Heat Pump Water Heaters

Last Updated: 06/08/2015

Scope

Select heat pump water heaters as an energy-efficient alternative to electric-resistance water heaters.

ENERGY STAR Certified Homes Version 3.0 Notes

To be ENERGY STAR labeled, electric water heaters must have an Energy Factor ≥ 2.0 and a First-Hour Rating ≥ 50 gallons per hour. Based on the available electric water heating products in the market today, this can only be achieved by HPWHs. In addition, the electric water heaters must have a warranty ≥ 6 years on sealed system and comply with UL 174 and UL 1995 safety requirements.

DOE Zero Energy Ready Home Notes

The DOE Zero Energy Ready Home National Program Requirements, Exhibit 2, states water heaters should be ENERGY STAR certified. Homes following the Prescriptive Path must meet this requirement. Homes following the Performance Path must meet the performance level of a target home built to the requirements shown in Exhibits 1 and 2.

Homes equipped with an ENERGY STAR qualified whole home gas tankless water heater or an ENERGY STAR qualified heat pump water heater are exempt from the solar water heating requirements of the Renewable Energy Ready Checklist of the Zero Energy Ready Home National Program Requirements.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
**Description**

A “heat pump” is a device that moves heat from one place to another. A HPWH moves heat from the surrounding space into the hot water tank. Most heat pumps operate as “hybrid” devices – i.e. they use the heat pump whenever possible, but built-in controls switch to conventional resistance heating when there are large hot water needs. While a HPWH is an efficient unit on its own, it does impact the surrounding area so the final determination of viability is dependent on the site conditions.

A heat pump water heater (HPWH) is an efficient electric water heating option (Energy Factor ratings of greater than 2.0), but the actual operating efficiency of the unit is highly variable depending on several site specific factors. HPWHs are primarily designed as alternatives or replacements for standard, electric resistance water heater tanks (ERWHs), but they should also be evaluated when oil or propane are the water heating fuels.

The HPWH products currently available in the market range in tank volume (gal), first-hour capacity ratings (gal), efficiency (EF), as well as physical size and weight. When selecting a water heater size, the first hour rating (FHR, listed in gallons) is probably the most important factor. The FHR is the amount of hot water that a water heater can deliver in a single hour (when starting with a full tank of hot water). The FHR should be equal to (or greater than) the highest volume of water typically used during any hour of normal operation in the home. While hot water use varies widely from home to home, some guidelines for first hour ratings in “typical” homes are shown in the table below. For more detailed analysis, see U.S. Department of Energy’s "Sizing a New Water Heater" site which provides a worksheet to estimate target FHRs.

<table>
<thead>
<tr>
<th>Number of Bathrooms</th>
<th>Number of Bedrooms</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 1.5</td>
<td>1</td>
<td>43</td>
<td>60</td>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 - 2.5</td>
<td>1</td>
<td>-</td>
<td>60</td>
<td>70</td>
<td>72</td>
<td>90</td>
</tr>
<tr>
<td>3 - 3.5</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>72</td>
<td>82</td>
<td>90</td>
</tr>
</tbody>
</table>

Guidelines for FHR ratings (gallons) for “typical” homes. Source: Consumer Energy Center

The efficiency of HPWHs is profoundly affected by the way hot water is used. When large quantities of hot water are used in clusters, HPWHs will revert to electric resistance mode, reducing the efficiency of the unit. A homeowner can reduce this effect by purchasing a larger HPWH, increasing the set point temperature, or changing behavior. By increasing the size and temperature of a HPWH, more hot water can be delivered at a given time before the resistance elements are needed. Spreading the water load over a longer period of time may also provide similar benefits and reduce standby losses.

HPWHs are not ideal for all applications; they remove heat from ambient air, generate more noise than other water heaters, and have special space and clearance requirements. Because they remove heat from the surrounding air, they impact the building loads of the home. In colder climates especially, these impacts should be considered before installing a HPWH.

**How to Locate and Install Heat Pump Water Heaters**

1. **Select the best location for the HPWH.** Determine the interaction with cooling and heating equipment. Should the unit be placed in conditioned space, semi-/unconditioned space, or in an attached garage? Hot climates will have a net cooling benefit, while cold climates will have a net heating penalty. Generally, homes in climate zones 1 and 2 have a net cooling benefit. For climate zones 1 and 2, installation in an attached garage or conditioned space may be appropriate.
2. **Select Location.**

<table>
<thead>
<tr>
<th>Condition</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficient room volume (750 to 1000ft$^3$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate ambient temperature (&gt; 50°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is sufficient space to meet clearance requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise will not interfere with living spaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate can be removed effectively</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **Can the floor support the unit?** If not, reinforce as necessary.

4. **Removal of older equipment (if applicable).** In the case of existing home retrofits, follow accepted industry procedures and practices as listed in the Standard Work Specification (SWS):
   a. Remove old water heater and associated components
   b. Seal any unused chimney openings
   c. Remove unused oil tank, lines, and associated equipment.

