

NAECA Water Heaters

	Tank (Storage) <4000 Btu/hr/gal	Tankless (Instantaneous) < 2 gallons
Natural Gas	≤ 75,000 Btu	≤ 200,000 Btu
Oil	≤ 105,000 Btu	≤ 210,000 Btu
Electric		
<ul style="list-style-type: none"> ➤ Resistance ➤ Heat Pump 	≤ 12 kW ≤ 24 amps	≤ 12 kW NA
Measure of Efficiency	Energy Factor (EF)	

Energy Factor

- A test dictated by the U.S. Department of Energy which simulates residential usage.
- Incorporates both thermal (combustion) efficiency and stand-by loss
- Assuming 64.3 gallons per day, EF is determined by drawing 10.7 gallons at the rate of 3 gpm once each hour for six hours and then an 18 hour stand-by period.
- Test is very difficult to conduct accurately since so many variables must be accurately measured.
- **Energy Factor is the only legal way to describe the efficiency of a NAECA heater.**

Range of Energy Factors

Volume (gallons)	Minimum EF	Maximum EF available
Natural Gas Storage Water Heater		
30	0.61	0.64
40	0.59	0.65
50	0.58	0.65
75	0.53	0.59
Electric Storage Water Heater		
40	0.92	0.95
50	0.90	0.95
66	0.88	0.95
80	0.86	0.95

How do we use hot water?

- Frequent short, low flow-rate draws
- Occasional long draws at low flow-rates
- High flow-rate and high volume draws are rare!

Any correlation between how we really use hot water and how we test water heaters is purely coincidental!

EPA Act Heaters

	Tank (Storage)	Tankless (Instantaneous) < 2 gallons
Natural Gas	> 75,000 Btu	> 200,000 Btu
Oil	> 105,000 Btu	> 210,000 Btu
Electric	> 12 kW	> 12 kW
Measure of Efficiency	Thermal Efficiency (TE) and standby loss	

EPAct Heaters

	Tank (Storage)	Tankless (Instantaneous) < 2 gallons
Natural Gas	> 75,000 Btu	> 200,000 Btu
Oil	> 105,000 Btu	> 210,000 Btu
Electric	> 12 kW	> 12 kW
Measure of Efficiency	Thermal Efficiency (TE) and standby loss	

News Flash!

- Recent Congressional action has started the move to eliminate the confusion.
- In the next 18-24 months a single efficiency measure will be used on all water heaters (both NAECA & EPAAct).
- The specific measure to be used has not been determined but it is unlikely to be Energy Factor.

Gas Storage (Tank) Water Heaters

Principle of Operation

- Gas burner fires when thermostat indicates tank temperature is below set-point
- Burner does not usually fire when small draws are made
- Burner only fires about 3 times a day in stand-by
- Pilot light provides a fair amount of heat
- Heat transfer is through both the flue and the bottom head, proportional to surface area.
- Anode provides critical protection for the steel tank.



Gas Storage Water Heaters

Amount of hot water available:

- Depends primarily on tank size
- Somewhat dependent on:
 - Flow rate
 - Length of dip tube
 - Inlet cold water temperature
- Is roughly 65% to 75% of tank volume

As tank is depleted:

- Hot water will abruptly become cold

Can keep up with a flow rate of roughly 1 gpm
(70° temperature change)

- 40,000 Btu burner

Recovery is generally slow

- Depends on burner size and on inlet water temperature

Gas Storage Water Heaters

Running Out of Hot Water

- Common complaint
- Simple Solutions
 - Raise the temperature of the tank
 - Change use pattern
 - Switch to lower flow rate fittings
 - Add insulation to the hot water pipes
 - Increase dip tube length
- Next time...
 - Bigger tank
 - Select a unit with a larger burner
 - Use drain heat recovery

Low Flow Rate Draws

- Want just a trickle? You can get it.

High Volume Draws

- Limited by tank volume and burner capacity

Gas Storage Water Heaters

Installation in New Construction

Well-Known and Relatively inexpensive

- Standard make up air
- Standard venting
- Small diameter gas line (1/2 inch up to 80,000 Btu)
- Earthquake strapping in some locations

Depending on the floor plan it is sometimes difficult to find space, but may be possible to select location for heater to minimize costs and improve performance.

Do not need a 110 VAC outlet near the heater unless it is a power vented unit with a fan.

