March 11-13, 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

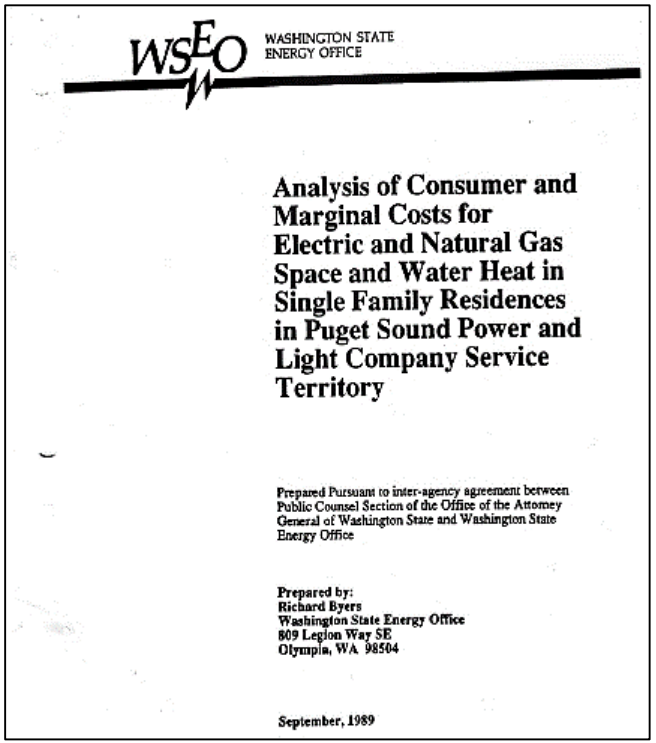
- Analyzing Fuel Choice
- Technology Considerations
- Beneficial Electrification of Water Heating: Three Conditions
- Strategies for Beneficial Electrification of Water Heating
- Concluding Thoughts

