ENERGY SOLUTIONS CENTER

Track: Commercial Natural Gas
Unit #4: Commercial Water Heating

An overview of Water Heating Technologies

Mr. Eric Burgis, Energy Solutions Center

Presentation Outline

- Market Overview
- Tank Style Water Heaters
- Tankless Water Heaters
- Booster Water Heaters
- Direct Contact Water Heater
- Small Boilers
- Heat Pump Water Heaters
- Water Heater Comparisons
- Case Studies

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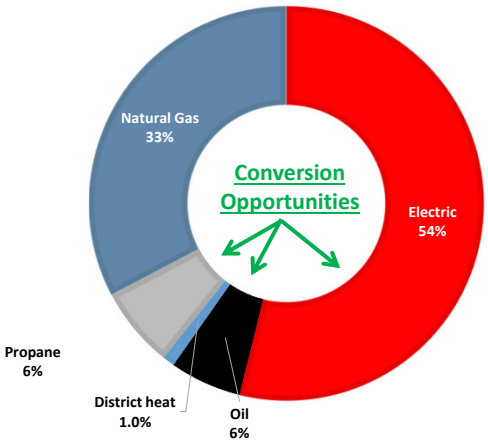
Market Overview Commercial Buildings Water Heating – Fuel Type Used

More than 78% of the 5.9M Commercial Buildings in the U.S. have some type of water heating capability.

www.eia.gov/cbecs

COMMERCIAL WATER HEATING ENERGY SOURCES



CBCES, Table B21

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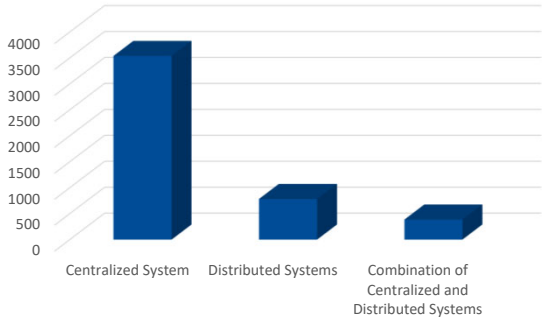
System Use

Centralized Water-Heating System: A type of water-heating equipment that heats and stores water (for purposes other than space heating) in tanks and then distributes this heated water throughout the building. A residential-type tank water heater is an example of a centralized water heater.

Distributed Water-Heating System: A type of system for heating water (for purposes other than space-heating) that heats water as needed for immediate use near the location where this water is used. It is often called a "point-of-use" water heating system, and is usually located in more than one place within a building. Because water is not heated until it is required, this equipment is more energy efficient.

Water Heating Equipment
(# buildings in 1,000's)



EIA, CBECS, Table B13. Selected principal building activity

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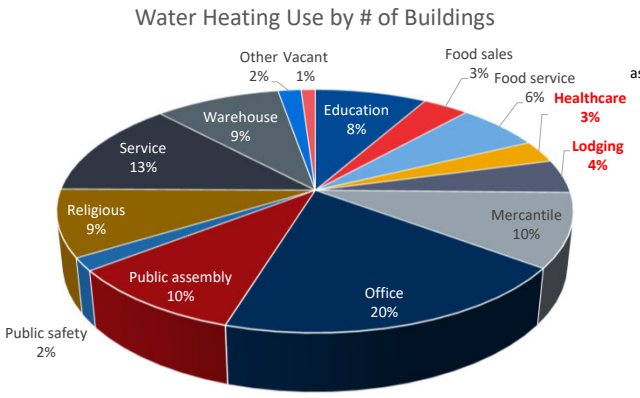
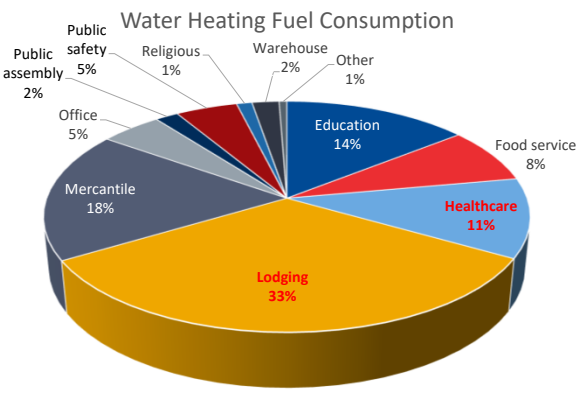
Natural Gas Consumption for Water Heating by Business Activity





