Wisconsin Contractors Institute

Continuing Education

<u>Waters Heaters Systems</u>

<u>(Course #13200) – 4 hours</u>

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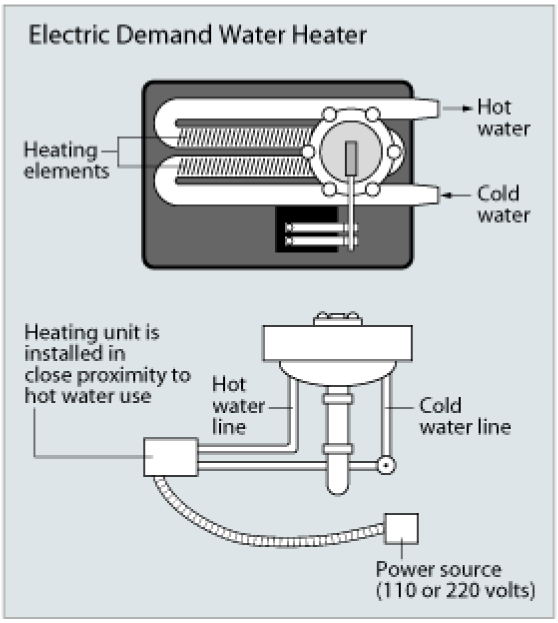
Demand (Tankless or Instantaneous) Water Heaters

Demand (tankless or instantaneous) water heaters provide hot water only as it is needed. They don't produce the standby energy losses associated with storage water heaters, which can save money. In the course you'll find basic information about how they work, whether a demand water heater might be right for your client's home, and what criteria to use when selecting the right model.



How They Work

Demand water heaters heat water directly without the use of a storage tank. Therefore, they avoid the standby heat losses associated with storage water heaters. When a hot water tap is turned on, cold water travels through a pipe into the unit. Either a gas burner or an electric element heats the water. As a result, demand water heaters deliver a constant supply of hot water. You don't need to wait for a storage tank to fill up with enough hot water. However, a demand water heater's output limits the flow rate.

Typically, demand water heaters provide hot water at a rate of 2–5 gallons (7.6–15.2 liters) per minute. Gas-fired demand water heaters produce higher flow rates than electric ones. Sometimes, however, even the largest, gas-fired model cannot supply enough hot water for simultaneous, multiple uses in large households. For example, taking a shower and running the dishwasher at the same time can stretch a demand water heater to its limit. To overcome this problem, you can install two or more demand water heaters, connected in parallel for simultaneous demands of hot water. You can also install separate demand water heaters for appliances—such as a clothes washer or dishwater—that use a lot of hot water in the home.

Other applications for demand water heaters include the following:

- Remote bathrooms or hot tubs
- Booster for appliances, such as dishwashers or clothes washers
- Booster for a solar water heating system.

Although gas-fired demand water heaters tend to have higher flow rates than electric ones, they can waste energy if they have a constantly burning pilot light. This can sometimes offset the elimination of standby energy losses when compared to a storage water heater. In a gas-fired storage water heater, the pilot light heats the water in the tank so the energy isn't wasted. The cost of operating a pilot light in a demand water heater varies from model to model. Ask the manufacturer how much gas the pilot light uses for the model you're considering. If you purchase a model that uses a standing pilot light, you can always turn it off when it's not in use to save energy. Also consider models that have an intermittent ignition device (IID) instead of a standing pilot light. This device resembles the spark ignition device on some gas kitchen ranges and ovens.

For homes that use 41 gallons or less of hot water daily, demand water heaters can be 24%–34% more energy efficient than conventional storage tank water heaters. They can be 8%–14% more energy efficient for homes that use a lot of hot water—around 86 gallons per day. You can achieve even greater energy savings of 27%–50% if you install a demand water heater at each hot water outlet.

Selecting a Demand Water Heater

Demand water heaters cost more than conventional storage water heaters. However, you may find that a demand water heater may have lower operating and energy costs, which could offset its higher purchase price.

Before buying or installing a demand water heater, you also need to consider the following:

- Size
- Fuel type and availability.
- Energy efficiency (energy factor)
- Estimate costs.

Installation and Maintenance

Proper installation and maintenance of a demand water heater can optimize its energy efficiency.

Proper installation depends on many factors. These factors include fuel type, climate, local building code requirements, and safety issues, especially concerning the combustion of gas-fired water heaters.

Most tankless water heaters have a life expectancy of more than 20 years. They also have easily replaceable parts that extend their life by many more years. In contrast, storage water heaters last 10–15 years. Periodic water heater maintenance can significantly extend the water heater's life and minimize loss of efficiency. Read the owner's manual for specific maintenance recommendations.

Sizing a Demand (Tankless or Instantaneous) Water Heater

Demand (tankless or instantaneous) water heaters are rated by the maximum temperature rise possible at a given flow rate. Therefore, to size a demand water heater, you need to determine the flow rate and the temperature rise you'll need for its application (whole house or a remote application, such as just a bathroom) in the home.

First, list the number of hot water devices you expect to use at any one time. Then, add up their flow rates (gallons per minute). This is the desired flow rate you'll want for the demand water heater. For example, let's say you expect to simultaneously run a hot water faucet with a flow rate of 0.75 gallons (2.84 liters) per minute and a shower head with a flow rate of 2.5 gallons (9.46 liters) per minute. The flow rate through the demand water heater would need to be at least 3.25 gallons (12.3 liters) per minute. To reduce flow rates, install low-flow water fixtures.

