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Track: Residential Natural Gas
Unit #2: Water Heating

An Overview of Hot Water Heating Options

Eric Burgis, Energy Solutions Center

Outline

Residential Topics

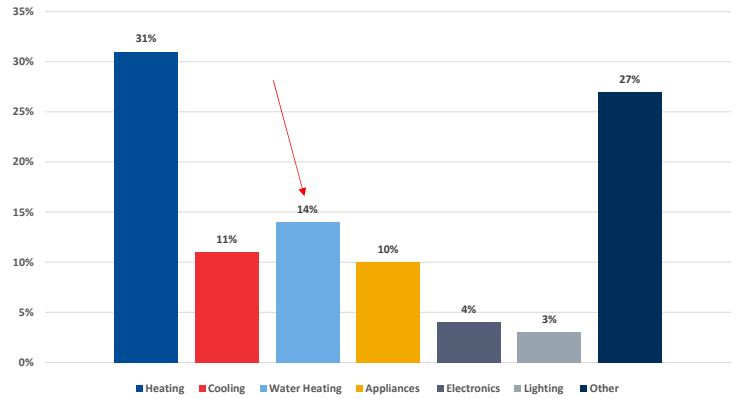
- Market Overview & Market Share
- Types of Water Heaters
- Energy Efficiency
- Water Heater Comparisons

Market Overview & Market Share

Residential Energy Bills

U.S. household energy use

- Water heating is 2nd largest energy use in the home



Source: US Energy Information Administration (EIA) Annual Energy Outlook - 2021

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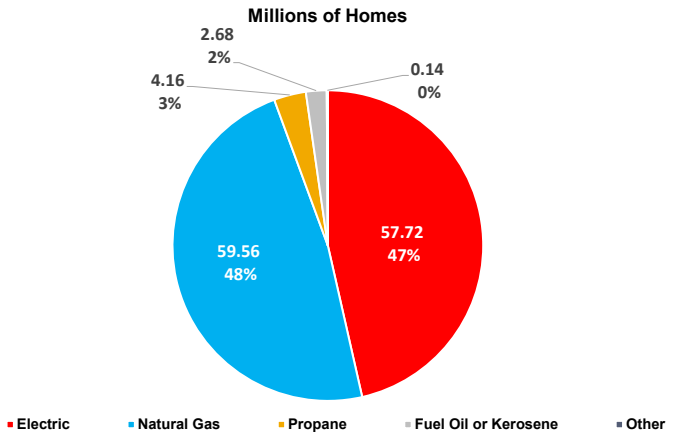
Fuel Used by Main Water Heater



Residential Energy Consumption Survey (RECS), 2020 Data, Released 3/2023, Table HC 1.8

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Market Overview – Hot Water Residential Energy Use

Average Hot Water Use	
Activity	**Gallons Per Use**
Clothes Washer	25
Shower	10
Dishwasher	6
Kitchen Faucet Flow	2/minute
Bathroom Faucet Flow	2/minute
Total Daily Average	**64**

Source: US DOE

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Residential Market Share

- In the U.S. 61% of households have natural gas (~75 million have natural gas of ~ 124 million total homes)[1]
- Natural gas water heaters have only a 47% market share overall, but 79.1% share in homes that have a gas service.[1]

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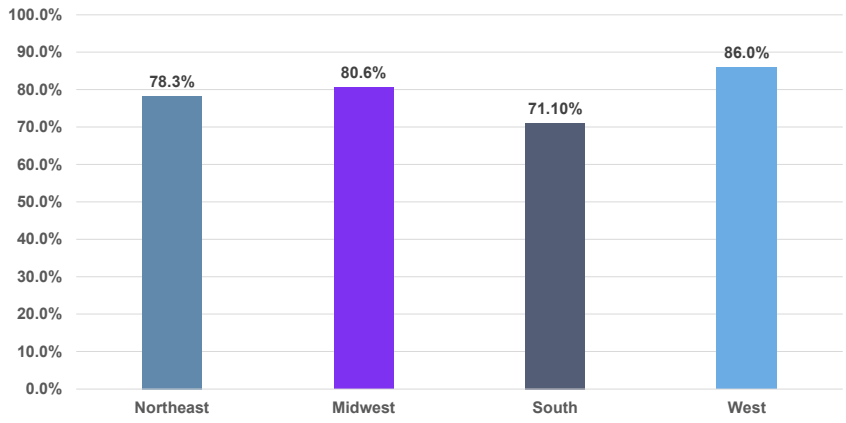
1: EIA's 2020 Residential Energy Consumption Survey, released 3/23

Gas Water Heaters in U.S. Homes
(Homes with Gas Service)



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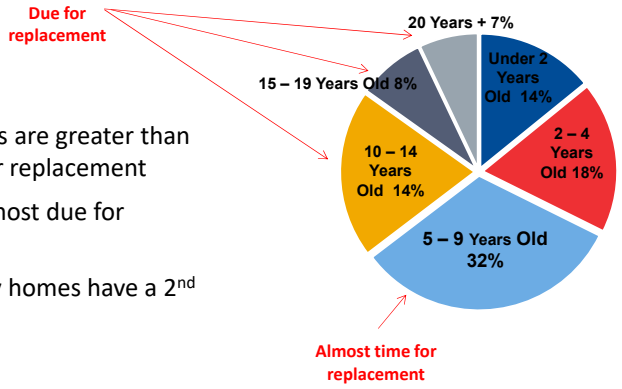
Source: EIA 2020 Residential Energy Consumption Survey, 3/23 Release date

Average Water Heater Age

- 29% of water heaters are greater than 9 years old & due for replacement
- Another 32% are almost due for replacement
- 4.7% of single-family homes have a 2nd water heater



Residential Energy Consumption Survey (RECS), 2020 Data, Released 3/2023, Table HC8.1

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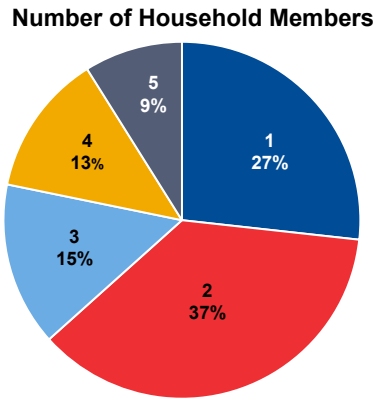
Average # of People Per Household



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Residential Energy Consumption Survey (RECS), 2020 Data, Released 3/2023, Table HC8.4

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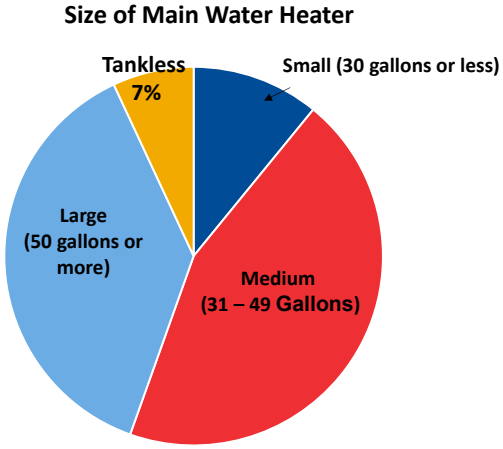
Average Water Heater Size

- 45% are 31-49 gallons
- 38% are ≥ 50 gallons



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Residential Energy Consumption Survey (RECS), 2020 Data, Released 3/2023, Table HC8.1

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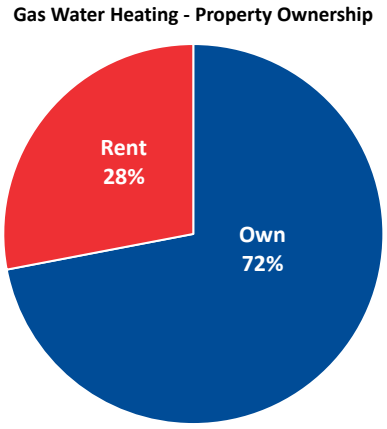
Property Ownership



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Residential Energy Consumption Survey (RECS), 2020 Data, Released32/2023, Table HC8.2

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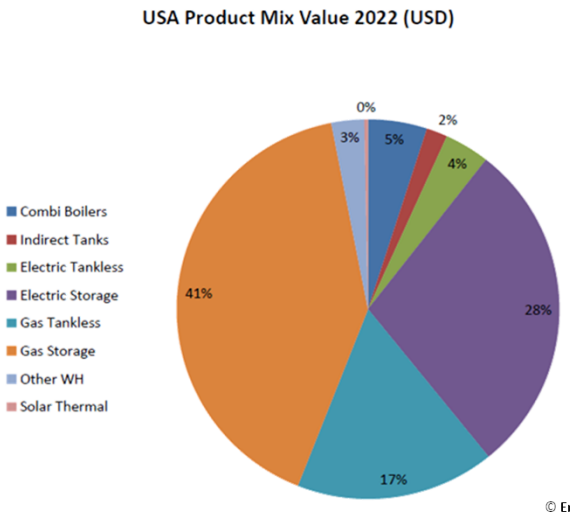
Water Heater Sales – U.S.



