8 November 2018

Beneficial Electrification of Space Heating

RAP Webinar

David Farnsworth
Senior Associate

Jim Lazar
Senior Advisor

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

Our Experts

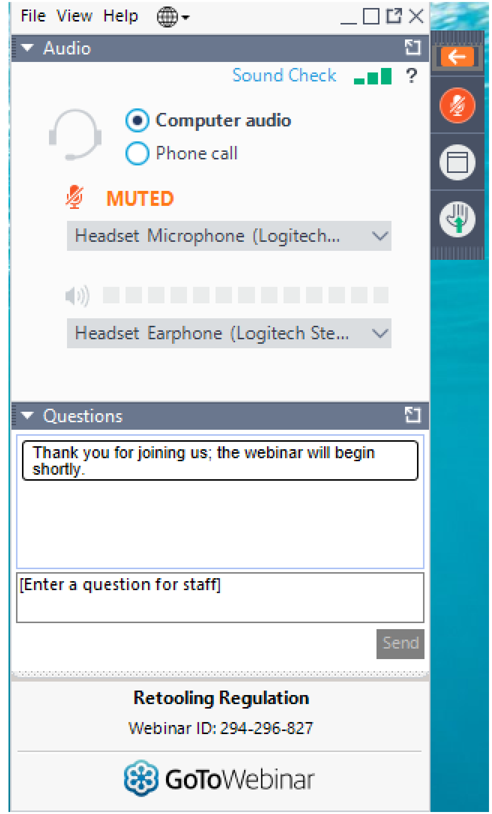
David Farnsworth

Jim Lazar

Jessica Shipley

Questions?

