UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Mr. Daniel M. Dodd
Chief Technology Officer
Sierra Energy
1222 Research Park Drive
Davis, CA 95618

Re: Applicability of Clean Air Act Other Solid Waste Incinerators Rule, 40 CFR Part 60, Subpart EEEE to FastOx Gasification Biorefinery Pilot Project, Monterey County, CA

Dear Mr. Dodd:

Sierra Energy submitted an External Technical Memo (Memo) to EPA on August 2, 2019, formally requesting a site-specific determination on the applicability of the Standards of Performance for Other Solid Waste Incinerators (OSWI) Rule, 40 CFR Part 60, subpart EEEE to the FastOx Gasification Biorefinery at the Department of Defense (DoD) facility Fort Hunter Liggett (FHL) in Monterey County, California. The request relates to a pilot demonstration gasification system, which converts solid materials into useful fuel and energy products. This pilot demonstration system will be used to test, optimize and validate the FastOx gasification technology. For the reasons set forth below, we conclude that the FastOx Gasification Biorefinery at FHL is not subject to the OSWI Standards of Performance for New Sources (NSPS) because it is not an OSWI unit as defined in the OSWI NSPS.

Background and Description of Process

In the Memo, Sierra Energy provided the following information regarding the installed FastOx Gasification Biorefinery ("FastOx Gasification system"), which includes feed prep and handling, the FastOx Gasifier, FastOx Polisher, air separation unit, recuperator, steam isle, syngas cleaning units, and syngas-to-end product conversion equipment. The process used in the FastOx Gasification system generally includes the gasification of a solid feedstock, composed of wood waste and municipal solid waste (MSW), using a pressurized fixed-bed updraft gasifier ("FastOx Gasifier") to produce synthetic gas (syngas). The syngas will be cleaned and used to generate electricity or Fischer-Tropsch diesel fuel. Any excess clean syngas will be flared. The FastOx Gasification system has a design capacity of 10 metric tonnes per 24 hours of solid feed acceptance. The wood waste to be used for the feedstock is a combination of biomass and waste wood that will have been inspected by the FHL Department of Public Works to verify that there is no treated or painted material in the waste. The MSW to be used in the feedstock is post-recycling MSW residuals generated both off- and on-site of FHL that meet the definition of

MSW in 40 CFR 60.2977[1]. The operators of the unit will conduct a thorough examination of the received material to verify that no recyclable materials, hazardous materials, or materials that could damage the unit are in the MSW feed.

After the solid waste feedstock is examined and prepped, the gasification process begins at the FastOx Gasifier. According to Sierra Energy, the FastOx Gasifier consists of a single, refractory-lined chamber, with no internal moving parts. The solid waste material feedstock is semi-continuously fed into the vessel through an airlock at the top and forms a packed bed where the reactions occur. The inherent design of the FastOx Gasifier (packed-bed updraft configuration) is such that the depth of the solid feed materials is approximately **Ex. 4 CBI** of material residing within the gasifier at any one time. The height of the packed bed is variable, but maintained via the controls system to ensure that it stays within the acceptable range **Ex. 4 CBI** **Ex. 4 CBI** **Ex. 4 CBI** in order to achieve complete conversion of gasification agents, oxygen, and steam to produce syngas. The gasifier is pressurized and heated, through steam and oxygen injection lances, to facilitate gasification. The packed bed material moves slowly downwards by gravity while the syngas produced during gasification rises slowly through the bed, without fluidization, resulting in efficient countercurrent heating and drying. Although the FastOx Gasifier consists of a single, refractory-lined chamber, the gasification process in the FastOx Gasifier can be described as four main reaction zones.

1. Drying Zone: This zone at the top of the gasifier operates between 82°F and 302°F. The syngas produced at the bottom of the gasifier rises and passes through the newly added solid feed materials, drying the solid feed as it passes.

2. Devolatilization Zone: In this zone, most of the volatile organic matter is pyrolyzed into syngas products. The operating temperature is between 302°F and 932°F.

3. Gasification Zone: Oxygen and steam is injected under controlled conditions into this zone to complete the gasification of any residual carbon-containing materials. The operating temperature of this zone is between 3632°F and 4000°F. The steam injected into the system allows the gasification reaction to continue but does not provide enough oxygen to allow combustion. The FastOx Gasifier maintains an Equivalence Ratio (ER) (mole-O2/mole-C) ~0.5, to ensure syngas production from gasification.