To determine temperature rise, subtract the incoming water temperature from the desired output temperature. Unless you know otherwise, assume that the incoming water temperature is 50ºF (10ºC). For most uses, you'll want your water heated to 120ºF (49ºC). In this example, you'd need a demand water heater that produces a temperature rise of 70ºF (39ºC) for most uses. For dishwashers without internal heaters and other such applications, you might want your water heated at 140ºF (60ºC). In that case, you'll need a temperature rise of 90ºF (50ºC).

Most demand water heaters are rated for a variety of inlet temperatures. Typically, a 70ºF (39ºC) water temperature rise is possible at a flow rate of 5 gallons per minute through gas-fired demand water heaters and 2 gallons per minute through electric ones. Faster flow rates or cooler inlet temperatures can sometimes reduce the water temperature at the most distant faucet. Some types of tankless water heaters are thermostatically controlled; they can vary their output temperature according to the water flow rate and inlet temperature.

EXAM QUESTIONS:

1.) **Demand water heaters heat water directly without the use of a storage tank.**
   a. True
   b. False

2.) **Typically, demand water heaters provide hot water at a rate of _____ gallons per minute.**
   a. 1 -3
   b. 2-5
   c. 4-7
   d. 6-10

3.) **Electric demand water heaters produce higher flow rates than gas-fired demand water heaters.**
   a. True
   b. False

4.) **Applications for demand waters heaters include the following:**
   a. Hot tubs
   b. Booster for appliances
   c. Remote bathrooms
   d. All of the above

5.) **For homes that use ____ gallons or less of hot water daily, demand water heaters can be 24%–34% more energy efficient than conventional storage tank water heaters.**
   a. 24
   b. 34
   c. 41
   d. 86

6.) **Demand water heaters cost more than conventional storage water heaters.**
   a. True
   b. False

7.) Before installing a demand water heater, the following needs to be considered.

a. Size
b. Fuel type
c. Energy efficiency
d. All of the above

8.) Most tankless water heaters have a life expectancy of more than ____ years.

a. 10
b. 20
c. 30
d. 40

9.) If you simultaneously run a hot water faucet with a flow rate of 0.50 gallons per minute and a shower head with a flow rate of 2.25 gallons per minute, what is the flow rate for a demand water heater?

a. 0.50
b. 2.25
c. 2.75
d. 3.25

10.) Assuming the incoming water temperature is 60ºF and you want the water heated to 140 ºF, what is the temperature rise needed for a demand water heater?

a. 60º
b. 70º
c. 80º
d. 90º

Solar Water Heaters

Solar water heaters—also called solar domestic hot water systems—can be a cost-effective way to generate hot water for the home. They can be used in any climate, and the fuel they use—sunshine—is free.

How They Work

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

- **Flat-plate collector**

  Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors—typically used for solar pool heating—have a dark absorber plate, made of metal or polymer, without a cover or enclosure.

- **Integral collector-storage systems**

  Also known as ICS or *batch* systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

- **Evacuated-tube solar collectors**

  They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. commercial applications.

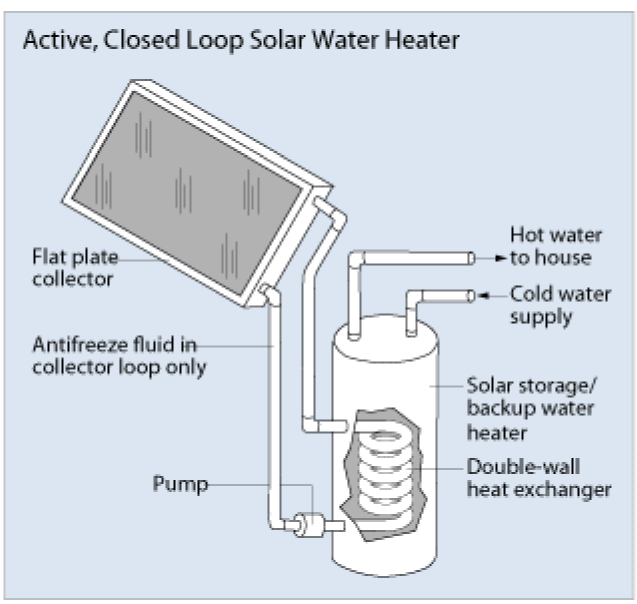
There are two types of active solar water heating systems:

- **Direct circulation systems**

  Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

- **Indirect circulation systems**

  Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.



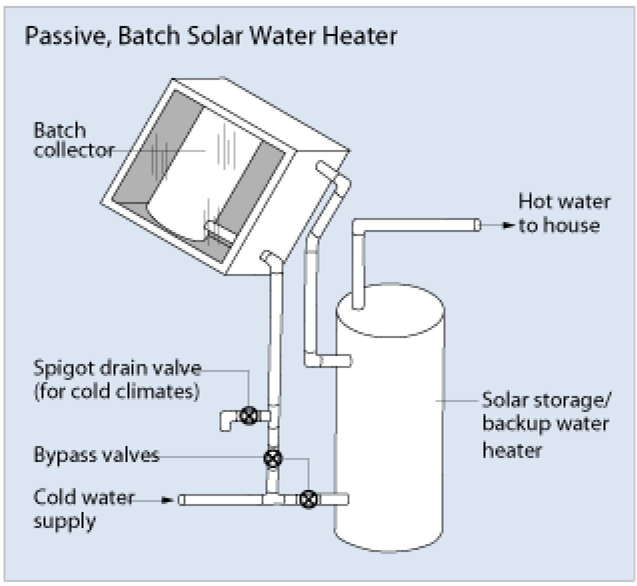
Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems:

- **Integral collector-storage passive systems**

  These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

- **Thermosyphon systems**

  Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.



Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a demand (tankless or instantaneous) water heater for backup.

Heat Exchangers for Solar Water Heating Systems

Solar water heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.

Heat exchangers can be made of steel, copper, bronze, stainless steel, aluminum, or cast iron. Solar heating systems usually use copper, because it is a good thermal conductor and has greater resistance to corrosion.

Types of Heat Exchangers

Solar water heating systems use two types of heat exchangers:

- **Liquid-to-liquid**

  This heat exchanger uses a heat-transfer fluid that circulates through the solar collector, absorbs heat, and then flows through a heat exchanger to transfer its heat to water in a storage tank. Heat-transfer fluids, such as antifreeze, protect the solar collector from freezing in cold weather. Liquid-to-liquid heat exchangers have either one or two barriers (single wall or double wall) between the heat-transfer fluid and the domestic water supply.

  A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water. Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol (antifreeze). Double walls are often required as a safety measure in case of leaks, helping ensure that the antifreeze does not mix with the potable water supply. An example of a double-wall, liquid-to-liquid heat exchanger is the "wrap-around heat exchanger," in which a tube is wrapped around and bonded to the outside of a hot water tank. The tube must be adequately insulated to reduce heat losses.

  While double-wall heat exchangers increase safety, they are less efficient because heat must transfer through two surfaces rather than one. To transfer the same amount of heat, a double-wall heat exchanger must be larger than a single-wall exchanger.

- **Air-to-liquid**

  Solar heating systems with air heater collectors usually do not need a heat exchanger between the solar collector and the air distribution system. Those systems with air heater collectors that heat water use air-to-liquid heat exchangers, which are similar to liquid-to-air heat exchangers.

EXAM QUESTIONS:

11.) Passive solar water heating systems have circulating pumps and controls.

a. True
b. False

12.) Which type of solar collector is typically used for solar pool heating?

a. Unglazed flat-plate collectors
b. ICS systems
c. Evacuated tube solar collectors
d. None of the above

13.) This type of solar collector is more frequently used for commercial applications.

a. Unglazed flat-plate collectors
b. ICS systems
c. Evacuated tube solar collectors
d. None of the above

14.) This type of solar collector should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

a. Unglazed flat-plate collectors
b. ICS systems
c. Evacuated tube solar collectors
d. None of the above

15.) Indirect circulation systems are popular in climates prone to freezing temperatures.

a. True
b. False

16.) Passive solar water heating systems are typically more expensive than active systems.

a. True
b. False

17.) Which of the following is a passive solar water heating system?

a. Direct circulation system
b. Indirect circulation system
c. Thermosyphon system
d. All of the above

18.) Solar water heating systems almost always require a backup system for cloudy days and times of increased demand.

a. True
b. False

19.) This heat exchanger uses a heat-transfer fluid that circulates through the solar collector, absorbs heat, and then flows through a heat exchanger to transfer its heat to water in a storage tank.

a. Liquid-to-liquid
b. Air-to-liquid
c. Coil-in tank
d. All of the above

Heat Exchanger Designs

There are many heat exchanger designs. Here are some common ones:

- **Coil-in-tank**

  The heat exchanger is a coil of tubing in the storage tank. It can be a single tube (single-wall heat exchanger) or the thickness of two tubes (double-wall heat exchanger). A less efficient alternative is to place the coil on the outside of the collector tank with a cover of insulation.

- **Shell-and-tube**

  The heat exchanger is separate from (external to) the storage tank. It has two separate fluid loops inside a case or shell. The fluids flow in opposite directions to each other through the heat exchanger, maximizing heat transfer. In one loop, the fluid to be heated (such as potable water) circulates through the inner tubes. In the second loop, the heat-transfer fluid flows between the shell and the tubes of water. The tubes and shell should be made of the same material. When the collector or heat-transfer fluid is toxic, double-wall tubes are used, and a non-toxic intermediary transfer fluid is placed between the outer and inner walls of the tubes.

- **Tube-in-tube**

  In this very efficient design, the tubes of water and the heat-transfer fluid are in direct thermal contact with each other. The water and the heat-transfer fluid flow in opposite directions to each other. This type of heat exchanger has two loops similar to those described in the shell-and-tube heat exchanger.

Sizing

A heat exchanger must be sized correctly to be effective. There are many factors to consider for proper sizing, including the following:

- Type of heat exchanger
- Characteristics of the heat-transfer fluid (specific heat, viscosity, and density)
- Flow rate
- Inlet and outlet temperatures for each fluid.

Usually, manufacturers will supply heat transfer ratings for their heat exchangers (in Btu/hour) for various fluid temperatures and flow rates. Also, the size of a heat exchanger's surface area affects its speed and efficiency: a large surface area transfers heat faster and more efficiently.

Installation

For the best performance, always follow the manufacturer's installation recommendations for the heat exchanger. Be sure to choose a heat-transfer fluid that is compatible with the type of heat exchanger you will be using. If you want to build your own heat exchanger, be aware that using different metals in heat exchanger construction may cause corrosion. Also, because dissimilar metals have different thermal expansion and contraction characteristics, leaks or cracks may develop. Either of these conditions may reduce the life span of the heat exchanger.

