

Naming, Scope and Definitions

- **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?
Answer: The term “boilers” has too long been associated with gas and should not be used. Heat pumps do not boil water. Suggest either air-to-water heat pumps, or hydronic heat pumps (which would also suggest water-to-air and water-to-water). “Air-to-water” is the most descriptive and least likely to lead to confusion. There should also be a subcategory called “three-function” to describe heat pumps capable of heating water for space heating and domestic water heating.
- **Question 2:** Are there broadly accepted industry definitions of air-to-water heat pumps or heat pump boilers?
Answer: Not sure about manufacturers or distributors. AHRI 550/590 2.1.3 calls them “Air-to-water heat pumps.” The California Energy Commission’s Modern Appliance Data Base System (MAEDBS) classifies them under “heat pump water heating packages”.
- **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?
Answer: No. The distribution system should not be bundled with the heat pump because there are so many options. That does present a problem though, because it precludes presenting rating methods similar to those used in AHRI 210/240 which presents performance for paired compressor units and indoor coils. Having heat pump and air handler (or radiant panel) ratings at leaving/entering water temperatures that align would be a great help to engineers.
- **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?
Answer: Agree. AWHPs that are qualified to be used for DHW should be tested and rated for Uniform Energy Factor using the same test standards used for HPWHs. This will require specification of a storage tank and heat exchanger as part of the rating.
- **Question 5:** EPA is interested in additional information about dual fuel boilers particularly market, cost, and performance information.
Answer: Frontier Energy, with whom I am employed, has conducted tests on several brands for over four years under a Central Valley Research Home project funded by PG&E and under an Energy Commission-funded project for Sonoma Clean Power. Reports are available. Frontier is currently testing two units in the lab. We may have compiled cost data for a Title 24 codes and standards report. Costs are a moving target due to general market cost increases, changing technology, and other factors. We believe that the potential for 3-function AWHPs to compete with air-to-air heat pumps combined with HPWHs is high, and that improved market volume will result in lower costs.
- **Question 6:** As the evaporators are likely to be located outdoors, what range of outside air conditions are most representative to determine overall performance?
Answer: Using the same rating temperatures for heating as air-to-air (17° and 47°) would allow performance comparisons, though 5° could also be used for cold climates as used by NEEP for cold climate heat pumps. Ratings must also include a standard supply water temperature, for example 120°F.

- **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?

Answer: First, dual fuel implies the other fuel is gas, and low outside temperature does not affect capacity for gas heating. Electric resistance heating is not included in air-to-air heat pump AHRI ratings and ought not to be required for AWHPs to allow a reasonable comparison of 550/590 and 210/240 ratings. The size of resistance heat required depends on many factors that the engineer should evaluate in each case. When used for water heating, AWHPs have a higher capacity than typical residential HPWHs because the compressor is larger, resulting in less resistance heat.

- **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?

Answer: In my opinion, AHRI 550/590 should be used for space heating ratings and 10CFR Part 430 Subpart B Appendix E for water heating ratings.

- **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?

Answer: Systems designed for load shifting are generally agnostic to the brand or type of AWHPs, though some may have higher or lower supply water temperature limits that would favor them for better load shifting performance. Low GWP refrigerants appear to allow higher supply water temperatures. My favorite application of load shifting is coupling AHHPs or chillers with a radiant slab, which if my house is any example, can operate entirely off-peak at maximum outdoor temperatures up to 110°F. The concrete floor provides very inexpensive thermal mass and when heated in winter exposed or tiled floors are very comfortable. This design strategy also eliminates the need for auxiliary heat during defrost cycles. For cooling in humid climates, the chilled water system can be tied to a fan coil to dehumidify indoor air. We demonstrated this in a home in Tucson that had no floor condensation during the monsoon season.

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

Answer: None that I have not already described – that I can think of now.

Specification Requirements

- **Question 11:** Do air-to-water heat pumps generally use multiple speed, variable speed, or inverter-driven compressors? For these products, do part-load tests in AHRI 550/590 reflect field operation?

Answer: Most, but not all, that we have tested are variable speed, inverter type. The integrated part load value (IPLV), which is analogous to SEER, is higher for those.

- **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?

Answer: That depends a lot on the design, for example if a storage tank is intersperse between the heat pump and the distribution system then part load performance would probably be better than if the heat pump is directly coupled to an air handler. Some of the Davis Energy Group/Frontier Energy reports we have produced may shed light on that question.

- **Question 13:** This test (AHRI 550/590)? 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?

Answer: I am not aware of any manufacturer-provided guidance, but it should be made abundantly clear that AWHPs should not be used in systems formerly using boilers without redesigning the distribution system for lower water temperatures.

- **Question 14:** Many hydronically-heated homes are located in cold climates in the US. Is there a need for separate criteria for cold climate ATWHPs?

Answer: Manufacturers should be required to provide expanded performance tables as are typically available from air-to-air heat pumps. Then it is up to the design engineer to consider that information in completing the design.

- **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?

Answer: The question is not clear. What is meant by “connected criteria”. I am not familiar with those AHRI standards but am interested in learning about them.

- **Question 16:** What is the cost of air-to-water heat pump systems? Does this provide the same service (e.g., covers full heating load, provides cooling, etc.) as competing systems? What are the design and installation costs for these systems in new construction and in a replacement scenario?

Answer: More data is needed to answer these questions. It is a chicken-and-egg problem. If they continue to have a small market share then costs will not be competitive due low production volume, the lack of installer familiarity with these systems, uncertainties about warranty and maintenance costs, etc. Incentives and workforce training is needed to overcome these barriers. AWHPs do not release refrigerant because they are factory charged, are much more easily zoned than forced air systems, in many cases need no auxiliary heat for defrost cycle operation, can provide space heat and water heating (important to avoid service upgrades in retrofits) and can readily be equipped with thermal storage for peak load avoidance. For these reasons they deserve market incentives to encourage their use.

- **Question 17:** Are there any other considerations about the implementation of an air-to-water heat pumps specification that EPA should be aware of?

Answer: I think I have covered everything in my responses.

My Background:

- Co-founder and past president of the Davis Energy Group (DEG, founded in 1981 and acquired by Frontier Energy in 2015).
- Manager for of US DOE Zero Energy Homes, Zero Energy Ready Homes, and Building America program activities for DEG and as the Consortium for Advanced Residential Buildings Building America team.
- Participant in Statewide Utility Codes and Standards Enhancement (CASE) team proposals under multiple code cycles.

- Voting member of ASHRAE TC 6.5 (Radiant Heating and Cooling)
- Extensive experience with design of residential and small commercial HVAC systems

Note that James Haile of Frontier Energy who has been managing testing of AWHPs for several years may also be responding. We may concur in most but possibly not all points of view.

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