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Heat is Power Association Responses to CEC RFI Regarding Waste Heat Resources & Technologies, Docket 19-ERDD-01

Additional submitted attachment is included below.

September 5, 2019

California Energy Commission
Energy Research and Development Division
1516 Ninth Street
Sacramento, California 95814

Re: **Heat is Power Association Responses to California Energy Commission Request for Information Regarding Waste Heat Resources & Technologies Docket No. 19-ERDD-01**

Dear Chairman Hochschild and Commission Members:

The Heat is Power Association ("HiP") is a national trade association representing the Waste Heat to Power ("WHP") industry. Our members include companies that design, develop, build, sell, own, operate, and/or service technologies that capture waste heat for productive use. One of HiP's missions is to educate policymakers about the clean energy opportunity presented by waste heat and WHP. Please see our website at www.heatispower.org for more information about our organization.

HiP appreciates this opportunity to respond to the California Energy Commission's request for information on "innovative waste heat recovery technologies to inform future research initiatives and solicitations aimed at reducing natural gas use and greenhouse gas emissions in the industrial sector."

1. What California industries have large volumes of ultra-low (<250º F) or ultra-high temperature (>1,600º F) waste heat?

A. Overview

The last national study of WHP technical and economic potential in the various states was published by the U.S. Department of Energy in 2015. *U.S. Department of Energy Waste Heat to Power (WHP) Market Assessment*, March 2015.[1]

DOE's 2015 Market Assessment described the technical potential for 14,594 MW of additional WHP Projects at over 2,900 industrial sites across the U.S. and over 4,000 MW of WHP projects with paybacks ≤ 3 years. California's technical potential was found to be third in the nation at 763 MW. Further, California was found to be among six states with WHP potential payback periods of < 3 years, and the only state with both a large

[1] http://www.heatispower.org/wp-content/uploads/2015/02/ORNL-WHP-Mkt-Assessment-Report-March-2015.pdf?utm_source=All+Contacts&utm_campaign=4c41642b32-HiP+Press+Release+re+DOE+WHP+Mkt+Assessment&utm_medium=email&utm_term=0_557cb131aa-4c41642b32-202179137

WHP technical potential capacity and a <3-year payback period. California was found to have the highest economic potential (53 percent) for WHP in the country.

While finding that California was among the most favorable sates for WHP due to relatively high grid electricity prices, DOE found that as of 2015 California had just 4 WHP projects producing 18 MW of electricity making California's share of existing national WHP capacity to be just 2.38%.

- ➔ A helpful piece of research for the Commission to consider would be an inventory and assessment of waste heat resources in California in various sectors and at various temperatures, including an analysis of the thermodynamics, the applicability of potential WHP technologies, and estimated costs and rate of return on investment.

B. Industries Driving California's WHP Potential

DOE's 2015 Market Assessment found WHP technical potential in California to be driven by petroleum refineries, oil and gas operations, cement plants, and pipeline compressor stations.

That Assessment estimated that over 40 percent of the national bottom-up WHP technical potential total capacity (3,593 MW) was in the petroleum refining sector. Natural gas pipeline transmission accounted for over 1,300 sites (46 percent of all sites), representing over 12 percent of the overall technical potential in terms of capacity (1,102 MW).

Natural gas pipeline compression stations are an excellent opportunity for both higher temperature (450º exhaust) and lower temperature (170-252ºF jacket water) waste heat recovery in California. ORC systems can be economically sized in small, sub-megawatt packages, and they are also well suited for using air-cooled condensers, making them appropriate for applications such as pipeline compressor stations that do not have access to water.[2]

DOE's 2015 study only considered industrial and field site potential and did not consider potential for heat sources < 450º F. As the Commission RFI recognizes, waste heat recovery and WHP technologies can operate at temperatures in low to high ranges. Common Rankine cycle methods for waste heat conversion are generally considered to require waste heat resources at temperatures ranging from 200º F to 1000º F[3]:

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[2] "Waste Heat to Power Systems," U.S. EPA Combined Heat and Power Partnership, 2016 https://www.epa.gov/chp/waste-heat-power-systems

[3] Lower Grade Waste Heat Workshop, December 13 - 14, 2016 San Francisco, CA, ARPA-e, DOE https://arpa-e.energy.gov/sites/default/files/Joseph%20King%20Opening%20-Overview%20Waste%20Heat%20-%20For%20Posting_Revised.pdf

Therefore, it behooves the Commission to consider opportunities for both low and high temperature WHP applications in California.

Ultra-Low Waste Heat Industries:

Studies have found that 60% of waste heat globally is in the low temperature ranges. In 2008, DOE found that the "Comparison of total work potential from different waste heat sources showed that the magnitude of low-temperature waste heat is sufficiently large that it should not be neglected in pursuing RD&D opportunities for waste heat recovery."[4] In 2016, ARPA-e Director Joseph King argued "the big opportunity [for WHP] is In lower quality heat." He noted that nonindustrial applications, such as exhaust from natural gas pipeline compressor drives and landfill gas engines, represent 1,000 to 2,000 MW of potential capacity nationwide.[5]

ORC systems can be subdivided into higher and lower temperature range technologies, and can operate at temperatures as low as 200º F:

Traditional ORC:
Inlet waste heat temperature - ~320-500º F (160-260º C)
Conversion efficiency from thermal to electrical energy: 15-20%*

Low-temperature ORC:
Inlet waste heat temperature - ~200-300º F (95-150º C)
Conversion efficiency from thermal to electrical energy: 8-9%*
including the parasitic loads

As an example of ORC technologies pushing the low temperature threshold potential in California, HiP Member ElectraTherm utilizes ORC and proprietary technologies to generate 24/7 heat to power capability from heat ranging from 170-252ºF from a biomass boiler in Plumas County California.

