	9.6	
Georgia	13.3	7.9	8.5	8.8	8.2	8.4	8.7	9.4	9.9	
Germany	172.4	152.7	119.8	115.8	116.6	109.0	112.6	119.4	127.8	
Ghana	13.8	14.4	16.1	15.8	17.0	18.0	19.0	20.3	21.6	
Greece	22.6	23.7	24.1	20.9	17.2	16.4	16.0	15.7	15.5	
Grenada	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	
Guatemala	9.9	11.4	36.9	22.4	23.7	25.1	26.5	28.1	29.6	
Guinea	14.5	15.2	15.3	17.1	18.4	19.1	19.8	20.7	21.6	
Guinea-Bissau	1.3	1.4	1.5	1.7	1.9	2.0	2.1	2.3	2.5	
Guyana	2.5	2.5	2.4	2.7	2.7	2.8	2.8	2.9	2.9	
Haiti	3.8	4.2	5.1	5.3	5.6	6.1	6.5	7.2	7.9	
Holy See	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Honduras	8.5	9.0	9.0	10.7	11.6	12.6	13.4	14.4	15.3	
Hungary	26.9	18.5	19.8	19.6	18.3	18.9	19.6	20.5	21.1	
Iceland	1.2	0.8	1.0	0.8	1.0	1.1	1.2	1.2	1.3	
India	766.7	817.6	854.5	898.4	1,004.6	1,058.5	1,124.0	1,211.4	1,315.2	
Indonesia	273.8	302.3	311.4	362.7	383.5	401.6	419.0	438.8	462.9	
Iran	66.9	76.8	84.2	96.7	102.7	108.1	113.5	122.5	132.3	
Iraq	16.0	18.8	19.0	19.4	19.9	21.6	23.6	25.8	28.1	
Ireland	23.0	24.0	24.2	22.5	22.2	22.8	22.9	23.2	23.3	

Israel	9.1	11.4	14.4	13.7	16.4	20.5	25.1	33.9	39.8	
Italy	82.0	86.3	90.7	86.8	80.7	85.5	89.9	95.1	99.3	
Jamaica	3.0	3.1	3.2	3.6	3.7	3.9	4.1	4.7	5.1	
Japan	94.5	104.5	103.5	94.4	93.7	106.1	122.4	144.8	165.1	
Jordan	7.3	9.4	10.3	11.7	14.7	15.6	17.4	19.5	21.6	
Kazakhstan	83.6	52.9	42.2	47.0	53.5	57.3	59.8	62.5	66.0	
Kenya	28.2	27.1	26.8	30.8	34.1	36.6	38.9	41.4	44.1	
Kiribati	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Kuwait	48.8	83.6	86.8	106.1	109.0	111.1	109.7	117.7	128.8	
Kyrgyzstan	8.4	4.3	4.1	4.0	4.4	4.8	5.1	5.4	5.8	
Laos	11.5	12.4	10.1	16.3	17.3	18.0	18.7	19.5	20.4	
Latvia	7.5	3.5	3.3	3.8	4.0	4.3	4.6	5.2	5.7	
Lebanon	1.8	2.1	2.3	2.4	2.7	3.1	3.5	4.2	4.8	
Lesotho	1.7	1.8	2.3	2.0	2.2	2.3	2.5	2.6	2.8	
Liberia	0.8	0.7	0.9	0.9	1.1	1.2	1.4	1.6	1.8	
Libya	57.6	58.4	59.8	71.0	81.0	74.8	68.8	70.2	71.5	
Liechtenstein	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Lithuania	13.1	6.8	7.3	8.6	9.4	9.7	10.0	10.8	11.3	
Luxembourg	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3	
Macedonia	4.5	3.1	3.0	3.2	3.7	4.3	4.8	5.8	6.4	
Madagascar	27.6	27.6	26.4	29.2	30.5	32.1	33.2	34.4	35.6	
Malawi	10.1	9.3	10.8	13.3	16.3	18.3	20.5	23.1	26.6	
Malaysia	61.8	69.8	71.5	81.4	87.2	96.0	105.5	119.6	137.0	
Maldives	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	
Mali	15.7	15.9	17.5	21.0	25.1	28.5	32.0	36.6	42.6	
Malta	0.2	0.3	0.3	0.4	0.5	0.6	0.7	1.0	1.1	
Marshall Islands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	

Mauritania	4.9	5.0	6.6	7.4	7.2	7.7	8.3	9.0	9.8	
Mauritius	0.4	0.4	0.5	0.5	0.6	0.7	0.9	1.1	1.2	
Mexico	153.5	168.0	195.1	211.6	240.4	251.9	267.9	295.0	325.7	
Micronesia (Federated States of)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	
Moldova	6.1	4.1	2.4	2.3	2.1	2.2	2.3	2.5	2.7	
Monaco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
Mongolia	12.1	12.8	13.0	9.7	13.7	16.8	20.9	26.6	34.6	
Montenegro	1.3	1.4	1.7	1.6	1.5	1.7	2.0	2.4	2.8	
Morocco	15.8	14.8	17.4	18.6	19.9	21.0	22.4	24.1	25.8	
Mozambique	20.3	18.8	23.4	24.9	25.6	26.2	26.7	27.2	27.7	
Namibia	5.9	5.3	7.5	8.3	7.6	8.1	8.4	8.7	8.9	
Nauru	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Nepal	23.5	26.2	29.3	30.6	33.2	36.9	40.8	45.4	50.9	
Netherlands	51.6	53.0	43.3	36.0	34.4	35.8	36.9	38.4	40.1	
New Zealand	36.4	37.1	39.6	41.4	41.5	43.7	45.6	47.8	50.0	
Nicaragua	7.1	6.6	7.9	8.5	9.0	9.7	10.2	10.8	11.4	
Niger	7.5	9.0	11.0	13.6	16.2	18.3	20.3	22.5	24.9	
Nigeria	140.6	146.4	168.6	190.0	201.3	222.9	239.9	256.4	272.5	
Niue	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.3	
North Korea	34.2	25.5	23.2	25.9	27.1	29.2	32.6	39.1	47.2	
Norway	14.8	11.8	11.7	10.8	9.7	10.3	10.9	11.7	12.8	
Oman	27.9	34.8	40.7	37.0	37.6	41.4	37.6	39.3	38.4	
Pakistan	86.3	99.0	113.4	131.6	154.5	169.4	184.3	201.5	220.4	
Palau	0.0	0.0	0.0	0.0	0.0	0.2	0.9	2.8	5.1	
Panama	5.0	5.3	5.3	6.0	6.4	7.0	7.5	8.1	8.7	
Papua New Guinea	5.6	9.6	8.6	7.2	7.7	8.1	8.4	8.7	9.1	

Paraguay	31.7	34.2	31.2	32.8	35.6	38.3	40.6	43.2	45.6	
Peru	24.7	26.4	30.9	31.2	33.1	35.5	37.7	40.4	43.1	
Philippines	42.8	47.7	53.1	57.4	62.7	68.3	75.2	85.7	96.3	
Poland	91.1	80.5	68.6	67.1	69.3	71.9	74.6	77.2	80.3	
Portugal	15.7	17.1	18.7	20.8	20.4	20.9	21.3	21.6	21.8	
Qatar	19.6	23.5	41.7	55.2	71.8	94.6	104.8	115.2	123.9	
Romania	70.9	51.2	40.7	44.0	43.2	43.5	43.7	44.4	45.1	
Russia	854.3	617.1	609.0	622.6	647.9	668.9	718.6	764.2	803.1	
Rwanda	2.5	2.7	3.1	3.7	4.1	4.5	4.9	5.4	5.9	
Saint Kitts and Nevis	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Saint Lucia	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	
Saint Vincent and the Grenadines	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Samoa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	
San Marino	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Sao Tome and Principe	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Saudi Arabia	23.3	27.0	31.4	37.1	41.3	46.4	51.6	59.5	66.9	
Senegal	9.0	9.8	11.4	12.5	13.6	14.8	16.0	17.2	18.5	
Serbia	14.3	12.9	11.8	11.6	11.4	11.7	12.1	12.7	13.3	
Seychelles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Sierra Leone	4.4	4.4	3.3	3.9	4.3	4.8	5.2	5.9	6.6	
Singapore	1.3	2.1	3.8	4.7	5.6	7.3	9.8	15.0	22.1	
Slovakia	11.4	8.6	8.2	8.8	6.8	6.8	7.0	7.4	7.7	
Slovenia	3.8	3.7	3.8	3.9	4.0	4.3	4.5	4.9	5.2	
Solomon Islands	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	
Somalia	21.4	21.0	22.2	23.8	23.0	23.9	24.9	26.4	28.0	
South Africa	73.5	71.4	71.9	75.2	81.6	88.4	95.6	109.4	119.5	

South Korea	43.4	47.6	62.0	73.2	84.1	95.8	111.6	143.3	170.1	
Spain	61.0	65.5	79.2	72.4	73.0	76.4	78.6	81.3	83.8	
Sri Lanka	23.5	24.6	24.0	25.5	26.3	28.0	29.4	31.1	32.9	
Sudan	81.0	94.7	117.7	140.5	150.1	158.2	165.2	173.6	181.0	
Suriname	1.9	1.9	1.6	1.5	1.6	1.6	1.7	1.8	2.0	
Swaziland	1.6	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	
Sweden	16.1	16.1	15.3	14.8	14.0	14.0	14.1	14.5	14.6	
Switzerland	8.4	7.8	7.6	7.6	8.0	8.4	8.7	9.1	9.4	
Syria	24.1	32.3	33.1	32.8	34.4	38.5	38.3	42.0	44.3	
Tajikistan	6.8	8.2	7.2	8.7	9.3	10.0	10.8	11.6	12.6	
Tanzania	61.4	57.9	57.2	64.5	66.7	69.5	71.5	73.6	75.7	
Thailand	85.7	91.5	89.6	101.2	112.5	118.5	125.7	138.0	150.7	
Timor-Leste	0.7	0.9	0.9	1.3	1.3	1.4	1.5	1.5	1.6	
Togo	5.2	4.7	4.8	4.9	5.2	5.5	5.8	6.2	6.6	
Tonga	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	
Trinidad and Tobago	0.9	0.9	1.0	1.1	1.3	1.5	1.6	1.8	2.0	
Tunisia	5.9	6.1	7.4	7.8	8.7	9.6	10.5	11.5	12.6	
Turkey	62.2	79.0	86.4	83.6	89.8	96.0	102.2	109.2	115.7	
Turkmenistan	28.1	20.8	29.5	40.5	43.9	50.0	53.7	55.5	57.7	
Tuvalu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Uganda	16.7	17.3	17.1	22.5	24.3	25.5	26.7	28.0	29.4	
Ukraine	206.5	131.3	98.7	95.5	91.1	90.9	91.5	92.4	93.5	
United Arab Emirates	12.7	15.0	17.6	20.9	24.1	26.6	28.7	31.8	34.9	
United Kingdom	174.5	150.4	119.2	96.6	92.5	96.3	99.1	102.2	103.8	
United States	1,044.6	1,073.8	1,078.6	1,058.2	1,152.0	1,251.3	1,360.1	1,486.6	1,570.7	
Uruguay	24.0	26.3	23.8	26.2	28.1	31.1	33.6	36.7	39.6	

Uzbekistan	69.8	85.9	92.7	99.7	110.5	122.9	131.2	135.0	138.9	
Vanuatu	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	
Venezuela	69.4	78.0	85.4	85.0	84.8	90.4	100.6	112.7	123.7	
Vietnam	57.4	69.6	82.0	92.5	98.8	104.8	110.4	117.3	125.4	
Yemen	4.7	4.9	5.9	7.0	8.0	9.1	10.4	12.2	14.1	
Zambia	79.3	67.5	52.3	62.1	65.5	67.8	70.2	72.9	75.7	
Zimbabwe	12.7	10.9	11.5	10.9	11.2	12.1	12.9	14.2	15.4	
World Totals	**9,909.0**	**9,942.0**	**10,059.8**	**10,927.6**	**11,701.8**	**12,489.6**	**13,337.3**	**14,537.9**	**15,799.5**	**-**
Rest of Africa	951.1	941.1	968.7	1,086.0	1,182.3	1,233.2	1,269.7	1,329.1	1,394.0	
Rest of Central and South America	128.6	124.5	155.8	154.6	168.5	181.6	193.8	209.5	223.9	
Rest of Middle East	81.5	101.1	127.6	138.7	159.0	191.7	200.0	218.9	232.2	
Rest of Non-OECD Asia	116.2	131.1	135.1	147.9	157.1	171.6	186.7	208.8	235.5	
Rest of Non-OECD Europe and Eurasia	20.3	19.0	21.4	20.8	20.4	21.4	22.5	24.2	25.8	
Africa	**1,560.0**	**1,535.6**	**1,568.9**	**1,737.3**	**1,890.0**	**2,001.0**	**2,088.7**	**2,207.8**	**2,327.9**	
Central and South America	**1,052.7**	**1,102.5**	**1,160.3**	**1,395.2**	**1,390.6**	**1,467.9**	**1,531.2**	**1,604.2**	**1,672.0**	
Middle East	**256.5**	**331.7**	**377.0**	**430.7**	**470.8**	**521.1**	**544.5**	**595.7**	**644.6**	
OECD	**2,795.0**	**2,852.1**	**2,827.7**	**2,751.8**	**2,892.8**	**3,094.8**	**3,314.9**	**3,604.7**	**3,837.4**	
Non-OECD Asia	**2,752.5**	**3,033.8**	**3,084.4**	**3,525.5**	**3,913.8**	**4,206.1**	**4,586.9**	**5,189.2**	**5,922.1**	
Non-OECD Europe & Eurasia	**1,492.4**	**1,086.3**	**1,041.4**	**1,087.1**	**1,143.9**	**1,198.7**	**1,271.1**	**1,336.4**	**1,395.6**	
EU	**1,141.7**	**1,036.0**	**939.8**	**874.1**	**857.5**	**880.3**	**906.1**	**941.5**	**972.0**	
						1,063.2	**1,111.0**	**1,192.5**	**1,277.2**	

OPEC	**620.4**	**691.5**	**768.0**	**887.7**	**985.3**					
World Totals	**9,909.0**	**9,942.0**	**10,059.8**	**10,927.6**	**11,701.8**	**12,489.6**	**13,337.3**	**14,537.9**	**15,799.5**	
Africa	16%	15%	16%	16%	16%	16%	16%	15%	15%	
Central and South America	11%	11%	12%	13%	12%	12%	11%	11%	11%	
Middle East	3%	3%	4%	4%	4%	4%	4%	4%	4%	
OECD	28%	29%	28%	25%	25%	25%	25%	25%	24%	
Non-OECD Asia	28%	31%	31%	32%	33%	34%	34%	36%	37%	
Non-OECD Europe & Eurasia	15%	11%	10%	10%	10%	10%	10%	9%	9%	
World Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	

From: Larsen, Kate M (OES)
Sent: Wednesday, January 09, 2013 12:04 PM
To: Reidmiller, David R
Cc: Talley, Trigg
Subject: Fw: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)
Importance: High

Dave - do you think you have this handy?

Kate M. Larsen
Office of Global Change
U.S. Department of State
+1.202.531.7498

From: Duke, Rick [mailto:Richard_Duke@ceq.eop.gov]
Sent: Wednesday, January 09, 2013 11:57 AM
To: Beauvais.Joel@epamail.epa.gov <Beauvais.Joel@epamail.epa.gov>; Larsen, Kate M (OES)
Cc: Ogden, Peter <Peter_R_Ogden@who.eop.gov>; Zaidi, Ali <Ali_A_Zaidi@ceq.eop.gov>
Subject: time sensitive request: need by 3pm today if possible (still potentially useful if comes later)

For 2012 (or other "current" year) and 2030 and for both US only and global, we need GHGs broken out by:

- Forestry
- Agriculture
- Industrial gases (i.e. non-CO2 GHGs other than agriculture)

Joel: can you help try to track down, e.g. maybe asking Maurice or Climate Indicators team?

Kate: can you check at State, e.g. maybe with Chris Dragisec (sp?)?

Thanks and call me at 2024071811 with any questions.

From:	Jennifer Jenkins
To:	Benjamin Hengst; Bill Irving; Chris Sherry; dodder.rebecca@epa.gov; grambsch.anne@epa.gov; Jeneva Craig; johnson.tim@epa.gov; MichaelS Brooks; Sara Ohrel; Suzanne Kocchi; Vincent Camobreco; Carl Mazza; Carrie Wheeler; David Solomon; Juan Santiago; Kevin Culligan; Paul Balserak; Anna Wood; Brian Doster; Elliott Zenick; Michael Ling; Paul Gunning; Reid Harvey; Rona Birnbaum; Scott Jordan
Subject:	SAB draft review report released
Date:	01/20/2012 04:14 PM
Attachments:	1-18-12+Biogenic+Carbon+Advisory+--+CLEAN+COPY.pdf

---

All:

(I have used last fall's distribution list for this message; please let me know if you notice names that should be added or subtracted.)

On Wednesday January 18, EPA's Science Advisory Board released a preliminary draft of its review report of EPA's draft "Accounting Framework for Biogenic CO2 Emissions from Stationary Sources." The url for the draft report is below, and a copy is attached for convenience.

As you'll recall, EPA submitted the draft Accounting Framework on September 15, 2011, and the SAB convened an 18-member Biogenic Carbon Emissions Panel to review the draft. The Panel met October 25-27, 2011 in person, and since then they have been working on written responses to the charge questions provided by EPA.

On January 27, the Panel will hold a publicly-accessible teleconference to discuss their findings and their draft review report. They will likely need at least one additional teleconference (now scheduled for March 20) to work on their report, and we expect the SAB to issue its final report in the May-June timeframe.

I will send out a separate invitation for next Thursday, for this group to meet by phone to discuss the SAB's draft and the upcoming teleconference.

thanks, and please let me know if you have any questions --
Jen Jenkins

The *Advisory on EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (Framework, September 2011* Draft Report, for the 11-34 Carbon Dioxide Accounting for Emissions from Biogenic Sources Advisory Activity, has been posted to the SAB Web site at this location:

http://yosemite.epa.gov/sab/sabproduct.nsf/0/2F9B572C712AC52E8525783100704886?OpenDocument

Jennifer C. Jenkins, Ph.D.
US Environmental Protection Agency
Climate Change Division, Climate Policy Branch
202-343-9361

Technical Support Document:
Social Cost of Carbon for Regulatory Impact Analysis
Under Executive Order 12866

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Energy and Climate Change
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

February 2010

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

This document presents a summary of the interagency process that developed these SCC estimates. Technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

I. Monetizing Carbon Dioxide Emissions

The "social cost of carbon" (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. We report estimates of the social cost of carbon in dollars per metric ton of carbon dioxide throughout this document.[1]

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to make it possible for agencies to incorporate the social benefits from reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. Most federal regulatory actions can be expected to have marginal impacts on global emissions.

For such policies, the benefits from reduced (or costs from increased) emissions in any future year can be estimated by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions; we do not attempt to answer that question here.

An interagency group convened on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key inputs and assumptions in order to generate SCC estimates. Agencies that actively participated in the interagency process include the Environmental Protection

[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

Agency, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. This process was convened by the Council of Economic Advisers and the Office of Management and Budget, with active participation and regular input from the Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature. In this way, key uncertainties and model differences can more transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020. See Appendix A for the full range of annual SCC estimates from 2010 to 2050.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised in this document and consider public comments as part of the ongoing interagency process.