Beneficial Electrification (BE) - Three Conditions

1. Saves Customers Money Over Long-Term

2. Reduces Environmental Impacts

3. Enables Better Grid Management



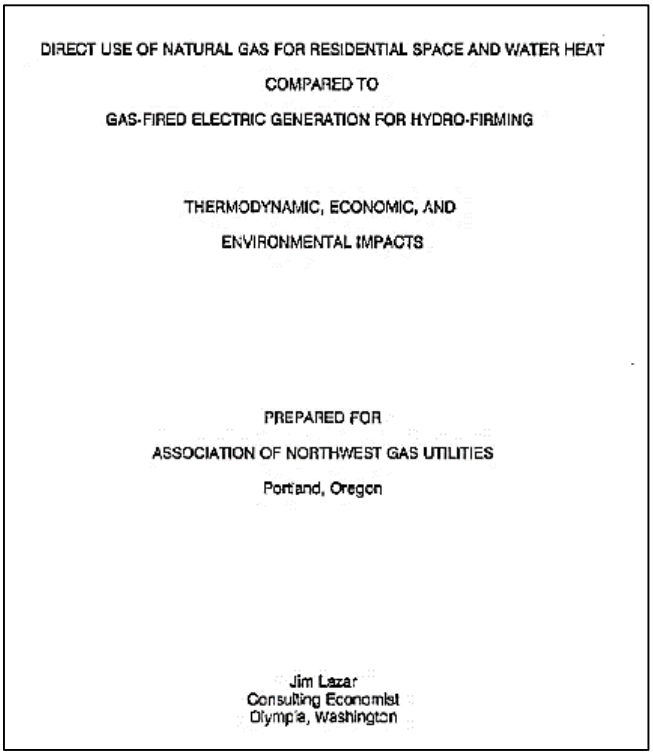
WSEO WASHINGTON STATE ENERGY OFFICE

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

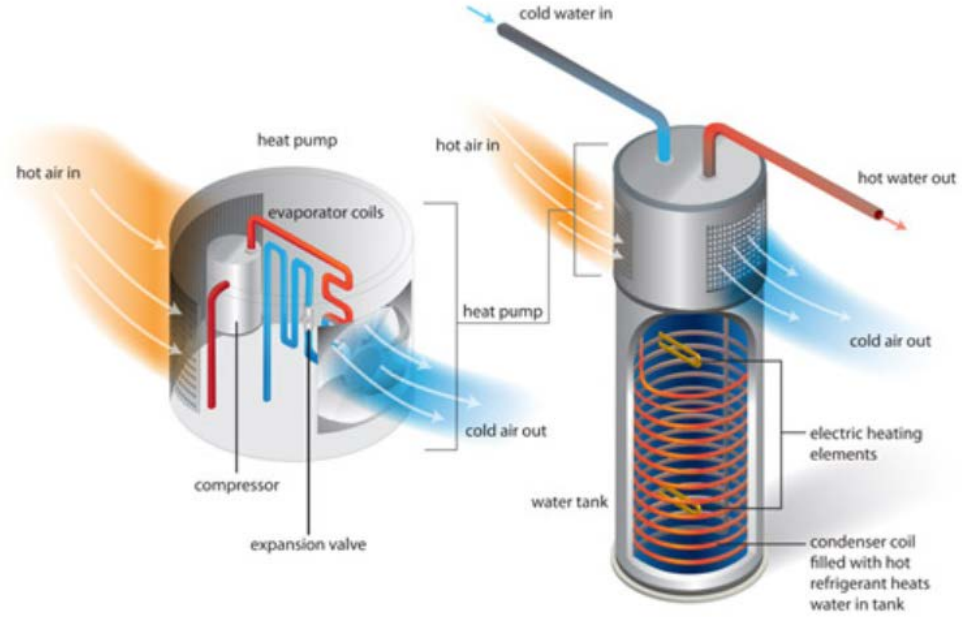
Fuel Choice – 1989

- 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

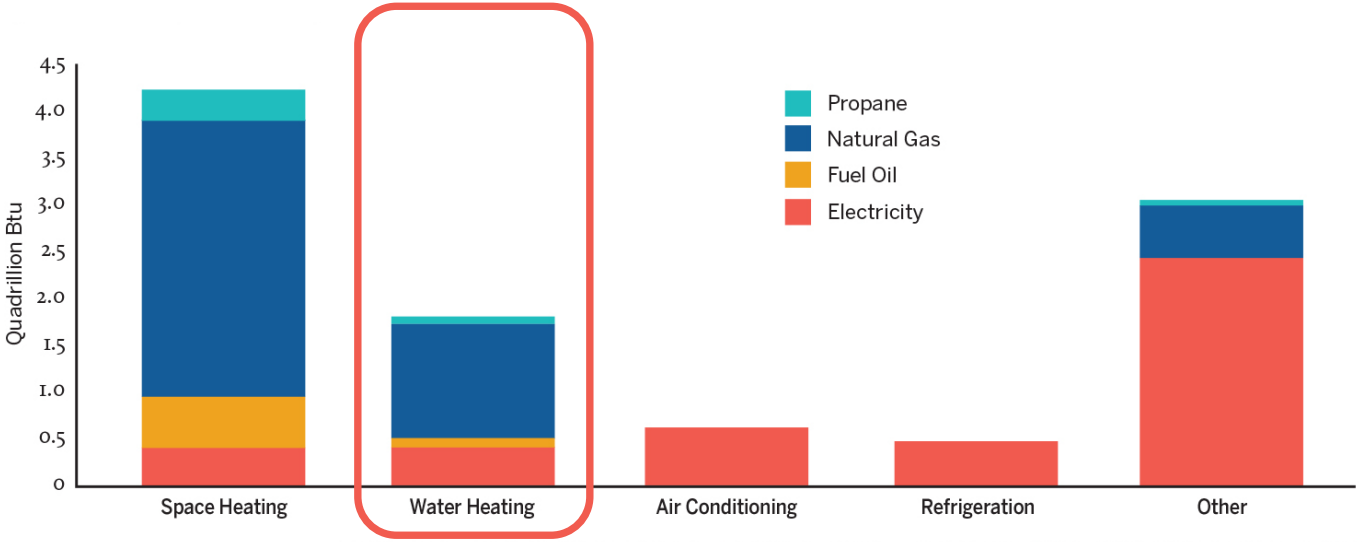
Fuel Choice Today

- 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 – Heat Pump Water Heating

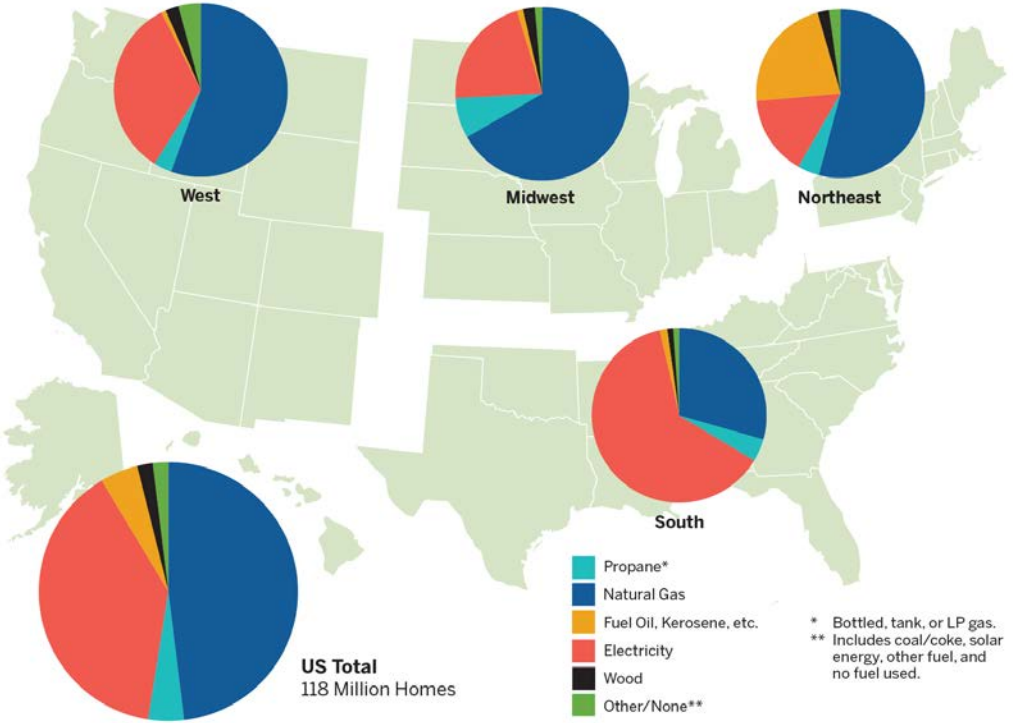


What's the Opportunity?



Source: Steinberg, D., Bielen, D., Eichman, J., Eurek, K., Logan, J., Mai, T., et al. (2017). *Electrification & Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization*, using data from Energy Information Administration 2009 Residential Energy Consumption Survey.