5. **HPWH installation.** Follow the guidelines for installation as listed in the Standard Work Specification (SWS). These requirements are as follows:
   a. Repair any existing water leaks before installation.
   b. Install an emergency drain pan. Connect a ¾” drain line or larger to tapping on pan and run to drain or pump to daylight.
   c. Install temperature and pressure relief valve according to manufacturer specifications. Temperature and pressure relief valve discharge tube will terminate within 6” of the floor, or as prescribed by local code.
   d. Install di-electric unions according to manufacturer specifications.
   e. Discharge temperature will be set to not exceed 120° or as prescribed by local code.
   f. Commissioning will be in compliance with manufacturer specifications and relevant industry standards. The following will be checked once the system has been filled and purged:
      - Safety controls
      - Combustion safety and efficiency
      - Operational controls
      - Water leaks
      - Local code requirements
   g. Occupants will be educated on the safe and efficient operation and maintenance of the system, including:
      - Adjustment of water temperature and target temperature per local code
      - Periodic drain and flush

In addition to the requirements outlined by the SWS, remember to install the following items for any water heater:

- Place the unit on blocks
- Install a condensate pump, if needed
- Install heat traps to prevent thermosiphoning
- Install tempering valves, if needed
- Insulate hot water lines
Ensuring Success
Climate

A HPWH moves heat from the air surrounding the water heater into the storage tank, so a HPWH will have an impact on the space conditioning loads of the building in which it is located. When a HPWH is located in conditioned space, there is a very direct effect on space conditioning loads and possibly on comfort. In the summer, the HPWH will reduce the cooling load of the building; conversely, the heating load will be increased in the winter. A HPWH’s energy consumption and its impact on the space conditioning depend heavily on climate, home configuration, HPWH location, and the space conditioning systems used. Regardless, the cooled air from the HPWH must be managed to ensure that there are no comfort issues for the occupants.

For HPWHs installed in unconditioned or “semi-conditioned” spaces such as basements, the space conditioning impacts are harder to determine. These spaces act as buffer spaces, so the heat transferred from the space into the storage tank is not necessarily transferred from the conditioned spaces. Air infiltration into the buffer space, ground coupling, solar gains, and heat transfer from mechanical equipment can all affect heat transfer between the buffer space and conditioned space. The transient effects of these heat transfer processes means that the HPWH space conditioning impacts are potentially reduced. Research is ongoing to better quantify the space conditioning impacts of HPWHs.

Research has determined that while the cooling/dehumidification benefits and higher COPs of an HPWH are more advantageous in the hot-humid climate, incoming water temperature tends to be higher. The incoming water temperature can be 85°F or higher for portions of the year. This means less water heating is required, which can minimize the cost benefit of the HPWH in hot-humid climate zones.

The technology, when applied appropriately, is still a better option than alternative electric/propane/oil water heating solutions, but overall savings expectations should be more conservative to account for space conditioning impacts and variations of performance from rating conditions.
Training

Right and Wrong Images

CAD
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Federal Water Heater Standard

The new Federal water heater standard, which takes effect in 2015, mandates EFs around 2.0 for all new electric storage water heaters with capacities greater than 55 gallons (Federal Register 2010). This regulation will effectively mandate the use of HPWHs in applications with large hot water demands and where electricity will be used to heat water.

ENERGY STAR Water Heater Key Product Criteria

To be ENERGY STAR labeled, electric water heaters must have an Energy Factor ≥ 2.0 and a First-Hour Rating ≥ 50 gallons per hour. Based on the available electric water heating products in the market today, this can only be achieved by HPWHs. In addition, the electric water heaters must have a warranty ≥ 6 years on sealed system and comply with UL 174 and UL 1995 safety requirements.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 1, Item 4) Hot water delivery systems (distributed and central) shall meet efficient design requirements or water heaters and fixtures shall meet efficiency criteria.

Exhibit 2 DOE Zero Energy Ready Home Target Home.
The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Water Heater) ENERGY STAR levels for the system Energy Factor, as follows:

- Gas/propane systems of ≤ 55 gallons, EF = 0.67
- Gas/propane systems of > 55 gallons, EF = 0.77
- Electric systems in detached dwellings, EF = 2.0
- Electric systems in attached dwellings, EF = 1.5
- For heating oil water heaters use EF = 0.60

Heat Pump Water Heaters - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about heat pump water heaters to help ensure that upon inspection, the water heating system will be accepted as being in compliance with the code. This code-related information is expected to result in increased compliance and timely, less challenging, and more uniform plan review and field inspections for all relevant parties verifying compliance (e.g., code officials, builders, contractors, designers, etc.).

Heat pump water heaters (HPWHs) are an energy-efficient alternative to electric-resistance water heaters. Instead of heating water stored in a tank by running electrical current through resistors (i.e., the electric water heater elements), HPWHs use a vapor-compression refrigerant cycle (the same basic mechanism used by standard heat pumps, air conditioners, and refrigerators) to transfer heat from the surrounding air to the water.

