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Additional submitted attachment is included below.

February 16, 2024

ELECTRONIC FILING

California Energy Commission
715 P Street, Sacramento, CA 95814

Re: Public comment to the EPIC Low GWP Heat Pump Solicitation Concept 23-ERDD-01

I am writing to provide comments from the Vermont Energy Investment Corporation (VEIC) in response to the California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) grant to advance the development of next generation, all electric heat pumps using low global warming potential (GWP) refrigerants.

VEIC is a mission driven non-profit organization, that has worked on providing high-impact energy solutions that decarbonize buildings, electrify transportation, and drive utility grid reliability and resilience for over 35 years. Since 2000, our work will have reduced greenhouse gases (GHG) emitted to the atmosphere by over 110,500,000 metric tons.

In addition to our full-service consulting business, VEIC administers three large-scale sustainable energy programs: **Efficiency Vermont**, **Efficiency Smart**, and the **DC Sustainable Energy Utility** (DCSEU), and serves on the program administration teams for **CalNEXT**, **Focus on Energy** (Wisconsin), **Hawaii Energy**, and **TECH Clean California**.

VEIC is nationally recognized for its programs and pilots that optimize energy use, reduce energy burdens for low-income customers, and advance emerging technologies and innovative program models. Its subject matter experts have also positioned VEIC as a pioneer in refrigerant management and natural refrigerants and led the advancement of regulatory assurance and allocation of funding for statewide strategies that address refrigerant-related emissions as crucial components to achieving ambitious climate laws, compliance with federal regulations and enforcement deadlines alongside evolving utility requirements.

We applaud CEC's approach to increasing awareness, and directing funding towards demonstration projects that elevate efficiency measures that maximize longer-duration GHG reductions, and also consider the refrigerant GWP impact of the technology and deliver grid benefits. Through our own analysis of the R-290 monobloc air to water heat pump system market potential for California's residential sector under **CalNEXT** we demonstrated this technology—as a replacement option for central and window air conditioning and fossil fuel heating systems—is arguably the fastest means of achieving the State's HFC reduction targets of

7.5 million MTCO2e by 2030, while also supporting the potential to load shift from high-carbon hours of grid operation to low carbon periods.

The next five years will be pivotal in raising awareness and accelerating adoption of commercially available natural refrigerant heat pump technology as a true decarbonization solution for California. The CEC's proposed EPIC grant provides a unique opportunity to do just that, while also elevating the need to incentivize measures that provide inherent load flexibility, customer cost savings, and additional workforce opportunities for professional HVAC technicians, plumbers, pipefitters, and boiler-focused mechanical contractors to transition into a new, climate-friendly technology market.

We have grouped our comments to the questions poised to stakeholders below, and have also provided additional ideas for inclusion and consideration in this solicitation's scope.

We would be happy to answer any questions you might have.

Zoe Dawson **zdawson@veic.org**
Tom Kacandes **tkacandes@veic.org**
Rebecca Rothman **rrothman@veic.org**
Melissa Stewart **mstewart@veic.org**

VEIC Consulting Division

Low GWP Heat Pump Draft Solicitation Questions

What type of considerations should CEC consider to encourage participation and achieve project success, and why? Please provide relevant comments regarding other considerations not explicitly listed above.

The use of R-290 across all categories is a key to the deployment of near-zero GWP water heating and space heating/cooling and the major barrier to use of R-290 adoption is manufacturers reluctance to introduce US models of technology sold elsewhere while UL continues in a process driven by stakeholders with vested interests in A2Ls that remains at variance with the relevant IEC standards adopted elsewhere in the world. The path CEC should consider is to demonstrate commercially available and near commercial R-290 heat pump technology from outside the US that can be quickly imported and tested in California to demonstrate its effectiveness and safety. To that end, we suggest that participation and project success would both be served by encouraging and prioritizing demonstration projects that include tasks to familiarize Authorities Having Jurisdiction (AHJs) who are capable of authorizing the sale and installation of A3 / R-290 heat pumps which can either be installed with all refrigerant outside, such as monobloc configuration air to water heat pumps (AWHP) or are able to heat / cool / provide domestic hot water (DHW) using very small charges, such as certain "through wall" or PTAC configuration units using and possibly heat pump hot water heaters (HPHWH).