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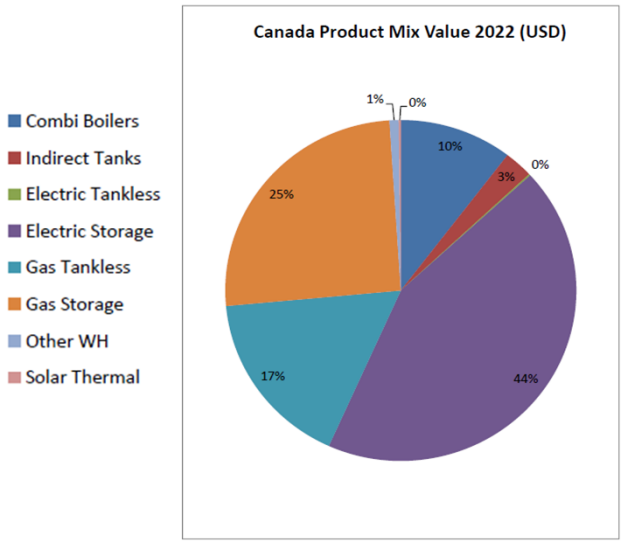
Water Heater Sales – Canada



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Average Unit Prices US Dollars (2022)

	USA	Canada
Electric Instantaneous	$440	$436
Electric Storage Residential	$386	$512
Gas Tankless Condensing	$1,199	$1,271
Gas Tankless Non-Condensing	$785	$0
Gas Storage Residential	$527	$537

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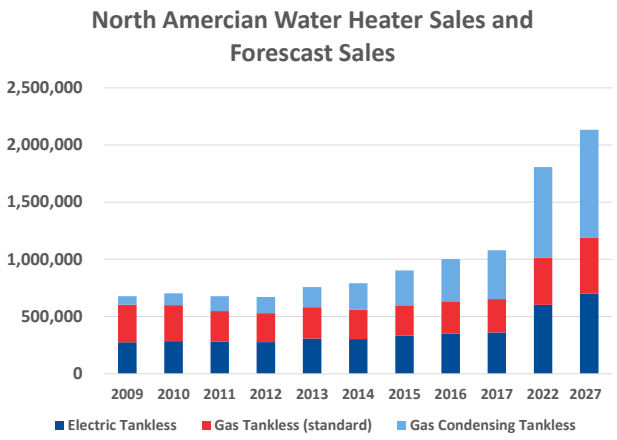
Tankless Growth Rates



Tankless Share of Water Heater Market	
2009	7%
2016	9%
2021	12%
2022	17%

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North American Distribution by Type of Water Heater

	Wholesalers	Retailers
Gas Storage Residential	**56%**	**43%**
Gas Tankless Water Heaters	**84%**	**10%**

- A large portion of tank style water heaters are sold through big box stores
- Very few tankless models are sold through the big box retailer
- 5% of tankless units are sold via the Internet

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Types of Water Heaters

Tank Water Heater
Tankless Water Heaters
Indirect Water Heaters
Misc. Water Heaters
Solar Water Heaters
Combination Systems

Tank Style Heaters

- Residential sizes typically range from 20-50 gallons (75-189 L)
- Spark ignition or standing pilot
- Venting options
  - Atmospheric
    - Vertical vent pipes or chimneys
  - Power-assisted or direct vent
    - Typically Horizontal

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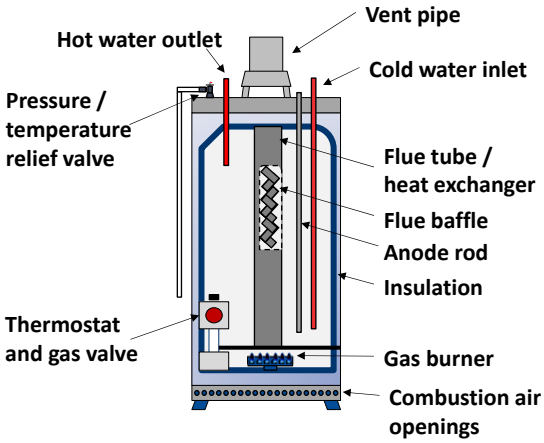
Tank Style Water Heaters



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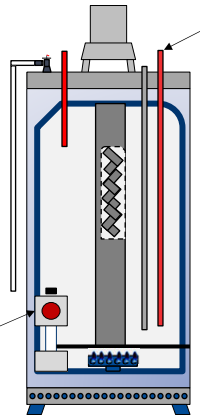
Tank Style – How it Works

- Cold water enters tank and travels down the Dip Tube to the bottom of the tank to be heated
- Thermostat senses water temperature and turns on burner to meet desired set temperature for water



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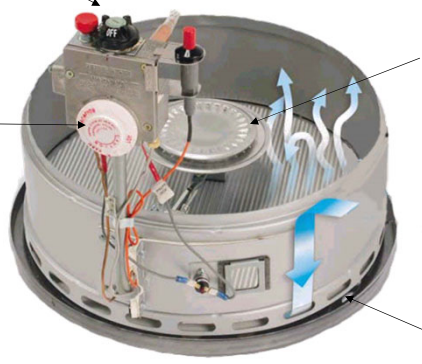
Tank Style – How it Works Atmospheric Burner



- The thermostat tells the gas valve to open or close to satisfy hot water requirement as set on the thermostat dial

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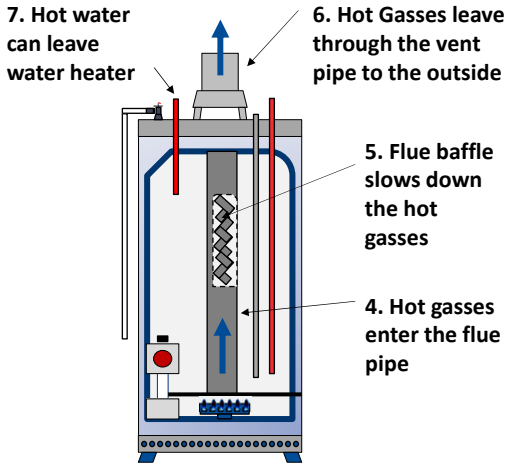
Tank Style –How it Works

- Heat from the combustion process travels up the flue
- Combustions gasses are slowed down by a baffle in the flue pipe which allows more heat to transfer to the water being heated.
- Hot gasses leave through the vent pipe and exhaust outdoors
- Hot Water naturally rises to the top of the tank where it is drawn off for use at any time



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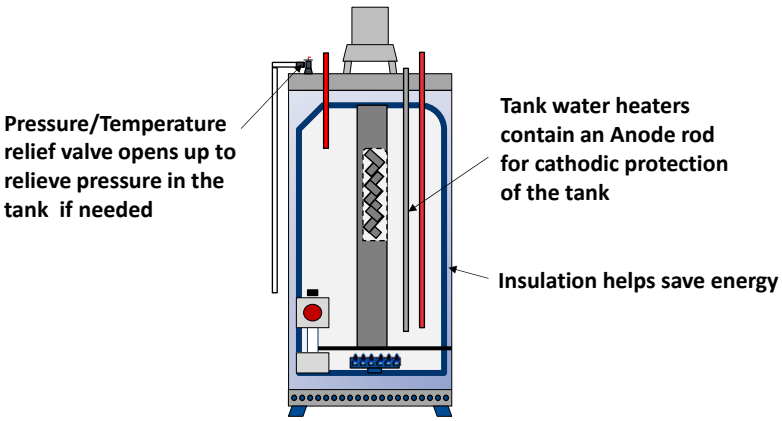
Tank Style – How it Works Miscellaneous Components



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Traditional Tank Water Heaters

Atmospheric

Direct Vent

Power Vent

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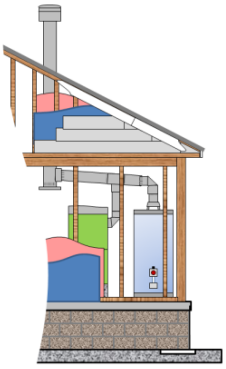
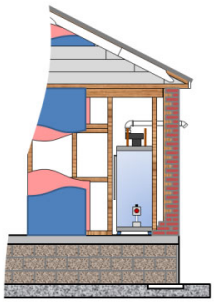
Tank Water Heater Venting



Atmospheric units typically use B vent and run vertically out through the roof or in a chimney



Direct or Power Vent units can run out the side wall

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High Efficiency Atmospheric Gas Units

- High Efficiency .70 UEF
- Advanced standard vent gas water heater
- Installs with the same gas, water and venting connections as a standard atmospheric model
- Electronic ignition

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High Efficiency Condensing Tank Style Water Heaters

- Achieve much higher efficiency by recapturing the heat in the flue gases that would otherwise be vented outside
- ENERGY STAR requirements
  - First Hour rating ≥ 51 GPH
  - Warranty ≥ 6 years
  - Minimum efficiencies