Heat-Transfer Fluids for Solar Water Heating Systems

Heat-transfer fluids carry heat through solar collectors and a heat exchanger to the heat storage tanks in solar water heating systems. When selecting a heat-transfer fluid, you should consider the following criteria:

- Coefficient of expansion – the fractional change in length (or sometimes in volume, when specified) of a material for a unit change in temperature
- Viscosity – resistance of a liquid to sheer forces (and hence to flow)
- Thermal capacity – the ability of matter to store heat
- Freezing point – the temperature below which a liquid turns into a solid
- Boiling point – the temperature at which a liquid boils

- Flash point – the lowest temperature at which the vapor above a liquid can be ignited in air.

For example, in a cold climate, solar water heating systems require fluids with low freezing points. Fluids exposed to high temperatures, as in a desert climate, should have a high boiling point. Viscosity and thermal capacity determine the amount of pumping energy required. A fluid with low viscosity and high specific heat is easier to pump, because it is less resistant to flow and transfers more heat. Other properties that help determine the effectiveness of a fluid is its corrosiveness and stability.

Types of Heat-Transfer Fluids

The following are some of the most commonly used heat-transfer fluids and their properties. Consult the local authority having jurisdiction to determine the requirements for heat transfer fluid in solar water heating systems in your area.

- **Air**

  Air will not freeze or boil, and is non-corrosive. However, it has a very low heat capacity, and tends to leak out of collectors, ducts, and dampers.

- **Water**

  Water is nontoxic and inexpensive. With a high specific heat, and a very low viscosity, it's easy to pump. Unfortunately, water has a relatively low boiling point and a high freezing point. It can also be corrosive if the pH (acidity/alkalinity level) is not maintained at a neutral level. Water with a high mineral content (i.e., "hard" water) can cause mineral deposits to form in collector tubing and system plumbing.

- **Glycol/water mixtures**

  Glycol/water mixtures have a 50/50 or 60/40 glycol-to-water ratio. Ethylene and propylene glycol are "antifreezes."

- **Hydrocarbon oils**

  Hydrocarbon oils have a higher viscosity and lower specific heat than water. They require more energy to pump. These oils are relatively inexpensive and have a low freezing point. The basic categories of hydrocarbon oils are synthetic hydrocarbons, paraffin hydrocarbons, and aromatic refined mineral oils. Synthetic hydrocarbons are relatively nontoxic and require little maintenance. Paraffin hydrocarbons have a wider temperature range between freezing and boiling points than water, but they are toxic and require a double-walled, closed-loop heat exchanger. Aromatic oils are the least viscous of the hydrocarbon oils.

- **Refrigerants/phase change fluids**

  These are commonly used as the heat transfer fluid in refrigerators, air conditioners, and heat pumps. They generally have a low boiling point and a high heat capacity. This enables a small amount of the refrigerant to transfer a large amount of heat very efficiently. Refrigerants respond quickly to solar heat, making them more effective on cloudy days than other transfer fluids. Heat absorption occurs when the refrigerant boils (changes phase from liquid to gas) in the solar collector. Release of the collected heat takes place when the now-gaseous refrigerant condenses to a liquid again in a heat exchanger or condenser.

For years chlorofluorocarbon (CFC) refrigerants, such as Freon, were the primary fluids used by refrigerator, air-conditioner, and heat pump manufacturers because they are nonflammable, low in toxicity, stable, noncorrosive, and do not freeze. However, due the negative effect that CFCs have on the earth's ozone layer, CFC production is being phased out, as is the production of hydro chlorofluorocarbons (HCFC). The few companies that produced refrigerant-charged solar systems have either stopped manufacturing the systems entirely, or are currently seeking alternative refrigerants. Some companies have investigated methyl alcohol as a replacement for refrigerants.

Since July 1, 1992, intentional venting of CFCs and HCFCs during service and maintenance or disposal of the equipment containing these compounds is illegal and punishable by stiff fines. Although production of CFCs ceased in the U.S. in 1996, a licensed refrigeration technician can still service your system. You may wish to contact your service professional to discuss the possible replacement of the CFC refrigerant with methyl alcohol or some other heat transfer fluid.

Ammonia can also be used as a refrigerant. It's commonly used in industrial applications. Due to safety considerations it's not used in residential systems. The refrigerants can be aqueous ammonia or a calcium chloride ammonia mixture.

- **Silicones**

  Silicones have a very low freezing point, and a very high boiling point. They are noncorrosive and long-lasting. Because silicones have a high viscosity and low heat capacities, they require more energy to pump. Silicones also leak easily, even through microscopic holes in a solar loop.

Solar Water Heating System Freeze Protection

Solar water heating systems, which use liquids as heat-transfer fluids, need protection from freezing in climates where temperatures fall below 42ºF (6ºC).

Don't rely on a collector's and the piping's (collector loop's) insulation to keep them from freezing. The main purpose of the insulation is to reduce heat loss and increase performance. For protecting the collector and piping from damage due to freezing temperatures, you basically have two options:

- Use an antifreeze solution as the heat-transfer fluid.
- Drain the collector(s) and piping (collector loop), either manually or automatically, when there's a chance the temperature might drop below the liquid's freezing point.