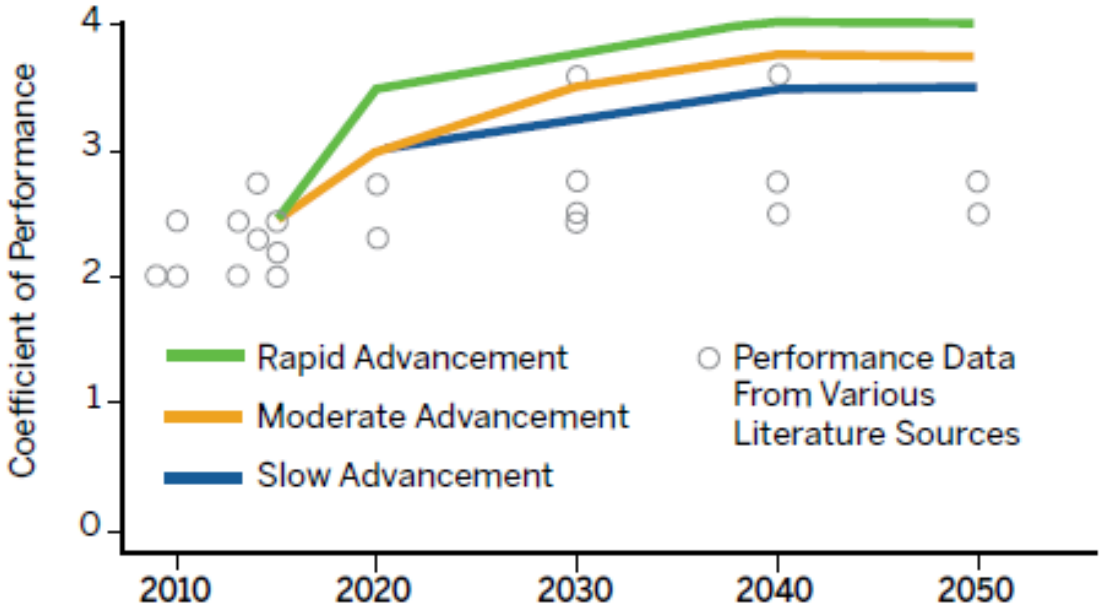
What's the Opportunity?



Technology Considerations

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.

