March 11, 2019

Beneficial Electrification of Water Heating

*Greenhouse Gas Reduction Strategies in the Water Heater Market*

ACEEE Hot Water Forum

Nashville, TN

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Introduction
Today’s Presentation

• Analyzing Fuel Choice
• Technology Considerations
• Beneficial Electrification of Water Heating: Three Conditions
• Strategies for Beneficial Electrification of Water Heating
• Concluding Thoughts
**Beneficial Electrification (BE) - Three Conditions**

1. Saves Customers Money Over Long-Term
2. Reduces Environmental Impacts
3. Enables Better Grid Management
Analysis of Consumer and Marginal Costs for Electric and Natural Gas Space and Water Heat in Single Family Residences in Puget Sound Power and Light Company Service Territory

Prepared Pursuant to inter-agency agreement between Public Counsel Section of the Office of the Attorney General of Washington State and Washington State Energy Office

Prepared by:
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Washington State Energy Office
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Seattle, WA 98104

September, 1989

DIRECT USE OF NATURAL GAS FOR RESIDENTIAL SPACE AND WATER HEAT COMPARED TO GAS-FIRED ELECTRIC GENERATION FOR HYDRO-FIRMING

THERMODYNAMIC, ECONOMIC, AND ENVIRONMENTAL IMPACTS

PREPARED FOR
ASSOCIATION OF NORTHWEST GAS UTILITIES
Portland, Oregon

Jim Lazar
Consulting Economist
Olympia, Washington
Fuel Choice – 1989

- Wind and solar were not viable economic resources
- Best heat pumps had a coefficient of performance of about 2
- Heat pump water heaters were not commonly available
- Best natural gas generating plants had about 42% conversion efficiency
Fuel Choice Today

- Wind and solar 2 - 3 ¢/kWh
- Heat pump COPs are better
- New gas generation is as much as 62% efficient
- Modern technology enables load control
Innovative & Efficient End Uses – Electrification is Underway – Heat Pump Water Heating
What’s the Opportunity?

What’s the Opportunity?

US Total
118 Million Homes

Electric Water Heating Technologies
Air Source Heat Pump Water Heaters
Electric Water Heating Technologies
Air Source Heat Pump Water Heaters
Controlled Electric Resistance Water Heaters

The CTA 2045 socket enables any control network to connect to any new water heater.
What’s “Beneficial Electrification”?

Isn’t ALL Electrification “Beneficial”?
Beneficial Electrification (BE) - Three Conditions

1. Saves Customers Money Over Long-Term
2. Reduces Environmental Impacts
3. Enables Better Grid Management
1. Saves Customers Money Long-Term
Consumer Economics: Key Factors

- Efficiency of water heating options
- Amount of water heating desired
- Incremental cost of installation
- Cost of fuel
Water Heat Life Cycle Costs – ACEEE

Water Heat Levelized Cost of Service ($/MMbtu) – NREL

<table>
<thead>
<tr>
<th>Water Heating</th>
<th>2020</th>
<th>2050</th>
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<tbody>
<tr>
<td><strong>Gas Water Heater - Reference</strong></td>
<td>28.9</td>
<td>33.5</td>
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<tr>
<td><strong>High Efficiency</strong></td>
<td>30.4</td>
<td>35.0</td>
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<td><strong>Electric Resistance Water Heater</strong></td>
<td>47.1</td>
<td>49.8</td>
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<tr>
<td><strong>Heat Pump Water Heater</strong></td>
<td>27.6</td>
<td>20.5</td>
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</tbody>
</table>

- **Capital**
- **Fuel**
- **Maintenance**

2. Reduces Environmental Impacts
Power Sector Fuel Mix is Changing: MISO Example

What Are the Marginal Emissions?

Municipal waste, demand response, interface, and other fuels are marginal units less than 1% of the time and excluded from the chart above.