Using an Antifreeze Solution

Solar water heating systems that use an antifreeze solution (propylene glycol or ethylene glycol) as a heat-transfer fluid have effective freeze protection as long as the proper antifreeze concentration is maintained. Antifreeze fluids degrade over time and normally should be changed every 3–5 years. Since these systems are pressurized, it is not practical for the average homeowner to check the condition of the antifreeze solution.

Draining the Collector and Piping

Solar water heating systems that use only water as a heat-transfer fluid are the most vulnerable to freeze damage. "Draindown" or "drainback" systems typically use a controller to drain the collector loop automatically. Sensors on the collector and storage tank tell the controller when to shut off the circulation pump, to drain the collector loop, and when to start the pump again.

Improper placement or the use of low-quality sensors can lead to their failure to detect freezing conditions. The controller may not drain the system, and expensive freeze damage may occur. Make sure that the sensor(s) have been installed according to the manufacturer's recommendations, and check the controller at least once a year to be sure that it is operating correctly.

To ensure that the collector loop drains completely, there should also be a means to prevent a vacuum from forming inside the collector loop as the liquid drains out. Usually an air vent is installed at the highest point in the collector loop. It is a good practice to insulate air vents so that they do not freeze. Also make sure that nothing blocks the airflow into the system when the drain cycle is active.

Collectors and piping must slope properly to allow the water to drain completely. All collectors and piping should have a minimum slope of 0.25 inches per foot (2.1 centimeters per meter).

In integral collector storage or "batch" systems, the collector is also the storage tank. Placing large amounts of insulation around the unglazed parts of the collector and covering the glazing at night or on cloudy days will help to protect the collector from cold temperatures. However, water in the collector can freeze over extended periods of very cold weather. The collector supply and return pipes are also susceptible to freezing, especially if they run through an unheated space or outside. This can happen even when the pipes are well insulated. It is best to drain the entire system before freezing temperatures occur to avoid any possible freeze damage.

Selecting a Solar Water Heater

Before you purchase and install a solar water heating system, you want to do the following:

- Consider the economics of a solar water heating system
- Evaluate your site's solar resource
- Determine the correct system size
- Determine the system's energy efficiency
- Estimate and compare system costs
- Investigate local codes, covenants, and regulations.

Installing and Maintaining the System

The proper installation of solar water heaters depends on many factors. These factors include solar resource, climate, local building code requirements, and safety issues.

After installation, properly maintaining the system will keep it running smoothly. Passive systems don't require much maintenance. For active systems, discuss the maintenance requirements with the system provider, and consult the system's owner's manual. Plumbing and other conventional water heating components require the same maintenance as conventional systems. Glazing may need to be cleaned in dry climates where rainwater doesn't provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3–5 years. Systems with electrical components usually require a replacement part or two after 10 years.

Sizing a Solar Water Heating System

Sizing your solar water heating system basically involves determining the total collector area and the storage volume you'll need to meet 90%–100% of your household's hot water needs during the summer.

Collector Area

Contractors usually follow a guideline of around 20 square feet of collector area for each of the first two family members. For every additional person, add 8 square feet if you live in the U.S. Sun Belt area or 12–14 square feet if you live in the northern United States.

Storage Volume

A small (50- to 60-gallon) storage tank is usually sufficient for one to two three people. A medium (80-gallon) storage tank works well for three to four people. A large tank is appropriate for four to six people.

For active systems, the size of the solar storage tank increases with the size of the collector—typically 1.5 gallons per square foot of collector. This helps prevent the system from overheating when the demand for hot water is low. In very warm, sunny climates, some experts suggest that the ratio should be increased to as much as 2 gallons of storage to 1 square foot of collector area.

Other Calculations

Additional calculations involved in sizing your solar water heating system will include the following:

- Evaluation of your building site's solar resource
- Orientation and tilt of the solar collector.

EXAM QUESTIONS:

20.) In this heat exchanger design, the tubes of water and the heat-transfer fluid are in direct thermal contact with each other?

a. Coil-in-tank
b. Shell-and-tube
c. Tube-in-tube
d. None of the above

21.) This heat exchanger design is a coil of tubing in the storage tank.

a. Coil-in-tank
b. Shell-and-tube
c. Tube-in-tube
d. None of the above

22.) Which of the following factors must be considered when sizing a heat exchanger?

a. Type
b. Flow rate
c. Inlet and outlet temperatures for each fluid
d. All of the above

23.) The lowest temperature at which the vapor above a liquid can be ignited in air is called:

a. Freezing point
b. Flash point
c. Boiling point
d. Thermal capacity

24.) Heat-transfer fluids for solar water heating systems exposed to high temperatures, as in a desert climate, should have a high boiling point.

a. True
b. False

25.) Which of the following are types of heat-transfer fluids?

a. Air
b. Water
c. Silicones
d. All of the above

26.) Solar water heating systems, which use liquids as heat-transfer fluids, need protection from freezing in climates where temperatures fall below ____ºF.

a. 22
b. 32
c. 42
d. 52

27.) The main purpose of a collector's and the piping's (collector loop's) insulation is to keep them from freezing.

a. True
b. False

28.) Solar water heating systems that use only _______ as a heat-transfer fluid are the most vulnerable to freeze damage.

a. Water
b. Air
c. Silicones
d. Oils

29.) All collectors and piping for solar systems should have a minimum slope of ____ inches per foot.

a. 0.25
b. 0.50
c. 1.00
d. 1.25

30.) How much collector area is needed for a solar system assuming you live in Wisconsin and there are 4 family members?