Portland General Electric

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

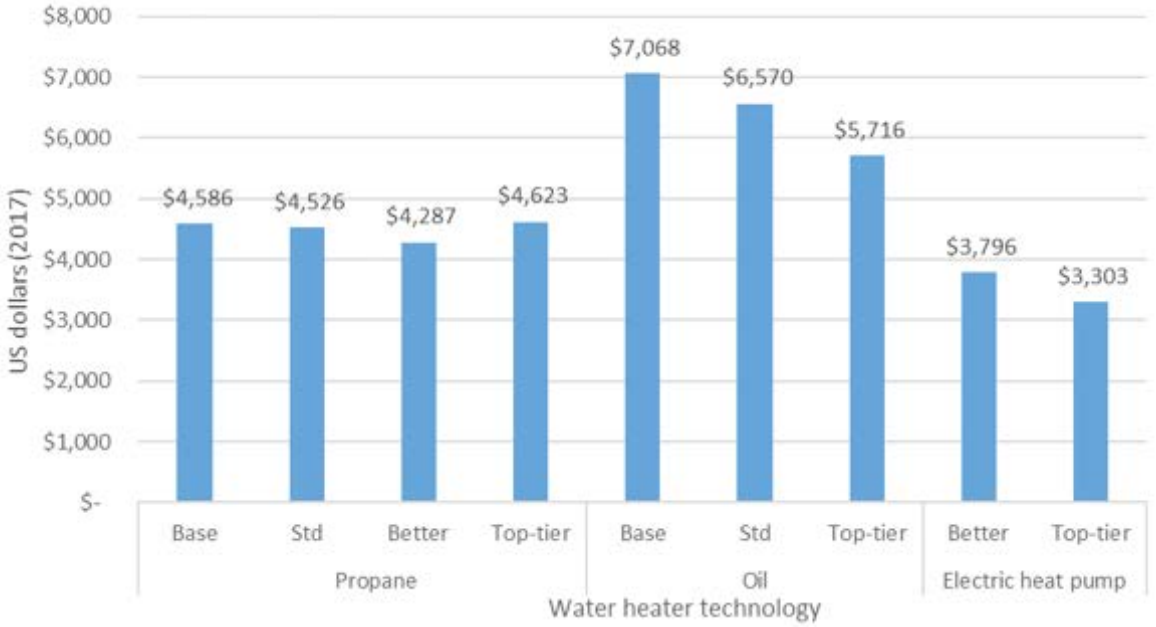
3. Enables Better Grid Management

1. Saves Customers Money Long-Term

Consumer Economics: Key Factors

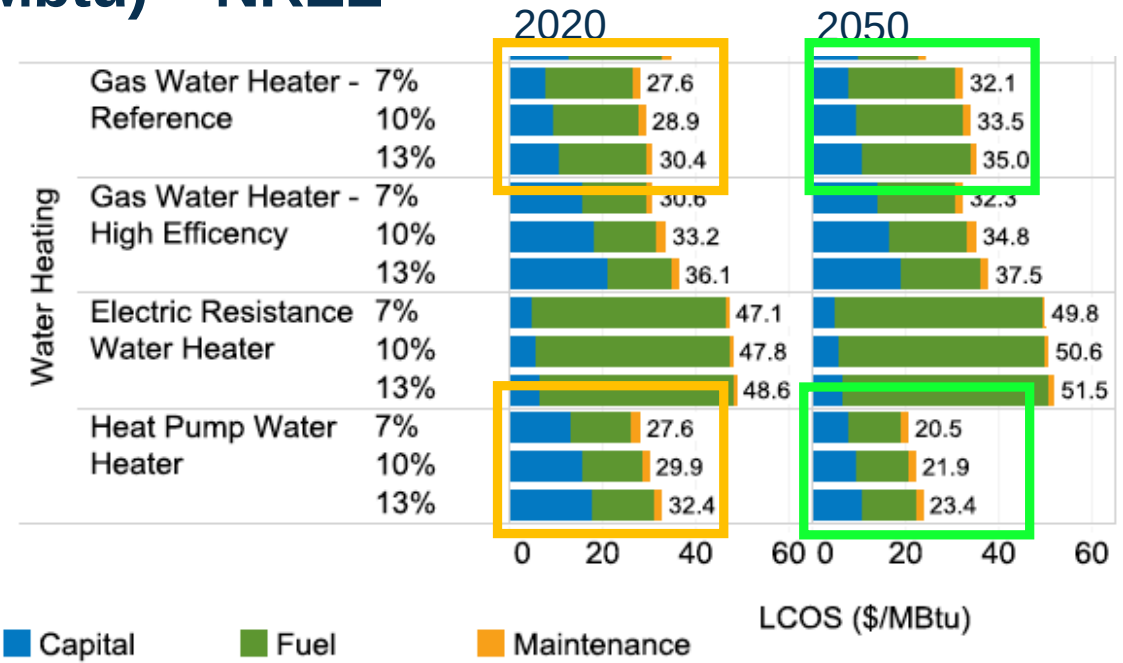
- Efficiency of water heating options
- Amount of water heating desired
- Incremental cost of installation
- Cost of fuel

Water Heat Life Cycle Costs – ACEEE



Nadel, S. (2018). *Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps.* American Council for an Energy-Efficient Economy. Retrieved from http://aceee.org/research-report/a1803

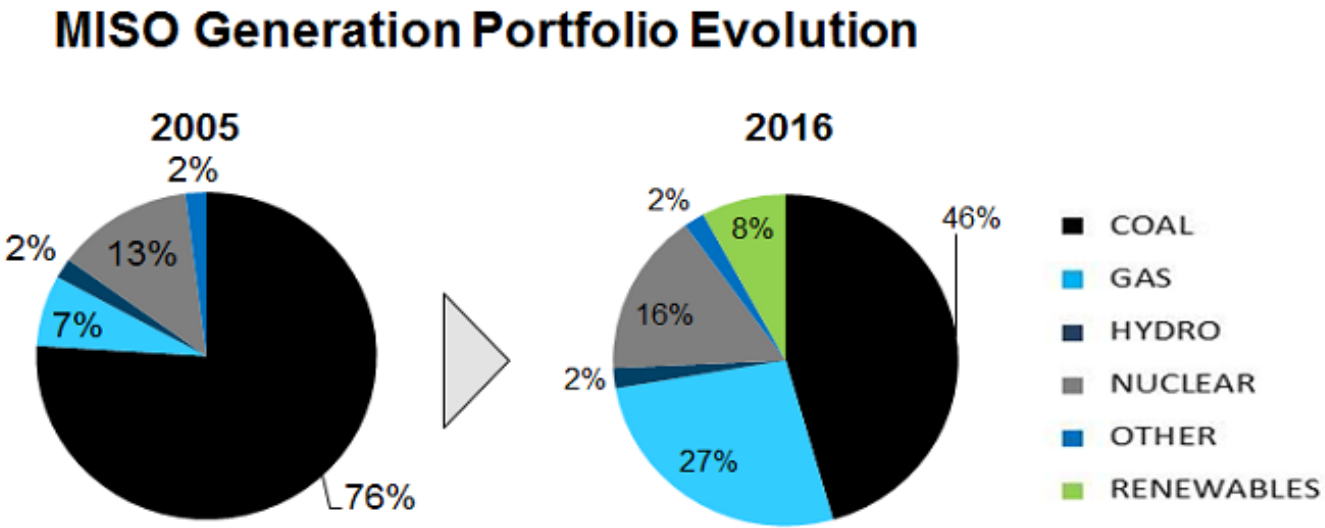
Water Heat Levelized Cost of Service ($/MMbtu) – NREL



Jadun, Paige, et al. 2017. Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050 . Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-70485. https://www.nrel.gov/docs/fy18osti/70485.pdf.

