

June 24th, 2011
Via Electronic Mail



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Office of Air and Radiation
Washington, DC 20460

Re: Energy Star Water Heaters; Proposed Product Specification Framework

The following comments are submitted for the record of the Agency's above-captioned proceeding regarding the product specification framework for Energy Star water heaters. They are submitted on behalf of the Northwest Energy Efficiency Alliance (NEEA) and members of the Northern Climate Heat Pump Water Heater Task Force (Task Force) identified in the signature block below. (Because of the compressed timeline for comments, not all Task Force members were able to review the comments and gain approval for endorsement in time.)

The Northwest Energy Efficiency Alliance is a non-profit organization working to maximize energy efficiency to meet our future energy needs. NEEA is supported by, and works in collaboration with, the Bonneville Power Administration, Energy Trust of Oregon and more than 100 Northwest utilities on behalf of more than 12 million energy consumers. NEEA facilitates collaboration between the region's electric utilities, public benefits administrators, state governments, public interest groups and efficiency industry representatives. This unique partnership has helped make the Northwest region a national leader in energy efficiency.

The Northern Climate Heat Pump Water Heater Task Force is a NEEA-facilitated stakeholder group working to encourage the development and adoption of heat pump water heater technologies that deliver superior energy efficiency performance and consumer satisfaction in the more severe operating environments of the northern half of the United States.

Overview

For heat pump water heaters (HPWHs), EPA has stated that it "is not aware of any opportunities in this category, but welcomes stakeholder[s] to flag them if they know of any." The Task Force believes the EPA should update its specifications in accordance with our recommendations here, at least as they apply to HPWH products intended to be used in northern climate field conditions.

The Task Force's product work is focused in two primary areas – the development and vetting of a specification for heat pump water heaters that will identify products that provide a high level of energy efficiency and consumer satisfaction in northern climates, and verifying the performance in the field of early qualifying products.

The Specification for Residential Heat Pump Water Heaters Installed in Northern Climates (Specification) was released in October, 2009 with the endorsement of the Task Force and is currently undergoing a revision which is expected to be complete by August 2011. See

Attachment A for the current draft. An updated specification will be provided once this version is finalized.

The Specification contains two major elements – an efficiency rating based on a set of test conditions that are representative of northern climate field conditions, and a list of features that Task Force members believe are important to maintain high consumer satisfaction with qualifying products. Many Task Force members have past experience with heat pump water heaters and have learned important lessons about applying this technology in the residential settings typical in colder, northern climate zones.

The Specification recognizes three product tiers allowing for some variation in product performance and supported applications.

Our comments here will be confined to those Energy Star specification issues the Task Force feels are most important in maximizing the efficiency potential of heat pump water heaters, or that directly impact the Task Force’s goals and objectives.

Technology Neutrality

The Task Force believes that EPA’s existing categorization by fuel source is sufficiently technology neutral for efficiency specification purposes. This does not mean that the specifications should focus only on efficiency, but that the criteria for the elements of the specifications should be largely the same across the various technologies that propose to serve the residential domestic hot water market. These criteria might be described as follows:

- Efficiency in typical daily cycles of use
- Durability
- Reliability, both of the product and its energy savings
- Ease of use and maintenance
- Appropriate application

All Energy Star water heaters should meet these criteria to the maximum extent practicable. The Task Force believes its proposed Northern Climate Heat Pump Water Heater specification meets these criteria, as described below, and should be adopted by EPA.

The Specification

The Northern Climate Specification consists of four parts:

- Northern Climate Efficiency
- Hot Water Delivery
- Essential Features
- Sound

We believe that all of these specification elements are essential for maximizing the energy efficiency potential of this technology in northern climate field conditions.

Efficiency

The Northern Climate Efficiency rating is based on a test procedure and test conditions that the Task Force has determined are reasonably representative of the conditions the products will face when in use. The test procedure has 3 different ambient temperature rating points, with performance determined under a specified set of draw conditions. To the extent possible at this time, the tests utilize portions of the current federal test procedure. This test procedure is being considered for revisions concurrently, and the Task Force is engaged in that process.

Delivery

This is the first and most important of the consumer satisfaction metrics. This specification attempts to ensure that a HPWH will maintain its rated efficiency when properly sized and delivering a level of service comparable to that of existing and competing products. It is measured in terms of the number of showers delivered in succession while maintaining a minimum level of efficiency in 50°F ambient conditions.