4. Melting Zone: The inorganic compounds found in this zone melt due to the high temperatures found in the gasification zone. The inorganic compounds collect at the bottom of the unit and are continuously removed as inert molten stone and alloyed metals. The operating temperature is between 2732°F and 3272°F.

The syngas yield and gasification efficiency is increased through the use of the FastOx Polisher downstream of the FastOx Gasifier. According to Sierra Energy, the purpose of the FastOx Polisher is to further break-down condensable hydrocarbon components (for example: acetic

[1] EPA notes that 40 CFR 60.2977 defines MSW to include wood waste and also specifies that MSW is "collected from" the general public (i.e., where there is a transfer of material from the site at which the material is generated to a separate site where the material is burned.) Because some of the municipal-type waste is generated on-site, it would be "institutional waste" as defined in 40 CFR 60.2977 if it were combusted or incinerated.

acid, ethanol, wax) from the FastOx Gasifier and convert them into additional non-condensable gaseous syngas components (i.e. CO and H_2). The FastOx Polisher achieves this by employing non-catalytic thermal cracking and steam reforming, controlled by steam and oxygen injection. The gas stream is then routed to the recuperator unit which cools the syngas so that it can be handled by the cleaning system, as well as recover heat for reuse within the plant.

The syngas from the recuperator then enters the Cleaning Unit portion of the plant, as described below:

1. Venturi Scrubber: The syngas enters the venturi scrubber at a temperature below 212°F where particulate matter is removed. The scrubber fluid pH and conductivity are monitored to ensure the unit is working properly. A pH control loop and metering pump is used to add sodium hydroxide solution to the system as necessary. A conductivity loop automatically drains scrubber water and adds fresh water as required.

2. Packed Bed Scrubber: The syngas then moves to the packed bed scrubber where a chilled solution over a packed bed is used to remove any excess water and acidic compounds. A heat exchanger is included in the recirculating scrubber solution stream to remove heat that is absorbed by the scrubbing fluids. A pH control loop and metering pump is used to add sodium hydroxide solution to the system as necessary. A conductivity loop automatically drains scrubber water and adds fresh water as required.

3. H_2S Guard Bed: The H_2S Guard Bed will remove the H_2S from the syngas stream via adsorption. As the syngas passes over the bed of iron oxide housed within the vessel, the H_2S will attach itself to the bed and be removed from the syngas stream.

4. Syngas Blower: A pressure control loop varies the motor speed of the blower in order to maintain 3 PSIG at the syngas header.

5. Carbon Bed: Any remaining organic compounds will be removed as it goes through this last part of the Cleaning Unit.

The final step is to convert the clean syngas to its end products. The clean syngas enters the low-pressure syngas header where it is either sent to a Siemens-Guascor genset for electricity production, converted to diesel fuel via the Fischer-Tripsch process, or routed to the FastOx Gasifier unit as auxiliary fuel. Oxy-fuel burners that utilize liquified petroleum gas or FastOx Syngas are used to pre-heat the refractory-lined FastOx Gasifier and Polisher vessels during start up. In addition, these burners can be used to raise or lower the heat to control the reaction to maximize and/or maintain syngas production. Any excess syngas is oxidized in an enclosed flare rated at 10 MMBTU/hr.

In emails sent to the U.S. Environmental Protection Agency on February 27, June 18, and July 10, 2020, Sierra Energy provided additional information detailing how the updraft FastOx Gasifier is monitored to maximize syngas generation (CO and H_2) over combustion products (CO_2 and H_2O). According to Sierra Energy, the FastOx Gasifier uses over 1,400 sensors monitoring process variables in real-time, including temperature sensors, a multigas analyzer and paramagnetic analyzer, which provide redundant sampling and measurement of the composition of the syngas at the exit of the FastOx Gasifier at a rate of up to once per second. These

