

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!

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	

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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 & EPCAct).
- 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
- Next time...
 - Bigger tank
 - Select a unit with a larger burner

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.

Gas Storage Water Heaters

Installation in Retrofit

- Well-known and relatively inexpensive
 - Standard make up air
 - Standard venting
 - Small diameter gas line (1/2 inch up to 80,000 Btu)
- New tanks with more insulation may not fit into existing spaces
- Will need to bring 110 VAC outlet to the heater if the new unit has sealed combustion with a fan.

Gas Storage Water Heaters

Life Expectancy

- Glass-lined steel tanks generally last 10-13 years without regular maintenance
- Storage water heater life is strongly dependent on the local water chemistry
- Even with heavy sediment build-up on the bottom of the tank, heat transfer efficiency remains acceptable due to the large surface area in the flue
- If maintained, drained and the anode checked, life can be much, much longer

Warranties

- Read the label – ranges from 2 to 12 years
- Relatively few exclusions

Condensing Storage 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



Atmospheric Gas Storage Water Heater Performance

Pro

- Inexpensive
- Standard installation
- Instant hot water
- Flow rate independent
- Maintenance free

Con

- Mediocre energy efficiency
- Large, heavy tank
- Limited hot water volume
- Standby losses
- Tank will eventually leak

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
 - 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