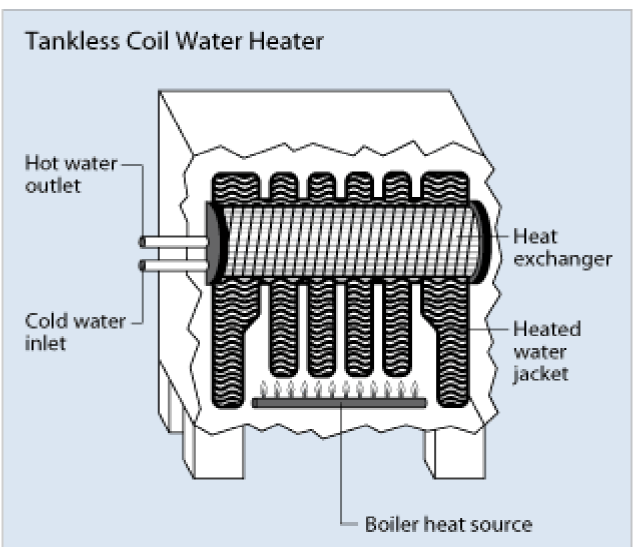
a. 20-20 square feet
b. 28-32 square feet
c. 48-52 square feet
d. 64-68 square feet

Tankless Coil and Indirect Water Heaters

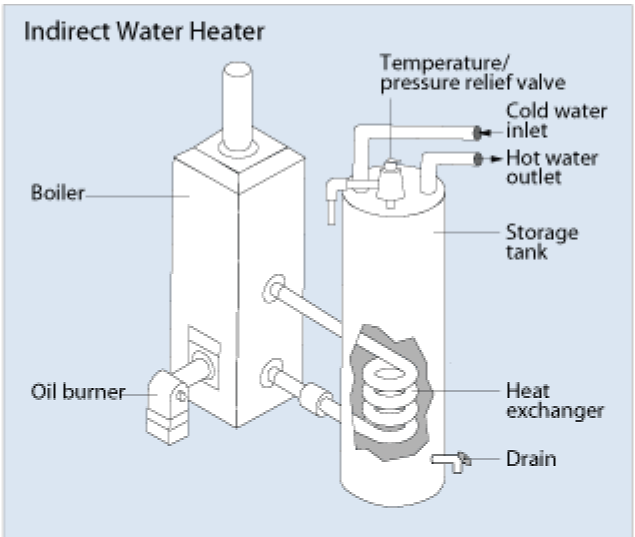
Tankless coil and indirect water heaters use a home's space heating system to heat water. They're part of what's called integrated or combination water and space heating systems.

How They Work

A tankless coil water heater uses a heating coil or heat exchanger installed in a main furnace or boiler. Whenever a hot water faucet is turned on, the water flows through the heat exchanger. These water heaters provide hot water on demand without a tank, like a demand water heater, but because they rely on the furnace or boiler to heat the water directly, tankless coil water heaters work most efficiently during cold months when the heating system is used regularly. That's why they can be an inefficient choice for many homes, especially for those in warmer climates.



Indirect water heaters offer a more efficient choice for most homes, even though they require a storage tank. An indirect water heater uses the main furnace or boiler to heat a fluid that's circulated through a heat exchanger in the storage tank. The energy stored by the water tank allows the furnace to turn off and on less often, which saves energy. Therefore, an indirect water heater is used with a high-efficiency boiler and well-insulated tank can be the least expensive means of providing hot water.



Indirect systems can be fired by gas, oil, propane, electric, solar energy, or a combination of any of these. Tankless systems are typically electric or gas-fired. Also, these integrated or combination water heating systems not only can work with forced air systems but also with hydronic or radiant floor heating systems.

Selecting a Combination Water and Space Heating System

Integrated or combination water and space heating systems usually cost more than a separate water heater and furnace or boiler, but installation and maintenance costs may be less. For example, you won't need multiple utility hook-ups since there's one source of heat. There also aren't as many moving parts to maintain or service. Some of these high efficiency systems may also provide you with lower utility costs.

Most combination water and space heating systems are usually designed for new construction. However, there are some retrofit units available that can work with an existing water heater.

When selecting a system, you need to consider its size. The sizing of a combination system involves some different calculations than those used for sizing a separate water heating or space heating system.

To determine the energy efficiency of a combination water and space heating system, use its combined appliance efficiency rating (CAE). The higher the number, the more energy efficient. Combination appliance efficiency ratings vary from 0.59 to 0.90.

EXAM QUESTIONS:

31.) Tankless coil water heaters work most efficiently during cold months when the heating system is used regularly.

a. True
b. False

32.) Indirect water heaters do not require a storage tank.

a. True
b. False

33.) Indirect systems can be fired by which of the following:

a. Oil
b. Propane
c. Electric or gas
d. All of the above

34.) Integrated or combination water and space heating systems usually cost more than a separate water heater and furnace or boiler.

a. True
b. False

Heat Pump Water Heaters

Most homeowners who have heat pumps use them to heat and cool their homes. But a heat pump also can be used to heat water—either as stand-alone water heating system, or as combination water heating and space conditioning system.

