Ms. Abigail Daken
Manager, ENERGY STAR HVAC Program
United States Environmental Protection Agency[1]
Washington, DC 20460

Re: AHRI, HRAI, and CIPH Comments to ENERGY STAR® Air-to-Water Heat Pump Discussion Guide

August 7, 2023

Dear Ms. Daken,

The Marley Company (TMC) appreciates EPA staff agreeing to AHRI's request for a 30-day extension for comments for this important topic. As described in our July 7th comments relating to the proposed boilers specification sunset, TMC makes the following over-arching comments related to this proposed rulemaking:

1) Replacing 30-year old boilers with modern boilers achieves the administrations objectives of improving efficiency and reducing emissions. Eliminating the Energy Star Program for Residential Boilers will encourage people to repair older inefficient boilers as opposed to replacing them with climate conscious drop-in alternatives. Market maturity must not be confused with market failure. Orderly replacement of 30-year old boilers with modern boilers is a market success.
2) Commercially available Cold-Climate Capable Heat Pumps don't exist in the country yet. As of today, the technology for a cold climate heat pump as a stand-alone appliance is not viable from a capability, cost, manufacturing and scale perspective. Technology may get there, but it is not there yet and market acceptance has not been validated.
3) A hybrid approach leveraging boilers provides for a viable transition, take advantage of existing and available technologies and products that reduce carbon impact and allow for an orderly transition towards a more sustainable future.

Additionally, TMC has the following general comments with the stated approach to discontinue Energy Star programs for fuel-fired residential furnaces and boilers and fuel-fired commercial boilers in lieu of Air-To-Water Heat Pumps.

TMC acknowledges there are heat pump based products which appear to market to the boiler industry. However, TMC is concerned that there is currently some level of confusion in these communications and that an Energy Star program relating to these products will greatly increase the market confusion unless several key points are explicitly communicated.

Primarily, our perspective is that because a product is offered on the market does not mean that the market accepts the product, that the product meets all application needs, and/or that the product is successful and will continue to be offered. As the economic definition of "Market Failure" is a distribution of goods or services in the free market that does not generate the most benefits to

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producers and consumers, leading consumers to believe producers have products available for distribution when there are none would result in a market failure[2].

The second item is that the heat pump based products currently on the market do not meet the water temperatures which hydronic boilers normally operate and to which the existing heating systems are built to utilize. This is important because the HVAC market is approximately 90% appliance replacements where the heat distribution system is already in place and in many cases you couldn't modify to allow for the present heat pump maximum temperatures.

The critical detail in this point is that today's heat pump technology cannot meet the replacement needs of heating capacity, outlet water temperature, and water flow rate that currently available boilers readily provide. In contrast to boilers, the output of air-to-hydronic heat pumps (in terms of heating capacity, maximum hot water temperature, maximum water flow rate, and efficiency) significantly degrades with outdoor ambient temperature and humidity, yet they are most needed during these same conditions. This temperature limitation is not an issue for forced air heating applications.

The tertiary point is that the existing building stock and the geographical location of each house determine the heating load and is the cornerstone of the heating industry. Additionally, the utilities and their transmission capabilities in the immediate area limit what appliance may be installed in each house. Heat pumps designed for single phase electricity, even operating on 240 Volts, will not meet the heat load of many homes in northern climates. The cost of adding three-phase electricity or higher amperage service panels in homes is not justifiable locally, even in cases where the local grid may be able to support it.

However, TMC believes that heat pump based products, even those operating at a lower water temperature, may be suitable for providing heat during the "shoulder seasons". For this reason, TMC supports combination hybrid heating systems utilizing Air-to-Hydronic Heat Pumps with fuel fired boiler and furnace backup systems.

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 1: TMC supports a more general term: Air-to-Hydronic Heat Pumps (ATHHP). TMC believes the general term "Air-To-Water Heat Pump" would cause confusion as it includes products covered by existing regulations, namely Heat Pump Water Heaters. Similarly the terminology "Hydronic Heat Pump" generally encompasses heat pump water heaters, heat pumps used for space heating, and energy storage embodiments. The term also includes Air-to-Water and Water-to-Water products. For these reasons, TMC believes the most applicable terminology is "Air-To-Hydronic Heat Pump".

Question 2: Are there broadly accepted industry definitions of air-to-water heat pumps or heat pump boilers?

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[2] It is noted that heating hydronic products must simultaneously provide adequate heating capacity, delivered water temperature, and efficiency at the 99% to 99.6% design condition to meet the market need.

Answer 2: TMC notes that there is not currently a "heat pump boiler industry" of sufficient size to consider it a market, let alone a success in the market. The 2022 edition of the BRG report states the outside air-to-water heat pumps are "not common" in the US and Canada. [3]
TMC encourages EPA to utilize the boiler industry definitions as they have long standing meaning and can be used to improve the possibility of market acceptance. As Energy Star indicated that they expect heat pump based technology to transition into the Hydronic industry, maintaining the common hydronic definitions would facilitate the transition. In support of this, TMC supports maintaining the terminology present in Siegenthaler's work[4].