Source: EIA CBECS Table B21

Source: EIA CBECS Table E1

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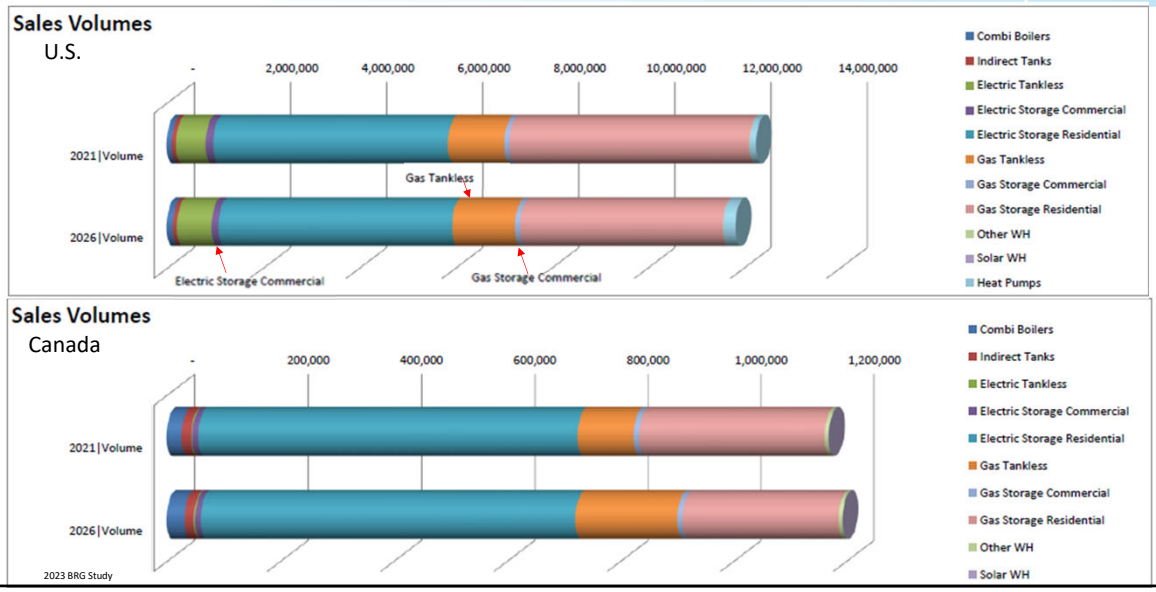
All Water Heater Sales



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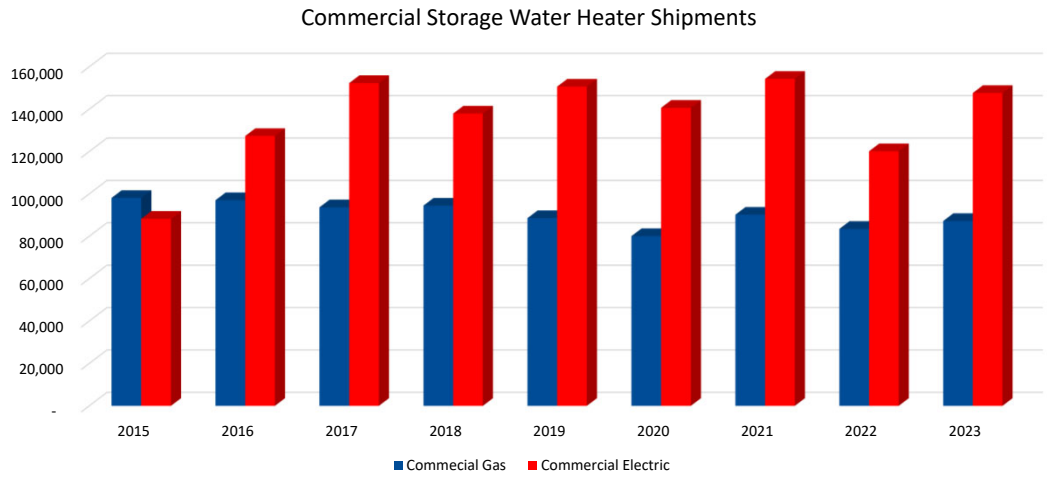
Commercial Water heater Shipments (U.S.)



http://www.ahrinet.org/statistics

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Commercial Water Heater Efficiency Standards

Title 10 Code of Federal Regulations, Part 431.110(a)

Commercial Type	Size	Min Thermal Efficiency for equipment manufactured after Oct 9, 2015 (%)	Min Thermal Efficiency for equipment manufactured after Oct 6, 2026 (%)
Electric Storage	All	N/A	N/A
Gas-fired Storage	**All**	**80%**	**95%**
Oil-fired Storage	All	80%	80%
Gas-fired Instantaneous & Boilers	**All**	**80%**	**96%**

Units <= 199,000 BTU/Hr are typically use Energy Factor or UEF, while larger inputs use Thermal Efficiency.