The installation and use of HPWHs requires special considerations that are not applicable to traditional electric-resistance water heaters. Because HPWHs remove heat from the surrounding air, a sufficient volume of air must be available to circulate around the unit so a steady supply of warm air can be drawn across the unit’s evaporator coil. For this reason, a small closet (especially if the door doesn’t have a louvered design) would not be suitable as a location for an HPWH.

As the surrounding air is drawn across an HPWH’s evaporator coil and cooled, moisture in the air will condense on the coil. This condensed water must be routed to a drain. If a gravity drain (i.e., floor drain) isn’t possible, then a condensate pump may be needed to move condensate to the appropriate drainage piping (e.g., clothes washer drain). While condensate from gas-fired equipment calls for the installation of a neutralizer, the condensate produced by a HPWH doesn’t need neutralization since it’s non-acidic (i.e., distilled water). An HPWH’s fan and compressor will make noise while operating.
so the unit should ideally be located in a place where this noise would not disturb occupants.

An HPWH located within a conditioned space (i.e., located inside a home’s thermal building envelope) would have a small impact on the space conditioning loads. During the summer, an HPWH will provide a minor reduction in the home’s cooling load. During the winter, the HPWH will cause a minor increase in the heating load. For a given home, the specific impact on space conditioning energy use depends on the climate, the home’s size and configuration, the location of the HPWH, and the space conditioning systems used. Care should be taken during site selection to ensure that cooled air from an HPWH does not cause comfort issues for occupants, although this issue is generally mitigated by common water heater locations (e.g., basements, storage areas, laundry rooms, etc.) that are not frequently visited by occupants. For HPWHs installed in unconditioned “buffer” spaces (e.g., garages), there is little to no impact (because those spaces exchange heat with conditioned spaces). Garages or basements that are infrequently occupied are good locations for an HPWH since the fan/compressor noise is isolated from occupants.

An important consideration for HPWHs located in unconditioned spaces like garages is the temperature of the surrounding air. HPWHs are more efficient when the surrounding air is warm. For this reason, warm climates with lengthy cooling seasons are a very good fit for HPWHs. The efficiency and capacity of heat pumps decrease with decreasing air temperature, so an HPWH located in a garage in a cold climate would have more difficulty producing hot water to meet load when operating in heat-pump-only mode. Nearly all HPWH models in the market come with backup electric-resistance heating elements, which allows them to operate in full electric-resistance mode or “hybrid” mode (i.e., the unit switches between heat-pump and electric-resistance modes as determined by the water temperature). The hybrid or full electric-resistance modes can be used to keep up with high hot water loads (e.g., periods of high hot water draw and/or during the winter for units located in the garage of a cold-climate home).

The provisions in the International Residential Code (IRC) and International Energy Conservation Code (IECC) do not specifically address provisions for HPWHs, but rather water heaters in general. Installers and code officials should pay close attention to manufacturer specifications and installation instructions. The Plan Review and Field Inspection sections below include topics that installers should address when site selecting and installing HPWHs even though they may not be codified. This will help installers expedite the plan review and inspection process for the safe installation and compliance approval of HPWHs.

The Technical Validation/Reference Materials section below characterizes Federal appliance standards for residential water heaters to assist in model selection and utility measurement and verification planning and additional resources applicable to HPWHs.


[2] Typically, 45-60 decibels depending on the model.

Plan Review:

This section lists applicable requirements and details helpful for plan review regarding provisions implemented to meet the requirements for HPWH systems and their components.

2018/2015 IRC, Section R104, Duties and Powers of the Building Official

- **Section R104.1 General.** The building official has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies, and procedures shall conform to the intent and purpose of this code.

- **2018/2015 IECC/IRC, Section R102.1/R104.11, Alternative Materials, Design and Method of Construction and Equipment.** The provisions of this code are not intended to prevent the installation of any material or prohibit any design or method of construction not specifically prescribed in the 2018/2015 IECC/IRC, provided that any such alternative has been approved. The building official is permitted to approve an alternative material, design, or method of construction in cases where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method, or work offered is for the purpose intended, and not less than the equivalent of that prescribed in the code. Compliance with specific performance-based provisions of the IRC and/or the IECC is an alternative to the specific requirements of this code.

- **Section R104.11.1, Tests.** Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official has authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.
**Construction Documentation.** Review the construction documents for details describing the system, location, piping and duct design, condensate measures, controls, electrical, and installation.

- **2018/2015 IECC/IRC, Section R103.3/R106.3, Examination of Documents.** The code official/building official must examine, or cause to be examined, construction documents for code compliance.

- **Section R103.2/N1101.5, Information on Construction Documents.** Construction documents should be of sufficient clarity to indicate the location, nature, extent of the work proposed, and show in sufficient detail pertinent data and features of the system. Construction documents should include:
  - HPWH system design criteria
  - Equipment type(s), size(s), and efficiencies
  - Location of the HPWH
  - Mechanical and service hot water piping design, heat traps on inlet and outlet lines to prevent thermo-siphoning, and installation specifications
  - Protection of piping exposed to outdoor elements
  - Installation specification of ducting the exhaust and air intake, and duct insulation and sealing
  - Condensate drain line installation specifications (depending on location, some systems could require a condensate pump)
  - Operating temperature of fluids to be transported connected to mechanical system and service hot water system
  - Equipment and system controls
  - Electrical (wiring methods and design, connections, grounding, and installation specifications [most manufacturers require a 240 VAC single phase 30 amp power supply for HPWHs]).