	≤55 Gallons	> 55 Gallons
UEF		>_.86
UEF Medium Draw	≥..81	
UEF High Draw	≥.86	

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Intelligence for Tank Water Heaters

- Microprocessor controls
  - Tank maintains consistent temperatures
- Integrated mixing devices
  - Allows for storage of hotter water – increasing amount of usable hot water available
- Set back controllers
  - Similar to programmable thermostat
- Leak detection devices
  - Shuts off water if tank leak is detected
- Atmospheric flue dampers
  - Reduces standby losses

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Microprocessor Controls

- Advanced Temperature Controls
  - Microprocessor constantly monitors and controls burner operation to maintain consistent and accurate water temperature levels
- Intelligent Diagnostics
  - Provides diagnostic codes to assist in troubleshooting

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Microprocessor Controls

- Self powered
  - Thermopile converts heat energy from the pilot flame into electrical energy to operate the gas valve and electronics
- Retrofit replacement
  - Service kits are available for direct replacement on certain units

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Integrated Mixing Device

- Automatically mixes cold water with hot water to provide a desired hot water temperature
- Allows water in the tank to be stored at higher temperatures
- Increases usable hot water by as much as 50%, while controlling the hot outlet at a lower temperature

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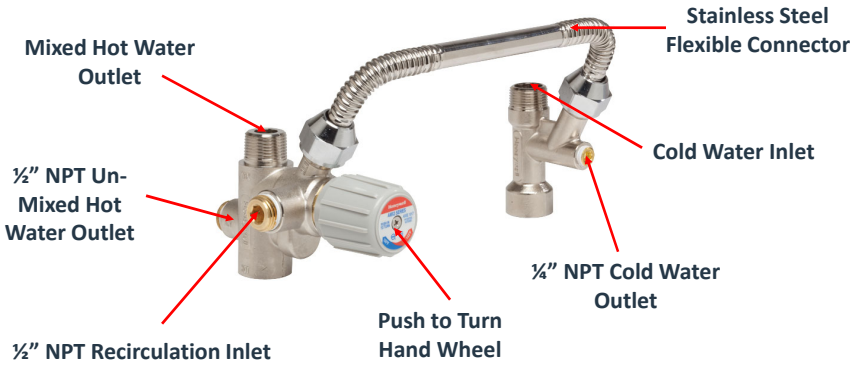
Integrated Mixing Device



*ASSE and UPC (IAPMO) Certified

Set Back Controller

- Similar user interface as heating/air conditioning thermostats
  - 7 day/4 period programmable display
  - Battery backup in case of power failure
  - Can be remotely wired
  - Hot water capacity indicator; provides an estimate of available hot water in the tank
- Energy savings of between 7% to 36%

Leak Detection

- Electronic sensor designed to detect leaks
- Triggers an alarm to alert homeowners when a water heater leak is detected
- Installs in water heater drain pan
- Components are re-usable – can be removed and installed on a new water heater

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Leak Detection Inlet Shut Off Valve

- Mounts on water heater inlet
- Shuts off the inlet water after a leak is detected and confirmed
- Requires electrical power to actuate valve
- Easily installed with provided bushings

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Tank Water Heater Market Share

Electric and Gas Tank Water Heater Break Out

2016 Sales	U.S.		Canada		Totals	
Manufacturer	Electric Tank	Gas Tank	Electric Tank	Gas Tank	Total	% Market Share
AO SMITH	1,849,000	1,604,015	170,000	118,700	3,741,715	40.7%
PALOMA	1,452,500	1,572,180	110,000	130,500	3,265,180	35.5%
BRADFORD WHITE	437,000	890,025	37,475	81,385	1,445,885	15.7%
GIANT	0	0	241,000	22,000	263,000	2.9%
All Others	221,500	166,980	45,025	38,615	472,120	5.1%
Total	**3,960,000**	**4,233,200**	**603,500**	**391,200**	**9,187,900**	100%

4 Manufacturers have 95% of the tank water heater sales in North America

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* Gas tank sales includes standard and condensing models

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Tankless Water Heaters

- Standard
- Condensing

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Tankless Water Heater History

1868	1905	1945	1960's	1980's	2025
UK, First Tankless water heater "the geyser"	First U.S Instantaneous Automatic Water Heater by Ruud	Tankless water heaters were Popular in Europe after WWII then Canada	60's & 70's used in Campers on propane	Mid 80's Paloma Pak gains some traction in the US	Today there are lots of tankless manufacturers

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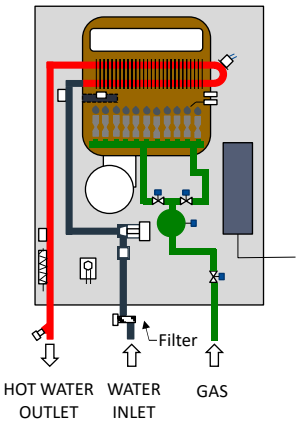
How it Works

(Internal View)



- Temperature is set via the controller
- Water tap opens & water begins to flow
- Turbine spins & sends signal to PC Board
- PCB determines water flow, firing rate & temperature
- Combustion fan motor starts
- Burner is ignited by direct electronic ignition and unit fires then modulates to match input with hot water flow
- When hot water tap is turned off – The unit returns to standby mode

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Tankless Water Heaters

- Heats water as required
- Never run out of hot water – continuous supply
- No downtime waiting for water heater to recover and be ready for use
- Multiple units for higher flow rates
- High efficiency – no standby losses
- Indoor or outdoor installations
- Burner maintains +/- 2°F (+/- 1.1°C) regardless of how much water is flowing
- Designed to last 20+ years

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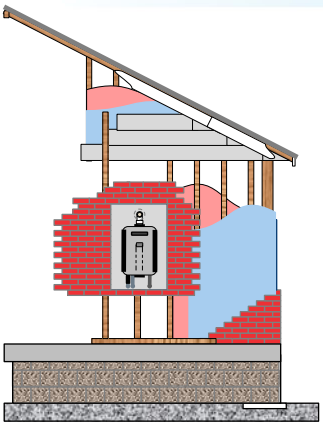
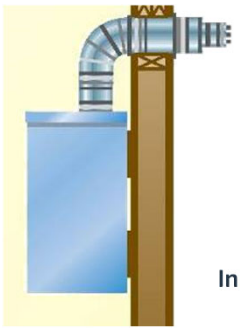
Installation and Venting Options



Outdoor Vent
Wall Mount

Direct vent to outdoor



Indoor Mount
Side Wall

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Tankless Heater Designs

- Indoor power vent (PV) or Direct Vent (DV)
  - Attics, garages & basements
  - Confined spaces without ample combustion air
- Outdoor
  - Mounted on wall - with or without pipe skirt
  - Mounted in recessed box
- Standard or Condensing models

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Tankless Considerations

- Sizing unit(s) is critical
- Know gas pressure requirements
- Location of heater to water load
- Variable burner maintains ⁺/- 2 °F (⁺/- 1.1°C) regardless of how much water is flowing
- Gas line must be sufficient to handle larger gas load
  - ¾” gas line used in typical installation
  - At least 10 foot (3.048 m) of ¾” water line to and from the unit in a typical installation

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Installation Considerations

- Units are not “Standardized”
- Compare units at same temperature rise (Delta T-(ΔT)
  - Do Not Compare a 45°F (25°C) rise vs. a 35°F (19°C) rise
- Know the minimum fuel pressure required
  - Natural gas - Varies from 4” to 6” water column
  - ¾” gas line used in typical installation

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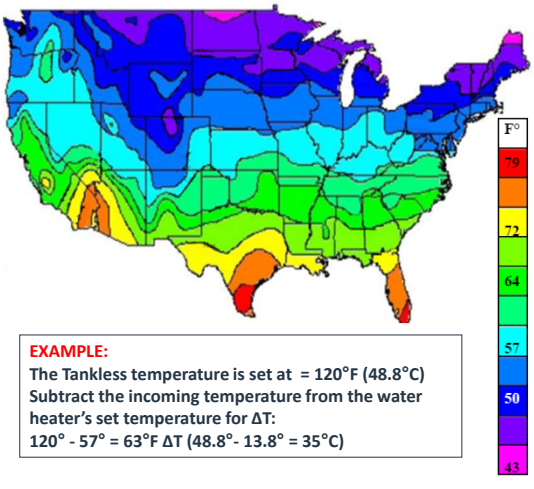
What is a Delta T (ΔT)?