* Code of Federal Regulations as of 5/23/24

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Residential-Duty Commercial Water Heater Efficiency Standards

Table 2 to § 431.110(c)—Residential-Duty Commercial Water Heater Energy Conservation Standards

Equipment	Specifications[a]	Draw pattern	Uniform energy factor[b]	
			Equipment manufactured before October 6, 2026	Equipment manufactured after October 6, 2026
Gas-fired storage	>75 kBtu/hr and ≤105 kBtu/hr and ≤120 gal	Very Small Low Medium High	0.2674–(0.0009 × V_r) 0.5362–(0.0012 × V_r) 0.6002–(0.0011 × V_r) 0.6597–(0.0009 × V_r)	0.5374–(0.0009 × V_r) 0.8062–(0.0012 × V_r) 0.8702–(0.0011 × V_r) 0.9297–(0.0009 × V_r)
Oil-fired storage	>105 kBtu/hr and ≤140 kBtu/hr and ≤120 gal	Very Small Low Medium High	0.2932–(0.0015 × V_r) 0.5596–(0.0018 × V_r) 0.6194–(0.0016 × V_r) 0.6470–(0.0013 × V_r)	0.2932–(0.0015 × V_r) 0.5596–(0.0018 × V_r) 0.6194–(0.0016 × V_r) 0.6470–(0.0013 × V_r)
Electric instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	Very Small Low Medium High	0.80 0.80 0.80 0.80	0.80 0.80 0.80 0.80

[a] Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) If the water heater requires electricity, it must use a single-phase external power supply; and (2) The water heater must not be designed to heat water to temperatures greater than 180 °F.

[b] V_r is the rated storage volume (in gallons), as determined pursuant to 10 CFR 429.44.

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Water Heating Technologies

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Commercial Water Heaters

- Tank Water Heater
- Tankless Water Heaters
- Booster Water Heaters
- Direct Contact Water Heaters
- Boilers
- Heat Pump Water Heater

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Tank Style Water Heater

- Most common
- Least expensive
- Flexible

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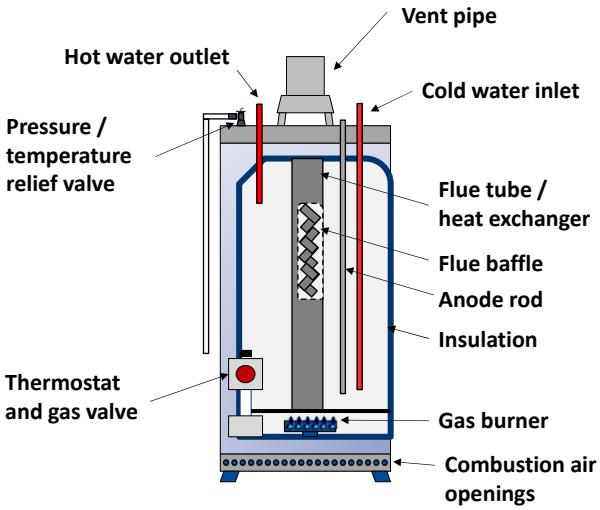
Tank Style Water Heater



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Tank Water Heater Offerings

Atmospheric

Direct Vent

Power Vent

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Tank Style Water Heater

- Sizing
  - Commercial – 35 gallons up to 300 gallons (132-1,135 liters)
- Efficiency
  - DOE minimum standard: 80% commercial Best available technology: 99%
- Considerations
  - Standby loss & Recovery Rate
  - First hour rating

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High Efficiency Storage Water Heater

- 399,000 – 2,000,000 BTU Input
- 125, 250, and 300 (473, 946, and 1,135 liters) Gallon Tanks
- Up To 99% Efficiency (low fire)
- Full Modulation with 10:1 Turndown
- Programmable Electronic Control with Digital Temperature Control
- Category IV Venting with CPVC Vent Material
- 10 Year Tank Warranty
- 3 Year Scale Warranty

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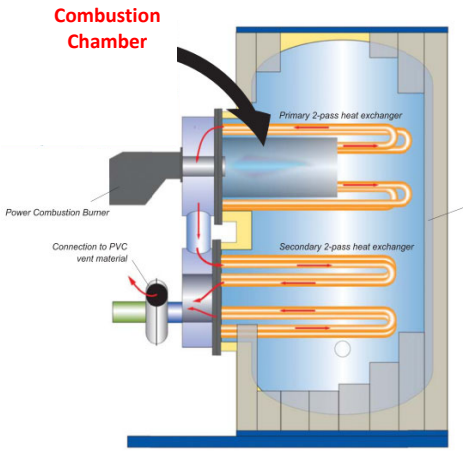
Commercial Fire Tube Condensing

- Removable dual heat exchangers
- Four passes of combustion gases through the water
- PVC venting
- Low NOx burners available



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Intelligence for Tank Water Heaters

- Microprocessor controls
  - Tank maintain 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
- 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