Please send questions through the Questions pane



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

Beneficial Electrification (BE) - Three Conditions

1. Saves Customers Money Over Long-Term

2. Reduces Environmental Impacts

3. Enables Better Grid Management

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

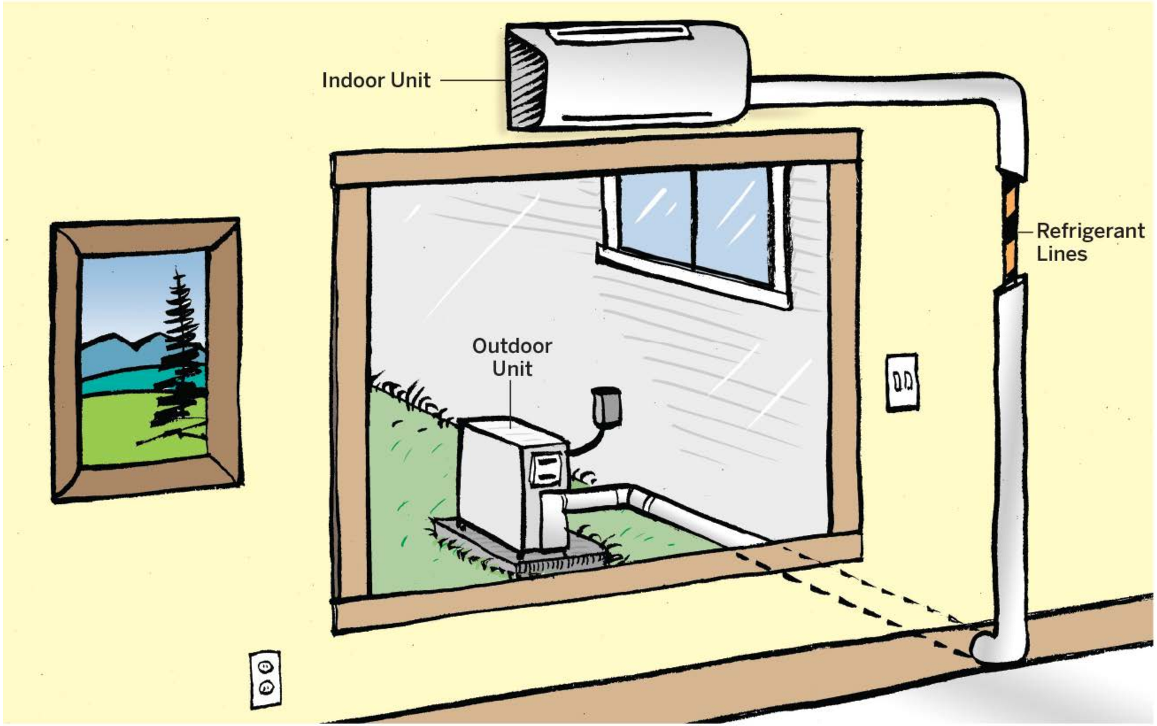
Fuel Choice – 1989

- 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

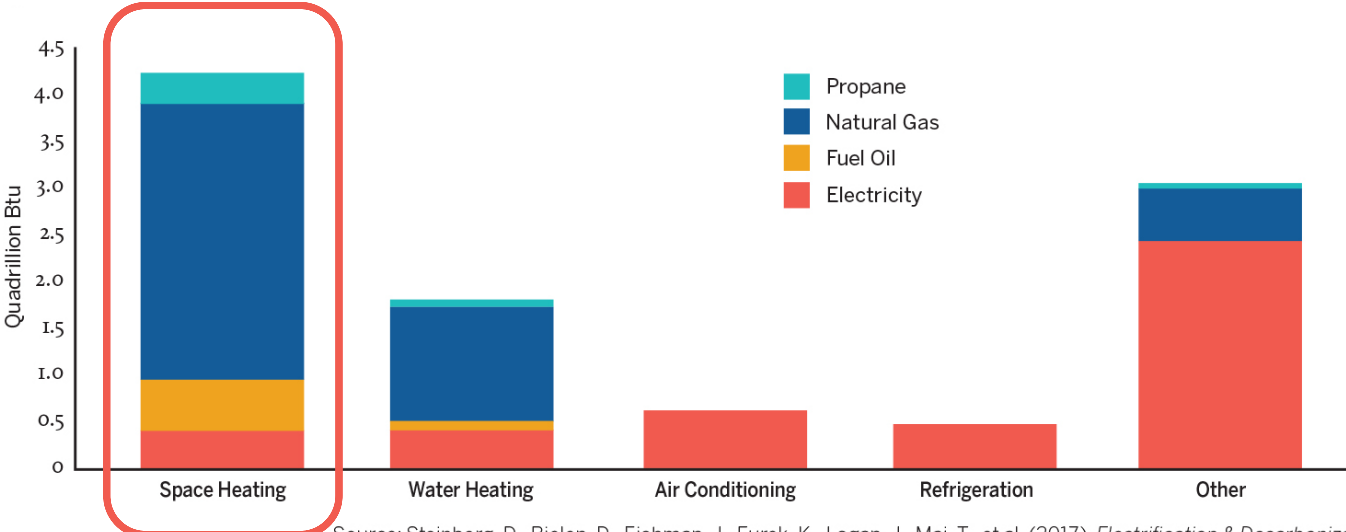
Fuel Choice Today

- **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

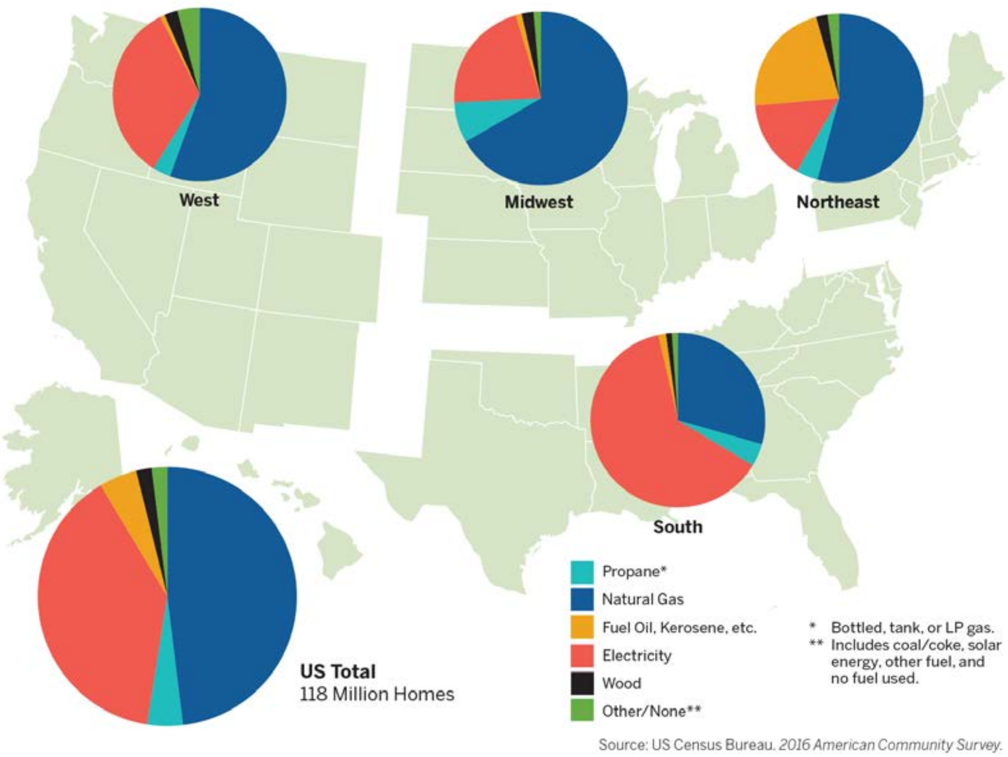


What’s The Opportunity?



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?