How They Work

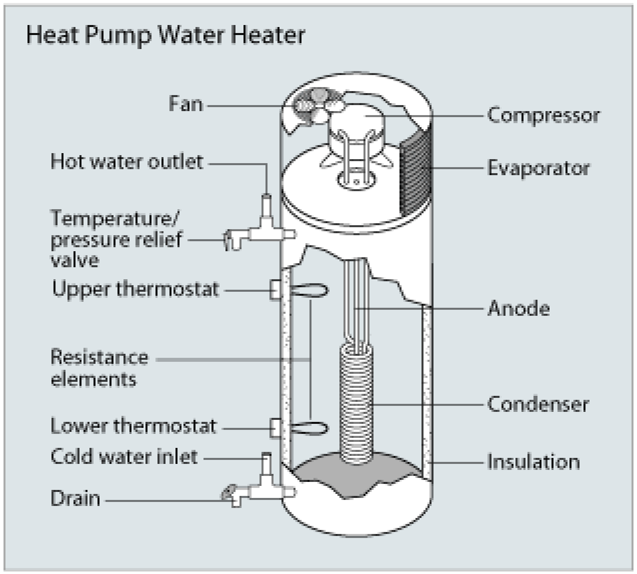
Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. Therefore, they can be two to three times more energy efficient than conventional electric resistance water heaters. To move the heat, heat pumps work like a refrigerator in reverse.

While a refrigerator pulls heat from inside a box and dumps it into the surrounding room, a stand-alone *air-source heat pump* water heater pulls heat from the surrounding air and dumps it—at a higher temperature—into a tank to heat water. You can purchase a stand-alone heat pump water heating system as an integrated unit with a built-in water storage tank and back-up resistance heating elements. You can also retrofit a heat pump to work with an existing conventional storage water heater.

Heat pump water heaters require installation in locations that remain in the 40º–90ºF (4.4º–32.2ºC) range year-round and provide at least 1,000 cubic feet (28.3 cubic meters) of air space around the water heater. Cool exhaust air can be exhausted to the room or outdoors. Install them in a space with excess heat, such as a furnace room. Heat pump water heaters will not operate efficiently in a cold space. They tend to cool the spaces they are in. You can also install an air-source heat pump system that combines heating, cooling, and water heating. These combination systems pull their heat indoors from the outdoor air in the winter and from the indoor air in the summer. Because they remove heat from the air, any type of air-source heat pump system works more efficiently in a warm climate.

Homeowners primarily install geothermal heat pumps—which draw heat from the ground during the winter and from the indoor air during the summer—for heating and cooling their homes. For water heating, you can add a *desuperheater* to a geothermal heat pump system. A desuperheater is a small, auxiliary heat exchanger that uses superheated gases from the heat pump's compressor to heat water. This hot water then circulates through a pipe to the home's storage water heater tank.

Desuperheaters are also available for demand (tankless or instantaneous) water heaters. In the summer, the desuperheater uses the excess heat that would otherwise be expelled to the ground. Therefore, when the geothermal heat pump runs frequently during the summer, it can heat all of your water. During the fall, winter, and spring—when the desuperheater isn't producing as much excess heat—you'll need to rely more on your storage or demand water heater to heat the water. Some manufacturers also offer triple-function geothermal heat pump systems, which provide heating, cooling, and hot water. They use a separate heat exchanger to meet all of a household's hot water needs.



Selecting a Heat Pump Water Heater

Heat pump water heater systems typically have higher initial costs than conventional storage water heaters. However, they have lower operating costs, which can offset their higher purchase and installation prices.

Before buying or installing a heat pump water heating system, you also need to consider the following:

- Size and first hour rating
- Fuel type and availability
- Energy efficiency (energy factor)
- Overall costs.

<u>EXAM QUESTIONS:</u>

35.) Heat pump water heaters use ______ to move heat from one place to another instead of generating heat directly.

a. Water
b. Heat
c. Electricity
d. Gas

36.) Wisconsin has an ideal climate to install a heat pump water heater.

a. True
b. False

37.) Before installing a heat pump water system, you need to consider the following:

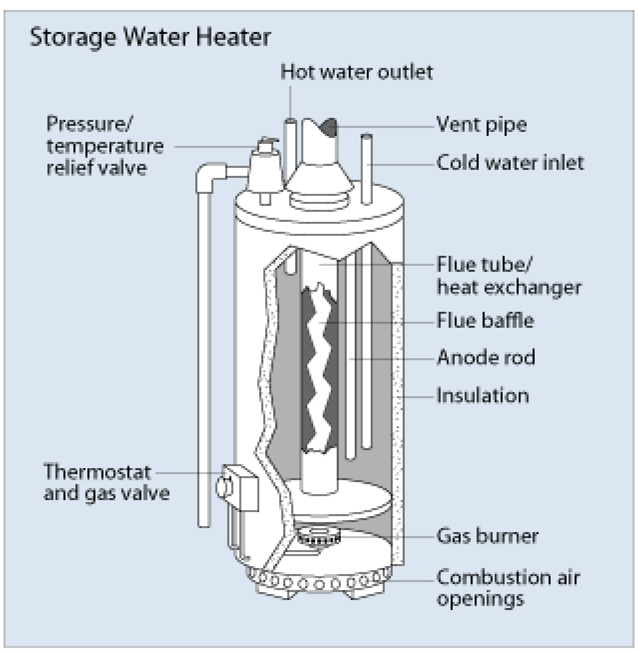
a. Size and first hour rating
b. Fuel type
c. Energy efficiency
d. All of the above

Conventional Storage Water Heaters

Conventional storage water heaters remain the most popular type of water heating system for the home. Here you'll find basic information about how storage water heaters work; what criteria to use when selecting the right model; and some installation, maintenance, and safety tips.