Biomass and pipeline compressor station projects, such as the projects described above, are good prospects for more low temperature WHP demonstration projects in California. We also concur with Berkeley Labs that geothermal resources and the food and beverage industries are good candidates for low temperature heat recovery demonstrations in California.

[4] U.S. Department of Energy Industrial Technologies Program Report: "Waste Heat Recovery – Technology and Opportunities in U.S. Industry", prepared by BCS, Inc., March 2008
[5] *Id.*

C. Ultra-High Waste Heat Industries:

In 2016, the amount of industrial waste heat available nationally at >500ºF was estimated to be between 6,000 to 8,000 megawatts.[6]

Industries with the potential for high temperature WHP applications in California include the iron and steel production, petroleum refining, ceramics and glass manufacturing, cement manufacturing, biogas production, and flared-NG and biogas.

2. What research is needed on advanced technologies or materials (including coatings) for recovering waste heat cost effectively in ultra-low heat or ultra-high temperatures?

A. Ultra-Low Heat:

While HiP supports further research on advanced WHP technologies, such as thermoelectric, and materials of all types, we would like to emphasize that there are many proven low heat technologies that could benefit from further demonstrations to prove large scale viability. These types of demonstration projects are needed to provide data and assurance to the marketplace and thereby bring down installed costs – the primary barrier to greater deployment of WHP in California and elsewhere.

B. Ultra-High Heat:

WHP technologies operating at high temperatures could benefit from research and demonstration projects focused on high contaminant waste heat streams (such as in the Glass industry), system configuration, and reducing installed costs.

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[6] Based on a range of net generation efficiencies of 20 to 30 percent and annual load factors of 50 to 85 percent - on a national basis. *Lower Grade Waste Heat Workshop*, December 13 - 14, 2016 San Francisco, CA, ARPA-e, citing: DOE *Engineering Scoping Study of Thermoelectric Generator Systems for Industrial Waste Heat Recovery*, T. Hendricks, Pacific Northwest National Laboratory, W. Choate, BCS Incorporated; *Report to U.S. DOE Industrial Technologies Program*, November 2006; *Waste Heat Recovery in Industrial Facilities: Opportunities for Combined Heat and Power and Industrial Heat Pumps,* EPRI, Palo Alto, CA: 2010; *Waste Heat Recovery: Technology and Opportunities in the United States*, Report for U.S. DOE, BCS, Incorporated, March 2008.

3. Should research focus primarily on the ultra-low or ultra-high temperature waste heat or, if not, what other temperature ranges?

HiP believes research and demonstration projects are needed in both temperature categories.

4. What advanced heat recovery technology improvements are needed to increase widespread deployment by industry?

As previously stated, many WHP technologies are known and proven, but what is lacking is demonstration projects that will increase market adoption. HiP supports all types of research and demonstration projects that focus on bringing down costs in all temperature ranges.

5. What are the cost and technical targets that must to be met to drive customer adoption (such as minimum rate of return or minimum percent heat recovery)?

As discussed above, there are opportunities for WHP at both low and high temperature ranges. But, as is shown below, the costs at different temperature ranges are very different. As cost is the primary barrier to WHP adoption, we believe Commission targets should be set to aggressively drive down costs.

Estimated Waste Heat to Power Capital and O&M Costs (2014$/kW)

Technolog	Cost Characteristic	Electric Capacity or WHP Technology				
		50-500	500-	1-5 MW	5-20 MW	>20 MW
Steam Rankine Cycle	Installed Capital	$3,000	$2,500	$1,800	$1,500	$1,200
	O&M Costs, $/kW h	$0.013	$0.009	$0.008	$0.006	$0.005
Organic Rankine Cycle	Installed Capital Cost, $/kW	$4,500	$4,000	$3,000	$2,500	$2,100
	O&M costs, $/kWh	$0.020	$0.015	$0.013	$0.012	$0.010

Source: Compiled from 2014 Manufacturer Data.

Cost Target: Reduce the costs shown above by 30% at every temperature range.

Payback Target: 2- 3 years

6. What complementary technologies and approaches can be combined to increase the value proposition of waste heat recovery systems?

→Incentives for WHP. California programs that include WHP in renewable energy or energy efficiency portfolio standards can help bring the payback period into acceptable ranges for business investors.

→Investment Tax Credits and/or Production Tax Credits for WHP. State and federal tax codes that provide credits for WHP on parity with other clean and efficient energy resource properties can help level the playing field for WHP, assist in financing, and reduce the payback period.

→Commercial Property Assessed Clean Energy Financing. C-PACE long-term, low interest on-bill financing for WHP project property can reduce upfront capital costs and, in some instances, can result in a positive cash flow in the first year.

→Complimentary technologies include combining WHP systems with other complimentary equipment, such as biomass boilers, reciprocating engines, and process heaters.

HiP appreciates the opportunity to present its views to the Commission on this important topic. I can be reached at pat@heatispower.org or 312.981.0404 should you have any further questions for us.

Respectfully submitted,

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