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Dear Abigail:

This letter comprises the comments of the American Council for an Energy-Efficient Economy on the May 2011 *Water Heaters V2.0 Specification Framework.* We are impressed with the open, collaborative nature of the document and the process you have outlined, and look forward to continued work with you on this important work.

The American Council for an Energy-Efficient Economy (ACEEE) is a non-profit research organization formed in 1980. We have worked extensively with EnergyStar® since its beginning. ACEEE is also an active participant in the DOE appliance testing and standards programs, the DOE/EPA Energy Star program, and many utility and state energy efficiency programs. ACEEE has carried out policy-related work on water heaters for many years, as investigators and as advisors to research projects led by others. Some of ACEEE's work was offered in the development of the original EnergyStar Water Heater Program, and we are most appreciative of the efforts EPA and DOE have made to start this key program. After all, hot water was the last major residential energy user *not* addressed by EnergyStar, for understandable reasons.

In this letter, we first respond to selected questions raised in the *Framework,* and then offer a few more general comments.

Responses to EnergyStar Questions in the Framework Document

1. *Do consumers set out to buy water heaters specifically with a tank, or are they indifferent?*

Proprietary industry data supports the inference that the consumer water heater market is heterogeneous. Roughly 70% of sales are reported to be "replace-on-failure," or emergency replacements. In these situations, the probability is low that consumers would accept the delays involved in changing major infrastructure of the house, such as the venting system, gas line capacity, of energy source (electricity to gas, or vice versa). On the other hand, the remaining 30% are planned replacements in which consumers may actively consider alternative technologies. One goal is an EnergyStar program that can meet needs of both consumer classes.

2. *Is it appropriate to assess tankless and storage technologies based on one EF level?*

The Energy Factor (EF) rating method was developed decades ago to compare relative performance of tank water heaters. We do not believe that the method developers anticipated or calibrated the rating method for tankless units. It is not surprising that field studies by Davis Energy Group and others find that EF values for tankless units are not comparable to those for tank units. The anomaly is serious enough that ACEEE and AHRI have reached a consensus on legislative language that would require revision of the rating method, and work is in progress at AHRI and ASHRAE to support this process.[1]

Thus, in this case equivalent federal ratings are not an appropriate basis for the EnergyStar program. We suggest alternatives that also vary by energy source:

- *Gas:* ACEEE suggests that the long-term goal should be limiting EnergyStar to products that capture a substantial portion of the latent heat of combustion of natural gas or propane. Such products would include tank, tankless, hybrid, and combo units. Using such a technology basis is rather straight-forward (particularly if coupled to a warranty requirement that assures corrosion-resistant construction).

[1] H.R. 482, Water Heater Rating and Improvement Act of 2011

This standard should be implemented immediately for tankless units, because there is enough market availability of condensing gas tankless water heaters – and more are coming.

However, this is not realistic for today's tank water heater market, so ACEEE supports continuation of the 0.67 EF level for this product class. We recommend that it be phased out within a decade from the implementation date of Version 2. ACEEE screening-level analysis suggests that the "high efficiency non-condensing" product class is unlikely to become very cost-effective, although products may have many other consumer values and amenities. In contrast, we anticipate that condensing units will become cost-effective, particularly for high volume users and as the "engines" of combo systems that also serve space-heating needs.

- *Electric:* When EnergyStar considers point-of-use electric products (Question 20 et seq.), at minimum the rating method will require modification. It appears that tank units < 20 gal or so that meet maximum power limitations cannot be tested by the EF protocol as it is written now.

3. *How might we compare system sizes between tank and tankless units?*

Mr. Michael Garrabrant, Stone Mountain Technologies,[2] has developed a comparative capacity table that is being used by ASHRAE SPC 118.2 for this purpose. It is based on manufacturer recommendations for the service capabilities of different technologies, and is probably the best basis available for answering this question.

4. *Should hybrid systems (more than 1 gal storage per 4,000 btu/hr input, but less than 20 gallons total) be considered? Is there a test method for these products?*

As suggested in our response to Question 2, ACEEE recommends inclusion of all products that capture substantial fractions of the latent heat of combustion, *i.e,* condensing appliances including hybrids and combo units.

7. *What is the potential for gas condensing storage products to be developed at or below 75,000 Btu/hr input rating?*

ACEEE respectfully suggests that this question has been answered in federal regulations. In adopting a condensing standard for tank water heaters > 55 gallons, to be effective in 2015, DOE has found through its analysis that cost-effective products can be developed.[3] The EnergyStar program, public benefit incentives, and "green" codes encourage early introduction of these products.