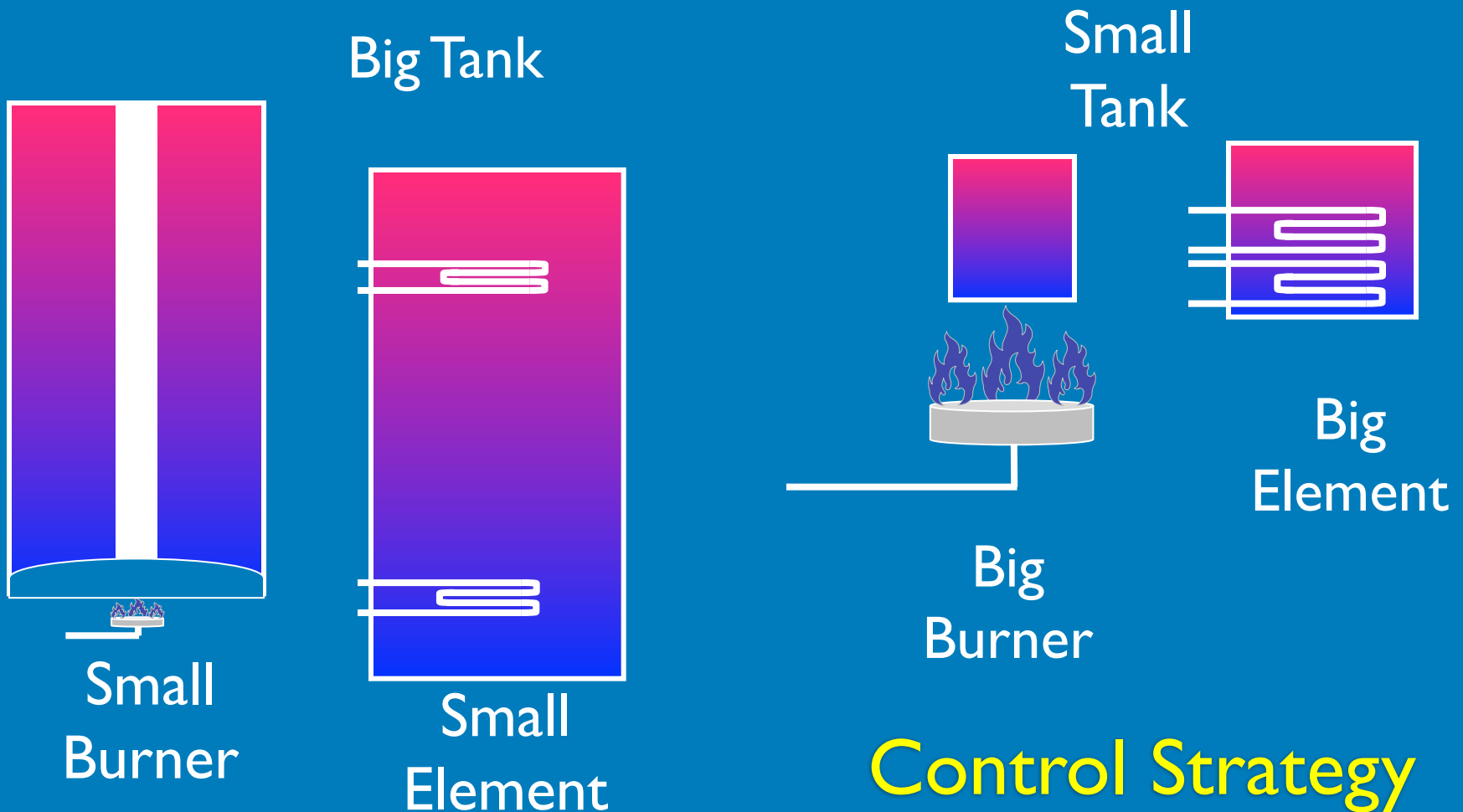
Recovery is generally slow

- Depends on element capacity and on inlet water temperature

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.

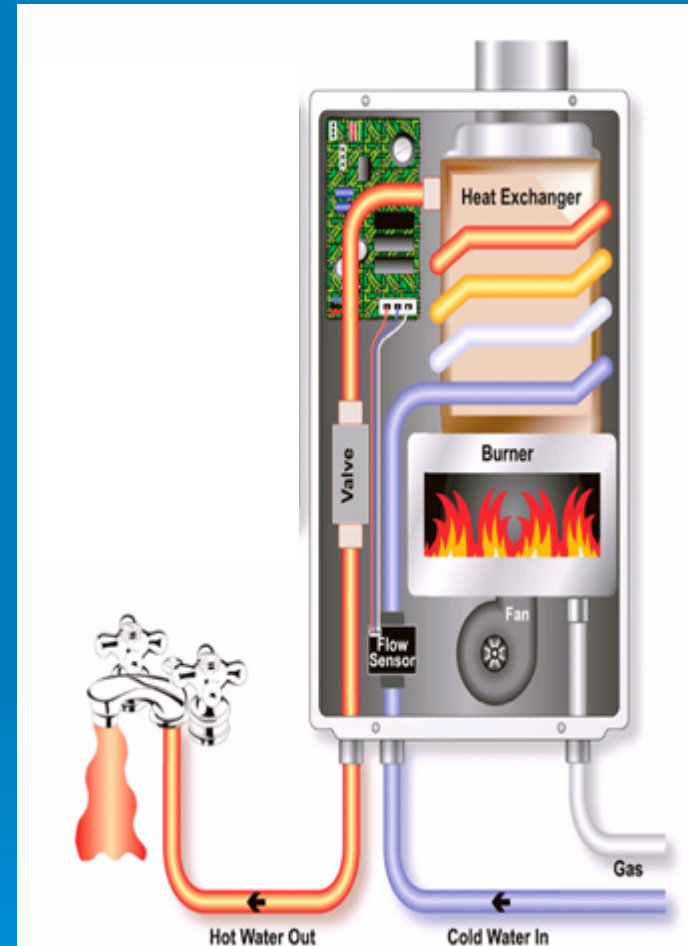
The Essential Differences Between Storage and Tankless Water Heaters?



Gas Tankless Water Heaters

Principle of Operation

- Flow is sensed
- Fan purges combustion chamber
- Burner is ignited and modulated to match measured flow rate
- Heat exchanger begins to heat water as it passes through
- When flow stops, burner is extinguished and combustion chamber is purged.
- Power supply is needed for the electronic controls and the fans



Gas Tankless Start Up

- There is a 10 to 15 second delay before hot water is produced.
- Increased wait at the fitting for hot water
- Additional water wasted down the drain
 - On the order of 10 - 15 gallons per day
 - 10 second delay times 60 draws per day times 1.0 to 1.5 gpm

(If hot water arrives at the fixture for each draw.)

Gas Tankless Cool Down

- For safety, once a draw is over, the fan continues to operate.
- This removes combustion byproducts from the flue and cools down the thin-walled heat exchanger.
- The “cool down” cycle takes 1-2 minutes.
- This heat is wasted!

Gas Tankless Water Heaters

- Tankless water heaters will be more energy and water efficient with long draws.
- How does the DOE EF test simulate hot water use?
 - Six long draws a day
- How do we use hot water?
 - Many short draws a day
- The DOE EF test favors tankless water heaters over storage water heaters.