II. Social Cost of Carbon Values Used in Past Regulatory Analyses

To date, economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the Department of Transportation (DOT) used both a "domestic" SCC value of $2 per ton of CO_2 and a "global" SCC value of $33 per ton of CO_2 for 2007 emission reductions (in 2007 dollars), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at $80 per ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per ton CO_2 (in 2006 dollars) for 2011 emission reductions (with a range of $0-$14 for sensitivity analysis), also increasing at 2.4 percent per year. A regulation finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per ton CO_2 for 2007 emission reductions (in 2007 dollars). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking for Greenhouse Gases identified what it described as "very preliminary" SCC estimates subject to revision. EPA's global mean values were $68 and $40 per ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006 dollars for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted.

The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006 dollars) of $55, $33, $19, $10, and $5 per ton of CO_2. The $33 and $5 values represented model-weighted means of the published estimates produced from the most recently available versions of three integrated assessment models—DICE, PAGE, and FUND—at approximately 3 and 5 percent discount rates. The $55 and $10 values were derived by adjusting the published estimates for uncertainty in the discount rate (using factors developed by Newell and Pizer (2003)) at 3 and 5 percent discount rates, respectively. The $19 value was chosen as a central value between the $5 and $33 per ton estimates. All of these values were assumed to increase at 3 percent annually to represent growth in incremental damages over time as the magnitude of climate change increases.

These interim values represent the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules and were offered for public comment in connection with proposed rules, including the joint EPA-DOT fuel economy and CO_2 tailpipe emission proposed rules.

III. Approach and Key Assumptions

Since the release of the interim values, interagency group has reconvened on a regular basis to generate improved SCC estimates. Specifically, the group has considered public comments and further explored the technical literature in relevant fields. This section details the several choices and assumptions that underlie the resulting estimates of the SCC.

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Academy of Science (2009) points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. Throughout this document, we highlight a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the agencies participating in the interagency process to estimate the SCC.

The U.S. Government will periodically review and reconsider estimates of the SCC used for cost-benefit analyses to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. In this context, statements recognizing the limitations of the analysis and calling for further research take on exceptional significance. The interagency group offers the new SCC values with all due humility about the uncertainties embedded in them and with a sincere promise to continue work to improve them.

A. Integrated Assessment Models

We rely on three integrated assessment models (IAMs) commonly used to estimate the SCC: the FUND, DICE, and PAGE models.[2] These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment. Each model is given equal weight in the SCC values developed through this process, bearing in mind their different limitations (discussed below).

These models are useful because they combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework. At the same time, they gain this advantage at the expense of a more detailed representation of the underlying climatic and economic systems. DICE, PAGE, and FUND all take stylized, reduced-form approaches (see NRC 2009 for a more detailed discussion; see Nordhaus 2008 on the possible advantages of this approach). Other IAMs may better reflect the complexity of the science in their modeling frameworks but do not link physical impacts to economic damages. There is currently a limited amount of research linking climate impacts to economic damages, which makes this exercise even more difficult. Underlying the three IAMs selected for this exercise are a number of simplifying assumptions and judgments reflecting the various modelers' best attempts to synthesize the available scientific and economic research characterizing these relationships.

The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into concentrations using the carbon cycle built into each model, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, climate sensitivity. Each model uses a different approach to translate warming into damages. Finally, transforming the stream of economic damages over time into a single value requires judgments about how to discount them.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. In PAGE, for example, the consumption-equivalent damages in each period are calculated as a fraction of GDP, depending on the temperature in that period relative to the pre-industrial average temperature in each region. In FUND, damages in each period also depend on the rate of temperature change from the prior period. In DICE, temperature affects both consumption and investment. We describe each model in greater detail here. In a later section, we discuss key gaps in how the models account for various scientific and economic processes (e.g. the probability of catastrophe, and the ability to adapt to climate change and the physical changes it causes).

---

[2] The DICE (Dynamic Integrated Climate and Economy) model by William Nordhaus evolved from a series of energy models and was first presented in 1990 (Nordhaus and Boyer 2000, Nordhaus 2008). The PAGE (Policy Analysis of the Greenhouse Effect) model was developed by Chris Hope in 1991 for use by European decision-makers in assessing the marginal impact of carbon emissions (Hope 2006, Hope 2008). The FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) model, developed by Richard Tol in the early 1990s, originally to study international capital transfers in climate policy. is now widely used to study climate impacts (e.g., Tol 2002a, Tol 2002b, Anthoff et al. 2009, Tol 2009).

The parameters and assumptions embedded in the three models vary widely. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments. In DICE, these parameters are handled deterministically and represented by fixed constants; in PAGE, most parameters are represented by probability distributions. FUND was also run in a mode in which parameters were treated probabilistically.

The sensitivity of the results to other aspects of the models (e.g. the carbon cycle or damage function) is also important to explore in the context of future revisions to the SCC but has not been incorporated into these estimates. Areas for future research are highlighted at the end of this document.

The DICE Model

The DICE model is an optimal growth model based on a global production function with an extra stock variable (atmospheric carbon dioxide concentrations). Emission reductions are treated as analogous to investment in "natural capital." By investing in natural capital today through reductions in emissions—implying reduced consumption—harmful effects of climate change can be avoided and future consumption thereby increased.

For purposes of estimating the SCC, carbon dioxide emissions are a function of global GDP and the carbon intensity of economic output, with the latter declining over time due to technological progress. The DICE damage function links global average temperature to the overall impact on the world economy. It varies quadratically with temperature change to capture the more rapid increase in damages expected to occur under more extreme climate change, and is calibrated to include the effects of warming on the production of market and nonmarket goods and services. It incorporates impacts on agriculture, coastal areas (due to sea level rise), "other vulnerable market sectors" (based primarily on changes in energy use), human health (based on climate-related diseases, such as malaria and dengue fever, and pollution), non-market amenities (based on outdoor recreation), and human settlements and ecosystems. The DICE damage function also includes the expected value of damages associated with low probability, high impact "catastrophic" climate change. This last component is calibrated based on a survey of experts (Nordhaus 1994). The expected value of these impacts is then added to the other market and non-market impacts mentioned above.

No structural components of the DICE model represent adaptation explicitly, though it is included implicitly through the choice of studies used to calibrate the aggregate damage function. For example, its agricultural impact estimates assume that farmers can adjust land use decisions in response to changing climate conditions, and its health impact estimates assume improvements in healthcare over time. In addition, the small impacts on forestry, water systems, construction, fisheries, and outdoor recreation imply optimistic and costless adaptation in these sectors (Nordhaus and Boyer, 2000; Warren

et al., 2006). Costs of resettlement due to sea level rise are incorporated into damage estimates, but their magnitude is not clearly reported. Mastrandrea's (2009) review concludes that "in general, DICE assumes very effective adaptation, and largely ignores adaptation costs."

Note that the damage function in DICE has a somewhat different meaning from the damage functions in FUND and PAGE. Because GDP is endogenous in DICE and because damages in a given year reduce investment in that year, damages propagate forward in time and reduce GDP in future years. In contrast, GDP is exogenous in FUND and PAGE, so damages in any given year do not propagate forward.[3]

The PAGE Model

PAGE2002 (version 1.4epm) treats GDP growth as exogenous. It divides impacts into economic, non-economic, and catastrophic categories and calculates these impacts separately for eight geographic regions. Damages in each region are expressed as a fraction of output, where the fraction lost depends on the temperature change in each region. Damages are expressed as power functions of temperature change. The exponents of the damage function are the same in all regions but are treated as uncertain, with values ranging from 1 to 3 (instead of being fixed at 2 as in DICE).

PAGE2002 includes the consequences of catastrophic events in a separate damage sub-function. Unlike DICE, PAGE2002 models these events probabilistically. The probability of a "discontinuity" (i.e., a catastrophic event) is assumed to increase with temperature above a specified threshold. The threshold temperature, the rate at which the probability of experiencing a discontinuity increases above the threshold, and the magnitude of the resulting catastrophe are all modeled probabilistically.

Adaptation is explicitly included in PAGE. Impacts are assumed to occur for temperature increases above some tolerable level (2°C for developed countries and 0°C for developing countries for economic impacts, and 0°C for all regions for non-economic impacts), but adaptation is assumed to reduce these impacts. Default values in PAGE2002 assume that the developed countries can ultimately eliminate up to 90 percent of all economic impacts beyond the tolerable 2°C increase and that developing countries can eventually eliminate 50 percent of their economic impacts. All regions are assumed to be able to mitigate 25 percent of the non-economic impacts through adaptation (Hope 2006).

The FUND Model

Like PAGE, the FUND model treats GDP growth as exogenous. It includes separately calibrated damage functions for eight market and nonmarket sectors: agriculture, forestry, water, energy (based on heating and cooling demand), sea level rise (based on the value of land lost and the cost of protection),

[3] Using the default assumptions in DICE 2007, this effect generates an approximately 25 percent increase in the SCC relative to damages calculated by fixing GDP. In DICE2007, the time path of GDP is endogenous. Specifically, the path of GDP depends on the rate of saving and level of abatement in each period chosen by the optimizing representative agent in the model. We made two modifications to DICE to make it consistent with EMF GDP trajectories (see next section): we assumed a fixed rate of savings of 20%, and we re-calibrated the exogenous path of total factor productivity so that DICE would produce GDP projections in the absence of warming that exactly matched the EMF scenarios.

ecosystems, human health (diarrhea, vector-borne diseases, and cardiovascular and respiratory mortality), and extreme weather. Each impact sector has a different functional form, and is calculated separately for sixteen geographic regions. In some impact sectors, the fraction of output lost or gained due to climate change depends not only on the absolute temperature change but also on the rate of temperature change and level of regional income.[4] In the forestry and agricultural sectors, economic damages also depend on CO_2 concentrations.

Tol (2009) discusses impacts not included in FUND, noting that many are likely to have a relatively small effect on damage estimates (both positive and negative). However, he characterizes several omitted impacts as "big unknowns": for instance, extreme climate scenarios, biodiversity loss, and effects on economic development and political violence. With regard to potentially catastrophic events, he notes, "Exactly what would cause these sorts of changes or what effects they would have are not well-understood, although the chance of any one of them happening seems low. But they do have the potential to happen relatively quickly, and if they did, the costs could be substantial. Only a few studies of climate change have examined these issues."

Adaptation is included both implicitly and explicitly in FUND. Explicit adaptation is seen in the agriculture and sea level rise sectors. Implicit adaptation is included in sectors such as energy and human health, where wealthier populations are assumed to be less vulnerable to climate impacts. For example, the damages to agriculture are the sum of three effects: (1) those due to the rate of temperature change (damages are always positive); (2) those due to the level of temperature change (damages can be positive or negative depending on region and temperature); and (3) those from CO_2 fertilization (damages are generally negative but diminishing to zero).

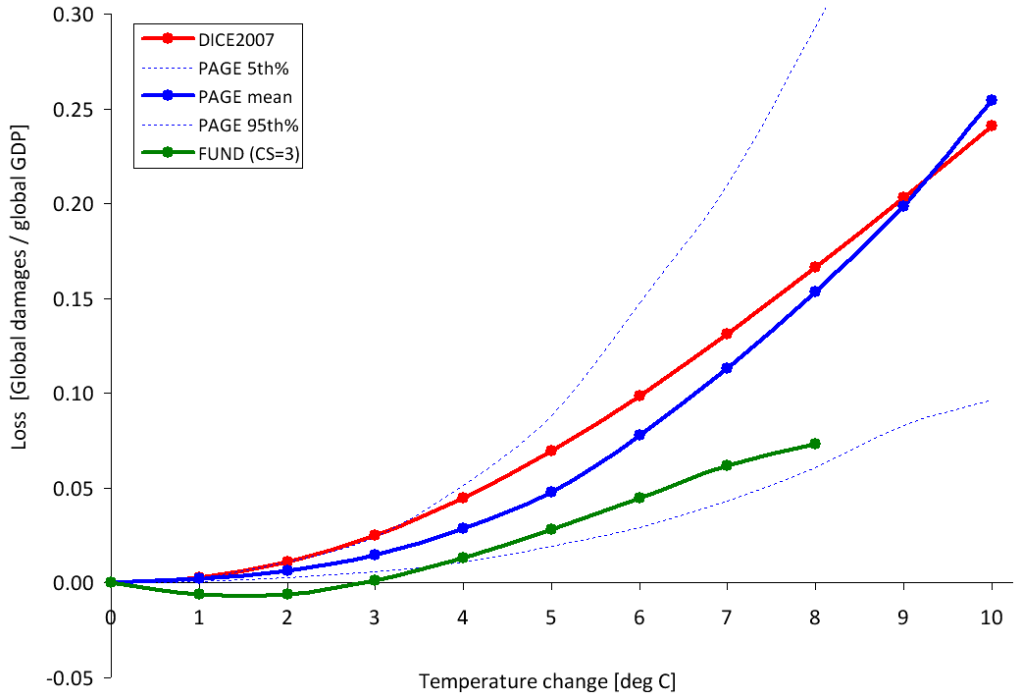
Adaptation is incorporated into FUND by allowing damages to be smaller if climate change happens more slowly. The combined effect of CO_2 fertilization in the agricultural sector, positive impacts to some regions from higher temperatures, and sufficiently slow increases in temperature across these sectors can result in negative economic damages from climate change.

Damage Functions

To generate revised SCC values, we rely on the IAM modelers' current best judgments of how to represent the effects of climate change (represented by the increase in global-average surface temperature) on the consumption-equivalent value of both market and non-market goods (represented as a fraction of global GDP). We recognize that these representations are incomplete and highly uncertain. But given the paucity of data linking the physical impacts to economic damages, we were not able to identify a better way to translate changes in climate into net economic damages, short of launching our own research program.

[4] In the deterministic version of FUND, the majority of damages are attributable to increased air conditioning demand, while reduced cold stress in Europe, North America, and Central and East Asia results in health benefits in those regions at low to moderate levels of warming (Warren et al., 2006).

Figure 1A: Annual Consumption Loss as a Fraction of Global GDP in 2100 Due to an Increase in Annual Global Temperature in the DICE, FUND, and PAGE models[5]



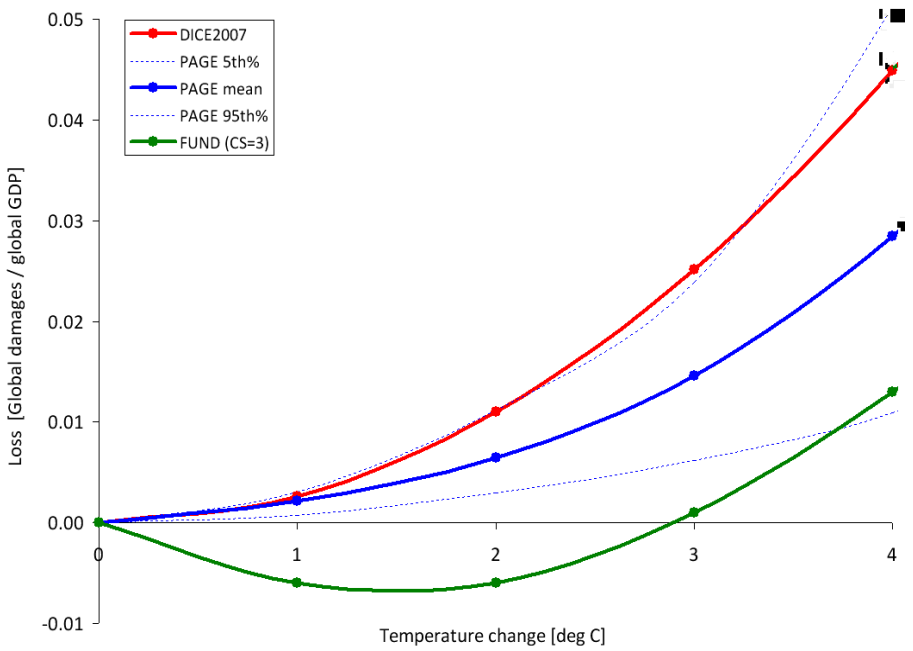
The damage functions for the three IAMs are presented in Figures 1A and 1B, using the modeler's default scenarios and mean input assumptions. There are significant differences between the three models both at lower (figure 1B) and higher (figure 1A) increases in global-average temperature.

The lack of agreement among the models at lower temperature increases is underscored by the fact that the damages from FUND are well below the 5th percentile estimated by PAGE, while the damages estimated by DICE are roughly equal to the 95th percentile estimated by PAGE. This is significant because at higher discount rates we expect that a greater proportion of the SCC value is due to damages in years with lower temperature increases. For example, when the discount rate is 2.5 percent, about 45 percent of the 2010 SCC value in DICE is due to damages that occur in years when the temperature is less than or equal to 3 °C. This increases to approximately 55 percent and 80 percent at discount rates of 3 and 5 percent, respectively.

These differences underscore the need for a thorough review of damage functions—in particular, how the models incorporate adaptation, technological change, and catastrophic damages. Gaps in the literature make modifying these aspects of the models challenging, which highlights the need for additional research. As knowledge improves, the Federal government is committed to exploring how these (and other) models can be modified to incorporate more accurate estimates of damages.

[5] The x-axis represents increases in annual, rather than equilibrium, temperature, while the y-axis represents the annual stream of benefits as a share of global GDP. Each specific combination of climate sensitivity, socio-economic, and emissions parameters will produce a different realization of damages for each IAM. The damage functions represented in Figures 1A and 1B are the outcome of default assumptions. For instance, under alternate assumptions, the damages from FUND may cross from negative to positive at less than or greater than 3 °C.

Figure 1B: Annual Consumption Loss for Lower Temperature Changes in DICE, FUND, and PAGE



B. Global versus Domestic Measures of SCC

Because of the distinctive nature of the climate change problem, we center our current attention on a global measure of SCC. This approach is the same as that taken for the interim values, but it otherwise represents a departure from past practices, which tended to put greater emphasis on a domestic measure of SCC (limited to impacts of climate change experienced within U.S. borders). As a matter of law, consideration of both global and domestic values is generally permissible; the relevant statutory provisions are usually ambiguous and allow selection of either measure.[6]

Global SCC

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if

[6] It is true that federal statutes are presumed not to have extraterritorial effect, in part to ensure that the laws of the United States respect the interests of foreign sovereigns. But use of a global measure for the SCC does not give extraterritorial effect to federal law and hence does not intrude on such interests.

significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable.

When quantifying the damages associated with a change in emissions, a number of analysts (e.g., Anthoff, et al. 2009a) employ "equity weighting" to aggregate changes in consumption across regions. This weighting takes into account the relative reductions in wealth in different regions of the world. A per-capita loss of $500 in GDP, for instance, is weighted more heavily in a country with a per-capita GDP of $2,000 than in one with a per-capita GDP of $40,000. The main argument for this approach is that a loss of $500 in a poor country causes a greater reduction in utility or welfare than does the same loss in a wealthy nation. Notwithstanding the theoretical claims on behalf of equity weighting, the interagency group concluded that this approach would not be appropriate for estimating a SCC value used in domestic regulatory analysis.[7] For this reason, the group concluded that using the global (rather than domestic) value, without equity weighting, is the appropriate approach.

Domestic SCC

As an empirical matter, the development of a domestic SCC is greatly complicated by the relatively few region- or country-specific estimates of the SCC in the literature. One potential source of estimates comes from the FUND model. The resulting estimates suggest that the ratio of domestic to global benefits of emission reductions varies with key parameter assumptions. For example, with a 2.5 or 3 percent discount rate, the U.S. benefit is about 7-10 percent of the global benefit, on average, across the scenarios analyzed. Alternatively, if the fraction of GDP lost due to climate change is assumed to be similar across countries, the domestic benefit would be proportional to the U.S. share of global GDP, which is currently about 23 percent.[8]

On the basis of this evidence, the interagency workgroup determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range. It is recognized that these values are approximate, provisional, and highly speculative. There is no a priori reason why domestic benefits should be a constant fraction of net global damages over time. Further, FUND does not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization). If more accurate methods for calculating the domestic SCC become available, the Federal government will examine these to determine whether to update its approach.

