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In Response to Request for Feedback for Innovative Waste Heat Recovery Technologies

Additional submitted attachment is included below.

August 5, 2019

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

Subject: Comments from Berkeley Lab, Energy Technologies Area in response to request for feedback for innovative waste heat recovery technologies.

Thank you for the opportunity to provide comments 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. The comments included in this letter are intended to provide valuable feedback regarding opportunities to identify and address research gaps and opportunities in the sectors mentioned in the feedback request.

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

Ultra-low: ARPA-E had a call on low-T waste heat recovery in 2016 that summarized the case for ultra-low waste heat quite well. Sectors of importance highlighted were the building/ commercial/ residence and also air conditioning, boilers, biomass, geothermal, etc. where several opportunities exist. Food (canning if 250F is the limit) and beverage (e.g. beer) would also be good candidates.

Ultra-high: Industries with ultra-high heat recovery opportunities may include refining, nonmetallic minerals (e.g., cement, lime), chemicals, primary metals, secondary metal processing (e.g. forges), steel, glass blowing, etc.

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?*

Improving efficiency and reducing costs of organic Rankine cycle to take advantage of low temperature heat (https://www.sciencedirect.com/science/article/pii/S136403211731198X); plug-and-play, modular heat pumps; developing novel materials and technologies for better utilizing solar thermal loading (e.g., for industrial drying); technologies and systems to utilize industrial waste heat for enabling district energy systems. Flexible heat exchangers, scalable heat engines (thermoelectric, thermophotovoltaics, thermionics), phase change materials or other thermal energy storage, thermal redirects/transistors, super thermal conductors, etc.

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

Within the middle range (between 250 - 1600) more research is needed to increase adoption of existing efficient waste heat recovery technologies; to defensibly answer this question we suggest the following:
1) a proper mapping of waste heat availability and utilization in CA industries and
2) rigorous thermodynamic analysis to estimate the amount of waste heat recoverable is needed;

Per ARPA-E, roughly 85% of work potential from waste heat is in ultra-low category. However, for ultra-low opportunities there is a need to identify sources with high volumes because thermodynamics will limit the amount of recoverable energy (see Tomlinson citation below for low temp residential applications and the need to extend analysis to industrial sector)

Tomlinson, J.; Christian, J.; Gehl, T. Evaluation of Waste Heat Recovery and Utilization from Residential Appliances and Fixtures; ORNL/TM-2012/243; Oak Ridge National Laboratory, 2012; pp 1–38.

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

Flexible direct thermal energy conversion devices, robust, self-healing materials, non-precious elements, recyclable components, cost calculators, integrating industrial facilities into urban system planning to utilize various temperature ranges of waste heat.

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

Technology must be cheaper than natural gas, with under two-year simple payback

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

Combining with other recirculating (Rankine) or blowers etc, district energy, carbon taxes

Should you need any clarification on the comments above, we would be delighted to provide it.

Respectfully,

Purabi Thakre
Program Manager, Energy Technologies Area
Lawrence Berkeley National Laboratory