- **2018/2015 IRC, Section M2005, General.** Water heaters should be installed in accordance with Chapter 28, Water Heaters, manufacturer instructions and requirements of the code.

- **Chapter 28, Water Heaters**
  - **Section P2801.1, Required.** Supplied with plumbing fixtures and appliances intended for bathing, washing, or culinary purposes.
  - **Section P2801.2, Drain valves.** Drain valves for emptying the tank, installed at the bottom of tank-type water heater and hot water storage tank. Drain valve inlet not less than ¾ inch nominal iron pipe size and the outlet provided with a male hose thread.
  - **Section P2801.3, Installation.** Water heaters to be installed in accordance with this chapter and Chapters 20 (Section M2005) and 24 (Fuel Gas is applicable).

**Location, Space Requirements, and Mounting.** Verify the location, surrounding space for air flow, access, and mounting equipment is correctly supported and installed in the structure. HPWH must have unrestricted airflow and, according to the typical manufacturer specification, a minimum installation space of 700 cubic feet (depending on size of system). (For example, a room that has an 8 foot tall ceiling and is 10 feet long by 8 ¾ feet wide would contain 700 cubic feet). If the room is smaller, the door must be louvered to allow free air passage into the space/room. The louvered panel must be at least 2 feet by 3 feet in size. A minimum clearance of 6 inches should be maintained from all sides and 6 inches from the top for access to the air filter (depending upon system).

Most manufacturers recommend the HPWH to be installed where the ambient air temperature is between ~45°F and ~110°F. When the temperature of the incoming air drops below the minimum temperature, the HPWH will switch into electric-resistance mode, which will reduce the energy efficiency of the unit (refer to the manufacturer specifications for recommended location and free space required around the unit).

- **2018/2015 IRC, Section P2801.4, Location.** Water heaters and storage tanks should be installed in accordance with Section M1305 and should be located and connected to provide access for observation, maintenance, servicing, and replacement.

- **Section M1305.1, Appliance access for inspection service, repair, and/or replacement.** A level working space not less than 30 inches deep and 30 inches wide (762 millimeters by 762 millimeters) must be provided in front of the control side to service an appliance. (Check manufacturer installation instructions. HPWHs typically require more working space than code.)

- **Section M1305.1.3.1/M1305.1.4.1, Ground Clearance.** Equipment and applications supported from the ground should be level and firmly supported on a concrete slab or other approved material extending not less than 3 inches (76 millimeters) above the adjoining ground. Such support should be in accordance with the manufacturer’s installation instructions. Appliances suspended over the floor should have a clearance of not less than 6 inches (152 millimeters) from the ground. (Most manufacturers require the water heater to be elevated from the floor at least 18 inches and on a proper platform capable of supporting the combined weight of the water heater and water.)
**Section P2801.7, Water Heaters Installed in Garages.** Water heaters having an ignition source should be elevated so the ignition source is not less than 18 inches (457 millimeters) above the garage floor (currently not relevant to HPWHs); refer to manufacturer specifications for installing HPWHs in garages).

**Section P2801.8, Water Heater Seismic Bracing.** In Seismic Design Categories D\(_0\), D\(_1\), and D\(_2\) and townhouses in Seismic Design Category C, water heaters should be anchored or strapped in the upper one-third and in the lower one-third of the appliance to resist a horizontal force equal to one-third of the operating weight of the water heater, acting in any horizontal direction, or in accordance with the appliance manufacturer’s recommendations.

**Drain Pan.** Where a storage tank-type water heater or a hot water storage tank is installed in a location where water leakage from the tank will cause damage

- **2018/2015 IRC, Section P2801.6, Required pan.** The tank should be installed in a pan constructed of one of the following:
  - Galvanized steel or aluminum of not less than 0.0236 inch (0.6010 millimeter) in thickness
  - Plastic not less than 0.036 inch (0.9 millimeter) in thickness
  - Other approved materials.

- **Section P2801.6.1, Pan Size and Drain.** The pan should be not less than 1-½ inches (38 millimeters) deep and should be of sufficient size and shape to receive dripping water or condensate from the tank or water heater. The pan should be drained by an indirect waste pipe of not less than ¾ inch in diameter.

- **Section P2801.6.2, Pan Drain Termination.** The pan drain should extend full size and terminate over a suitably located indirect waste receptor or should extend to the exterior of the building and terminate not less than 6 inches and not more than 24 inches above the adjacent ground surface.

**Relief Valves.** Verify that the water heater is protected with appropriate relief valves as directed in Section P2804 of the IRC.

