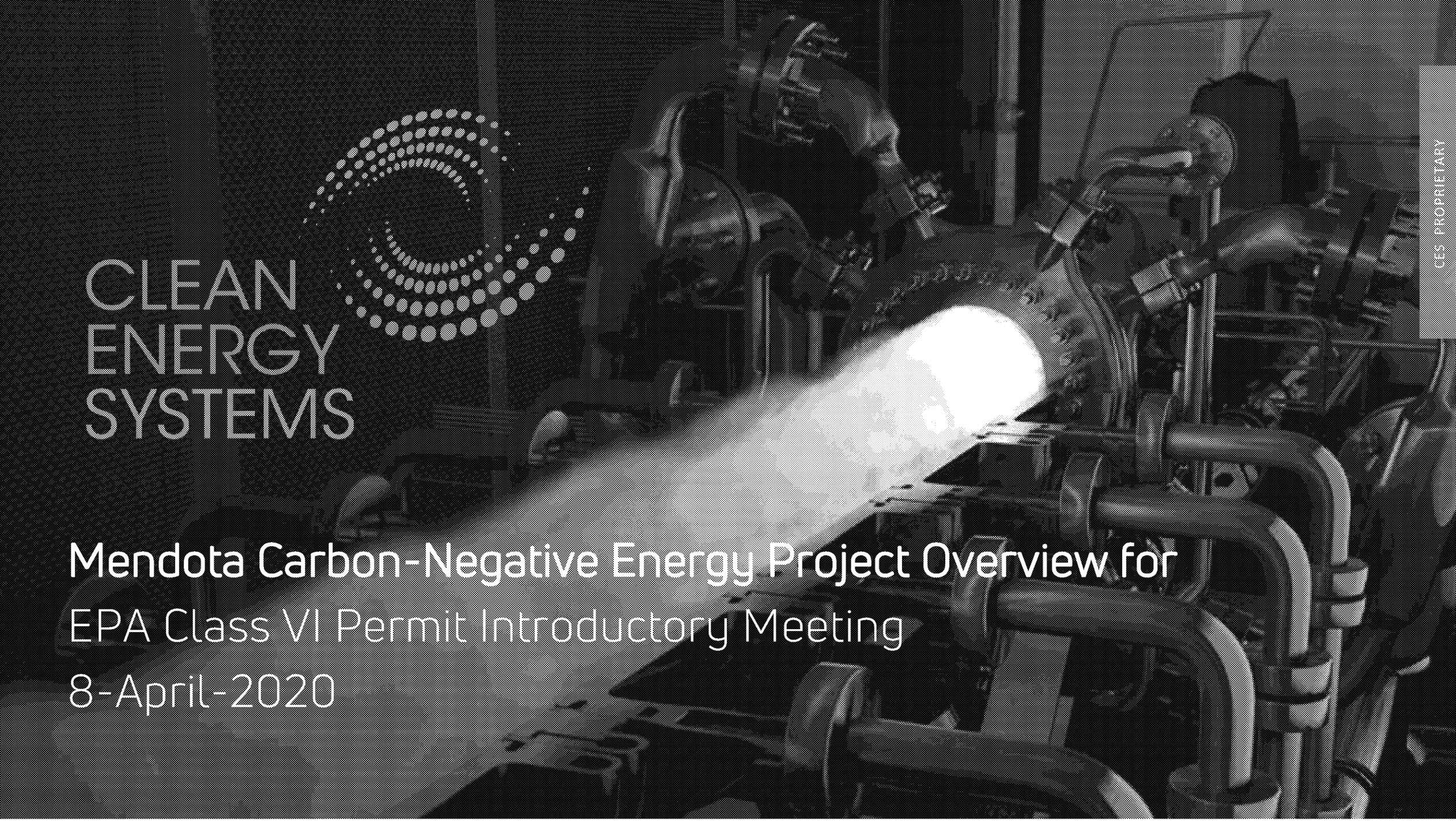

CLEAN ENERGY SYSTEMS

Mendota Carbon-Negative Energy Project Overview for

EPA Class VI Permit Introductory Meeting

8-April-2020

CES PROPRIETARY

OUTLINE

CLEAN ENERGY SYSTEMS

- Introduction to Clean Energy Systems
- Mendota Carbon-Negative Energy Project
  - CNE - How it Works
  - Mendota Project Overview
  - Highlights from EPA Class VI Permit Application
- Summary & Next Steps

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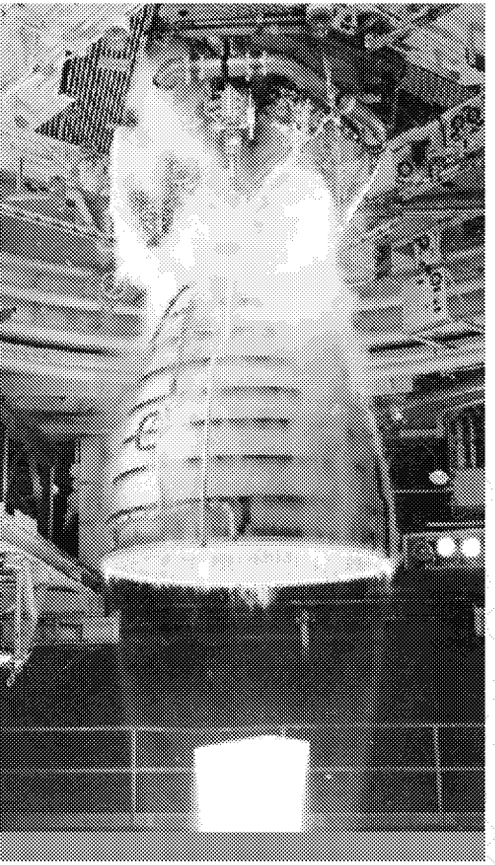
CES | COMPANY BACKGROUND & OVERVIEW

CLEAN ENERGY SYSTEMS



- Founded in 1993 by former Aerojet (a GenCorp company) aerospace engineers; incorporated in 1996, Clean Energy Systems, Inc. (CES)
- Multiple locations in California; Headquarters in Rancho Cordova (Sacramento Area)
- Over 30 patents issued on zero-emissions oxy-combustion technologies and power cycles
- More than 20 years and $135 MM invested to develop enabling technologies for advanced clean energy systems; includes:
  - Oxy-Fuel (O-F) Pressurized Direct and Indirect Steam Gas Generators, Reheat Combustors, Compact Diffusion Bonded Heat Exchangers, and O-F Turbines (OFTs)
- Today, working to develop and deploy Carbon Negative Energy (CNE) projects across the state of California, taking advantage of unique attributes
  - Using a multi-phase deployment plan beginning with retrofit and restart of idled biomass facilities in the Central Valley

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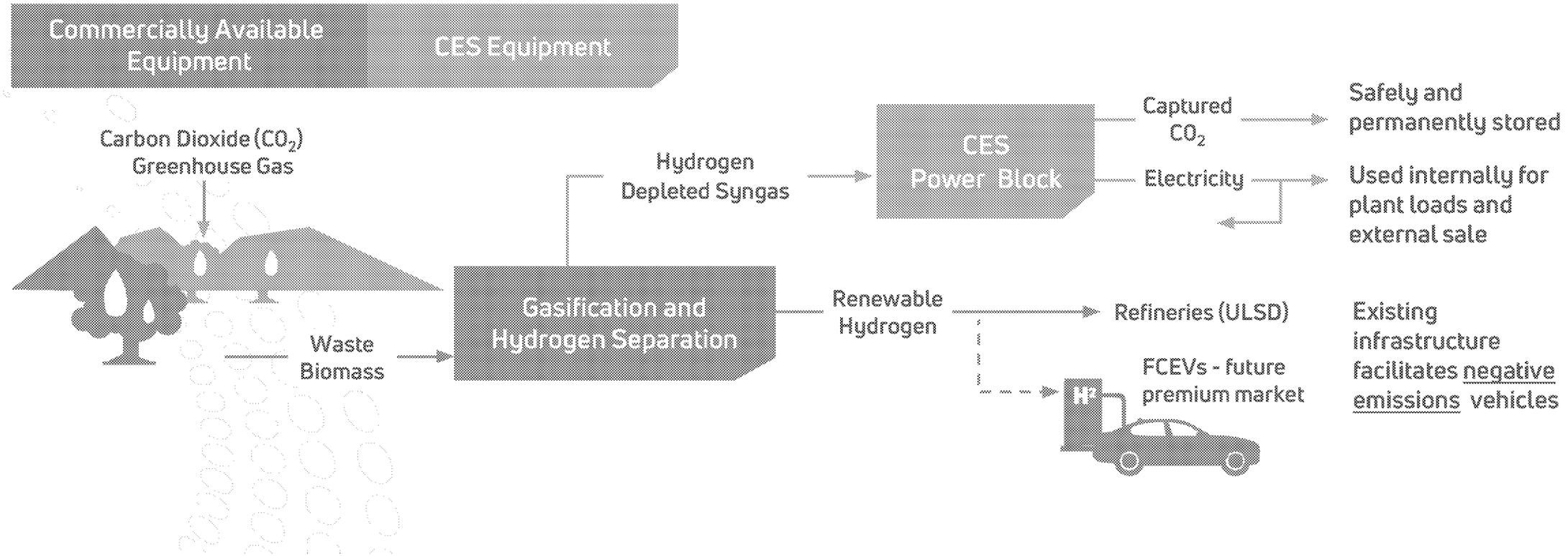
CNE I HOW IT WORKS

CLEAN ENERGY SYSTEMS

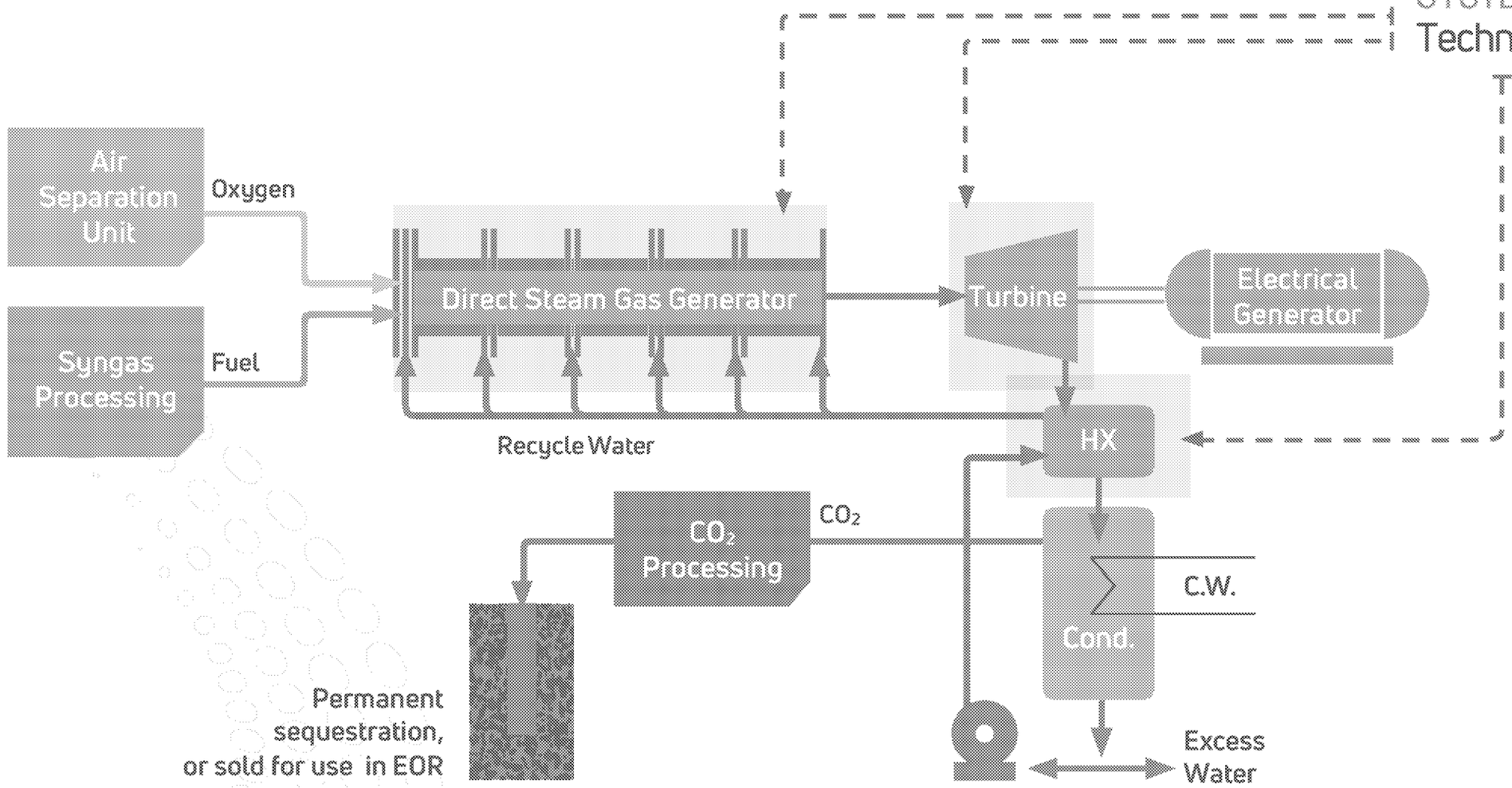
CES CNE plants gasify waste biomass fuels to produce syngas, from which hydrogen is separated for sale to the transportation sector. The resulting hydrogen-depleted syngas is used in CES' oxy-fuel power block to produce electricity with full carbon capture. Generated electricity can be used for plant loads and/or sold for electric vehicle charging.