Space can be an issue

- Basement, Garage, Attic, External Closet

Power Vented Water Heaters



- A fan sucks the combustion products thru the water heater flue and pushes them outside.
- Fan assist can make the unit more energy efficient than an atmospheric water heater. EF's are typically in the 0.65 to 0.70 range.
- Most Energy Star gas storage water heaters are power vented units.
- PVC venting

Power Direct Vented Water Heaters



- Similar to power vented water heaters except they draw their combustion air from the outside.
- These two pipe systems eliminate many home ventilation issues
- Some of these models are Energy Star rated.
- Many EPAC heaters are power direct vented units
- PVC venting

Condensing Residential Water Heaters

- When a water heater heat exchanger is very efficient:
 - The temperature of the exhaust gases is very low (<150 °F)
 - The water vapor in the combustion products condenses into water
 - This slightly acidic water is known as the condensate.

Condensing Residential Water Heaters

- The term “condensing” implies high efficiency.
- Thermal efficiency required for condensing is about 84% but it depends on a lot of variables.
- Once you have dealt with the issues associated with condensing, additional efficiency is not very expensive.
- Hence, most condensing water heaters are >90% thermal efficient and many are more like 96-98%.
- Condensing commercial water heaters have been available for more than a decade.

Condensing Residential Water Heaters

- Challenges in designing condensing water heaters:
 - Need more heat exchanger surface
 - Need to protect heat exchanger surface from the condensate
 - Need to provide a condensate drain
 - Condensate means PVC venting is required
 - More heat exchanger means a powered combustion system

Condensing Residential Water Heaters

➤ When?

- Several super-premium (EPAct) products on the market today
 - American's Polaris
 - AOSmith's Vertex
 - Grand Hall's Eternal
- With Energy Star and pressure from energy efficiency advocates, more will appear in the near future.
- Initial introduction will be on premium or super-premium models
- **Ultimately, all residential gas water heaters will be condensing.**

Condensing Residential Water Heaters

- Heater exchanger is a coil
- Glass inside the coil is different from glass on the water side
- Note condensate drain
- Vertex has same foot print as standard. 50 gal heater
- B-W uses a three pass flue design to achieve 99.1%



Condensing Residential Water Heaters

- Impact on plumbers, contractors and homeowners:
 - Power, condensate drain and PVC venting required
 - More sophisticated controls
 - Noise considerations
 - Increased costs
 - Installation will no longer be a direct replacement

Electric Storage (Tank) Water Heaters

Principle of Operation

- Tank is heated with electric resistance elements.
- If the tank is sized correctly, usually only the bottom element fires but top element will come on if tank is depleted of hot water. Interlocked so that only one comes on at a time.
- Elements only fire when thermostat senses low tank temperature.
- Elements may fire only once a day during standby.
- Elements do not fire for small draws.
- Anode protection is critical to long tank life with steel tanks.



Electric Storage Water Heaters

Amount of hot water available:

- Depends primarily on tank size
- Somewhat dependent on:
 - Flow rate
 - Length of dip tube
 - Inlet cold water temperature
- Is roughly 65% to 75% of tank volume

As tank is depleted:

- Hot water will abruptly become cold

Can keep up with a flow rate of roughly 1/3 gpm

- Upper and Lower 4,500 watt elements

Recovery is generally slow

- Depends on element capacity and on inlet water temperature

Heat Pump Water Heaters

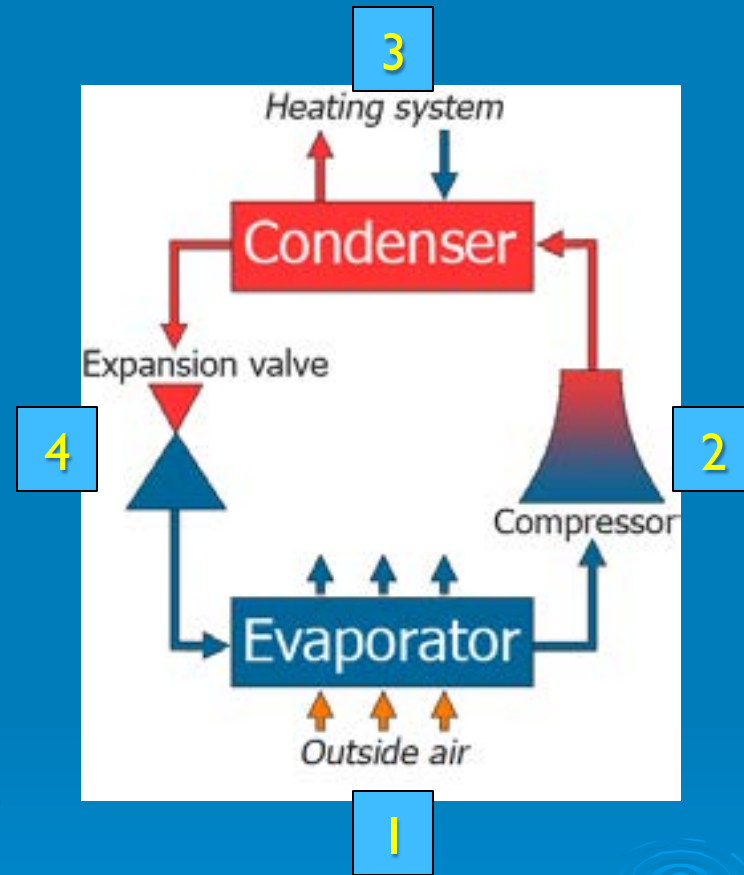
- HPWH primarily seen as a more efficient replacement for electric resistance water heaters
 - Energy Star requires $EF = 2.0$ min.
 - Japanese and European HPWH have demonstrated EF 's as high as 6.0
- HPWH may be competitive with propane water heaters depending on fuel costs.

Heat Pump Water Heaters

- Use the refrigeration cycle to extract heat from the ambient air and use it to heat water.
- Heat pumps use energy to move heat rather than to generate heat.
- Heat pumps are a mature technology which has not been widely applied to water heaters in North America.
- Significant market penetration in Japan and Europe.

HPWH Operation

1. A fan forces air through the evaporator (1). The liquid refrigerant evaporates and absorbs air heat from the ambient air.
2. The warm gaseous refrigerant is compressed (2) and the refrigerant becomes a hot liquid.
3. The refrigerant then passes through the condenser (3) and loses its heat to the water.
4. The cooler refrigerant goes through an expansion valve (4) where it returns to the gaseous state and the cycle starts over.



Potential HPWH Issues

- Reliability
- Slow Recovery
- Installation Limitations
 - Adequate airflow is very important
 - All HPWH have filters which need cleaning
- Condensate drain needed
- Noise
- Cost – Value Proposition

GE GeoSpring™ Hybrid Electric Water Heater



- Based on a design developed at Oak Ridge National Labs
- To be assembled in the U.S.
- 50 gallon tank, 190 lbs.,
- EF = 2.35, FHR = 63 gallons
- Two 4,500 Watt elements, non-replaceable sacrificial anode
- MSRP = \$1699
- Assuming an installation cost of \$500 and annual savings of \$320, the payback is 6.9 years compared to standard electric resistance water heater.
 - With Federal tax credit, payback is 4.8 yrs.

Rheem Heat Pump Water Heater



- Uniquely pumps water to the heat pump components
- 50 gallon tank (new 40 gallon model)
- EF = 2.0, FHR = 67 gallons
- Non-replaceable sacrificial anode
- MSRP = \$1495
- Assuming an installation cost of \$500 and annual savings of \$286, the payback is 7.0 years compared to standard electric resistance water heater.
 - With Federal tax credit, payback is 4.9 yrs.

A. O. Smith VoltexTM Hybrid Electric

- Will probably be assembled in the U.S.
- 80 gallon tank (recently introduced 60 gallon model)
- EF = 2.35, FHR = 72 gallons
- Two 4,500 watt elements, powered anode
- MSRP \$1995
- Assuming an installation cost of \$500 and annual savings of \$360, the payback is 6.9 years compared to standard electric resistance water heater.

— With Federal tax credit, payback is 4.9 yrs



Heat Pump Water Heaters

- Although there is a lot of interest in HPWH, they are years away from making significant market penetration in the U.S.
 - Designs must be refined
 - Costs must come down
 - Consumer acceptance must be developed
 - Life expectancy must be validated
- Ultimately, electric resistance water heaters will be replaced by HPWHs.

Tankless Water Heaters

- Gas tankless water heaters are growing in popularity due, in part, to extensive advertising of claims for energy efficiency and “endless” hot water.
- In 2009, approximately 350,000 gas tankless water heaters were sold in the U.S. out of a total market of about 7,500,000 water heaters.