TMC notes that the concepts described are already covered in regulations. Specifically, EPCA already has definitions for heat pump type water heaters[5], but TMC notes that ATHHP primarily addresses (heats) non-potable water. EPCA also provides for the more general term "heat pump"[6]. TMC notes that even "mono-block" constructions of ATHHP, with all components located outside a home, provide an indoor conditioning coil in the form of a brazed plate heat exchanger to provide indoor air heating. If these definitions are not sufficient, EPCA also includes definitions within commercial and industrial equipment as types of "commercial package air conditioning and heating equipment"[7]. Additionally, EPCA identifies a "packaged terminal heat pump" as a type of packaged terminal air conditioner[8]. WMT believes the later definition to be the preferred embodiment described in EPA's Residential Boiler Discussion Guide.

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 3: TMC notes that EPA is using the term "boilers" out of context and provides our response in the context of ATHHP's. There is a significant difference between the two applications with respect to ATHHP's and therefore currently the same ATHHP cannot be used in both situations.

Today's boilers can be set to run at different application temperatures. For forced air applications, you can set the water temperature in the low 100's when the system is designed. You see this application mostly in multi-family environments. For true hydronic heat applications, especially in older homes you need a significantly higher temperature to effectively run the heating system.

The bifurcation of the markets exists because air-conditioning and heat pump technology for force air applications operates at different temperatures relative to the boiler industry and the water heating industry. Therefore, economic market solutions have evolved the different approaches which must be utilized to meet the market expectations of independent utility. As mentioned previously, products which are capable of providing higher water temperatures (180°F) can often meet lower water

[3] North American Heating & Cooling Product Markets, 2022 Ed. BRG Building Solutions, Westbury, NY. p 230
[4] Modern Hydronic Heating for Residential and Light Commercial Buildings, Third Ed, John Siegenthaler, Delmar-Cengage, 2012.
[5] 42 USC §6291 (27)(C)
[6] 42 USC §6291 (24)
[7] 42 USC §6311 (8)
[8] 40 USC §6311 (10)(B)

temperature application needs, but lower water temperature appliances (120°F) cannot meet the needs of higher water temperature applications. TMC notes that it is easier to think of this from the needs of the heat emitter design than the appliance design and adopts this perspective in our comments.

One reminder of importance is that the Center for Disease and Control (CDC) identifies that legionella grows best in the temperature range of 77°F to 113°F. The lower water temperatures generated by heat pump based systems can readily result in portions of the distribution system operating within this range of water temperatures.[9] Although heating systems are typically closed systems, service and maintenance could expose technicians to Legionella if adequate water temperatures are not maintained. The important point is that EPA's low water temperature rating condition must be above the 113°F water temperature as the water exiting the product is the highest temperature the water will reach. The water loses energy after exiting the heating appliance.

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 4: For the same reasons as we stated in our response to Question 3 above, no. TMC believes there is an existing definitional distinction between the products in question as they are each already covered be different laws and regulations. DOE has previously identified that heat pumps used in hydronic space heating are covered under the Boiler product type[10]. Separately, Heat Pump Water Heaters are already defined products as types of Consumer Water Heaters[11]. For these reasons, TMC proposes the term "Air-to-Hydronic Heat Pumps" (ATHHP) as it is a more specific term for such combination products, but notes that the products are already covered by EPCA.

TMC notes that this general term, "Air-To-Hydronic Heat Pump" (ATHHP), may be further broken down into the application needs of high water temperature and water flow rate (if those products become technically and economically feasible), medium, and low water temperatures and flow rates. TMC recognizes that both EPA and DOE must operate with respect to EPCA definitions which typically identity the products, not the manner in which the product's application. However, for hydronic systems it is often times more useful to consider the appliance from the requirements of the heat distribution system used in the specific application, hence this approach is easier to differentiate and describe.

TMC notes that the higher water temperature options can typically meet requirements of lower water temperature applications, but lower water temperature ATHHP's cannot meet the needs of higher water temperature applications. The High Water Temperature ATHHP's would be intended for applications similar to standard hydronic boilers, Medium Water Temperature ATHHP's to water heating and water coils used in air circulating furnaces, and the Low Water Temperature ATHHP's apply to

[9] https://www.cdc.gov/legionella/index.html

[10] EERE-2019-BT-TP-0037

[11] 10 CFR §430.2 Definitions

radiant systems such as under floor and snow melt systems. TMC expects each of the application types would have a different test procedure and hence a difference performance metric.

Alternatively, it may be useful to think of the distinction between boilers and water heaters by their available time to meet the heating load. While storage type water heaters have opportunity to heat water over a long period of time, boilers and tankless water heaters must meet the heating load in short time periods, hence we can reference the difference as the concept of “Trickle or Flood”.