Given this, the question arises why such products have not yet been introduced, given the existing opportunity in Energy Star Version 1. ACEEE believes that the available "commercial" products marketed for residential use are ways to test and build market demand at lower cost. For example, an existing commercial product design can be offered without the redesign that might be required to meet FVIR requirements associated with residential tank products in the US.[4]

8*. What is the range of projected installed costs for gas condensing storage units? What are the associated maintenance costs over a product's lifetime?*

DOE has provided its analyses and findings in the *Technical Support Document,* Chapter 8, and its Appendix. With the exception of the flue gas to water heat exchanger, all of the technologies required for a condensing tank water heater have been commonly used in furnaces for decades in the US. Our conjecture is that condensing tank units will have fewer challenges from hard water precipitates than tankless water heaters, for two reasons: the heat exchanger passages are much larger, and the longer paths imply much lower temperature gradients.

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[2] Stone Mountain Technologies, Unicoi, TN

[3] 75 FR 20112, April 16, 2010; *Federal Register*, 75 FR 21981, April 27, 2010. See http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr.html

[4] Ironically, ACEEE knows of no tankless product in any size category with FVIR technology, ostensibly because they are generally mounted higher, where flammable vapor concentrations might be lower.

***9**. Do gas condensing storage water heaters reliably draw enough energy out of flue gas to condense, or is there an issue with partial load that affects efficiency under field load conditions?*

From the basic thermodynamics, and allowing for 10% excess air in combustion, a substantial fraction of the energy available from latent heat recovery will be captured at tank temperatures in the range of 120F – 125F.[5] This is the default temperature range for US residential products as shipped, according to industry sources. Thus, at steady state, it's hard to conceive a condensing tank water heater design that does not capture a substantial fraction of the potential of latent heat recovery. On the other hand, the mind can imagine that a much warmer reservoir (140F) would not capture much latent heat during transient phases of start-up. It might also be possible to design one that some combination of low flow rates, high tank temperatures, and heat exchange area biased strongly toward the top (hotter) part of the tank would minimize condensing. Hard, but might be accomplished by willful misdesign.

***10**. How do consumers make a decision to purchase a solar water heater? What do they compare it to for cost and operational savings?*

A survey of potential participants in the California Center for Sustainable Energy's Solar Water Heating Pilot Program (SWHPP) conducted by Itron, Inc. (Itron) suggested that the three predominant motivations for installing a solar water heater are "environmental concerns," "energy savings," and "money payback."[6] With the first two of these in mind, ACEEE has long believed that "early adoption" consumers who choose solar systems generally do so for environmental rather than narrow economic reasons. Installed costs for complete residential solar water heating systems can easily reach over $5000 and are unlikely to prove cost effective without financial incentives to offset this substantial cost premium. These initial costs were also found by Itron to be the primary concern among consumers when purchasing a solar water heating system. A large minority of those surveyed by Itron who did not participate in the program said that they either might or would install a solar water heating system if there were sufficient financial incentives. Significantly, the vast majority of participants in SWHPP earned over $100,000 and had 1-2 occupants in the household, while larger households earning less than $100,000 made up the majority of non-participants surveyed. These findings suggest that until costs decline, financial incentives will be necessary to entice larger households (where savings are greater) to purchase solar water heating systems. We do not believe that this should discourage inclusion of the products in the EnergyStar program, because of their potential to reduce energy waste and prevent pollution.

Incremental costs could discourage consumers from choosing a solar water heater in an emergency replacement scenario. In a planned replacement, consumers may compare first cost and operating costs of solar systems to other advanced tech water heaters such as condensing gas, heat pumps, and tankless, as well as conventional storage units. Consumers may also compare the different amenities that each of these technologies provides. However, as stated previously, the decision to purchase a solar water heating system is likely to be based on environmental, rather than economic grounds.

***11.** How does the SEF metric compare to EF metric? Could they be considered equivalent compared? Does SRCC calculate a First Hour Rating parameter that could be compared to that from the DOE test?*

The Solar Rating & Certification Corporation's solar water heating system test, OG-300, is based on a modified version of the federal EF test procedure and is designed to allow direct comparisons between solar water heaters and conventional electric and gas-fired water heaters. A description of the SRCC test and its similarities and differences from the federal EF test procedure is available on the SRCC Web site: http://solar-rating.org/.