2 Technology Considerations

Electric Space Heating Technologies We Looked At

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

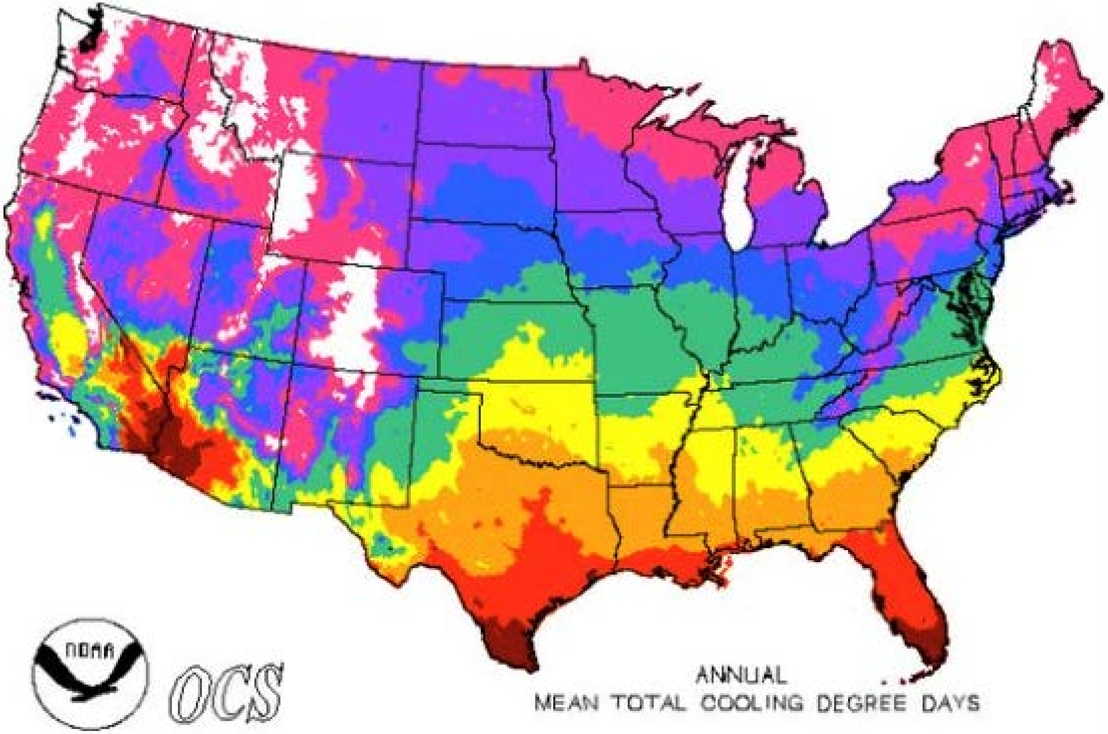
Example Supplemental Heating Sources For Cold Climates and Power Outages

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 Housing Type

Summary of Technology Considerations

	Single Family Homes		
Coldest outdoor temperature	New well-insulated	Existing with Oil or Propane heating	Existing with Natural gas heating
30 degrees F	✓	✓	✓ ?
5 degrees F	✓	✓ ✓ ?	✓ ?
Less than 5 degrees F	✓ ✓	✓ ?	✓ ?
Any temperature	✓		

✓ Air source heat pump

✓ Cold climate Air source heat pump

✓ ASHP w supplemental heat

✓ Electric resistance storage

✓ Ground source heat pump

Summary of Technology Considerations

	Apartments		Single Family Homes			Manufactured	
Coldest outdoor temperature	New	Existing	New well-insulated	Existing with Oil or Propane heating	Existing with Natural gas heating	New	Existing
30 degrees F	✓	✓	✓	✓	✓ ?	✓	✓
5 degrees F	✓	✓ ?	✓	✓ ✓ ?	✓ ?	✓ ?	✓ ?
Less than 5 degrees F	✓ ✓	✓ ✓ ✓ ?	✓ ✓	✓ ?	✓ ?		
Any temperature	✓		✓			✓	

✓ Air source heat pump

✓ Cold climate air source heat pump

✓ ASHP with supplemental heat

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3 BE for Space Heating – Three Conditions

Questions?

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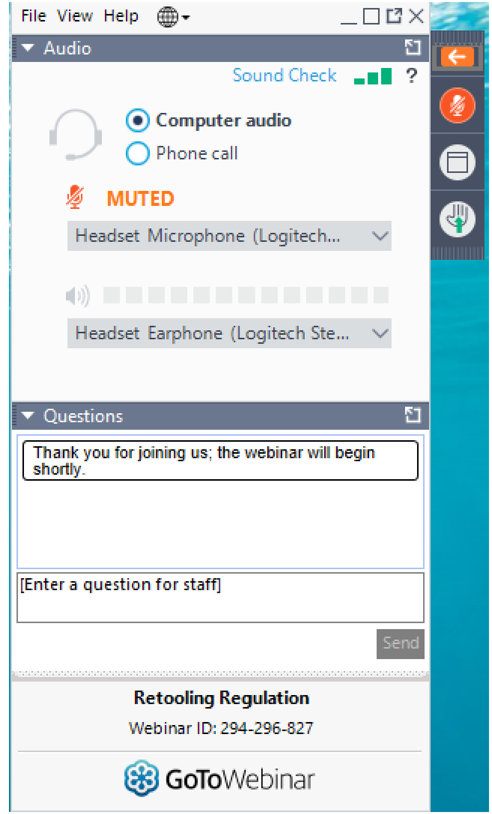


What’s “*Beneficial* Electrification”?