[7] It is plausible that a loss of $X inflicts more serious harm on a poor nation than on a wealthy one, but development of the appropriate "equity weight" is challenging. Emissions reductions also impose costs, and hence a full account would have to consider that a given cost of emissions reductions imposes a greater utility or welfare loss on a poor nation than on a wealthy one. Even if equity weighting—for both the costs and benefits of emissions reductions—is appropriate when considering the utility or welfare effects of international action, the interagency group concluded that it should not be used in developing an SCC for use in regulatory policy at this time.

[8] Based on 2008 GDP (in current US dollars) from the *World Bank Development Indicators Report*.

C. Valuing Non-CO_2 Emissions

While CO_2 is the most prevalent greenhouse gas emitted into the atmosphere, the U.S. included five other greenhouse gases in its recent endangerment finding: methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The climate impact of these gases is commonly discussed in terms of their 100-year global warming potential (GWP). GWP measures the ability of different gases to trap heat in the atmosphere (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. However, because these gases differ in both radiative forcing and atmospheric lifetimes, their relative damages are not constant over time. For example, because methane has a short lifetime, its impacts occur primarily in the near term and thus are not discounted as heavily as those caused by longer-lived gases. Impacts other than temperature change also vary across gases in ways that are not captured by GWP. For instance, CO_2 emissions, unlike methane and other greenhouse gases, contribute to ocean acidification. Likewise, damages from methane emissions are not offset by the positive effect of CO_2 fertilization. Thus, transforming gases into CO_2-equivalents using GWP, and then multiplying the carbon-equivalents by the SCC, would not result in accurate estimates of the social costs of non-CO_2 gases.

In light of these limitations, and the significant contributions of non-CO_2 emissions to climate change, further research is required to link non-CO_2 emissions to economic impacts. Such work would feed into efforts to develop a monetized value of reductions in non-CO_2 greenhouse gas emissions. As part of ongoing work to further improve the SCC estimates, the interagency group hopes to develop methods to value these other greenhouse gases. The goal is to develop these estimates by the time we issue revised SCC estimates for carbon dioxide emissions.

D. Equilibrium Climate Sensitivity

Equilibrium climate sensitivity (ECS) is a key input parameter for the DICE, PAGE, and FUND models.[9] It is defined as the long-term increase in the annual global-average surface temperature from a doubling of atmospheric CO_2 concentration relative to pre-industrial levels (or stabilization at a concentration of approximately 550 parts per million (ppm)). Uncertainties in this important parameter have received substantial attention in the peer-reviewed literature.

The most authoritative statement about equilibrium climate sensitivity appears in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

> *Basing our assessment on a combination of several independent lines of evidence…including observed climate change and the strength of known feedbacks simulated in [global climate models], we conclude that the global mean equilibrium warming for doubling CO_2, or 'equilibrium climate*

[9] The equilibrium climate sensitivity includes the response of the climate system to increased greenhouse gas concentrations over the short to medium term (up to 100-200 years), but it does not include long-term feedback effects due to possible large-scale changes in ice sheets or the biosphere, which occur on a time scale of many hundreds to thousands of years (e.g. Hansen et al. 2007).

sensitivity', is likely to lie in the range 2 °C to 4.5 °C, with a most likely value of about 3 °C. Equilibrium climate sensitivity is very likely larger than 1.5 °C. [10]

For fundamental physical reasons as well as data limitations, values substantially higher than 4.5 °C still cannot be excluded, but agreement with observations and proxy data is generally worse for those high values than for values in the 2 °C to 4.5 °C range. (Meehl et al., 2007, p 799)

After consulting with several lead authors of this chapter of the IPCC report, the interagency workgroup selected four candidate probability distributions and calibrated them to be consistent with the above statement: Roe and Baker (2007), log-normal, gamma, and Weibull. Table 1 included below gives summary statistics for the four calibrated distributions.

Table 1: Summary Statistics for Four Calibrated Climate Sensitivity Distributions

	Roe & Baker	Log-normal	Gamma	Weibull
Pr(ECS < 1.5°C)	0.013	0.050	0.070	0.102
Pr(2°C < ECS < 4.5°C)	0.667	0.667	0.667	0.667
5th percentile	1.72	1.49	1.37	1.13
10th percentile	1.91	1.74	1.65	1.48
Mode	2.34	2.52	2.65	2.90
Median (50th percentile)	3.00	3.00	3.00	3.00
Mean	3.50	3.28	3.19	3.07
90th percentile	5.86	5.14	4.93	4.69
95th percentile	7.14	5.97	5.59	5.17

Each distribution was calibrated by applying three constraints from the IPCC:

(1) a median equal to 3°C, to reflect the judgment of "a most likely value of about 3 °C";[11]
(2) two-thirds probability that the equilibrium climate sensitivity lies between 2 and 4.5 °C; and
(3) zero probability that it is less than 0°C or greater than 10°C (see Hegerl et al. 2006, p. 721).

We selected the calibrated Roe and Baker distribution from the four candidates for two reasons. First, the Roe and Baker distribution is the only one of the four that is based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations (Roe and Baker 2007,

[10] This is in accord with the judgment that it "is likely to lie in the range 2 °C to 4.5 °C" and the IPCC definition of "likely" as greater than 66 percent probability (Le Treut et al.2007). "Very likely" indicates a greater than 90 percent probability.

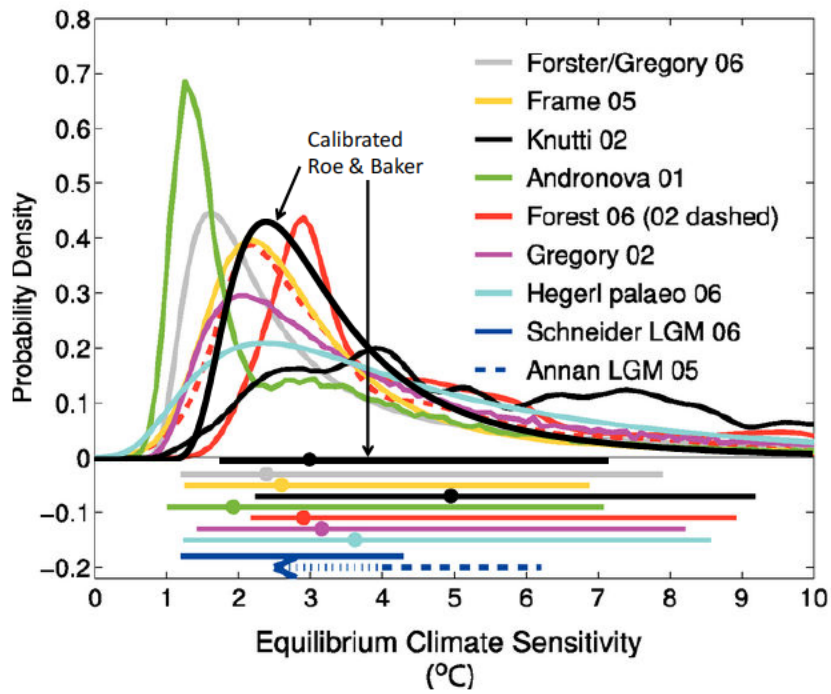
[11] Strictly speaking, "most likely" refers to the mode of a distribution rather than the median, but common usage would allow the mode, median, or mean to serve as candidates for the central or "most likely" value and the IPCC report is not specific on this point. For the distributions we considered, the median was between the mode and the mean. For the Roe and Baker distribution, setting the median equal to 3°C, rather than the mode or mean, gave a 95th percentile that is more consistent with IPCC judgments and the literature. For example, setting the mean and mode equal to 3°C produced 95th percentiles of 5.6 and 8.6 °C, respectively, which are in the lower and upper end of the range in the literature. Finally, the median is closer to 3°C than is the mode for the truncated distributions selected by the IPCC (Hegerl, et al., 2006); the average median is 3.1 °C and the average mode is 2.3 °C, which is most consistent with a Roe and Baker distribution with the median set equal to 3 °C.

Roe 2008). In contrast, the other three distributions are mathematical functions that are arbitrarily chosen based on simplicity, convenience, and general shape. The Roe and Baker distribution results from three assumptions about climate response: (1) absent feedback effects, the equilibrium climate sensitivity is equal to 1.2 °C; (2) feedback factors are proportional to the change in surface temperature; and (3) uncertainties in feedback factors are normally distributed. There is widespread agreement on the first point and the second and third points are common assumptions.

Second, the calibrated Roe and Baker distribution better reflects the IPCC judgment that "values substantially higher than 4.5°C still cannot be excluded." Although the IPCC made no quantitative judgment, the 95th percentile of the calibrated Roe & Baker distribution (7.1 °C) is much closer to the mean and the median (7.2 °C) of the 95th percentiles of 21 previous studies summarized by Newbold and Daigneault (2009). It is also closer to the mean (7.5 °C) and median (7.9 °C) of the nine truncated distributions examined by the IPCC (Hegerl, et al., 2006) than are the 95th percentiles of the three other calibrated distributions (5.2-6.0 °C).

Finally, we note the IPCC judgment that the equilibrium climate sensitivity "is very likely larger than 1.5°C." Although the calibrated Roe & Baker distribution, for which the probability of equilibrium climate sensitivity being greater than 1.5°C is almost 99 percent, is not inconsistent with the IPCC definition of "very likely" as "greater than 90 percent probability," it reflects a greater degree of certainty about very low values of ECS than was expressed by the IPCC.

Figure 2: Estimates of the Probability Density Function for Equilibrium Climate Sensitivity (°C)



To show how the calibrated Roe and Baker distribution compares to different estimates of the probability distribution function of equilibrium climate sensitivity in the empirical literature, Figure 2 (below) overlays it on Figure 9.20 from the IPCC Fourth Assessment Report. These functions are scaled

to integrate to unity between 0 °C and 10 °C. The horizontal bars show the respective 5 percent to 95 percent ranges; dots indicate the median estimate.[12]

E. Socio-Economic and Emissions Trajectories

Another key issue considered by the interagency group is how to select the set of socio-economic and emissions parameters for use in PAGE, DICE, and FUND. Socio-economic pathways are closely tied to climate damages because, all else equal, more and wealthier people tend to emit more greenhouse gases and also have a higher (absolute) willingness to pay to avoid climate disruptions. For this reason, we consider how to model several input parameters in tandem: GDP, population, CO_2 emissions, and non-CO_2 radiative forcing. A wide variety of scenarios have been developed and used for climate change policy simulations (e.g., SRES 2000, CCSP 2007, EMF 2009). In determining which scenarios are appropriate for inclusion, we aimed to select scenarios that span most of the plausible ranges of outcomes for these variables.

To accomplish this task in a transparent way, we decided to rely on the recent Stanford Energy Modeling Forum exercise, EMF-22. EMF-22 uses ten well-recognized models to evaluate substantial, coordinated global action to meet specific stabilization targets. A key advantage of relying on these data is that GDP, population, and emission trajectories are internally consistent for each model and scenario evaluated. The EMF-22 modeling effort also is preferable to the IPCC SRES due to their age (SRES were developed in 1997) and the fact that 3 of 4 of the SRES scenarios are now extreme outliers in one or more variables. Although the EMF-22 scenarios have not undergone the same level of scrutiny as the SRES scenarios, they are recent, peer-reviewed, published, and publicly available.

To estimate the SCC for use in evaluating domestic policies that will have a small effect on global cumulative emissions, we use socio-economic and emission trajectories that span a range of plausible scenarios. Five trajectories were selected from EMF-22 (see Table 2 below). Four of these represent potential business-as-usual (BAU) growth in population, wealth, and emissions and are associated with CO_2 (only) concentrations ranging from 612 to 889 ppm in 2100. One represents an emissions pathway that achieves stabilization at 550 ppm CO_2e (i.e., CO_2-only concentrations of 425 – 484 ppm or a radiative forcing of 3.7 W/m^2) in 2100, a lower-than-BAU trajectory.[13] Out of the 10 models included in the EMF-22 exercise, we selected the trajectories used by MiniCAM, MESSAGE, IMAGE, and the optimistic scenario from MERGE. For the BAU pathways, we used the GDP, population, and emission trajectories from each of these four models. For the 550 ppm CO_2e scenario, we averaged the GDP, population, and emission trajectories implied by these same four models.

---

[12] The estimates based on instrumental data are from Andronova and Schlesinger (2001), Forest et al. (2002; dashed line, anthropogenic forcings only), Forest et al. (2006; solid line, anthropogenic and natural forcings), Gregory et al. (2002a), Knutti et al. (2002), Frame et al. (2005), and Forster and Gregory (2006). Hegerl et al. (2006) are based on multiple palaeoclimatic reconstructions of north hemisphere mean temperatures over the last 700 years. Also shown are the 5-95 percent approximate ranges for two estimates from the last glacial maximum (dashed, Annan et al. 2005; solid, Schneider von Deimling et al. 2006), which are based on models with different structural properties.

[13] Such an emissions path would be consistent with widespread action by countries to mitigate GHG emissions, though it could also result from technological advances. It was chosen because it represents the most stringent case analyzed by the EMF-22 where all the models converge: a 550 ppm, not to exceed, full participation scenario.

Table 2: Socioeconomic and Emissions Projections from Select EMF-22 Reference Scenarios

Reference Fossil and Industrial CO_2 Emissions ($GtCO_2$/yr)

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	26.6	31.9	36.9	40.0	45.3	60.1
MERGE Optimistic	24.6	31.5	37.6	45.1	66.5	117.9
MESSAGE	26.8	29.2	37.6	42.1	43.5	42.7
MiniCAM	26.5	31.8	38.0	45.1	57.8	80.5
550 ppm average	26.2	31.1	33.2	32.4	20.0	12.8

Reference GDP (using market exchange rates in trillion 2005$)[14]

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	38.6	53.0	73.5	97.2	156.3	396.6
MERGE Optimistic	36.3	45.9	59.7	76.8	122.7	268.0
MESSAGE	38.1	52.3	69.4	91.4	153.7	334.9
MiniCAM	36.1	47.4	60.8	78.9	125.7	369.5
550 ppm average	37.1	49.6	65.6	85.5	137.4	337.9

Global Population (billions)

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	6.1	6.9	7.6	8.2	9.0	9.1
MERGE Optimistic	6.0	6.8	7.5	8.2	9.0	9.7
MESSAGE	6.1	6.9	7.7	8.4	9.4	10.4
MiniCAM	6.0	6.8	7.5	8.1	8.8	8.7
550 ppm average	6.1	6.8	7.6	8.2	8.7	9.1

We explore how sensitive the SCC is to various assumptions about how the future will evolve without prejudging what is likely to occur. The interagency group considered formally assigning probability weights to different states of the world, but this proved challenging to do in an analytically rigorous way given the dearth of information on the likelihood of a full range of future socio-economic pathways.

There are a number of caveats. First, EMF BAU scenarios represent the modelers' judgment of the most likely pathway absent mitigation policies to reduce greenhouse gas emissions, rather than the wider range of possible outcomes. Nevertheless, these views of the most likely outcome span a wide range,

[14] While the EMF-22 models used market exchange rates (MER) to calculate global GDP, it is also possible to use purchasing power parity (PPP). PPP takes into account the different price levels across countries, so it more accurately describes relative standards of living across countries. MERs tend to make low-income countries appear poorer than they actually are. Because many models assume convergence in per capita income over time, use of MER-adjusted GDP gives rise to projections of higher economic growth in low income countries. There is an ongoing debate about how much this will affect estimated climate impacts. Critics of the use of MER argue that it leads to overstated economic growth and hence a significant upward bias in projections of greenhouse gas emissions, and unrealistically high future temperatures (e.g., Castles and Henderson 2003). Others argue that convergence of the emissions-intensity gap across countries at least partially offset the overstated income gap so that differences in exchange rates have less of an effect on emissions (Holtsmark and Alfsen, 2005; Tol, 2006). Nordhaus (2007b) argues that the ideal approach is to use superlative PPP accounts (i.e., using cross-sectional PPP measures for relative incomes and outputs and national accounts price and quantity indexes for time-series extrapolations). However, he notes that it important to keep this debate in perspective; it is by no means clear that exchange-rate-conversion issues are as important as uncertainties about population, technological change, or the many geophysical uncertainties.

from the more optimistic (e.g. abundant low-cost, low-carbon energy) to more pessimistic (e.g. constraints on the availability of nuclear and renewables).[15] Second, the socio-economic trajectories associated with a 550 ppm CO_2e concentration scenario are not derived from an assessment of what policy is optimal from a benefit-cost standpoint. Rather, it is indicative of one possible future outcome. The emission trajectories underlying some BAU scenarios (e.g. MESSAGE's 612 ppm) also are consistent with some modest policy action to address climate change.[16] We chose not to include socio-economic trajectories that achieve even lower GHG concentrations at this time, given the difficulty many models had in converging to meet these targets.

For comparison purposes, the Energy Information Agency in its 2009 Annual Energy Outlook projected that global carbon dioxide emissions will grow to 30.8, 35.6, and 40.4 gigatons in 2010, 2020, and 2030, respectively, while world GDP is projected to be $51.8, $71.0 and $93.9 trillion (in 2005 dollars using market exchange rates) in 2010, 2020, and 2030, respectively. These projections are consistent with one or more EMF-22 scenarios. Likewise, the United Nations' 2008 Population Prospect projects population will grow from 6.1 billion people in 2000 to 9.1 billion people in 2050, which is close to the population trajectories for the IMAGE, MiniCAM, and MERGE models.

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane, nitrous oxide, fluorinated greenhouse gases, and net land use CO_2 emissions out to 2100. These assumptions also are used in the three models while retaining the default radiative forcings due to other factors (e.g. aerosols and other gases). See the Appendix for greater detail.

F. Discount Rate

The choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law. Although it is well understood that the discount rate has a large influence on the current value of future damages, there is no consensus about what rates to use in this context. Because carbon dioxide emissions are long-lived, subsequent damages occur over many years. In calculating the SCC, we first estimate the future damages to agriculture, human health, and other market and non-market sectors from an additional unit of carbon dioxide emitted in a particular year in terms of reduced consumption (or consumption equivalents) due to the impacts of elevated temperatures, as represented in each of the three IAMs. Then we discount the stream of future damages to its present value in the year when the additional unit of emissions was released using the selected discount rate, which is intended to reflect society's marginal rate of substitution between consumption in different time periods.

For rules with both intra- and intergenerational effects, agencies traditionally employ constant discount rates of both 3 percent and 7 percent in accordance with OMB Circular A-4. As Circular A-4 acknowledges, however, the choice of discount rate for intergenerational problems raises distinctive

[15] For instance, in the MESSAGE model's reference case total primary energy production from nuclear, biomass, and non-biomass renewables is projected to increase from about 15 percent of total primary energy in 2000 to 54 percent in 2100. In comparison, the MiniCAM reference case shows 10 percent in 2000 and 21 percent in 2100.

[16] For example, MiniCAM projects if all non-US OECD countries reduce CO_2 emissions to 83 percent below 2005 levels by 2050 (per the G-8 agreement) but all other countries continue along a BAU path CO_2 concentrations in 2100 would drop from 794 ppmv in its reference case to 762 ppmv.

problems and presents considerable challenges. After reviewing those challenges, Circular A-4 states, "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent." For the specific purpose of developing the SCC, we adapt and revise that approach here.

Arrow et al. (1996) outlined two main approaches to determine the discount rate for climate change analysis, which they labeled "descriptive" and "prescriptive." The descriptive approach reflects a positive (non-normative) perspective based on observations of people's actual choices—e.g., savings versus consumption decisions over time, and allocations of savings among more and less risky investments. Advocates of this approach generally call for inferring the discount rate from market rates of return "because of a lack of justification for choosing a social welfare function that is any different than what decision makers [individuals] actually use" (Arrow et al. 1996).