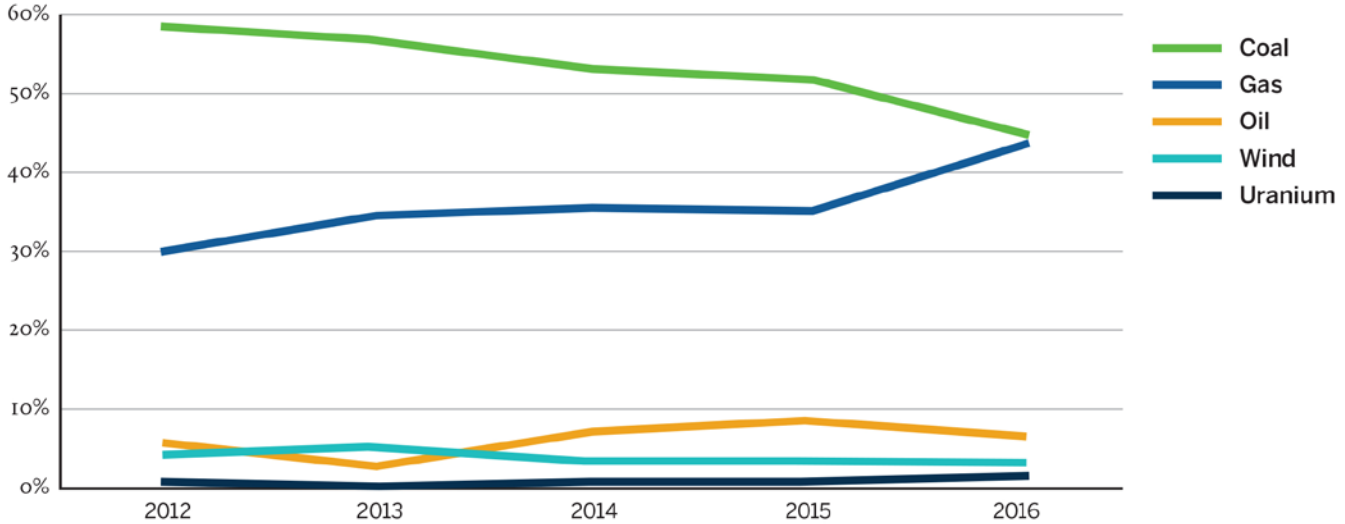
2. Reduces Environmental Impacts

Power Sector Fuel Mix is Changing: MISO Example



http://www.misomatters.org/2017/03/3-electricity-industry-issues-we-are-watching-in-2017/

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.

Adapted from: PJM Interconnection. (2017). *2012-2016 CO_2, SO_2 and NO_X Emission Rates.*

Emissions

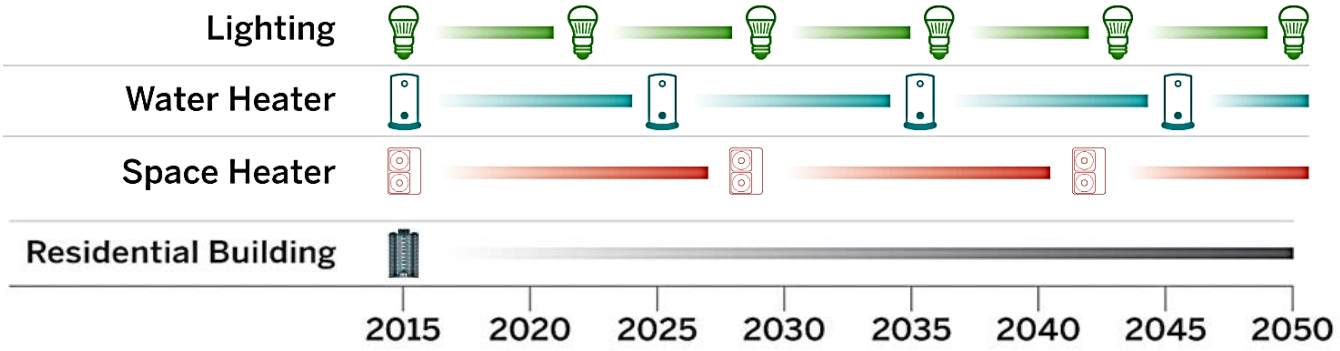
Oil Water Heater	Heat Pump WH
150 gallons oil/year	1,500 kWh/year
22 lb CO_2/gallon	50% Gas 50% Coal 1,400 lb CO_2/MWh
3,300 lb CO_2/year	2,100 lb CO_2/year

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

	Energy factor / COP	Electric Units				
		100% coal	50% gas/50% coal	100% gas	50% gas / 50% non-carbon	100% non-carbon
Resistance Water Heater	0.95	715	494	274	137	0
Heat Pump Water Heater	3.0	226	157	87	43	0

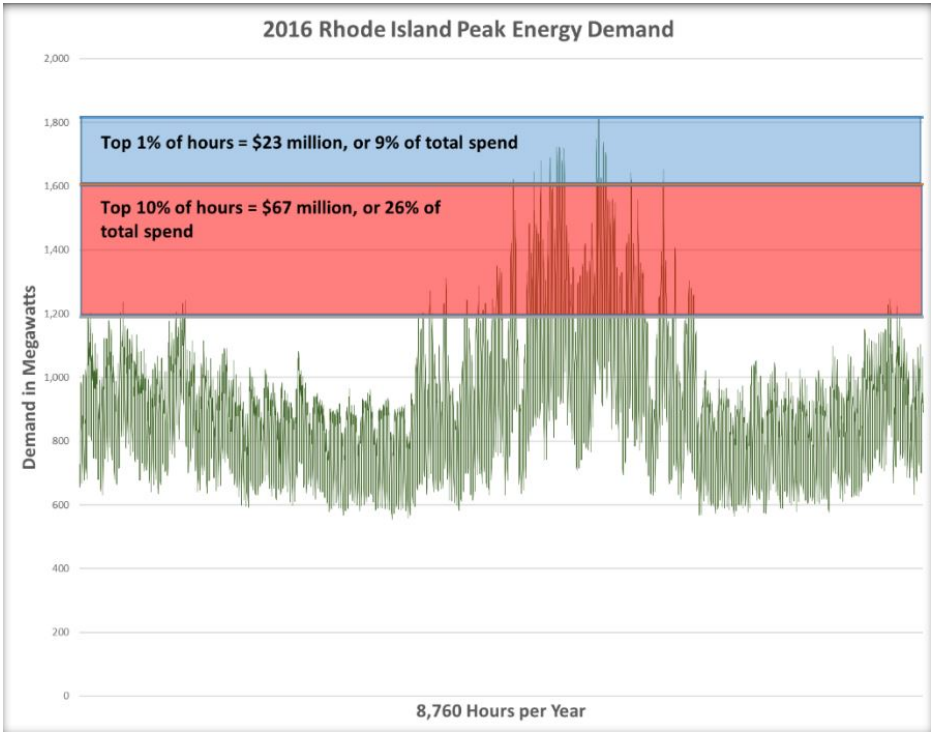
Residential Energy Investments Are Long - Lived