## Emissions

<table>
<thead>
<tr>
<th>Oil Water Heater</th>
<th>Heat Pump WH</th>
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</thead>
<tbody>
<tr>
<td>150 gallons oil/year</td>
<td>1,500 kWh/year</td>
</tr>
<tr>
<td>22 lb CO₂/gallon</td>
<td>50% Gas 50% Coal</td>
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<tr>
<td>3,300 lb CO₂/year</td>
<td>1,400 lb CO₂/MWh</td>
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<tr>
<td></td>
<td>2,100 lb CO₂/year</td>
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## Emissions Efficiency Depends on Electricity System Fuel Mix

Emissions Efficiency (pounds of CO2/MMBTU of useful water heating) for various electric options located on different power grids

<table>
<thead>
<tr>
<th>Energy factor / COP</th>
<th>100% coal</th>
<th>50% gas/50% coal</th>
<th>100% gas</th>
<th>50% gas / 50% non-carbon</th>
<th>100% non-carbon</th>
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</thead>
<tbody>
<tr>
<td>Resistance Water Heater</td>
<td>0.95</td>
<td>715</td>
<td>494</td>
<td>274</td>
<td>137</td>
</tr>
<tr>
<td>Heat Pump Water Heater</td>
<td>3.0</td>
<td>226</td>
<td>157</td>
<td>87</td>
<td>43</td>
</tr>
</tbody>
</table>

- **Resistance Water Heater**
  - Energy factor/COP: 0.95
  - Emissions Efficiency: 715 pounds of CO2/MMBTU for 100% coal, 494 pounds of CO2/MMBTU for 50% gas/50% coal, 274 pounds of CO2/MMBTU for 100% gas, 137 pounds of CO2/MMBTU for 50% gas / 50% non-carbon, 0 pounds of CO2/MMBTU for 100% non-carbon

- **Heat Pump Water Heater**
  - Energy factor/COP: 3.0
  - Emissions Efficiency: 226 pounds of CO2/MMBTU for 100% coal, 157 pounds of CO2/MMBTU for 50% gas/50% coal, 87 pounds of CO2/MMBTU for 100% gas, 43 pounds of CO2/MMBTU for 50% gas / 50% non-carbon, 0 pounds of CO2/MMBTU for 100% non-carbon
Residential Energy Investments Are Long-Lived
3. Enables Better Grid Management
Avoid High-Cost Hours

- Top 1% of hours = 9% of total spending
- Top 10% of hours = 26% of total spending

Source: Rhode Island Power Sector Transformation, Phase One Report to Governor Gina M. Raimondo (November 2017)
Reducing Renewables Curtailment

Note: All curtailment percentages shown represent both forced and economic curtailment. PJM’s 2012 curtailment estimate is for June through December only.

Water Heater Load ... Let's Talk About Managing It
Controllability is Key

Strategies for BE Space Heating

1. State Energy Policies
2. Rate Design
3. Incentive Programs
Energy Efficiency Resource Standards

- Adopt a carve-out for electrification
- Adapt metrics to reflect reductions in primary energy use or GHG emissions
Affordability

The Ultimate Guide to Senior Citizen Low Income Assistance Programs

LIHEAP
Rate Design

Make the choices the customer makes to minimize their own bill consistent with the choices they would make to minimize system costs.

Shift usage to lower-cost and lower-emission hours.
A TOU Rate Does Not Mean a Higher Bill for Typical Residential Consumers

**Flat Rate**
1,000 kWh @ $0.10 = $100

**TOU Rate**
800 kWh @ $.05 off-peak
+ 200 kWh @ $.30 on-peak
= $100

- Hourly Consumption
- Flat Rate $0.10
- Off-Peak TOU Rate $0.05
- On-Peak TOU Rate $0.30
Advanced Pricing Helps Grid Flexibility
Incentive Programs

- Run by utilities, states, and third parties
- May enable or obstruct beneficial electrification
- Tend to reward switching to a more efficient appliance that uses the *same fuel*
- Many explicitly disallow *fuel switching*
- Programs may be working at cross-purposes to BE
Final Thoughts

- Electrification can mean innovation and opportunities
- *Beneficial* Electrification is a framework to help you sort through those opportunities
- Circumstances will vary
  - Analyze for local conditions and trends
  - ID opportunities
  - Remove barriers
  - Consider pilots
  - Educate consumers
Our BE Series

*Beneficial Electrification of Water Heating* is the third of four papers
Additional Resources

- Ensuring Electrification in the Public Interest
- Beneficial Electrification of Space Heating
- Beneficial Electrification of Water Heating
- Beneficial Electrification of Transportation
- Affordable Heat: Whole-Building Efficiency Services for Vermont Families and Businesses
- The carbon floor price – a hammer in need of a toolbox
- Carbon caps and efficiency resources Vt Law Rev 2008
About RAP

The Regulatory Assistance Project (RAP)® is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

Learn more about our work at raponline.org

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