Water Heating for Commercial & Industrial Facilities

An Overview of the technologies and opportunities

3/21/13
Presented by:
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Session Outline

• Market Overview
• Market Issues
• Types of Water Heaters
• Water Heating Costs
Water Heating
Market Overview
• In the United States, there are over 4.7 million commercial establishments
  o Market uses approximately 18,260 trillion Btus of energy per year
  o Spends $179.2 billion on their energy
  o Approximately 3.5 million (a little more than 75%) utilize some type of water heating capability

Source: U. S. Department of Energy, 2012 Buildings Energy Data Book – Table 3.1.1 & 3.3.3
Fuel Consumption for Water Heating by Business Activity

<table>
<thead>
<tr>
<th>Business Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodging</td>
<td>29%</td>
</tr>
<tr>
<td>Health Care</td>
<td>16%</td>
</tr>
<tr>
<td>Food Service</td>
<td>11%</td>
</tr>
<tr>
<td>Education</td>
<td>11%</td>
</tr>
<tr>
<td>Office</td>
<td>4%</td>
</tr>
<tr>
<td>Public Order</td>
<td>4%</td>
</tr>
<tr>
<td>Public Assy</td>
<td>5%</td>
</tr>
<tr>
<td>Religious</td>
<td>0%</td>
</tr>
<tr>
<td>Warehouse</td>
<td>1%</td>
</tr>
<tr>
<td>Vacant</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
<tr>
<td>Food Sales</td>
<td>1%</td>
</tr>
<tr>
<td>Mercantile/Service</td>
<td>16%</td>
</tr>
<tr>
<td>Vacant</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
<tr>
<td>Education</td>
<td>11%</td>
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</tr>
<tr>
<td>Health Care</td>
<td>16%</td>
</tr>
<tr>
<td>Lodging</td>
<td>29%</td>
</tr>
</tbody>
</table>

Commercial Buildings Water Heating
Fuel Type Used

- Natural Gas: 0.44
- Electricity: 0.58
- Fuel Oil: 0.03
- Renewables: 0.03

Water Heating
Market Issues
## Legislative policies – Minimum efficiency standards

<table>
<thead>
<tr>
<th>Residential Type</th>
<th>Title 10 Code of Federal Regulations, Part 430</th>
<th>Jan 20, 2004 / April 16, 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Storage</td>
<td>Energy Factor</td>
<td></td>
</tr>
<tr>
<td>Electric Instantaneous</td>
<td>Energy Factor</td>
<td>0.97 / 0.96</td>
</tr>
<tr>
<td>Electric Heat Pump</td>
<td>Energy Factor</td>
<td>0.93 / 0.93</td>
</tr>
<tr>
<td>Gas-fired Storage (40 Gal)</td>
<td>Energy Factor</td>
<td>0.59 / 0.62 (40 Gal Tank)</td>
</tr>
<tr>
<td>Gas-fired Instantaneous</td>
<td>Energy Factor</td>
<td>0.62 / 0.82</td>
</tr>
<tr>
<td>Oil-fired Storage (40 Gal)</td>
<td>Energy Factor</td>
<td>0.59 / 0.68</td>
</tr>
<tr>
<td>Solar</td>
<td>Solar Energy Factor (% from Solar)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Storage</td>
<td>Thermal Efficiency</td>
<td>NA</td>
</tr>
<tr>
<td>Gas-fired Storage</td>
<td>Thermal Efficiency</td>
<td>0.80</td>
</tr>
<tr>
<td>Oil-fired Storage</td>
<td>Thermal Efficiency</td>
<td>0.78</td>
</tr>
<tr>
<td>Gas-fired Instantaneous</td>
<td>Thermal Efficiency</td>
<td>0.80</td>
</tr>
<tr>
<td>Packaged Boiler 2.5+ MMBtu/Hr</td>
<td>Thermal Efficiency</td>
<td>0.82</td>
</tr>
</tbody>
</table>

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

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.

Water Heater types that qualify for Energy Star

- High Efficiency Gas Storage Water Heaters (>= .67 EF)
- Gas Condensing Water Heaters (>= .8 EF)
- Tankless Water Heaters (50,000 to 200,000 Btu/Hr, >=.82EF)
- Heat Pump Water Heater (Electric >= 2.0 EF)
- Solar Water Heaters (Requires back-up)
Energy Star Note on Electric Water Heaters

• “Electric storage tank and tankless water heaters cannot earn the ENERGY STAR because they have limited energy savings potential.”
  
  o Note that the only electric water heater that can earn Energy Star is the electric heat pump water heater.