The speed with which near-zero GWP heat pump technologies can be deployed at scale is the metric most capable of reducing short lived climate pollutant (SLCP) emissions when coupled with recovery of older refrigerant at end of life. By promoting the net result of including AHJ's or regional governmental organizations that can choose to establish a near-zero GWP heat pump policy, the anticipated work funded by CEC would have the most practical effect ultimately. This could be achieved by inviting city and local government officials and other AHJs to tour demonstration sites and gain familiarity with system designs, safety measures and other installation considerations that allow A3 refrigerants to be sold, installed and used safely elsewhere in the world.

Are the GWP limits of 150 reasonable for the current state of the art systems? If not, why and what should the limit be?

A GWP limit of 150 is completely reasonable and attainable for each target technology group listed under this solicitation and is in line with the EU f-gas ban of GWP less than 150 starting 2027 and transition towards natural refrigerants where technically possible. The proposed limit

admits for the possibility of a newly developed synthetic refrigerant to come to market, however, if current state of the art is the standard, the limit could be lowered to 10 to more clearly focus on the increased development and demonstration of heat pump technology using natural refrigerants in ways that are sufficiently safe either through charge limits per IEC guidance or automatic leak detection and shut off with dispersal or as monobloc equipment with all refrigerant being located outdoors for larger charge sizes.

Do the three Project Groups in Section IV of this document address the primary objectives of expanding and improving heat pump technology? If not, why?

While the project groups do address critical improvement aspects for heat pump technology, the inherent load flexibility of each technology should be a primary research goal across all technology groups. If California solely focuses on incentivizing inflexible electrification efforts, it will continue to create capacity issues, and potentially increase the carbon impact on the grid (upstream). There is an immediate opportunity under this solicitation to elevate technologies that can **shift HVAC electric load** with minimal to no impact on the customer's comfort as a critical objective to supporting the net benefit to the State's capacity and grid decarbonization goals. Combined systems as characterized under Group 2 that move heat and cooling energy using hydronic distribution can replace those that use A2L medium-GWP refrigerants to move energy, thereby reducing total charge and total system GWP to near-zero. Hydronic distribution is also a key to unlocking configurations of HVAC equipment that can shift load in time to provide load flexibility that is crucial to lowering net carbon grid emissions.

Are there alternative pathways or priorities that should be considered?

In addition to researching the reduction opportunities under Group 1 and 3 technologies, load flexibility and consideration of thermal energy storage (TES) should be added as a consideration to Group 2 specifically.

Further, the total customer cost of installation (including electrical upgrades) should be reviewed alongside O&M cost considerations across all groups.

A key baseline consideration and priority for Group 2 should be a focus on the residential market and retrofit opportunity for single family homes that have central AC, no AC or window AC and are replacing fossil fuel heating (furnace, boilers).

What are the near-term and medium-term technical targets (e.g., costs, efficiency, ramp rate, emissions levels) to advance low GWP heat pump technologies to a higher TRL?

While the low GWP heat pump technology market in the US is still nascent, it is relatively mature in Europe and growing exponentially. To help accelerate the California market adoption of ultra-low GWP technology the following short and mid-term technology targets should be considered:

Near term goals:

- *Cost comparison*. This funding should support and demonstrate the cost-benefit of ultra-low GWP and natural refrigerant heat pump technology vs. mid-GWP (<750) HFC and synthetics. The consideration and comparison of any HFC >750 while still available should not be considered due to their phaseout.
- *Thermodynamic properties*. This funding should demonstrate how refrigerant selection considerations for new systems respond to heating and cooling demand and deliver hot water temperatures effectively. The focus should be on advancing those refrigerants with the most favorable properties (COP) for heat transfer that can lead to energy savings.
- *Overall emissions impact of system design*. This funding should focus on system designs that effectively reduce refrigerant charge, minimize refrigerant leakage, have superior performance.
- *Installability / constructability*. This funding should demonstrate that the technologies are easy to install and maintain, and will be comparably cheaper and accessible for purchase than in-kind replacement options.

Long term goals:

- *Support higher efficiency standards that require zero-emission technology solutions*. The goal of this funding is to ensure market adoption of heat pump technology that is future proofed against phase down requirements under the AIM Act alongside additional PFAS or environmental regulations.

What should be the starting and target TRLs for these groups?

The target TRL for all groups should be >8. The starting TRL for group 2 should be revised to 6-8 as the technology described is not an emerging one. Combined heating, cooling and domestic hot water system with low GWP are commercially available and installed across the UK, Europe and Asia. Specifically, R-290 is widely used as a refrigerant in residential monobloc and split system applications worldwide (supported by IEC standard IEC 60335-2-40), however the current UL standard is incomplete in its harmonization with this standard and does not adequately define how to use hydrocarbon refrigerants safely in indoor vs. outdoor installations. This has led to market confusion and a reluctance by manufacturers to invest in US markets without

clearer signals from AHJs, states or other bodies supporting consistency with international safety standards.

