Harvest Thermal
663 Coventry Rd
Kensington, CA 94707

To: Abigail Daken
EPA Manager, ENERGY STAR HVAC Program
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

September 25, 2023

Re.: ENERGY STAR Residential Boilers Discussion Guide

Dear Ms. Daken,

Harvest Thermal ("Harvest") is a U.S.-based manufacturer of a smart thermal battery system for combined heating and hot water, using a heat pump water heater as an air-to-water heat pump, and thermal energy storage to reduce the energy costs of residential space and water heating.

We appreciate the opportunity to submit comments on the ENERGY STAR Residential Boilers Discussion Guide, and respectfully submit the following responses to the questions posed in the Discussion Guide.

We support EPA's initiative to develop a specification for air-to-water heat pumps because we believe these products have a key role to play in cost-effective home decarbonization.

Question 1: Is the name "ENERGY STAR Heat Pump Boilers" for the new specification preferable to "ENERGY STAR Air-to-Water Heat Pumps"? Is there another name that would better align with customer expectations of the product?

The term boiler could confuse the public about the capabilities of air-to-water heat pumps which have different design temperatures and operating conditions than boilers. The public is becoming increasingly familiar with heat pumps but could confuse air-to-water heat pumps with the more common air-to-air type, so a qualifier would be helpful. Air-to-water could work although it is quite technical, another option would be "hydronic heat pumps".

Question 3: Is there any need to distinguish boilers that are used with hydronic coils in a forced- air distribution system from those used with hydronic distribution? Are the same products used in both situations?

Forced air vs. hydronic heat distribution is not necessarily a relevant and meaningful distinction: there is a wide range of designs within each category. For example, some forced air systems are designed for low temperature delta across the heat exchanger whereas others such as the Harvest Thermal system are designed for a temperature delta of more than 60 deg F. Similarly, radiant floor applications can be designed for a wide range of flow rate and temperature differential.

The use of thermal energy storage (TES) further complicates the application space because there are multiple technologies and designs for TES (sensible/latent, stratified/mixed) each of which works best with different types of hydronic heat pumps.

It would be quite challenging and expensive to test and qualify entire systems, focusing on the heat pump itself is much simpler. Instead of separating heat pumps by type of distribution, we recommend testing hydronic heat pumps in a range of representative application conditions, requiring that the hydronic heat pump meet qualification criteria for at least one type of application, and listing which application the heat pump meet the criteria for.

Question 4: EPA believes that products that can serve as domestic water heaters or as air-to- water heat pumps for space heating could simply be tested and rated for each use. Is there any need for a definitional distinction between heat pump water heaters and air-to- water heat pumps for space heating? If so, what would the distinction be?

Two primary distinctions between air-to-water heat pumps (AWHPs) and HPWH are 1) a HPWH delivers potable water; 2) HPWHs typically only provide heating, not cooling. A HPWH with the right capacity, performance characteristics, and application design can power a forced-air or hydronic heating system highly efficiently. For example, Harvest Thermal uses a HPWH to deliver an annual field-measured coefficient of performance (COP) around 3 in a combined heating and hot water application. Conversely hydronic heat pumps designed for space heating can deliver domestic hot water (DHW) efficiently too.

It would be useful for the qualified product list to note which systems have which capabilities, but we do not see a need to separate them into different categories.

Question 6: As the evaporators are likely to be located outdoors, what range of outside air conditions are most representative to determine overall performance?

47F, 17F, and 5F cover a wide range of winter operating conditions throughout the U.S.

Question 7: At very low outside temperatures, the compressors for ATWHPs and dual fuel HPs may no longer provide useful efficient heat. We assume ATWHPs will include backup heating for this circumstance. Ideally, the test method would capture this behavior and incorporate it into an estimate of annual energy use. What is the best way to include backup heat in the test method? What other testing considerations should be evaluated for performance in cold climates?

Backup heat can be applied in a variety of manners, with varying degrees of efficiency. For example, Harvest Thermal uses an air-to-air heat pump as backup heat, then an inline auxiliary heater that supplements the SANCO2 down to -25 F. This is driven by application design rather than the hydronic heat pump itself. It may be simplest to just measure hydronic heat pump efficiency and capacity at version test points as with air-to-air heat pumps.

Question 8: How often are air-to-water heat pumps applied in combination systems that also provide domestic hot water? For these applications, can they use the test and metric for domestic hot water delivery efficiency found in 10CFR Part 430 Subpart B Appendix E? Would this test fully capture the performance of the product in space and water heating modes?

There are already several technologies on the U.S. market that use air-to-water heat pumps in combination systems, including Harvest Thermal, and more are expected to enter the U.S. market as they are more common overseas.

We propose that combination systems be listed as qualified either or both as Air-to-Water/Hydronic Heat Pump and Heat Pump Water Heater depending on which specifications they meet. An AWHP that can meet both specifications would be listed under both product categories.