- **2018/2015 IRC, Section P2804.1, Relief valves required.** Appliances and equipment used for heating water or storing water hot water should be protected by one of the following two valve types:
  1. A separate pressure-relief valve and a separate temperature relief valve

- **Section P2804.2, Rating.** Relief valves should have a minimum rated capacity for the equipment served and should conform to American National Standards Institute (ANSI) Z21.22.

- **Section P2804.3, Pressure-Relief Valves.** Pressure-relief valves should have a relief rating adequate to meet the pressure conditions for the appliances or equipment protected. In tanks, valves should be installed directly into a tank tapping or in a water line close to the tank. They should be set to open at not less than 25 psi (172 kPa) above the system pressure but not over 150 psi (1034 kPa). The relief-valve setting should not exceed the rated working pressure of the tank.

- **Section P2804.4, Temperature Relief Valves.** Temperature relief valves should have a relief rating compatible with the temperature conditions of the appliances or equipment protected. The valves should be installed such that the temperature-sensing element monitors the water within the top 6 inches (152 millimeters) of the tank. The valve should be set to open at a temperature of not greater than 210°F (99°C).

- **Section P2804.5, Combination Pressure-/Temperature Relief Valves.** Combination pressure-/temperature relief valves should comply with all the requirements for separate pressure- and temperature relief valves.

- **Section P2804.6, Installation of Relief Valves.** A check or shutoff valve should not be installed in the following locations:
  1. Between a relief valve and the termination point of the relief valve discharge pipe.
  2. Between a relief valve and a tank.
  3. Between a relief valve and heating appliances or equipment.

- **Section P2804.6.1, Requirements for Discharge Pipe.** The discharge piping serving a pressure-relief valve, temperature relief valve, or combination valve should:
  1. Not be directly connected to the drainage system.
  2. Discharge through an air gap located in the same room as the water heater.
3. Not be smaller than the diameter of the outlet of the valve served and should discharge full size to the air gap.
4. Serve a single relief device and should not connect to piping serving any other relief device or equipment.
5. Discharge to the floor, to the pan serving the water heater or storage tank, to a waste receptor, or to the outdoors.
6. Discharge in a manner that does not cause personal injury or structural damage.
7. Discharge to a termination point that is readily observable by the building occupants.
8. Not be trapped.
9. Be installed to flow by gravity.
10. Terminate not more than 6 inches (152 millimeters) and not less than two times the discharge pipe diameter above the floor or waste receptor.
11. Not have a threaded connection at the end of the piping.
12. Not have valves or tee fittings.
13. Be constructed of those materials listed in Section P2905.5 or materials tested, rated, and approved for such use in accordance with ASME Standard A112.4.1.
14. Be one nominal size larger than the size of the relief-valve outlet, where the relief-valve discharge piping is constructed of PEX or PE-RT tubing. The outlet end of such tubing should be fastened in place.

- **Section P2804.7, Vacuum-Relief Valve.** Bottom-fed tank-type water heaters and bottom-fed tanks connected to water heaters should have an installed vacuum-relief valve that complies with ANSI Standard Z21.22.

**Potable Water System Protection.** Verify that potable water connections to the equipment are correct.

- **2018/2015 IRC, Section P2902.1, General.** A potable water supply system should be designed and installed as to prevent contamination from non-potable liquids, solids, or gases being introduced into the potable water supply. Connections should not be made to a potable water supply in a manner that could contaminate the water supply or provide cross-connection between the supply and a source of contamination except where approved methods are installed to protect the potable water supply. Cross-connections between an individual water supply and a potable public water supply should be prohibited.

**Piping Insulation and Protection.** Verify the piping meets the applicable code requirements and manufacturer specifications. For example, manufacturers may specify heat traps on the system, which is not a code requirement. Heat traps prevent thermo-siphoning (i.e., the transfer of heat from the storage tanks down the cold or hot water lines). Hot water, being less dense than colder water, will tend to rise in a vertical pipe. In some cases, this movement of hot water will result in a considerable amount of energy being removed from a hot water tank. A simple U-bend of a heat trap will limit hot water from rising into a piping system.

- **2018/2015 IECC/IRC, Section R403.4/N1103.4, Mechanical system piping insulation (Mandatory).** Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3. (Mandatory means the provisions are required regardless of what path is chosen to demonstrate compliance (e.g., prescriptive, performance based, or Energy Rating Index).
- **Section R403.4.1/N1103.4.1, Protection of piping insulation.** Piping insulation exposed to weather shall be protected from damage, including damage caused by sunlight, moisture, equipment maintenance, and wind, and shall provide shielding from solar radiation that can degrade the material. Adhesive tape shall not be permitted.
- **Section R403.5.3/N1103.5.3, Hot water pipe insulation.** Insulation for hot water pipe with a minimum R-value of R-3 should be applied to the following:
  - Piping ¾ inch (19.1 millimeters) and larger in nominal diameter.
  - Piping serving more than one dwelling unit.
  - Piping located outside the conditioned space.
  - Piping from the water heater to distribution manifold.
  - Piping located under a floor slab.
  - Buried piping.
  - Supply and return piping in recirculation systems other than demand recirculation systems.