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

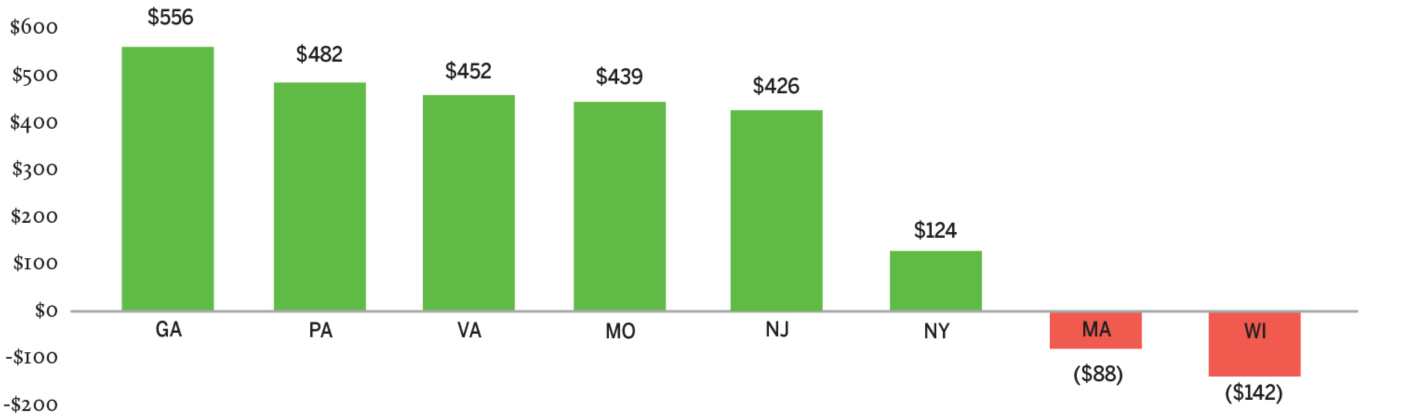
Photo credit: Flickr 401(k) 2012

1. Saves Customers Money Long-Term

Consumer Economics: Key Factors

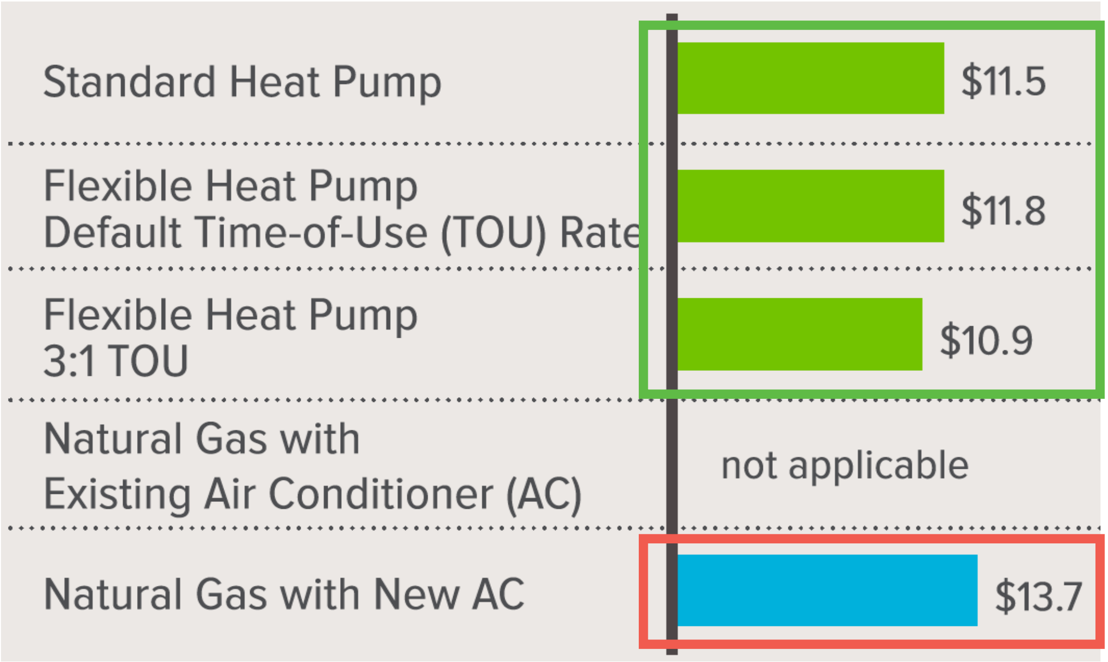
- Efficiency of space heating options
- Building type and its thermal efficiency
- Space cooling desired?
- Incremental cost of installation
- Cost of fuel