These fundamental differences would make a test procedure exceedingly complicated to develop as well as to operate on an ongoing basis may run afoul of EPCA’s test procedure burden limitation.[12]

Proposed Covered Products	Proposed Product Classes	Currently Covered Products
Air-to-Hydronic Heat Pumps[13]	High Water Temperature	Residential Boilers[14]
	Medium Water Temperature	Residential Boilers[9] & Water Heaters[15]
	Low Water Temperature	Residential Boilers[9] & Water Heaters[10]
Water-to-Hydronic Heat Pumps[8]	High Water Temperature	Residential Boilers[9]
	Medium Water Temperature	Residential Boilers[9] & Water Heaters[10]
	Low Water Temperature	Residential Boilers[9] & Water Heaters[10]

Table 1: Possible Structure of Hydronic Heat Pump Categories

Question 5: EPA is interested in additional information about dual fuel boilers particularly market, cost, and performance information.

Answer 5: TMC understands this question as either:

1. Please provide additional information on ‘dual fuel boilers’ where a single appliance containing an electric air-to-hydronic heat pump and also a fuel-fired backup heating source.
2. Please provide information on gas powered heat pumps, which use a sorption-type or a thermal compression-type cycle which includes a step with direct heating of the refrigerant by a gas burner.

In response to question 1: TMC notes that the term ‘dual fuel boiler’ already exists in the hydronics industry and refers to a boiler in which the burner can transition between using natural gas, propane,

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[12] 42 USC 6293 (b)(3)

[13] Air-to-Water and Water-to-Water Heat Pumps would be separate Covered Product from Water Heaters defined in 42 USC §6291(24).

[14] These products meet the definition of a boiler, which is a type of furnace per 42 USC §6291 (23). It is noted that 42 USC §6291(20) defines AFUE as the efficiency descriptor for boilers and furnaces which are either indoor or outdoor installations. Split heat pumps have both indoor and outdoor portions, excluding them from using the AFUE energy descriptor.

[15] These products meet the definition of Water Heater per 42 USC §6291(27)(c)

biogases, fuel oil #2, low sulfur diesel, or blended fuel oils.[16,17,18] Therefore, TMC believes EPA used the term 'dual fuel boiler' to reference an electric air-to-hydronic heat pump which operates during the 'shoulder seasons' and the portions of the heating season with less extreme cold conditions, coupled with a fuel-fire boiler which takes priority during extreme cold weather. While TMC believes this product concept is a path to improve the integration of heat pump technology into the heating market smoothly, WMT also believes this terminology will result in confusion in the market.

With respect to the market size of ATHHP coupled with fuel-fired backup, TMC has not identified any market material for this exact case. In general, the market research TMC has found has significant variation in the market estimates of heat pumps in heating dominate markets, only agreeing in the fact that heat pumps in colder climates are a niche market within a niche market and have relatively few shipments within the US heating markets. The 2022 edition of the BRG report estimates that during 2020 approximately 6,000 new homes installing heat pumps in the Northeast. This estimate includes all residential heat pumps, not just ATHHPs.[19] The market of ATHHP would therefore be much less than 1% of the US Boiler and barley a decimal point in the US furnace market.

In response to question 2: TMC understands this technology (gas powered heat pumps) may have the ability to operate at higher water temperatures and heating capacities at lower ambient conditions relative to electric compressor technologies, but typically achieves lower COP than electric compressor technologies. Gas powered heat pumps can also generate larger heating capacities using single phase electricity. TMC does not have information on costs, market, or performance of these products.

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 6: TMC understands the relationship between ambient air temperature and humidity, decreasing heat pump capacity, decreasing delivery water temperatures, and decreasing COP is well known and documented, but different for each heat pump technology and manufacturer. A survey of existing heat pump rating conditions, shown in Table 1, identifies that an average ambient temperature of 47-50°F and wet bulb temperatures of 43-44.3°F are used in the heat pump heating industry.

Reviewing regulations for rating of air-to-air heat pumps also identified that variable speed compressor technology utilizes two rating points to determine part loading performance[20]. Therefore, TMC believes standard rating conditions should include part loading and be evaluated at the common points of 47°F dry bulb and 43°F wet bulb and 17°F dry bulb and 15°F wet bulb to adequately represents the usage of heat pumps nationally. For product use in the cold climates, TMC believes that the a combination of the specifications within DOE's Cold Climate Heat Pump Challenge and the Energy Star Specification for Central Air Conditioner and Heat Pump Final Specification (Version 6.1) should be utilized. Where the two rating points would be 5°F dry bulb and 4°F wet bulb (max) and at -15°F dry bulb and 4°F wet bulb (max) temperatures. TMC further recommends a minimum water temperature of 120°F to avoid

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[16] https://www.powerflame.com/burners/type-c
[17] https://www.webstercombustion.com/Products/hdrmb-series
[18] https://www.weishaupt-america.com/products/burners/wgl30-40-dual-fuel-burners-for-gas-and-oil
[19] North American Heating & Cooling Product Markets, 2022 Ed. BRG Building Solutions, Westbury, NY. p 230
[20] Appendix M and M1 to SubPart B of Part 430 of 10 CFR.