One theoretical foundation for the cost-benefit analyses in which the social cost of carbon will be used—the Kaldor-Hicks potential-compensation test—also suggests that market rates should be used to discount future benefits and costs, because it is the market interest rate that would govern the returns potentially set aside today to compensate future individuals for climate damages that they bear (e.g., Just et al. 2004). As some have noted, the word "potentially" is an important qualification; there is no assurance that such returns will actually be set aside to provide compensation, and the very idea of compensation is difficult to define in the intergenerational context. On the other hand, societies provide compensation to future generations through investments in human capital and the resulting increase in knowledge, as well as infrastructure and other physical capital.

The prescriptive approach specifies a social welfare function that formalizes the normative judgments that the decision-maker wants explicitly to incorporate into the policy evaluation—e.g., how inter-personal comparisons of utility should be made, and how the welfare of future generations should be weighed against that of the present generation. Ramsey (1928), for example, has argued that it is "ethically indefensible" to apply a positive pure rate of time preference to discount values across generations, and many agree with this view.

Other concerns also motivate making adjustments to descriptive discount rates. In particular, it has been noted that the preferences of future generations with regard to consumption versus environmental amenities may not be the same as those today, making the current market rate on consumption an inappropriate metric by which to discount future climate-related damages. Others argue that the discount rate should be below market rates to correct for market distortions and uncertainties or inefficiencies in intergenerational transfers of wealth, which in the Kaldor-Hicks logic are presumed to compensate future generations for damage (a potentially controversial assumption, as noted above) (Arrow et al. 1996, Weitzman 1999).

Further, a legitimate concern about both descriptive and prescriptive approaches is that they tend to obscure important heterogeneity in the population. The utility function that underlies the prescriptive approach assumes a representative agent with perfect foresight and no credit constraints. This is an artificial rendering of the real world that misses many of the frictions that characterize individuals' lives

and indeed the available descriptive evidence supports this. For instance, many individuals smooth consumption by borrowing with credit cards that have relatively high rates. Some are unable to access traditional credit markets and rely on payday lending operations or other high cost forms of smoothing consumption. Whether one puts greater weight on the prescriptive or descriptive approach, the high interest rates that credit-constrained individuals accept suggest that some account should be given to the discount rates revealed by their behavior.

We draw on both approaches but rely primarily on the descriptive approach to inform the choice of discount rate. With recognition of its limitations, we find this approach to be the most defensible and transparent given its consistency with the standard contemporary theoretical foundations of benefit-cost analysis and with the approach required by OMB's existing guidance. The logic of this framework also suggests that market rates should be used for discounting future consumption-equivalent damages. Regardless of the theoretical approach used to derive the appropriate discount rate(s), we note the inherent conceptual and practical difficulties of adequately capturing consumption trade-offs over many decades or even centuries. While relying primarily on the descriptive approach in selecting specific discount rates, the interagency group has been keenly aware of the deeply normative dimensions of both the debate over discounting in the intergenerational context and the consequences of selecting one discount rate over another.

Historically Observed Interest Rates

In a market with no distortions, the return to savings would equal the private return on investment, and the market rate of interest would be the appropriate choice for the social discount rate. In the real world risk, taxes, and other market imperfections drive a wedge between the risk-free rate of return on capital and the consumption rate of interest. Thus, the literature recognizes two conceptual discount concepts—the consumption rate of interest and the opportunity cost of capital.

According to OMB's Circular A-4, it is appropriate to use the rate of return on capital when a regulation is expected to displace or alter the use of capital in the private sector. In this case, OMB recommends Agencies use a discount rate of 7 percent. When regulation is expected to primarily affect private consumption—for instance, via higher prices for goods and services—a lower discount rate of 3 percent is appropriate to reflect how private individuals trade-off current and future consumption.

The interagency group examined the economics literature and concluded that the consumption rate of interest is the correct concept to use in evaluating the benefits and costs of a marginal change in carbon emissions (see Lind 1990, Arrow et al 1996, and Arrow 2000). The consumption rate of interest also is appropriate when the impacts of a regulation are measured in consumption (-equivalent) units, as is done in the three integrated assessment models used for estimating the SCC.

Individuals use a variety of savings instruments that vary with risk level, time horizon, and tax characteristics. The standard analytic framework used to develop intuition about the discount rate typically assumes a representative agent with perfect foresight and no credit constraints. The risk-free rate is appropriate for discounting certain future benefits or costs, but the benefits calculated by IAMs are uncertain. To use the risk-free rate to discount uncertain benefits, these benefits first must be

transformed into "certainty equivalents," that is the maximum certain amount that we would exchange for the uncertain amount. However, the calculation of the certainty-equivalent requires first estimating the correlation between the benefits of the policy and baseline consumption.

If the IAM projections of future impacts represent expected values (not certainty-equivalent values), then the appropriate discount rate generally does not equal the risk-free rate. If the benefits of the policy tend to be high in those states of the world in which consumption is low, then the certainty-equivalent benefits will be higher than the expected benefits (and vice versa). Since many (though not necessarily all) of the important impacts of climate change will flow through market sectors such as agriculture and energy, and since willingness to pay for environmental protections typically increases with income, we might expect a positive (though not necessarily perfect) correlation between the net benefits from climate policies and market returns. This line of reasoning suggests that the proper discount rate would exceed the riskless rate. Alternatively, a negative correlation between the returns to climate policies and market returns would imply that a discount rate below the riskless rate is appropriate.

This discussion suggests that both the post-tax riskless and risky rates can be used to capture individuals' consumption-equivalent interest rate. As a measure of the post-tax riskless rate, we calculate the average real return from Treasury notes over the longest time period available (those from Newell and Pizer 2003) and adjust for Federal taxes (the average marginal rate from tax years 2003 through 2006 is around 27 percent).[17] This calculation produces a real interest rate of about 2.7 percent, which is roughly consistent with Circular A-4's recommendation to use 3 percent to represent the consumption rate of interest.[18] A measure of the post-tax risky rate for investments whose returns are positively correlated with overall equity market returns can be obtained by adjusting pre-tax rates of household returns to risky investments (approximately 7 percent) for taxes yields a real rate of roughly 5 percent.[19]

The Ramsey Equation

Ramsey discounting also provides a useful framework to inform the choice of a discount rate. Under this approach, the analyst applies either positive or normative judgments in selecting values for the key parameters of the Ramsey equation: η (coefficient of relative risk aversion or elasticity of the marginal utility of consumption) and ρ (pure rate of time preference).[20] These are then combined with g (growth

[17] The literature argues for a risk-free rate on government bonds as an appropriate measure of the consumption rate of interest. Arrow (2000) suggests that it is roughly 3-4 percent. OMB cites evidence of a 3.1 percent pre-tax rate for 10-year Treasury notes in the A-4 guidance. Newell and Pizer (2003) find real interest rates between 3.5 and 4 percent for 30-year Treasury securities.

[18] The positive approach reflects how individuals make allocation choices across time, but it is important to keep in mind that we wish to reflect preferences for society as a whole, which generally has a longer planning horizon.

[19] Cambell et al (2001) estimates that the annual real return from stocks for 1900-1995 was about 7 percent. The annual real rate of return for the S&P 500 from 1950 – 2008 was about 6.8 percent. In the absence of a better way to population-weight the tax rates, we use the middle of the 20 – 40 percent range to derive a post-tax interest rate (Kotlikoff and Rapson 2006).

[20] The parameter ρ measures the *pure rate of time preference*: people's behavior reveals a preference for an increase in utility today versus the future. Consequently, it is standard to place a lower weight on utility in the future. The parameter η captures *diminishing marginal utility*: consumption in the future is likely to be higher than consumption today, so diminishing marginal utility of consumption implies that the same monetary damage will

rate of per-capita consumption) to equal the interest rate at which future monetized damages are discounted: $\rho + \eta \cdot g$.[21] In the simplest version of the Ramsey model, with an optimizing representative agent with perfect foresight, what we are calling the "Ramsey discount rate," $\rho + \eta \cdot g$, will be equal to the rate of return to capital, i.e., the market interest rate.

A review of the literature provides some guidance on reasonable parameter values for the Ramsey discounting equation, based on both prescriptive and descriptive approaches.

- η. Most papers in the climate change literature adopt values for η in the range of 0.5 to 3 (Weitzman cites plausible values as those ranging from 1 to 4), although not all authors articulate whether their choice is based on prescriptive or descriptive reasoning.[22] Dasgupta (2008) argues that η should be greater than 1 and may be as high as 3, since η equal to 1 suggests savings rates that do not conform to observed behavior.

- ρ. With respect to the pure rate of time preference, most papers in the climate change literature adopt values for ρ in the range of 0 to 3 percent per year. The very low rates tend to follow from moral judgments involving intergenerational neutrality. Some have argued that to use any value other than $\rho = 0$ would unjustly discriminate against future generations (e.g., Arrow et al. 1996, Stern et al. 2006). However, even in an inter-generational setting, it may make sense to use a small positive pure rate of time preference because of the small probability of unforeseen cataclysmic events (Stern et al. 2006).

- g. A commonly accepted approximation is around 2 percent per year. For the socio-economic scenarios used for this exercise, the EMF models assume that g is about 1.5-2 percent to 2100.

Some economists and non-economists have argued for constant discount rates below 2 percent based on the prescriptive approach. When grounded in the Ramsey framework, proponents of this approach have argued that a ρ of zero avoids giving preferential treatment to one generation over another. The choice of η has also been posed as an ethical choice linked to the value of an additional dollar in poorer

---

cause a smaller reduction of utility for wealthier individuals, either in the future or in current generations. If $\eta = 0$, then a one dollar increase in income is equally valuable regardless of level of income; if $\eta = 1$, then a one percent increase in income is equally valuable no matter the level of income; and if $\eta > 1$, then a one percent increase in income is less valuable to wealthier individuals.

[21] In this case, g could be taken from the selected EMF socioeconomic scenarios or alternative assumptions about the rate of consumption growth.

[22] Empirical estimates of η span a wide range of values. A benchmark value of 2 is near the middle of the range of values estimated or used by Szpiro (1986), Hall and Jones (2007), Arrow (2007), Dasgupta (2006, 2008), Weitzman (2007, 2009), and Nordhaus (2008). However, Chetty (2006) developed a method of estimating η using data on labor supply behavior. He shows that existing evidence of the effects of wage changes on labor supply imposes a tight upper bound on the curvature of utility over wealth (CRRA < 2) with the mean implied value of 0.71 and concludes that the standard expected utility model cannot generate high levels of risk aversion without contradicting established facts about labor supply. Recent work has jointly estimated the components of the Ramsey equation. Evans and Sezer (2005) estimate $\eta = 1.49$ for 22 OECD countries. They also estimate $\rho = 1.08$ percent per year using data on mortality rates. Anthoff, et al. (2009b) estimate $\eta = 1.18$, and $\rho = 1.4$ percent. When they multiply the bivariate probability distributions from their work and Evans and Sezer (2005) together, they find $\eta = 1.47$, and $\rho = 1.07$.

countries compared to wealthier ones. Stern et al. (2006) applies this perspective through his choice of ρ = 0.1 percent per year, η = 1 and g = 1.3 percent per year, which yields an annual discount rate of 1.4 percent. In the context of permanent income savings behavior, however, Stern's assumptions suggest that individuals would save 93 percent of their income.[23]

Recently, Stern (2008) revisited the values used in Stern et al. (2006), stating that there is a case to be made for raising η due to the amount of weight lower values place on damages far in the future (over 90 percent of expected damages occur after 2200 with η = 1). Using Stern's assumption that ρ = 0.1 percent, combined with a η of 1.5 to 2 and his original growth rate, yields a discount rate greater 2 percent.

We conclude that arguments made under the prescriptive approach can be used to justify discount rates between roughly 1.4 and 3.1 percent. In light of concerns about the most appropriate value for η, we find it difficult to justify rates at the lower end of this range under the Ramsey framework.

Accounting for Uncertainty in the Discount Rate

While the consumption rate of interest is an important driver of the benefits estimate, it is uncertain over time. Ideally, we would formally model this uncertainty, just as we do for climate sensitivity. Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2006) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term (see Weitzman 1998, 1999, 2001; Newell and Pizer 2003; Groom et al. 2006; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2009).

The proper way to model discount rate uncertainty remains an active area of research. Newell and Pizer (2003) employ a model of how long-term interest rates change over time to forecast future discount rates. Their model incorporates some of the basic features of how interest rates move over time, and its parameters are estimated based on historical observations of long-term rates. Subsequent work on this topic, most notably Groom et al. (2006), uses more general models of interest rate dynamics to allow for better forecasts. Specifically, the volatility of interest rates depends on whether rates are currently low or high and variation in the level of persistence over time.

While Newell and Pizer (2003) and Groom et al (2006) attempt formally to model uncertainty in the discount rate, others argue for a declining scale of discount rates applied over time (e.g., Weitzman 2001, and the UK's "Green Book" for regulatory analysis). This approach uses a higher discount rate

[23] Stern (2008) argues that building in a positive rate of exogenous technical change over time reduces the implied savings rate and that η at or above 2 are inconsistent with observed behavior with regard to equity. (At the same time, adding exogenous technical change—all else equal—would increase g as well.)

initially, but applies a graduated scale of lower discount rates further out in time.[24] A key question that has emerged with regard to both of these approaches is the trade-off between potential time inconsistency and giving greater weight to far future outcomes (see the EPA Science Advisory Board's recent comments on this topic as part of its review of their *Guidelines for Economic Analysis*).[25]

The Discount Rates Selected for Estimating SCC

In light of disagreement in the literature on the appropriate market interest rate to use in this context and uncertainty about how interest rates may change over time, we use three discount rates to span a plausible range of certainty-equivalent constant discount rates: 2.5, 3, and 5 percent per year. Based on the review in the previous sections, the interagency workgroup determined that these three rates reflect reasonable judgments under both descriptive and prescriptive approaches.

The central value, 3 percent, is consistent with estimates provided in the economics literature and OMB's Circular A-4 guidance for the consumption rate of interest. As previously mentioned, the consumption rate of interest is the correct discounting concept to use when future damages from elevated temperatures are estimated in consumption-equivalent units. Further, 3 percent roughly corresponds to the after-tax riskless interest rate. The upper value of 5 percent is included to represent the possibility that climate damages are positively correlated with market returns. Additionally, this discount rate may be justified by the high interest rates that many consumers use to smooth consumption across periods.

The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach.[26] Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.

[24] For instance, the UK applies a discount rate of 3.5 percent to the first 30 years; 3 percent for years 31 - 75; 2.5 percent for years 76 - 125; 2 percent for years 126 - 200; 1.5 percent for years 201 - 300; and 1 percent after 300 years. As a sensitivity, it recommends a discount rate of 3 percent for the first 30 years, also decreasing over time.

[25] Uncertainty in future damages is distinct from uncertainty in the discount rate. Weitzman (2008) argues that Stern's choice of a low discount rate was "right for the wrong reasons." He demonstrates how the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. Newbold and Daigneault, (2009) and Nordhaus (2009) find that Weitzman's result is sensitive to the functional forms chosen for climate sensitivity, utility, and consumption. Summers and Zeckhauser (2008) argue that uncertainty in future damages can also work in the other direction by increasing the benefits of waiting to learn the appropriate level of mitigation required.

[26] Calculations done by Pizer et al. using the original simulation program from Newell and Pizer (2003).

IV. Revised SCC Estimates

Our general approach to estimating SCC values is to run the three integrated assessment models (FUND, DICE, and PAGE) using the following inputs agreed upon by the interagency group:

- A Roe and Baker distribution for the climate sensitivity parameter bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.
- Five sets of GDP, population and carbon emissions trajectories based on EMF-22.
- Constant annual discount rates of 2.5, 3, and 5 percent.

Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SCC in year *t*.

For each of the IAMS, the basic computational steps for calculating the SCC in a particular year *t* are:

1. Input the path of emissions, GDP, and population from the selected EMF-22 scenarios, and the extrapolations based on these scenarios for post-2100 years.

2. Calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions.

    a. In PAGE, the consumption-equivalent damages in each period are calculated as a fraction of the EMF GDP forecast, depending on the temperature in that period relative to the pre-industrial average temperature in each region.
    b. In FUND, damages in each period depend on both the level and the rate of temperature change in that period.
    c. In DICE, temperature affects both consumption and investment, so we first adjust the EMF GDP paths as follows: Using the Cobb-Douglas production function with the DICE2007 parameters, we extract the path of exogenous technical change implied by the EMF GDP and population paths, then we recalculate the baseline GDP path taking into account climate damages resulting from the baseline emissions path.

3. Add an additional unit of carbon emissions in year *t.* (The exact unit varies by model.)

4. Recalculate the temperature effects and damages expected in all years beyond *t* resulting from this adjusted path of emissions, as in step 2.

5. Subtract the damages computed in step 2 from those in step 4 in each year. (DICE is run in 10 year time steps, FUND in annual time steps, while the time steps in PAGE vary.)

6. Discount the resulting path of marginal damages back to the year of emissions using the agreed upon fixed discount rates.

7. Calculate the SCC as the net present value of the discounted path of damages computed in step 6, divided by the unit of carbon emissions used to shock the models in step 3.

8. Multiply by 12/44 to convert from dollars per ton of carbon to dollars per ton of CO_2 (2007 dollars) in DICE and FUND. (All calculations are done in tons of CO_2 in PAGE).

The steps above were repeated in each model for multiple future years to cover the time horizons anticipated for upcoming rulemaking analysis. To maintain consistency across the three IAMs, climate damages are calculated as lost consumption in each future year.

It is important to note that each of the three models has a different default end year. The default time horizon is 2200 for PAGE, 2595 for DICE, and 3000 for the latest version of FUND. This is an issue for the multi-model approach because differences in SCC estimates may arise simply due to the model time horizon. Many consider 2200 too short a time horizon because it could miss a significant fraction of damages under certain assumptions about the growth of marginal damages and discounting, so each model is run here through 2300. This step required a small adjustment in the PAGE model only. This step also required assumptions about GDP, population, and greenhouse gas emission trajectories after 2100, the last year for which these data are available from the EMF-22 models. (A more detailed discussion of these assumptions is included in the Appendix.)

This exercise produces 45 separate distributions of the SCC for a given year, the product of 3 models, 3 discount rates, and 5 socioeconomic scenarios. This is clearly too many separate distributions for consideration in a regulatory impact analysis.

To produce a range of plausible estimates that still reflects the uncertainty in the estimation exercise, the distributions from each of the models and scenarios are equally weighed and combined to produce three separate probability distributions for SCC in a given year, one for each assumed discount rate. These distributions are then used to define a range of point estimates for the global SCC. In this way, no integrated assessment model or socioeconomic scenario is given greater weight than another. Because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context, we present SCCs based on the average values across models and socioeconomic scenarios for each discount rate.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC across models and socio-economic and emissions scenarios at the 2.5, 3, and 5 percent discount rates. The fourth value is included to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. (The full set of distributions by model and scenario combination is included in the Appendix.) As noted above, the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range.

As previously discussed, low probability, high impact events are incorporated into the SCC values through explicit consideration of their effects in two of the three models as well as the use of a probability density function for equilibrium climate sensitivity. Treating climate sensitivity probabilistically results in more high temperature outcomes, which in turn lead to higher projections of damages. Although FUND does not include catastrophic damages (in contrast to the other two models), its probabilistic treatment of the equilibrium climate sensitivity parameter will directly affect the non-catastrophic damages that are a function of the rate of temperature change.

In Table 3, we begin by presenting SCC estimates for 2010 by model, scenario, and discount rate to illustrate the variability in the SCC across each of these input parameters. As expected, higher discount rates consistently result in lower SCC values, while lower discount rates result in higher SCC values for each socioeconomic trajectory. It is also evident that there are differences in the SCC estimated across the three main models. For these estimates, FUND produces the lowest estimates, while PAGE generally produces the highest estimates.