By using fuel that consumes carbon over its lifetime and safely and permanently storing produced CO_2, the process results in net-negative carbon emissions, effectively removing CO_2 (greenhouse gas) from the atmosphere.



CES I POWER BLOCK

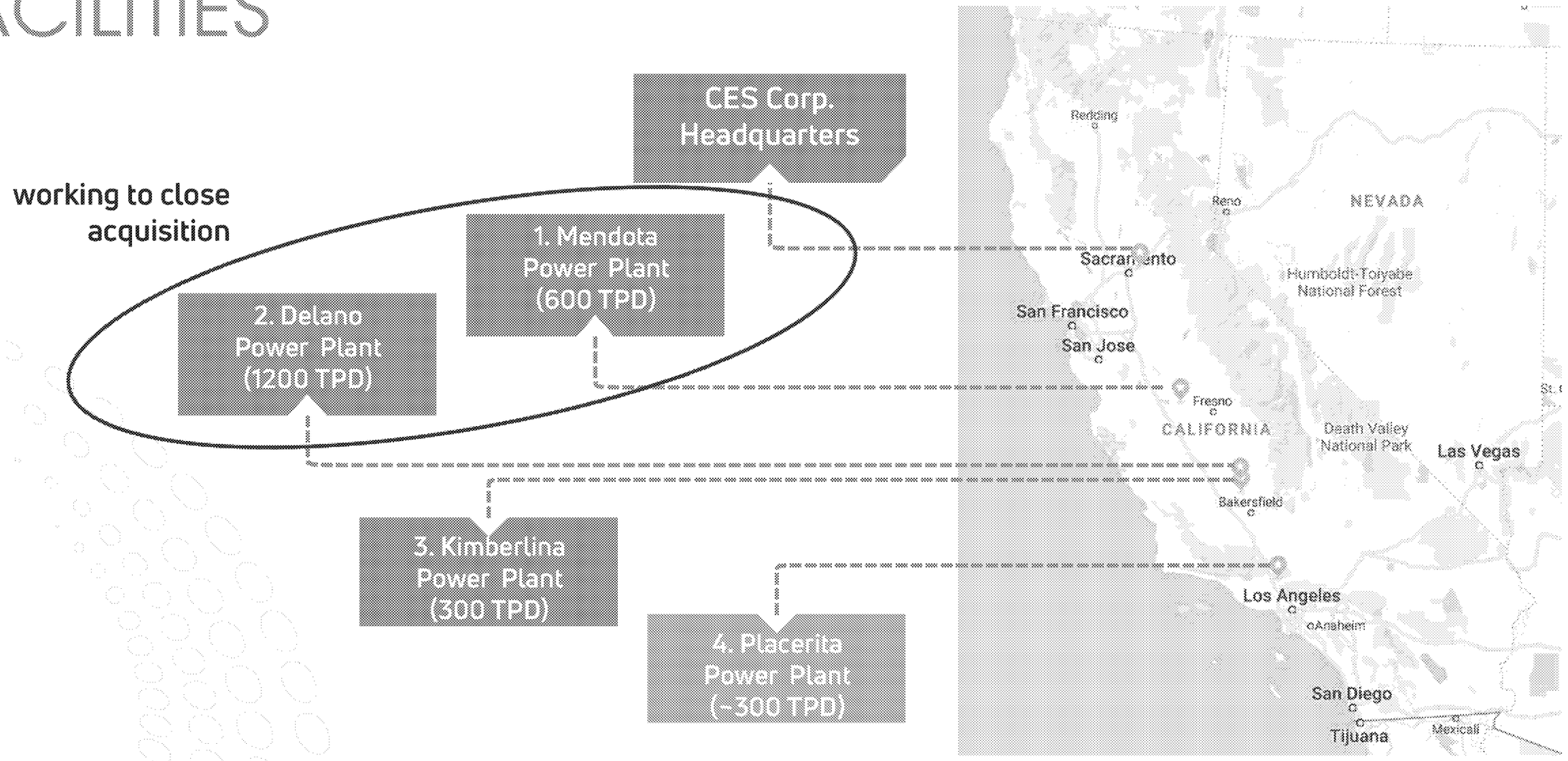
CLEAN ENERGY SYSTEMS Technologies*



*Visit www.CleanEnergySystems.com for more info

CES | CALIFORNIA FACILITIES

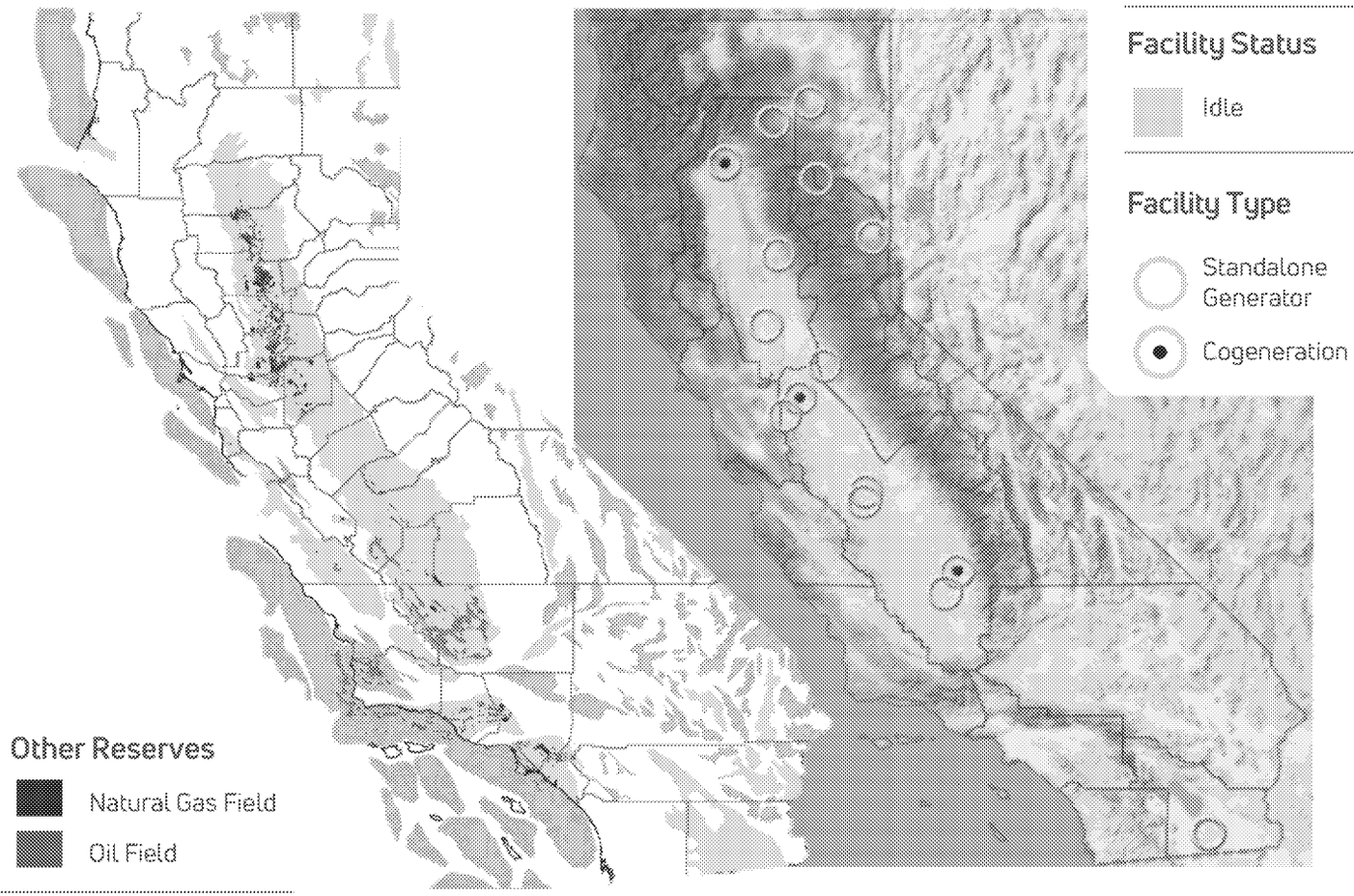
CLEAN ENERGY SYSTEMS



CNE I POTENTIAL PROJECTS ACROSS CALIFORNIA

CLEAN ENERGY SYSTEMS

- At least 15 idle biomass power plants in California today (>375 MW), with more anticipated to close in the coming years
- A comparison of idle biomass facilities to California's sedimentary basins shows excellent potential for carbon capture and storage and possible use in enhanced oil or gas recovery (EOR/EGR)
- Several benefits of retrofit deployment strategy



Sedimentary Basin Status

- **Basin with Carbon Sequestration Potential**
- Basins lacking Carbon Sequestration Potential
- Offshore Basins with Unkown Carbon Sequestration Potential

Other Reserves

- Natural Gas Field
- Oil Field

Map Courtesy of WESTCARB

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CNE I COMMUNITY BENEFITS

CLEAN ENERGY SYSTEMS

- Revitalization of existing biomass plants, supporting economic growth and jobs
- Elimination of criteria pollutant and CO_2 greenhouse gas emissions – improving local air quality
- Reduction and possible elimination of open field burning of agricultural wastes – solving waste management issues
- Decarbonization of the California transportation sector
  - Electricity or hydrogen from CNE plants removes ~3 lbs of CO_2 from the atmosphere for every mile driven
- Helps address tree mortality and wildfire crisis in the state
- Absolute necessity to meet the world's goal of less than 2 °C global temperature rise

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2019 American Lung Association "State of the Air" Report

Top 10 Most Polluted U.S. Cities:

Ozone		Short-Term Particle Pollution (24-hour $PM_{2.5}$)		Year-Round Particle Pollution (Annual $PM_{2.5}$)	
1	Los Angeles-Long Beach, CA	1	Bakersfield, CA	1	Fresno-Madera-Hanford, CA
2	Visalia, CA	2	Fresno-Madera-Hanford, CA	2	Bakersfield, CA
3	Bakersfield, CA	3	Fairbanks, AK	3	Fairbanks, AK
4	Fresno-Madera-Hanford, CA	4	San Jose-San Francisco-Oakland, CA	4	Visalia, CA
5	Sacramento-Roseville, CA	5	Missoula, MT	5	Los Angeles-Long Beach, CA
6	San Diego-Chula Vista-Carlsbad, CA	6	Yakima, WA	6	San Jose-San Francisco-Oakland, CA
7	Phoenix-Mesa, AZ	7	Los Angeles-Long Beach, CA	7	Pittsburgh-New Castle-Weirton, PA-OH-WV
8	San Jose-San Francisco-Oakland, CA	8	Salt lake City-Provo-Orem, UT	8	El Centro, CA
9	Houston-The Woodlands, TX	9	Seattle-Tacoma, WA	9	Cleveland-Akron-Canton, OH
10	New York-Newark, NY-NJ-CT-PA	10	Pittsburgh-New Castle-Weirton, PA-OH-WV	10	Medford-Grants Pass, OR

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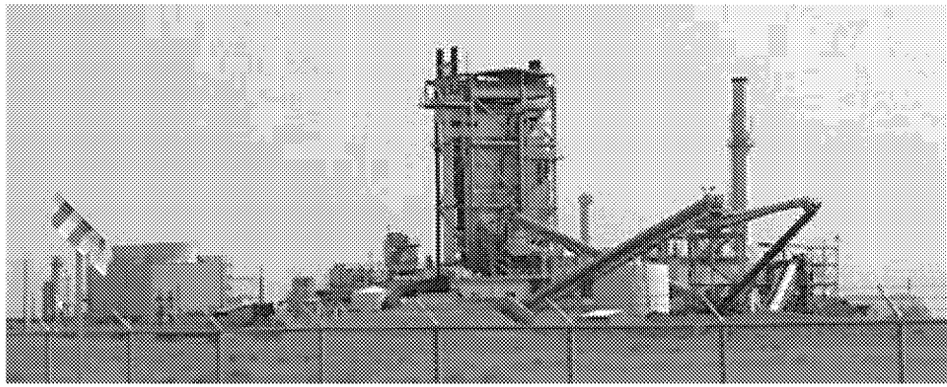
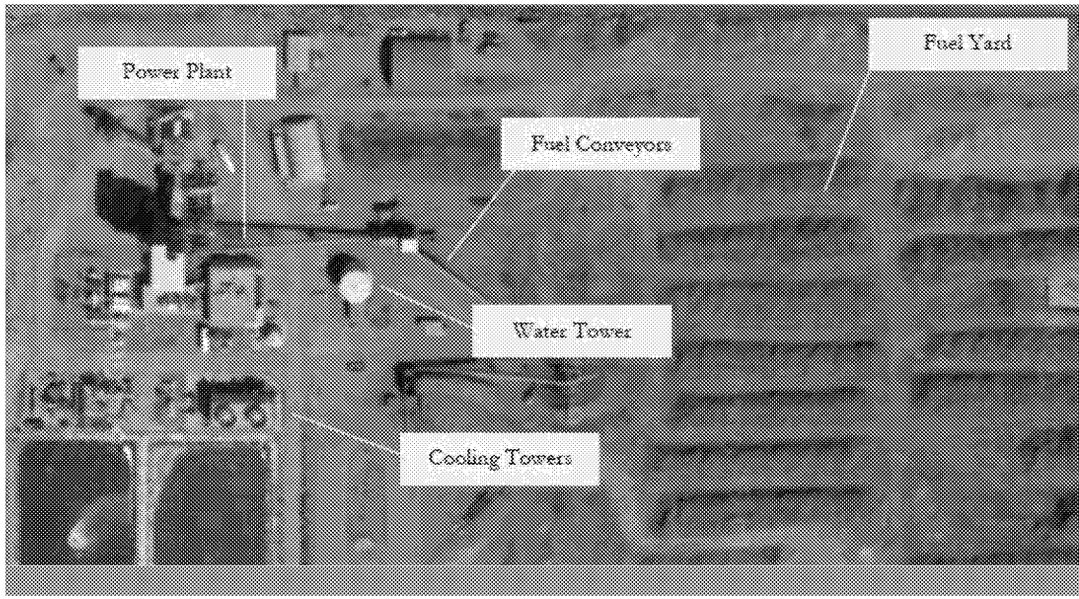
CNE I PROJECT SITE #1