Current Economics of Converting Existing Oil Furnaces to Air Source Heat Pumps



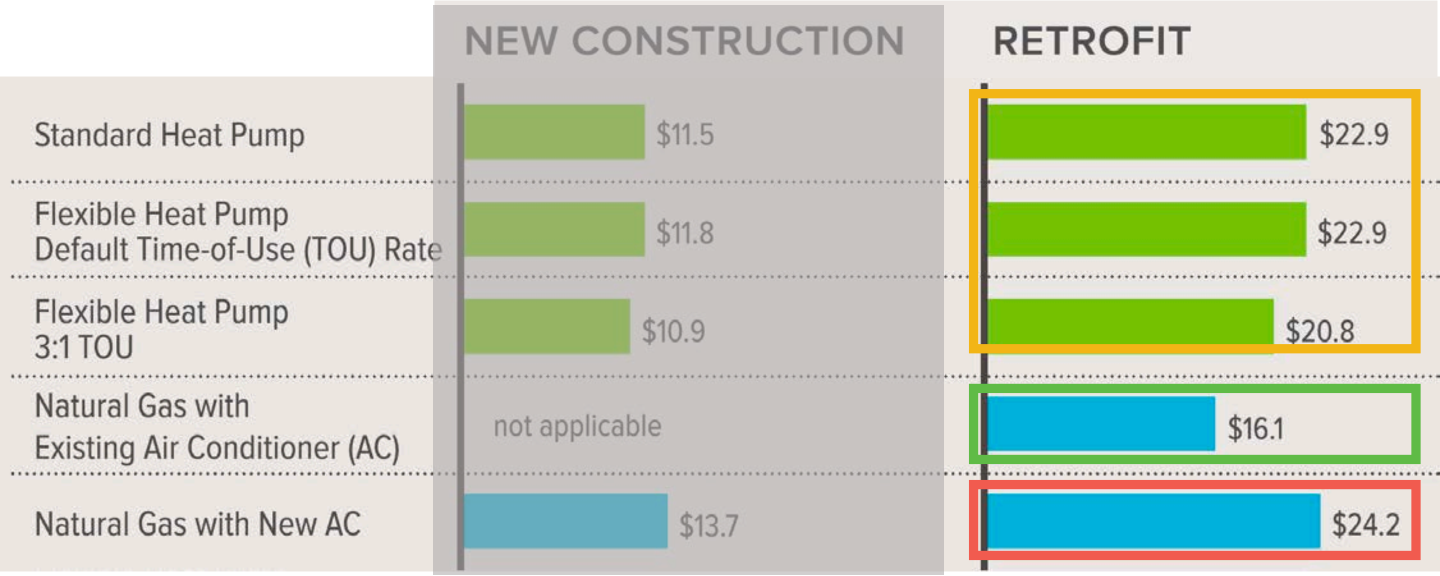
Source: Compiled with data from American Council for an Energy-Efficient Economy and US Energy Information Administration.

