WASHINGTON STATE UNIVERSITY
EXTENSION ENERGY PROGRAM

Energy Efficiency
FACTSHEET

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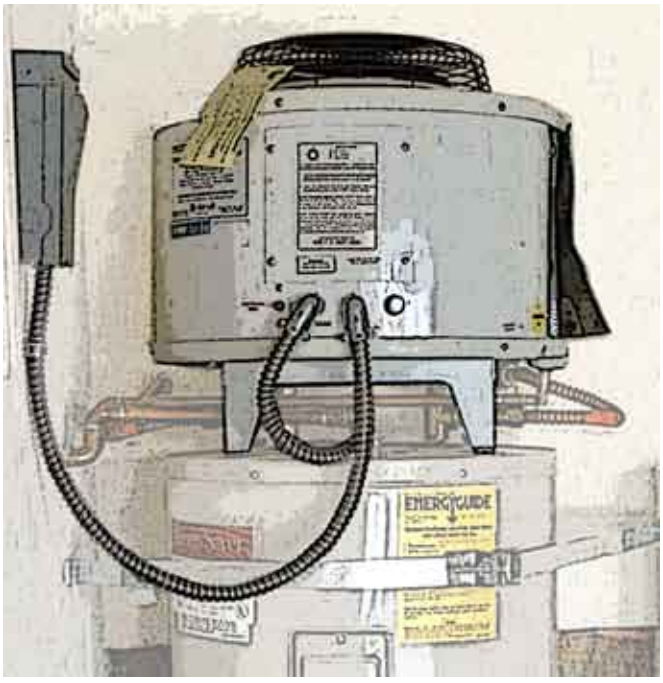
Residential Heat Pump Water Heaters

Description

Heat pumps are a well-established technology for space heating. The same principle of transferring heat is at work in heat pump water heaters (HPWHs) except that the heat they extract from air (indoor, exhaust or outdoor air) is delivered to water. Some models come as a complete package including tank and back-up resistance heating elements while others work as an adjunct to a conventional water heater. A HPWH uses about half as much electricity as a conventional electric resistance water heater.

The simplest HPWH is the ambient air-source unit, which removes heat from surrounding air, providing the additional benefit of space cooling. Exhaust air units extract heat from a continuously exhausted air stream and work better in heating dominated climates because they do not cool ambient air. Some units can even be converted between the two modes of operation for optimum operation in either summer or winter. In mild climates you can locate units in unheated but protected spaces such as garages, essentially using outdoor air as a heat source.



A storage water heater can be converted to a HPWH with an add-on unit, either wall-mounted or sitting on top of the existing tank.

Types of Heat Pump Water Heaters

- **Add-on Heat Pump Water Heaters:** An add-on heat pump water heater is installed in conjunction with an existing storage water heater (either wall-mounted or on top of the existing tank) and may be a good option as a retrofit. It converts the conventional water heater into a heat pump water heater by replacing the function of the tank's lower element. The add-on unit is intended to provide most or all of the water heating needs, while the standard water heater provides storage and can also serve as a back-up heater to provide additional capacity as needed during periods of high usage. When the tank needs to be heated, a small pump circulates water through piping installed between the existing storage water heater and the heat pump water heater.

- **Drop-In Heat Pump Water Heaters:** In a "drop-in" or "integral" heat pump water heater, the heat pump portion is integral to the tank, which has the same footprint and connections as a conventional water heater. Installation procedures are essentially the same as for a conventional water heater, except for the requirement to

provide for drainage of condensate.

- **Desuperheaters:** Heat pump water heating is also available as the desuperheater feature on some central air conditioners and heat pumps. A desuperheater is a small, auxiliary heat exchanger that uses superheated gases from the central air conditioner's compressor to heat water, providing economical supplemental water heating as a byproduct of air conditioning. In most such systems, the heat pump water heating only occurs during normal demand for space conditioning, with resistance electric coils providing water heating the rest of the time. During the cooling season, the desuperheater actually improves the efficiency of the air conditioning system while heating water at no direct cost. In an average climate, a desuperheater might meet 20% to 40% of annual water heating demand. As a caution to avoid confusion, the term "add-on heat pump water heater" may also be used to describe these desuperheater water heaters.

Applications

Properly applied, HPWHs save energy in almost every situation. Initial investment is recouped fastest if electric rates and hot water usage are high and there is a steady need for the cool air generated as a by-product. HPWHs have difficulty being cost effective when low-cost natural gas is available. Best energy savings are accomplished when temperatures are mild or warm. Because HPWH efficiency and capacity drop as temperature drops, avoid applications where the ambient air is cold.