How They Work

A single-family storage water heater offers a ready reservoir—from 20 to 80 gallons—of hot water. It operates by releasing hot water from the top of the tank when you turn on the hot water tap. To replace that hot water, cold water enters the bottom of the tank, ensuring that the tank is always full.



Conventional storage water heater fuel sources include natural gas, propane, fuel oil, and electricity. Natural gas and propane water heaters basically operate the same. A gas burner under the tank heats the water. A thermostat opens the gas valve as the water temperature falls. The valve closes when the temperature rises to the thermostat's setpoint. Oil-fired water heaters operate similarly, but they have power burners that mix oil and air in a vaporizing mist, ignited by an electric spark. Electric water heaters have one or two electric elements, each with its own thermostat. With two electric elements, a standby element at the bottom of the tank maintains the minimum thermostat setting while the upper demand element provides hot water recovery when demand heightens.

Because water is constantly heated in the tank, energy can be wasted even when a hot water tap isn't running. This is called *standby heat loss*. Only tankless water heaters—such as demand water heaters and tankless coil water heaters—avoid standby heat losses. However, you can find some storage water heater models with heavily insulated tanks, which significantly reduce standby heat losses, lowering annual operating costs. Look for models with tanks that have a thermal resistance (R-Value) of R-12 to R-25.

Gas and oil water heaters also have venting-related energy losses. Two types of water heaters—a fan-assisted gas water heater and an atmospheric sealed-combustion water heater—reduce these losses. The fan-assisted gas water heater uses a draft-induced fan that regulates the air that passes through the burner, which minimizes the amount of excess air during combustion, increasing efficiency. The atmospheric sealed-combustion water heater uses a combustion and venting system that is totally sealed from the house.

You might also want to consider some less conventional storage water heaters—heat pump water heaters and solar water heaters. These water heaters are usually more expensive but they typically have lower annual operating costs.

Selecting a Storage Water Heater

The lowest-priced storage water heater may be the most expensive to operate and maintain over its lifetime. While an oversized unit may be alluring, it carries a higher purchase price and increased energy costs due to higher standby energy losses.

Installation and Maintenance

Proper installation and maintenance of your water heater can optimize its energy efficiency.

Proper installation depends on many factors. These factors include fuel type, climate, local building code requirements, and safety issues, especially concerning the combustion of gas- and oil-fired water heaters.

Periodic water heater maintenance can significantly extend your water heater's life and minimize loss of efficiency. Read your owner's manual for specific maintenance recommendations.

Routine maintenance for storage water heaters, depending on what type/model, may include:

- Flushing a quart of water from the storage tank every three months
- Checking the temperature and pressure valve every six months
- Inspecting the anode rod every three to four years.

Sizing Storage and Heat Pump (with Tank) Water Heaters

To properly size a storage water heater for a home, use the water heater's first hour rating (FHR). The first hour rating is the amount of hot water in gallons the heater can supply per hour (starting with a tank full of hot water). It depends on the tank capacity, source of heat (burner or element), and the size of the burner or element.

The Energy Guide Label lists the first hour rating in the top left corner as "Capacity (first hour rating)." The Federal Trade Commission requires an Energy Guide Label on all new conventional storage water heaters but not on heat pump water heaters. Product literature from a manufacturer may also provide the first hour rating. Look for water heater models with a first hour rating that matches within 1 or 2 gallons of the peak hour demand—the daily peak 1-hour hot water demand for your home.

Do the following to estimate the peak hour demand:

- Determine what time of day (morning, noon, evening) the most hot water is used in the home. Keep in mind the number of people living in the home.
- Use the worksheet below to estimate your maximum usage of hot water during this one hour of the day—this is your peak hour demand. Note: the worksheet does not estimate total daily hot water usage.

The worksheet example shows a total peak hour demand of 46 gallons. Therefore, this household would need a water heater model with a first hour rating of 44 to 48 gallons.

Worksheet for Estimating Peak Hour Demand/First Hour Rating

Use	Average gallons of hot water per usage		Times used during 1 hour		Gallons used in 1 hour
Shower	12	×		=	
Bath	9	×		=	
Shaving	2	×		=	
Hands & face washing	4	×		=	
Hair shampoo	4	×		=	
Hand dishwashing	4	×		=	
Automatic dishwasher	14	×		=	
Food preparation	5	×		=	
Wringer clothes washer	26	×		=	
Automatic clothes washer	32	×		=	
			Total Peak Hour Demand	=	

EXAMPLE

3 showers	12 × 3	= 36
1 shave	2 × 1	= 2
1 shampoo	4 × 1	= 4
1 hand dishwashing	4 × 1	= 4
Peak Hour Demand		= 46

EXAM QUESTIONS:

38.) The first hour rating is the amount of hot water in gallons the heater can supply per hour (starting with a tank full of hot water).

a. True
b. False

39.) What is the Peak Hour Demand for a household that takes 3 showers, 1 shave, 2 hands & face washing, and 1 food preparation during the daily peak 1-hour?

a. 47
b. 51
c. 54
d. 58

40.) What is the Peak Hour Demand for a household that takes 2 showers, 1 shave, 1 shampoo and 1 hand dishwashing during the daily peak 1-hour?

a. 34
b. 40
c. 46
d. 54