Gas Tankless Water Heaters

Flow Rate

- A gas tankless water heater needs a minimum flow rate to turn the unit. Some current models only require 0.4 gpm to ignite the burner.
- Minimum burner firing rate is limiting factor for the minimum required flow rate
- Maximum flow rate depends burner capacity and temperature rise:
 - Approximately 40,000 Btu per gallon per minute at 70 F temperature rise
- The minimum flow rate **can** it difficult to use:
 - with standard recirculation systems. (Exception is demand controlled recirculation.)
 - as booster for preheated water (such as from solar, geothermal, heat pump)

Gas Tankless Water Heaters

Temperature Stability

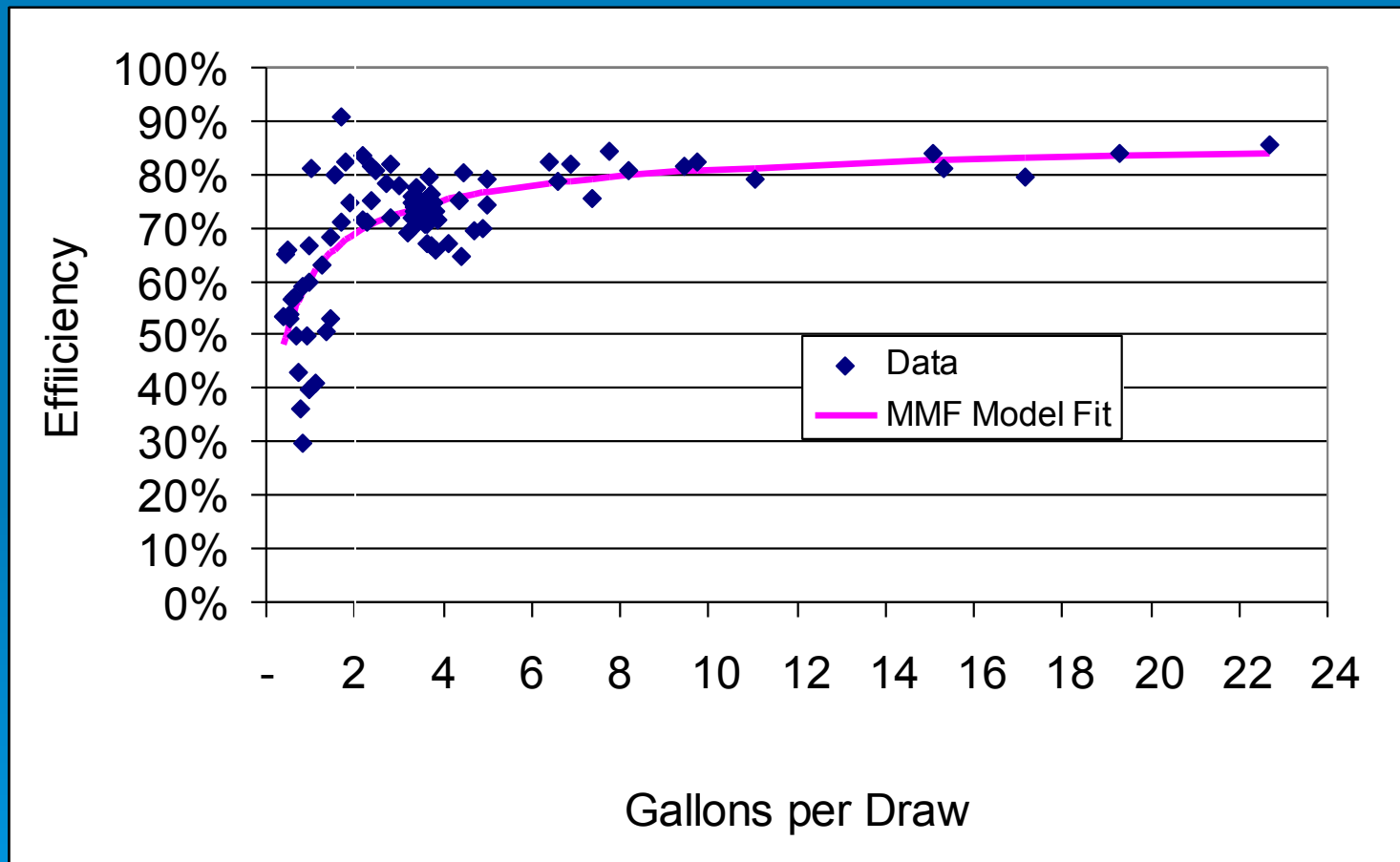
- Gas tankless water heaters maintain very constant temperature output under steady-state conditions.
- Rapid changes in flow rate can result in temperature spikes....both up and down.

How do tankless water heaters perform in actual installations?