Are the proposed levels of project funding for each group appropriate to achieve the desired outcomes? If not, why?

Group 2 should be considered a test and demonstration project and have proportionate funding to the others.

What would be the typical range of costs (e.g., capital costs) for the anticipated projects, and could projects leverage CEC funding to encourage private investments?

The capital costs for the anticipated projects will vary depending on the market (res/commercial), the size and quantity of units looking to deploy. For group 2, a typical residential installation of an R290-AWHP monobloc with DHW is ~ $16,000.

As noted above, manufacturers are eager to access US markets with this technology and would readily invest in demonstration projects such as these to support that goal.

A minimum 20% match would likely be required with the funding levels listed above, and this requirement would be waived for projects sited in and benefitting Disadvantaged Communities (DACs) and Low-Income Communities (LICs). Is this sufficient to encourage DAC and LIC projects? If not, how could this be improved?

Yes, this is sufficient.

5. Should Group 1 in Section IV also include small commercial? If so, why?

Yes. While small commercial typically have larger and more varied DHW demand and capacity requirements they face similar challenges as residential single-family homeowners when it comes to options available to support effective decarbonization and/or address emergency replacement needs.

6. Should Group 3 in Section IV narrow its focus? e.g., to only residential or only commercial. If so, which one and why?

No. It's important for Group 3 to address GWP<150 ASHPs for both residential and commercial application so that this funding solicitation can receive consideration from technology providers that are focused on both ducted and ductless options for low-GWP HP applications.

Additionally, air to water heat pumps with hydronic distribution can be "ganged" similar to VRF in order to address capacity needs up to 20 tons as systems. There is no meaningful distinction among applying R-290 air to water heat pumps to large single family, multifamily or commercial applications up to 20 tons because all such applications can be addressed by outdoor units with controls to share load to a correctly designed hydronic distribution system that can use a variety of emitter units including AHU, FCU of all types, radiant heating and/or cooling emitters and hydronic piping can serve varied vertical and horizontal building configurations and demised indoor spaces.

7. Is four years a feasible project timeline? Are there potential barriers or challenges in implementing the proposed projects in that timeframe?

Yes, four years is a feasible timeframe, with the caveat that for the CEC to support the effective demonstration of high-efficiency zero-emission technology solutions site AHJs should harmonize with the IEC 60335-2-40 immediately, vs. waiting for the UL and EPA process to conclude, given the time this process will likely require.

8. Which end-use sectors, facilities, or communities are expected to be most positively impacted by these types of projects?

Based on our experience and prior market research around the potential impact of R-290 air to water heat pump systems (which aligns with Group 2) the biggest market impact will be in providing an endpoint decarbonization solution for single-family residential retrofits (homes that are already looking to replace their fossil fuel heating and hot water) and have central AC, no AC or window AC.

The advantages of a multi-functional unit as described under Group 2 has also been shown to reduce installation costs, and eliminate electrical upgrade requirements. This is especially beneficial for house with fossil fuel systems built before 1980s.

9. How could this solicitation encourage projects to more fully center equity and community engagement?

We recommend adding the following research requirements to the solicitation to ensure technology solutions presented under Group 1, 2 and 3 provide insights into how they will address equitable access and purchasing, and solicit feedback from all key stakeholders.

- How accessible is the technology for purchase and installation by sole proprietor contractors or small contractors?
- What is your plan to engage distributers and contractors across the state?

- How do you plan to solicit feedback from key stakeholders?
- How will you address split incentives and market scaling to the California renting population?
- What is your approach to controlling for costs associated with added electrical load?

Again, it's relevant to mention the ability of R-290 to be used with very small charge sizes in HVAC configurations such as "saddle style" window units and interior "through wall" or PTHP configuration units with limited output (7,000 – 12,000 Btu rated, for example) at very high efficiency is a natural fit for flexible and low-cost heat pump applications. Such configurations can be applied to provide whole-unit space heating and cooling for apartments and houses on a "most rooms" distributed (meaning not centralized) basis with 120V power supply and low-cost installation due to the minimal interior work and likely avoided electrical panel upgrades required by 240 VAC central units. This approach avoids any refrigerant handling, linesets or complicated installation beyond basic carpentry being more similar to appliance installation that is DIY-friendly for occupants or building owners.