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Heat Pump Water Heater provisions

Additional submitted attachment is included below.

From: Gary Klein, Gary Klein & Associates and Nick Brown, Build Smart Group

With the release of code language regarding heat pump water heaters (HPWHs) in the 2025 standards, we submit these markups that will help ensure that HPWHs provide efficient water heating with sufficient capacity for California buildings. We base these comments on (1) our experience in the field specifying and troubleshooting HPWH installations; (2) Larsen and Gantley's study "Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Configurations"; (3) our experience teaching HPWH installation to ~200 plumbers over the past year; and (4) Gary's 30+ years working on water heating systems. New code language needs to provide for various locations, air from inside and outside, and HPWHs with different size compressors and fans. We also wish to provide for future HPWHs with expected larger compressors with the language giving guidance for appropriate locations and ventilation.

Definitions section, p. 185

Neither of the terms "Split-refrigerant HPWH" nor "Split hydronic HPWH" are used in the sections. Recommend removal of these definitions (~~strikethrough~~ shown and highlighted) or adding text to reserve their use in the future. Also recommend indenting "multi-pass WH" and "single-pass WH" since they are types of HPWHs.

WATER HEATER definitions include the following:
CONSUMER WATER HEATER is a water heater that meets the definition of a consumer product under USDOE 10 CFR 430.
HEAT PUMP WATER HEATER (HPWH) is a water heater that transfers thermal energy from one temperature level to another temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

INTEGRATED HEAT PUMP WATER HEATER is a HPWH which has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.

~~**SPLIT-REFRIGERANT HEAT PUMP WATER HEATER** is a HPWH which has a single outdoor section and one or more indoor sections connected to the outdoor section via a refrigerant circuit.~~

~~**SPLIT-HYDRONIC HEAT PUMP WATER HEATER** is a HPWH that consists of multiple separate sections. One section houses all the refrigerant components, while one or more additional sections are designated for water storage. These sections are interconnected through a hydronic circuit.~~

MULTI-PASS WATER HEATER is a water heater which the cold water passes through multiple times. The water temperature increases with each pass, until the storage tank reaches the intended storage temperature.

SINGLE-PASS WATER HEATER is a water heater which the cold water passes through once and is heated to the intended use temperature.

Section 110.3, p. 201

We increased space needed for HPWH installations in enclosed rooms to allow for high draw patterns. See justification at end of document. We increased the ventilation multiplier to allow for high draw pattern and larger compressor HPWHs. See justification at end of document. Also, please review numbering of 1-7. Provision 7.iv allows for manufacturer instructions to govern, while provision 1 requires the greater of 250 cuft per kbtu or manufacturer guidance. These need to be made consistent.

7.**Air-source Heat Pump Water Heaters (HPWHs).** HPWH shall meet the following requirements:

A.**Backup Heat.** Backup heat is required for ~~air-source~~ systems when inlet air is unconditioned, unless the compressor cutout temperature is below the Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup heat shall be electric resistance and may be internal or external to HPWH

B.**Ventilation.** Consumer integrated HPWHs shall meet one of the ventilation requirements below. Minimum volume and opening size requirements shall be the sum of all HPWHs installed within the same space. Compressor capacity shall be determined using AHRI 540 Table 4 reference conditions for refrigeration with the "High" rating test point:

1 For HPWH installation without ducts, the installation space shall have a volume equal to the greater of ~~100~~ 250 cubic feet per kBtu per hour of compressor capacity, or the minimum volume provided by the manufacturer for this method; or

2 For HPWH installation without ducts, the installation space shall be vented to a communicating space via permanent openings, according to the following requirements:

3 Communicating space shall meet the minimum volume of section 110.3(c)7B1 above, minus the volume of the HPWH installation space; and

4 Permanent openings shall consist of a single layer of fixed flat slat louvers or grilles, with a total minimum NFA the larger of ~~125 square inches plus 25square inches~~ 75 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method. The permanent openings shall be fully louvered doors or two openings of equal area, one located within 12 inches from the enclosure top and one located within 12 inches from the enclosure bottom; or

