COOPERATIVE EXTENSION
WASHINGTON STATE UNIVERSITY
ENERGY PROGRAM

Energy Efficiency FACTSHEET

Heat Pump Water Heaters—Residential

Description: Heat pumps are a well-established technology for space heating. The same principal of transferring heat is at work in heat pump water heaters (HPWHs) except that they extract heat from air (indoor, exhaust or outdoor air) and deliver it 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. Because it extracts heat from air, the HPWH delivers about twice the heat for the same electricity cost 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 variation of the stand-alone heat pump water heater is the de-superheater feature available on some central air conditioners. It provides economical supplemental water heating as a byproduct of air conditioning. De-superheater water heating can be part of an integrated package with a heat pump or air conditioner system. 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 de-superheater actually improves the efficiency of the air conditioning system while heating water at no direct cost. In an average climate, a de-superheater might meet 20% to 40% of annual water heating demand.

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 byproduct. 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
- Where there is adequate space for a larger storage tank
- 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) and the Energy Factor (EF). COP is the ratio of heat energy of the HPWH to the electrical energy input when both are in consistent units. There is no standard rating condition for COP testing for HPWHs, so manufacturers' claims are not comparable.

The EF 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.

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 $700 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 $0.07/kWh, savings in annual hot water heating would be $184. Assuming an installed cost for an exhaust air heat pump water heater to be $1,500, the simple payback would be $1500/$184 or 8.2 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 6.5 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 currently available from several manufacturers. In recent years the market has stagnated somewhat because of competition with gas water heaters enjoying favorable gas prices and the failure of electric rates to rise as fast as projected in many areas. Meanwhile, the addition of de-superheaters to air conditioning equipment has grown more popular.

For Additional Information:

Residential Heat Pump Water Heaters

A Federal Technology Alert

http://www.pnl.gov/fta/3_res.htm

The Drop-In Residential Heat Pump Water Heater

Oak Ridge Laboratory is developing this new HPWH aimed at the electric water heater replacement market.

http://www.ornl.gov/ORNL/BTC/hotwater.html

Heat Pump Water Heaters

This website of the Greenhouse Gas Technology Information Exchange contains a technology summary and literature abstracts.

http://www.greentie.org/HPWH.htm

The E-Tech Residential Heat Pump Water Heater Worth a Closer Look

An abstract regarding this E Source publication

http://www.esource.com/publicdomain/Abstract/PP964.html

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