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Submission via HVAC@energystar.gov; Daken.Abigail@epa.gov; Tapani.holly@epa.gov

Re: Proposals to sunset the ENERGY STAR Boilers specification and to launch a new specification to cover heat pump hydronic heating appliances

Dear ENERGY STAR:

Energy Kinetics is a leading manufacturer of heat and hot water boilers located in Lebanon, New Jersey. We respectfully submit these comments in response to the ENERGY STAR Boiler labeling proposal and to the proposed test method and first draft specification to cover air to water heat pumps.

There are several compelling reasons for ENERGY STAR to continue to label gas, and oil and renewable liquid heating fuel (RLHF) boilers, and for consumers to rely upon ENERGY STAR labels for these products to make more informed and efficient choices that reduce fuel consumption and carbon emissions.

1) Boilers are used in cold climates, and air to water heat pumps (ATWHPs) using widely available refrigerants and technology cannot supply the hydronic water temperatures required to adequately heat cold climate homes served with conventional baseboard and cast iron radiation. ENERGY STAR recognizes that hybrid systems that combine boilers and ATWHPs will be required to adequately serve these homes.

   The most common the consumer decision points for boiler replacement occur as an emergency or urgent replacement, or as a proactive measure near the end of life of the boiler. As an ATWHP cannot serve the entire load in typical applications, a replacement boiler will be required to properly heat the home; if an ATWHP is desired, two systems will need to be purchased making this option prohibitively expensive. In a “down boiler” situation, a replacement boiler will likely be purchased to prevent freezing as an ATWHP alone will not adequately meet the needs of the consumer. The installation of an ATWHP at a later date could be considered for significant added expense. This leads to the conclusion that ATWHPs will be purchased as a partial heating measure purchased with discretionary income. As ATWHPs will not constitute a majority of boiler purchases in the coming years, it is critically important that boilers are replaced with efficient and lower carbon emitting models. In actively supporting and pursuing this market influencing effort, ENERGY STAR could reinforce the energy savings achieved with early adopters of ATWHP technology.

2) Through the Inflation Reduction Act (IRA), Congress encouraged a combination of improved efficiency and better, cleaner fuels. To respect the will of Congress when they last spoke on the the specific issue of boilers, ENERGY STAR could consider labeling guidelines for oilheat and RLHF boilers consistent with the IRA established criteria an AFUE level of 87 or higher combined with a biofuel certified boiler certified for use with a 20% biofuel blend (B20). Expanding and exceeding that baseline with an even higher AFUE combined with B100 certification would send a strong market message to achieve energy savings and lower carbon emission goals. Although B100 certified boilers are not on the market today, I anticipate they will be available by the end of 2023.

   Since biofuels and state blending mandates are becoming more prevalent, consumers and the environment can benefit from higher efficiency boilers that use ever increasing blend levels. For example, the Mid-Atlantic and Northeast regions of the United States are primary and substantial boiler markets. Biofuel blends currently have mandates in Connecticut, Massachusetts, Rhode Island, and New York, with additional states considering biofuel blending mandates for RLHF applications. As such, these states encourage and mandate higher blend levels and are actively engaged in reducing carbon in liquid fuel and RLHF applications.

   Supportive influence from ENERGY STAR boiler labeling can further assist in market transformation to higher blends and lower emissions.

3) It is our understanding that a majority of gas, and oil and RLHF boilers provide both heat and hot water. Savings from upgrades to heat and hot water boilers with high steady state thermal efficiency and low idle loss is much greater than shown with AFUE alone as demonstrated in an analysis of a Brookhaven National Laboratories study (BNL Study)[1]. As such, very meaningful energy savings can be achieved.
   a. **Gas boilers** Analysis of the AHRI directory for residential boilers indicates that 95 AFUE and higher rated condensing boilers are constructed from stainless steel and aluminum materials. The high AFUE indicates a high steady state thermal efficiency, and the construction materials indicate low mass and likely low idle loss. Analysis of the BNL Study indicates an upgrade from a non-condensing boiler to this type of design can yield savings in excess of 20%.[1] Although there is not a strong differentiation in AFUE for combined heat and hot water boilers, substantial savings can be realized.
   b. **RLHF and Oil Boilers** NORA is an organization centered around advancing zero carbon home heating that conducted a boiler savings analysis study and report focused on oil and RLHF boiler upgrades[2]. The average savings was found to be 20% when upgrading existing equipment, and 6% savings when the results of 87 AFUE boilers with low idle loss were compared to 86 AFUE boilers with higher idle loss. For the 6,412 boiler upgrades done as of the beginning of 2021, the total savings after one year was 1,090,040 gallons, $3,488,128, and 15,833 tons of greenhouse gas emissions. These savings were extended to 5, 10, and 25 years. Simple payback on the NORA upgrade incentive was found to be about 1 year, indicating a strong value for the consumer combined with exceptional results for emissions reductions. Two alternative approaches were used to estimate annual energy savings associated with the equipment upgrades. Approach 1 involves correlations between heating degree days and heating fuel energy input based on delivery data. Approach 2 involves use of boiler system estimated steady state thermal efficiency and idle loss.