5 For HPWH installations with ducts, the following requirements shall be met:

6 The space joined to the installation space via ducts shall meet the minimum volume of section 110.3(c)7B1 above, minus the volume of the HPWH installation space; and

7 All duct connections and building penetrations shall be sealed; and

i Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and

ii ~~If~~ Where only the HPWH inlet or outlet is ducted, installation space shall include permanent openings consist of a louvered door or a single layer of fixed flat slat louvers or grilles in the bottom half of the room, ~~and/or a door undercut~~. The minimum NFA of the permanent openings shall be the larger of 75 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method. ~~With a ducted inlet, the minimum NFA shall be equal to the cross-sectional area of the duct. With a ducted exhaust, the minimum NFA shall be the larger of 20 square inches or the minimum NFA provided by the manufacturer for this method;~~ and

iii ~~If~~ Where the inlet and outlet ducts both terminate within the same pressure boundary, airflow from the termination points shall be diverted away from each other; or

iv ~~Installed using a method certified by the manufacturer to meet the ventilation requirements of 110.3(c)7B.~~

Section 160.9, p, 586-589

To provide for the HP-ready situation, we recommend that the airflow be capable of supporting the installation of 16,000 BTU/hour HPWH. Such a HPWH would have essentially the same heat rate as a 4,500-watt 240VAC electric resistance element, which is typical of virtually all residential electric resistance water heaters sold in the US market. The advantage of this is that the time to heat a given amount of hot water will be very similar between the HPWH and the resistance tank.

Using 75 square inches per kBTU of capacity, the ventilation for 16 kBTU/hr needs to be 1,200 square inches, split equally between high and low. Since the kBTU of the future HPWH is unknown at the time of construction, it makes sense to provide for an amount of free vent area corresponding to a large HPWH compressor. The airflow for a 16kBTU/hr compressor leads to larger capped ducts of 12" diameter rather than 8" diameter. Language in C.iii can be deleted, as ducts are not likely to be installed at the time of HPWH-ready, so they don't really need to be here. When the future system is installed, then this provision will become applicable and should be added to the requirements for that section of this code.

We are proposing to eliminate the minimum volume of enclosed space requirement. When making the building retrofit ready, the provisions should focus on ensuring access to the warm air "fuel".

(e) Individual Heat Pump Water Heater Ready. Systems using gas or propane water heaters to serve individual dwelling units shall include the following components and shall meet the requirements of Section 160.9(f):
1. A dedicated 125 volt, 20 amp electrical receptacle that is connected to the electric panel with a 120/240 volt 3 conductor branch circuit rated to 30 amps minimum, within 3 feet from the

water heater and accessible to the water heater with no obstructions. In addition, all the following:
A. Both ends of the unused conductor shall be labeled with the word “spare” and be electrically isolated; and
B. A reserved single pole circuit breaker space in the electrical panel adjacent to the circuit breaker for the branch circuit in A above and labeled with the words “Future 240V Use”; and
2. A condensate drain that is no more than 2 inches higher than the base of the installed water heater, and allows natural draining without pump assistance, and
3. The construction drawings shall designate a space at least 39 inches by 39 inches and 96 inches tall for the future location of heat pump water heater.
4. A ventilation method meeting one of the following:
~~A. The designated space for the future heat pump water heater shall have a minimum volume of 700 cubic feet per kbtu of compressor; or~~
B. Where the HPWH will be using indoor air, the ~~The~~ designated space for the future heat pump water heater shall vent to a communicating space in the same pressure boundary via permanent openings with a minimum total NFA of ~~75~~ 1,200 square inches ~~per kbtu of compressor., so that the total combined volume connected via permanent openings is 700 cubic feet per kbtu of compressor or larger~~. The permanent openings shall be:
i. Fully louvered doors with fixed louvers; or
ii. Two permanent fixed openings of equal area located within 12 inches from the enclosure top and bottom; or a combination of louvered doors and fixed openings; or
iii. two ~~8~~ 12 inches~~-~~ diameter or equivalent capped ducts; or a combination of louvered doors, or fixed openings and one capped duct. The louvered door or fixed opening shall not be less than 600 square inches.
C. Where the HPWH will be using outdoor air, the ~~The~~ designated space for the future heat pump water heater shall vent to the outdoors via permanent openings with a minimum total NFA of 1,200 square inches following the provisions in B above or; where installed in an interior space shall include two ~~8~~ 12 inches~~-~~ diameter or equivalent capped ducts, venting to the building exterior:
i. All ducts, connections, and building penetrations shall be sealed.
ii. Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to a minimum insulation level of R-6.
iii. ~~Airflow from termination points shall be diverted away from each other.~~