**Controls and Supplemental Devices**
• **2018/2015 IRC, Section M2005.4, Supplemental Water-Heating Devices.** Potable water-heating devices that use refrigerant-to-water heat exchangers should be approved and installed in accordance with the manufacturer’s installation instructions.
  
  o **IECC/IRC, Section R403.5.1/N1103.5.1, Heated water circulation and temperature maintenance systems (mandatory).** Heated water circulation systems shall be in accordance with Section R403.5.1.1/N1103.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.5.1.2/N1103.5.1.2. Automatic controls, temperature sensors, and pumps shall be accessible. Manual controls shall be readily accessible.

• **Section R403.5.1.1.1/N1103.5.1.1, Circulation systems.** Heated water circulation systems shall be provided with a circulation pump. The system return pipe shall be dedicated return pipe or a cold water supply pipe. Gravity and thermosiphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

• **Section R403.5.1.2/N1103.5.1.2, Heat trace systems.** Electric heat trace systems shall comply with IEEE[1] 515.1 or Underwriters Laboratory UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

• **2018 IECC/IRC, Section R403.5.2/N1103.5.2, Demand recirculation water systems.** Demand recirculation water systems[2] shall have controls that comply with both of the following:
  
  o **2015 IECC/IRC, Section R403.5.2/N1103.5.2, Demand recirculation systems.** A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a demand recirculation water system (this description was moved to a new definition in the 2018 IECC/IRC for demand recirculation water systems). Pumps shall have controls that comply with both of the following:
    
    - The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
    
    - The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C). 2018 IRC changed wording to “not greater than 104°F (40°C)”.

• **Section R403.5.4/N1103.5.4, Drain Water Heat Recovery Units.** Drain water heat recovery units should comply with CSA B55.2. Drain water heat recovery units should be tested in accordance with CSA B55.a. Potable water-side pressure loss of drain water heat recovery units should be less than 3 psi for individual units connected to three or more showers.

**Electrical.** Most manufacturers specify the water heater must be installed by qualified and licensed personnel. The installer should be guided by the instructions furnished by the manufacturer and with the local codes and utility company requirements. In the absence of local codes, preference should be given to the National Electrical Code, ANSI/NFPA 70[3]. In the 2018/2015 IRC, the electrical parts are Chapters 34 through 43, are copyrighted by the National Fire Protection Association (NFPA), and are based on the 2017/2014 (NEC) (NFPA 70-2017/2014). In the section numbers listed below, the section numbers of the corresponding text in the National Electrical Code (NFPA 70) appears in parentheses or brackets after the IRC text. Not all of the electrical provisions are listed below. Refer to these chapters and/or manufacturer specifications for full listings of provisions.

• **Section E3607.1, System service ground.** The premises wiring system should be grounded at the service with a grounding electrode conductor connected to a grounding electrode system as required by code. Grounding electrode conductors should be sized in accordance with Table E3603.4 [250.20(B)(1) and 250.24(A)]

• **Section E3702.10, Branch circuits serving heating loads.** Water-heating appliances should be considered to be continuous loads. Branch circuits supplying two or more outlets for fixed electric space-heating equipment should be rated 15, 20, 25, or 30 amperes. (2018 IRC wording changed the rating to not be rated over 30 amperes.) [424.3(A)]

• **Section E37061, Panelboard rating.** All panelboards should have a rating not less than that of the minimum service or feeder capacity required for the calculated load. (408.30)

• **Section E3706.2, Panelboard circuit identification.** All circuits and circuit modifications should be legibly identified as to their clear, evident, and specific purpose or use. The identification should be included in a circuit directory located on the face of the panelboard enclosure or inside the panel door. [408.4(A)]

• **Chapter 38, Wiring Methods, Section E3801, General Requirements.** Wiring methods for services, feeders, and branch circuits for electrical power distribution should meet the provisions in Chapter 38 or local codes, and/or manufacturer specifications. (300.1)

• **Chapter 41, Appliance Installation, Section E4101.1, Scope.** This section covers installation requirements for appliances and fixed heating equipment. (422.1 and 424.1)

**Drain Water Heat Recovery Units.**

- Drain water heat recovery units should comply with CSA B55.2. Drain water heat recovery units should be self-tested in accordance with CSA B55.a. Potable water-side pressure loss of drain water heat recovery units should be less than 3 psi for individual units connected to three or more showers.

**Electrical.** Most manufacturers specify the water heater must be installed by qualified and licensed personnel. The installer should be guided by the instructions furnished by the manufacturer and with the local codes and utility company requirements. In the absence of local codes, preference should be given to the National Electrical Code, ANSI/NFPA 70[3]. In the 2018/2015 IRC, the electrical parts are Chapters 34 through 43, are copyrighted by the National Fire Protection Association (NFPA), and are based on the 2017/2014 (NEC) (NFPA 70-2017/2014). In the section numbers listed below, the section numbers of the corresponding text in the National Electrical Code (NFPA 70) appears in parentheses or brackets after the IRC text. Not all of the electrical provisions are listed below. Refer to these chapters and/or manufacturer specifications for full listings of provisions.