Current Economics of Space and Water Heating Electrification

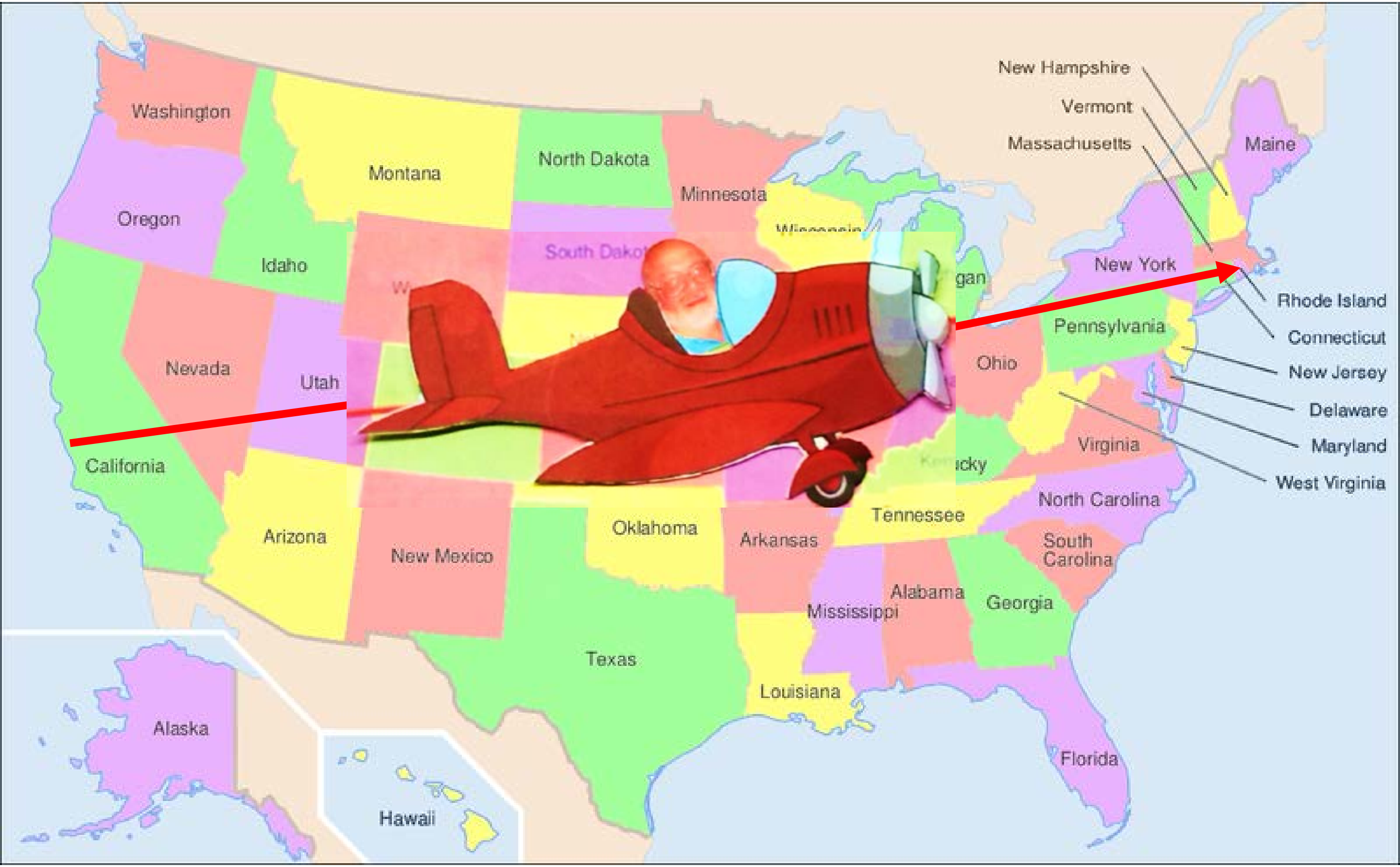


Source: Billimoria, S., et al (2018). The Economics of Electrifying Buildings. Boulder, CO: Rocky Mountain Institute. Retrieved from https://www.rmi.org/insights/reports/economics-electrifying-buildings (Oakland – New Construction)

Current Economics of Space and Water Heating Electrification



Source: 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 (Oakland – Retrofit)



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Minnesota
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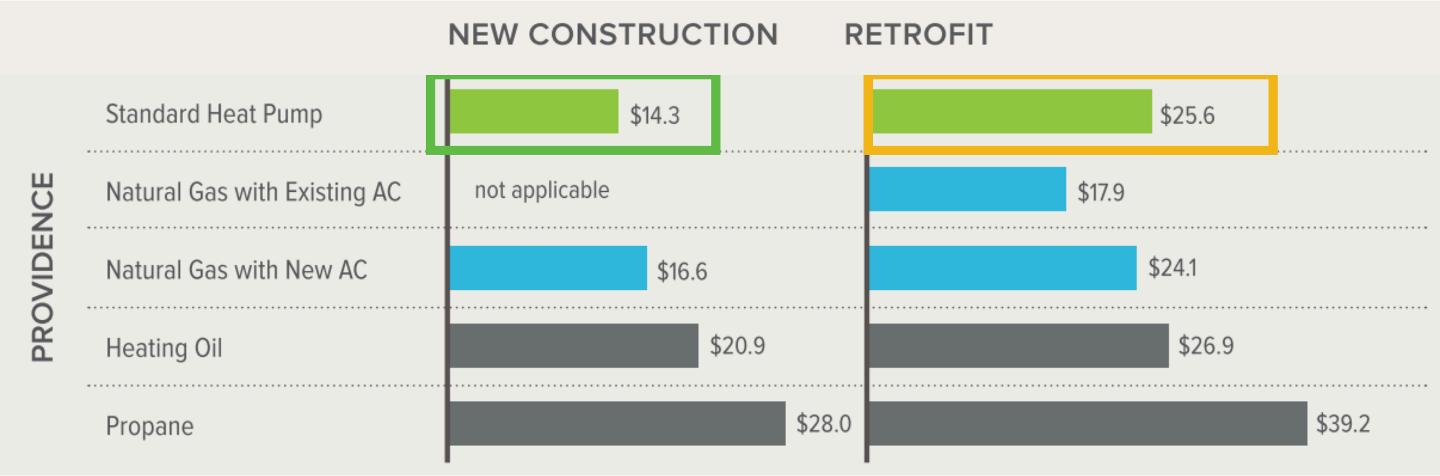
Mississippi
Alabama
Georgia
Florida
Tennessee
Ohio
Pennsylvania
New York
Maine
New Hampshire
Vermont
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
West Virginia
Virginia
North Carolina
South Carolina
Alaska
Hawaii