CLEAN ENERGY SYSTEMS

Mendota CNE Plant (Expected Online 2022)

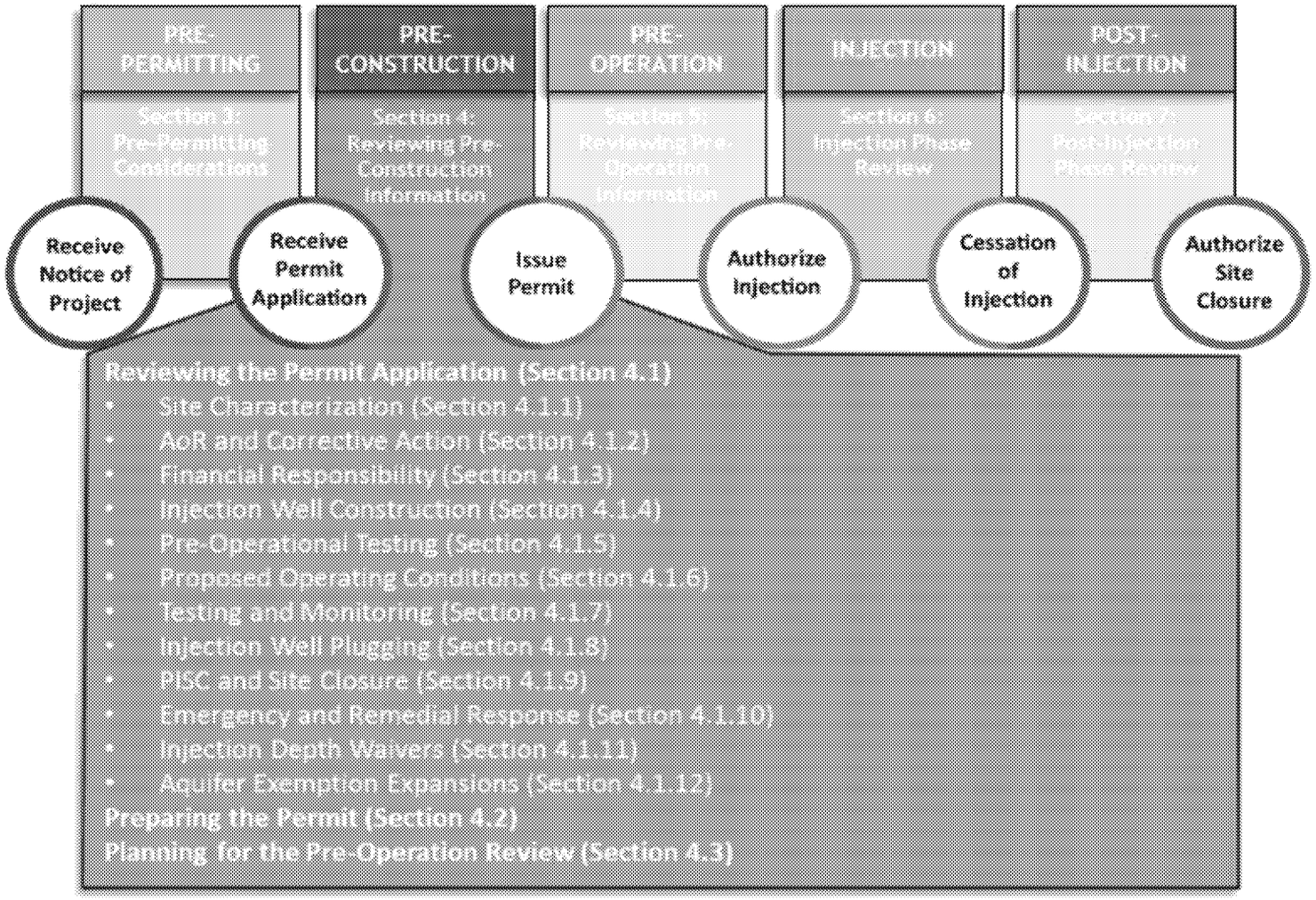
- Former Covanta Biomass Power Plant; operational through 2015
  - In due diligence to acquire site; closing in the next month or two
- 80-acre site on the east side of the City of Mendota (Fresno County); in the heart of the San Joaquin Valley, surrounded by agriculture
- 600 TPD biomass input; local agricultural and urban wood wastes
- Generating up to ~4,000 kg/day renewable H_2 or 6 MW electricity
- Capturing and permanently storing ~1050 USTPD (~950 mTPD) CO_2
  - Removes approx. 350,000 TPY, or 7 million tons of CO_2 from the atmosphere over a 20-year operating life
  - Equivalent to removing more than 68,500 passenger vehicles from the roads each year
- Plant will make use of existing infrastructure including biomass (fuel) handling systems, cooling towers, power and electrical systems
  - Replace existing biomass-fired CFB with gasifier, oxygen supply system, and CES oxy-combustion power block
  - Add CO_2 processing and storage equipment





CNE I MENDOTA PROJECT; EPA PERMITTING PROCESS

CLEAN ENERGY SYSTEMS



- CES Mendota currently in the Pre-Construction phase of EPA permitting process
  - EPA permitting running parallel with other project development activities
- Class VI underground injection control (UIC) permit application submitted in Feb-2020
  - CES working with Schlumberger to develop application material
  - Passed Administrative Review, now under Technical Review
- Models and documents developed using existing public or commercially licensed data; i.e. no wells have been drilled on site
  - Good amount of information available due to past exploration in the region

Clean Energy Systems
EPA Class VI UIC Permit Application Kick Off Meeting for the CES Mendota Site

4/08/2020

Wayne Rowe
Wade Zaluski
Lee Swager
Julian Ogolo

Schlumberger

Schlumberger-Private

Agenda

- Site Location
- Subsurface Geology
- Groundwater Wells
- Simulated CO_2 Plume
- CO_2 Injection Well Construction
- Oil and gas wells within a 2.5 mile radius of the proposed Mendota_INJ_1
- Historical Seismicity

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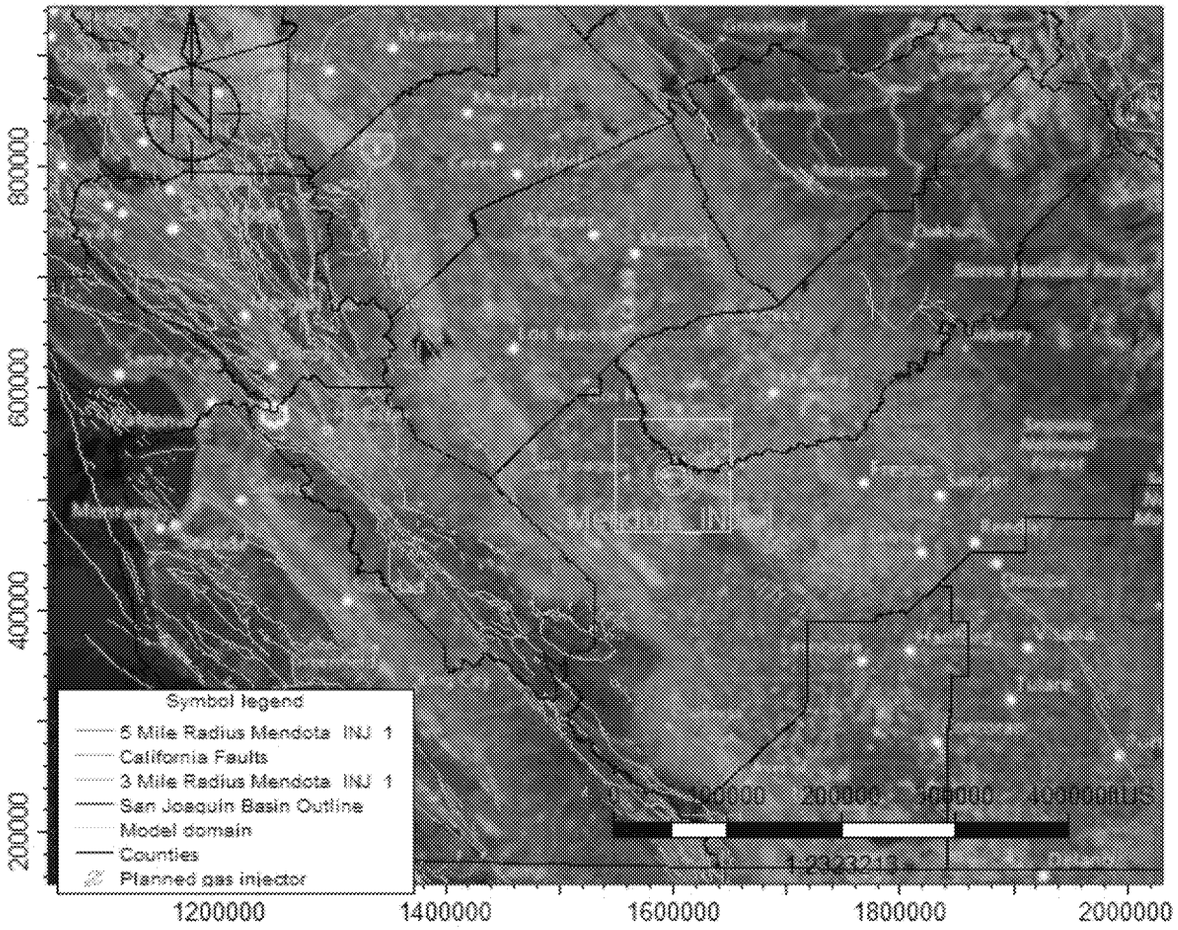
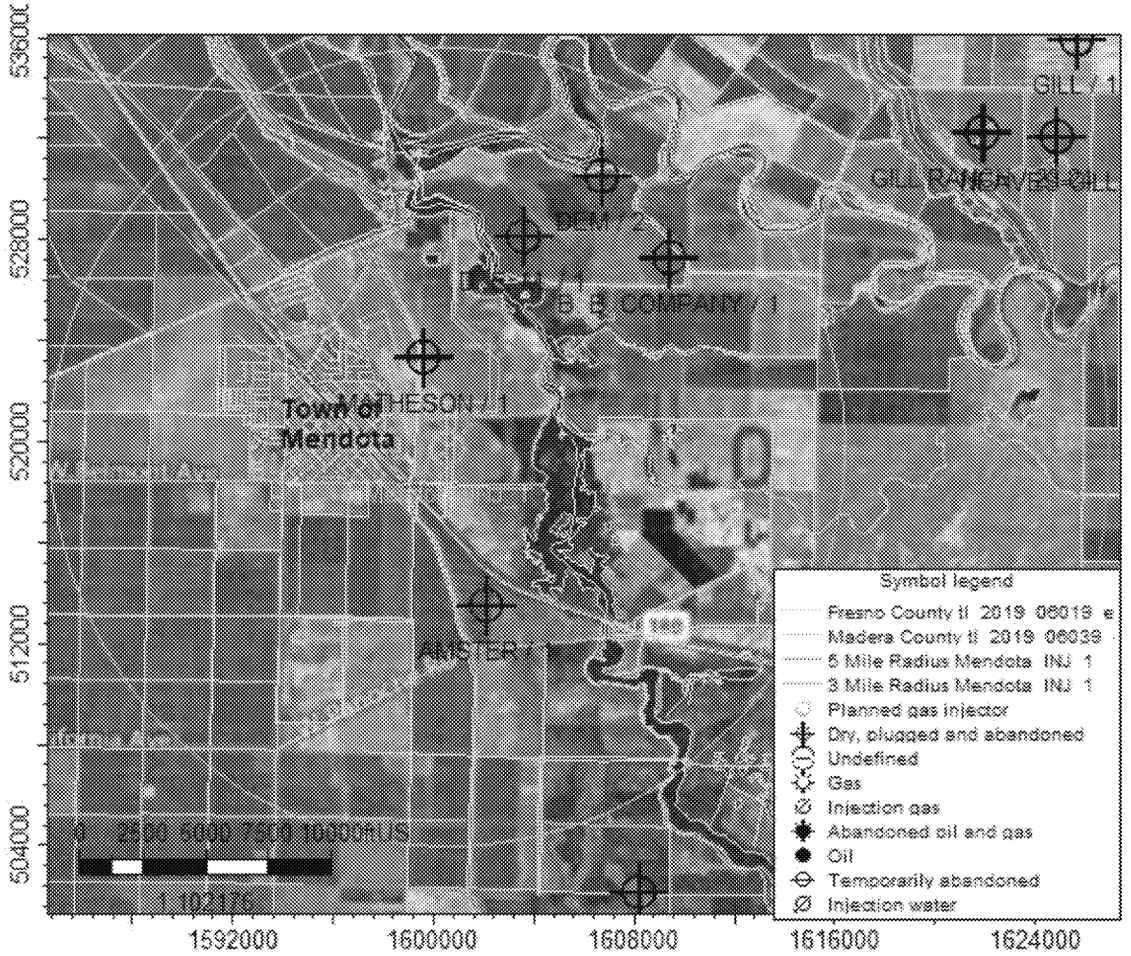
Site Location