Section 170.2, p. 632-634

Provision 1.B Exception 2 allows 120V HPWHs for units up to 1 bedroom, assuming a certain HPWH capacity of about 4,000 BTU/hr and likely a 900 watt resistance element. Based on the requirements for first hour rating in the California Plumbing Code (see Table 501.1(2) below), a 120VAC HPWH could be suitable for a much larger number of bedrooms. We find that Rheem’s 50-gallon shared circuit 120V HPWH is capable of providing hot water for a 2 bedroom 2.5 bath home per UPC/CPC plumbing code requirement of 49 gallons first hour rating and 51 gallons and 55 gallons first hour ratings of their 120V dedicated and shared circuit models respectively.

120V 80-gallon shared circuit model has first hour rating of 72 gallons, sufficient to meet UPC/CPC requirements for 4 bed 2.5 bath or 3 bed 3 bath residences (see excerpt from Rheem's catalog below). At present, the capabilities of the 120VAC HPWHs are similar among different manufacturers.

Suggest including reference to the UPC/CPC Table 501.1(2) in the building energy code and so that these requirements can be used rather than the 1 bedroom maximum currently in the language.

TABLE 501.1(2)
FIRST HOUR RATING[1]

Number of Bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating,[2] Gallons	38	49	49	49	62	62	74	62	74	74	74

For SI units: 1 gallon = 3.785 L

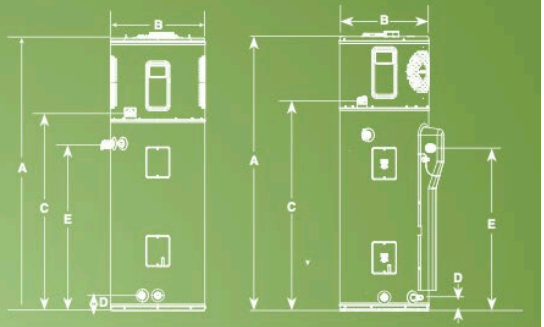
Notes:

[1] The first-hour rating is found on the "Energy Guide" label.

[2] Solar water heaters shall be sized to meet the appropriate first-hour rating as shown in the table.

PROTERRA™ PLUG-IN

Rheem® ProTerra® Plug-in Specifications



ProTerra Plug-in Heat Pump Water Heater – 120V Dedicated Circuit

DESCRIPTION				ENERGY INFO		FEATURES			TANK DIMENSIONS						
NOMINAL GALLON CAPACITY	RATED GALLON CAPACITY	MODEL NUMBER	ELECTRIC BREAKER (TIME DELAY) SIZE	VOLTAGE	UNIFORM ENERGY FACTOR (UEF)	COMPRESSOR BTU/H	FIRST HOUR RATING (GALLONS)	RECOVERY IN G.P.H. 60° F RISE	HEIGHT (A)	DIAMETER (B)	HEIGHT TO CONDENSATE (C)	HEIGHT TO COLD INLET & DRAIN (D)	HEIGHT TO HOT OUTLET AND T&P (E)	UNIT WT. (LBS)	APPROX. SHIP WT. (LBS)
40	37	PROPH40 T0 RH120	15A	120V	3.0	12,000	51	28	65-5/8"	20-1/4"	47-13/16"	3-5/8"	39-5/8"	200	242
50	46	PROPH50 T0 RH120	15A	120V	3.0	12,000	51	29	65"	22-1/4"	47-1/4"	3-5/8"	39-5/8"	210	252

ProTerra Plug-in Heat Pump Water Heater with HydroBoost and LeakGuard™ – 120V Shared Circuit