Measured Efficiency vs. Draw Volume

Gas Tankless Water Heater Performance vs. Draw Size (15 second monitoring interval)



Efficiency also varies by flow rate and draw schedule.

Gas Tankless Water Heaters

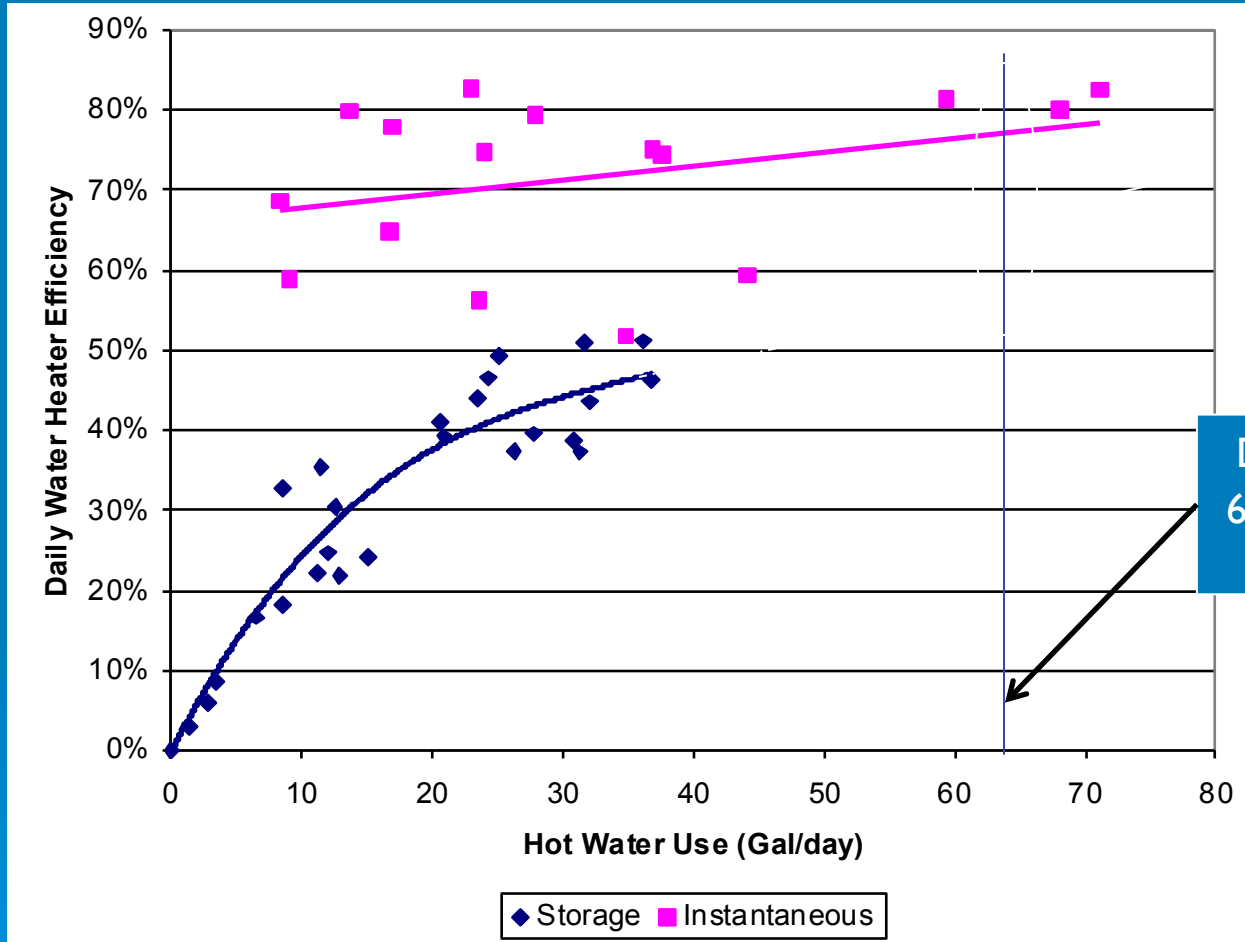
“Endless hot water” if sized correctly

- Depends on flow rate (gpm) and change in water temperature desired.
- If capacity is exceeded, most gas tankless heaters will limit flow and maintain temperature
- If incoming water temperature is very low, even the largest models will have only a modest flow rate capacity.

Will “Endless hot water” result in increased hot water use?

Measured Comparative Efficiency

Field Measurements of Gas Storage and Tankless Water Heater Performance



Neither one meets the claimed EF

DOE Test Volume-
64 Gallons Per Day