      The combination of 20% energy savings and a B20 blend of biofuel can deliver carbon reduction in excess of 30%.

c. Analysis of savings from upgrading to the top performing combined heat and hot water boilers with the lowest idle loss demonstrates even greater savings than shown above.

4) The ENERGY STAR label and support for energy efficiency and low carbon liquid heating fuels would support generational effects on reduced carbon emissions. Lower carbon emissions realized from installing more efficient and RLHF boilers today delivers compounded emissions reductions well into the future. If consumers fall away from making an easy choice for energy efficiency by selecting a boiler without the ENERGY STAR label because that label is no longer applicable, they may select a lower efficiency product which has compounded emissions increases over better performing boilers. ENERGY STAR's influence in supportive labeling for boilers can lead to reduced emissions and more broad awareness and installation of better performing boilers. This is particularly true before nascent ATWHP technology develops a substantial market presence.

5) If ENERGY STAR labeling sunsets for boilers, it would dilute the differentiation between higher and lower energy saving products and likely unintentionally influence consumers to buy lower cost, lower efficiency, higher carbon emitting boilers, which is counter to the stated objective.

6) We estimate that over 95% of the residential boiler market is for replacement applications. As this cold climate market segment cannot be fully served with ATWHPs, it important that ENERGY STAR continue to influence consumers in the direction of higher efficiency, higher performing products.

We offer the following with respect to the specific questions posed by ENERGY STAR regarding Air to Water Heat Pumps:

Question 1: "Heat Pump Boiler" is a catchy marketing name and implies a drop in replacement for boilers. As a vast majority of boilers are used in cold climates and traditional hydronic radiation requires 180° supply water temperature, referring to air-to-water heat pumps as Heat Pump Boilers with currently available refrigerants that are incapable of delivering these temperatures is misleading. As such, the transition to the name "Heat Pump Boiler" should be reserved for systems capable of producing much higher temperatures. Even next generation refrigerants and compressors that can produce at least 160°F hydronic supply temperatures are marginal in this capacity. Hot water "boilers" don't "boil", so maybe it is time for a new, more appropriate name – in the meantime, "ENERGY STAR Air-to-Water Heat Pumps" is more representative of expectations. This should be further clarified to represent the appliance performance based upon supply temperature ranges; further details and suggestions can be found later in this document.

Question 3: This question is more appropriate for the implementation of ATWHPs than boilers. Properly designed warm air coil systems can adequately heat homes with much lower hydronic supply water temperatures than can be used with typical baseboard and cast iron radiator systems. For that reason, if the entire building is heated with warm air coils designed for 135°F supply water, ATWHPs could be adequate with today's refrigerants. If higher temperature radiation, like baseboard, is also connected, the 135°F ATWHP would not adequately heat those zones in nearly all cases.

Question 4: Testing ATWHPs as water heaters poses several problems that cause market confusion. More advanced technology will be able to convert waste heat from air conditioning mode into domestic hot water. This will likely involve warm air coil operation for cooling, more complex piping for hot water, and more advanced integration and controls, so the technology and the installation will be more expensive. There are various ways technology can be applied to provide hot water solutions. Using a standard hot water test procedure that does not recognize and reward these benefits would incentivize product development that is not capable of these much higher efficiencies and of the utilization of waste heat. Overall test procedures must also be field validated at scale before adopted as a standard to ensure products are fairly represented and reflect overall field performance. This will help manufacturers appropriately design and rate products and ensure consumers can make informed choices.

Question 5: Dual fuel boilers or hybrid integration of ATWHPs with current boiler technology provides an opportunity to use existing code compliant refrigerants in ATWHPs to cover a portion of the annual heating load. This is fundamentally an enabling technology that will not limit ATWHPs to special applications such as in-floor radiant heat that can provide adequate comfort with lower hydronic supply water temperatures. To address the prior associated topic, gas powered heat pumps, Renewable Liquid Heating Fueled (RLHF) heat pumps, and electric heat pumps must be evaluated at source efficiency to allow an informed decision regarding emissions. Operating costs based on field performance are also important for informed decisions. With the recent significant increases in residential electricity prices in New England (a primary boiler market with an average residential electricity price of 31.08 cents/kWh in April 2023[3]), and limited natural gas supply to that region, further advances in efficiency from gas powered heat pumps could become a cost effective technology in the not too distant future. RLHF heat pumps are another emerging technology that must not be overlooked as a solution in the increasingly volatile electricity and heating fuel markets.