DESCRIPTION				ENERGY INFO		FEATURES			TANK DIMENSIONS						
NOMINAL GALLON CAPACITY	RATED GALLON CAPACITY	MODEL NUMBER	ELECTRIC BREAKER SIZE	VOLTAGE	UNIFORM ENERGY FACTOR (UEF)	COMPRESSOR BTU/H	FIRST HOUR RATING (GALLONS)	RECOVERY IN G.P.H. 60°F RISE	HEIGHT (A)	DIAMETER (B)	HEIGHT TO CONDENSATE (C)	HEIGHT TO COLD INLET & DRAIN (D)	HEIGHT TO HOT OUTLET (E)	UNIT WT. (LBS)	APPROX. SHIP WT. (LBS)
40	36	PROPH40 T0 RH120-MSO	15A	120V	2.8	4,200	45	12	63"	20-1/4"	47"	3-5/8"	39-5/8"	157	194
50	46	PROPH50 T0 RH120-MSO	15A	120V	3.0	4,200	55	12	62"	22-1/4"	47"	3-5/8"	39-5/8"	178	218
65	59	PROPH65 T0 RH120-MSO	15A	120V	3.3	4,200	55	12	65"	24-1/4"	49"	3-7/8"	42-3/8"	225	262
80	72	PROPH80 T0 RH120-MSO	15A	120V	3.5	4,200	72	12	75"	24-1/4"	59"	3-7/8"	42-3/8"	244	281

ProTerra Plug-in Heat Pump Water Heater with HydroBoost – 120V Shared Circuit

DESCRIPTION				ENERGY INFO		FEATURES			TANK DIMENSIONS						
NOMINAL GALLON CAPACITY	RATED GALLON CAPACITY	MODEL NUMBER[1]	ELECTRIC BREAKER SIZE	VOLTAGE	UNIFORM ENERGY FACTOR (UEF)	COMPRESSOR BTU/H	FIRST HOUR RATING (GALLONS)	RECOVERY IN G.P.H. 60°F RISE	HEIGHT (A)	DIAMETER (B)	HEIGHT TO CONDENSATE (C)	HEIGHT TO COLD INLET & DRAIN (D)	HEIGHT TO HOT OUTLET (E)	UNIT WT. (LBS)	APPROX. SHIP WT. (LBS)
40	36	PROPH40 T0 RH120-M	15A	120V	2.8	4,200	45	12	63"	20-1/4"	47"	3-5/8"	39-5/8"	157	194
50	46	PROPH50 T0 RH120-M	15A	120V	3.0	4,200	55	12	62"	22-1/4"	47"	3-5/8"	39-5/8"	178	218
65	59	PROPH65 T0 RH120-M	15A	120V	3.3	4,200	55	12	65"	24-1/4"	49"	3-7/8"	42-3/8"	225	262
80	72	PROPH80 T0 RH120-M	15A	120V	3.5	4,200	72	12	75"	24-1/4"	59"	3-7/8"	42-3/8"	244	281

[1]*M-models are LeakGuard and LeakSense ready. Easily add available leak sensor and shut-off valve upgrade kit.*

NOTE: *Uniform Energy Factor and rated gallon capacity based on Department of Energy (DOE) requirements. All units have integrated Wi-Fi control board.*

Regarding the single-pass requirement in section 2Ai, work by Redwood Energy, AEA, ForStrategy Consulting, and Small Planet Supply/Waterdrop has proven the merit of multiple integrated HPWHs in series to provide central water heating for multifamily buildings. These are multi-pass and should be provided for by the code, not prohibited as the current language does. Recommend removing requirement to be single-pass.

In 2Avi, we revised language to be clearer with same meaning.