3. Enables Better Grid Management

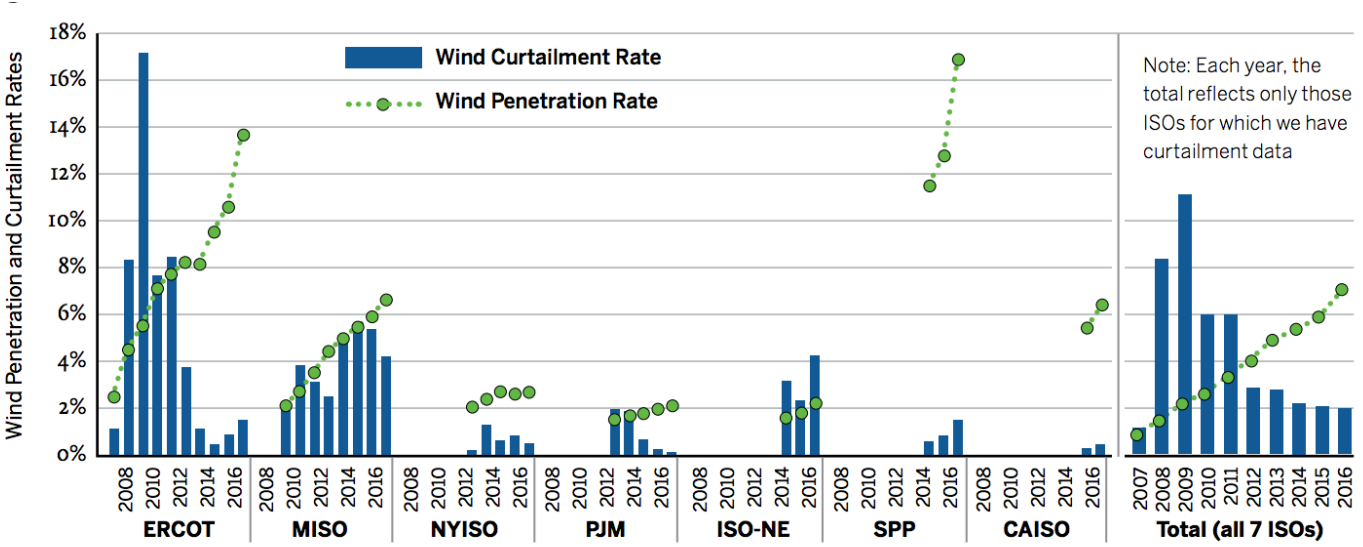
Avoid High-Cost Hours

- 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)