Current Economics of Space and Water Heating Electrification



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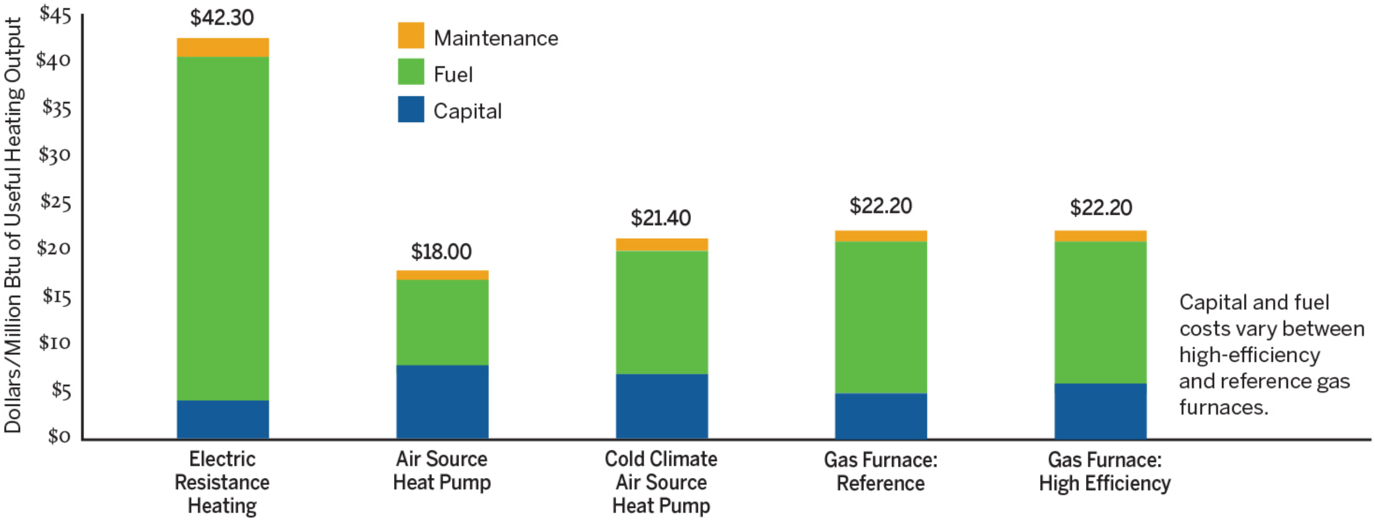
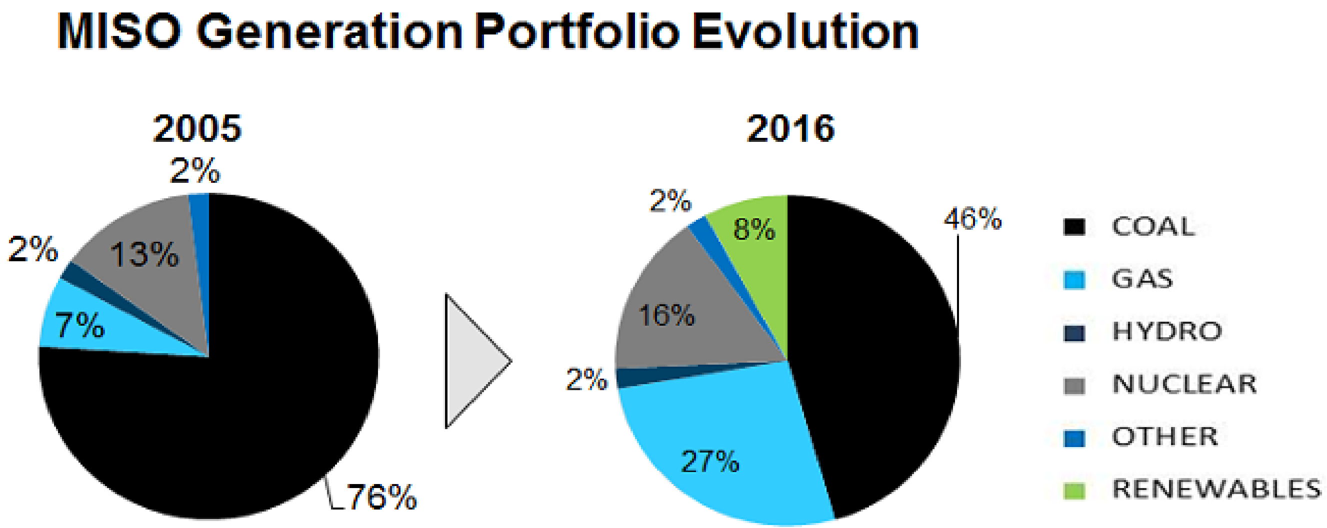
Future Economics of Converting Existing Gas Furnaces to Air Source Heat Pumps



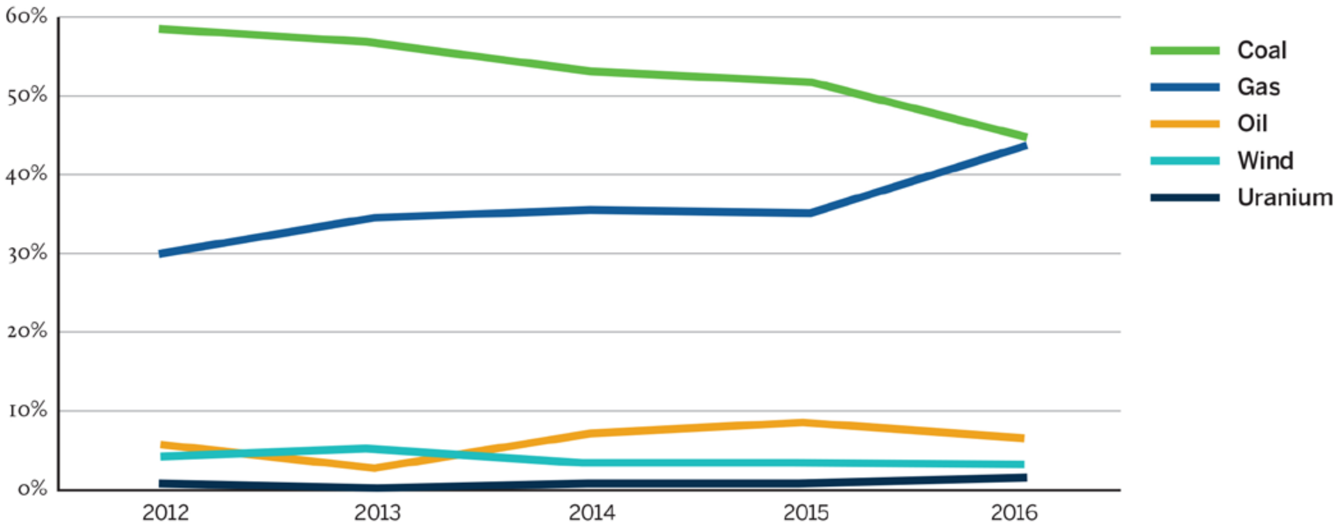
Source: Jadun, P., McMillan, C., Steinberg, D., Muratori, M., Vimmerstedt, L., and Mai, T. (2017). *Electrification Futures Study: End-use Electric Technology Cost and Performance Projections Through 2050*

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.