- The difference of the incoming ground water and the tankless water heater’s set point temperature is known as (ΔT)
- (ΔT) determines the flow rate of the tankless water heater



EXAMPLE:
The Tankless temperature is set at = 120°F (48.8°C)
Subtract the incoming temperature from the water heater’s set temperature for ΔT:
120° - 57° = 63°F ΔT (48.8°- 13.8° = 35°C)

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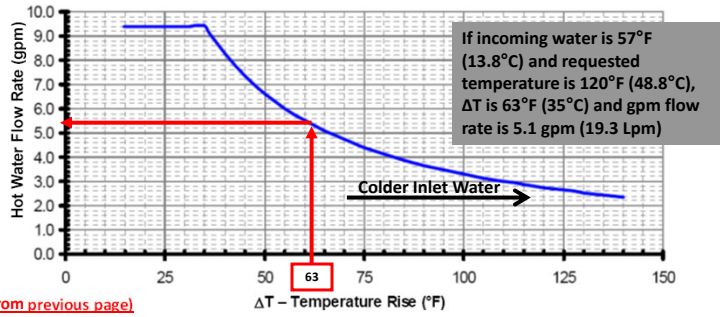
Understanding Flow Rate

The tankless water heater's first priority is to provide the set point temperature to the user
Based on the ΔT, the tankless product may regulate flow to ensure it can provide the selected temperature



EXAMPLE (from previous page)

Subtract the incoming ground water temperature from the water heater's set temp. for ΔT 120°-57° = 63°F (35°C)

The maximum GPM flow rate for any given ΔT can be found at the intersecting points along each model's specific flow curve

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Residential Flow Rate

Ground Water Temperature	
Summer Season 70°F (21°C)	Winter Season 50°F (10°C)
	
	

- Shower heads assumed to be 2.5 GPM (9.4 LPM) mixed flow rate or less (standard size for most residential shower heads)
- A residential washing machine or dishwasher is equivalent to one shower head
- Bathroom sink faucets assumed to be 2 GPM (7.6 LPM) mixed flow rate or less
- Assumed mixed temperature on shower heads and bathroom faucets are set to 104°F (40°C)

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Tankless Installation Considerations

- Clearance to Combustibles
  - Varies from .5” to 6” (1.27 – 15.24 cm) or more on the sides
  - 0” to 2” (0 – 5.08 cm) in rear
  - 12” to 36” (30.48 – 91.44 cm) to the top and 6”-24” (15.24 – 60.96 cm) to the front
- Minimum Activation Flow
  - Varies from .5 to .78 GPM (1.89 – 2.95 LPM)
  - At least 10’ (3.048 m) of ¾” (1.905 cm) water line to and from the unit in a typical installation

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Tankless Installation Considerations

- Can the unit detect scale buildup ?
  - Preventive maintenance requirements – purge to clean system due to water hardness (Scale)
- Is bigger better?
  - Slightly lower efficiency
  - Possible loss of system redundancy for multiple unit installations
  - 200,000 BTU/hr & higher – not Energy Star rated

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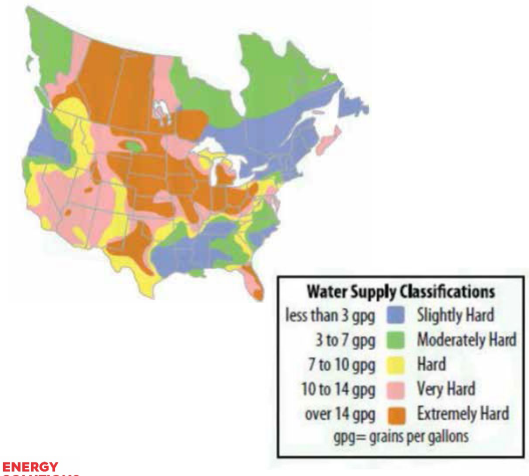
Scale Control



Flush Kit

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Condensing Technology

- Condensing technology delivers energy saving performance by recycling exhaust gases to extract and re-use the latent heat
- This makes for a highly efficient use of energy which also significantly reduces carbon dioxide emissions into the atmosphere
- Greater than 98% of the fuel turned into heat, making the unit more energy & cost efficient
- Energy efficiency upgrades & a new high-efficiency heating system can often cut fuel bills & pollution output in half

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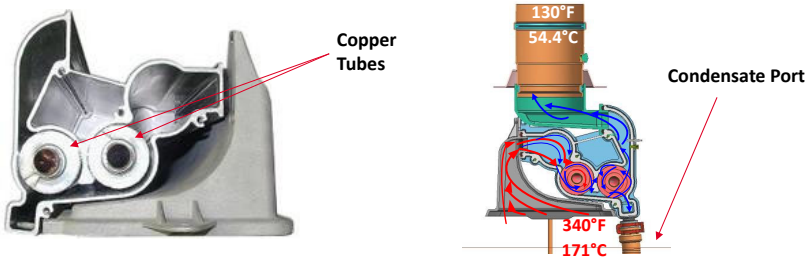
On-Demand Water Heater Technology

- Condensing Heat Exchanger (HEX)
  - Aluminum and copper HEX = engineered for best heat transfer
  - Water is exposed solely to copper in the entire hot water piping - galvanic corrosion eliminated



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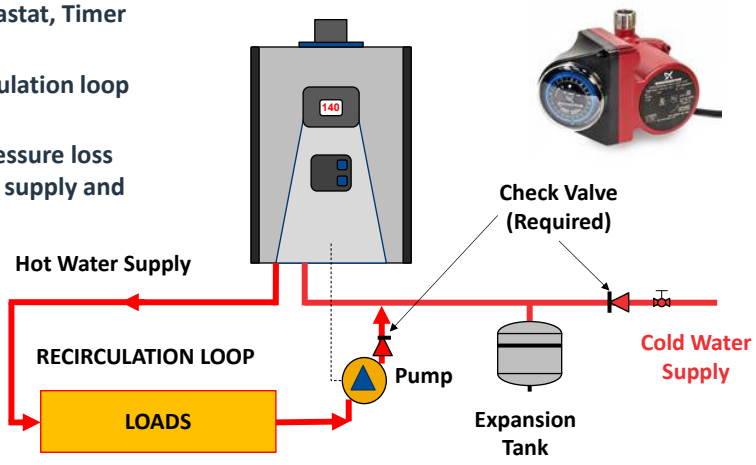
Recirculation Pumps

- Controlled by an Aquastat, Timer and/or both
- Sized to maintain circulation loop temperature
- Sized to overcome pressure loss through water heater supply and return plumbing



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Exhaust Venting

- Is PVC used in venting limited to 140°F (60°C), 149°F (65°C) or what?
- We often will hear it's 140°F (60°C),
- But that's a fluid pressure rating of 20 PSI
- Schedule 40 PVC has the following ratings:
  - Maximum Temperature: 158°F (70°C)
  - Minimum Temperature: -13°F (-25°C)
  - Melting Point: 176°F (80°C)
  - Tensile Strength: 6,500 psi

Sch 40 PVC ULS S636 IIA 149°F / 65°C	Sch 40 & 80 CPVC ULC S636 IIB 194°F / 90°C	Polypropylene ULC S636 IIC 230°F / 110°C

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Product Life

- With a typical life expectancy of 20 years (nearly twice that of a traditional tank water heater) a tankless unit will outlast the average tank, and will also reduce the amount of material that ends up in landfills
- Tankless water heaters are field repairable which can lessen the cost of repairs and allow them to occur in a more-timely manner

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Electric Tankless Options

- Electric tankless units are available
- 110V, 120V, 208V, 220V, 240V, and 277V
- Will have various requirements in amp draw and may require electrical upgrade
- Point of use to "whole house" units
- Same continuous benefits as gas
- Lower first cost
- Shorter life expectancy
- Mostly for point of use

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Lots of Tankless Products Available

American Water Heaters, Rheem, A.O. Smith, Bosch, Chofu, Eternal, Excel, FlowMax Technologies, GE Appliances, Giant, intelli-hot, Kenmore, Monitor, Navien, Noritz, Paloma, Quietside, Reliance, Rheem, Richmond, Rinnai, Ruud, State Water Heaters, Takagi, U.S. Craftmaster, Waiwela

Note that most manufactures have multiple models to choose from. Specifications vary from model to model.

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Indirect Fired Water Heaters

- Utilize a heat exchanger within a boiler or a hot water boiler for heat source
- High efficiency storage tank

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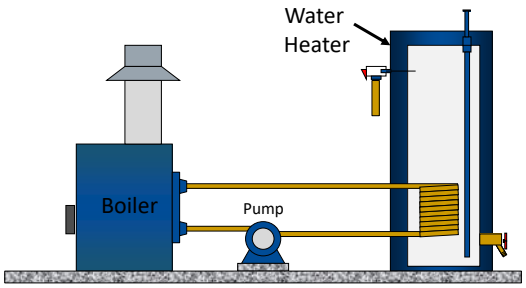
How Indirect Water Heaters Work

Heat source provides heat to coil in indirect water heater to heat up and store hot water.