analyzers continuously monitor the concentration of several compounds including O_2, H_2, CO, CO_2, CH_4, and C_3H_8. The feedback from these analyzers and temperature sensors in the gasifier is used to adjust the inlet flow of steam and oxygen into the gasifier and maximize the syngas yield and syngas energy content. This feedback-controlled process, in addition to the maintaining optimal bed height and temperature profile, is vital to ensure gasification takes place instead of combustion, and in effect maximizes gasification yields. Additionally, Sierra Energy provided approximate oxygen levels for the zones identified above. The O_2 levels are maintained below 0.5% by volume, except in a portion of the gasification zone where steam and oxygen are injected in a controlled manner to facilitate the gasification. In this zone the oxygen levels can reach 50-60%. The O_2 content of the exit gas is measured using a multigas analyzer and paramagnetic analyzer located at the exit of the FastOx Gasifier to ensure sufficient O_2 content to oxidize the char but not enough to convert CO to CO_2. Sierra Energy explained that any small increase in CO_2 with a corresponding decrease in CO and H_2 observed by the controls system triggers adjustments to oxygen input to avoid deviating far from the 'optimum syngas generation operating setpoints'. Deviations are mitigated before reaching combustion conditions.

Ex. 4 CBI

Ex. 4 CBI The depth of the fixed bed is important to ensure that the equilibrium reactions in the gasification zone are driven towards CO and H_2, by excess residual solid feed materials. To ensure excess residual solid feed materials, the bed height is measured in real-time to ensure the bed height is maintained above a minimum level **Ex. 4 CBI**

Regulatory Background

The OSWI rule applies to new OSWI incineration units. See 40 CFR 60.2885 and 60.2886. An OSWI unit per 40 CFR 60.2977 means:

> "…a very small municipal waste combustion unit or an institutional waste incineration unit, as defined in this subpart…While not all OSWI units will include all of the following components, an OSWI unit includes, but is not limited to, the municipal or institutional solid waste feed system, grate system, flue gas system, waste heat recovery equipment, if any, and bottom ash system. The OSWI unit does not include air pollution control equipment or the stack. The OSWI unit boundary starts at the municipal or institutional waste hopper and extends through two areas:
>
> 1. The combustion unit flue gas system, which ends immediately after the last combustion chamber or after the waste heat recovery equipment, if any; and
>
> 2. The combustion unit bottom ash system, which ends at the truck loading station or similar equipment that transfers the ash to final disposal. The OSWI unit includes all ash handling systems connected to the bottom ash handling system."

Additionally, 60.2977 states that a very small municipal waste combustion unit means "any municipal waste combustion unit that has the capacity to combust less than 35 tons per day of municipal solid waste…" and an institutional waste incineration unit means "any combustion

unit that combusts institutional waste (as defined in this subpart) and is a distinct operating unit of the institutional facility that generated the waste…"

Municipal Solid Waste is defined in 60.2977 as:

> "…refuse (and refuse-derived fuel) collected from the general public and from residential, commercial, institutional, and industrial sources consisting of paper, wood, yard wastes, plastics, leather, rubber, and other combustible materials and non-combustible materials such as metal, glass and rock, provided that:
>
> 1. The term does not include industrial process wastes or medical wastes that are segregated from such other wastes; and
>
> 2. An incineration unit shall not be considered to be combusting municipal solid waste for purposes of this subpart if it combusts a fuel feed stream, 30 percent or less of the weight of which is comprised, in aggregate, of municipal solid waste, as determined by 60.2887(b)[2]."

Solid waste also is defined in 60.2977, in relevant part, as "any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous materials…," where contained gaseous material is defined as "gases that are in a container when that container is combusted."

Institutional waste is defined in 60.2977, in relevant part, as "solid waste that is combusted at any institutional facility using controlled flame combustion in an enclosed, distinct operating unit… Institutional waste also means solid waste combusted on site in an air curtain incinerator that is a distinct operating unit of any institutional facility."

The preamble to the final rule discusses that certain combustion devices (e.g. thermal oxidizers) may combust uncontained gases (generally from industrial processes) instead of solid waste, in which case they would not be subject to the final OSWI rules. The preamble to the final rule also describes gasification as a "technolog[y] that [is] specifically designed to prevent combustion reactions, and, instead are used to produce fuel or chemical feedstocks via controlled chemical reactions." See 70 FR 74876-74877.

<u>EPA Analysis and Determination</u>

In Sierra Energy's Memo, they state that the FHL Gasification Biorefinery was constructed after December 9, 2004 and will accept solid waste generated both off- and on-site of FHL. In addition, the Memo states that the unit is located at the DoD facility FHL; therefore, it is a distinct operating unit of an institutional facility.