We do not see the need for a specific combination system product category: most of our customers are looking to replace either their water heater or their hydronic system and often discover combination systems when looking for one or the other, they often do not specifically look for a combination system.

Question 9: Air-to-water heat pump systems can be designed to offer load shifting in addition to their other functions. Are there products offered that are specific to such applications? In other words, are systems that provide these functions designed and assembled on site using any air-to-water heat pump, or is there something specific about the product as it leaves the factory that enables this? Are there metrics appropriate for evaluating these capabilities in a product?

Load shifting requires thermal energy storage, which comes in different flavors: sensible/latent, stratified/mixed, storage temperature and volume for sensible, phase change temperature and capacity for latent.

Achieving good performance and load shifting capacity requires designing a whole system where the AWHP is carefully paired with a particular thermal energy storage system and operated to optimize the performance and its capacity.

These systems may be assembled onsite or at the factory depending on their level of integration. Either way, they will most likely use a specific heat pump in a specific way to achieve target performance objectives.

Performance metrics to measure load shifting effectiveness can include the following:

- % load shifted off-peak for a peak period of X hours and a thermal energy demand of Y BTUs during that peak period
- BTUs shifted off-peak for a peak period of X hours and a thermal energy demand of Y BTUs during that peak period

- Average power avoided on a peak period of X hours and a thermal energy demand of Y BTUs during that peak period
- Average annual COP increase from shifting load from colder to warmer times of day

These metrics are dependent on thermal energy usage load shapes, and peak period duration and overlap with usage load shapes. We are not aware of a standard test method for these metrics, they are currently measured in the field.

A test method would be very valuable to quantify the benefits of load shifting, incentivize technologies based on performance, and therefore encourage their development and adoption in the market.

An initial step toward such a test method would be to define thermal energy storage capacity in its intended application i.e., at application-specific charge and discharge temperatures.

Question 10: Are there additional considerations for the test method for air-to-water heat pumps?

The test method should not impose a leaving water temperature of 110 F. Some hydronic heat pumps are designed to produce significantly higher temperature water than 110 F water, and may not even be able to, or efficient at, producing 110 F water. For example, the SANCO2 GS4 HPWH can only produces 145 F-150 F water. The test method should be flexible and allow testing at the temperature the AWHP is optimized for.

Question 12: If units are sized for design conditions, what does that mean for their part-load heating performance? What have users' experiences been in the field?

In thinking of part-load heating performance, please consider the case of thermal energy storage which enables the decoupling of design load and AWHP sizing. With appropriate thermal energy storage, the AWHP can be sized for daily design load instead of hourly design load.

Part-load efficiency of the hydronic heat pump is not necessarily indicative of application efficiency. AWHP with thermal energy storage can run most efficiently at a single speed and use thermal energy storage to buffer their output and manage part loads and peak loads.

Question 13: This test defines performance with 110F leaving water temperature. This will not provide sufficient heat when used in legacy heat exchangers, typically designed for 160-180F water. Do manufacturers recommend using these products in retrofit situations? If so, is there anything special they recommend making sure residents have enough heat?

Per our answer to question #10, 110 F does not work with all AWHP, the leaving water temperature should be flexible to better match the design of the heat pump.

Hydronic heat pumps can be used in retrofit applications. Some radiant floors work well with lower supply temperatures, others do require high temperatures depending on the technology.

Radiators may work with lower supply temperature, depending on the technology, surface area, and the design heating load of the home, or they may need to be upgraded to low-temperature models. In all cases, these are application-specific design decisions that need to be made by the designer and/or installer for each home. The test method can help by providing the capacity and efficiency of the AWHP for representative points of its operating temperature range.

Question 15: Would it be useful for EPA to define connected criteria for air-to-water heat pumps, given that they can be deployed in systems that offer load shifting? How would the needed criteria compare to those in AHRI 1380 or AHRI 1430?

AHRI 1430 is very applicable to systems with integrated energy storage, whether thermal or electro-chemical, because a heating system with energy storage has very similar capabilities to a HPWH, albeit typically with higher storage and load shifting capacity.

Conclusion

Harvest Thermal and other technologies combining hydronic heat pumps with thermal energy storage have the potential to provide a highly efficient and cost-effective alternative to conventional heat pumps and battery storage. The potential for major energy cost reductions could make them a game changing solution that can slash heating carbon emissions and consumer energy costs while improving electric grid resiliency and reducing grid system costs.

ENERGY STAR can play a major role in recognizing and encouraging energy-efficient, grid-flexible solutions that are emerging in the HVAC space. This will foster innovation by allowing innovative solutions to compete for incentives based on merits, setting the stage for rapid cost reductions and customer adoption, and helping the United States achieve its climate, economic growth, and technology leadership goals.

Thank you for this opportunity to comment and for considering our input.

Sincerely,

Pierre Delforge
Head of Product and Operations
Harvest Thermal