Features

There is a list of features the Task Force believes are important for maintaining consumer satisfaction and performance of the HPWH. These features are optional at tier 1 and required in order to meet tier 2 or tier 3 product levels. These features include:

Freeze Protection: The units will often be located in environments that are occasionally subjected to below-freezing temperatures, such as garages. In a northern climate, the product should be able to withstand an occasional ambient excursion to temperatures below 32°F.

Ducting: The units should be capable of being ducted, so that tempered air can be ducted to the unit and/or cooler exhausted air can be directed out of an interior space. This will be important to the HPWH's adaptability to many existing installations as a replacement product, as well as allowing the optimization of some new installations.

Compressor shut-down/notification: This feature is critical to maintaining the operating efficiency of the HPWH. If the unit reverts for an extended period to electric resistance back-up because of a controls issue or compressor failure, the efficiency of the system will be significantly compromised. The home's occupants should be notified of this situation as quickly and reliably as possible so that system efficiency can be restored in a timely fashion.

10-year warranty/service: This has been a feature of some Energy Star specifications in the past, particularly in the early stages of a technology's development. This specification element is important for consumer confidence in the technology and for helping to guarantee the reliability of the energy savings from the HPWH.

Condensate Management: Heat pump water heaters require a condensate drain. This critical product feature has occasionally been dealt with poorly over past years, with cases of building damage caused by HPWH condensate adding to consumer skepticism about the technology. This specification element is designed to make sure that the product performs as expected, without adverse impact on the dwelling, to the maximum extent practicable.

Air Filter Management: This is the primary maintenance element associated with a HPWH. Since air flow over the heat exchanger is critical to proper functioning of the unit, filter maintenance is also critical. This specification element is designed to maximize the likelihood that this maintenance will be regularly performed.

Sound

The specification has maximum sound ratings at each of the three tiers, with separate values for indoor and outdoor applications. Given that current electric water heaters make no noise at all, it is important that HPWHs minimize noise levels in order to maximize consumer satisfaction in all applications.

Test Considerations

As more water heaters incorporate electronic controls, the control settings will play a larger role in their efficiency. These changes are particularly evident in heat pump water heaters. As a general rule, Energy Star can make the testing procedures more equal between models and manufacturers by requiring that all testing be done at the default control settings. In some cases, such as temperature set point, the default control settings are also mandated at the time of shipment.

The currently available heat pump water heaters can operate in either heat pump only or electric resistance assisted modes. The first hour rating and the COP will be different in these two modes. It would be helpful to specify which mode must be used for testing and possibly also which mode is the default. In any case, the testing mode and the default mode should be the same.

Summary

Air-source heat pump water heaters for residential applications have charted a very uneven path through the market over the past 30+ years. The technology has the potential to deliver exceptional energy savings, but will struggle to do so if the product specifications do not adequately address the critical issues the Task Force has listed above. We urge EPA to adopt these specifications, at the very least for product eligible for installation in northern climates, to help the marketplace achieve these savings. The Task Force is working with a number of HPWH manufacturers who have stated their intent to bring products to market, in the very near term, that meet these specifications. We are currently testing some very promising early products. We would welcome EPA's collaboration in these efforts through the adoption of an appropriate product specification for heat pump water heaters in the Energy Star program.

Thank you for the opportunity to comment on this very important matter.

Bonneville Power Administration

British Columbia Ministry of Energy and Mines, Energy Efficiency Branch

Connecticut Light and Power

Energy Trust of Oregon

Idaho Falls Power

Northwest Energy Efficiency Alliance

Northeast Energy Efficiency Partnerships

PECI

Ravalli Electric Co-op

Seattle City Light

Snohomish County PUD

ATTACHMENT A

**A Specification for
Residential Heat Pump Water Heaters
Installed in Northern Climates
Version 4.0**

Updated Version: Draft for Discussion

June 24, 2011

Background.

In the early 1980's, electric utilities in colder, northern portions of North America introduced heat pump technology into the residential water heating market. These programs have spanned three generations of technology and produced detailed measurement of technical performance and consumer acceptance. The experience gained from these programs yields definitive direction about key consumer needs as well as important technical criteria for proper application of this technology in cold climates.

The ENERGY STAR program released its first specification for residential water heaters in 2008, which included qualifying criteria for heat pump water heaters (HPWHs). The DOE included requirements for efficiency (EF 2.0 or better), capacity (first hour rating 50 gallons per hour), longevity (warranty \geq 6 years), and electrical safety (UL 174 and UL 1995). While these requirements are important, the ENERGY STAR program did not address critical performance and comfort issues which have inhibited adoption of HPWHs in northern climates. In 2009, several major manufacturers launched integrated HPWH units in North American markets which were ENERGY STAR qualified but failed to address key northern climate issues.

