May 7, 2019

Beneficial Electrification of Space Heating

RAP Presentation for American Public Power Association

Jessica Shipley
Associate
1 Introduction

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.

www.raponline.org
Today’s Presentation

1. Analyzing Fuel Choice
2. Technology Considerations
3. Beneficial Electrification of Space Heating: Three Conditions
4. Strategies for Beneficial Electrification of Space Heating
5. Concluding Thoughts
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:
Richard Byers
Washington State Energy Office
809 Legion Way SE
Olympia, WA 98504

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
What’s The Opportunity?

What’s The Opportunity?
2 Technology Considerations
Electric Space Heating Technologies We Looked At

- Air-source heat pumps
  - Ducted or ductless
  - Standard and cold-climate

Electric resistance heater photo: Steffes Corp.
Electric Space Heating Technologies We Looked At

- Air-source heat pumps
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- Air-source heat pumps with back-up or storage heating ("dual fuel")

Electric resistance heater photo: Steffes Corp.
Electric Space Heating Technologies We Looked At

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- Ground-source heat pumps

Electric resistance heater photo: Steffes Corp.
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- Air-source heat pumps with back-up or storage heating (“dual fuel”)
- Ground-source heat pumps
- Electric resistance heating with storage

Electric resistance heater photo: Steffes Corp.
Example Supplemental Heating Sources For Cold Climates and Power Outages

35,000 BTU Vented Propane Room Heater

30,000 BTU Propane Fireplace Insert

Steffes Electric Thermal Storage Room Heater
Optimal Heating Technology Varies by Climate Condition
Optimal Heating Technology Varies by Climate Condition
Optimal Heating Technology Varies by Housing Type
Optimal Heating Technology Varies by Housing Type
## Summary of Technology Considerations

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<th>Coldest outdoor temperature</th>
<th>Single Family Homes</th>
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<tr>
<td></td>
<td>New well-insulated</td>
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<tr>
<td>30 degrees F</td>
<td>✓</td>
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<td>5 degrees F</td>
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- **Air source heat pump**
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- **ASHP w/ supplemental heat**
- **Electric resistance storage**
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3 BE for Space Heating – Three Conditions
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 space heating options
- Building type and its thermal efficiency
- Space cooling desired?
- Incremental cost of installation
- Cost of fuel
Current Economics of Converting Existing Oil Furnaces to Air Source Heat Pumps

Annual Fuel Cost Savings (or Loss) by Switching to Air Source Heat Pump From Oil Furnace

![Bar chart showing annual fuel cost savings or losses for different states.](chart)

Source: Compiled with data from American Council for an Energy-Efficient Economy and US Energy Information Administration.
Current Economics of Space and Water Heating Electrification (Oakland, CA)

- **Standard Heat Pump**: $11.5
- **Flexible Heat Pump**
  - Default Time-of-Use (TOU) Rate: $11.8
  - 3:1 TOU: $10.9
- **Natural Gas with Existing Air Conditioner (AC)**: not applicable
- **Natural Gas with New AC**: $13.7

# Current Economics of Space and Water Heating Electrification (Oakland, CA)

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Current Economics of Space and Water Heating Electrification (Providence, RI)

Future Economics of Converting Existing Gas Furnaces to Air Source Heat Pumps

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

Power Sector Fuel Mix Is Changing: Public Power

Public Power Generation by Energy Source - National, 2007

- Coal, 45.7%
- Gas, 16.3%
- Hydro, 18.1%
- Nuclear, 16.6%
- Other, 1.9%

Public Power Generation by Energy Source - National, 2017

- Coal, 35.0%
- Gas, 24.3%
- Hydro, 22.5%
- Nuclear, 15.9%
- Other, 2.1%
Emissions

Oil Furnace

Heat Pump (ENERGY STAR®)
Emissions

Oil Furnace

513 gallons oil/year

22 lb CO₂/Gallon

11,300 lb CO₂/year

Heat Pump (ENERGY STAR®)
Emissions

Oil Furnace

- 513 gallons oil/year
- 22 lb CO₂/Gallon
- 11,300 lb CO₂/year

Heat Pump (ENERGY STAR®)

- 7,754 kWh/year
- 50% Gas; 50% Coal
- 1,400 lb CO₂/MWh
- 10,855 lb CO₂/year
Emissions Efficiency Depends on Electricity System Fuel Mix

Emissions Efficiency (pounds/MMBTU of useful space heating) for various electric technologies, located on different power grids.
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Emissions Efficiency (pounds/MMBTU of useful space heating) for various electric technologies, located on different power grids

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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)
Reduce Renewables Curtailment

Note: Each year, the total reflects only those ISOs for which we have curtailment data.

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

4 Strategies for BE Space Heating

1. Building Codes
2. State Energy Policies
3. Rate Design
4. Incentive Programs
Building Codes

- Importance of thermal efficiency
- Move toward requiring high-efficiency electric space heating and cooling
- New residential structures “all electric ready”?
Energy Efficiency Resource Standards

- Adopt a *carve-out* for electrification
- Adapt metrics to reflect reductions in primary energy use or GHG emissions
Affordability
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.
Smart Rate Design
For a Smart Future

Authors
Jim Lazar and
Wilson Gonzalez

July 2015
Key Elements of TOU Rates: Fort Collins, Colorado

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Two-Peak Rate Design

Rate design as modeled for Oakland 3:1 TOU scenario

- Off Peak
- Preheat
- Peak

Times:
- 6 a.m.
- 12 p.m.
- 6 p.m.
Two-Peak Rate Design

Rate design as modeled for Oakland 3:1 TOU scenario

Potential two-peak TOU rate design
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
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**

- Muni incentive programs have more flexibility
- **SMUD:**
  - Up to $5000 for new all-electric homes
  - Up to $13,750 for gas-to-electric conversions

Source for images www.mitsubishicomfort.com
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 Space Heating* is the second of four papers.
- *Beneficial Electrification: Ensuring Electrification in the Public Interest* was published in June 2018.
- Papers on BE considerations for water heating and electric transportation published early 2019.
Beneficial Electrification Resources from RAP

- Beneficial Electrification: Ensuring Electrification in the Public Interest
- Utilities Can Get a “LEG” Up with Beneficial Electrification—But Regulators Also Have to be Ready
- Beneficial Electrification: A Growth Opportunity
- Beneficial Electrification: A Key to Better Grid Management
- Environmentally Beneficial Electrification: The Dawn of Emissions Efficiency (Electricity Journal)
About RAP

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Learn more about our work at raponline.org

Contact Jessica at: jshipley@raponline.org