- 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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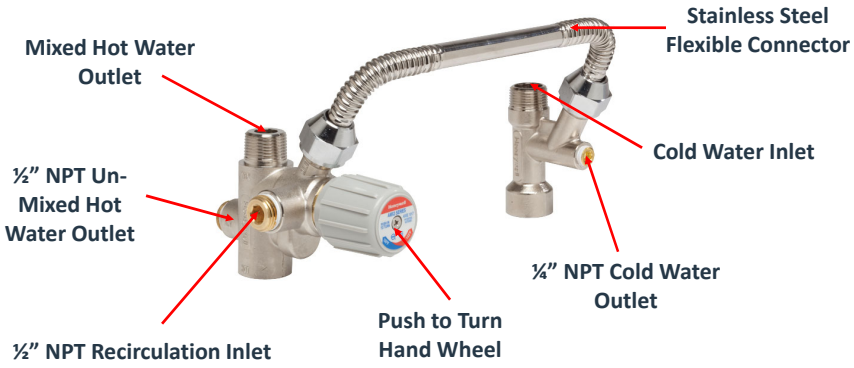
Integrated Mixing Device



*ASSE and UPC (IAPMO) Certified

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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%

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Leak Detection

- Electronic sensor designed to detect leaks
- Triggers an alarm to alert business 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

CONTINUED

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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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Atmospheric Flue Damper

- Reduces stand-by loss resulting in less gas consumption and higher EF Ratings
- Damper blade opens and closes automatically during operation and stand-by mode
- Requires power to control damper

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Tankless Water Heater

- Standard Models
- Condensing Models

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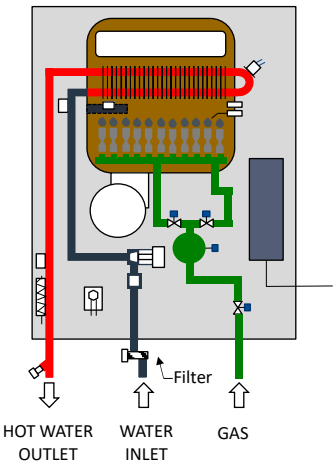
How it Works

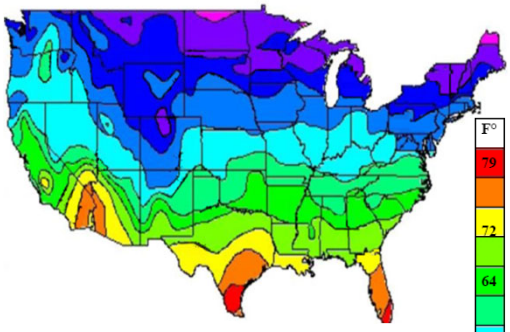
(Internal View)



- 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

What is a Delta T (ΔT)?

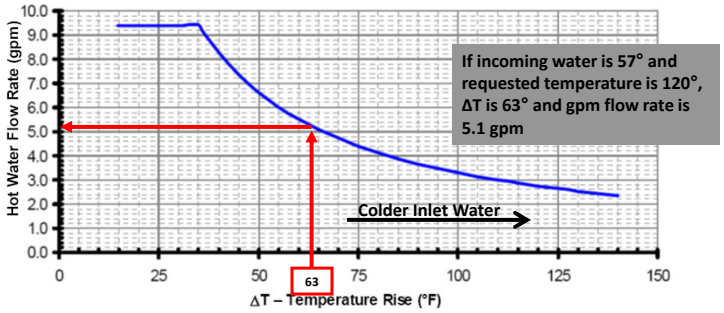
- The difference of the incoming ground water and the tankless water heater's set point temperature is known as Delta T (ΔT)
- Delta T determines the flow rate of the tankless water heater



EXAMPLE:
The Tankless temperature is set at = 120°
Subtract the incoming temperature from the water heater's set temperature for ΔT:
120° - 57° = 63° ΔT

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 °

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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Tankless Water Heaters

- Sizing
  - Up to 380,000 Btu/hr
- Efficiency
  - DOE minimum standard: 80% present
  - DOE minimum standard: 96% as of 10/6/26
  - Best available technology: 98%
- Benefits
  - Higher flow rates than electric
  - Compact size
  - Long-life – 20 years or more
  - Easy to service and repair
- Gas Piping Requirements – ¾" gas line
  - 5.0 inches wc minimum (12.7 centemeters)

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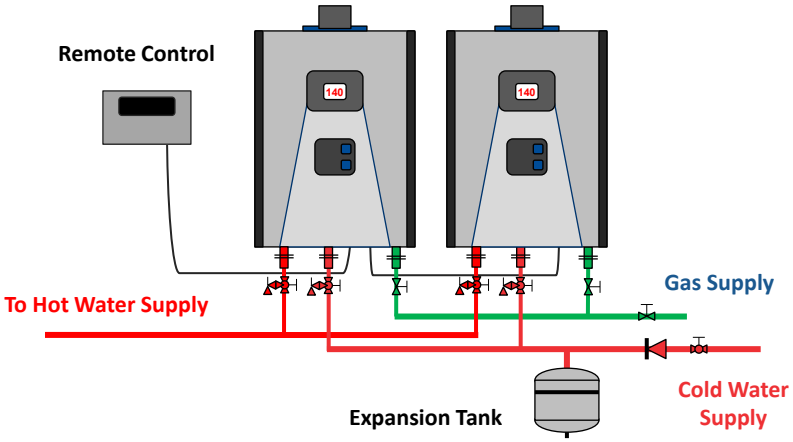
Typical Manifold Installation Options