Legionella, and would limit the rated heating capacity to that capacity determined at the lowest ambient temperature tested in either case. The maximum temperature should be in the 180°F to meet all application needs. Finally, we would recommend a COP >3 at lowest temp range to have operations cost at parity with present technology.

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 7: The Marley Company understands this as one of the key points in the transition of the heating sector towards heat pump technology. Because heat pumps capable of operating in low temperatures are not readily available and cost effective, a pathway is needed for existing homes which often utilize fuel-fired boilers in these regions. TMC believes that a backup (supplemental) fuel-fired boiler which operates in the event of either a compressor cut out temperature (also known as a transition temperature), an emergency situation, or a utility directed grid stabilization scenario, should be teamed with an ATHHP to improve the concerns of climate change while assuring the heating needs are met.

TMC proposes that a combination rating of separate systems is the most appropriate to achieve this combined appliance rating. This proposal follows the Department of Energy's prior tentative guidance that combination appliances may be rated using separate metrics. TMC has submitted this proposal to our trade association as an option for consideration. Due to the proposed timing of the Energy Star schedule, this proposal is attached as an appendix to our comments as well.

	General Description	**Acronym**	**AHRI Program**	**Outdoor**		**Indoor**	
				Dry Bulb	**Wet Bulb**	**Dry Bulb**	**Wet Bulb**
1	Heat Pump Pool Heaters[21]	HPPH	AHRI 1160	50	44.3		
2	Water Cooled Water Chilling[22]	WCCL	AHRI 550/590	47	43		
				17	15		
3	Packaged Terminal Heat Pumps[23]	PTHP	AHRI 310/380	47*	43	70	60
4	Unitary Heat Pump Equipment[24]	USHP	AHRI 210/240	47	43	70	60
				35	33	70	60

[21] AHRI 1160, Table 2: Low Air Temperature - Mid Humidity (63% RH).
[22] AHRI 550/590 Table 4: AC Heat Pump - High Heating.
[23] AHRI 310-380, Table 1: Heating - Standard rating conditions and high-temperature heat pump heating.
[24] AHRI 210-240, Table 8: H1, H2, H3 all at Full Heat and H4 at Boost Heat conditions.

				17	15	70	60
				5	3	70	60

Table 2: Heat Pump Rating Conditions

In summary: The proposed "Integrated Combined Thermal Efficiency" (TE_{IC}) calculation uses the approach of Appendix C of ASHRAE 103 and portions of Appendix EE and Appendix P to SubPart B of 10 CFR §430 to determine the ASHRAE 146 based Thermal Efficiency of a residential boiler and heat pump. A Combined Integrated Thermal Efficiency of Hydronic Heat Pump with a Fuel-Fired Backup Boiler using Zones IV, V, VI of Table 10a of ASHRAE 116-2010, is identified at a Transition Point of 32°F (from the tabulated values in the ASHRAE 116 standard), at which the capacity of many hydronic heat pumps cannot efficiently keep up with the home heating load. Summing the bins for these three zones for temperatures above 32°F and again for bins of 32°F and lower results in 70.9% of the time operating at ambient temperatures above 32°F. Recognizing that Thermal Efficiency equals COP x 100 and using calculations previously determined within the existing AFUE test procedure to determine an Integrated Thermal Efficiency which is weighted for the electrical consumption of the boiler results the following equation,

$$TE_{IC} = 0.709(ET_{ATHHP}) + 0.291(TE_{I})$$

Please see Appendix A of these comments for further details, including a list of advantages and limitations identified relating to this proposal.

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 8: Because the estimated total number of new home installations of heat pumps in cold climates is much less than 1%, WMT believes that the answer to this question is virtually never.[25] TMC believes the very small market size of these fledgling products serves to make this request untimely. Mere theoretical considerations must be balanced with practical experience in order to achieve a method of test which is meaningful to the consumer. Again this goes back to that there is not a heat pump available yet for high temp applications. As noted earlier, you can take a high temp product down for lower temperature applications but not vice versa.

In general, TMC has been a supporter of updating ASHRAE 124 for several years to address similar concerns. We are not aware of any method of test which currently achieves the objective to adequately describe the performance of space heating and water heating appliance in all the possible embodiments. This experience guided our decision to provide the Integrated Combined Thermal Efficiency (TE_{IC}) methodology mentioned previously. It is acknowledged that the TE_{IC} is an intermediate step to allow a smooth transition towards heat pump based hydronic heating.

[25] North American Heating & Cooling Product Markets, 2022 Ed. BRG Building Solutions, Westbury, NY. p 230

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 9: TMC points out that having a fuel fired supplemental heating system coupled with a heat pump could allow load shifting off the electrical grid in time of high electrical demand or grid resiliency concerns, but the practical requirements would require significant efforts.