(d) **Domestic Hot Water Systems** ~~**Water-heating systems.**~~ Water-heating systems shall meet the applicable requirements of ~~either~~ 1, 2, 3 or 4 below:~~.~~
~~For recirculation distribution systems serving individual dwelling units, only demand recirculation systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used. Recirculation system serving multiple dwelling units shall meet the requirements of Sections 110.3(c)2 and 110.3(c)5, and shall be capable of automatically controlling the recirculation~~
~~n pump operation based on measurement of hot water demand and hot water return temperature:~~
1. **Individual Systems.** For systems serving individual dwelling units, the water-heating system shall meet the requirement of either A, or B or C, or shall meet the performance compliance requirements of Section 170.1. For recirculation distribution systems serving individual dwelling units, only demand recirculation systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used.:
A. A single 240 volt heat pump water heater. In addition, meet the following:
i. A compact hot water distribution system as specified in Reference Appendix RA4.4.6 in climate zones 1 and 16; and
ii. A drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9 in Climate Zone 16.
B. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. In addition, for climate zone 16, a drain water heat recovery system that is field verified as specified in Reference Appendix RA3.6.9.
~~C. A gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank.~~
Exception 1 to Section 170.2(d)1: Multifamily buildings four habitable stories or greater may install a gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank.
Exception 2 to Section 170.2(d)1: A 120V HPWH may be installed in place of a 240V HPWH for new dwelling unit that meets the first hour rating requirement in CPC Table 501.1(2).~~with one bedroom or less.~~
2. **Central Systems.** For systems serving multiple dwelling units, the water-heating system shall meet the applicable requirement of A through F, or shall meet the performance compliance requirements of Section 170.1:
A. For heat pump water-heating systems serving multiple dwelling units, the water-heating system shall be installed according to the manufacturer's design and installation guidelines and

meet the following requirements, or meet the requirements of NEEA Advanced Water Heater Specification for commercial heat pump water heater Tier 2 or higher:

~~iA. The primary heat pump water heater shall be a single-pass heat pump water heater.~~

ii. The hot water return from the recirculation loop shall connect to a recirculation loop tank and shall not directly connect to the primary heat pump water heater inlet or the primary thermal storage tanks.

iiiB. The fuel source for the recirculation loop tank shall be electricity~~. if auxiliary heating is needed. The recirculation loop heater shall be capable of multi-pass water-heating operation. C. For systems with single pass primary heat pump water heater, the primary thermal storage tanks shall be piped in series if multiple tanks are used. For systems with multi-pass primary heat pump water heater, the primary thermal storage tanks shall be piped in parallel if multiple tanks are used.~~

ivD. The primary storage tank temperature setpoint shall be at least 135°F.

vE. The recirculation loop tank temperature setpoint shall be at least 10°F lower than the primary thermal storage tank temperature setpoint ~~such that hot water from the recirculation loop tank is used for the temperature maintenance load before engaging the recirculation loop tank heater.~~

viF. ~~The minimum heat pump water heater compressor cut-off temperature shall be 40°F ambient air temperature.~~ The low-temperature cut-off for the heat pump water heater compressor shall not be greater than 40°F ambient air temperature.

~~G. A recirculation system.~~

~~**Exception to Section 170.2(d)2G: Buildings** with eight or fewer dwelling units.~~

viiH. Design documentation shall be provided in accordance with JA14.4.

~~3~~B. For gas or propane systems serving multiple dwelling units, the ~~a central~~ water-heating system that includes the following components shall be installed:

i~~A~~. For Climate Zones 1 through 9, gas service water-heating systems with a total installed gas water-heating input capacity of 1 MMBtu/h or greater shall have gas service water-heating equipment with a minimum thermal efficiency of 90 percent. Multiple units are allowed to meet this requirement with an input capacity-weighted average of at least 90 percent.

Exception 1 to Section 170.2(d)Bi~~3A~~: Individual gas water heaters with input capacity at or below 100,000 Btu/h shall not be included in the calculations of the total system input or total system efficiency.

Exception 2 to Section 170.2(d)Bi~~3A~~: If 25 percent of the annual water-heating requirement is provided by site-solar energy or site-recovered energy.

~~B. A recirculation system.~~

~~**Exception to Section 170.2(d)3B:** Buildings with eight or fewer dwelling units.~~

ii~~C~~. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of either i or ii below:

i. A minimum solar savings fraction of 0.20 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.35 in Climate Zones 10 through 16; or

ii. A minimum solar savings fraction of 0.15 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.30 in Climate Zones 10 through 16. In addition, a drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9.