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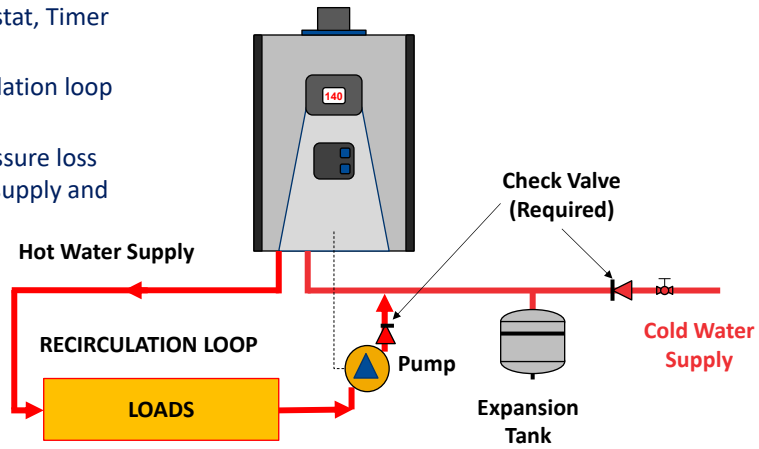
Recirculation Pumps

- 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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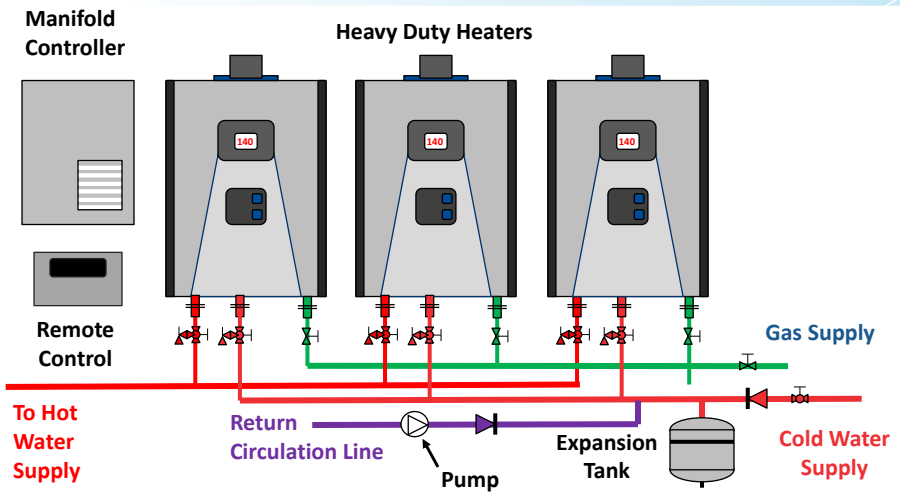
Typical Commercial Manifold with Direct Recirculation



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Good applications for Tankless Water Heaters in the Commercial Market

- Tankless models fit in a variety of commercial applications such as:
  - Restaurants
  - Hotels
  - Multi-family housing
  - Government buildings such as schools
  - Car washes
  - Coin laundries
  - Gyms
  - Others

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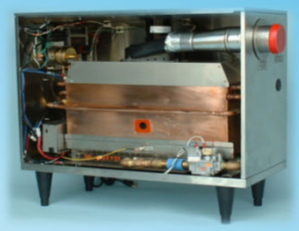
Booster Water Heaters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Booster Water Heaters

- Designed to heat rinse water for better cleaning with fewer spots – especially on glassware
- Heats hot water from 120°-140°F (48.8-60°C) up to 180°F (82.2°C) water
- Improves cleaning and sanitizing of dishes
- Shortens drying time
- Less wear & tear on dishwashing equipment and dishware
- Eliminates need for chemical rinse aids
- Environmentally friendly

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Low Temp Dishwashing

- Does not effectively remove food and soil, resulting in a dish that is not visibly clean and may need re-washing
- 140°F (60°C) water temperature does not melt fats or proteins such as lipstick
- If water hardness is over 6-7 grains, spotting of dishware occurs
- Chemical effect on metals & etching of glasses and china
- Longer drying times due to low rinse temperatures

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Other Booster Water Heater Advantages

- High temperature cleans better, especially on lipstick and grease residues.
- Dishes flash dry with high temperature giving you quicker turnaround and less water on the floor.
- High temperature units reduce chemical, water and sewer usage.
- Labor reduction & increased production (Reduce re-washing dishes)
- Safety in the workplace (Less water on floor means less slip and fall injuries)

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Direct Contact Water Heaters

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Direct Contact Water Heaters