Table 3: Disaggregated Social Cost of CO_2 Values by Model, Socio-Economic Trajectory, and Discount Rate for 2010 (in 2007 dollars)

	Discount rate:	**5%**	**3%**	**2.5%**	**3%**
Model	*Scenario*	Avg	Avg	Avg	95th
DICE	IMAGE	10.8	35.8	54.2	70.8
	MERGE	7.5	22.0	31.6	42.1
	Message	9.8	29.8	43.5	58.6
	MiniCAM	8.6	28.8	44.4	57.9
	550 Average	8.2	24.9	37.4	50.8
PAGE	IMAGE	8.3	39.5	65.5	142.4
	MERGE	5.2	22.3	34.6	82.4
	Message	7.2	30.3	49.2	115.6
	MiniCAM	6.4	31.8	54.7	115.4
	550 Average	5.5	25.4	42.9	104.7
FUND	IMAGE	-1.3	8.2	19.3	39.7
	MERGE	-0.3	8.0	14.8	41.3
	Message	-1.9	3.6	8.8	32.1
	MiniCAM	-0.6	10.2	22.2	42.6
	550 Average	-2.7	-0.2	3.0	19.4

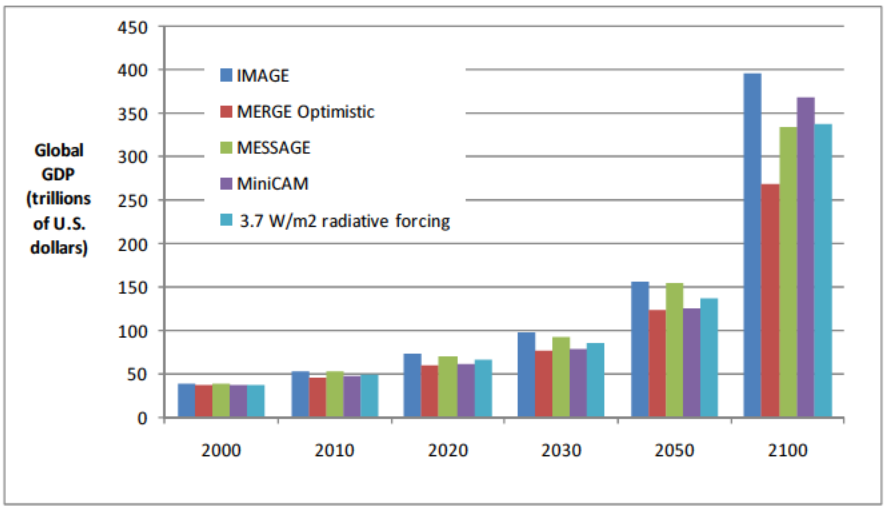
These results are not surprising when compared to the estimates in the literature for the latest versions of each model. For example, adjusting the values from the literature that were used to develop interim

SCC values to 2007 dollars for the year 2010 (assuming, as we did for the interim process, that SCC grows at 3 percent per year), FUND yields SCC estimates at or near zero for a 5 percent discount rate and around $9 per ton for a 3 percent discount rate. There are far fewer estimates using the latest versions of DICE and PAGE in the literature: Using similar adjustments to generate 2010 estimates, we calculate a SCC from DICE (based on Nordhaus 2008) of around $9 per ton for a 5 percent discount rate, and a SCC from PAGE (based on Hope 2006, 2008) close to $8 per ton for a 4 percent discount rate. Note that these comparisons are only approximate since the literature generally relies on Ramsey discounting, while we have assumed constant discount rates.[27]

The SCC estimates from FUND are sensitive to differences in emissions paths but relatively insensitive to differences in GDP paths across scenarios, while the reverse is true for DICE and PAGE. This likely occurs because of several structural differences among the models. Specifically in DICE and PAGE, the fraction of economic output lost due to climate damages increases with the level of temperature alone, whereas in FUND the fractional loss also increases with the rate of temperature change. Furthermore, in FUND increases in income over time decrease vulnerability to climate change (a form of adaptation), whereas this does not occur in DICE and PAGE. These structural differences among the models make FUND more sensitive to the path of emissions and less sensitive to GDP compared to DICE and PAGE.

Figure 3 shows that IMAGE has the highest GDP in 2100 while MERGE Optimistic has the lowest. The ordering of global GDP levels in 2100 directly corresponds to the rank ordering of SCC for PAGE and DICE. For FUND, the correspondence is less clear, a result that is to be expected given its less direct relationship between its damage function and GDP.

Figure 3: Level of Global GDP across EMF Scenarios



[27] Nordhaus (2008) runs DICE2007 with ρ = 1.5 and η = 2. The default approach in PAGE2002 (version 1.4epm) treats ρ and η as random parameters, specified using a triangular distribution such that the min, mode, and max = 0.1, 1, and 2 for ρ, and 0.5, 1, and 2 for η, respectively. The FUND default value for η is 1, and Tol generates SCC estimates for values of ρ = 0, 1, and 3 in many recent papers (e.g. Anthoff et al. 2009). The path of per-capita consumption growth, g, varies over time but is treated deterministically in two of the three models. In DICE, g is endogenous. Under Ramsey discounting, as economic growth slows in the future, the large damages from climate change that occur far out in the future are discounted at a lower rate than impacts that occur in the nearer term.

Table 4 shows the four selected SCC values in five year increments from 2010 to 2050. Values for 2010, 2020, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using a simple linear interpolation.

Table 4: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that this approach allows us to estimate the growth rate of the SCC directly using DICE, PAGE, and FUND rather than assuming a constant annual growth rate as was done for the interim estimates (using 3 percent). This helps to ensure that the estimates are internally consistent with other modeling assumptions. Table 5 illustrates how the growth rate for these four SCC estimates varies over time. The full set of annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 5: Changes in the Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth	**5%**	**3%**	**2.5%**	**3.0%**
Rate (%)	Avg	Avg	Avg	95th
2010-2020	3.6%	2.1%	1.7%	2.2%
2020-2030	3.7%	2.2%	1.8%	2.2%
2030-2040	2.7%	1.8%	1.6%	1.8%
2040-2050	2.1%	1.4%	1.1%	1.3%

While the SCC estimate grows over time, the future monetized value of emissions reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. Damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency—i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate. For example,

climate damages in the year 2020 that are calculated using a SCC based on a 5 percent discount rate also should be discounted back to the analysis year using a 5 percent discount rate.[28]

V. Limitations of the Analysis

As noted, any estimate of the SCC must be taken as provisional and subject to further refinement (and possibly significant change) in accordance with evolving scientific, economic, and ethical understandings. During the course of our modeling, it became apparent that there are several areas in particular need of additional exploration and research. These caveats, and additional observations in the following section, are necessary to consider when interpreting and applying the SCC estimates.

Incomplete treatment of non-catastrophic damages. The impacts of climate change are expected to be widespread, diverse, and heterogeneous. In addition, the exact magnitude of these impacts is uncertain because of the inherent complexity of climate processes, the economic behavior of current and future populations, and our inability to accurately forecast technological change and adaptation. Current IAMs do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature (some of which are discussed above) because of lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. Our ability to quantify and monetize impacts will undoubtedly improve with time. But it is also likely that even in future applications, a number of potentially significant damage categories will remain non-monetized. (Ocean acidification is one example of a potentially large damage from CO_2 emissions not quantified by any of the three models. Species and wildlife loss is another example that is exceedingly difficult to monetize.)

Incomplete treatment of potential catastrophic damages. There has been considerable recent discussion of the risk of catastrophic impacts and how best to account for extreme scenarios, such as the collapse of the Atlantic Meridional Overturning Circulation or the West Antarctic Ice Sheet, or large releases of methane from melting permafrost and warming oceans. Weitzman (2009) suggests that catastrophic damages are extremely large—so large, in fact, that the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. However, Nordhaus (2009) concluded that the conditions under which Weitzman's results hold "are limited and do not apply to a wide range of potential uncertain scenarios."

Using a simplified IAM, Newbold and Daigneault (2009) confirmed the potential for large catastrophe risk premiums but also showed that the aggregate benefit estimates can be highly sensitive to the shapes of both the climate sensitivity distribution and the damage function at high temperature changes. Pindyck (2009) also used a simplified IAM to examine high-impact low-probability risks, using a right-skewed gamma distribution for climate sensitivity as well as an uncertain damage coefficient, but in most cases found only a modest risk premium. Given this difference in opinion, further research in this area is needed before its practical significance can be fully understood and a reasonable approach developed to account for such risks in regulatory analysis. (The next section discusses the scientific evidence on catastrophic impacts in greater detail.)

[28] However, it is possible that other benefits or costs of proposed regulations unrelated to CO_2 emissions will be discounted at rates that differ from those used to develop the SCC estimates.

Uncertainty in extrapolation of damages to high temperatures: The damage functions in these IAMs are typically calibrated by estimating damages at moderate temperature increases (e.g., DICE was calibrated at 2.5 °C) and extrapolated to far higher temperatures by assuming that damages increase as some power of the temperature change. Hence, estimated damages are far more uncertain under more extreme climate change scenarios.

Incomplete treatment of adaptation and technological change: Each of the three integrated assessment models used here assumes a certain degree of low- or no-cost adaptation. For instance, Tol assumes a great deal of adaptation in FUND, including widespread reliance on air conditioning ; so much so, that the largest single benefit category in FUND is the reduced electricity costs from not having to run air conditioning as intensively (NRC 2009).

Climate change also will increase returns on investment to develop technologies that allow individuals to cope with adverse climate conditions, and IAMs to do not adequately account for this directed technological change.[29] For example, scientists may develop crops that are better able to withstand higher and more variable temperatures. Although DICE and FUND have both calibrated their agricultural sectors under the assumption that farmers will change land use practices in response to climate change (Mastrandrea, 2009), they do not take into account technological changes that lower the cost of this adaptation over time. On the other hand, the calibrations do not account for increases in climate variability, pests, or diseases, which could make adaptation more difficult than assumed by the IAMs for a given temperature change. Hence, models do not adequately account for potential adaptation or technical change that might alter the emissions pathway and resulting damages. In this respect, it is difficult to determine whether the incomplete treatment of adaptation and technological change in these IAMs under or overstate the likely damages.

Risk aversion: A key question unanswered during this interagency process is what to assume about relative risk aversion with regard to high-impact outcomes. These calculations do not take into account the possibility that individuals may have a higher willingness to pay to reduce the likelihood of low-probability, high-impact damages than they do to reduce the likelihood of higher-probability but lower-impact damages with the same expected cost. (The inclusion of the 95th percentile estimate in the final set of SCC values was largely motivated by this concern.) If individuals do show such a higher willingness to pay, a further question is whether that fact should be taken into account for regulatory policy. Even if individuals are not risk-averse for such scenarios, it is possible that regulatory policy should include a degree of risk-aversion.

Assuming a risk-neutral representative agent is consistent with OMB's Circular A-4, which advises that the estimates of benefits and costs used in regulatory analysis are usually based on the average or the expected value and that "emphasis on these expected values is appropriate as long as society is 'risk neutral' with respect to the regulatory alternatives. While this may not always be the case, [analysts] should in general assume 'risk neutrality' in [their] analysis."

Nordhaus (2008) points to the need to explore the relationship between risk and income in the context of climate change across models and to explore the role of uncertainty regarding various parameters in

[29] However these research dollars will be diverted from whatever their next best use would have been in the absence of climate change (so productivity/GDP would have been still higher).

the results. Using FUND, Anthoff et al (2009) explored the sensitivity of the SCC to Ramsey equation parameter assumptions based on observed behavior. They conclude that "the assumed rate of risk aversion is at least as important as the assumed rate of time preference in determining the social cost of carbon." Since Circular A-4 allows for a different assumption on risk preference in regulatory analysis if it is adequately justified, we plan to continue investigating this issue.

V. A Further Discussion of Catastrophic Impacts and Damage Functions

As noted above, the damage functions underlying the three IAMs used to estimate the SCC may not capture the economic effects of all possible adverse consequences of climate change and may therefore lead to underestimates of the SCC (Mastrandrea 2009). In particular, the models' functional forms may not adequately capture: (1) potentially discontinuous "tipping point" behavior in Earth systems, (2) inter-sectoral and inter-regional interactions, including global security impacts of high-end warming, and (3) limited near-term substitutability between damage to natural systems and increased consumption.

It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. In the meantime, we discuss some of the available evidence.

Extrapolation of climate damages to high levels of warming

The damage functions in the models are calibrated at moderate levels of warming and should therefore be viewed cautiously when extrapolated to the high temperatures found in the upper end of the distribution. Recent science suggests that there are a number of potential climatic "tipping points" at which the Earth system may exhibit discontinuous behavior with potentially severe social and economic consequences (e.g., Lenton et al, 2008, Kriegler et al., 2009). These tipping points include the disruption of the Indian Summer Monsoon, dieback of the Amazon Rainforest and boreal forests, collapse of the Greenland Ice Sheet and the West Antarctic Ice Sheet, reorganization of the Atlantic Meridional Overturning Circulation, strengthening of El Niño-Southern Oscillation, and the release of methane from melting permafrost. Many of these tipping points are estimated to have thresholds between about 3 °C and 5 °C (Lenton et al., 2008). Probabilities of several of these tipping points were assessed through expert elicitation in 2005–2006 by Kriegler et al. (2009); results from this study are highlighted in Table 6. Ranges of probability are averaged across core experts on each topic.

As previously mentioned, FUND does not include potentially catastrophic effects. DICE assumes a small probability of catastrophic damages that increases with increased warming, but the damages from these risks are incorporated as expected values (i.e., ignoring potential risk aversion). PAGE models catastrophic impacts in a probabilistic framework (see Figure 1), so the high-end output from PAGE potentially offers the best insight into the SCC if the world were to experience catastrophic climate change. For instance, at the 95th percentile and a 3 percent discount rate, the SCC estimated by PAGE across the five socio-economic and emission trajectories of $113 per ton of CO_2 is almost double the value estimated by DICE, $58 per ton in 2010. We cannot evaluate how well the three models account for catastrophic or non-catastrophic impacts, but this estimate highlights the sensitivity of SCC values in the tails of the distribution to the assumptions made about catastrophic impacts.

Table 6: Probabilities of Various Tipping Points from Expert Elicitation

Possible Tipping Points	Duration before effect is fully realized (in years)	Additional Warming by 2100		
		0.5-1.5 C	1.5-3.0 C	3-5 C
Reorganization of Atlantic Meridional Overturning Circulation	about 100	0-18%	6-39%	18-67%
Greenland Ice Sheet collapse	at least 300	8-39%	33-73%	67-96%
West Antarctic Ice Sheet collapse	at least 300	5-41%	10-63%	33-88%
Dieback of Amazon rainforest	about 50	2-46%	14-84%	41-94%
Strengthening of El Niño-Southern Oscillation	about 100	1-13%	6-32%	19-49%
Dieback of boreal forests	about 50	13-43%	20-81%	34-91%
Shift in Indian Summer Monsoon	about 1	Not formally assessed		
Release of methane from melting permafrost	Less than 100	Not formally assessed.		

PAGE treats the possibility of a catastrophic event probabilistically, while DICE treats it deterministically (that is, by adding the expected value of the damage from a catastrophe to the aggregate damage function). In part, this results in different probabilities being assigned to a catastrophic event across the two models. For instance, PAGE places a probability near zero on a catastrophe at 2.5 °C warming, while DICE assumes a 4 percent probability of a catastrophe at 2.5 °C. By comparison, Kriegler et al. (2009) estimate a probability of at least 16-36 percent of crossing at least one of their primary climatic tipping points in a scenario with temperatures about 2-4 °C warmer than pre-Industrial levels in 2100.

It is important to note that crossing a climatic tipping point will not necessarily lead to an economic catastrophe in the sense used in the IAMs. A tipping point is a critical threshold across which some aspect of the Earth system starts to shifts into a qualitatively different state (for instance, one with dramatically reduced ice sheet volumes and higher sea levels). In the IAMs, a catastrophe is a low-probability environmental change with high economic impact.

Failure to incorporate inter-sectoral and inter-regional interactions

The damage functions do not fully incorporate either inter-sectoral or inter-regional interactions. For instance, while damages to the agricultural sector are incorporated, the effects of changes in food supply on human health are not fully captured and depend on the modeler's choice of studies used to calibrate the IAM. Likewise, the effects of climate damages in one region of the world on another region are not included in some of the models (FUND includes the effects of migration from sea level rise). These inter-regional interactions, though difficult to quantify, are the basis for climate-induced national and economic security concerns (e.g., Campbell et al., 2007; U.S. Department of Defense 2010) and are particularly worrisome at higher levels of warming. High-end warming scenarios, for instance, project water scarcity affecting 4.3-6.9 billion people by 2050, food scarcity affecting about 120 million

additional people by 2080, and the creation of millions of climate refugees (Easterling et al., 2007; Campbell et al., 2007).

Imperfect substitutability of environmental amenities

Data from the geological record of past climate changes suggests that 6 °C of warming may have severe consequences for natural systems. For instance, during the Paleocene-Eocene Thermal Maximum about 55.5 million years ago, when the Earth experienced a geologically rapid release of carbon associated with an approximately 5 °C increase in global mean temperatures, the effects included shifts of about 400-900 miles in the range of plants (Wing et al., 2005), and dwarfing of both land mammals (Gingerich, 2006) and soil fauna (Smith et al., 2009).

The three IAMs used here assume that it is possible to compensate for the economic consequences of damages to natural systems through increased consumption of non-climate goods, a common assumption in many economic models. In the context of climate change, however, it is possible that the damages to natural systems could become so great that no increase in consumption of non-climate goods would provide complete compensation (Levy et al., 2005). For instance, as water supplies become scarcer or ecosystems become more fragile and less bio-diverse, the services they provide may become increasingly more costly to replace. Uncalibrated attempts to incorporate the imperfect substitutability of such amenities into IAMs (Sterner and Persson, 2008) indicate that the optimal degree of emissions abatement can be considerably greater than is commonly recognized.

VI. Conclusion

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020.

We noted a number of limitations to this analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. The limited amount of research linking climate impacts to economic damages makes this modeling exercise even more difficult. It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling.

References

Andronova, N., and M. Schlesinger. 2001. "Objective estimation of the probability density function for climate sensitivity." *J. Geophys. Res*., 106(D19), 22605–22611.

Annan, J., et al., 2005. "Efficiently constraining climate sensitivity with paleoclimate simulations." *Scientific Online Letters on the Atmosphere*, 1, 181–184.

Anthoff D, C. Hepburn, and R. Tol. 2009a. "Equity Weighting and the Marginal Damage Costs of Climate Change." *Ecological Economics* 68:836-849.

Anthoff, D., R. Tol, and G. Yohe. 2009b. "Risk aversion, time preference, and the social cost of carbon." *Environmental Research Letters* 4: 024002 (7pp).

Arrow, K. 2007. "Global climate change: a challenge to policy." *Economist's Voice* 4(3):Article 2.

Arrow, K. 2000. "A Comment on Cooper." *The World Bank Research Observer*. vol 15, no. 2.

Arrow, K., et al. 1996. *Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles*. Washington, D.C., AEI Press. pp. 13-14.

Arrow, K.J., et al. 1996. "Intertemporal equity, discounting and economic efficiency," in Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the *Second Assessment Report of the Intergovernmental Panel on Climate Change*.

Campbell, J., P. Diamond, and J. Shoven. 2001. "Estimating the Real Rate of Return on Stocks Over the Long Term." Presented to the Social Security Advisory Board. August.

Campbell, K. et al. 2007. *The age of consequences: The foreign policy and national security implications of global climate change*. Center for Strategic & International Studies, 119 pp.

Castles, I. and D. Henderson. 2003. "The IPCC Emission Scenarios: An Economic-Statistical Critique." *Energy and Environment* 14(2-3): 159-185.