~~4~~C. All hot water distribution piping shall be sized in accordance with the California Plumbing Code Appendix M.

D. The central system shall have a recirculation system with mechanical or digital thermostatic master mixing valve on each distribution supply and return loop, and meet the requirements specified in the Residential Reference Appendix RA4.4.20.

Exception to Section 170.2(d)2D: Buildings with eight or fewer dwelling units.

E. A water-heating system serving multiple dwelling units determined by the Executive Director to use no more energy than the one specified in Subsection ~~1, 2 or 3~~A or B above.

Justifications

110.3(c)7B1

We calculate that the minimum space volume that has been proposed is insufficient; and the space required without access to external air likely needs to be significantly above 250 cubic feet per kBtu/hr in order for the HPWH to operate primarily in heat pump mode, rather than resistance mode. This is based on Larsen and Gantley's report "Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Configurations" sponsored by PG&E, December 2023. The circled data point for the AO Smith unit with high draw pattern (85 gallons per day) shows COP of 2.5 at 1,000 cubic feet with a 4,000 btu/hr heat pump. Any enclosed space reduces the COP. The higher the draw pattern in an enclosed space, the lower the COP in heat pump mode, until eventually, the hybrid HPWHs switch to resistance mode with a COP of 1. A key reason for the lower efficiency is that as the intake air for the heat pump gets colder, it is harder to extract energy from the air. Hence, we propose the 250 cubic feet per kbtu/hr minimum requirement to allow for high draw patterns in enclosed spaces. Note that this allows for installation in one-car garages for typical hybrid HPWHs and in two-car garages for 12kbtu/hr HPWHs, without added ventilation in either of these two spaces.