- City water pressure feeds cold water into a vertical tower
- The cold water falls by gravity through an area filled with stainless steel packing rings
- The burner provides hot combustion gases to the vertical tower of the heater – where the hot gases come into direct contact with the falling water
- Rings increase the available surface area inside the tower to transfer heat and also keeps the water broken into smaller droplets

City water pressure through an engineered nozzle creates a specific spray pattern

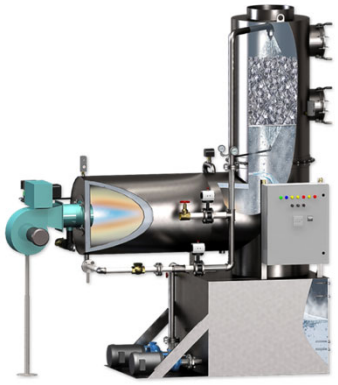
Market Opportunities
- Laundries
- Foodservice Facilities

Not intended for installations where water is re-circulated

Stainless steel rings promote 99% efficient heat transfer

Direct Contact Water Heaters

- Droplets have a smaller diameter, enabling them to take on heat with nearly 100% efficient heat transfer
- As the combustion gases rise through the unit they transfer heat to the water falling in the opposite direction and are cooled until they exit through the stack
- Exhaust gases are close to the same temperature as the temperature of the water spraying through the top nozzle and are at near 100% relative humidity
- The heated water falls down into the reservoir or storage area at the bottom
- A distribution pump, will deliver the hot water, on demand or continuously at the needed discharge pressure and desired temperature



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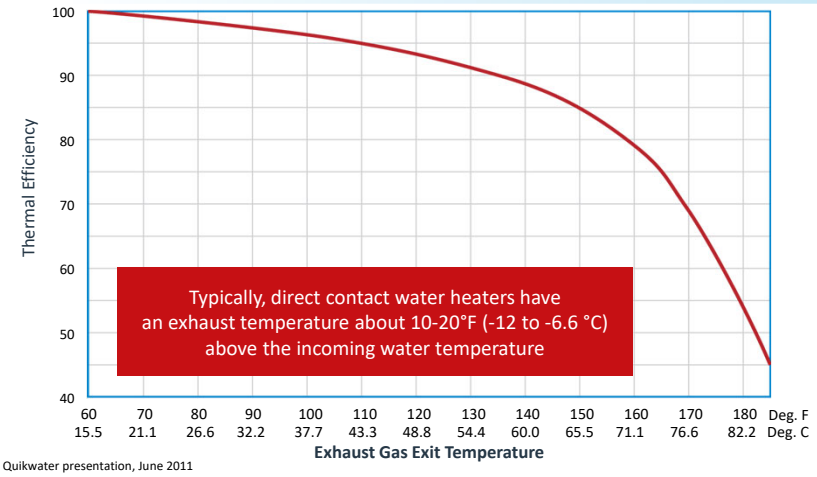
Direct-Contact Heater - Thermal Efficiency



Quikwater presentation, June 2011

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Boilers for Larger Hot Water Needs

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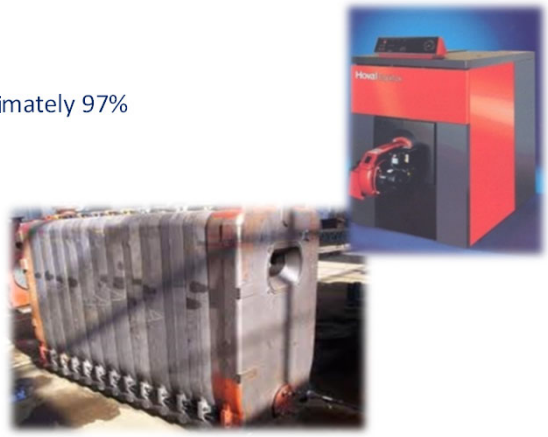
Sectional Boilers

- Contains multiple cast sections
- Unit sizing up to 150 hp
- New Condensing Boilers available
  - Maximum Efficiencies approximately 97%



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Small Fire Tube Boilers

- The furnace/burner section is a single large-diameter tube with many small diameter tubes connected to it
- The small-diameter tubes are arranged above the burner section to provide a larger heating surface area to heat the water
- Burner and tubes are contained entirely within an outer boiler shell that contains the water being heated
- Sizes ranges from under 50 HP to over to 1000 horsepower

https://www.burnhamcommercial.com/product/series-3-firetube-boiler/

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Coiled Tube Boilers

- As in a water tube boiler, water passes through boiler tubes while combustion gases remain in the shell side, passing over the tube surfaces
- Unlike conventional water tube boilers the tubes in a coiled tube boiler form a coil allowing for a more compact vertical configuration and very low water inventory.