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Indirect Water Heaters

- Benefits
  - Higher flow rates than electric models
  - Stored hot water always available
  - Can be least expensive water heating option – high-efficiency boiler combined with well-insulated storage tank
- Considerations
  - Work best during cold months when heating system used regularly
  - Less efficient, less economical in warmer climates

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Misc. Water Heaters

- Electric Tank Water Heaters
- Electric Heat Pump Water Heaters
- Gas Heat Pump Water Heaters
- Propane Water Heaters
- Hybrid Water Heaters
- Oil Fired water Heaters

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Electric Tank Water Heaters

- **Why do electric tank water heaters compete with gas water heaters especially in new construction?**
- Lower installed cost
  - Save ~$350-$1,100 over gas model
- No venting required
- Electric is typically already installed
  - No gas pipe required

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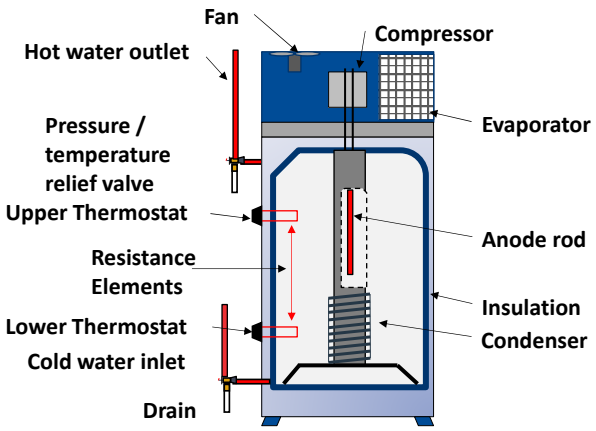
Electric Heat Pump Water Heater

(For comparison)



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Residential Electric Heat Pump Water Heating Systems

- Requires installation in locations that remain in the 40°–90°F (4.4°–32.2°C) range year-round
- Install them in a space with excess heat such as a furnace room
- **Cost almost 3X that of a Gas** tank water heater ($1467 versus $527 for gas unit)
- **Only save about $70/Year over a gas tank** unit, or about 70% over electric tank unit.

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Propane Water Heaters

- Propane Tank Units are similar to natural gas tank units but while most appliances convert very easily from propane to natural gas, tank water heaters do not
- Properties of natural gas and propane are very different and impact the FVIR system in different ways
- Conversion typically requires the replacement of the gas valve as well as thermal switch which could cost as much as $500
- A new atmospheric gas tank costs approximately $525 prior to installation

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Hybrid Water Heaters

- Up to 98% efficient
- Combine tank and tankless technologies
- Continuous hot water without cold water slug between uses

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Oil Fired Water Heaters

~2% of installed water heaters in the U.S. and 1.5%of water heaters installed in Canada are oil fired water heaters

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Solar Water Heaters

- System Types
- Collector Types
- Back-up Options
- Sizing Considerations
- Regional Issues
- Maintenance

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Solar Water Heater System Types

- Passive
- Active
  - Drainback
- Open
- Closed

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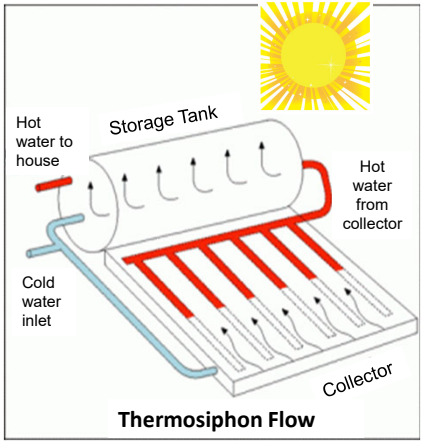
Passive System

- When the fluid or water inside the collector(s) is heated, convection causes it to flow between the collector and the solar storage tank or heat exchanger
- The solar storage tank or heat exchanger must be above the collector for these type systems to operate



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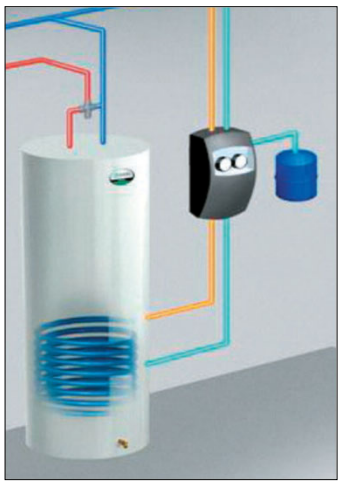
Active System

Active, or **forced-circulation**, systems use electric pumps, valves and controllers to move heated water (open loop) or heat transfer fluid (closed loop) from the collectors to the storage tank or heat exchanger.



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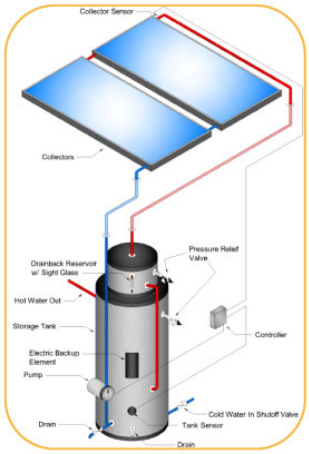
Active with Drainback



Graphic courtesy of Alternate Energy Technologies

- A drain-back system is an indirect active system that prevents freezing and overheating by storing fluid in a reservoir (not collectors) when system is at rest
- Fluid (typically distilled water) is pumped through collectors, allowing heat to be gathered, and then through heat exchanger
- Proper installation is critical – plumbing must ensure all fluid drains into reservoir

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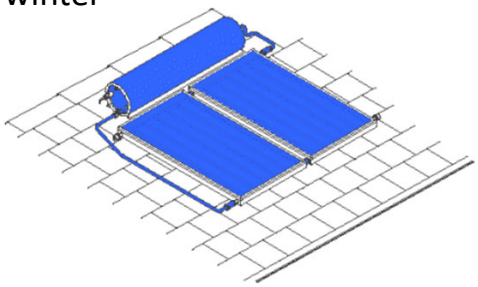
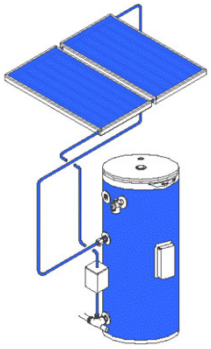
Open Loop Solar Water Heating

- Open loop systems use water from the main water supply to circulate between the collector(s) and the storage tank
- Not suitable for cold climates since the water in the collector can freeze at night or in winter



Passive Open Loop



Active Open Loop

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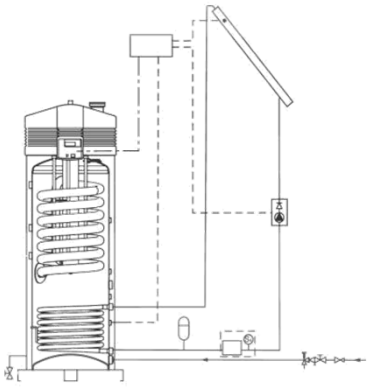
Closed Loop System

- Closed loop systems use a non-toxic antifreeze heat transfer fluid (HTF) such as propylene glycol that circulates between the collector(s) and a heat exchanger
- The heat exchanger can be inside (internal) or outside (external) the storage tank
- Suitable for cold climates and can operate year round



Active or Passive

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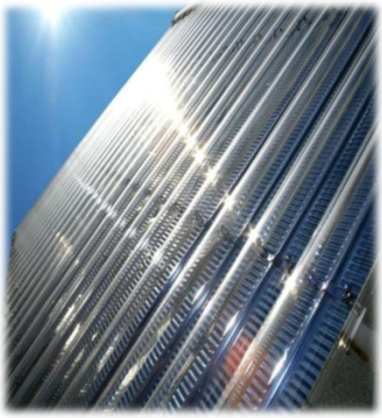
Collector Types

- Flat Plate
- Vacuum Tube
- Polymer

The sun provides roughly ½ the hot water. A back up is needed for the other ½.



Do not confuse these with Photo Voltaic (PV)

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Back-up Options

- Typically, 50% of a home's hot water needs can be met with solar water heating. Some form of auxiliary or back-up heating is required for when the sun isn't shining or when additional hot water is needed beyond what the solar panels can produce.
  - Natural Gas – **Preferred!**
  - Electric

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Important Sizing Considerations

- Know # of occupants in residence – solar is gallons per day, not gallons per hour
- Determine total collector area and storage volume to provide 90-100% of hot water during summer months.
- Approx. 20 ft2 (1.85 m2) collectors / person
- 1.5 – 2.0 gallons (5.6 – 7.5 liters) of storage per ft2 (m2) of collector surface area
- Size backup as if there were no solar (no lifestyle disruptions!)

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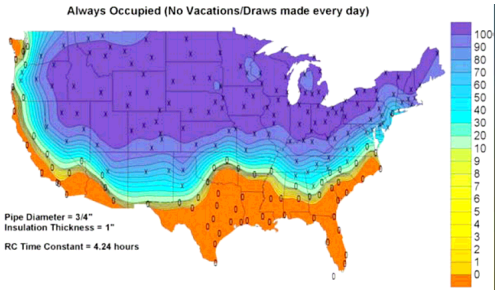
Regional Factors

- Best results where you can receive direct sunlight from 10AM to 4PM year round
- Panels should face south within 10 degrees
- Open Loop Systems not suitable for cold climates



Map shows:
- **Probability of at least one pipe freeze in 20 yrs.**
- Shows the geographic limitations of some systems.