Chetty, R. 2006. "A New Method of Estimating Risk Aversion." *American Economic Review* 96(5): 1821–1834.

Dasgupta P. 2006. "Comments on the Stern Review's economics of climate change." University of Cambridge working paper.

Dasgupta P. 2008. "Discounting climate change." *Journal of Risk and Uncertainty* 37:141-169.

Easterling, W., et al. 2007. *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. Intergovernmental Panel on Climate Change, 976 pp. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm, last accessed March 25, 2010.

Evans D., and H. Sezer. 2005. "Social discount rates for member countries of the European Union." *J. Econ. Stud*. 32 47–59.

Forest, C., et al. 2002. “Quantifying uncertainties in climate system properties with the use of recent observations.” *Science* 295, 113.

Forest, D., P. Stone, and A. Sokolov. 2006. “Estimated PDFs of climate system properties including natural and anthropogenic forcings.” *Geophys. Res. Lett*., 33, L01705.

Forster, P., and J. Gregory. 2006. “The climate sensitivity and its components diagnosed from Earth radiation budget data.” *J. Clim*., 19, 39–52.

Frame, D., et al. 2005. “Constraining climate forecasts: The role of prior assumptions.” *Geophys. Res. Lett*., 32, L09702.

Gingerich, P. 2006. “Environment and evolution through the Paleocene-Eocene thermal maximum.” *Trends Ecol. Evol.* 21: 246-253.

Gollier, C. 2008. “Discounting with fat-tailed economic growth.” *Journal of Risk and Uncertainty* 37:171-186.

Gollier, C. and M. Weitzman (2009). "How Should the Distant Future be Discounted When Discount Rates are Uncertain?" Harvard University, mimeo, Nov 2009.

Gregory, J., et al. 2002a. “An observationally based estimate of the climate sensitivity.” *J. Clim*., 15(22), 3117–3121.

Groom, B., Koundouri, P., Panipoulou, E., Pantelidis, T. 2006. “An econometric approach to estimating long-run discount rates.” *Journal of Applied Econometrics.*

Hall R, and C. Jones . 2007. “The value of life and the rise in health spending.” Quarterly *Journal of Economics* 122(1):39-72.

Hansen, J.,M. Sato, P. Kharecha, G. Russell, D. W. Lea and M. Siddall. 2007. “Climate change and trace gases.” *Phil. Trans. Roy. Soc. A* 365: 1925-1954.

Hegerl G, et al. 2007. “Understanding and attributing climate change.” in Solomon S, et al. (eds) *Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

Hegerl, G., T. Crowley, W. Hyde, and D. Frame. 2006. “Constraints on climate sensitivity from temperature reconstructions of the past seven centuries.” *Nature* 440.

Holtsmark, B., and K. Alfsen. 2005. “PPP Correction of the IPCC Emission Scenarios – Does it Matter?” *Climatic Change* 68(1-2): 11-19.

Hope C. 2006. “The marginal impact of CO2 from PAGE2002: an integrated assessment model incorporating the IPCC’s five reasons for concern.” *The Integrated Assessment Journal* 6(1):19-56.

Hope C. 2008. “Optimal carbon emissions and the social cost of carbon under uncertainty.” *The Integrated Assessment Journal* 8(1):107-122.

Intergovernmental Panel on Climate Change (2007). "Summary for Policymakers." In *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Just, R., D. Hueth, and A. Schmitz. 2004. *The Welfare Economics of Public Policy*. Glos UK: Edward Elgar Publishing Limited.

Knutti, R., T. Stocker, F. Joos, and G. Plattner. 2002. "Constraints on radiative forcing and future climate change from observations and climate model ensembles." *Nature*, 416, 719–723.

Kriegler, E. et al. 2009. "Imprecise probability assessment of tipping points in the climate system." *Proc. Natl. Acad. Sci.* 106: 5041-5046.

Kotlikoff, L. and D. Rapson. 2006. "Does It Pay, at the Margin, to Work and Save? – Measuring Effective Marginal Taxes on Americans' Labor Supply and Saving." National Bureau of Economic Research, Working Paper, No. 12533.

Le Treut H., et al. 2007. "Historical Overview of Climate Change." in Solomon et al., *Climate Change 2007*.

Lenton, T., et al. 2008. "Tipping elements in the Earth's climate system." *Proc. Natl. Acad. Sci.* 105: 1786-1793.

Levy, M., et al. 2005. "Ecosystem conditions and human well-being." In: *Ecosystems and Human Well-being: Current State and Trends, Volume 1.* [R. Hassan, R. Scholes, and N. Ash, eds.] Washington: Island Press. pp. 123-164.

Lind, R. 1990. "Reassessing the Government's Discount Rate Policy in Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility." *Journal of Environmental Economics and Management* 18, S-8-S-28.

Mastrandre, M. 2009. "Calculating the benefits of climate policy: Examining the assumptions of Integrated Assessment Models." Pew Center on Global Climate Change Working Paper, 60 pp.

Meehl, G, et al. 2007. "Global Climate Projections." in Solomon et al., *Climate Change 2007*.

National Research Council (2009). *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. National Academies Press.

Newbold S, Daigneault A. 2009. "Climate response uncertainty and the benefits of greenhouse gas emissions reductions." *Environmental and Resource Economics* 44:351-377.

Newell, R., and W. Pizer. 2003. Discounting the distant future: how much do uncertain rates increase valuations? *Journal of Environmental Economics and Management* 46: 52-71.

Nordhaus, W. 1994. "Expert Opinion on Climate Change." *American Scientist* 82: 45-51.

Nordhaus, W. 2007a. *Accompanying notes and documentation on development of DICE-2007 model: notes on DICE-2007.delta.v8 as of September 21, 2007.*

Nordhaus, W. 2007b. "Alternative measures of output in global economic-environmental models: Purchasing power parity or market exchange rates?" *Energy Economics* 29: 349-372.

Nordhaus W. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. New Haven, CT: Yale University Press.

Nordhaus, W. 2009. "An Analysis of the Dismal Theorem. Cowles Foundation Discussion Paper. No. 1686. January.

Nordhaus W., and Boyer J. 2000. *Warming the World: Economic Models of Global Warming*. Cambridge, MA: MIT Press.

Pindyck, R. 2009. "Uncertain Outcomes and Climate Change Policy." NBER Working Paper, No. 15259. August.

Ramsey, F. 1928. "A Mathematical Theory of Saving." *The Economic Journal* 38(152): 543-559.

Roe, G. 2008. "Feedbacks, timescales, and seeing red." *Annual Review of Earth and Planetary Sciences* 37:5.1-5.23.

Roe, G., and M. Baker. 2007. "Why is climate sensitivity so unpredictable?" *Science* 318:629-632.

Schneider von Deimling, T., H. Held, A. Ganopolski, and S. Rahmstorf. 2006. "Climate sensitivity estimated from ensemble simulations of glacial climate." *Clim. Dyn*., 27, 149–163.

Smith, J. et al. 2009. "Transient dwarfism of soil fauna during the Paleocene-Eocene Thermal Maximum." *Proc. Natl. Acad. Sci.* 106: 17665-17660.

Stern, N., et al. (2006), *Stern Review: The Economics of Climate Change*, HM Treasury, London. See http://www.hm-treasury.gov.uk/stern_review_report.htm, last accessed March 25, 2010.

Stern N. 2008. "The economics of climate change." *American Economic Review* 98(2):1-37.

Sterner, T., and U. Persson. 2008. An even Sterner review: Introducing relative prices into the discounting debate. *Rev. Env. Econ. Pol.* 2: 61-76.

Summers, L., and R. Zeckhauser. 2008. "Policymaking for Posterity." Journal of Risk and Uncertainty 37: 115-140.

Szpiro, G. 1986. "Measuring Risk Aversion: An Alternative Approach." *The Review of Economics and Statistics* 68(1): 156-9.

Tol, R. 2002a. "Estimates of the damage costs of climate change. Part I: benchmark estimates." *Environmental and Resource Economics* 21:47-73.

Tol, R. 2002b. "Estimates of the damage costs of climate change. Part II: dynamic estimates." *Environmental and Resource Economics* 21:135-160.

Tol, R. 2006. "Exchange Rates and Climate Change: An Application of FUND." *Climatic Change* 75(1-2): 59-80.

Tol, R. 2009. “An analysis of mitigation as a response to climate change.” Copenhagen Consensus on Climate. Discussion Paper.

U.S. Department of Defense. 2010. Quadrennial Defense Review Report. February.

Warren, R., et al. 2006. “Spotlight Impact Functions in Integrated Assessment.” Tyndall Center for Climate Change Research, Working Paper 91.

Weitzman, M. 2009. “On modeling and interpreting the economics of catastrophic climate change.” *Review of Economics and Statistics* 91:1-19.

Weitzman, M. 2007. “A review of The Stern Review of the Economics of Climate Change.” *Journal of Economic Literature* 45:703-724.

Weitzman, M. 1999. In Portney P.R. and Weyant J.P. (eds.), *Discounting and Intergenerational Equity*, Resources for the Future, Washington, D.C.

Weitzman, M. 1998. “Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate.” *Journal of Environmental Economics and Management* 36 (3): 201-208.

Wing, S. et al. 2005. “Transient floral change and rapid global warming at the Paleocene-Eocene boundary.” *Science* 310: 993-996.

Appendix

Table A1: Annual SCC Values: 2010–2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2011	4.9	21.9	35.7	66.5
2012	5.1	22.4	36.4	68.1
2013	5.3	22.8	37.0	69.6
2014	5.5	23.3	37.7	71.2
2015	5.7	23.8	38.4	72.8
2016	5.9	24.3	39.0	74.4
2017	6.1	24.8	39.7	76.0
2018	6.3	25.3	40.4	77.5
2019	6.5	25.8	41.0	79.1
2020	6.8	26.3	41.7	80.7
2021	7.1	27.0	42.5	82.6
2022	7.4	27.6	43.4	84.6
2023	7.7	28.3	44.2	86.5
2024	7.9	28.9	45.0	88.4
2025	8.2	29.6	45.9	90.4
2026	8.5	30.2	46.7	92.3
2027	8.8	30.9	47.5	94.2
2028	9.1	31.5	48.4	96.2
2029	9.4	32.1	49.2	98.1
2030	9.7	32.8	50.0	100.0
2031	10.0	33.4	50.9	102.0
2032	10.3	34.1	51.7	103.9
2033	10.6	34.7	52.5	105.8
2034	10.9	35.4	53.4	107.8
2035	11.2	36.0	54.2	109.7
2036	11.5	36.7	55.0	111.6
2037	11.8	37.3	55.9	113.6
2038	12.1	37.9	56.7	115.5
2039	12.4	38.6	57.5	117.4
2040	12.7	39.2	58.4	119.3
2041	13.0	39.8	59.0	121.0
2042	13.3	40.4	59.7	122.7
2043	13.6	40.9	60.4	124.4
2044	13.9	41.5	61.0	126.1
2045	14.2	42.1	61.7	127.8
2046	14.5	42.6	62.4	129.4
2047	14.8	43.2	63.0	131.1
2048	15.1	43.8	63.7	132.8
2049	15.4	44.4	64.4	134.5
2050	15.7	44.9	65.0	136.2

This Appendix also provides additional technical information about the non-CO_2 emission projections used in the modeling and the method for extrapolating emissions forecasts through 2300, and shows the full distribution of 2010 SCC estimates by model and scenario combination.

1. Other (non-CO_2) gases

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane (CH_4), nitrous oxide (N_2O), fluorinated gases, and net land use CO_2 emissions to 2100. These assumptions are used in all three IAMs while retaining each model's default radiative forcings (RF) due to other factors (e.g., aerosols and other gases). Specifically, to obtain the RF associated with the non-CO_2 EMF emissions only, we calculated the RF associated with the EMF atmospheric CO_2 concentrations and subtracted them from the EMF total RF.[30] This approach respects the EMF scenarios as much as possible and at the same time takes account of those components not included in the EMF projections. Since each model treats non-CO_2 gases differently (e.g., DICE lumps all other gases into one composite exogenous input), this approach was applied slightly differently in each of the models.

FUND: Rather than relying on RF for these gases, the actual emissions from each scenario were used in FUND. The model default trajectories for CH_4, N_20, SF_6, and the CO_2 emissions from land were replaced with the EMF values.

PAGE: PAGE models CO_2, CH_4, sulfur hexafluoride (SF_6), and aerosols and contains an "excess forcing" vector that includes the RF for everything else. To include the EMF values, we removed the default CH_4 and SF_6 factors[31], decomposed the excess forcing vector, and constructed a new excess forcing vector that includes the EMF RF for CH_4, N_20, and fluorinated gases, as well as the model default values for aerosols and other factors. Net land use CO_2 emissions were added to the fossil and industrial CO_2 emissions pathway.

DICE: DICE presents the greatest challenge because all forcing due to factors other than industrial CO_2 emissions is embedded in an exogenous non-CO_2 RF vector. To decompose this exogenous forcing path into EMF non-CO_2 gases and other gases, we relied on the references in DICE2007 to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) and the discussion of aerosol forecasts in the IPCC's Third Assessment Report (TAR) and in AR4, as explained below. In DICE2007, Nordhaus assumes that exogenous forcing from all non-CO_2 sources is -0.06 W/m^2 in 2005, as reported in AR4, and increases linearly to 0.3 W/m^2 in 2105, based on GISS projections, and then stays constant after that time.

---

[30] Note EMF did not provide CO_2 concentrations for the IMAGE reference scenario. Thus, for this scenario, we fed the fossil, industrial and land CO_2 emissions into MAGICC (considered a "neutral arbiter" model, which is tuned to emulate the major global climate models) and the resulting CO_2 concentrations were used. Note also that MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

[31] Both the model default CH_4 emissions and the initial atmospheric CH_4 is set to zero to avoid double counting the effect of past CH_4 emissions.

According to AR4, the RF in 2005 from CH_4, N_20, and halocarbons (approximately similar to the F-gases in the EMF-22 scenarios) was 0.48 + 0.16 + 0.34 = 0.98 W/m^2 and RF from total aerosols was -1.2 W/m^2. Thus, the -.06 W/m^2 non-CO_2 forcing in DICE can be decomposed into: 0.98 W/m^2 due to the EMF non-CO_2 gases, -1.2 W/m^2 due to aerosols, and the remainder, 0.16 W/m^2, due to other residual forcing.

For subsequent years, we calculated the DICE default RF from aerosols and other non-CO_2 gases based on the following two assumptions:

(1) RF from aerosols declines linearly from 2005 to 2100 at the rate projected by the TAR and then stays constant thereafter, and
(2) With respect to RF from non-CO_2 gases not included in the EMF-22 scenarios, the share of non-aerosol RF matches the share implicit in the AR4 summary statistics cited above and remains constant over time.

Assumption (1) means that the RF from aerosols in 2100 equals 66 percent of that in 2000, which is the fraction of the TAR projection of total RF from aerosols (including sulfates, black carbon, and organic carbon) in 2100 vs. 2000 under the A1B SRES emissions scenario. Since the SRES marker scenarios were not updated for the AR4, the TAR provides the most recent IPCC projection of aerosol forcing. We rely on the A1B projection from the TAR because it provides one of the lower aerosol forecasts among the SRES marker scenarios and is more consistent with the AR4 discussion of the post-SRES literature on aerosols:

Aerosols have a net cooling effect and the representation of aerosol and aerosol precursor emissions, including sulphur dioxide, black carbon and organic carbon, has improved in the post-SRES scenarios. Generally, these emissions are projected to be lower than reported in SRES. {WGIII 3.2, TS.3, SPM}.[32]

Assuming a simple linear decline in aerosols from 2000 to 2100 also is more consistent with the recent literature on these emissions. For example, Figure A1 shows that the sulfur dioxide emissions peak over the short-term of some SRES scenarios above the upper bound estimates of the more recent scenarios.[33] Recent scenarios project sulfur emissions to peak earlier and at lower levels compared to the SRES in part because of new information about present and planned sulfur legislation in some developing countries, such as India and China.[34] The lower bound projections of the recent literature have also shifted downward slightly compared to the SRES scenario (IPCC 2007).

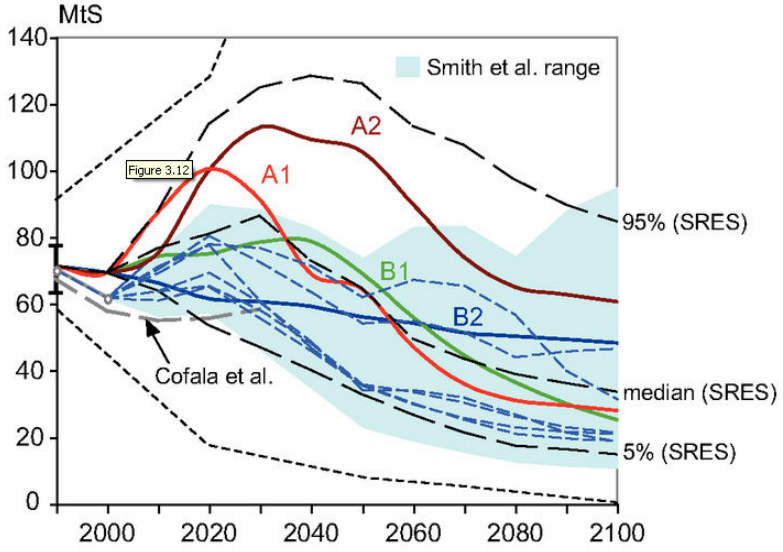
[32] AR4 Synthesis Report, p. 44, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

[33] See Smith, S.J., R. Andres, E. Conception, and J. Lurz, 2004: Historical sulfur dioxide emissions, 1850-2000: methods and results. Joint Global Research Institute, College Park, 14 pp.

[34] See Carmichael, G., D. Streets, G. Calori, M. Amann, M. Jacobson, J. Hansen, and H. Ueda, 2002: Changing trends in sulphur emissions in Asia: implications for acid deposition, air pollution, and climate. Environmental Science and Technology, 36(22):4707- 4713; Streets, D., K. Jiang, X. Hu, J. Sinton, X.-Q. Zhang, D. Xu, M. Jacobson, and J. Hansen, 2001: Recent reductions in China's greenhouse gas emissions. Science, 294(5548): 1835-1837.

With these assumptions, the DICE aerosol forcing changes from -1.2 in 2005 to -0.792 in 2105 W/m^2; forcing due to other non-CO_2 gases not included in the EMF scenarios declines from 0.160 to 0.153 W/m^2.

Figure A1: Sulphur Dioxide Emission Scenarios



Notes: Thick colored lines depict the four SRES marker scenarios and black dashed lines show the median, 5th and 95th percentile of the frequency distribution for the full ensemble of 40 SRES scenarios. The blue area (and the thin dashed lines in blue) illustrates individual scenarios and the range of Smith et al. (2004). Dotted lines indicate the minimum and maximum of SO_2 emissions scenarios developed pre-SRES.
Source: IPCC (2007), AR4 WGIII 3.2, http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3-ens3-2-2-4.html.

Although other approaches to decomposing the DICE exogenous forcing vector are possible, initial sensitivity analysis suggests that the differences among reasonable alternative approaches are likely to be minor. For example, adjusting the TAR aerosol projection above to assume that aerosols will be maintained at 2000 levels through 2100 reduces average SCC values (for 2010) by approximately 3 percent (or less than $2); assuming all aerosols are phased out by 2100 increases average 2010 SCC values by 6-7 percent (or $0.50-$3)–depending on the discount rate. These differences increase slightly for SCC values in later years but are still well within 10 percent of each other as far out as 2050.

Finally, as in PAGE, the EMF net land use CO_2 emissions are added to the fossil and industrial CO_2 emissions pathway.

