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DEBA Program Comments - Waste Heat Recovery

Additional submitted attachment is included below.

Waste Heat to Power Resource Characterization

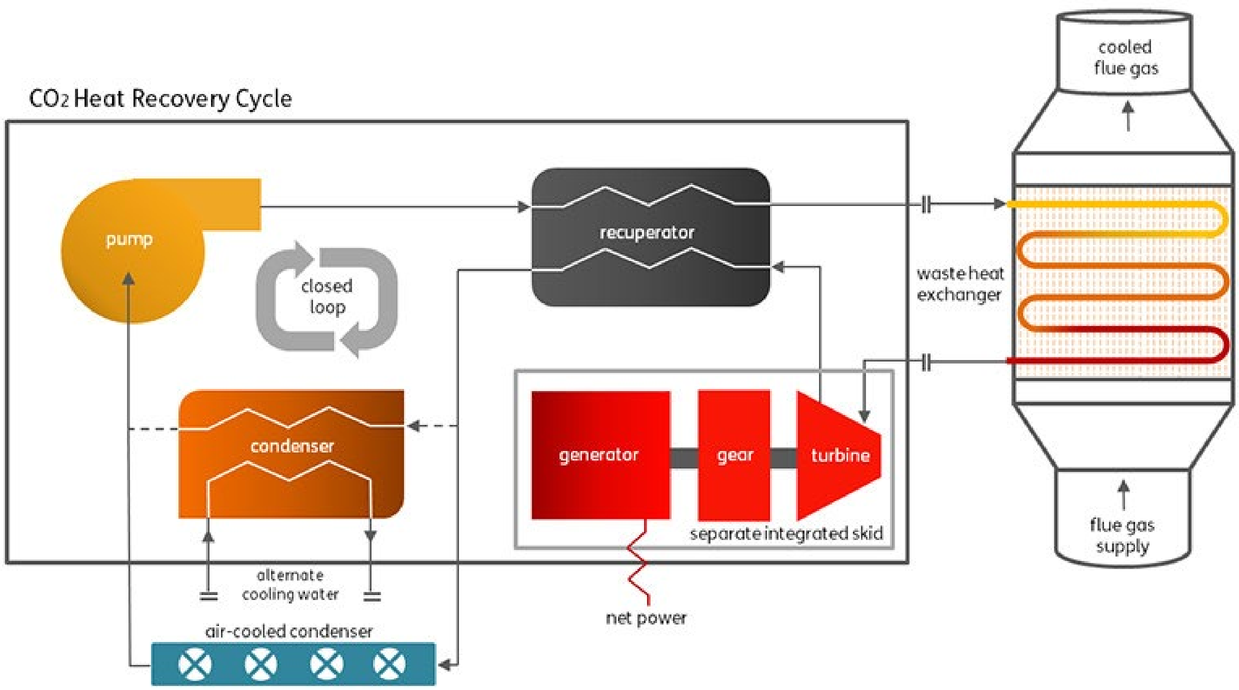
1) Please provide a general overview of the resource, including the following:

a. Resource category (e.g., supply, demand) and type (e.g., solar) and scale (e.g.,

utility, distributed)?

The technology utilized is large-scale supercritical CO_2 (sCO_2) Organic Rankine Cycle. Heat, which in this case would be harvested from large industrial sources (likely power plants that do not have steam co-generation facilities attached) and fed to the ORC system. The heat is cross-exchanged with sCO_2 which increases the pressure of the closed-loop system. The sCO2 is moved across a turbo-expander, which then turns a generator to produce power. (note: this is a sister technology to the smaller systems currently outlined on ICE's website).

This is a supply-type resource, which produces emission-free power at an industrial scale (10MW or more per installation).



2) How does the resource compare to conventional generation in terms of greenhouse gas and

priority pollutant emissions?

The sCO_2 ORC system produces 100% emissions-free power. The generators use a closed-loop process where working fluid (CO_2) streams are circulated internally; the only output from the system is electricity.

3) How does the resource support reliability (e.g., supply, permanent load reduction, net peak

reduction, or emergency asset?) (List all that apply.)