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Small Water Tube Boilers

- Water circulates inside tubes heated externally by the burner
- Fuel is burned inside the furnace, creating hot gas which passes over the water tubes, heating the water in the tubes
- Typically larger than Fire Tube boilers

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Finned Tube Boilers

- Water passes through boiler tubes while combustion gases remain on the shell side passing over the boiler tube surfaces
- Unlike conventional water tube boilers, the tubes are fitted with fins that increase the area available to transfer heat to the water

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Condensing Wall Mounted Boiler

- Ultra-High Efficiency Condensing Technology – up to 98% Thermal Efficient (95%+ AFUE)
- Stainless Steel Heat Exchanger
- Ultra Low NOx emissions - SCAQMD approved
- Designed for low maintenance and easy serviceability
- Fully adjustable outdoor reset technology with the sensors available
- Domestic Hot Water has Priority over hot water used to provide space heat

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Commercial Heat Pump Water Heater

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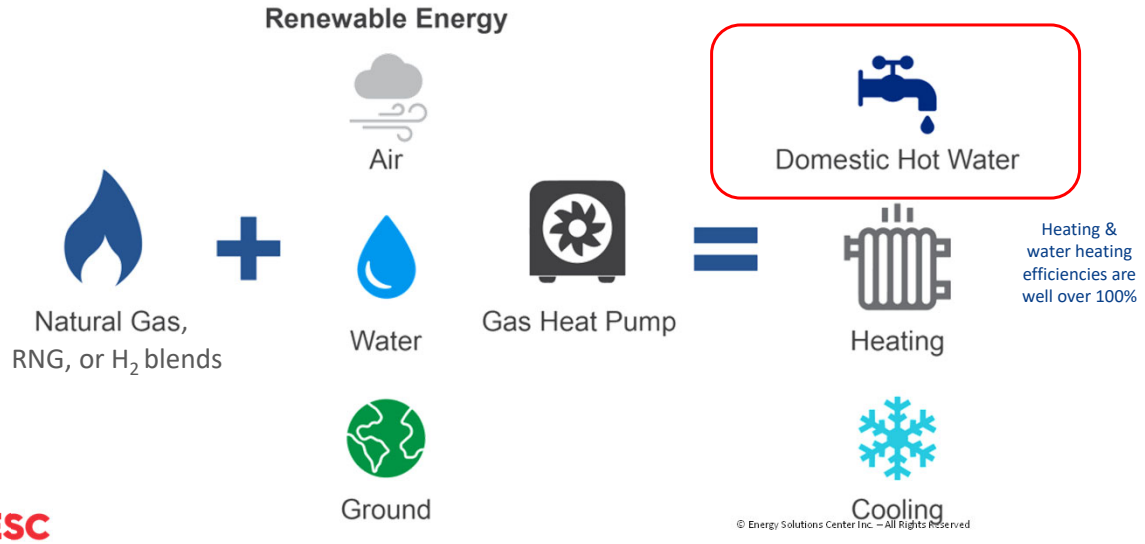
Gas Heat Pumps (GHP)



Natural Gas Heat Pump Water Heaters

- Heat is extracted from the environment
- Types
  - Engine driven
  - Absorption
  - Thermal compression
- Waste heat from combustion is recovered to supplement the heat supplied by the heat pump
- Efficiencies of approx. 140%

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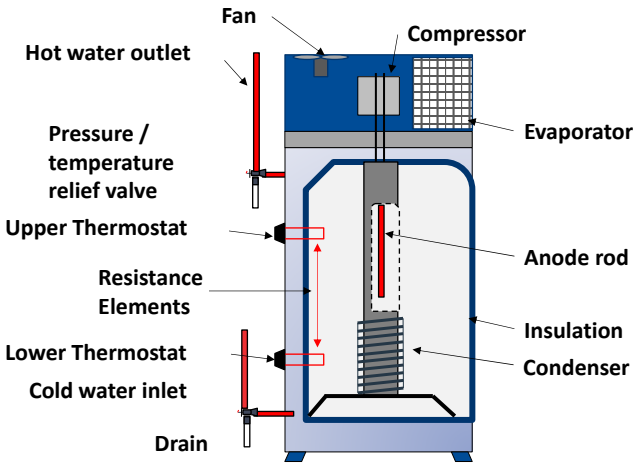
Electric Heat Pump Water Heater (Residential)



- 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
- **Generally cost 2X that of a Gas** tank water heater ($1660 versus $850 for gas unit installed)
- **Only save about $30/Year over a standard gas tank unit**, or about 50% over electric tank unit

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Water Heater Comparisons

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Gas vs Electric Water Heater Comparisons

- Tank Style Water Heaters
  - First Hour Rating
  - Recovery rate
- Water Heater Cost Comparisons
  - Energy
  - Installed Costs
  - Life Cycle Costs
- Emissions

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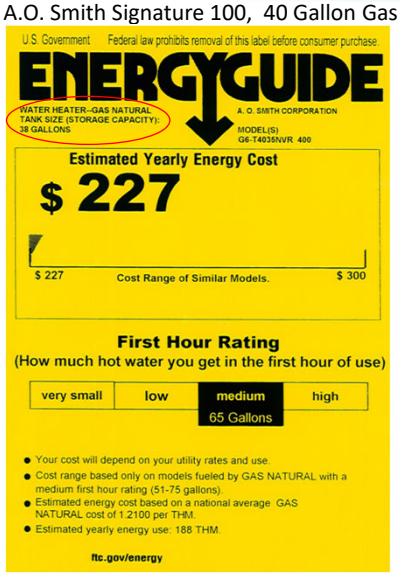
Gas vs. Electric Tank Water Heater

A.O. Smith Signature 100, 40 Gallon Gas



First Hour Rating
Gas: 65 gallons
Electric: 53 gallons

Gas unit provides 23% more hot water in the first hour.