Further, absorption heat pumps are very competitive (efficiency wise) when taking into account source efficiency. As the planned capacity of offshore wind projects in New England and New York does not cover present grid loads, absorption heat pumps with efficiencies up to 140% represent a highly competitive option until renewable grid capacity is capable of providing adequate power for the marginal increases which are anticipated with large scale adoption of electric heat pumps.

Questions 6 and 7 Related to an ATWHP Standard

Classes for low, medium, and high temperature ATWHPs are necessary for proper application, performance, and comfort using existing housing stock and associated hydronic radiation. These levels could be considered at approximately 130°F to 140°F hydronic supply temperatures, 150°F to 170°F hydronic supply temperatures, and 180°F and higher hydronic supply temperatures, respectively, to enable informed decisions on product applications by installing contractors, engineers, and consumers. Further, these differentiation points would allow estimates of the adequate alternate heating source that would be required as low and medium temperature systems would only offset a fraction of the entire seasonal heating load.

Low temperature (130°F to 140°F hydronic supply temperatures) ATWHP systems include existing code compliant high HFO content refrigerants such as R410A and its replacement, R32, or R454B. These hydronic supply temperatures preclude whole house conversion as the connected hydronic radiation will not typically be adequate for outdoor temperatures below roughly 35°F to 40°F, based on 180° design day hydronic supply temperature and linear ODR curves analysis. This would cover less than half of total Heating Degree Days (HDDs) as far north as Portland, Maine.
This low temperature ATWHP is well represented by the current AHRI 550-590 standard as the standard is based on 105°F to 140°F supply temperatures at 47° and 17° outdoor temperatures. However, based on the practical application of current housing stock installed hydronic radiation and consumer comfort expectations of performance, the low supply temperatures in this standard are unrealistic and not representative of what is required for cold climates.

Next generation refrigerants/appliances:
Medium temperature (150°F to 170°F hydronic supply temperatures) ATWHP systems include R290 as a refrigerant. These ATWHPs could offset up to 70% or 80% of the HDD annual load, and work effectively down to 20°F outdoor air temperatures in much of the Northeast and Mid-Atlantic region. R290 compressors and heat pumps are available in Europe and United States building codes are currently expected to be updated to allow their use summer 2024, although this is complicated by the fact that R290 is a flammable (A3) refrigerant.

High temperature (180°F+ hydronic supply temperatures) ATWHP systems include R717 or R744 refrigerants. At these hydronic supply temperatures, high temperature ATWHPs would be a 100% drop in replacement for most high temperature radiation systems. These refrigerant applications are further complicated as R717 is considered toxic and mildly flammable (B2L), and although R744 does not suffer from these concerns as an A1 refrigerant, it does have significant mechanical high pressure challenges and lower absolute efficiencies when compared to alternative refrigerants.

Question 6 Related to Test Conditions

Low temperature ATWHPs are not likely to be used as 100% drop in boiler replacement appliances, so 'normal' air source heat pump testing conditions should be acceptable (47° and 35° outdoor air temperatures; test conditions H1 and H2 in the air-to-air standard AHRI 210-240; only the 47° outdoor air temperature test is in the AHRI 550-590 Chiller Standard).

Medium temperature ATWHP systems will be expected to work at colder outdoor air temperature conditions, so adding the H3 (17° outdoor air temperature) test point would be appropriate. This condition is also in the AHRI 550-590 Chiller Standard.

High temperature ATWHP systems designed for full boiler replacement should be tested at the H4 (5°F outdoor air temperature) condition. This is only in the air-to-air test standard and would need to be supplemented into the AHRI 550-590 Chiller Standard.

Question 7:
Because low hydronic supply water temperature ATWHPs are state of the art technology today, they are not expected to provide heat during colder winter temperatures. Although a "backup" heating technology could be integrated into these systems, a more innovative and cost effective solution is to integrate the system operation with a high efficiency, low mass, thermally purgeable boiler for the best overall annual efficiency. This could be in the form of a modulating condensing gas boiler or an appropriate RLHF boiler. As such, these systems should have fully integrated control designs to optimize performance. The cold weather boiler application could be evaluated as a standalone system, and low idle loss should be included to provide the best combined heat and hot water performance.