Cast iron boilers and other "high mass" boilers currently provide this benefit as the energy stored in their mass is used to provide heat to the home through control methods added to the boilers. This is possible due to the specific heat of cast iron and the ability of the cast iron can to survive at the higher temperatures amongst other reasons. However, using water as the storage media for home heating would either require very large volumes of water or exceedingly high temperatures, or a combination thereof. Heat pump technology currently cannot create the elevated temperatures which would be needed to take significant advantage of this opportunity.

Furthermore, the safety standard for residential water heaters (ANSI Z21.10.1) limits residential water heaters from providing water a maximum outlet temperature of 210°F[26] while multiple building codes and the ASME BPV code limits water heaters to 150 psig working pressure. Should the Agency and Department consider increasing the maximum storage temperature while maintaining the maximum outlet water temperature, then concerns of standby loss as well as the reliability of scald prevention need to be addressed. Furthermore, the confounding nature of combinations of heating load profiles and hot water usage profiles further complicates this scenario as the stored volume would have to account for both.

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

Answer 10: TMC is working with AHRI on this topic and support's AHRI's efforts. We look forward to working with EPA and DOE on the AHRI standards development for this effort.

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 11: The Marley Company supports the usage of all available technologies to improve better usage of our natural resources and to protect our climate. As such, we support inclusion of all compressor technologies include fuel fired options in this endeavor.

The Marley Company is not convinced that the AHRI 550/590 method of test is either the most technically accurate option or the fastest path to establishing a test procedure for the products in question. In general, The Marley Company encourages the use of a simple rating method at average operating conditions for federal compliance of both residential and commercial products and recognizes the need for this approach to utilize tests at various ambient conditions when performance is

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[26] CSA/ANSI Z21.10.1-2019, Section 3, Water Heater definition on page 37

significantly dependent upon those conditions. Additionally, The Marley Company sees benefit in with optionally providing interested users and engineers more complex information relating to part-load efficiency that may confuse the average users. Ideally, the referenced method of test would include both high heat load and part load testing options, but the mandatory federal programs would only require reporting the national average rating conditions to satisfy the representative annual usage.

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 12: TMC considers this a theoretical consideration because the estimated total number of new home installations of heat pumps in cold climates is much less than 1%.[27] WMT believes that there is not sufficient experience in the US market to provide practical responses to this question.

Theoretically, the efficiency, outlet water temperature, and capacity of ATHHP systems can decrease with decreasing outdoor temperatures. It is therefore a reasonable expectation that heat pumps sized for necessary capacity at low ambient temperature operation will be cost prohibitive in the market. However, TMC notes that, for an adequately sized system, the number of operating hours during the "shoulder seasons" decreases while the number of standby hours typically increases. ATHHP systems are well suited for use in the shoulder seasons as they can provide heat in these conditions until they are operating 24 hours a day during or until the heat demand is not met.

TMC notes that usage of ATHHP during shoulder seasons would therefore not be required to meet the design conditions because the supplemental fuel fired boilers would operate during those periods of time.

TMC further notes that the EPCA defines consumer heat pumps as powered by single phase electricity and having a maximum of 65 MBTUH of heating capacity amongst other descriptors.[28] EPCA also defines certain commercial and industrial equipment including "single packaged vertical heat pump" which is a type of "single packaged vertical air conditioner".[29] Because federal definitions of furnaces and boilers limit residential heating capacity to 225 and 300 MBTUH respectively and small commercial heat pumps to 135 MBTUH[30], it is intuitive that current compressor technology will not be able to meet the heat load requirements of the entire heating market.[31]

Therefore, TMC considers this use of fuel-fired backup heating systems to be a viable transition approach to heat pump technology.

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?

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[27] North American Heating & Cooling Product Markets, 2022 Ed. BRG Building Solutions, Westbury, NY. p 230
[28] 42 USC §6291 (24)
[29] 42 USC §6311(10),(22), and (23)
[30] 42 USC §6311 (8)(B)
[31] 42 USC §6291 (23)

Answer 13: Stress more WM Technologies stresses that 110°F water temperature is not sufficient for home heating temperatures.   TMC notes that the use of water temperatures below 120°F in performance test procedures risks miscommunication of the dangers of legionella. Additionally, TMC points out that the flow rate of the heated water is as important as well as the heating capacity during cold weather. TMC further notes the hot water delivery of the appliance occurs at the appliance water outlet connection.

TMC currently believes that not all ATHHP technologies may be adaptable to the retrofit market. TMC is encouraged that the advantages of ATHHP technologies used during the shoulder season may provide adequate heat during significant portions of the heating season, while improving energy efficiency and reducing emissions. In many of today's applications the system requires 160-180F as noted based on design of home. To lower that temperature you would need to make significant investment in the house to increase/change emitters, improve efficiency of home,etc and since many of these homes are on the older side, the building infrastructure, etc typically makes this difficult at minimum.

For these reasons, TMC continues to support the ratings of ATHHP as to their performance to High. Medium, and Low Water Temperatures and at standard and cold climate ratings for each. TMC expects this foundation to serve EPA and DOE's needs as the market continues to transition towards heat pump technologies. TMC believes continued research is needed to confirm this important topic.