HPWHs should be considered for the following situations:

- Buildings with large, steady requirements for hot water, such as residences occupied by larger families (4 or more persons)
- Buildings with a fairly steady need for air conditioning most of the year, such as in warm climates
- Where electric resistance water heaters are presently used
- Where electricity rates are high and other alternatives (natural gas, propane, or oil) are expensive or not available
- In mild/cool climates when heat pumps are used for space conditioning
- In mild/cool climates where there is a need for continual mechanical ventilation, such as for humidity/moisture control
- In mild/cool climates where the water heater can extract heat from a large, unconditioned basement or crawl space

Cautions:

- HPWHs should not be installed in unventilated closets or small rooms inside a residence unless a ducted air supply can be provided.
- Exhaust air design HPWHs should not be used near open-flame devices (gas stoves, fireplaces) unless those devices have dedicated makeup air supply.
- HPWHs are not recommended for installation in outside or unconditioned spaces where the potential for freezing conditions exists.

Performance/Costs

Two terms are used to describe the performance of HPWHs:

- The heating coefficient of performance (COP), which is the ratio of heat energy of the HPWH to the electrical energy input when both are in consistent units.

- The Energy Factor (EF), which is the ratio of heat output to energy input as measured during a specific 24-hour test procedure. A conventional electric resistance water heater EF would ideally be 1, but is slightly lower because of tank standby losses (heat loss through piping and tank walls). Testing procedure and calculations to determine EF are the same for all heater manufacturers.

HPWH performance varies, but in typical usage, HPWHs tend to operate with an EF around 2 to 2.5. This means that they heat over twice as much hot water as you would get from an electric resistance water heater with the same electrical energy input. EFs that are "GAMA Efficiency Rating Certified" (*http://ari.org/Content/GAMAIBRCertification_581.aspx*) are useful in comparing different models.

There are new Energy Star criteria for heat pump water heaters that become effective January 1, 2009. Residential drop-in heat pump water heaters require a minimum EF of 2.0 and a minimum First-Hour Rating of 50 gallons-per-hour. Add-on heat pump water heaters will not qualify.

Residential exhaust air heat pumps vary widely in capacity from about 9,000 Btu/hr to 90,000 Btu/hr and tanks range in size from 80 to 120 gallons. Contribution to air-conditioning equals about 2/3 the Btu/hr of the water heating capacity when operating as an ambient air-source unit. Ambient air-source units start about $400 for retrofits to existing water heaters, and exhaust air units cost $1,400 or more. Paybacks are reported to range from 3 to 20 years, but are quickest in applications where cooling air can be used year-round.

Example: Water heating in a residence varies with family size, but a family of four may use an average of 60 gallons per day. This would require 12 kWh per day of electric resistance (EF of 0.86) water heating (from 55°F to 120°F). An exhaust air heat pump water heater rated with an EF of 2.5 would provide the same amount of hot water for 4.8 kWh/day – a savings of 2,628 kWh/year.

Assuming an electricity cost of $0.10/kWh, savings in annual hot water heating would be $262. Assuming an installed cost for an exhaust air heat pump water heater to be $1,500, the simple payback would be $1500/$262 or 5.7 years.

If you are replacing a failed water heater, assuming a cost premium of $1,200 for installing an exhaust air HPWH rather than a conventional electric water heater, the simple payback would be 4.6 years.

There are minor routine maintenance requirements with HPWHs, mainly filter changing. The technology is considerably more complex than a conventional water heater, so when repairs are necessary, they can be more costly.

Availability

Residential heat pump water heaters are available from several U.S. manufacturers, including Applied Energy Recovery Systems, Aqua Products, Beyond Pollution, Nyle International, Parker Davis, and Trevor-Martin. Japanese manufacturers of heat pump water heaters include Mitsubishi, Hitachi, Sanyo Electric, Daikin, Matsushita, Corona and Toshiba. For more information, refer to the manufacturers' websites and to the following webpage: *www.aceee.org/consumerguide/waterheating.htm#heatpump*.

For Additional Information

Gas Appliance Manufacturers Association (GAMA) Efficiency Rating Certified
The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certifies EFs of heat pump water heaters
http://ari.org/Content/GAMAIBRCertification_581.aspx

Heat Pump Water Heaters
A current list of manufacturers. From *Consumer Guide to Home Energy Savings: Condensed Online Version*, American Council for an Energy-Efficient Economy
www.aceee.org/consumerguide/waterheating.htm#heatpump

Residential Heat Pump Water Heaters
A Federal Technology Alert
www.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf

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