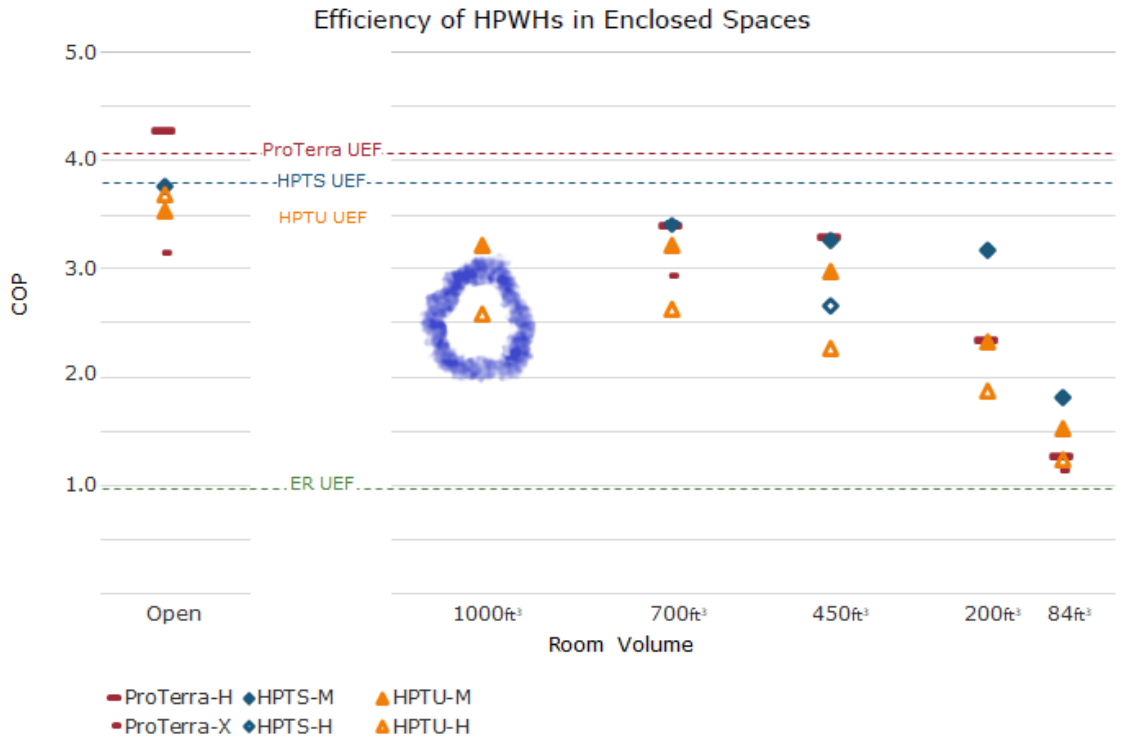


FIGURE 12. HPWH EFFICIENCY IN ENCLOSED SPACES

An unintended consequence of enclosed spaces is to limit the amount of hot water that can be made in heat pump mode. This is due to two factors: how much energy can get into the room via conduction only and how many hours the HPWH can operate in heat pump mode inside this room.

Again, referencing the Larsen/Gantley report, for every 2 hours the HPWH runs in heat pump mode, the room takes at least one hour to recover the heat that has been extracted. And this was based on the space surrounding the enclosed room always being warmer, so heat could flow inwards via conduction, implying that this only works when the HPWH is installed inside a conditioned envelope. This means that the heat pump can only run 16 hours out of every day.

The amount of energy that can get into an enclosed space via conduction depends on the insulation value or conductivity of the room's envelope and the temperature difference between inside and outside of that room. Some possible insulation (heat transfer) values for the envelope of an enclosed space are R-2, U-0.5, R-4, U-0.25, R-10, U-0.1 and R20, U-0.05. An R-2 enclosure is the equivalent of 1 inch of wood with stationary air films on both sides. An R-4 enclosure is what can be expected from 2x4 framing with sheet rock on both sides. An R-10 enclosure is the same construction with insulation between the framing members. An R-20 enclosure is what can be expected from 2x6 framing with insulation between the framing members.

Since, at present, HPWH make noise that customers will want to mitigate, it does not make sense to assume too little insulation. For interior enclosures, R-4 to R-10 are reasonable assumptions.

Let's assume the space outside the HPWH room is at 70F and the temperature drop when the HPWH is running averages 15F. The surfaces of a 450 cubic foot enclosure insulated to R-4 can transfer about 1,300 BTU per hour into the room. Running 16 hours a day, this means that 20,800 BTU get into the room. The compressor adds heat to the water along with the air. Assuming a 400-Watt compressor, this adds about 1,360 BTU/hour. Running 16 hours per day, this is 21,700 BTU for a total of 42,500 BTU. This is between 55 and 75 gallons at 90F and 70F temperature rise, respectively.

If the envelope of this 450 cubic foot enclosure is insulated to R-10, the surfaces can transfer about 535 BTU/hour into the room for a 16-hour total of 8,560 BTU. Added to the heat provided by the compressor, the total available energy is 30,260 BTU, a reduction of almost 30 percent. This reduced the number of gallons to about 39 and 54 gallons at 90F and 70F temperature rise, respectively.

The preceding calculations are based on an assumption that there is always a warmer temperature outside the enclosure. This is not likely to be true if the enclosure is connected to the outside, say an outside closet or the garage. Outdoor temperatures vary throughout the day and over the course of the year. Many hours of many days the delta-T will be going the wrong way.

7B4 Ventilation:

The Larsen/Gantley report recommended a minimum of 150 square inches of net free area for both high and low grilles (or a full-louvered door with the same net free area). We are also recommending a simpler approach to determining the air flow than is currently proposed.

The market for unitary HPWHs has begun to change making units with larger compressors available. Rheem has a dedicated circuit 120VAC model with a 12,000 BTU/hr compressor. LG is now offering a 240VAC model with a 10,000 BTU/hr compressor. Using 75 square inches per kBTU results in 300 square inches for a 4kBTU HPWH, 750 square inched for a 10kBTU HPWH and 900 square inches for a 12 kBTU HPWH.

This unrestricted access to ventilation also allows for higher draw patterns in heat pump mode, without causing hot water shortfalls.

Since it doesn't make sense to restrict access of the HPWHs to their fuel, warm air, we are recommending that the building energy standard use the Larsen/Gantey findings for air flow as the basis for the minimum code.