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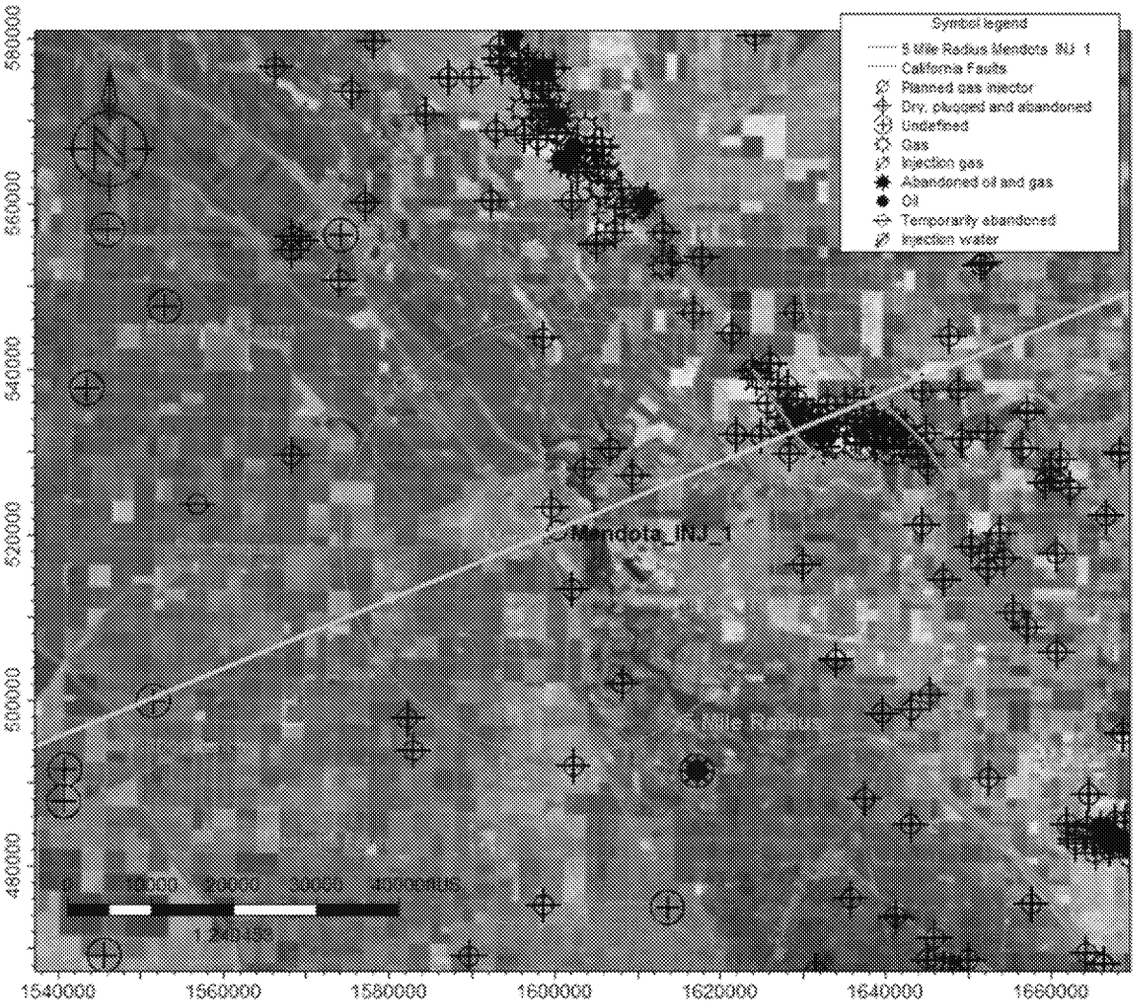
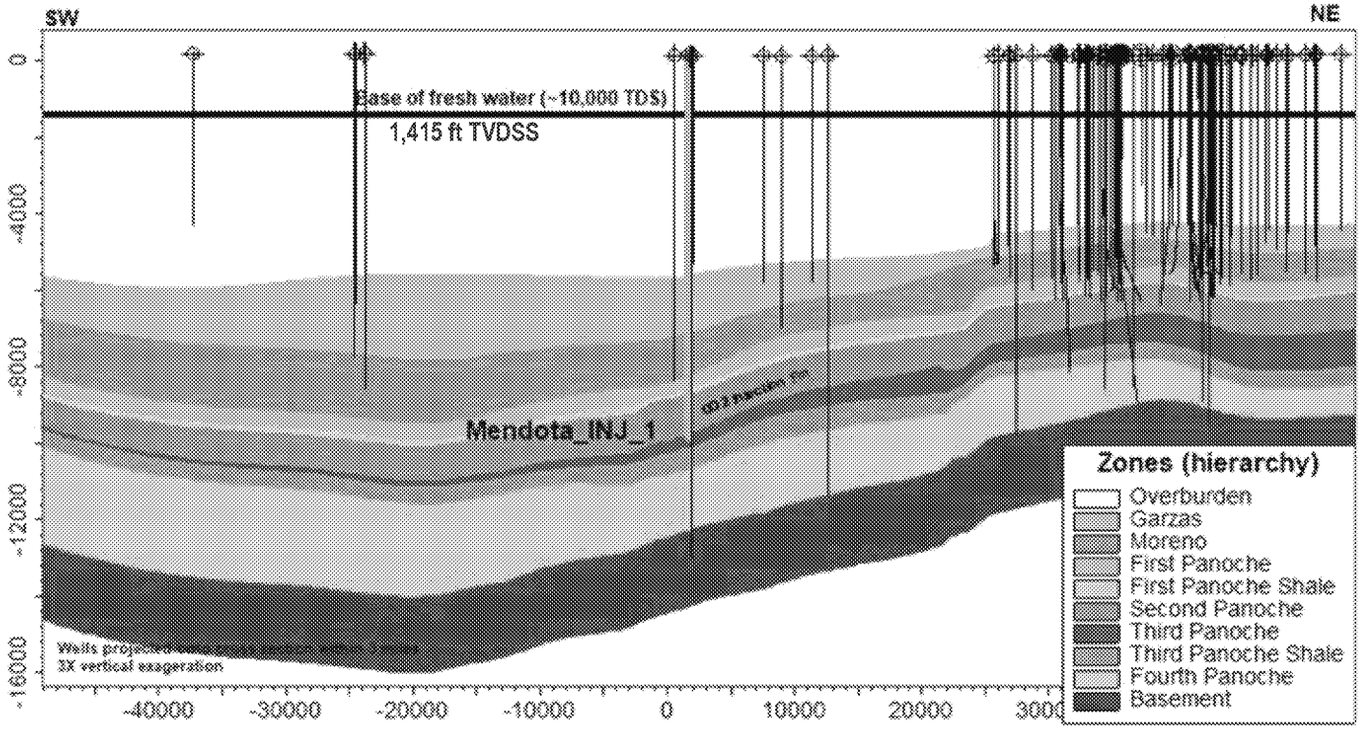
Subsurface Geology





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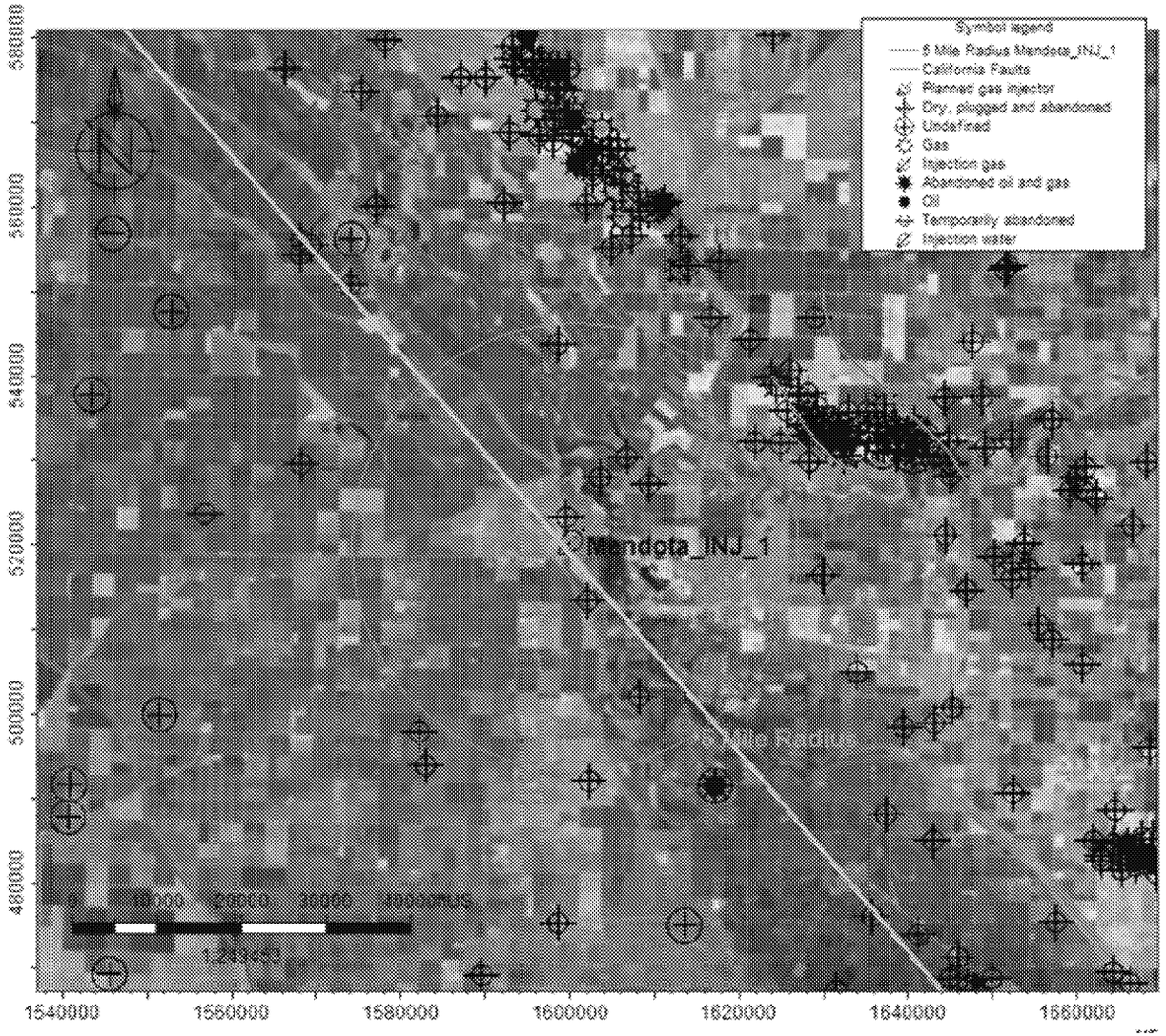
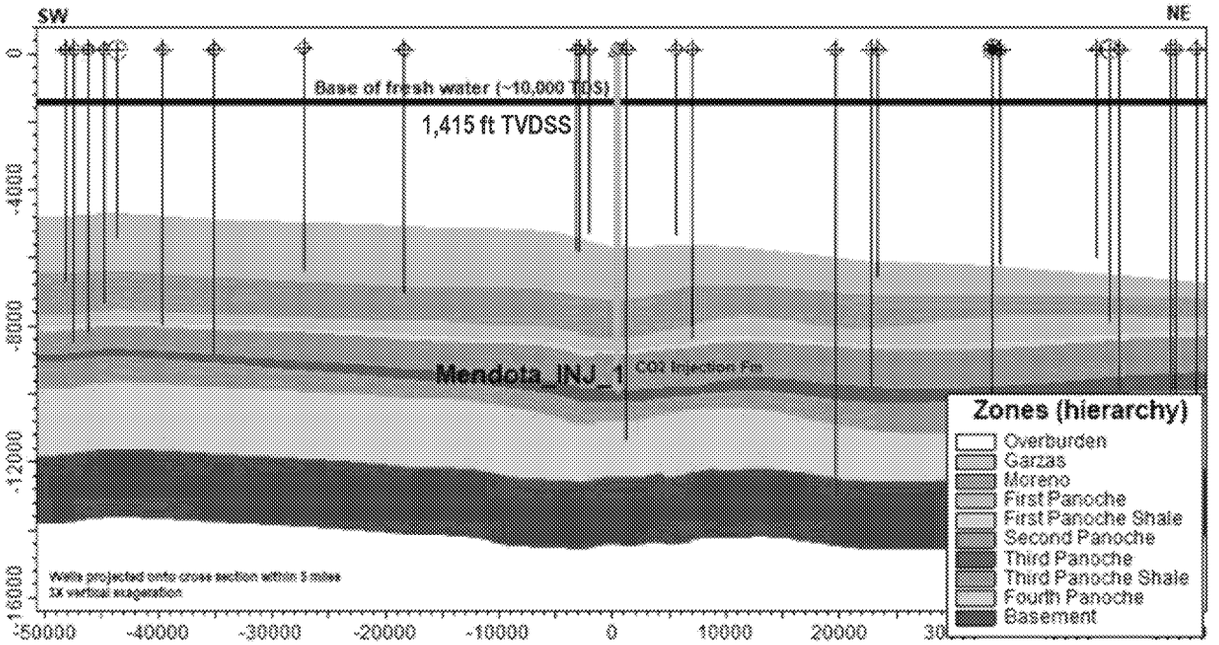
Subsurface Geology