1.0 Purpose

This specification provides guidance to manufacturers who are interested in developing products that not only meet ENERGY STAR criteria but are able to provide high levels of customer satisfaction and energy performance in cooler, northern climates. The end goal of this effort is to ensure that the North American introduction of this new generation of HPWH products will be as successful as possible in order to pave the way for HPWHs to become the standard product for the electric water heating market.

Utilities and other entities that invest in market transformation programs and/or incentives will require effective energy savings. Accordingly, the specification is also intended as a foundational document for utility program efforts that will work in partnership with manufacturers to accelerate market adoption of HPWH for northern

climates. Using this specification will help improve market acceptance and ensure the expected savings materialize.

This specification addresses key issues that fall in two main categories:

- Performance - Northern climate energy efficiency and savings, condensate management, freeze protection, user controls, ease of installation, lifespan
- Comfort – exhaust air, noise, hot water delivery, reliability/service

2.0 Scope

2.1 Equipment Type. This specification covers residential, integrated (with tank) heat pump water heaters with storage volumes of 40-120 gallons. Heat pump water heaters configured to “add-on” to existing storage tanks are not covered by this specification. In addition to integrated units, there are currently several “split-system” HPWH units on the market. These units consist of a heat pump that is located outdoors which transfers heat to a water storage tank that is usually located within the building. A future version of this specification will address these split systems.

2.2 Applications. Focus is on replacements for existing electric resistance storage water heaters and alternatives to new electric resistance water heaters. As such, storage tanks shall be configured to meet the space and installation requirements for typical electric resistance storage water heaters. Units meeting this specification are expected to provide configuration options for use in conditioned spaces, unconditioned spaces, and semi-conditioned spaces.

2.3 Climate. This specification is intended for climates with 4,000 heating degree days or higher and average ambient temperatures below 60 degrees Fahrenheit. This equates roughly to locations in North America with latitudes above 40 degrees herein referred to as “Northern climates”.

3.0 Product Tiers

3.1 Overview. Three product tiers are incorporated into this specification recognizing variations in product performance and supported applications. The following table summarizes each tiering level:

	Minimum Northern Climate EF	Minimum “Northern Climate” Features	Sound levels
Tier 1	TBD	<ul style="list-style-type: none"> • ENERGY STAR compliance • Exhaust ducting (req. only for interior locations) 	dBA < 60 (garages, crawl spaces, attics) +dBA < 55 (interior)

Tier 2	TBD	<ul style="list-style-type: none"> • ENERGY STAR compliance • Freeze protection • Exhaust ducting • Compressor shut-down/notification • 10 year Warranty • Condensate Mgmt • Air Filter Mgmt 	<p>dBa < 60 (garages, crawl spaces, attics) +dba < 55 (interior)</p>
Tier 3	TBD	<ul style="list-style-type: none"> • ENERGY STAR compliance • Freeze protection • Exhaust ducting • Intake ducting • Compressor shut-down/notification • 10 year Warranty • Condensate Mgmt • Air Filter Mgmt 	<p>+dBA < 55 (garages, crawl spaces, attics) +dba < 50 (interior)</p>

4.0 Requirements for All Units (Tiers 1, 2, 3)

4.1 ENERGY STAR Compliance. The unit shall meet ENERGY STAR criteria in effect at time of manufacture under default (out of the box) operating mode settings.

4.2 Northern Climate Energy Factor. The unit shall be rated for a Northern Climate Energy Factor under default operating mode settings. See **Appendix A** for the Northern Climate Performance Test Method and corresponding Northern Climate EF calculation.

4.3 Northern Climate Delivery Rating. The unit shall be rated on its ability to deliver hot water in cool ambient conditions while maintaining high efficiency operation under default operating mode settings. See **Appendix B** for details.

4.4 Sound Levels. The unit shall be rated on its sound level. See **Appendix D** for Sound Measurement Test Method. (Acceptable sound levels at each product tier are still under discussion; levels indicated in section 3.1 above are tentative.)

5.0 Additional Requirements Tiers 2 and 3

5.1 Freeze Protection Test. The unit shall pass 24 hour power-off freeze protection test as specified in **Appendix C**.

5.2 Compressor Shut-down and Notification. In the event of compressor shut down or failure, the unit shall provide notification to the customer that the heat-pump operation of the product has been disabled.