***13**. Are there any alternatives to the OG-100 test and/or OG-300 rating method?*

We understand EnergyStar concerns with consistency, comparability, and the use of proprietary rating methods (OG-100 and OG-300). On the other hand, solar is a small industry. If the industry consensus is that the present method isn't broken, we would encourage EPA to postpone consideration of change until the product category

[5] Eyeball interpolation from Durkin 2006, ASHRAE Journal, Figure 2.

[6] http://www.cpuc.ca.gov/NR/rdonlyres/C1C7FD10-05AA-493B-8CD0-F2C24DCA955A/0/CCSE_SWHPP_Rpt.pdf

has a larger footprint. The cost of changing rating methods must be weighed carefully against the present value of the benefits. Additionally, the Department of Energy has repeatedly found that it does not have the authority to regulate the efficiency of solar water heaters.[7] We encourage ENERGY STAR to adopt solar energy factor (SEF) as the ranking metric for solar water heaters instead of solar fraction (SF), the latter of which introduces an unnecessary variable (EF) to the ranking system. The SEF rating for solar water heating systems ought to provide a better comparison for consumers regarding the relative efficiencies of solar water heaters and electric and gas-fired units.

> ***14**. In what situations are add-on heat pump water heaters actually used? Are there situations in which they compete directly with new units, particularly new integrated heat pump units?*

So few add-on HPWH are in use that generalizations are dangerous. ACEEE's conjectures about potential *buyers* include:

- People who move into a new (to them) home, and find that the relatively new electric water heater costs a lot to operate. An add-on HPWH could be very cost-effective in most cases, as would a drop-in unit. For many consumers, the environmental value of *not* discarding the nearly new existing water heater also matters.
- Coldly analytical consumers who determine that the incremental cost of an add-on HPWH over a free-standing dehumidifier will "kill two birds with one stone," reducing operating costs while drying the moldy basement.

In addition, some plumbers will learn to use add-on products as an up-sell for emergency replacements: carrying an add-on unit takes less space in the truck than a complete second water heater.

These hypothetical situations (and others that can be imagined) pose questions whose answers would require extensive consumer research. Our judgment (or conjecture) is that national energy savings will increase if add-on products can be incorporated in EnergyStar. Based on the bullets above, we anticipate that they could marginally reduce sales of drop-in units. Since the market is so dominated by emergency replacements, we think the potential penetration of that market offsets any share loss in the planned market. But, these inferences are offered with humility: they are data-free.

> ***16**. Is COP the most appropriate metric for assessing the efficiency of Add-On Heat Pump water heaters? How could COP be used in conjunction with the EF of the tank to determine total system efficiency?*

ACEEE does not support the concept of a new metric (COP) for these units. We believe that the underlying construct is faulty: we are not just interested in the electrical efficiency but the performance of the system with a non-integral tank. In particular, the proposed COP approach cannot include the variability introduced by alternative control strategies, including pump dispatch.[8]

ACEEE strongly supports bringing add-on HPWH into the federal standards program.[9] Until this is done, we recommend that EPA adopt the following strategy:

- Require the manufacturer to rate the product with the EF test, with addenda.
- The addenda should include:
    - Defined length and insulation of lines connecting HPWH to tank.

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[7] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_fedreg.pdf

[8] As an extreme example that we encountered in the field, the manufacturer's control strategy for a related product put the tank temperature sensor in the condensing unit. The pump ran continuously, to assure that the heat pump water heater would know when tank temperature had dropped. Between the pump energy and the heat loss in the relatively long lines between condensing unit and tank, the measured EF was lower than for a resistance tank unit.

[9] DOE's argument for excluding them is that they are not complete water heaters without the services provided by the tank. By the same logic, almost all split system air conditioners should be excluded, also, since they cannot function without the services provided by the (furnace) air handler.

- Tank to be used must be current (2004) minimum EF 50 gallon tank – the most commonly installed size. That is EF = 0.90.

This approach is not perfect, but it may be the best compromise available. The DOE test does control for indoor chamber test conditions (Temperature and humidity), it uses a representative tank, and it requires some controls sophistication to optimize performance on a reasonable test. As important, it is a basis that can evolve as new rating methods are developed.

> ***17****. At what performance level would a COP requirement be set so as to assure the consumer of significant energy savings? What are the costs associated with this?*

Please see Q. 16. ACEEE does not support COP, but recommends EF.

> ***18****. What additional performance requirements should be considered for the add-on heat pump category? How could those requirements be verified?*

Please see Q. 16. These requirements can be verified through the AHRI certification program and the new EnergyStar "CCE" program (certification, compliance, and enforcement). We are not aware of any particular impediments for this product class.