• “This technology has little to no room for improvement. The perfect electric (storage tank or tankless) water heater could not exceed an Energy Factor of 1.0 due to this technology’s physical limitations.”

http://energystar.supportportal.com/ics/support/KBAnswer.asp?questionID=24866
Types of Water Heaters

- Tank Water Heaters
- Tankless Water Heaters
- Booster Water Heaters
- Condensing Water Heaters
- Direct Contact Water Heaters
- Boilers
- Infrared Water Heaters
- Solar Water Heaters
- Heat Pump Water Heaters
Tank Style Water Heaters

- Most common
- Least expensive
- Flexible
- Large volume users
- Off-peak water heaters
Tank Style Water Heater

- Hot water outlet
- Cold water inlet
- Pressure / temperature relief valve
- Vent pipe
- Flue tube / heat exchanger
- Flue baffle
- Anode rod
- Insulation
- Gas burner
- Combustion air openings
- Thermostat and gas valve
Tank Style Water Heater

• Sizing
  o Residential - 20 to 120 gallons
  o Commercial - 35 gallon up to 250 gallons

• Efficiency
  o DOE minimum standard: 67% residential, 80% commercial (apply derate of resid. Eff. based on storage volume)
  o Best available technology: 98% residential, 99% commercial

• Considerations
  o Standby loss
  o First hour rating
  o Recovery
High Efficiency Atmospheric Units

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

• Achieve much higher efficiency by recapturing the heat that would otherwise be vented

• Up to 98% Efficiency

• These models are direct-vented

• Otherwise similar to standard tank storage water heaters

• ENERGY STAR rated - cutting water heating expenses by about 30%
High Efficiency Storage Water Heater

• 399,000 - 2,000,000 BTU Input
• 125, 250, and 300 Gallon Tank
• 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
Commercial Fire Tube Condensing

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

- Provides space and water heating
- Water heater supplies both
- Can use Tank or Tankless Water Heaters
Tankless Water Heaters
Tankless Water Heaters

- Flow Sensor detects hot water turned on
- When minimum water flow rate is sensed - Gas Valve opens and gas ignites
- Flow control valve and burner settings control temperature of hot water output

Basic Design Concept - Varies by Manufacturer
**Tankless Water Heaters**

- **Sizing**
  - Up to 380,000 Btu/hr

- **Efficiency**
  - DOE minimum standard: 80%
  - Best available technology: 98%

- **Benefits**
  - Efficient
  - 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 pressure
  - 10.5 inches wc maximum pressure
## Product Life Expectancy

### Comparison of Water Heaters

<table>
<thead>
<tr>
<th>Water Heater Type</th>
<th>Energy Savings vs. Minimum Standards</th>
<th>Expected Energy Savings Over Equipment Life</th>
<th>Expected Life</th>
<th>Major Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Efficiency Storage (Tank)</td>
<td>10-20%</td>
<td>Up to $500</td>
<td>8-10 Years</td>
<td>Lowest first cost</td>
</tr>
<tr>
<td>[Oil, Gas, Electric]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tankless</td>
<td>45-60%</td>
<td>Up to $1,800</td>
<td>20 Years</td>
<td>Unlimited supply of hot water</td>
</tr>
<tr>
<td>[Gas, Electric]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, tankless water heater are field repairable which can lessen the cost of repairs and allow them to occur in a more timely manner.

Source: Energy Star - High Efficiency water heaters document
Typical Manifold Installation Options

Remote Control

To Hot Water Supply

Gas Supply

Expansion Tank

Cold Water Supply
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

![Diagram of recirculation system]

- Hot Water Supply
- RECIRCULATION LOOP
- LOADS
- Check Valve (Required)
- Cold Water Supply
- Expansion Tank
- Pump
Understanding Tankless Water Heaters

• Units are not “Standardized”

• Compare units at same temperature rise
  - Do Not Compare a 45° F rise vs. a 35° F rise
  - GAMA rates units at 77° F rise

• Know the minimum fuel pressure required
  - Natural gas - Varies from 5” to 8.5” water column
Understanding Tankless Water Heaters

• Clearance to Combustibles
  o Varies from .5” to 6” or more on the sides
  o 0” to 2” in rear
  o 12” to 36” to the top and 6”-24” to the front

• Minimum Activation Flow
  o Varies from .5 to .78 GPM
• Can the unit detect scale buildup?
  o Preventive maintenance requirements - purge to clean system due to water hardness (Scale)

• Is bigger better?
  o Generally slightly lower efficiency
  o Possible loss of system redundancy for multiple unit installations
  o 200,000 Btu/Hr & higher - not Energy Star rated
Can the unit detect scale buildup?
Preventive maintenance requirements - purge to clean system due to water hardness (Scale)
Booster Water Heaters
Booster Water Heaters

- Designed to heat rinse water for better cleaning with fewer spots - especially on glassware
- Heats hot water from 120°-140° up to 180°F 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
Direct Contact Water Heaters
Direct Contact Water Heaters