5.2.1 Normal, Temporary Event. If the compressor is temporarily disabled due to specific operational controls (e.g. low intake temperature or defrosting), the unit shall display to the customer that the heat pump is not currently operating but shall restore compressor operation as soon as conditions return to allowable control parameters (e.g. return to minimum intake temperature or completion of the defrost cycle).

5.2.2 User Selected Override. If the compressor is temporarily disabled due to consumer override, the unit shall provide a maximum override period of 48 hours before resetting to normal operating parameters.

5.3 Warranty and Service. The unit shall carry a warranty of a minimum of 10 years for all system parts as well as a minimum of 1 year for labor.

5.3.1 Contact Information. The unit shall include clear information on how to obtain warranty service, replacement filters or other maintenance items, and technical support via a toll-free phone number clearly marked on the exterior of the unit.

5.4 Exhaust Ducting. The unit shall be equipped with or have readily available manufacturer-supplied accessories to provide for exhaust air ducting. Ducting the exhaust air from the heat pump to the exterior during the heating season is critical to minimize occupant comfort concerns and reduce the penalty to space heating.

5.4.1 Ducting Hardware. The unit shall include all necessary flanges, collars, or other connections that are capable of directly connecting to common ducting products. Alternatively, manufacturer-supplied add-on ducting modifications may be used if they provide the same capabilities.

5.4.2 Minimum Flow Rate/Pressure Drop. The unit shall be capable of delivering its rated air-flow across the evaporator at a minimum intake (if present) and exhaust duct static pressure drop of 0.25 inch water gauge.

5.4.3 Application Options. The unit shall be capable of operating with or without ducting installed. Manufacturers shall clearly identify which models are qualified for which applications along with the appropriate layout/configurations and accessory parts necessary to meet the requirements for specific applications.

5.5 Condensate Management. Condensate must be drained away according to plumbing codes.

5.5.1 Acceptable Condensate Piping. The unit shall include a minimum piping connection for condensate drainage of ¼ inch (inside diameter) or greater. The manufacturer shall supply appropriate condensate piping specifications including piping diameter, length, allowable turns, and acceptable termination for gravity drains and for condensate pumping in locations such as basements where gravity drainage is not possible. Instructions for the installer shall highlight importance of correct condensate line installation practices to minimize potential water damage and customer problems.

5.5.2 Condensate Overflow Shut-off and Alarm. Units shall include a safety switch to shut off compressor operation in the event of a blockage of the condensate removal system. In the event of compressor shut-off due to condensate drain failure, an audible and visible alarm shall be activated to signal the need for service.

5.5.3 Condensate Collection Pan and Drain Service. The condensate collection pan and drain shall be designed to be self-cleaning without regular maintenance or interaction by the consumer. In the event of a blockage, the pan and drain shall be designed to allow the consumer to be able to clear the drain with normal household tools and restore normal operation of the condensate line.

5.5 Air Filters: Routine Maintenance and Homeowner Notification. Any air filters shall be either 1) permanent, washable media or 2) replaceable, standard furnace filters in shape and form that are obtainable at a typical home improvement store. The unit shall provide visible and alarm notification to the homeowner of appropriate need to change or service the filter in order to prevent compromise of performance of the heat pump from reduced air flow.

6.0 Additional Requirements Tiers 3

6.1 Intake ducting. The unit shall be equipped with or have readily available manufacturer-supplied accessories to provide for exhaust air ducting. Requirements for exhaust ducting in 5.4 above shall also apply to intake ducting.

Appendix A: Northern Climate Energy Factor

Concept: Measure and calculate an Energy Factor (EF_{NC}) representative of water heater performance for equipment installed in unconditioned, house buffer spaces (e.g. garages and unheated basements) in northern climates.

Determining the Northern Climate Energy Factor (EF_{NC}) consists of lab measurement of energy use and a calculation procedure.

Northern Climate EF Test Procedure

To receive a Northern Climate EF rating, conduct a simulated use test representative of Northern Climate installation and operation. The test is similar to the DOE 24-Hours simulated use test and generates an energy factor in a similar way.

Test Conditions:

The test conditions shall follow those listed for the DOE-24hr test except as noted below:

- Ambient conditions shall be either: 40°F dry bulb, 37°F wet bulb (75% R.H.) or 50°F dry bulb, 44°F wet bulb (58% R.H.).
 - If the operating range of the compressor is limited to temperatures warmer than 40°F, the 50°F test conditions shall be used. If the operating range is below 40°F, the 40°F test conditions shall be used.
- Inlet water temperature: 45°F
- Outlet water temperature: 120°F
- Tank temperature: 120°F \pm 1°F (average at start of test)

Draw Profile:

Target 50 gallons of water. Design profile to be conducted in 12 hours to allow for enough variation in draw type, recovery time, and adequate measurement of standby losses.