2. Extrapolating Emissions Projections to 2300

To run each model through 2300 requires assumptions about GDP, population, greenhouse gas emissions, and radiative forcing trajectories after 2100, the last year for which these projections are available from the EMF-22 models. These inputs were extrapolated from 2100 to 2300 as follows:

1. Population growth rate declines linearly, reaching zero in the year 2200.
2. GDP/ per capita growth rate declines linearly, reaching zero in the year 2300.
3. The decline in the fossil and industrial carbon intensity (CO_2/GDP) growth rate over 2090-2100 is maintained from 2100 through 2300.
4. Net land use CO_2 emissions decline linearly, reaching zero in the year 2200.
5. Non-CO_2 radiative forcing remains constant after 2100.

Long run stabilization of GDP per capita was viewed as a more realistic simplifying assumption than a linear or exponential extrapolation of the pre-2100 economic growth rate of each EMF scenario. This is based on the idea that increasing scarcity of natural resources and the degradation of environmental sinks available for assimilating pollution from economic production activities may eventually overtake the rate of technological progress. Thus, the overall rate of economic growth may slow over the very long run. The interagency group also considered allowing an exponential decline in the growth rate of GDP per capita. However, since this would require an additional assumption about how close to zero the growth rate would get by 2300, the group opted for the simpler and more transparent linear extrapolation to zero by 2300.

The population growth rate is also assumed to decline linearly, reaching zero by 2200. This assumption is reasonably consistent with the United Nations long run population forecast, which estimates global population to be fairly stable after 2150 in the medium scenario (UN 2004).[35] The resulting range of EMF population trajectories (Figure A2) also encompass the UN medium scenario forecasts through 2300 – global population of 8.5 billion by 2200, and 9 billion by 2300.

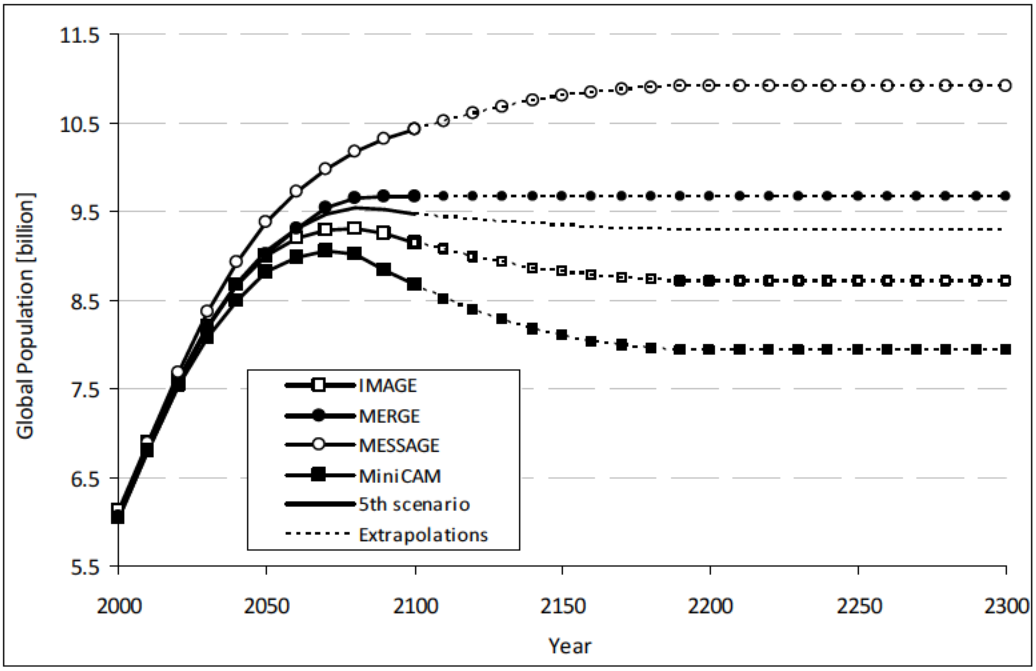
Maintaining the decline in the 2090-2100 carbon intensity growth rate (i.e., CO_2 per dollar of GDP) through 2300 assumes that technological improvements and innovations in the areas of energy efficiency and other carbon reducing technologies (possibly including currently unavailable methods) will continue to proceed at roughly the same pace that is projected to occur towards the end of the forecast period for each EMF scenario. This assumption implies that total cumulative emissions in 2300 will be between 5,000 and 12,000 GtC, which is within the range of the total potential global carbon stock estimated in the literature.

Net land use CO_2 emissions are expected to stabilize in the long run, so in the absence of any post 2100 projections, the group assumed a linear decline to zero by 2200. Given no a priori reasons for assuming a long run increase or decline in non-CO_2 radiative forcing, it is assumed to remain at the 2100 levels for each EMF scenario through 2300.

Figures A2-A7 show the paths of global population, GDP, fossil and industrial CO_2 emissions, net land CO_2 emissions, non-CO_2 radiative forcing, and CO_2 intensity (fossil and industrial CO_2 emissions/GDP) resulting from these assumptions.

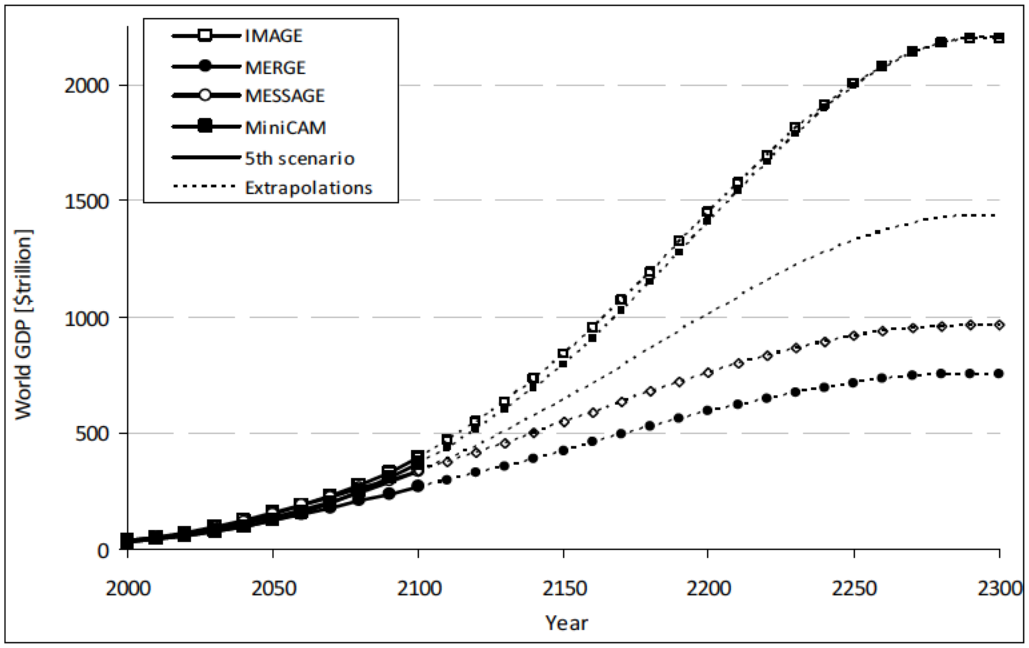
[35] United Nations. 2004. *World Population to 2300*.
http://www.un.org/esa/population/publications/longrange2/worldpop2300final.pdf

Figure A2. Global Population, 2000-2300 (Post-2100 extrapolations assume the population growth rate changes linearly to reach a zero growth rate by 2200.)



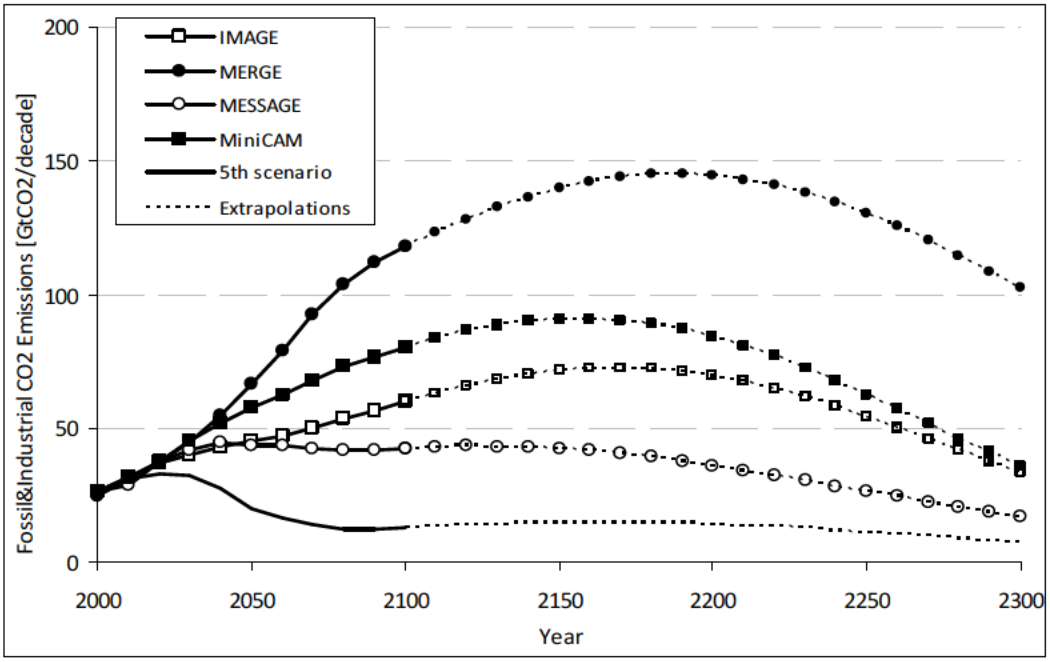
Note: In the fifth scenario, 2000-2100 population is equal to the average of the population under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A3. World GDP, 2000-2300 (Post-2100 extrapolations assume GDP per capita growth declines linearly, reaching zero in the year 2300)



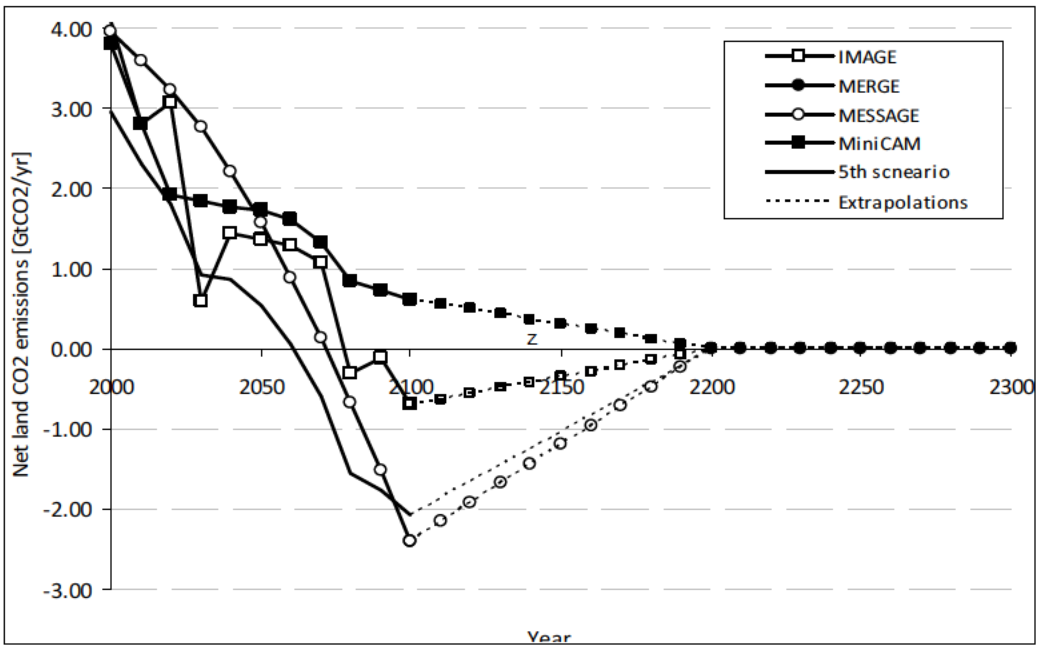
Note: In the fifth scenario, 2000-2100 GDP is equal to the average of the GDP under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A4. Global Fossil and Industrial CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume growth rate of CO_2 intensity (CO_2/GDP) over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

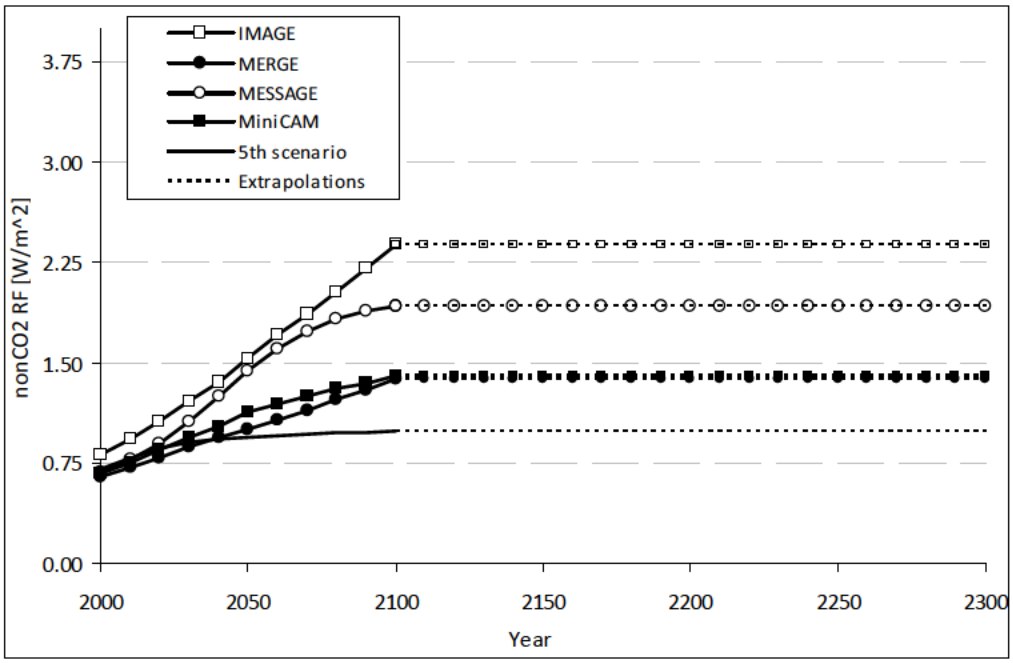
Figure A5. Global Net Land Use CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume emissions decline linearly, reaching zero in the year 2200)[36]



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

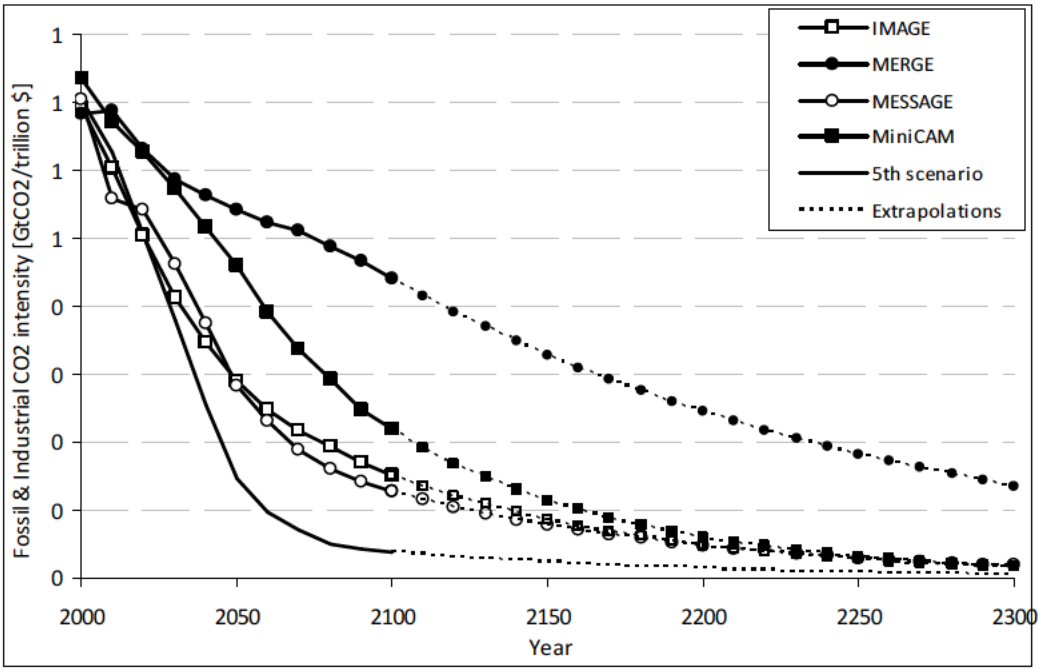
[36] MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

Figure A6. Global Non-CO_2 Radiative Forcing, 2000-2300 (Post-2100 extrapolations assume constant non-CO_2 radiative forcing after 2100.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A7. Global CO_2 Intensity (fossil & industrial CO_2 emissions/GDP), 2000-2300 (Post-2100 extrapolations assume decline in CO_2/GDP growth rate over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Table A2. 2010 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	3.3	5.9	8.1	13.9	28.8	65.5	68.2	147.9	239.6	563.8
MERGE optimistic	1.9	3.2	4.3	7.2	14.6	34.6	36.2	79.8	124.8	288.3
Message	2.4	4.3	5.8	9.8	20.3	49.2	50.7	114.9	181.7	428.4
MiniCAM base	2.7	4.6	6.4	11.2	22.8	54.7	55.7	120.5	195.3	482.3
5th scenario	2.0	3.5	4.7	8.1	16.3	42.9	41.5	103.9	176.3	371.9
Scenario						**DICE**				
IMAGE	16.4	21.4	25	33.3	46.8	54.2	69.7	96.3	111.1	130.0
MERGE optimistic	9.7	12.6	14.9	19.7	27.9	31.6	40.7	54.5	63.5	73.3
Message	13.5	17.2	20.1	27	38.5	43.5	55.1	75.8	87.9	103.0
MiniCAM base	13.1	16.7	19.8	26.7	38.6	44.4	56.8	79.5	92.8	109.3
5th scenario	10.8	14	16.7	22.2	32	37.4	47.7	67.8	80.2	96.8
Scenario						**FUND**				
IMAGE	-33.1	-18.9	-13.3	-5.5	4.1	19.3	18.7	43.5	67.1	150.7
MERGE optimistic	-33.1	-14.8	-10	-3	5.9	14.8	20.4	43.9	65.4	132.9
Message	-32.5	-19.8	-14.6	-7.2	1.5	8.8	13.8	33.7	52.3	119.2
MiniCAM base	-31.0	-15.9	-10.7	-3.4	6	22.2	21	46.4	70.4	152.9
5th scenario	-32.2	-21.6	-16.7	-9.7	-2.3	3	6.7	20.5	34.2	96.8