This resource is best served to behave as a permanent supply asset, operating 24/7. So long as the primary turbine at a subject power plant is operating, this technology will supply power. In contrast to traditional Heat Recovery Steam Generators (HRSG), this system can be System can be operated unmanned (no licensed boiler operator required) and utilizes a simple single-pressure heat exchanger rather a multi-pressure HRSG. Cooling the Super Critical C)2 system is also much easier, both due to lack of icing risk in sub-freezing temperatures, and the much higher density of CO2 in the cooler/condenser (factor of 2000), which allows for smaller piping & components in the cooling system

a. How can the resource be used as an incremental on-call resource during

emergencies?

In a power plant deployment, the system would tie into the exhaust stack of the primary generation unit and harvest the heat that would otherwise be released into the atmosphere to generate approximately 20% more electricity.

Due the mobile, modular design of the system, it may also be deployable in emergency situations where they need to be installed quickly and operate for longer periods of time. However, to avoid down time the units would need to be constructed ahead of time (lead time is approximately 18 months)

4) How many new MWs and MWhs can the resource provide per year, taking into account

resource characteristics and known barriers between now and 2035?

According to the EIA's power generation data for 2022, there are 43 power plants in CA which do not employ co-gen or other heat recycling technology. In 2022, these plants generated approximately 5,500,000 MWh of electricity. If we were to assume that the ICE-proposed system could be placed across this entire population, it could in theory increase this by 20%, adding an additional 1,100,000 MWh to supply. At 10MW system sizes, this is an installed capacity of about 125MW.

a. How is that different if used incrementally as an emergency asset during an extreme

heat event?

The hurdle to building these systems as emergency assets is that financing becomes nearly impossible without a continuous generation PPA agreement over 10-15 years to lend against.

5) What is the levelized cost for the resource in $/MW-yr. and $/MWh-yr. from 2023 to 2035?

The estimated cost of this system would be $125 - $150/MWh in 2023 and increase 2-3% annually.

6) What is the average length of time from ordering or purchasing the resource to operation?

Approximately 18 months, driven by equipment lead times and permitting requirements.

How long does that typically take in today's market?

The aforementioned timeline is taking into account today's market challenges.

What conditions must be met to deploy the technology rapidly? (e.g., transmission interconnection, building electrification or upgrades, etc.)

Transmission interconnection may or may not be applicable, depending on the arrangements at the existing simple-cycle power plants where we would place the systems. Permitting would need to be better understood, and varies based on location.

Supply chain timing could be shortened for higher volume programs, where the quantity would provide leverage to work with necessary vendors on preference in manufacturing queue.

7) For an emerging technology, when will it be ready for deployment, and at what scale?

Approximately 18 months, at full scale (multiple 10MW systems).

8) Is the target customer primarily residential, commercial, agricultural or industrial?

The target customer for this resource is mid to large size industrial or manufacturing facilities and simple-cycle power generation operations. Any operation or process with un-tapped heat resources has potential for a waste-heat to power project.

9) What are the key non-financial barriers to the development and implementation of this resource (including, but not limited to, permitting, interconnection, supply chain, customer acceptance, and alignment with policy goals)?

Regulatory acceptance and REC credit generation in California would be very helpful. The current California RPS standards do not recognize this technology as appliable to the standard, although many other states are amending and adding waste heat generation to their portfolios. The addition of RECs or a pathway to LCFS acceptance (in projects where it would be applicable) would greatly reduce barriers for implementation.

Permitting for larger multi-MW systems at FERC regulated power plants is an unknown process at his point as we have held only preliminary discussions with clients on regulatory requirements. Anecdotally, CARB and other regulators are supportive of this technology, however, we have not pursued permits officially. The CEC could really help adoption and growth of this technology with thoughtful rulemaking and perhaps revisiting of the California RPS Standards.

10) What are the key financial barriers to the development and implementation of this resource?

For large scale power-plant scale projects the uncertainty around permitting and limited number of operating examples for a newer technology makes traditional project financing difficult (this technology has had several hundred demonstration hours performed).

11) What types of benefits or impacts is the resource anticipated to have on low income and disadvantaged communities, and tribes, if any in terms of development and deployment?

The benefits from ORC systems for lower income and members of disadvantaged communities include lower total cost of power, emission-free generation of electricity in their neighborhoods, a reduction in greenhouse gasses, and baseload support in times of rolling utility outages.