Based on the information provided by Sierra Energy and as described above, EPA believes that the FastOx Gasifier of the FastOx Gasification system is designed and operated to ensure the gasification of the feedstock to produce a syngas. EPA understands that gasification by itself is

[2] As discussed in the body of the letter, we do not believe the FastOx system is an OSWI unit. Therefore, it is not necessary to determine if it combusts greater than 30% MSW.

not combustion, and as discussed above, we describe gasification as a "technolog[y] that [is] specifically designed to prevent combustion reactions, and, instead is used to produce fuel or chemical feedstocks via controlled chemical reactions." Since the desired outcome is the production of syngas to be used as a fuel and/or chemical feedstock (i.e. in the Siemens-Guascor genset for electricity production and/or conversion to diesel fuel via the Fischer-Tropsch process), the process is controlled and optimized to prevent the production of combustion products.

40 CFR 60.2977 states that "pyrolysis/combustion" units are a type of "municipal solid waste incinerator" and the definition of institutional waste incinerator (IWI) includes "custom built incineration units operating with starved…air." While "pyrolysis/combustion" unit is not defined in 60.2977, the preamble to the final rule states that pyrolysis/combustion units are two chamber incinerators with a starved air primary chamber followed by an afterburner to complete combustion and are considered OSWI units. See 70 FR 74876-74877. As described in the Memo, the FastOx does not meet this definition. Instead, the FastOx system consists of the gasifier followed by the polisher and recuperator unit operations. After the polisher and recuperator operations, the syngas is routed through several cleaning operations before being routed for energy production or conversion to diesel fuel.

Regarding applicability to OSWI as an IWI, the facility-generated waste used in the FastOx Gasification system is not combusted using controlled flame, or incinerated in an air curtain incinerator, therefore the on-site generated waste used in the FastOx Gasification system does not meet the definition of institutional waste as defined in 60.2977.

Regarding the remaining syngas that is flared, Subpart EEEE applies to the combustion of solid waste. According to the definition in 40 CFR 60.2977, solid waste includes, in relevant part solid, liquid, semisolid, or contained gaseous materials. While derived from solid waste, the syngas is not a solid, liquid, semisolid, or a contained gaseous material, since it is not in a container when combusted in the flare. Therefore, Subpart EEEE does not apply to the flare. Finally, some portion of the syngas will be used as auxiliary fuel in the oxy-burners and as fuel in the Siemens-Guascor genset for electricity production. In order to be used as fuel, it is expected the syngas fuel would meet the legitimacy criteria for non-waste fuel found in 40 CFR 241.3(d)(1).[3] This non-waste fuel determination is self-implementing and does not require a determination from EPA.

Based on the information provided to the EPA by Sierra Energy, we conclude that the FastOx Gasification Biorefinery located at FHL does not combust solid waste and is therefore not an OSWI unit as defined at 40 CFR §60.2977. Accordingly, it is not subject to the OSWI NSPS. If

[3] Legitimacy criteria for non-hazardous secondary materials used as a fuel in combustion units include the following: (i) The non-hazardous secondary material must be managed as a valuable commodity based on the following factors:(A) The storage of the non-hazardous secondary material prior to use must not exceed reasonable time frames;(B) Where there is an analogous fuel, the non-hazardous secondary material must be managed in a manner consistent with the analogous fuel or otherwise be adequately contained to prevent releases to the environment;(C) If there is no analogous fuel, the non-hazardous secondary material must be adequately contained so as to prevent releases to the environment;(ii) The non-hazardous secondary material must have a meaningful heating value and be used as a fuel in a combustion unit that recovers energy.(iii) The non-hazardous secondary material must contain contaminants or groups of contaminants at levels comparable in concentration to or lower than those in traditional fuel(s) that the combustion unit is designed to burn.

any changes are made to the FastOx Gasification system, a new applicability determination may be required.

This determination was coordinated with EPA's Office of Enforcement and Compliance Assurance, the Office of Air Quality Planning and Standards, the Office of Land and Emergency Management, Region IX's Enforcement and Compliance Assurance Division, and Region IX's Office of Regional Counsel. If you have any questions regarding this letter, please contact Mario Zuniga of my staff at (415) 947-4282 or zuniga.mario@epa.gov.

Sincerely,

ELIZABETH ADAMS

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Date: 2020.07.31 12:29:51 -07'00'

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Director, Air and Radiation Division

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