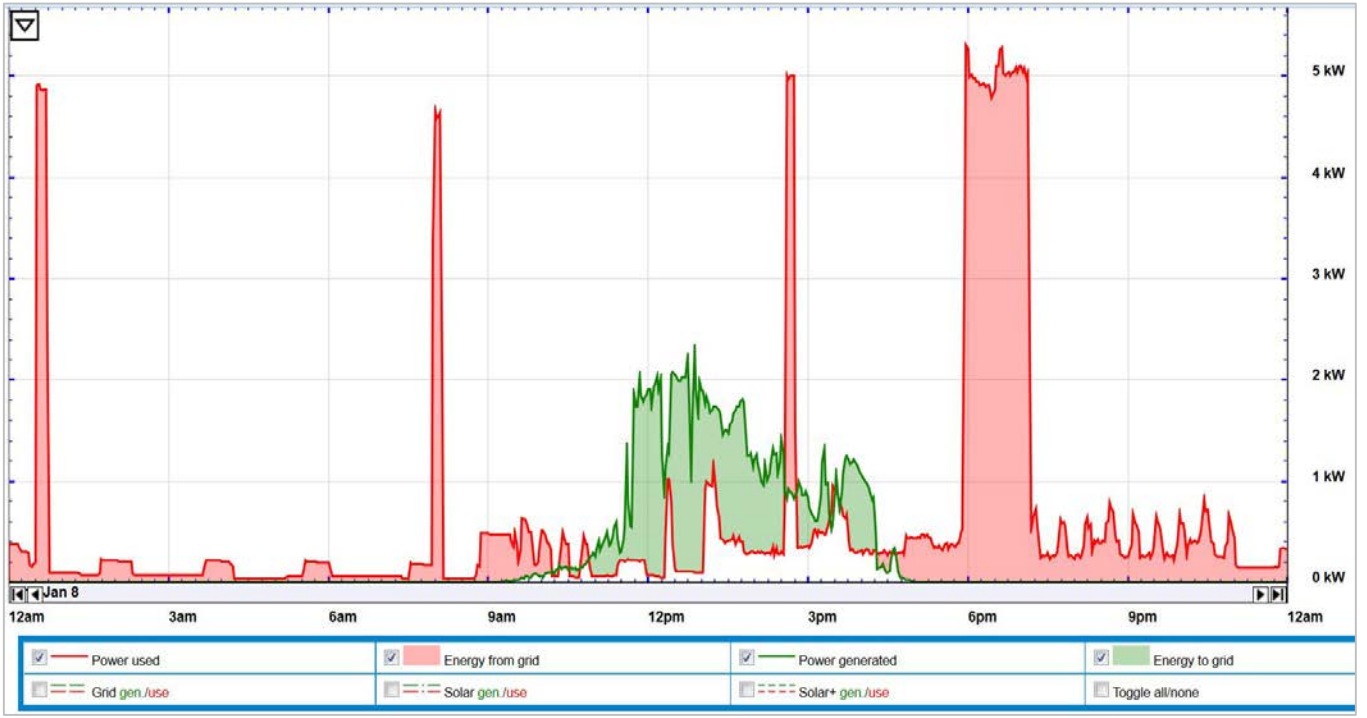
Reducing Renewables Curtailment



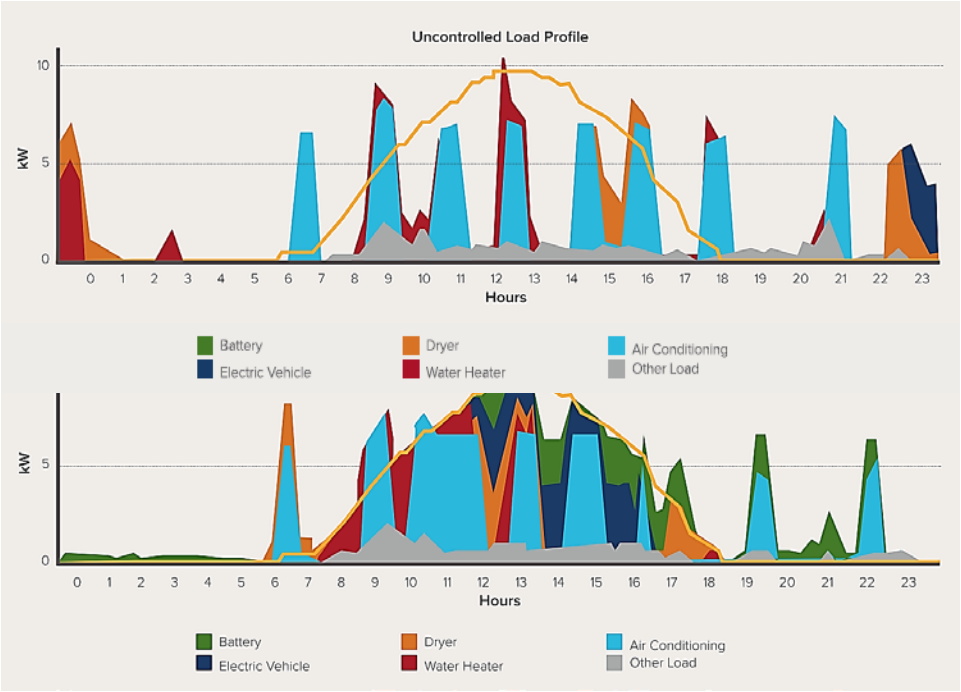
Note: All curtailment percentages shown represent both forced and economic curtailment.
PJM's 2012 curtailment estimate is for June through December only.

Source: Wiser, R., & Bolinger, M. (2017). *2016 Wind Technologies Market Report.*

Water Heater Load …
Let's Talk About Managing It



Controllability is Key



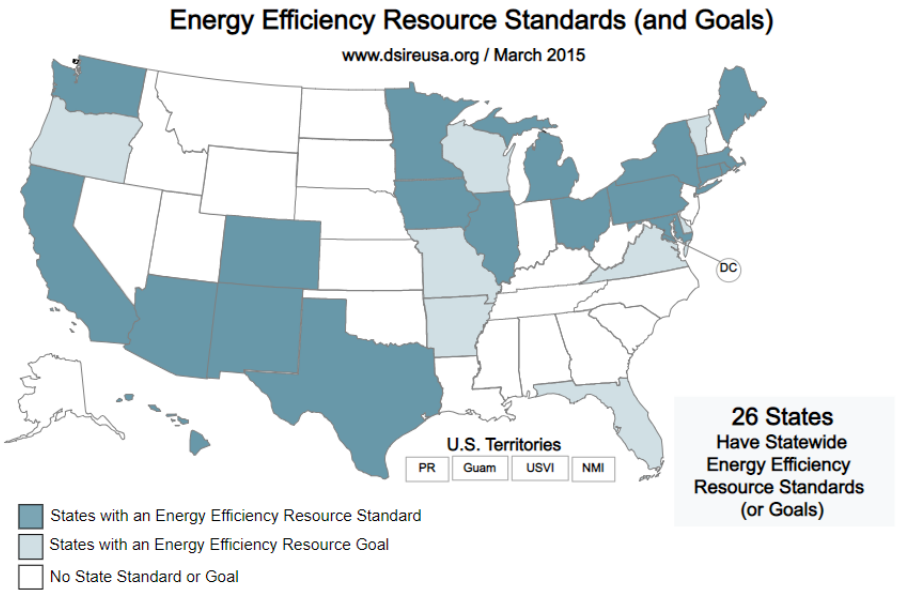
Billimoria, S., et al (2018). *The Economics of Electrifying Buildings*. Boulder, CO: Rocky Mountain Institute. Retrieved from https://www.rmi.org/insights/reports/economics-electrifying-buildings. Thermostat image: Nest.com.