(Map from DOE Solar Energy Technologies)

Freeze protection needed in colder climates

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Solar Maintenance Considerations

Outside
- Collector is clean and not shaded
- Collector is sound, sealing/glazing are not cracked
- Fasteners connecting collector to roof are sound
- Piping and wiring are well-connected, well-insulated
- Roof penetrations are well-sealed

Inside
- Pressure relief valve is not stuck closed
- Pumps (active systems) activate when the sun is shining
- Pipes are free of mineral build-up. If you live in an area with hard water, you may need to add de-scaling agents to the water every few years

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Combination Systems

(Heating and hot water from one boiler or water heater)

- Three Types of Systems
- Boiler with domestic hot water coil
  - aka Summer-Winter Hook-up
- Tank or tankless with Hydronic Furnace
- Domestic hot water and radiant heating loop
  - Tankless
  - Wall Hung Boilers

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Boiler with Hot Water Coil

- Domestic coil could be located in the boiler or could be an external heat exchanger
- Boiler can be floor or wall mounted

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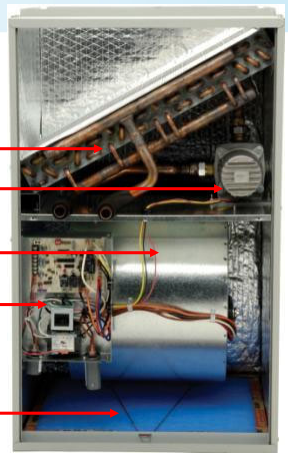
Hydronic Furnace



Basically, a residential air handler that contains a heating coil

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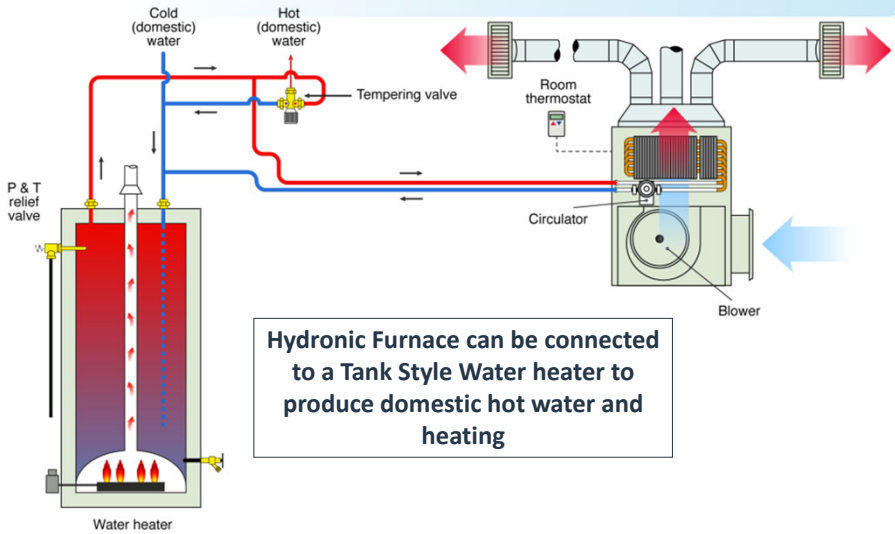
Tank Water Heater + Hydronic Furnace



Hydronic Furnace can be connected to a Tank Style Water heater to produce domestic hot water and heating

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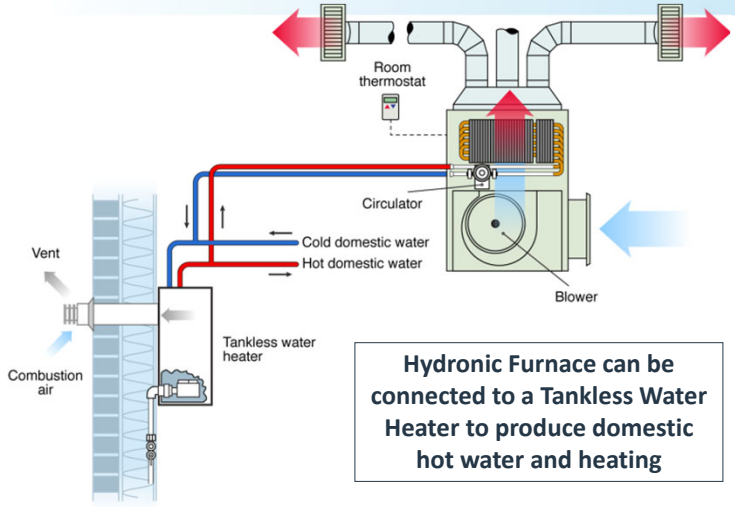
Tankless Heater + Hydronic Furnace



Hydronic Furnace can be connected to a Tankless Water Heater to produce domestic hot water and heating

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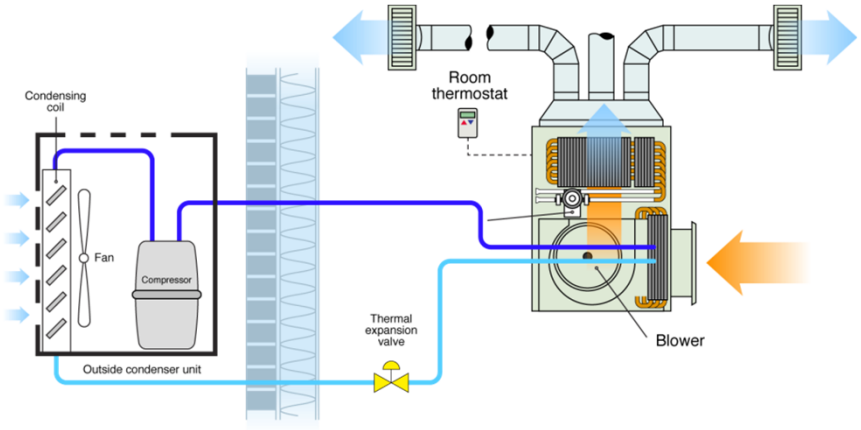
Hydronic Furnace with Cooling Coil



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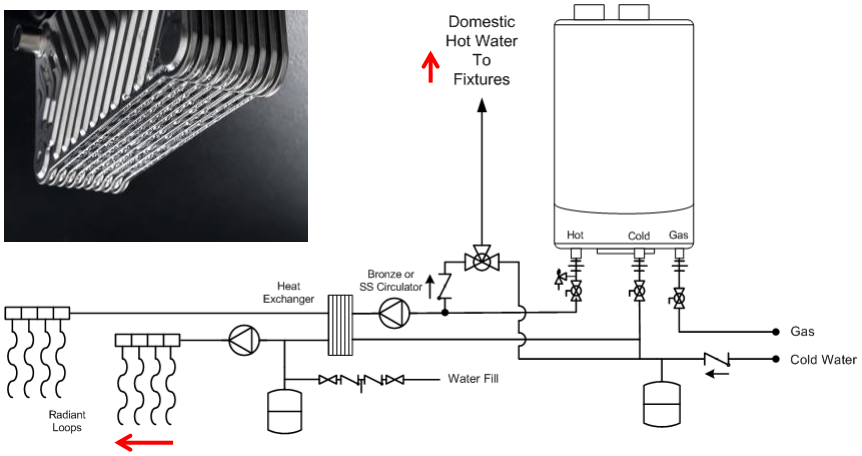
Radiant Heat and Domestic Hot Water



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Wall Hung Boilers

- Wall Hung Boilers working as combination heater / water heaters are making inroads in North America.
- Typically condensing units with efficiencies > 95%
- Slightly larger than tankless

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Energy Efficiency

UEF Math for Water Heater Efficiency

Changes affecting residential water heaters:

- No physical changes to the heaters
- Uniform Energy Factor (UEF) instead of EF
- Based on BIN
- A higher UEF is more efficient

BIN	BIN Daily Usage (Gallons)	First Hour Rating (Tank-Type Water Heaters)	Max GPM (Tankless Water Heaters)
Very Small	10	Less than 18 gallons	Less than 1.7
Low	38	18 to 51 gallons	1.7 to 2.8
Medium	55	51 to 75 gallons	2.8 to 4
High	84	75 gallons or larger	4 or more

First Hour Rating determines the BIN

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Water Heater -Uniform Energy Factor

- The **Uniform Energy Factor (UEF)** is the DOE's developed metric for **communicating the energy efficiency of water heaters**. The previous Energy factor (EF) has been replaced with UEF.
- The goal of the UEF regulation is to make it easier to make "apples to apples" comparisons between two water heaters (within the same bin).
- UEF ratings are determined by assigning water heaters into one of four different categories of hot water usage and then evaluating their performance based on that usage.
- These categories are called bins. A water heater is assigned a UEF within its bin based upon its first hour rating.
- Must compare two water heaters from the same BIN and the higher UEF is more efficient.