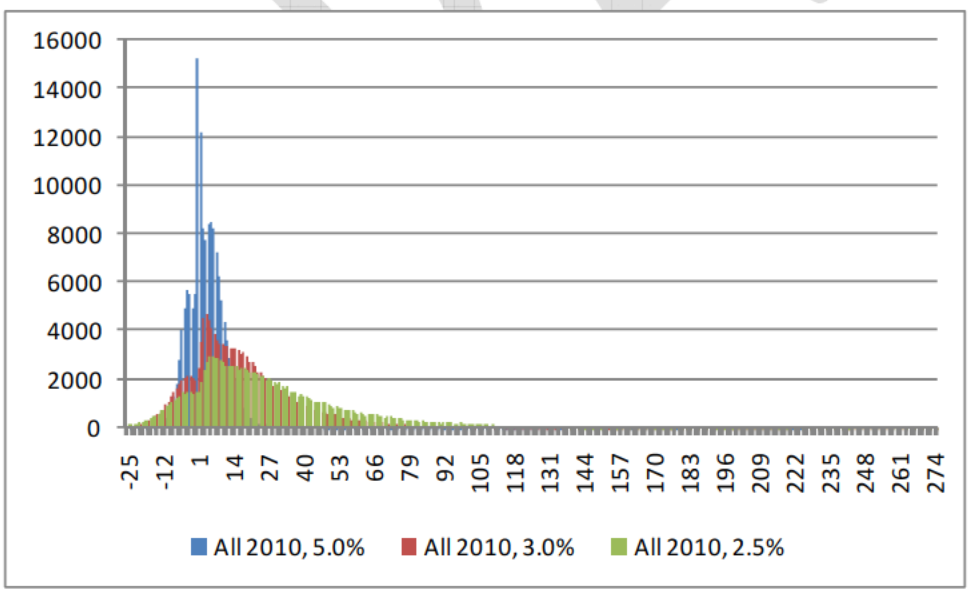
Table A3. 2010 Global SCC Estimates at 3 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	2.0	3.5	4.8	8.1	16.5	39.5	41.6	90.3	142.4	327.4
MERGE optimistic	1.2	2.1	2.8	4.6	9.3	22.3	22.8	51.3	82.4	190.0
Message	1.6	2.7	3.6	6.2	12.5	30.3	31	71.4	115.6	263.0
MiniCAM base	1.7	2.8	3.8	6.5	13.2	31.8	32.4	72.6	115.4	287.0
5th scenario	1.3	2.3	3.1	5	9.6	25.4	23.6	62.1	104.7	222.5
Scenario						**DICE**				
IMAGE	11.0	14.5	17.2	22.8	31.6	35.8	45.4	61.9	70.8	82.1
MERGE optimistic	7.1	9.2	10.8	14.3	19.9	22	27.9	36.9	42.1	48.8
Message	9.7	12.5	14.7	19	26.6	29.8	37.8	51.1	58.6	67.4
MiniCAM base	8.8	11.5	13.6	18	25.2	28.8	36.9	50.4	57.9	67.8
5th scenario	7.9	10.1	11.8	15.6	21.6	24.9	31.8	43.7	50.8	60.6
Scenario						**FUND**				
IMAGE	-25.2	-15.3	-11.2	-5.6	0.9	8.2	10.4	25.4	39.7	90.3
MERGE optimistic	-24.0	-12.4	-8.7	-3.6	2.6	8	12.2	27	41.3	85.3
Message	-25.3	-16.2	-12.2	-6.8	-0.5	3.6	7.7	20.1	32.1	72.5
MiniCAM base	-23.1	-12.9	-9.3	-4	2.4	10.2	12.2	27.7	42.6	93.0
5th scenario	-24.1	-16.6	-13.2	-8.3	-3	-0.2	2.9	11.2	19.4	53.6

Table A4. 2010 Global SCC Estimates at 5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	0.5	0.8	1.1	1.8	3.5	8.3	8.5	19.5	31.4	67.2
MERGE optimistic	0.3	0.5	0.7	1.2	2.3	5.2	5.4	12.3	19.5	42.4
Message	0.4	0.7	0.9	1.6	3	7.2	7.2	17	28.2	60.8
MiniCAM base	0.3	0.6	0.8	1.4	2.7	6.4	6.6	15.9	24.9	52.6
5th scenario	0.3	0.6	0.8	1.3	2.3	5.5	5	12.9	22	48.7
Scenario						**DICE**				
IMAGE	4.2	5.4	6.2	7.6	10	10.8	13.4	16.8	18.7	21.1
MERGE optimistic	2.9	3.7	4.2	5.3	7	7.5	9.3	11.7	12.9	14.4
Message	3.9	4.9	5.5	7	9.2	9.8	12.2	15.4	17.1	18.8
MiniCAM base	3.4	4.2	4.7	6	7.9	8.6	10.7	13.5	15.1	16.9
5th scenario	3.2	4	4.6	5.7	7.6	8.2	10.2	12.8	14.3	16.0
Scenario						**FUND**				
IMAGE	-11.7	-8.4	-6.9	-4.6	-2.2	-1.3	0.7	4.1	7.4	17.4
MERGE optimistic	-10.6	-7.1	-5.6	-3.6	-1.3	-0.3	1.6	5.4	9.1	19.0
Message	-12.2	-8.9	-7.3	-4.9	-2.5	-1.9	0.3	3.5	6.5	15.6
MiniCAM base	-10.4	-7.2	-5.8	-3.8	-1.5	-0.6	1.3	4.8	8.2	18.0
5th scenario	-10.9	-8.3	-7	-5	-2.9	-2.7	-0.8	1.4	3.2	9.2

Figure A8. Histogram of Global SCC Estimates in 2010 (2007$/ton CO_2), by discount rate



* The distribution of SCC values ranges from -$5,192 to $66,116 but the X-axis has been truncated at approximately the 1st and 99th percentiles to better show the data.

Table A5. Additional Summary Statistics of 2010 Global SCC Estimates

Discount rate:	5%				3%				2.5%			
Scenario	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	9.0	13.1	0.8	0.2	28.3	209.8	1.1	0.9	42.2	534.9	1.2	1.1
PAGE	6.5	136.0	6.3	72.4	29.8	3,383.7	8.6	151.0	49.3	9,546.0	8.7	143.8
FUND	-1.3	70.1	28.2	1,479.0	6.0	16,382.5	128.0	18,976.5	13.6	150,732.6	149.0	23,558.3

DRAFT

4.2. METHANE AND NITROUS OXIDE EMISSIONS FROM AGRICULTURE

4.2.1 ADVANCED AGRICULTURAL SYSTEMS FOR N_2O EMISSION REDUCTION

Technology Description

No-tillage cropping system in irrigated agriculture to reduce Net global warming potential (A.D. Halvorson, USDA-ARS, Fort Collins. Colorado)

Low fertilizer nitrogen-use efficiency in agricultural systems is primarily caused by large nitrogen losses due to leaching and gaseous emissions (ammonia, nitrous oxide, nitric oxide, nitrogen). It is axiomatic then that most strategies that increase the efficiency use of fertilizer nitrogen will reduce emissions of N_2O and probably NO. In general, nitrogen oxide emissions from mineral and organic nitrogen can be decreased by management practices that optimize the crop's natural ability to compete with processes where plant-available nitrogen is lost from the soil-plant system, and/or by directly lowering the rate and duration of the loss processes. Strategies to increase the overall efficiency of nitrogen are therefore necessary to decrease nitrogen oxide emissions. Advanced agricultural systems are a group of technologies that can be applied to this goal. These systems enable a process of collecting and using increasingly detailed, site-specific information in conjunction with traditional farm-management tools, and applying the best available information to better manage individual farming operations. These systems conceptually provide for improved understanding, control, and manipulation of the soil/plant/atmosphere environment to match nutrient, water, pesticide, and other inputs for crop production demand, which will increase efficiency of nutrients and decrease gaseous and leaching losses. These systems provide an integrated capability to improve environmental quality while enhancing economic productivity by increasing energy efficiency, optimizing fertilizer and other chemical applications, and conserving soil and water resources. Most system concepts for reduction of GHG emissions are, however, theoretical and remain untested.

System Concepts

- Precision agriculture – global-positioning infrastructure and remote and *in situ* sensors for soil, crop, and microclimate characterization; this practice includes variable rate water, fertilizer, and pesticide application in space and time.
- Cropping system models, data and information analysis, and management tools.
- Control-release fertilizer and pesticide delivery to match crop demand and timing of pest infestation.
- Biological and chemical methods for manipulating soil microbial processes to increase efficiency of nutrient uptake, suppress N_2O emissions, and reduce leaching.
- Best-management practices to limit nitrogen gas emissions, soil erosion, and leaching.
- Soil-conservation practices utilizing buffers and conservation reserves.
- Recycling of livestock manure.
- Plant breeding to increase nutrient-use efficiency and decrease demand for pesticides and energy consumption.

Representative Technologies

- Global-positioning satellites and ground systems, satellite- and aircraft-based remote and *in situ* electrical, magnetic, optical, chemical, and biological sensors.
- Advanced artificial intelligence and information networking technologies; autonomous control and robotics systems; soil/ crop moisture, pest and microclimate responsive (smart) materials.
- Control-release fertilizers and pesticides.
- Nitrogen transformation inhibitors.
- Livestock waste delivery systems.
- Best-management practices.
- Genetically engineered plants that are resistant to herbicides or specific pests.

Technology Status/Applications

- Many first-generation precision agriculture technologies are available; in 1998, used on about 14% of farms.
- Information management and networking tools; rapid soil-characterization sensors; selected crop stress, yield, and quality sensors; and a systematic integration of all technologies for all major cropping systems are not yet at technical performance levels and require field testing.
- Strong understanding of soil microbiology and soil processes and relationships exist in the agriculture, energy, and university research community.
- Capability exists for the development of control-release materials and biological process inhibitors.
- Best-management practices are in place in many production sectors.

Current Research, Development, and Demonstration

RD&D Goals

- Precision agriculture technologies that improve production efficiencies and reduce energy consumption.
- Remote and field-deployed sensors/monitors and information-management systems for accurate, real-time monitoring and analysis of crops, soils, water, fertilizer, and agricultural chemicals use/efficiency to meet the fertilizer and energy reduction goals.
- Smart materials for prescription release utilized in major crops.
- Advanced fertilizers and technologies to improve fertilizer efficiency and reduce nitrogen inputs.
- Methods of manipulating soil microbial processes to increase efficiency of nitrogen use.
- Deployment of first-generation integrated system models, technology, and supporting education and extension infrastructure.
- Genetically designed major crop plants to utilize fertilizer more efficiently.
- First generation integrated system models, technology and supporting education and extension infrastructure need to be implemented, and research on using these techniques to improve management expanded.
- Full utilization of best-management practices.

RD&D Challenges

- Precision agriculture in general requires advances in rapid, low-cost, and accurate soil nutrient and physical property characterization; real-time crop water need characterization; real-time crop yield and quality characterization; real-time insect and pest infestation characterization; autonomous control systems; and integrated physiological model and massive data/information management systems. All of these require a full understanding of the spatial and temporal dynamics that occur within a field.
- Smart materials that will release chemicals based on soil and crop status depend on modest breakthroughs in materials technology.
- Improved understanding of specific soil microbial processes is required to support development of methods for manipulation and how manipulation impacts greenhouse gas emissions.
- Models that represent accurate understanding of plant physiology must be coupled with models that represent soil processes such as decomposition, nutrient cycling, gaseous diffusion, water flow, and storage to understand how ecosystems respond to environmental and management change.
- Detailed and simultaneous examination of biogeochemical reactions that occur in near-surface ground water is required to improve understanding of nutrient cycling, GHG emissions, and degradation of contaminants.
- Improved understanding of agro-ecosystem management on nitrogen cycling and GHG emissions.
- Development of plant varieties that increase nutrient use efficiency.
- Conduct direct basic and applied research effort on sensors, information sciences, materials, and microbial processes.
- Apply whole-systems engineering and integration to effectively develop and guide program formulation and implementation to include the concept of whole system net GHG emissions.

RD&D Activities

- Complementary efforts are underway in both public and private sectors.
- Sponsors include USDA, DOE, NASA, universities, state agencies, commodity groups, and sensor and satellite developers – the principal funding comes from USDA.

- Life-cycle analysis of tractor and irrigation pump emissions.
- Use of cover crops or mulch that would reduce or delay emissions.

Recent Progress

- High-resolution satellite imagery can identify stress and disease in some crops at 1-to-2-m resolution.
- Research programs have related reflectance spectra to disease or nutrient status.
- Control-release formulations for fertilizers and pesticides are in use.
- Rf-link deployable field sensors exist for ground moisture monitoring.
- On-farm use of yield-monitoring equipment is increasing.
- Commercial sensors for sensitive, precise, and rapid analysis of GHGs are now marketed.
- Best-management practices are in place for many crops and regions of the country.
- Genetically modified crop varieties are being used that are resistant to specific herbicides or pests.

Commercialization and Deployment Activities

- Global-positioning systems, geographic information system software for parameter mapping, remotely sensed imagery, selected field monitors, and selected variable rate control systems for seed, fertilizer, and chemical applications are commercialized and in application in the United States, Canada, Australia, and Europe.
- Slow-bleed release pesticides are available commercially.
- Nitrogen transformation inhibitors are available commercially, and were applied to approximately 10% of corn acres in 1996. Inhibitor application increased net revenue $8-$20/acre.
- Control-release fertilizers are produced and used mainly in horticultural and ornamental crops.

Market Context

- Market for technologies exists not only in the United States but worldwide. In developing countries dependent on agriculture, the market for improved agricultural systems is substantial.

4.4 NITROUS OXIDE EMISSIONS FROM COMBUSTION AND INDUSTRIAL SOURCES

4.4.1 NITROUS OXIDE ABATEMENT TECHNOLOGIES FOR NITRIC ACID PRODUCTION

Technology Description

Nitric acid (HNO_3) is an inorganic compound used primarily to make synthetic commercial fertilizer. As a raw material, it also is used for the production of adipic acid and explosives, metal etching, and in the processing of ferrous metals. Plants making adipic acid used to be high emitters of nitrous oxide (N_2O), but now that adipic acid plants in the United States have implemented nitrous oxide abatement technologies, nitric acid production itself is the largest industrial source of N_2O emissions. The nitric acid industry currently controls NO_x emissions using both nonselective catalytic reduction (nonselective catalytic reduction) and selective catalytic reduction (selective catalytic reduction) technologies to reduce N_2O to elemental nitrogen. While nonselective catalytic reduction is more effective than selective catalytic reduction at controlling N_2O, nonselective catalytic reduction units are not generally preferred in today's plants because of high-energy costs and associated high gas temperatures. Only 20% of nitric acid plants use nonselective catalytic reduction today. Additional research is needed to develop new catalysts that reduce N_2O with greater efficiency, and to improve nonselective catalytic reduction technology to make it a preferable alternative to selective catalytic reduction and other control options.

Nitric-acid plant controls for NO_x using both nonselective catalytic reduction and selective catalytic reduction technologies. Nonselective catalytic reduction is very effective at controlling N_2O.

System Concepts

- Nonselective catalytic reduction uses a fuel and a catalyst to consume free oxygen in the tail gas and convert NO_x to elemental nitrogen (Chartier, 1999). Nonselective catalytic reduction can reduce N_2O emissions by 80%-90%. (IPCC, 2000)

Representative Technologies

- The gas from the NO_x abatement is passed through a gas expander for energy recovery. Nonselective catalytic reduction units produce stack gases in the 1,000°F to 1,100°F range that require more exotic materials for constructing the expander and have higher maintenance costs.

Technology Status/Applications

- Virtually all of the nitric acid produced in the United States is manufactured by the catalytic oxidation of ammonia (EPA, 1991). During this reaction, N_2O is formed as a byproduct and is released from reactor vents to the atmosphere. While the waste gas stream may be cleaned of other pollutants – such as nitrogen dioxide – there are currently no control measures aimed at specifically eliminating N_2O emissions.

Current Research, Development, and Demonstration

RD&D Goals

- RD&D goals are focused on the catalysts used to convert NO_x into elemental nitrogen.

RD&D Challenges

- The use of a catalyst that can reduce a higher percentage of N_2O emissions is not the focus of the current research. The technology is primarily implemented in order to reduce NO_x emissions, not as an N_2O emission-reduction technology.
- Develop catalysts that reduce N_2O to elemental nitrogen with greater efficiency.
- Promote the use of nonselective catalytic reduction over other NO_x control options such as selective catalytic reduction and extended absorption.

RD&D Activities

- Information on R&D activities to develop new catalysts for nonselective catalytic reduction technologies is unavailable. To date, RD&D expenditures have been made by the industry. Estimates of future expenditures by the industry are not available.

Recent Progress

- Currently, the nitric acid industry controls for NO_x using both nonselective catalytic reduction and selective catalytic reduction technologies. Nonselective catalytic reduction is very effective at controlling N_2O, while selective catalytic reduction can actually increase N_2O emissions. Nonselective catalytic reduction units are generally not preferred in modern plants because of high energy costs and associated high gas temperatures. Only 20% of nitric acid plants use nonselective catalytic reduction.

Commercialization and Deployment Activities

- Nonselective catalytic reduction units were widely installed in nitric acid plants built between 1971 and 1977. It is estimated that approximately 20% of nitric acid plants use nonselective catalytic reduction (Choe, et al., 1993). Information on the status of the commercial development of nonselective catalytic reduction catalysts is not currently available, however.

Market Context

- Approximately 80% of current plants do not employ nonselective catalytic reduction, but instead use selective catalytic reduction or extended absorption units, neither of which are known to reduce N_2O emissions. Research is underway into materials for catalysts that are applicable for N_2O control in nitric acid plants that do not employ nonselective catalytic reduction. Nitrous oxide emissions from nitric acid production will be influenced by the degree and type of NO_x emission control efforts that are applied in both new and existing nitric acid plants.

4.4.2 NITROUS OXIDE ABATEMENT TECHNOLOGIES FOR TRANSPORTATION

Technology Description

Basic research is needed to understand the formation and magnitude of N_2O emissions from fuel combustion and catalytic-converter operation.

Nitrous oxide (N_2O) can be produced from fuel combustion and catalytic-converter operation in vehicles, primarily due to the nitrogen in the air. Little is understood about how much N_2O is produced by vehicles and under what conditions and with what catalytic-converter technology. The main research thrust in the near term is to begin to answer these basic questions.

In addition to direct emissions of N_2O, nitrogen oxide (NO_x) emissions from mobile and stationary sources have a significant impact on atmospheric N_2O levels. More than 25 million tons of NO_x is emitted annually in the United States. Following transport and chemical interactions, approximately 7 million tons of these nitrogen emissions are deposited downwind. This compares to about 11 million tons of nitrogen deposited from fertilizer application. Since the 11 million tons is reported to account for about 70% of anthropogenic N_2O emissions, the 7 million tons from atmospheric deposition appear to be significant. In the past, greenhouse gas emissions inventories have ignored the atmospheric nitrogen deposition due to uncertainties involved. Research is needed to define the contribution of NO_x emissions to nitrogen deposition and subsequent N_2O emissions, and to identify the global warming benefits from ongoing and future NO_x emissions control programs.

System Concepts

- Better understand the formation and magnitude of N_2O emissions from fuel combustion and catalytic-converter operation.
- Evaluate the climate-forcing potential atmospheric nitrogen deposition, especially from combustion sources.
- Develop emission models to assess the potential climate benefits from changes in emissions from nitrogen oxides.

Representative Technologies

- Combustion and post-combustion NO_x control technologies used in the tropospheric ozone control program.

Technology Status/Applications

- NO_x control technologies are in place due to the ozone and acid deposition programs.

Current Research, Development, and Demonstration

RD&D Goals

- Accurately understand the amount of N_2O produced in various vehicles, how it forms, and how it can be reduced.
- Develop N_2O measurement techniques for emerging gasoline and diesel engines and their emission-control systems. Measurement technology is needed for both laboratory and field measurement.
- Develop vehicle- and engine-testing programs to generate data about N_2O emissions for a variety of vehicles and engines equipped with a range of current and advanced emission-control technologies and operated over a range of real-world operating conditions.

• Research on the relationship of N_2O emissions to technologies and approaches that reduce fuel consumption by stationary and mobile combustion sources, including programs that reduce vehicle miles traveled. • Quantify the climate-forcing impacts due to NO_x emissions, nitrogen deposition, and N_2O emissions. **RD&D Challenges** • To establish linkages of NO_x emissions to climate-change impacts due to nitrogen deposition and enhance modeling capabilities to address these linkage issues.
Recent Progress
• EPA's ozone-control program has reduced emissions of NO_x.
Commercialization and Deployment Activities
• Additional NO_x emissions controls will be implemented in the future to meet ambient air quality standards for ozone and particulate matter.