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Utilization of waste resources for renewable hydrogen production

Additional submitted attachment is included below.

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Response to CEC 16-ALT-02
"2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program"

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Category: Producer of clean renewable energy from waste

Dear ARFVTP team:

My colleagues and I at Sierra Energy, waste to renewable energy company based in Davis, CA, thank you for the opportunity to submit comments regarding your proposed ARFVTP 2017-2018 Investment Plan. The ARFVTP program sets the bar for state initiated, strategic investments of alternative fuels and vehicles, helping Sierra Energy and many others bridge the gap from early R&D to early commercialization. ARFVTP has great merit and benefit to taxpayers, enabling commercialization of clean fuels and vehicles, reducing dependence on fossil fuels, reducing GHG emissions, and improving air quality and economic opportunities in California.

One area that we at Sierra Energy would like to see more focus on is **utilization of waste resources for the production of renewable hydrogen.** Technologies, such as Sierra Energy's FastOx gasification and other thermochemical or anaerobic digestion methods, can produce significant volumes of clean hydrogen from waste. If funded through ARFVTP, waste to renewable hydrogen projects could greatly expand upon the CEC's intended 38% renewable hydrogen content from ARFVTP funded hydrogen generation projects.

FastOx is a thermochemical waste gasification process whereby waste is converted via high pressures and temperatures, without burning, to synthesis gas (syngas). Coupled with established hydrogen separation and purification technologies, FastOx has the ability to produce 20 kg of low cost, clean hydrogen per 1 metric ton of municipal solid waste, biomass, or other currently landfilled waste streams.

Benefits of waste to H2

Producing renewable hydrogen from waste in a renewable manner, in distributed locations where it is needed, and at lower cost, has the potential to transform energy, transportation, and manufacturing markets.

Sierra Energy's, and others', methods of producing renewable hydrogen from waste have key advantages for government partners and commercial markets more broadly:

- Production of a fully renewable source of fuel (with near zero or below zero gCO2/MJ life cycle carbon intensities[1]) and much lower emissions than conventional natural gas-produced hydrogen.
- Reduction of methane emissions, pollution, and other environmental and health liabilities associated with landfills, and in some contexts reduction of even greater health and environmental hazards associated with open burn pits.
- Reduction of hydrogen cost to less than $1/kg at commercial system size.
- Project economics that benefit from landfill tip fees and renewable energy and fuel credits.
- Decreased transportation, logistics and infrastructure costs, as hydrogen is produced from waste feedstocks, which are co-located near populations with energy and fuel demand.
- Ability to scale the size of the system, wastes handled, and hydrogen output, based on need, from Sierra Energy's current DOD and CEC-funded demonstration of 15 metric tons per day (MTPD) to smaller units (e.g., 5 MTPD systems, for potential mobile waste-to-energy applications) and to larger, commercially demanded 250, 500, and 1,000 MTPD systems.

Producing low-cost, renewable hydrogen with a small, distributed market model has the potential to enable a hydrogen energy and fueling infrastructure for the United States. Fuel generation can take place in distributed locations, in communities where waste is generated and where energy and transport fuel is required. This distributed waste-to-hydrogen fuel concept eliminates hefty economic and environmental costs of transporting hydrogen fuel via truck or pipeline over large distances, or installing power lines.

Distributed, low-cost, renewable hydrogen production also has the potential to help lessen the burden of higher hydrogen storage and infrastructure costs, as part of an entire fueling solution. Distributed hydrogen production from waste provides baseload power, lessening the need for energy storage in general. As clean hydrogen from waste projects come on line—in addition to other hydrogen production efforts— hydrogen storage and infrastructure, fuel cell manufacturing, permitting and other costs would continue to decrease, enabling a hydrogen economy more readily.

A parallel problem addressed by the proposed waste-to-hydrogen system is GHG emissions and other short climate pollutants from landfill methane emissions. Landfills are the largest source of human-generated methane, which has a global warming

[1] ARB's registered LCFS pathways for hydrogen production from waste streams all have carbon intensities less than 0 gCO2e/MJ.

impact 84 as potent as carbon dioxide over a 20-year global warming potential (GWP) period. Converting waste into hydrogen fuel would not only reduce these harmful climate pollutants, but would reduce dependence on foreign oil and improve local air quality.

Current status

Sierra Energy is currently partnered with DOD's Environmental Security Technology Certification Program (ESTCP) program and the CEC to build a small-scale commercial gasification facility at the US Army's training garrison, Fort Hunter Liggett (FHL), in Monterey County, California. Heterogeneous biomass and municipal solid wastes will be pre-processed to small diameters, then fed into Sierra Energy's 15 metric ton per day (MMTPD) FastOx® Pathfinder demonstration system. Sierra Energy's patented FastOx thermochemical gasification process breaks down waste into its molecular components by heating the feedstock to 4,000°F in a gasifier vessel via injection of oxygen and steam. Approximately 90% of the material is captured as energy dense syngas, and the remaining 10% forms into inert stone and metals. Syngas passes through a gas cleaning isle to remove impurities. The clean syngas is a versatile intermediate energy feedstock—consisting of roughly 40% H2, 40% CO, and 20% CO2—which can be used directly to produce renewable electricity (ESTCP-funded project), renewable diesel (CEC-funded project), and renewable hydrogen for electricity generation and fuel (pending DOD project). The current project at FHL, which helps the US Army to achieve zero net waste and zero net energy goals, is under construction and will be commissioned in early 2017.

Syngas produced by the FastOx Pathfinder system can be readily subjected to pressure swing adsorption (PSA) across a special adsorbent to yield a gaseous product that is composed of 99.9% hydrogen. PSA is a proven technology that can deliver a continuous hydrogen product that meets the stringent requirements of another proven technology, a stationary, polymer electrolyte membrane (PEM) fuel cell. Sierra Energy recently completed a Phase 1 SBIR DOD project to demonstrate the most feasible technical and commercial pathway to produce renewable hydrogen from waste, and has a pending Phase 2 award that would enable construction of a H2 isle at FHL to demonstrate 50 kg/day of H2 production from 2.5 metric tons of biomass and municipal solid wastes. This is enough renewable, low-cost hydrogen per day to:

- Power a fleet of up to 10 fuel cell vehicles (e.g., Toyota Mirai) that each drive 300 miles per day (a total of up to 3,000 zero emission miles per day).

Thank you for your consideration of this feedback. My colleagues and I would be pleased to discuss our work and thoughts with you, on the value of renewable hydrogen production from waste, as you establish your investment plans for ARFVTP.

Sincerely,

Paul Gruber
VP of External Relations
Sierra Energy