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

Stainless steel rings promote 99% efficient heat transfer

Market Opportunities
• Laundries
• Foodservice Facilities

Not intended for installations where water is recirculated
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

• Droplets have a smaller diameter, enabling them to take on heat with nearly 100% efficient heat transfer
Direct Contact Water Heaters

• 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
Boilers
Boilers

• Used for larger commercial facilities with higher demand water needs
• Central water systems can be installed with higher water temperatures and pressures
• Can be used for both potable and space heating loads
• May require a system operator
Sectional Boilers

- Contains multiple cast sections
- Unit sizing up to 150 horsepower
- New Condensing Boilers available
  - Efficiencies approaching 97%
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 100 to 1200 horsepower.
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
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
Condening 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
Indirect Fired Water Heaters

• High efficiency storage tank

• Utilizes a heat exchanger within the tank as a heat source to heat the water
How Indirect Water Heaters Work

- Heating equipment - furnace or boiler
- Storage water heater
Indirect Water Heaters

• Benefits
  o Higher flow rates than electric models
  o Stored hot water always available
  o Can be least expensive water heating option - high-efficiency boiler combined with well-insulated storage tank

• Applications
  • Larger capacity needs
  • Boiler heated facilities
  • Colder climates - where heating system used regularly

• Considerations
  • Work best during cold months when heating system used regularly
  • Less efficient, less economical in warmer climates
Hybrid Systems - Solar/Gas

- Solar water heater with 97% gas-fired back-up heat exchanger
- Internal solar heat exchanger to transfer heat from a solar panel
- Combines with a highly efficient all-in-one storage tank
Solar 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)
Heat Pump
Water Heaters
Small Electric Heat Pump Water Heating Systems

• Better suited for Residential use only

• An electric heat pump can be used to heat water—either as stand-alone water heating system, or as combination water heating and space conditioning system

• 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
Electric Heat Pump Water Heater

- Hot water outlet
- Cold water inlet
- Pressure / temperature relief valve
- Upper Thermostat
- Resistance Elements
- Lower Thermostat
- Drain
- Fan
- Compressor
- Evaporator
- Anode rod
- Insulation
- Condenser
• For larger C&I customers
• Heat is extracted from the environment
  o Note: In Winter the heat gathered by the heat pump may be coming from the space heating system
• A Natural Gas engine replaces the electric motor to drive the system compressor
• The Engine also produces waste heat that is recovered to supplement the heat supplied by the heat pump
• The Engine drives a small electrical generator to provide electricity for fan motors, pump and controls
• Efficiencies up to twice that of a gas-fired boilers
Natural Gas Engine-Driven Heat Pump Water Heater

![Diagram of a natural gas engine-driven heat pump with a heat balance table.]

Heat Balance:

<table>
<thead>
<tr>
<th>Component</th>
<th>Energy [Btu/hr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  Heat Out (A1 + A2)</td>
<td>550,000</td>
</tr>
<tr>
<td>A1 Refrigeration Cycle</td>
<td>419,000</td>
</tr>
<tr>
<td>A2 Engine Heat Recovery</td>
<td>131,000</td>
</tr>
<tr>
<td>B  Natural Gas (@ HHV)</td>
<td>292,000</td>
</tr>
<tr>
<td>C  Heat From Environment</td>
<td>336,000</td>
</tr>
<tr>
<td>D  Electrical Parasitics</td>
<td>17,000</td>
</tr>
<tr>
<td>E  Unrecovered Engine Heat</td>
<td>61,000</td>
</tr>
</tbody>
</table>

COP = A / B = 550/292 = 1.9
Gas Heat Pump Water Heater Product Specifications

- 400,000-600,000 BTU/Hour (4-6 Therms)
- Engine (<50 bhp)
- Ford 2.3 L 4 Cylinder
- Ultra Low Emissions
- Small 5 kW generator for parasitic load
- Next-generation control system
- Internet-Based
- Touch-screen display
- Advanced communications (CAN)
- Efficient, low-pressure, HFC-134a refrigerant
- Open-drive reciprocating compressor
- Custom evaporator coil design
- Compact brazed plate condenser
Costs

• Energy Cost - Gas vs. Electric
• Equipment Costs
• Equipment Life & Life Cycle Cost
  o Tank service life ~ 12 years
  o Tankless service life ~ 20+ years
  o Solar panel service life ~ 24 years
Additional User Savings

• Water temperature setting - set to lowest required temperature or incorporate a reset controller

• Incorporate periodic blowdown of water system and tank to remove sediment to improve efficiency and extend life