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 14: TMC is adamant that the answer to this question is a resounding "YES". ATHHP output (heating capacity, maximum hot water temperature, maximum water flow rate, and efficiency) significantly degrades with outdoor ambient temperature and humidity, yet they are most needed during these same conditions.

ASHRAE 116-2010 does not include Zone 7 as heat pumps were not practical in these temperature ranges when this standard was last updated in 2010. Although progress is being made towards offerings in this region, TMC has not found evidence that the market has developed to date. More specifically, TMC believes that colder climates can benefit from backup fuel-fired boiler operations which would provide heat for homes when the outdoor temperature falls below 32°F. This approach provides Energy Star approval for oil and natural gas-fired boilers for use as backup heating in cases of extreme cold, emergency operation, or grid resilience and stability.

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 15: TMC believes the answer to this question is yes, but not at the present time. Specifically, TMC notes that the connected criteria can similarly be utilized to force the transition of residential heating to fuel-fired alternatives in times of electrical grid reliability or other concerns. While this concept is conceptually feasible, significant efforts must be worked out before requiring connected criteria in a market that has not yet developed.

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 16: TMC believes that, due to the immature nature of the associated market, the scope of this program must be determined before the costs could be understood.

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

Answer 17: Yes, WMT believes there are a number of considerations which aren't presently known, as the potential market is in a state of infancy.

TMC notes that the importance of qualifications and abilities of the installer base cannot be discounted in this conversation. During the same time that regulations continue to force technological advances of products, the number of qualified installers and contractors is in a state of flux, if not decreasing. The Bureau of Labor Statistics expects the number of contractors to increase 5% from 2021 to 2031[32]. However, the Air Conditioning, Heating, Refrigeration News acknowledges that one in five HVAC companies fail each year[33]. If the contractor workforce has this rate of change, there will not be experienced and qualified people to install and service the complicated appliances of tomorrow.

In general, TMC is evolving our beliefs accordingly and is confident that the transition towards a Climate Conscious future is a four-way balance between electricity generation, the expansion and strengthening of the national electric grid, the appliances and products providing utility to the consumers and industry, and a qualified workforce to install and maintain such high-tech systems. The strong underpinning of each of these topics is the availability of a highly trained American workforce.

In closing, The Marley Company thanks the Energy Star Program for the opportunity to work together towards a more sustainable future and encourages the Program to facilitate a smooth transition into tomorrow. We feel there are lots of opportunities to improve efficiency and reduce emissions and we are committed to this, but we feel for hydronic specific applications heat pump technology is not there yet as a standalone appliance and feel it is too soon to reduce incentives on boiler replacements. As a minimum it needs to be allowed for and incented for hybrid applications.

Sincerely,

Mike Doorhy, General Manager
The Marley Company, LLC

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[32] https://www.bls.gov/ooh/installation-maintenance-and-repair/heating-air-conditioning-and-refrigeration-mechanics-and-installers.htm#tab-6

[33] https://www.achrnews.com/articles/153041-remaining-viable-in-a-crazy-hvac-contracting-economy. From May 19, 2023.

APPENDIX A

Determination of Combined Integrated Thermal Efficiency of Air-To-Hydronic Heat Pump with Fuel-Fired Backup Boiler

Summary: This proposed approach provides a method to achieve a combined rating of an Air-To-Hydronic Heat Pump with a Backup Fuel-Fired Boiler using independent test procedures for each product. The approach brings together various aspects from existing regulations and ASHRAE standards which are cited in the text. The combined rating for the system is calculated from values determined during testing of individual components and does not require additional testing at the system level.

Method

Given the national average number of Burner Operating Hours (BOH) for the Backup Fuel-Fired Boiler, generally taken from Informative Appendix C of ASHRAE 103-2017[34].

Given there are 8,760 hours in a year (365 days/yr x 24 hours/day)
2080 (hours) = national average heating load hours as noted in Appendix C to ASHRAE 103 – 2017.
OFF_{HR} (hours) = 6,680 hours (8,760 – 2080)

- For products including a power switch or instructing users to turn off power to appliance during summer, OFF_{HR} = zero (0).

Based upon the 2022 Residential Boiler NOPR LCC analysis, DOE determined the average Burner Operating hours for all residential boilers to be 665.7 hours[35]. Output of the BOH determinations for all Residential Boiler product categories from a 10,000 iteration Crystal Ball analysis is presented in Figure 1.

BOH_{SS}=665.7 Hrs
$StandBy_{HR}$ (hours) = 2080-BOH_{SS} Hrs = 1414.3 Hrs.