- **Section E3607.1, System service ground.** The premises wiring system should be grounded at the service with a grounding electrode conductor connected to a grounding electrode system as required by code. Grounding electrode conductors should be sized in accordance with Table E3603.4 [250.20(B)(1) and 250.24(A)]

- **Section E3702.10, Branch circuits serving heating loads.** Water-heating appliances should be considered to be continuous loads. Branch circuits supplying two or more outlets for fixed electric space-heating equipment should be rated 15, 20, 25, or 30 amperes. (2018 IRC wording changed the rating to not be rated over 30 amperes.) [424.3(A)]

- **Section E37061, Panelboard rating.** All panelboards should have a rating not less than that of the minimum service or feeder capacity required for the calculated load. (408.30)

- **Section E3706.2, Panelboard circuit identification.** All circuits and circuit modifications should be legibly identified as to their clear, evident, and specific purpose or use. The identification should be included in a circuit directory located on the face of the panelboard enclosure or inside the panel door. [408.4(A)]

- **Chapter 38, Wiring Methods, Section E3801, General Requirements.** Wiring methods for services, feeders, and branch circuits for electrical power distribution should meet the provisions in Chapter 38 or local codes, and/or manufacturer specifications. (300.1)

- **Chapter 41, Appliance Installation, Section E4101.1, Scope.** This section covers installation requirements for appliances and fixed heating equipment. (422.1 and 424.1)
- **Section E4102.1, Installation.** Appliances and equipment should be installed in accordance with manufacturer’s installation instructions and specifications. Electrically heated appliances and equipment should be installed with the required clearances to combustible materials. [110.3(B) and 422.17]

**Existing Buildings and Replacement.** New HPWHs that are part of an addition should comply with new construction Section R403.4 and relevant sections of the IRC. An exception is, per IRC Section P2801.6.1, a drain pan should not be required for a replacement water heater installation where a drain pan was not previously installed. Switching to an HPWH may be more difficult depending on location of the existing unit and whether there is adequate space for proper venting and, if switching from a gas unit to a HPWH, will rerouting of gas lines and changes to venting be needed. Existing piping will also need to be rerouted to meet the needs of the HPWH as well.

- **2018/2015 IECC/IRC, Section R502/N1108, Additions**
  - **Section R502.1/N1108.1, General.** Additions to an existing building or building system or portion should conform to the provisions of this chapter as they relate to new construction without requiring the unaltered portion of the existing building or building system to comply.
  - **Section R502.1.3/N1108.1.3, Service hot water systems.** New service hot water systems that are part of an addition should comply with Section R403.5/N1103.5.

- **Section R503/N1109, Alterations**
  - **Section R503.1/N1109.1, General.** Alterations to an existing building, building system, or portion should conform to the provisions of this chapter as they relate to new construction without requiring unaltered portion of the existing building or building system to comply.
  - **Section R503.1.3/N1109.1.3, Service hot water systems.** A new service hot water system that is part of the alteration should comply with Section R403.5/N1103.5.


[3] National Electrical Code, ANSI/NFPA No. 70, Chapters 34 through 43 of the IRC is produced and copyrighted by NFPA and is based on the 2014 National Electrical Code (NEC) (NFPA 70-2014)

**Field Inspection:**

This section provides details for HPWHs where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Verifying code compliance for HPWHs would typically be at the mechanical rough-in, electrical, and final inspection stages.

Per the 2018/2015 IECC, Section R104, Inspections, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required inspections include footing and foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the 2018/2015 IRC, Section R109, Inspections, the wording is somewhat different in that for onsite construction, from time to time the building official, upon notification from the permit holder or his agent, can make, or cause to be made, any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.

Inspections should provide verification with the following items if specified and approved on the construction documents and per manufacturer specifications and installation:

- The HPWH is labeled and meets capacity and efficiency rating.
- The HPWH is properly located, installed, and mounted.
- The drain pan and waste pipe are properly installed.
- Pressure and temperature relief valves are properly installed with a discharge pipe run to an adequate drain and sheltered from freezing (if applicable).
- Condensate drain lines are properly installed and piped to an adequate drain or condensate pump installed.
- All piping is properly installed, insulated, sealed (free of leaks), and protected from exposed elements (below freezing temperatures) if applicable. Heat traps on inlet and outlet are properly installed.
- Exhaust and air intake ducts are properly installed.
- For the electrical service, check the markings on the rating plate of the HPWH to verify the power supply corresponds to the HPWH requirements (240V/30A).
Technical Validation(s):

This section provides additional related information and references to materials that are applicable to this provision.

• **2018/2015 IECC**—International Energy Conservation Code

Author(s): ICC
Organization(s): ICC
Publication Date: October 2017, May 2014

This code establishes a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water-heating systems in homes and commercial businesses.