> ***19****. What are the appropriate warranty requirements to assure consumers a reliable product?*

Unless the drop-in HPWH program has had unusual problems, we recommend using the same warranty approach.

> ***20****. How would models appropriate for POU be distinguished from whole home models? Maximum input power? Storage capacity as well or instead? Should there be a limit on physical dimensions?*

ACEEE has been working with manufacturers of this equipment to agree on a common-sense power limitation. The current legislated limit for residential electric POU units is 12 kW. 25 kW would support a single efficient bathroom with two simultaneous fixtures, in winter, and is thus a suggested limit for POU electric tankless water heaters. Very small electric tank water heaters that can support the same service level should be included to keep the program technology neutral.[10] We have not done the analysis, but that capacity would probably be < 20 gallons, the current lower limit of DOE regulations.

> ***21****. How can the efficiency of POU systems be characterized? Are the current test procedure and existing metrics sufficient?*

It is conceptually difficult to build a compact *inefficient* tankless electric water heater. For example, while running a 90% (thermal efficiency) 25 kW ETWH would dissipate 2.5 kW or 8500 Btu/h. Where would that heat go, if not into the water? For very small tank types, which have somewhat larger surface area, we propose that EPA consider extension of the DOE formula for tank water heaters, which would require EF ~ 0.95, depending on the exact size limit chosen. As noted above, ETWH capacity changes require congressional action for them to be covered products subject to efficiency regulation. We do not believe that this precludes inclusion in the EnergyStar program. Similarly, tank water heaters < 20 gal. are exempt products that could be included. In both cases, appropriate CCE will be required to verify unit efficiency.

> ***23****. Can the efficiency of whole home and POU systems be compared? If so, how?*

Very simple ACEEE models, based on work by Gary Klein, assume that the average application that would otherwise use a central water heater will lose 50% of the water heater's output in the distribution lines, on a daily

[10] By this logic, gas POU equipment should also be included. Gas equipment faces substantially greater installation barriers and could be reserved for future study.

basis. More sophisticated modeling approaches should be used, but the weak spot is poor understanding of the distribution architecture in existing houses.[11]

24*. What additional performance requirements should be considered for the point-of-use category? How should those factors be verified?*

ACEEE and manufacturers of POU Electric Tankless Water Heaters are working on agreement proposal that would outline additional (consensus) requirements that assure high quality products that are “preadapted” to serve as POU boosters for solar water systems. That is, they could provide water at any desired temperature equal to or greater than the temperature of the incoming water. In effect, this moves solar back-up from the central system to the point of use, with large expected savings.

Other Responses to the EnergyStar Framework Document

As noted above, ACEEE is very impressed with the effort behind the Framework document, and the principles underlying. The Energy Star Water Heater program was controversial, and the very existence of this document suggests recognition of the potential of this program to transform the water heater market.

In our response to some questions, ACEEE alludes to complementary activities under other auspices that provide leverage for this work by EnergyStar. For example, H.R. 482, the Water Heater Rating and Improvement Act of 2011, has been introduced, and would have DOE and stakeholders work to change the EF rating method within a very short time frame. This could moot the question of condensing tankless water heaters, as well as handling questions about POU electric equipment. Overlapping groups at AHRI and ASHRAE are working on revised rating methods. There seems to be an informal working understanding that the next generation will need different ratings for different capacities or applications. Groups in Canada and at LBL are pulling together all possible field data on use patterns and distribution losses, to provide a better basis for simulated uses than the present model that uses six large draws and no small ones. And, new technologies are invigorating an old field.

We all share an interest in helping to implement an EnergyStar Version 2 program that will help America prevent pollution, support innovation, and save water.

Sincerely,

Harvey M. Sachs
Senior Fellow

Jacob Talbot
Analyst, Buildings Program

[11] In very rough *source* energy terms, today a 0.95 EF POU tankless water heater is “equivalent” to a POU 0.3 EF gas unit. But, if we consider distribution losses at 50%, then the electric POU at the actual POU would be equivalent to a 0.6 EF gas – roughly the current national standard. But, it would be much better than a central resistance tank, with an equivalent “delivered” EF of ~0.45 in this comparison. A central HPWH at EF 2.3 would roughly equal the POU electric resistance unit with no distribution losses. *All of this is very approximate, for illustration, and is founded on assumed 50% daily losses in the pipes.*