Based upon Appendix P to SubPart B of 10 CFR §430, for fossil fuel-fired pool heaters, the average annual fuel energy for fuel-fired backup boiler, EF, is defined as:

$$EF = BOH_{SS}\ Q_{IN}$$

The average annual electrical energy consumption for fuel-fired boilers, EAE, is expressed in Btu and defined as:

$$EAE = EAE_{active} + EAE_{standby,off}$$

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[34] It is recognized that heat pumps referencing Appendix M of SubPart B of 10 CFR Part 430 also considers 2080 heating hours per year adequate, Appendix M1 utilizes 1572 heating hours per year for certain other heat pumps.
[35] These values were found by applying forecast cells to the different product categories' BOH calculations and running the referenced Crystal Ball analysis. It is recognized that the burner operating hours of any backup appliance may be determined using this approach and arriving at different values for BOH.

$$EAE_{active} = BOH_{SS} * PE$$

$$EAE_{standby,off} = (StandBy_{HR})\ P_{W,SB}(Btu/h) + (Off_{HR})\ P_{W,OFF}(Btu/h)$$

where:
EAE_{active} = electrical consumption in the active mode,
$EAE_{standby,off}$ = auxiliary electrical consumption in the standby mode and off mode,
PE = for fossil fuel-fired heaters tested according to section 8.2 of Appendix EE to SubPart B in 10 CFR §430.
$P_{W,SB}$ (Btu/h) = electrical energy consumption rate during standby mode expressed in Btu/h = 3.412 $P_{W,SB}$, Btu/h, as defined in 8.10 of Appendix EE to SubPart B in 10 CFR §430.
$P_{W,OFF}$ (Btu/h) = electrical energy consumption rate during off mode expressed in Btu/h = 3.412 $P_{W,OFF}$, Btu/h, as defined in 8.10 of Appendix EE to SubPart B in 10 CFR §430.

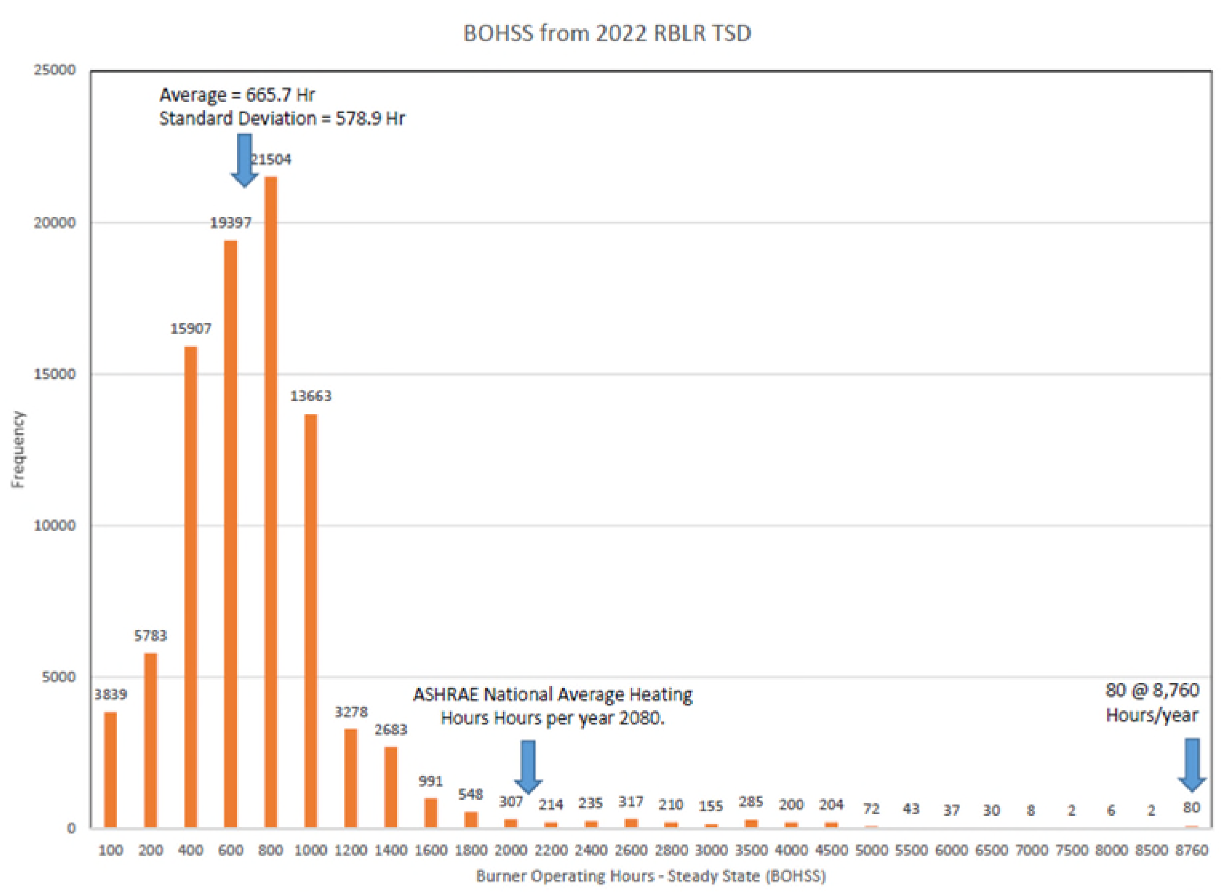

Figure 1: DOE determined National Average of Burner Operating Hours

Integrated Thermal Efficiency of fuel-fired backup boiler

Calculate the seasonal useful output of the fuel-fired backup boiler as:

$$E_{OUT} = BOH_{SS}[(Et/100)(Q_{IN} + PE)]$$

where:
BOH_{SS} = as defined in previously,
Et = thermal efficiency as Q_{OUT}/Q_{IN},
Q_{IN} = as defined previously,
PE = as defined previously, and
100 = conversion factor, from percent to fraction.