Strategies for BE Space Heating

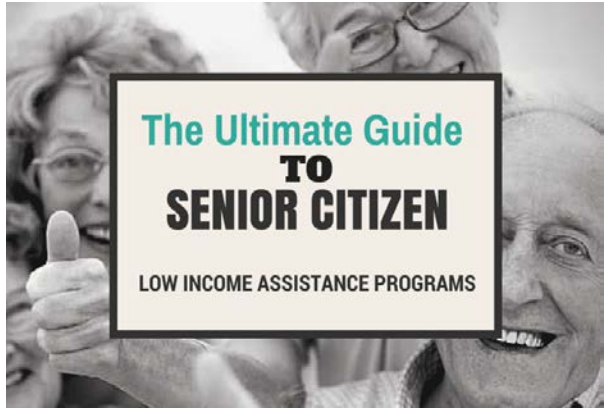
1. State Energy Policies
2. Rate Design
3. Incentive Programs

Energy Efficiency Resource Standards

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



Affordability

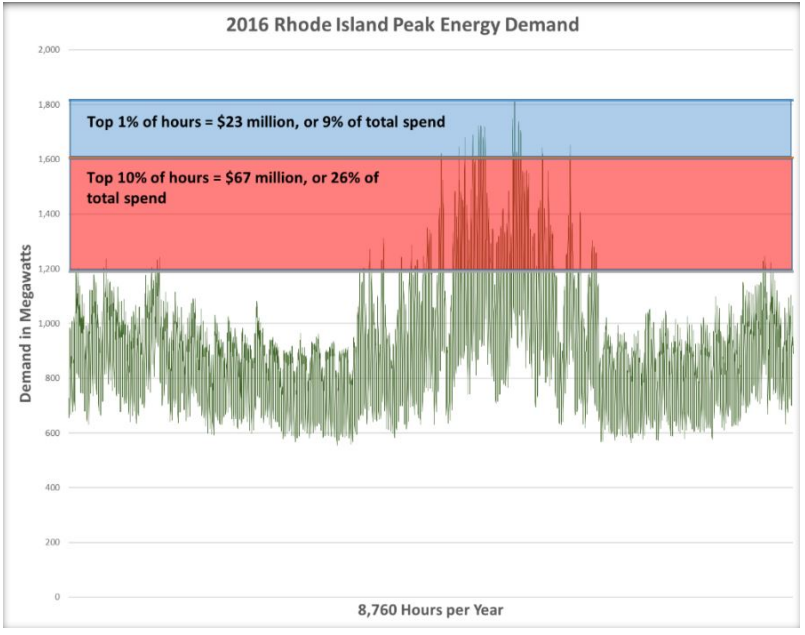


LIHEAP

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.



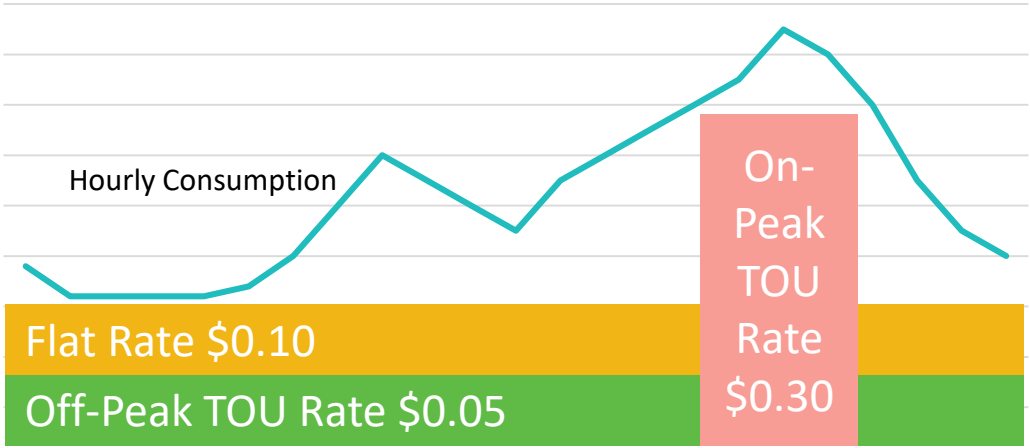
A TOU Rate Does Not Mean a Higher Bill for Typical Residential Consumers

Flat Rate

1,000 kWh @ $0.10 = $100

TOU Rate

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

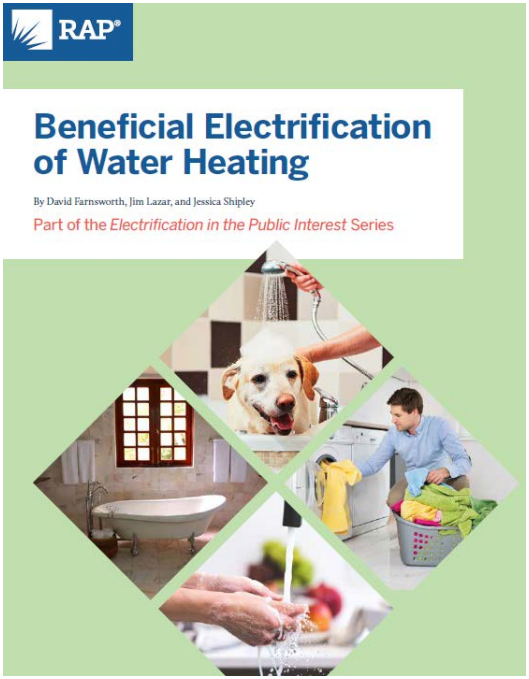


Incentive Programs

- 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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