• Consider timers if system equipped with pumps
## First Cost / Operating Costs

<table>
<thead>
<tr>
<th>Type Water Heater (Small water heaters)</th>
<th>Efficiency Factor</th>
<th>Average Installed Cost</th>
<th>Annual Operating Cost</th>
<th>CO2 (Pounds / Year)</th>
<th>Annual Natural Gas Usage (Therms)</th>
<th>Annual Electric Usage (KWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Gas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Gas Tank</td>
<td>0.60</td>
<td>$ 850</td>
<td>$ 280</td>
<td>3,145</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>High Eff Gas Tank (Condensing)</td>
<td>0.86</td>
<td>$ 2,000</td>
<td>$ 207</td>
<td>2,331</td>
<td>174</td>
<td>100</td>
</tr>
<tr>
<td>Standard Gas Tankless</td>
<td>0.80</td>
<td>$ 1,800</td>
<td>$ 221</td>
<td>2,495</td>
<td>187</td>
<td>100</td>
</tr>
<tr>
<td>High Eff Gas Tankless (Condensing)</td>
<td>0.93</td>
<td>$ 2,500</td>
<td>$ 192</td>
<td>2,222</td>
<td>161</td>
<td>100</td>
</tr>
<tr>
<td><strong>Solar</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar with Gas Backup</td>
<td>1.2</td>
<td>$ 8,000</td>
<td>$ 146</td>
<td>1,671</td>
<td>125</td>
<td>50</td>
</tr>
<tr>
<td>Solar with Electric Backup</td>
<td>2.5</td>
<td>$ 6,500</td>
<td>$ 202</td>
<td>3,459</td>
<td></td>
<td>1,756</td>
</tr>
<tr>
<td><strong>Electric</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Electric Tank</td>
<td>0.90</td>
<td>$ 750</td>
<td>$ 561</td>
<td>6,940</td>
<td></td>
<td>4,879</td>
</tr>
<tr>
<td>High Eff Electric Tank</td>
<td>0.95</td>
<td>$ 820</td>
<td>$ 532</td>
<td>6,574</td>
<td></td>
<td>4,622</td>
</tr>
<tr>
<td>Electric Heat Pump</td>
<td>2.00</td>
<td>$ 1,660</td>
<td>$ 252</td>
<td>3,122</td>
<td></td>
<td>2,195</td>
</tr>
</tbody>
</table>

Source: Spring 2010 Natural Living Magazine
Life Cycle Cost

<table>
<thead>
<tr>
<th>Life Cycle Cost</th>
<th>Electric Tank</th>
<th>Gas Tank (Power Vent)</th>
<th>Gas Tankless (Standard)</th>
<th>Gas Tankless (Condensing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Cost - Year 1</td>
<td>$ 750</td>
<td>$ 1,200</td>
<td>$ 1,800</td>
<td>$ 2,500</td>
</tr>
<tr>
<td>Tank Replacement - After Yr 12</td>
<td>$ 750</td>
<td>$ 1,200</td>
<td>$ 0</td>
<td>$ 0</td>
</tr>
<tr>
<td>Operating Costs - Year 1</td>
<td>$ 574</td>
<td>$ 238</td>
<td>$ 195</td>
<td>$ 166</td>
</tr>
<tr>
<td>12 Year Life Cycle Cost</td>
<td>$ 8,030</td>
<td>$ 4,056</td>
<td>$ 4,140</td>
<td>$ 4,492</td>
</tr>
<tr>
<td>24 Year Life Cycle Cost</td>
<td>$ 16,983</td>
<td>$ 8,112</td>
<td>$ 6,480</td>
<td>$ 6,484</td>
</tr>
</tbody>
</table>

Assumes that electric prices increase at 1% per year and that gas prices hold stable for the foreseeable future.
Manufacturers

• Numerous manufacturers exist for each water heating technology

• Listed on the following slides are some of the major manufactures by technology type
Tank Water Heater Manufacturers

- Bradford White Corp - http://www.bradfordwhite.com
- GSW - http://www.gsw-wh.com
- Lochinvar - http://www.lochinvar.com
- Rheem - http://www.rheem.com
Tankless Water Heater Manufacturers

• A.O. Smith Water Products Co. - http://www.aosmith.com
• Bosch - http://www.boschhotwater.com
• Bradford White Corp - http://www.bradfordwhite.com
• GasMaster - http://www.gasmaster-ind.com
• Marathon International - BAXI - http://www.wallhungboilers.com
• Navien America Inc. - http://www.navienamerica.com
• Noritz America - http://www.noritz.com/
• Paloma - http://www.palomatankless.com
• Rheem - http://www.rheem.com
• Rinnai - http://www.rinnai.us
• Takagi - http://www.takagi-usa.com
Note that most manufacturers have multiple models to choose from. Specifications vary from model to model. The following slides depict typical product offerings.
Wrap Up: Key Benefits of Using Natural Gas vs. Electric

- Price: Natural Gas is less expensive than electric
- More hot water from gas tank than electric tank
- Faster recovery of gas tank versus electric tank
- Better for the environment
Thank You!

Any Questions?

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