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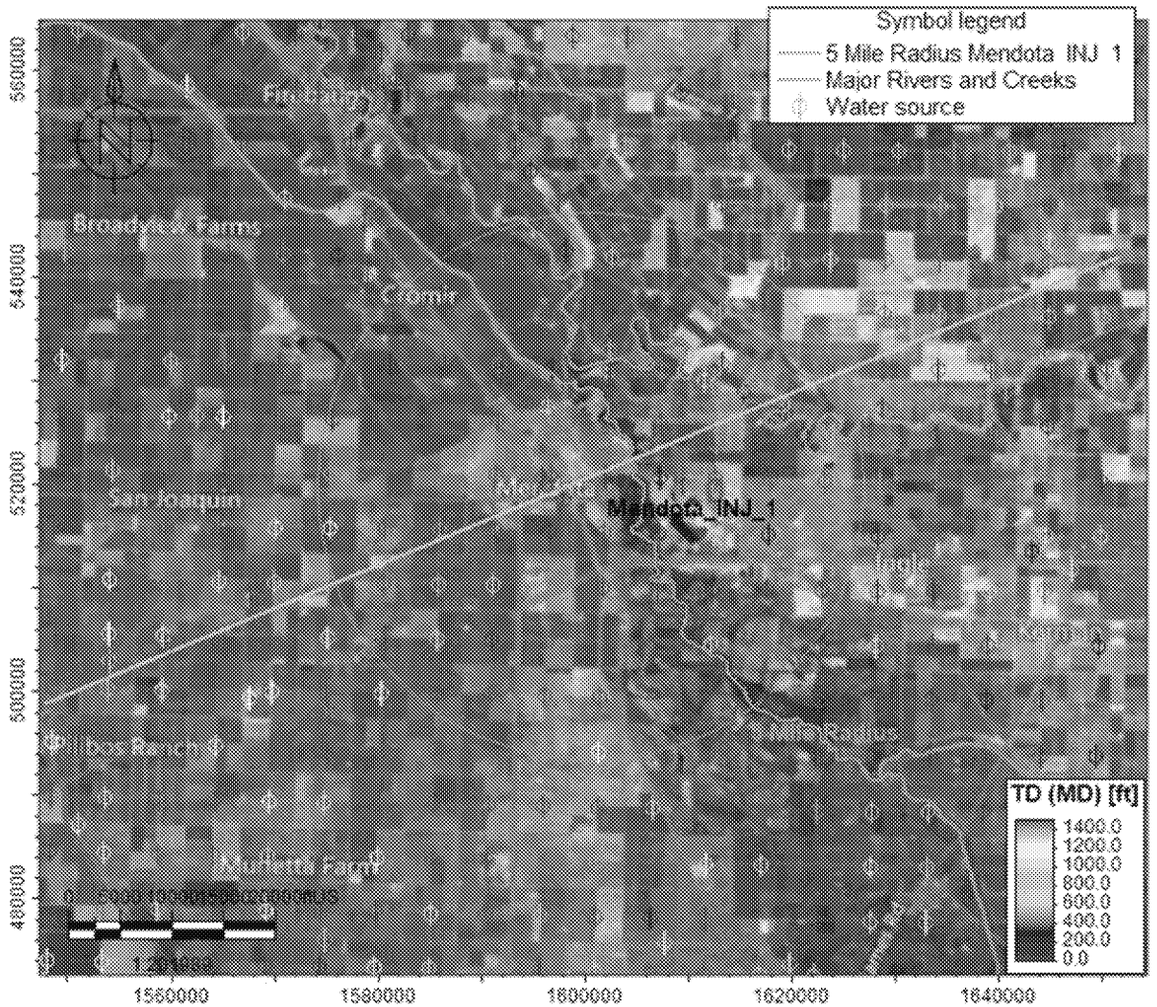
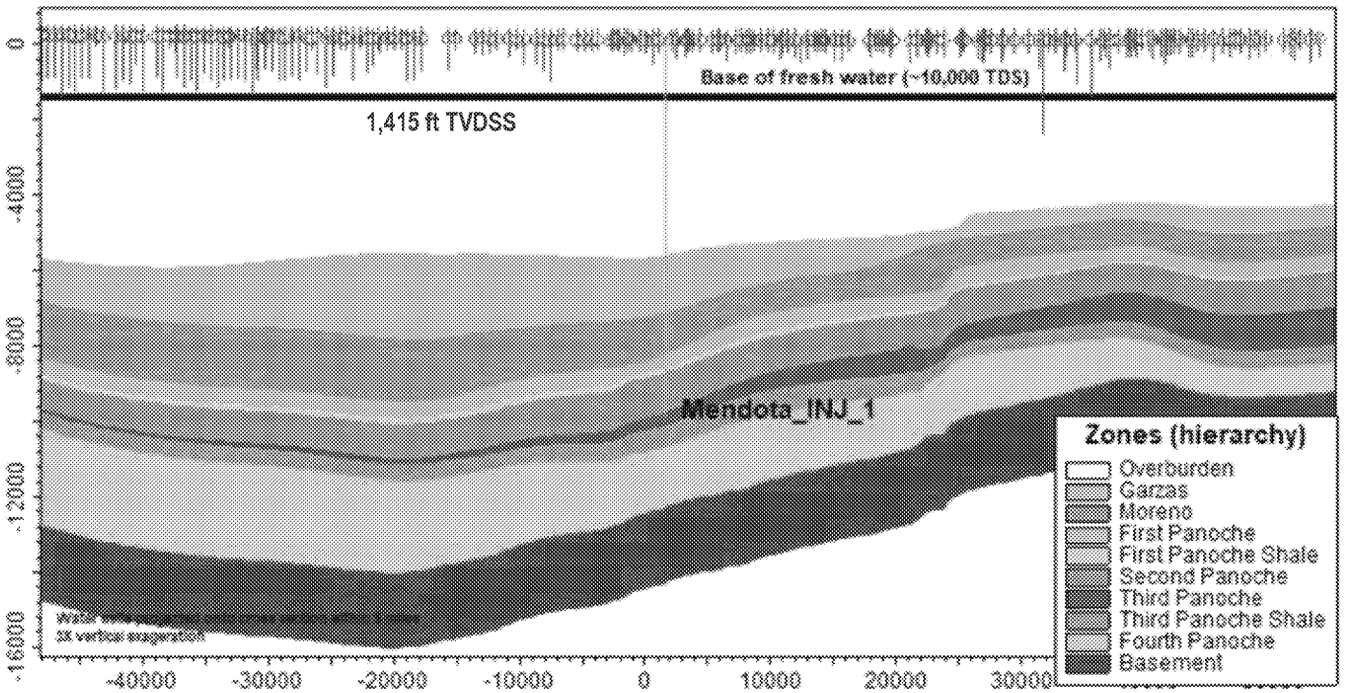
Groundwater Wells



How deep



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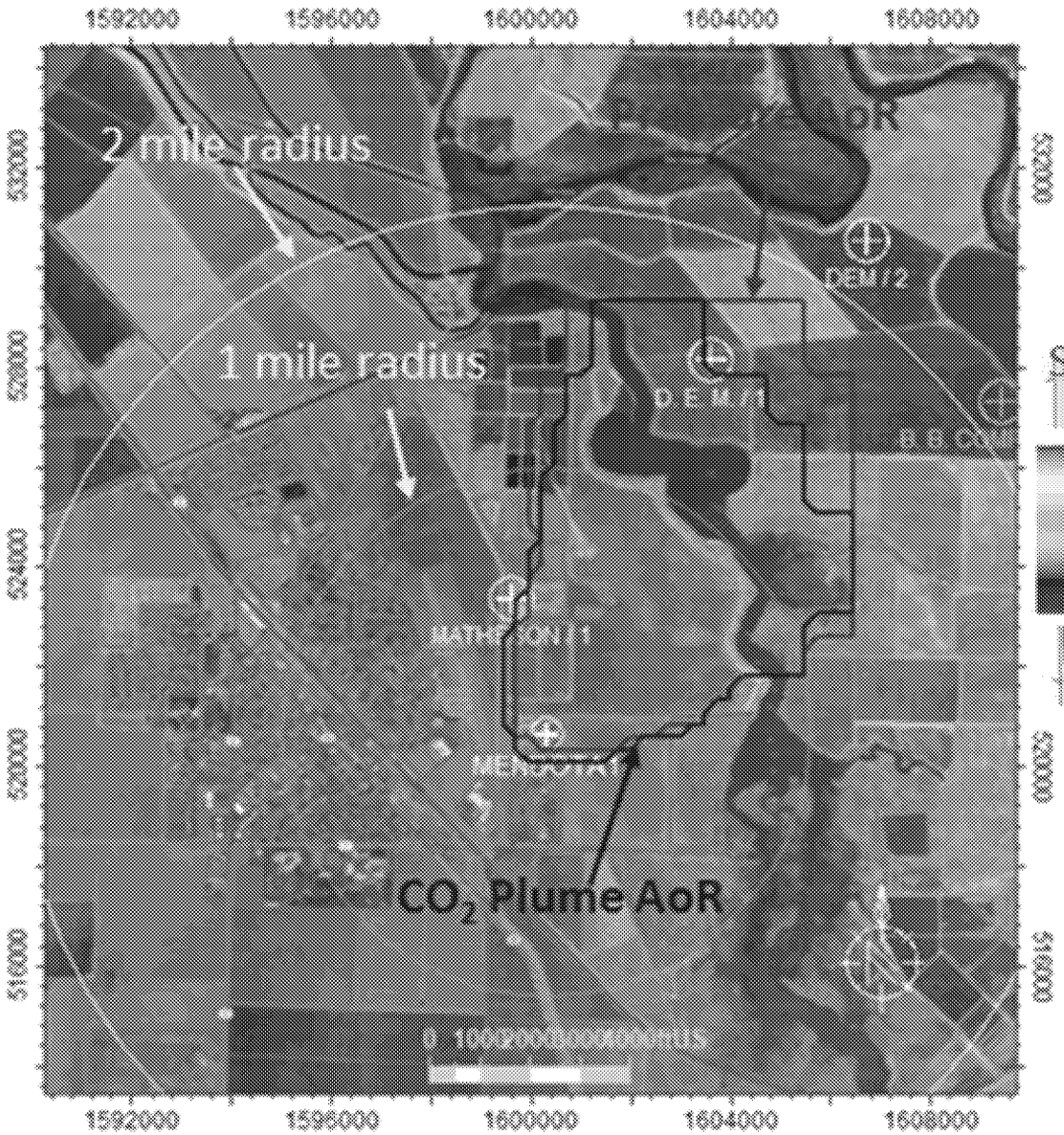
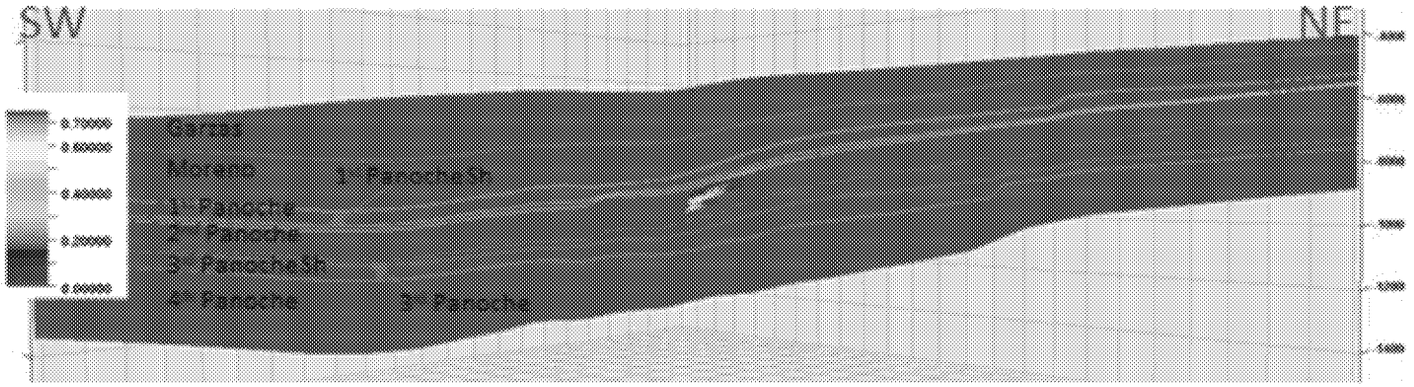
Simulated CO_2 Plume