Northern Climate EF Calculation Method

The Northern Climate EF is a temperature bin weighted calculation using results from the standard DOE 24hr simulated use test, the Northern Climate simulated use test, and the calculation method in this section. The method is based on the one used for calculation the Heating Seasonal Performance Factor (HSPF) for space conditioning heat pumps.

First, calculate the energy factor for the Northern Climate simulated use test, EF_{40} (or EF_{50}) Use the procedure in Section 6 of 10 CFR Pt. 430, Subpt. B, App. E, except substitute the different test conditions for the Northern Climate test for the values used in the normalizing calculation portions in Section 6.

Definitions:

EF_{67} is the energy factor from the standard DOE 24-hr test.

EF_{50} is the energy factor from the Northern Climate simulated use test at 50°F.

EF_{40} is the energy factor from the Northern Climate simulated use test at 40°F.

EF_R is the energy factor for the HPWH operating in resistance heat only mode.

The temperature bins for use in the EF weightings are given in Table 1. These temperatures are based on typical garage and unheated basement temperatures for houses in northern climates. Temperature data is derived from simulated garage and unheated basement temperatures in different climates using SUNCODE (for garages) and SEEM (for basements) modeling tools. The temperatures are daily averages for the dry bulb temperature in the buffer space. Climate data comes from the TMY datasets.

NOTE: Decisions on which climate data (e.g which cities, at which weightings) and well as which scenarios (well insulated/poorly insulated garages, well insulated/poorly insulated basements) must still be made. Table 1 below provides data which is a weighted average of three northern climate cities (Seattle, Chicago, Boston), in garages with insulation between the garage and the house. This garage scenario shares 1.5 of the walls with the house and 2/3 of the ceiling area. The other surface areas are exposed to the outside, attic, or ground. The garage area is 484ft² with two car doors. The outside walls are insulated to a nominal value of R-19.

Table 1. Temperature Bins. Tdb bin gives the bin center. For example, the 62F bin covers the 5 degree range 59.5F to 64.5F. “f” is fractional number of days per year in each of the temperature bins.

j	T db(F)	f
1	77	0.022
2	72	0.090
3	67	0.092
4	62	0.109
5	57	0.137
6	52	0.122
7	47	0.131
8	42	0.128
9	37	0.087
10	32	0.082

The Northern Climate Energy Factor is calculated as:

$$EF_{NC} = \sum_{j=1}^{10} EF_j * f_j \quad (1)$$

Where j is the bin number from Table 1, f_j is the fraction of hours for that bin, and

$$EF_j = (T_j-40) * m_{EF} + EF_{40} \quad (2a)$$

$$EF_j = (T_j-50) * m_{EF} + EF_{50} \quad (2b)$$

Where m_{EF} is the slope of the line connecting the two measured energy factors:

$$m_{EF} = (EF_{67} - EF_{40}) / (67 - 40) \quad (3a)$$

$$m_{EF} = (EF_{67} - EF_{50}) / (67 - 50) \quad (3b)$$

If the Northern Climate Energy Factor test was conducted at 40°F, use equations 2a and 3a above. If it was conducted at 50°F, use equations 2b and 3b above.

For equipment that limits heat pump operation below a certain temperature, the EF for those temperature bins shall be assigned a default value of 0.85. Alternatively, the simulated use test at 40°F may be conducted in resistance only mode in which case, that value may be used for the low temperature bins.

An example of the calculation is given for several scenarios:

Example A: EF₆₇= 2.4, EF₄₀= 1.5, no low temperature compressor limit

Example B: EF₆₇= 2.4, EF₅₀= 1.7, 45°F low temperature compressor limit

Example C: EF₆₇= 2.2, EF₅₀= 1.5, 45°F low temperature compressor limit

Table 2. Example EF_{NC} calculations

Tdb	EF A	EF B	EF C
77	2.73	2.81	2.61
72	2.57	2.61	2.41
67	2.40	2.40	2.20
62	2.23	2.19	1.99
57	2.07	1.99	1.79
52	1.90	1.78	1.58
47	1.73	1.58	1.38
42	1.57	0.85	0.85
37	1.40	0.85	0.85
32	1.23	0.85	0.85
EF_{NC}:	2.03	1.90	1.72

Appendix B: Northern Climate Delivery Rating

Concept: Rate units on ability to deliver hot water in cool ambient conditions while maintaining high efficiency operation in the default operating mode. Reported in how many showers the water heater can give until the outlet temperature gets too cold or the efficiency drops significantly (resistance element turns on).