Question 8:
Would 10CFR Part 430 Subpart B Appendix E fully capture the performance of the product in space and water heating modes? No, this is a hot water only standard. As ATWHPs will likely run in a hybrid application with an existing boiler, idle loss is even more important if the boiler continues to make hot water during an "extended" seasonal hot water only mode as more heating hours are served by the ATWHP. This means most boilers would run in a lower efficiency mode for more hours per year. This does indicate that an ATWHP may become an even more expensive installation if domestic hot water system is upgraded simultaneously. Oddly, the Heat Pump Water Heater (HPWH) standard does not account for imposing a cooling load on residences and the boiler AFUE standard assumes all jacket losses are gained in the conditioned space, two contradictory positions.

Question 4 and 8 Related Response

There is a very high market penetration of boilers that make both heat and hot water. We expect future ATWHP products to also provide combination heat and hot water due to the even better synergy of 'free' domestic hot water when cooling using air handlers with an ATWHP.

There are at least two ways to make domestic hot water with the heat pump. Any testing standard development needs have extensive field testing to validate that it is representative of actual performance to properly inform consumer choice.:

1) **Hot water production outside of coincident space cooling operation**: Circulate heat to a storage tank vs the home or building. In this case, testing the unit separately as a water heater or heat pump water heater (HPWH) would seem logical. There is a primary conflict with regard to space conditioning impacts during the heating season. Water heating with a HPWH cools the conditioned space, but that cooling is not represented as a heating load; conversely, the AFUE standard for indoor boilers and furnaces considers jacket losses as heating gains to the conditioned space. These two interpretations are opposites.
2) **Hot water production during coincident space conditioning operation**: The ATWHP can use desuperheater high quality heat to produce hot water. In this mode, a combined test option would be required to quantify the synergy of sending the highest temperature water to the DHW tank while supplying lower temperature hydronic supply water for heating. The efficiency rating must also address that desuperheating uses waste heat for "free" domestic hot water when the unit is in space cooling mode.

Question 9:

Load shifting and thermal energy storage is a good technological match for ATWHPs from a mechanical perspective. For example, the addition of an insulated tank to hold 500+ gallons of water. Challenges include cost effective payback for providing this service to the grid, the amount of thermal storage vs future load needs and timing, the potentially prohibitively large space required to place the storage tank(s), and more. The focus of thermal storage should be on thermostats which can communicate with grid operators to receive pricing or load signals. Further additional controls and integration, such as adding a heating or cooling thermal storage tank zone, may be required in the ATWHP to enable this feature.

Question 12: If units are sized for design conditions, what does that mean for their part-load heating performance?

Sizing ATWHPs for design conditions really means that the hydronic radiation or air handlers are suitable for use on design day with the supplied hydronic water temperatures. The distribution efficiency for hydronic baseboard and cast iron radiation generally accepted to be in the area of 95%. However ducted distribution, which could provide adequate heat with lower hydronic supply temperatures, has much greater losses and extremely poor performance at 30% or lower capacity.

Question 14:

See comment on Question 6 and 7 for rating bands based on hydronic supply temperatures.

For boilers, the story is even more stark. Today's refrigerants, R410A and R32 (which is replacing R410A) are only are capable of generating 135°F hydronic supply water temperature using conventional compressor operation. Hot water baseboard and cast iron radiation found in cold climates, like Maine, are designed around 180°F temperatures, so air to water heat pumps simply won't keep Mainers with this type of radiation warm. If air to water heat pumps become more broadly available, those homes will need a hybrid system with a boiler for colder weather. This further adds importance to retaining an ENERGY STAR boiler labeling program.

In summary, we believe it is important to have a transitional strategy toward introducing new technology. Maintaining a strong presence with ENERGY STAR labeling of boilers in a way that is supportive of mainstream high efficiency and lower carbon emitting boiler products and that simultaneously introduces new ATWHPs can more effectively accelerate early adopters and optimize results.

Thank you for your consideration.

Respectfully submitted,

Roger Marran
President

[1]Data and conclusions are drawn from the report "Performance of Integrated Hydronic Heating Systems" (2007), Energy Resources Division, Department of Energy Sciences and Technology, Brookhaven National Laboratory, Under Contract No. DE-ACO2-98CH10886 with the United States Department of Energy by Dr. T. Butcher.

https://www.eia.gov/tools/faqs/faq.php?id=50&t=8 4.99 trillion cubic feet residential sector 2022

[2] Report on Equipment Upgrade Incentive Project, December 2921: https://f542d7.p3cdn1.secureserver.net/wp-content/uploads/2021/11/NORA-Rebate-Report-Nov-2021-1.pdf

[3]https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a