• **2018/2015 IRC**—International Residential Code for One- and Two-Family Dwellings

Author(s): ICC
Organization(s): ICC
Publication Date: October 2017, May 2014

This code for residential buildings creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy, and electrical provisions for one- and two-family residences.


• Federal Standard for Residential Water Heaters.

Related BASC Guides:

• Building America Guide for Heat Pump Water Heaters

NEW Energy Conservation Standards for Residential Water Heaters:

Because electric-resistance water heaters convert electrical energy into heat, their maximum theoretical efficiency is 100% (corresponding to an energy factor (EF) of 1, or one unit of energy supplied to the water per unit of energy input to the water heater). [1] HPWHs can achieve EFs of greater than 1 because more than one unit of heat energy can be moved from the surrounding air to the water per unit of electrical energy used by the heat pump's compressor (ENERGY STAR certified HPWHs have rated EFs of 2.21-3.39). [2]

A new federal standard for the minimum allowable EFs for residential water heaters became effective on April 16, 2015. [3] All water heaters manufactured on or after the effective date must comply with the standard.

Water heaters manufactured prior to April 16, 2015, had to comply with the previous federal standard, which had been in effect since January 20, 2004. Under the previous standard, electric storage water heaters with a rated storage volume (RSV) [4] of 20-120 gallons were required to have a minimum EF of:

\[
EF = 0.97 - (0.00132 \times RSV).
\]

For a typical 50-gallon electric storage water heater, the minimum EF under the previous standard was 0.97 – (0.00132 × 50) = 0.904. For an 80-gallon electric storage water heater, the minimum EF was: 0.97 – (0.00132 × 80) = 0.864.

Under the new federal standard, electric storage water heaters with an RSV of 20-55 gallons must have a minimum EF of:

\[
EF = 0.960 - (0.0003 \times RSV).
\]

For a typical, 50-gallon water heater, the minimum EF is 0.960 – (0.0003 × 50) = 0.945. Electric storage water heaters with an RSV >55 gallons but ≤120 gallons must have a minimum EF of:

\[
EF = 2.057 - (0.00113 \times RSV).
\]
For an 80-gallon water heater, the minimum EF is: 2.057 – (0.00113 × 80) = 1.967.

The new federal standard effectively mandates the use of HPWHs for residential applications where electricity is the water-heating fuel and a storage volume >55 gallons is desired.

[1] In practice, there are losses associated with the energy conversion, so the EF of most electric resistance water heaters is approximately 0.9.


[4] The RSV is the water storage capacity of a water heater, in gallons, as certified by the manufacturer.
More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

   - **Author(s):** Colon, Martin
   - **Organization(s):** BA-PIRC
   - **Publication Date:** August, 2017
   
   The Florida Solar Energy Center (FSEC) has completed a fourth year-long evaluation on residential hot water heating systems in a laboratory environment (east central Florida, hot-humid climate). This report contains a summary of research activities regarding the evaluation of two residential electric heat pump water heaters (HPWHs), a solar...

2. **Technology Case Studies: Retrofit Integrated Space and Water Heating - Field Assessment**
   - **Author(s):** NSTAR
   - **Organization(s):** NSTAR
   - **Publication Date:** May, 2014
   
   Case study describing how combination (combi) space and water heating systems can be used in homes with efficient thermal enclosures, decreasing energy consumption and costs.

3. **Technology Solutions Case Study: Field Performance of Heat Pump Water Heaters in the Northeast, Massachusetts and Rhode Island**
   - **Author(s):** CARB
   - **Organization(s):** CARB
   - **Publication Date:** December, 2013

References and Resources*

1. **Field Performance of Heat Pump Water Heaters in the Northeast**
   - **Author(s):** Shapiro, Puttagunta
   - **Organization(s):** CARB, Steven Winter Associates, SWA
   - **Publication Date:** August, 2013
   
   Research study evaluating 14 heat pump water heaters, attempting to provide publically available field data on new HPWHs by monitoring the performance of three recently released products.

2. **Heat Pump Water Heaters 101**
   - **Author(s):** Steven Winter Associates
   - **Organization(s):** Steven Winter Associates, SWA
   - **Publication Date:** January, 2012
   
   Brochure providing consumer information about heat pump water heaters.

   - **Author(s):** Steven Winter Associates
   - **Organization(s):** Steven Winter Associates, SWA
   - **Publication Date:** June, 2012
   
   Guide providing detailed selection and installation instructions for heat pump water heaters.

4. **Measure Guideline: Heat Pump Water Heaters in New and Existing Homes**
   - **Author(s):** Shapiro, Puttagunta, Owens
   - **Organization(s):** CARB, National Renewable Energy Laboratory, Steven Winter Associates, SWA
   - **Publication Date:** February, 2012
   
   Document with evaluation of 14 heat pump water heaters (including three recently released HPWH products) installed in existing homes in the northeast region of the United States.

   - **Author(s):** NEEA
   - **Organization(s):** NEEA
   - **Publication Date:** May, 2014
   
   Website providing consumers with resources to find, select and install heat pump water heaters.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-
dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
The following authors and organizations contributed to the content in this Guide.

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