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Water Heater – Uniform Energy Factor

New formulas (V equals volume of storage)

	Volume (Gal)	Medium UEF Example	Very Small Draw (UEF)	Low Draw (UEF)	Medium Draw (UEF)	High Draw (UEF)
Electric Storage	≥20 and ≤55 gal	**40 Gal = .92**	.8808-.0008V	.9254-.0003V	.9307-.0002V	.9349-.0001V
Electric Storage	>55 and ≤120 gal	**80 gal = 2.03**	1.9236-.0011V	2.0440-.0011V	2.1171-.0011V	2.2418-.0011V
Electric Tankless	<2 gal	**.91**	.91	.91	.91	.92
Gas Storage	≥20 and ≤55	**40 Gal = .58**	.3456-.0020V	.5982-.0019V	.6483-.0017V	.6920-.0013V
Gas Storage	>55 and ≤100	**80 gal = .76**	.6470-.0006V	.7689-.0005V	.7897-.0004V	.8072-.0003V
Gas Tankless	<2 gal and >50,000 Btu/h	**.81**	0.80	0.81	0.81	0.81
Oil Storage	≤50 gal	**40 Gal = .54**	.2509-.0012V	.5330-.0016V	.6078-.0016V	.6815-.0014V
Grid Enabled	>75 gal	**80 gal = .91**	1.0136-.0028V	.9984-.0014V	.9853-.0010V	.9720-.0007V

https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

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Water Heater Minimum UEFs

				Current Minimum UEF			
		Volume (Gal)	4/16/15 EF	Very Small Draw (UEF)	Low Draw (UEF)	Medium Draw (UEF)	High Draw (UEF)
Gas Storage	≥20 and ≤55	30	0.63		0.54	0.60	0.65
		40	0.62		0.53	0.58	0.64
		50	0.60		0.51	0.57	0.63
	>55 and ≤100	65	0.75			0.77	0.79
		75	0.74			0.76	0.79
Gas Tankless	<2 gal and >50,000 Btu/h	1.5	0.82	.80	.81	0.81	0.81
Electric Storage	≥20 and ≤55	30	0.95		0.92	0.93	
		40	0.95		0.91	0.92	
		50	0.95		0.91	0.92	
	>55 and ≤120	65	1.98			2.05	2.18
		80	1.97			2.04	2.16
		100	1.94			2.02	2.14
		120	1.92			2.00	2.12
Electric Tankless		<2	0.93	0.91	0.91	0.91	0.92
Oil Storage	≤50	30	0.62		0.49	0.57	0.65
		50	0.59		0.46	0.54	0.60
Grid-Enabled Water Heaters	>75	80	0.93			0.91	0.92
		100	0.89			0.90	0.91
		120	0.86			0.88	0.90

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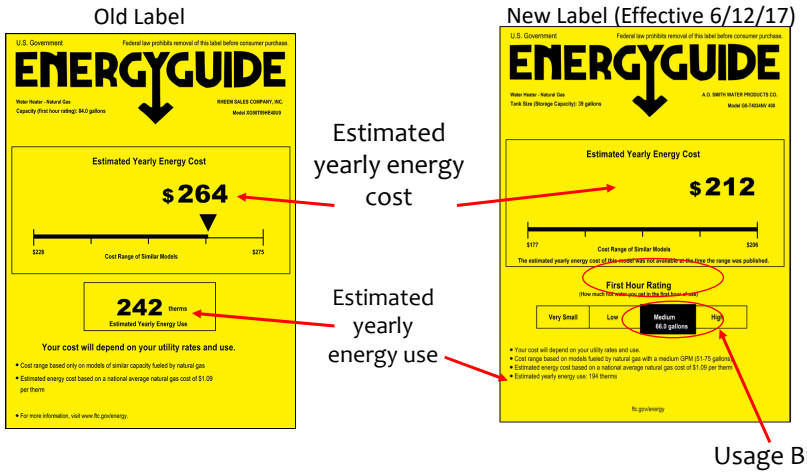
New Energy Guide Label



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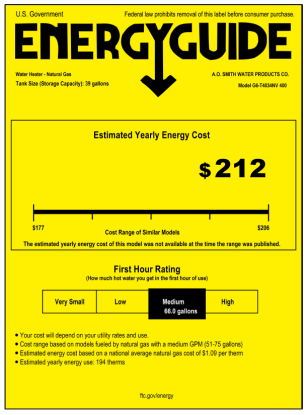
UEF Can Be Confusing to Consumers

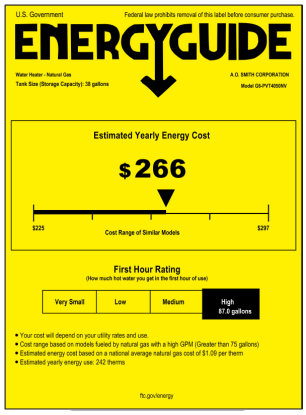


- 40-gallon, atmospheric water heater
- 34,000 BTU/Hr
- UEF = .57
- $409 at big box store

Both labels are from 40-gallon water heaters sold at a big box retailer.

The label on the right appears to cost the consumer more money per year than the left label & could impact purchase decision.

These products are not apples to apples as the one on the right is more efficient. It has a higher first hour rating and as such is in the higher BIN.



- 40-gallon, power vent water heater
- 50,000 BTU/Hr
- UEF = .70
- $774 at big box store

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ENERGY STAR – a Program of the U.S. EPA and DOE

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy "helping us all save money and protect the environment through energy efficient products and practices."

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Energy Star Water Heaters

Water Heater types that qualify for Energy Star

- Gas Storage Water Heaters
- Gas Condensing Water Heaters
- Tankless Water heaters
- Heat Pump Water Heater (electric)
- Solar Water Heaters (Requires back-up)

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Energy Star Eligible Product Types

- **Gas Tank Water Heater:** <=75,000 BTU per hour & contain more than 1 gallon of water per 4000 BTU input.
  - *This means that a water heater with 75,000 BTU input needs at least 18 gallons of storage capacity. The typical tank model is 40+ gallons.*
- **Electric Storage Water Heater:** Heat pump water heaters with max current rating of 24 amperes at 250V or less input. **NOTE: must be a heat pump water heater**
- **Tankless Water Heater:** Less than 1 gallon of water for every 4,000 BTU input, & input rating less than 200,000 BTU per hour.
  - *This means that a 200,000 BTU tankless unit cannot have more than 50 gallons of stored water. Most tankless have only a gallon or two.*
- **High Capacity Tank Water Heater:** Delivery temp less than 180°F, with inputs between 75,000 and 105,000 BTU/h. Can be considered Light Duty EPACT-Covered if reporting thermal efficiency & standby losses and Residential-Duty if reporting UEF.

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Energy Star Criteria

Criteria for Certified Gas-fired Storage Water Heaters

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	Tank Volume >20 gallons and ≤ 55 gallons	Medium Draw Pattern: UEF ≥ 0.81 High Draw Pattern: UEF ≥ 0.86
	Tank Volume > 55 gallons	UEF ≥ 0.86
First Hour Rating		FHR ≥ 51 gallons per hour
Warranty		Warranty ≥ 6 years on system (including parts)
Safety		ANSI Z21.10.1/CSA 4.1

Criteria for Certified Gas-fired Instantaneous Water Heaters

Criteria	ENERGY STAR Requirements
Uniform Energy Factor	UEF ≥ 0.95
Maximum Gallons Per Minute	Max GPM ≥ 2.8 over a 67° rise
Warranty	Warranty ≥ 6 years on heat exchanger and ≥ 5 years on parts
Safety	ANSI Z21.10.3/CSA 4.3

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Energy Star Criteria

Criteria for Certified Electric Storage Water Heaters

Criteria		ENERGY STAR Requirements
Uniform Energy Factor	Integrated HPWH	UEF ≥ 3.30
	Integrated HPWH, 120 Volt / 15 Amp Circuit	UEF ≥ 2.20
	Split System HPWH	UEF ≥ 2.20
First Hour Rating		FHR ≥ 45 gallons per hour
Warranty		Warranty ≥ 6 years on sealed system
Safety		UL 174 and UL1995 or UL 60335-2-40
Lower Compressor Cut-Off Temperature (Reporting Requirement Only)		Report ambient temperature (°F) below which the compressor cuts off and electric resistance only operation begins
Upper Compressor Cut-Off Temperature (Optional Reporting Only)		Partners may report the ambient temperature above which the compressor cuts off and electric resistance only operation begins

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Energy Star Criteria

ENERGY STAR Criteria – Solar Energy Factor

Solar water heater models must meet all of the identified criteria to be labeled as ENERGY STAR.