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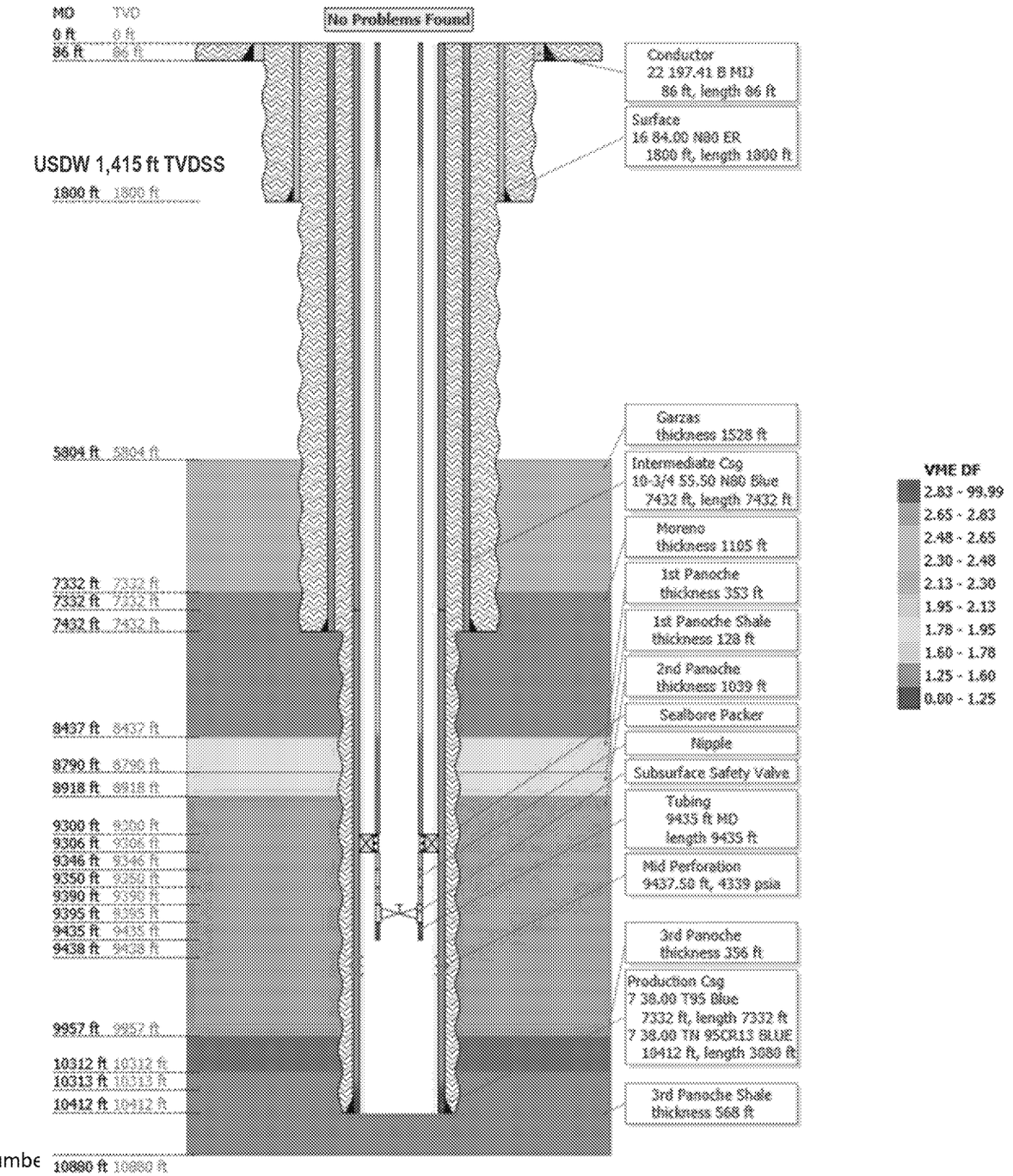
CO_2 Injection Well Construction



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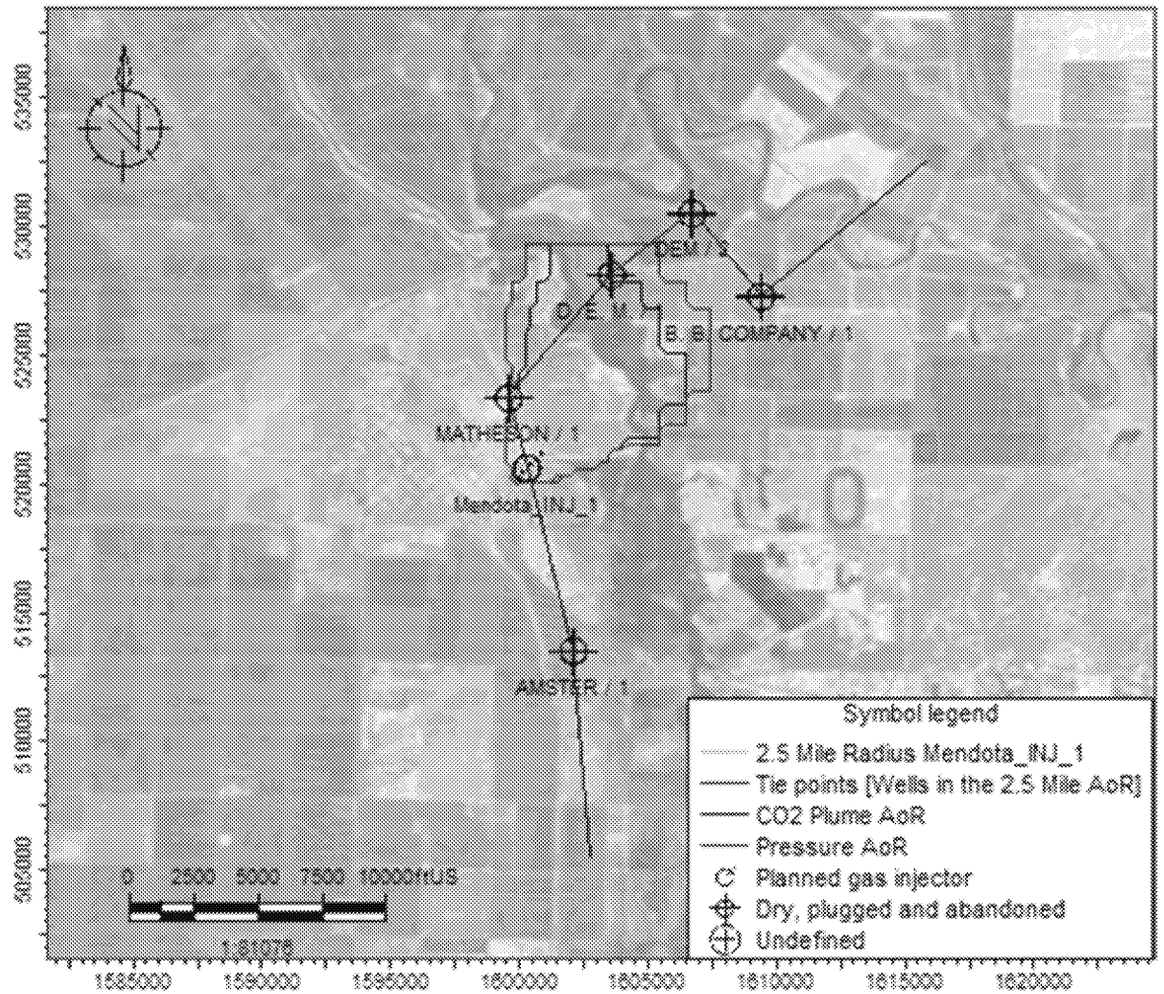
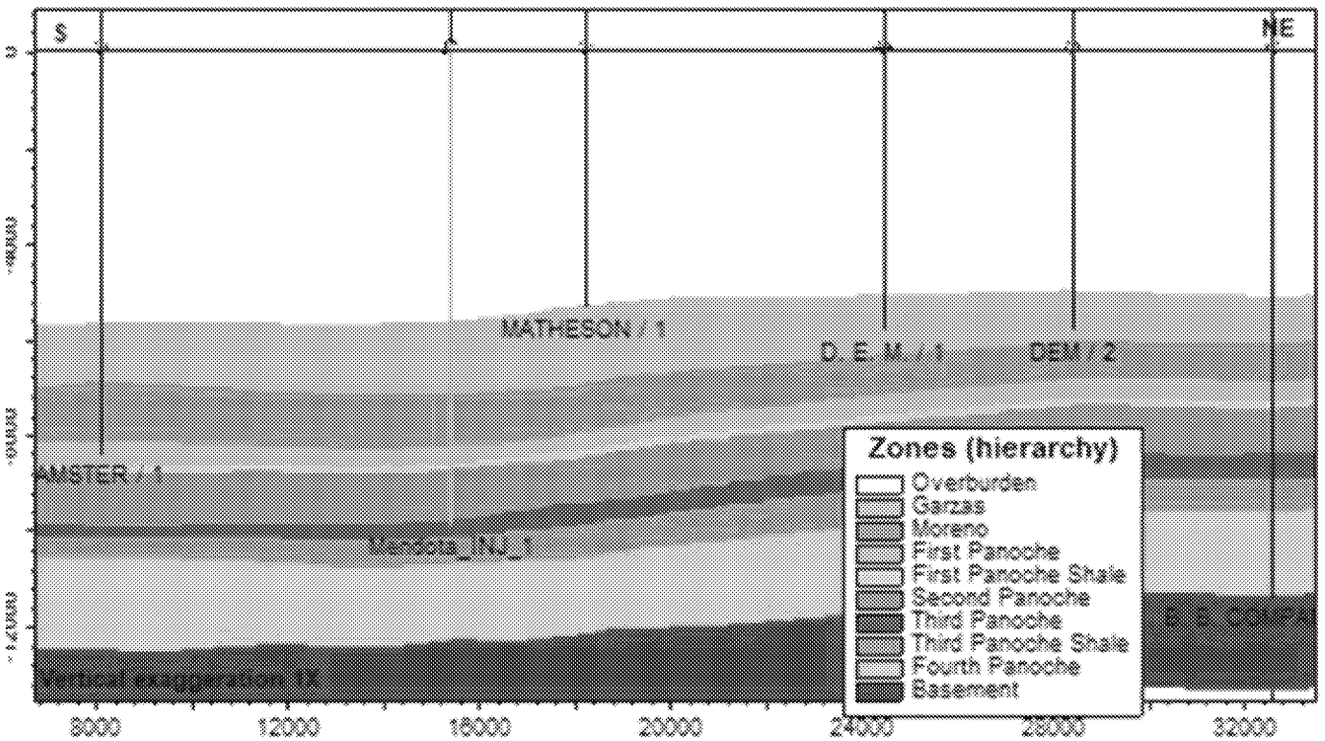
Oil and gas wells within a 2.5 mile radius of the proposed Mendota_INJ_1