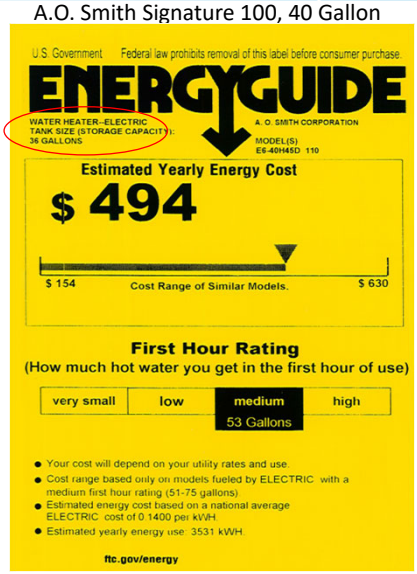
GHP Recovery Rate at 90 Deg F
Gas: 38 GPM
Electric: 20.7 GPM

Gas units recover almost twice as fast as the electric units.

Electric unit costs more than 2X the cost of a Gas tank for energy per year.

Source: Lowes.com

A.O. Smith Signature 100, 40 Gallon



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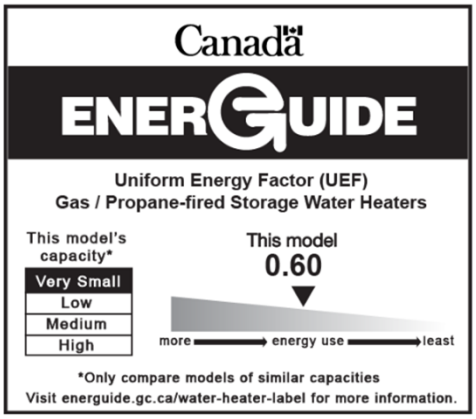
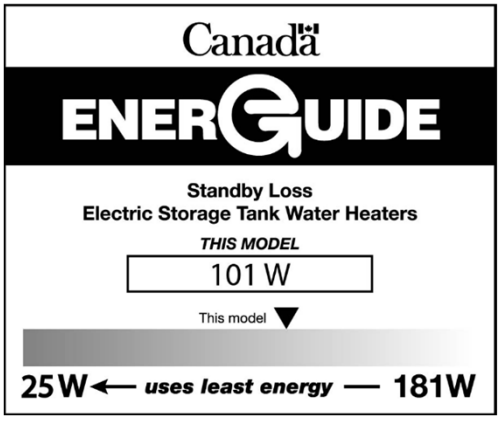
Canadian EnerGuide System



Gas Label



Electric Label

Benefits of Natural Gas Water Heating

- Uses less energy – costing about ½ as much to operate versus electric
- Rapid recovery – 2 times faster than electric tank units
- Style and sizes to fit most installations
  - Tank style
  - Tankless – Never run out of hot water
  - Boilers for larger hot water needs
  - GHPs for very high efficiency
- Long life – 20 years or more with tankless, boilers and absorption GHPs

Case Studies

Ice Rink – Zamboni Filler

- 15 GPM (56.7 LPM) at 165°F (73.8°C) to fill Zamboni storage tank at ½-1 hour intervals
- Prior system was gas fired tanks lasting 1.5-2 years
- Monthly fuel savings realized by tankless is $3,000

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Eat-In Restaurant Application

- New Installation
- Multi-temp system meeting all kitchen & public washroom requirements

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Hotel Tankless Application

- Hotel tankless system
- Providing over 100 GPM (378.5 LPM) / 4,400 GPH (16,655.8 LPH)
- Retrofitted to old boiler room location

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Residential – Condo Application

- 33 Story - 387 Unit Condominium
- 3 condensing boilers for domestic hot water and base load heating
- 3 Boilers for retail hot water
- 3 condensing boilers for domestic hot water in recreation facility

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Elementary School – LEED Building

- LEED building
- 75,000 ft^2 (6,967.7 m^2) facility
- Two A.O. Smith Cyclone XHE® gas water heaters rated at 94% thermal efficiency

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Fitness Center Conversion

- 10 tankless water heaters replaced (2) 2,000,000 BTU boilers and 1,800 gallons (6,813.7 liters) of storage
- This system runs 42 showers and 10 lavatories

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Thank you …

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