Calculate the total annual input to the backup boiler as:

$$E_{IN} = EF + EAE$$

where:
EF = as defined previously, and
EAE = as defined previously.

Calculate the fuel-fired backup boiler integrated thermal efficiency (**TE_I**) (in percent).

$$\mathbf{TE_I = 100(E_{OUT}/E_{IN})}$$

where:
E_{OUT} = as defined previously,
E_{IN} = as defined previously, and
100 = conversion factor, from fraction to percent.

It is noted that this high-fire, steady state efficiency results in lower (conservative) efficiencies as part-load conditions increase efficiency. These values are conservative relative to the DOE required Metric.

Air-To-Hydronic Heat Pumps
Calculate the COP according to approved method of testing (e.g. section 11.1 of ASHRAE 146)[36].
Calculate the thermal efficiency, ET_{ATH} (expressed as a percent):

$$ET_{ATH} = 100(COP)$$

Air-To-Air Heat Pumps
Calculate the HSPF2 according to approved method of testing (Appendix M1 to SubPart B of 10 CFR Part 430). Convert the HSPF2 (BTU/watt-Hours) to COP[37], then to the thermal efficiency, ET_{ATH} (expressed as a percent):

$$ET_{ATH} = 100(COP_{HP}) = 100(0.293(HSPF2))$$

[36] It is recognized that any method of test resulting in an applicable TE, ET, or COP may be used in this general approach.
[37] COP = (HSPF2 BTU/watt-hour x 1054.8 Joules/BTU)/3600 Joules /watt-hour = 0.293 HSPF2.

Combined Integrated Thermal Efficiency of Air-To-Hydronic Heat Pump with Fuel-Fired Backup Boiler

Calculate TE_{IC}, the Combined Integrated Thermal Efficiency of Air-To-Hydronic Heat Pump with Fuel-Fired Backup Boiler using Zones IV, V, VI of Table 10a of ASHRAE 116-2010[38].

Considering a Transition Point of 32°F[39], at which the capacity of the heat pump boiler cannot efficiently keep up with the home heating load, and summing the bins for these three zones for temperatures above 32°F and again for bins of 32°F and lower results in 70.9% of the time operating at ambient temperatures above 32°F.

$$\mathbf{TE_{IC} = 0.709(ET_{HPB}) + 0.291(TE_{I})}$$

Important points of consideration for this approach include:

- Provides a transition period until cold-climate heat pumps and the necessary test procedures are developed.
- May be used in the replacement market, as opposed to limiting installations to new construction.
    - Heat Pump technology may be added to existing furnace or boiler installations
- Provides both EPA and DOE one method to use to achieve combined appliance ratings for fuel fired backups.
    - DOE may establish a minimum and EPA establish a higher Energy Star level, different transition temperatures, etc..
- EPCA does not limit the use of a Thermal Efficiency metric to certain product types. EPCA does limit the use of AFUE to furnaces and boilers. 42 USC §6291 (20)
    - AFUE is further limited to furnaces and boilers that are either indoor or outdoor units, where some air-to-hydronic heat pumps have both indoor and outdoor components.
- The Combined Appliance Ratings utilize Individual covered products ratings without requiring additional testing.
    - This is in agreement with DOE's tentatively noted direction if they were to decide on combined appliance ratings instead of a formal test procedure for such products.
- The approach works with any Heat Pump test procedure generating a COP, HSPF, or thermal efficiency based rating.
- The approach may be used for other combination appliances although the factors would require further development for each combination based on the driving criteria (outdoor temperature, on-time for each application, etc..)

  Due to the small percentage contribution (~30%) for the fuel-fired boilers, a change in AFUE has limited impact upon the TE_{IC} rating of the combined system.

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[38] Recognizing that bins for Zone VII are not included in this document and may necessitate further evaluation of the factors.

[39] The selection of the Transition Point is based on commonly tabulated values and may have different values between Energy Star and DOE's programs and may be changed as Cold-Weather-Heat Pump technology improves.

- The weighting of the off-mode and standby electrical consumption in the calculation provides lower thermal efficiencies (TE_I) of fuel-fired products than expected. These ratings are therefore conservative with respect to DOE's requirements and should not be problematic.
- It is recognized that the rating conditions of the different test procedures may not agree, increasing uncertainty in the systems level efficiency. Specifically temperatures of the heating medium and ambient conditions vary between test procedures.
- Not all combination products may be adequately evaluated by the existing DOE prescribed product test procedures. This is especially applicable to products within the same jacket or encasement.