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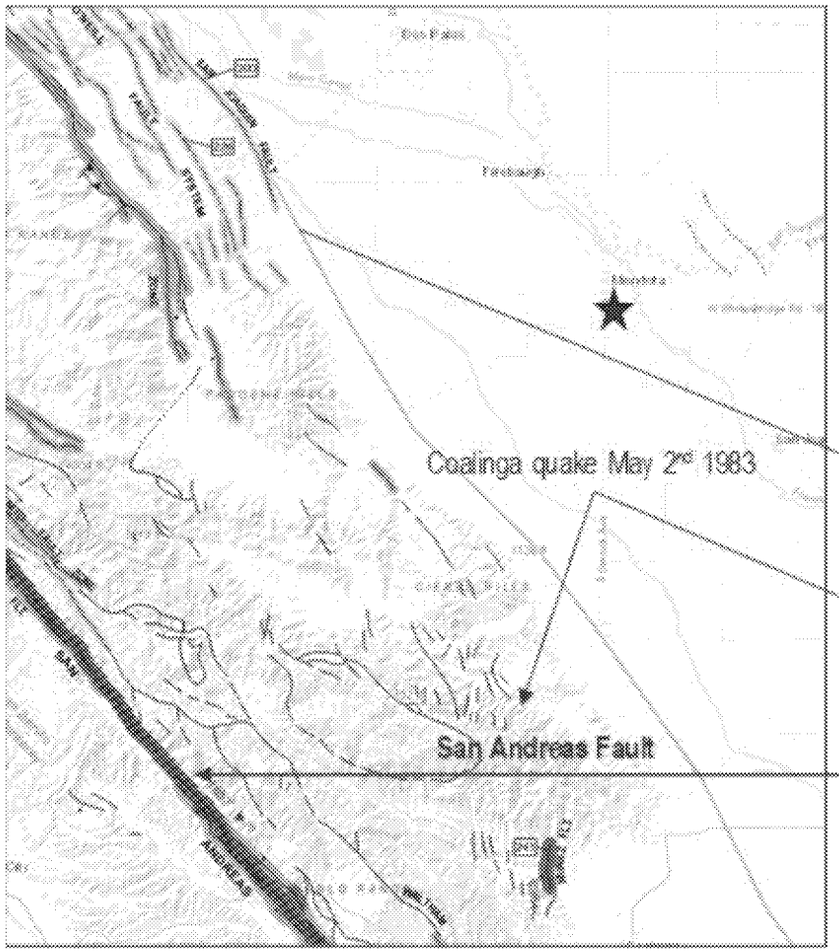
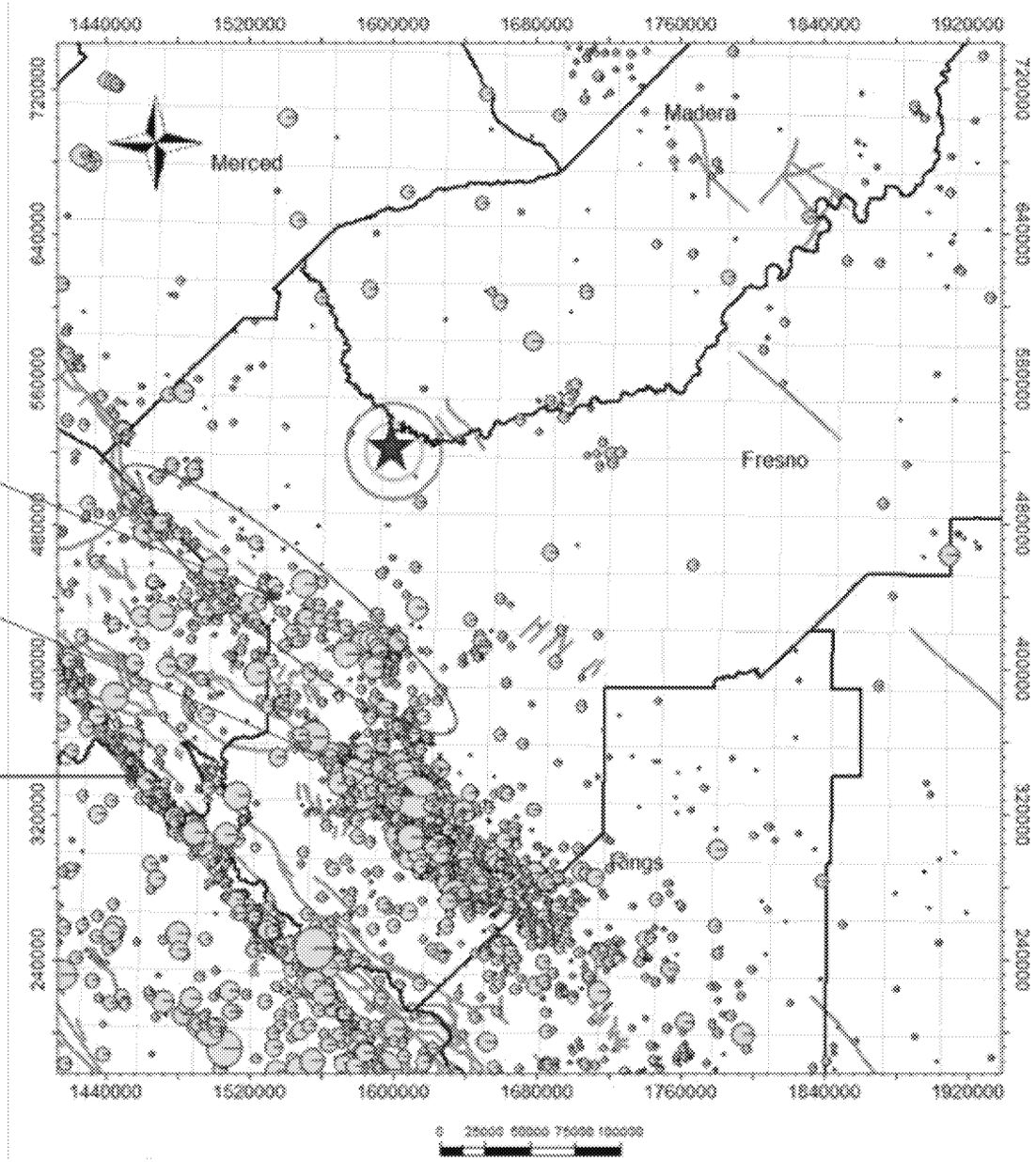
Historical Seismicity





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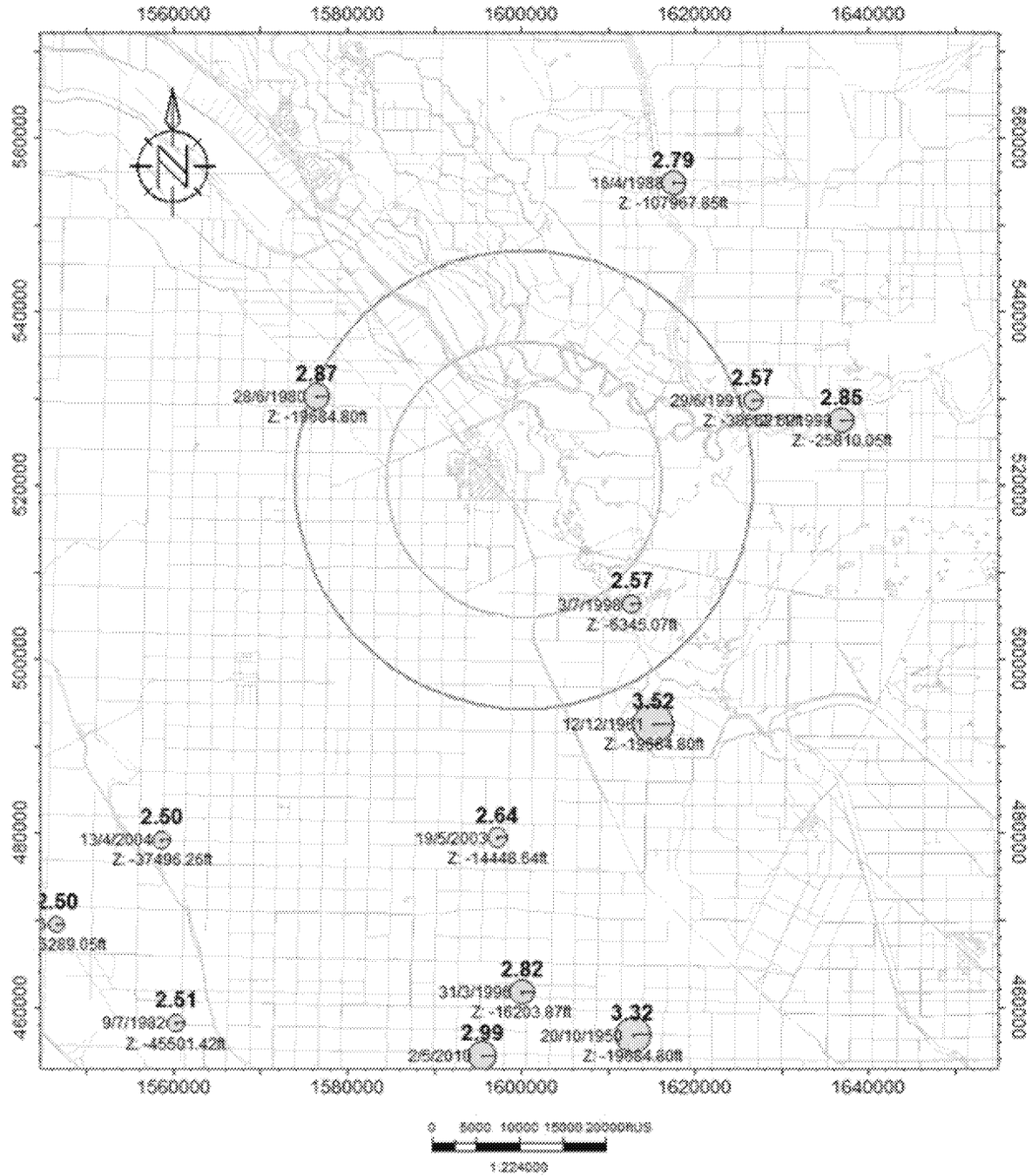
Historical Seismicity



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CNE I SUMMARY & NEXT STEPS

CLEAN ENERGY SYSTEMS

- CES has been working for 25 years to adapt and deploy proprietary oxy-combustion technologies to enable cost-effective carbon capture for sequestration - The Power to Reverse Climate Change
- Currently working to deploy Carbon Negative Energy (CNE) plants across California on a retrofit basis, starting with the Mendota Biomass facility in Fresno County
  - CNE plants have the potential to generate renewable power and/or fuels (i.e. hydrogen) while effectively removing millions of tons of CO_2 from the atmosphere and revitalizing existing assets
- Working with Schlumberger, CES has developed and submitted Class VI UIC permit application to EPA using existing subsurface data; pre-construction application under technical evaluation
- Next steps include:
  - Continue project development activities of the first two CNE project sites, e.g. finalize and secure feedstock and offtake agreements, complete EPC work, secure LCFS pathway, etc.
  - Develop and submit Carbon Capture and Sequestration (CCS) Project application to the California Air Resources Board (CARB)
  - Work with local regulators and representatives on additional permitting and public outreach activities

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Thank You!

For more information, please contact :

Rebecca Hollis, Direct of Business Development - CNE
RHollis@CleanEnergySystems.com
Office: +1 916-638-7967, or visit
www.CleanEnergySystems.com/cne

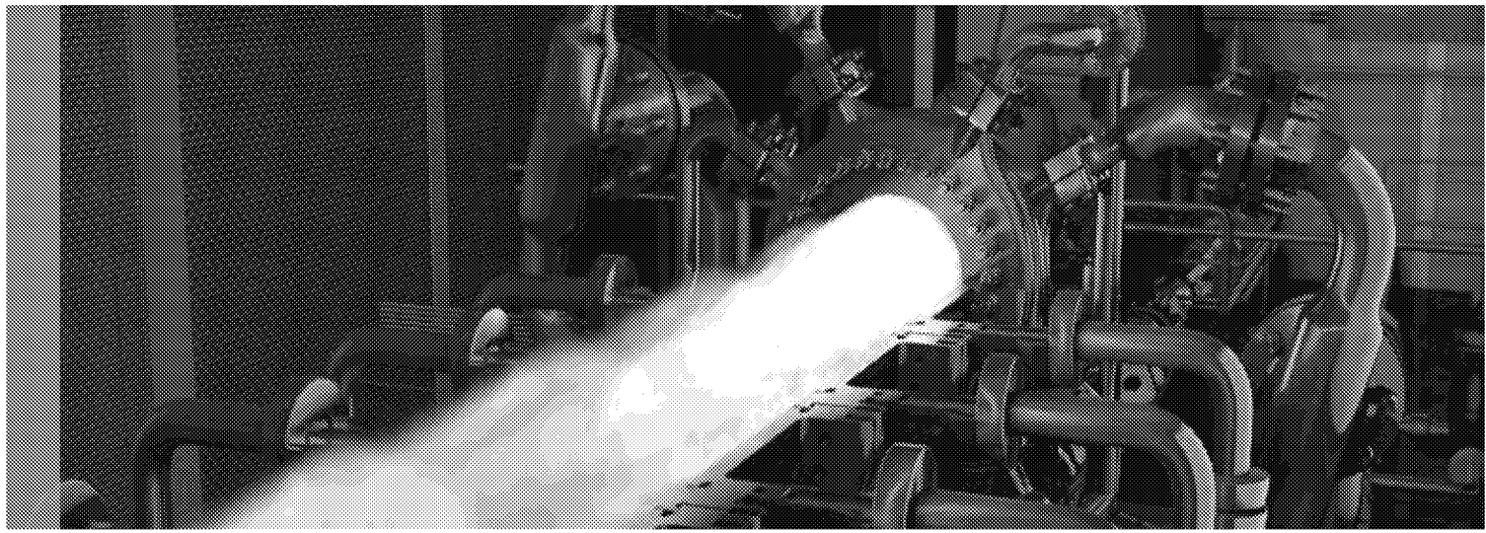
REFERENCE SLIDES

CLEAN ENERGY SYSTEMS

CES ENABLING TECHNOLGY | PRESSURIZED OXY-COMBUSTION

Derived from the American space program, CES combustion systems burn nearly pure oxygen (instead of air) with fuel such as natural gas, associated gas, syngas, high-CO_2 content natural gas, or liquid fuels, for a cleaner, more efficient combustion process