Test Conditions:

$T_{amb} = 50^{\circ}\text{F}$, $T_{set\ point} = 120^{\circ}\text{F}$, $T_{inlet\ water} = 45^{\circ}\text{F}$, Airflow = unrestricted

The draw pattern is 2 gpm for 9 minutes followed by 15 minutes of 0 gpm.

This pattern is repeated until the ending conditions are met.

The ending conditions, from a calculation perspective are defined as follows:

- when the water outlet temperature, T_{out} , falls below 105°F
- when the cumulative COP falls below 2.0

For practical testing purposes, follow this procedure to terminate the test:

- Observe the outlet water temperature, T_{out} , and state (on or off) of the resistance elements in the tank (any of the elements)
- When T_{out} falls below 105°F or the resistance element engages, finish the current draw cycle. Then, complete one subsequent draw cycle. Allow the tank to recover. Terminate data collection when recovery complete.

Appendix C: Freeze Protection Test

Concept: Test the water heater's ability to withstand adverse environmental events and still remain functional afterwards.

Test setup:

- The ambient air in which the water heater is located shall be maintained at 30°F dry bulb and 28°F wet bulb (80% R.H.) for the duration of the test.
- Set tank water temperature set point to 120°F.
- Inlet and outlet water lines shall be insulated with 1" thick pipe insulation.

Test procedure:

- Establish normal water heater operation: If water heater not operating, initiate a draw. Terminate that draw when heater cut-in occurs. When the tank recovers and the heaters cut-out, wait 5 minutes. Then, shut off all power to the water heater and let sit for 24 hours.
- After 24 hours, turn on power to the water heater and allow it to recovery to set point.
- Initiate a draw until the equipment compressor cuts in. Allow tank to recover.
- Shut off power to water heater and inspect for damage.

The water heater will have passed the test if all the following criteria are met:

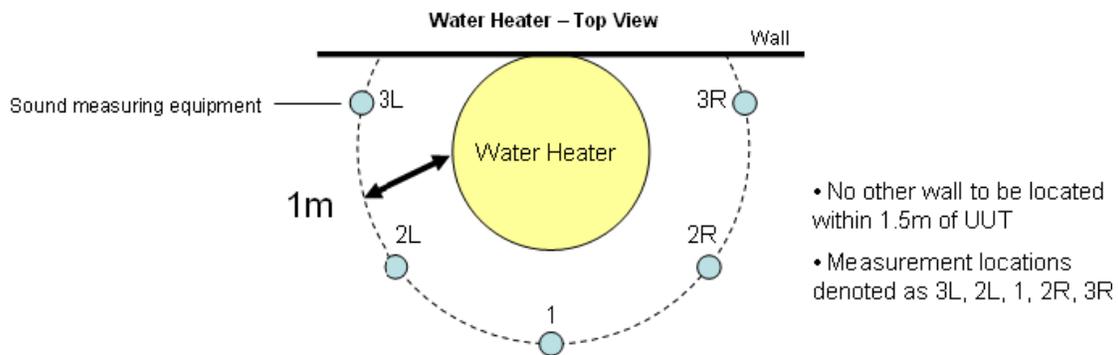
- The compressor runs and the tank recovers after the 24hr off period.
- There is no freezing or rupture of any water-related connections or components including but not limited to heat exchangers, pumps, condensate lines, or other heat pump components apart from the standard plumbing connections required for a traditional electric resistance water heater.

Appendix D: Sound Measurement Test Method

Concept: A simplified, repeatable test to measure sound level.

Procedure:

- Place the water heater against a wall in a room with low ambient noise (need to define, <35dBa?)
 - All other walls or objects shall be at least 1.5 meters away from the water heater.
- Turn on water heater in an operating mode which uses all moving components including but not limited to the compressor, fan, or pumps.
- Measure the A-weighted noise level:
 - At five points 1 meter distant from the water heater surface at 1.8 meter height from the base of the water heater.
- Average all five measurements into a single sound level.



Note: A-weighting is known to significantly undervalue low-frequency noises – such as compressor noise. Currently exploring methods which account for low frequency/annoyance noises better than A-weighting. One possibility is C-weighting which does not discount low-frequencies as much as A-weighting.