Criteria for Certified Solar Water Heaters

Criteria	ENERGY STAR Requirements
Solar Uniform Energy Factor	SUEF ≥ 3.00 for electric backup
	SUEF ≥ 1.80 for gas backup
Warranty	≥ 10 years on collector ≥ 6 years sealed system ≥ 2 years on controls ≥ 1 year on parts

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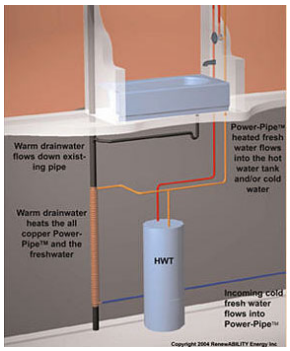
Drain Water Heat Recovery

- Drain Water Heat Recovery systems capture some of the heat from water going down the drain and uses it to preheat incoming water
- Typical installed cost is $750-$1500
- Save 25%-40% on water heating
- Typical payback 2-4 years



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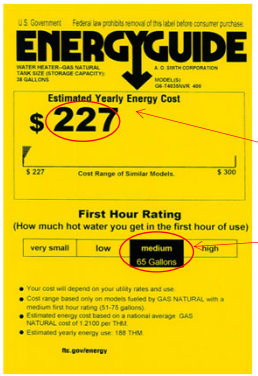
Gas versus Electric Water Heater Comparisons

Gas vs. Electric Tank Water Heater

AO Smith 40 Gallon Gas, .59 UEF



GPH Recovery at 90 Deg F = 38

Cost from Lowes.com
Gas $539
Electric $429

½ the energy cost

First Hour Rating
Gas 65 gallons
Electric 55 gallons

Gas unit provides 20% more hot water in the first hour.

AO Smith 40 Gallon Electric, .92 UEF

GPH Recovery at 90 Deg F = 20.7

Gas unit recovers almost twice as fast as the electric unit once cold

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Source: Lowes.com

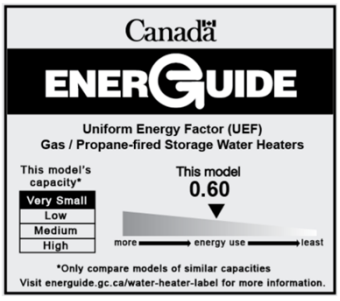
Canadian EnerGuide Labels

EnerGuide label for an Electric Storage Tank Water Heater

Items displayed on the label:

- Standby loss of water heater indicated in Watts
- Range available for similar models (same type and similar capacity)
- The indicator, which positions the model compared with the most efficient and least efficient models in the same class

EnerGuide label for a Gas Storage Tank Water Heater



Items displayed on the label:

- The uniform energy factor (UEF) of the water heater model
- The model's capacity based on the first hour rating
- the indicator, which positions the model compared with the most efficient and least efficient models in the same class

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Costs of Tank-Type Water Heaters

Factors Affecting Price

- Size/capacity of heater: most common sizes are 40, 50 and 75 gallon
- Energy Efficiency: Energy Star rated models have a higher first cost but cost less to operate
- Brand: well known brands may cost more
- Material: stainless steel units cost more than standard steel but can have longevity

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Estimated Costs by Fuel Type

- Gas Water Heaters
  - Average price range: $400 - $1,200
  - Higher installation cost due to required venting
- Electric Water Heaters
  - Average price range: $300 - $900
  - May be cheaper to install but tend to have higher operating costs
- Solar Water Heaters
  - Average price range: $2,000 - $5,000+
  - High initial cost, significant savings on energy bill and an eco-friendly option

Gas heaters typically cost $200 - $400 per year while electric units can cost $400 - $600 annually

These ranges are estimates and can vary based on location, local labor costs, and specific model features.

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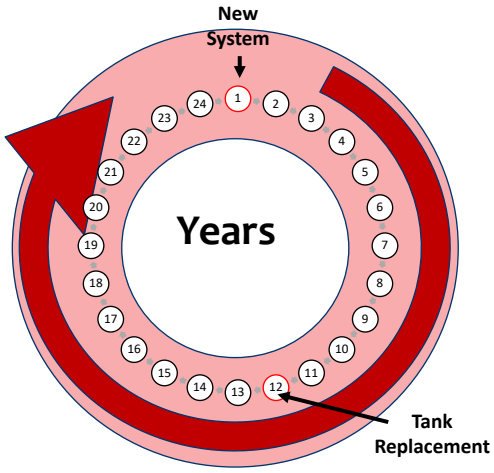
Life Cycle Cost Analysis



Water Heating System installed year 1

Annual Costs include:

- Capital Cost
- Energy Cost
- Tank replacement in year 12 for all tank models
- Assume 24-year Life for tankless model

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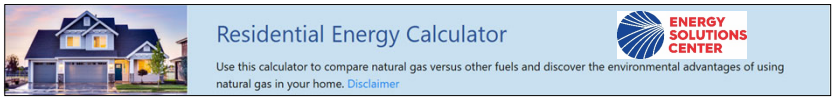
Reducing Carbon Footprint

- Water Heating Carbon Footprint for family of 4

Water Heater Type	CO_2 #/Year
Electric Tank	4,816
Gas Tank	3,081
Gas Tankless	2,388



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HERS Rating and New Construction

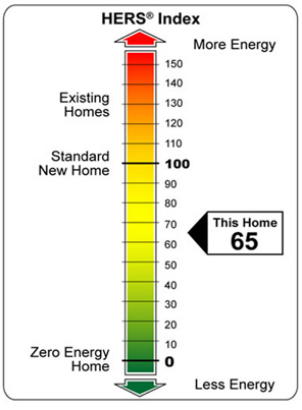
RESNET (Residential Energy Service Network)

Created HERS index to rate homes for Mortgage Industry

Based off a home built to 2006 IECC standards

Lower score is better

Every number = 1% Energy Savings



RESNET

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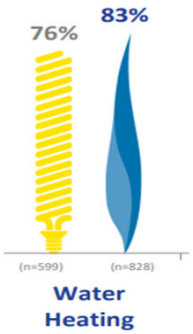
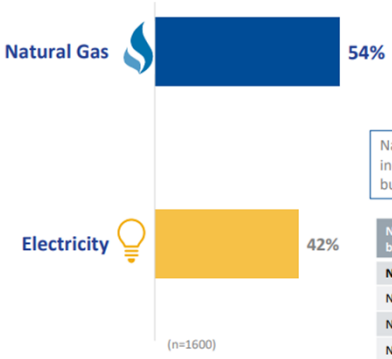
Customer Preference

How do you rate your overall satisfaction with...



And which energy type do you prefer for your...?

Which energy source would you recommend to a family member or friend?



Natural Gas recommendations increase with the number of burner tips.

Natural Gas Recommendation by burner tips	%
Non-Natural Gas	23
NG – 1 burner tip	31
NG – 2 burner tips	59
NG – 3+ burner tips	76

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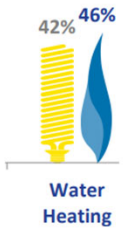
Consumer Home Energy Study – Sparks Research, April 2025

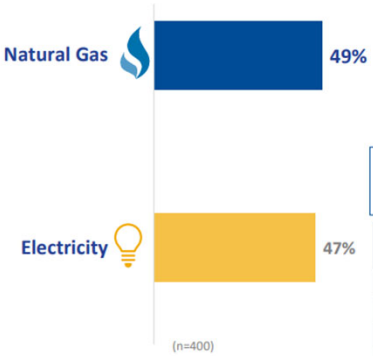
Customer Preference

How do you rate your overall satisfaction with...

And which energy type do you prefer for your...?



Which energy source would you recommend to a family member or friend?



Natural Gas recommendations increase with the number of burner tips.

Natural Gas Recommendation by burner tips	%
Non-Natural Gas	15%
NG – 1 burner tip	21%
NG – 2 burner tips	59%
NG – 3+ burner tips	79%

SPARK RESEARCH 1971 50 YEARS 2021 CELEBRATING 50 YEARS OF EXCELLENCE

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Consumer Home Energy Study – Sparks Research, April 2025

Reasons for Water Heating Source Selection

Reasons for Selecting – Natural Gas

Reason	Percent Selecting
More affordable	37%
Efficient	13%
Heats quicker	11%
Generally positive	10%
Works better	10%
More reliable	9%
Cleaner	7%
What I'm used to	6%
Less outages	5%
Easy to use	4%

(n=866)

Reasons for Selecting – Electricity

Reason	Percent Selecting
Safer	19%
More affordable	15%
Easy to use	12%
What I'm used to	10%
More efficient	9%
Generally positive	7%
Heats quicker	7%
Works better	5%
More reliable	4%
Cleaner	4%

(n=675)

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Consumer Home Energy Study – Sparks Research, April 2025

Reasons for Water Heating Source Selection

Reasons for Selecting – Natural Gas

Reason	Percent Selecting
More affordable	43%
Heats quicker	11%
More efficient	10%
More reliable	9%
Generally positive	8%
Works better	8%
What I'm used to	7%
Cleaner	7%
Readily available	5%
Better for environment	4%

(n=194)

Reasons for Selecting – Electricity

Reason	Percent Selecting
Safer	17%
More affordable	16%
Easy to use	11%
Generally positive	11%
More reliable	10%
Better for environment	9%
Cleaner	8%
What I'm used to	6%
More efficient	5%
Readily available	4%

(n=189)

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Benefits of Natural Gas Water Heating

- Uses less energy – costing about ½ as much to operate versus electric
- Style and sizes to fit most installations
- Tankless – Never run out of hot water
- Long life – 20 years or more with tankless

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Thank You

Consider taking the on-line test while course material is fresh in your mind

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