The intimate mixing of gases via unique IP creates combustion with only water (high pressure steam) and CO_2 as its two products which are easily separated for capture and storage



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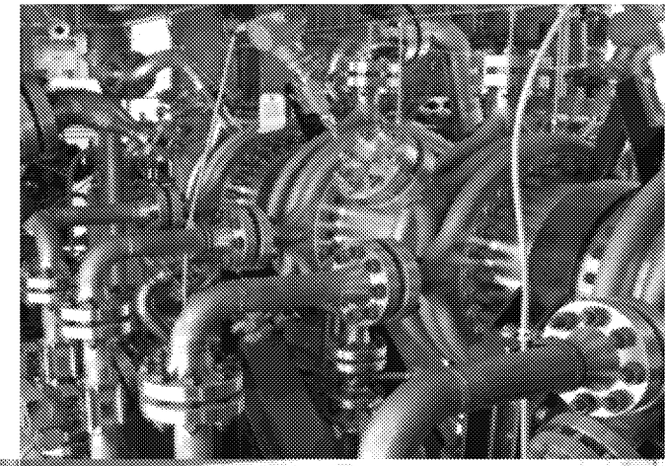
CES I DIRECT STEAM GAS GENERATORS

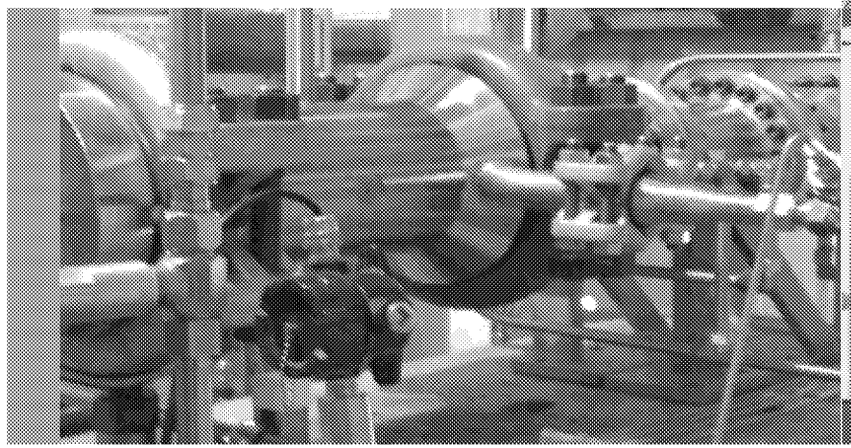
CLEAN ENERGY SYSTEMS

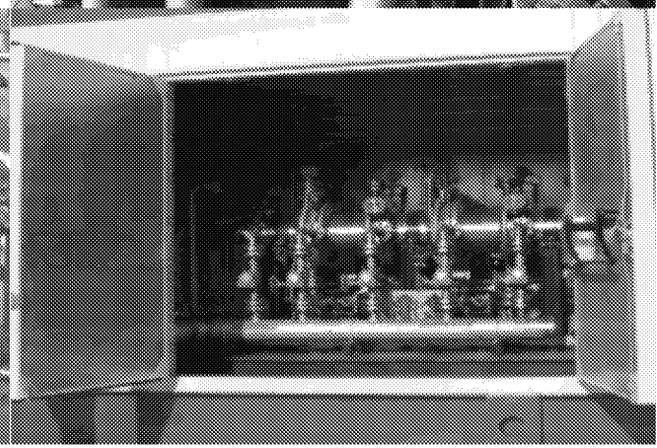
Compact system produces only steam and high purity CO_2 (when burning a hydrocarbon based fuel), and massive amounts of thermal energy

- Current designs with 10 cm (4 inch) or 30 cm (12 inch) internal diameter
- Range from 10 to 200 MWt delivering temperatures up to 1,650 °C (3,000 °F) and capable of pressures over 110 bar (1,600 psi)

- Water injection and jacket cooling incorporated for long life
- Standalone installation-Includes control and monitoring system
- Ramps to full power in seconds







CES I OXY-FUEL TURBINES

CLEAN ENERGY SYSTEMS

With development partners, turbines designed for high-quality steam and high CO_2-content drive gas

- Currently two turbines retrofit; modified for pressurized steam/CO_2 gas
- Removed front-end compressor section and replaced with steam/CO_2 inlet and thrust balance system
- Operate at gas turbine conditions

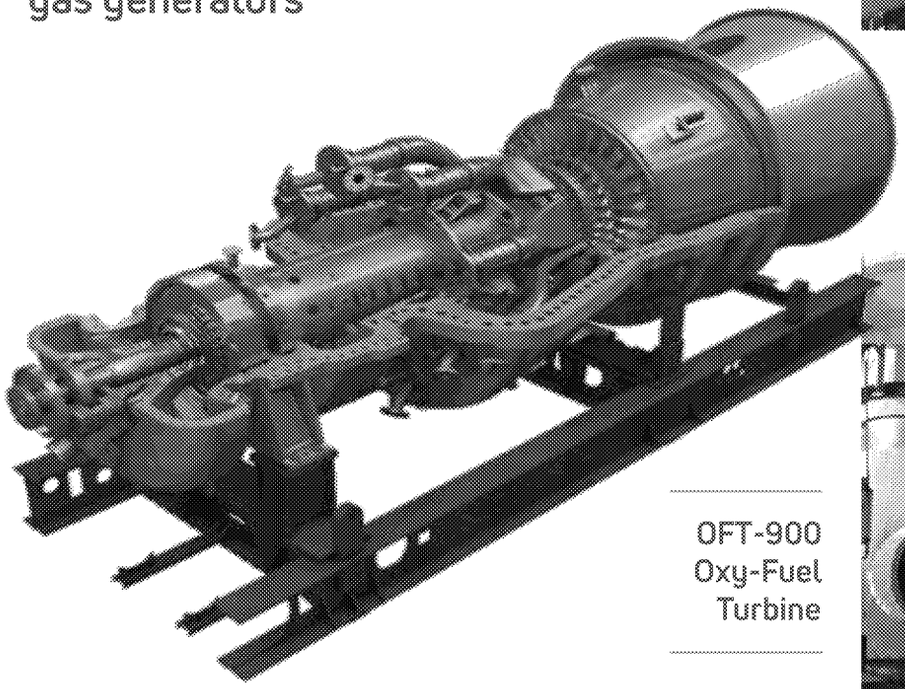
GE J79 retrofit to OFT-J79

- Up to 43 MWe from 12 MWe baseline

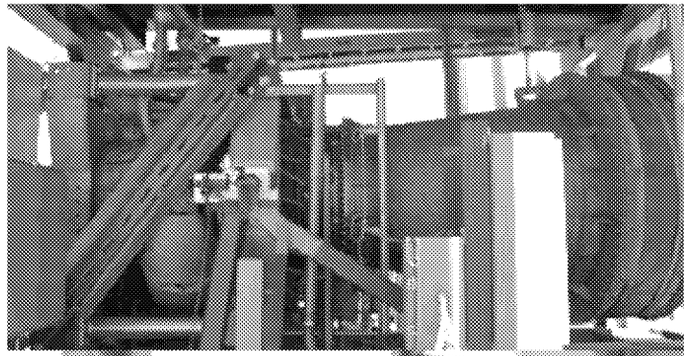
SGT-900 (W251 B12) retrofit to OFT-900

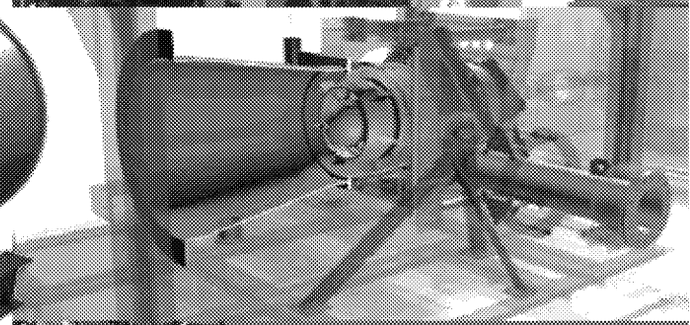
- Up to 150 MWe from 43 MWe baseline
- Makes use of CES reheat combustors
- CES, FTT, and Siemens design

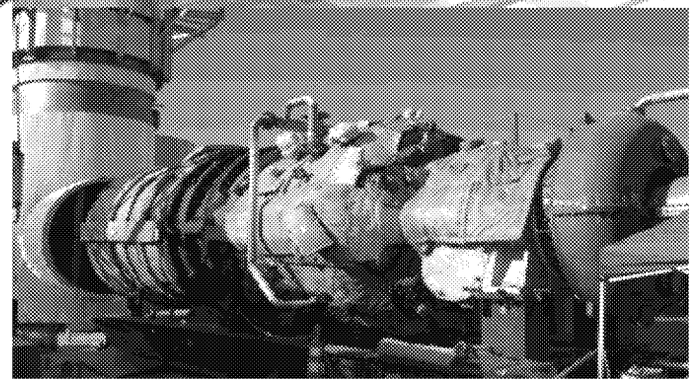
Future potential for new turbine designs matching temperature/pressure profile of CES direct steam gas generators



OFT-J79 Oxy-Fuel Turbine







OFT-900 Oxy-Fuel Turbine

With development partners

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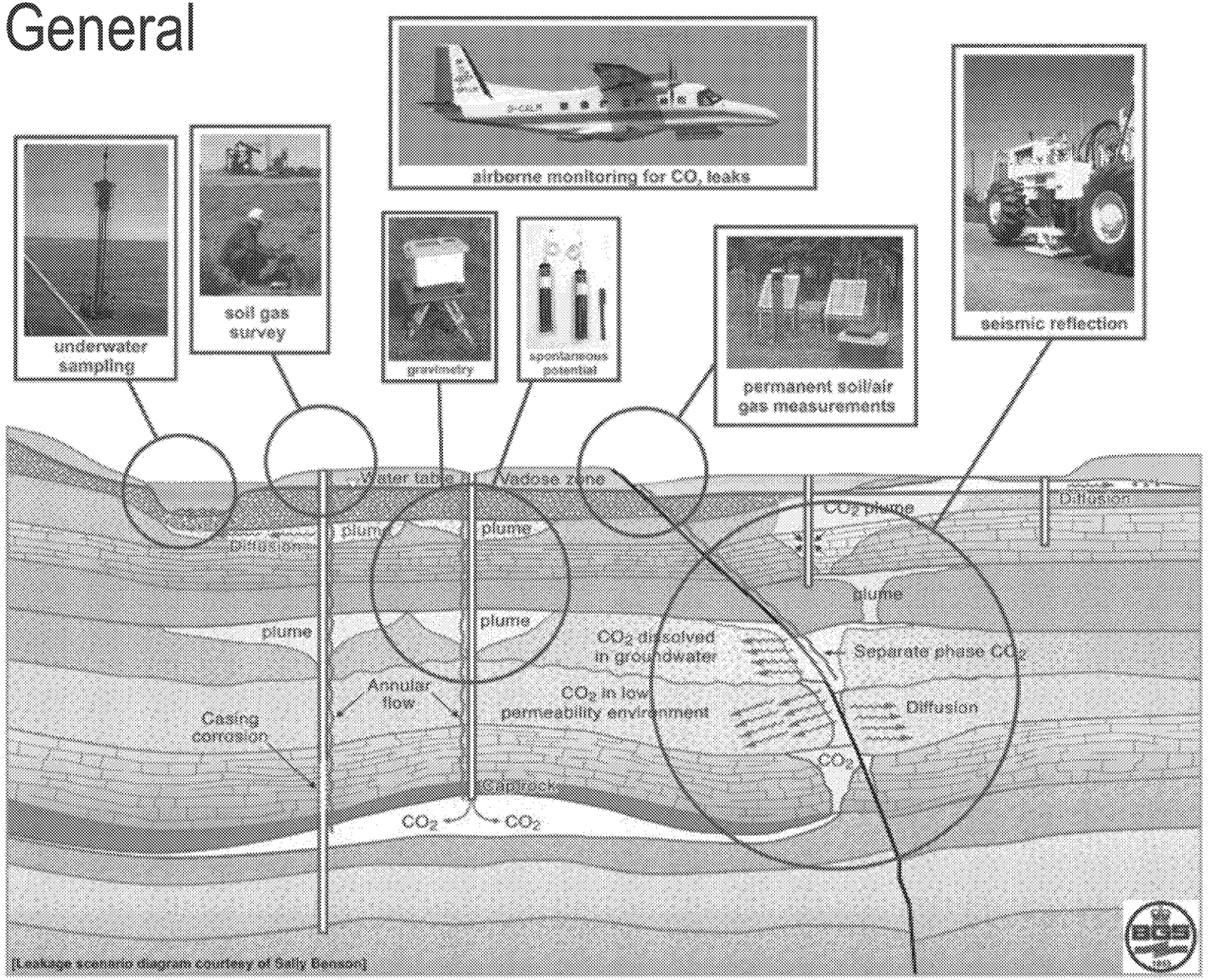
Monitoring - General



Schlumberger

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