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

Emissions

Oil Furnace

513 gallons oil/year

22 lb CO_2/Gallon

11,300 lb CO_2/year

Heat Pump (ENERGY STAR®)

7,754 kWh/year

50% Gas; 50% Coal
1,400 lb CO_2/MWh

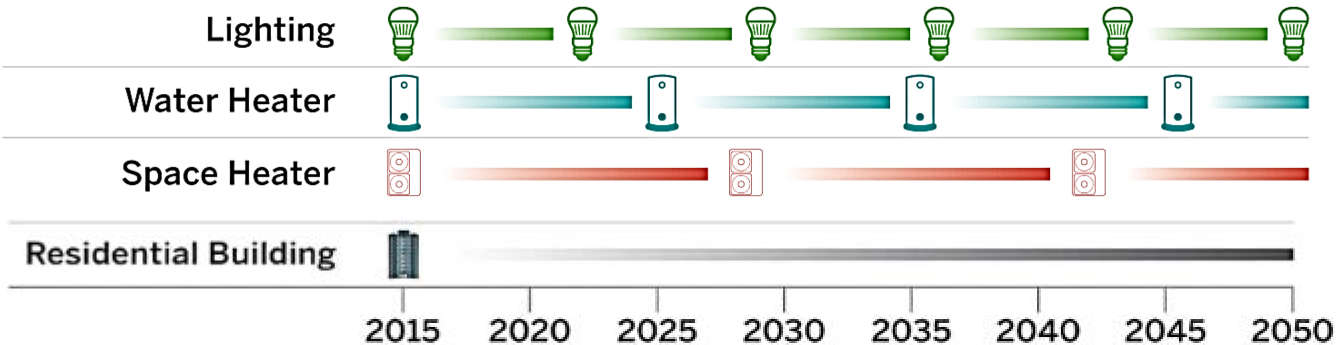
10,855 lb CO_2/year

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

		Electric Power System Mix				
	Energy Factor (Coefficient of Performance)	100% Coal	50% Gas, 50% Coal	100% Gas	50% Gas, 50% Non-Carbon	100% Non-Carbon
Air-Source Heat Pump						
Standard HP	3.0	226	157	87	43	00
Cold Climate HP	2.5	272	188	104	52	00
With Propane Backup 10% of Heating	3.0	218	156	93	54	15
Ground-Source Heat Pump	4.0	170	117	65	33	00
Electric Resistance Storage	1.0	679	470	260	130	00

Residential Energy Investments Are Long-Lived

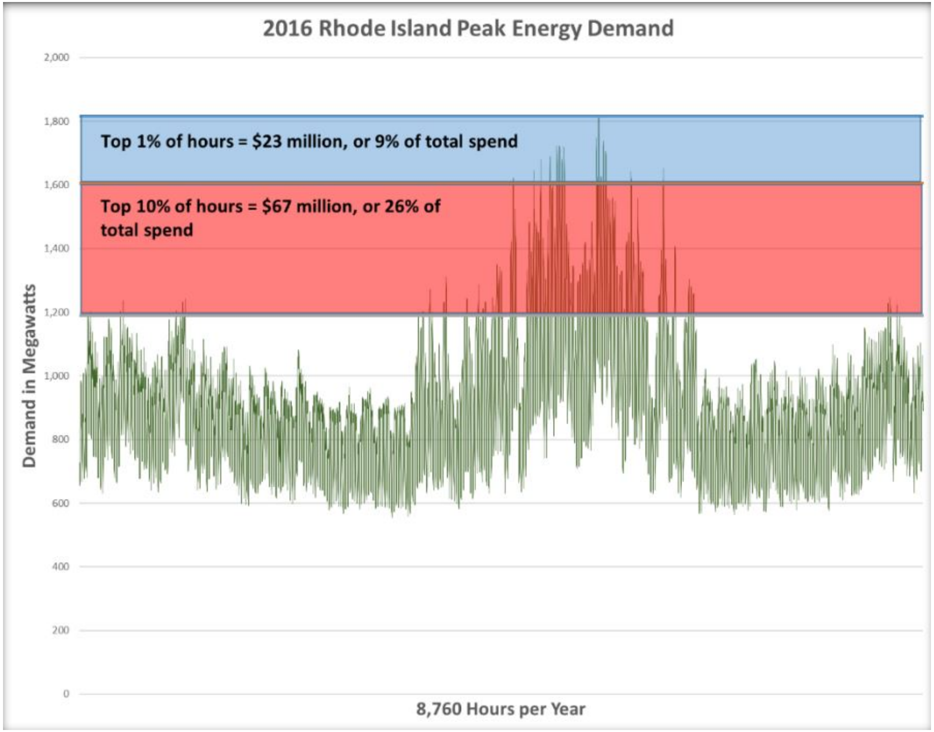


3. Enables Better Grid Management

Avoid High-Cost Hours

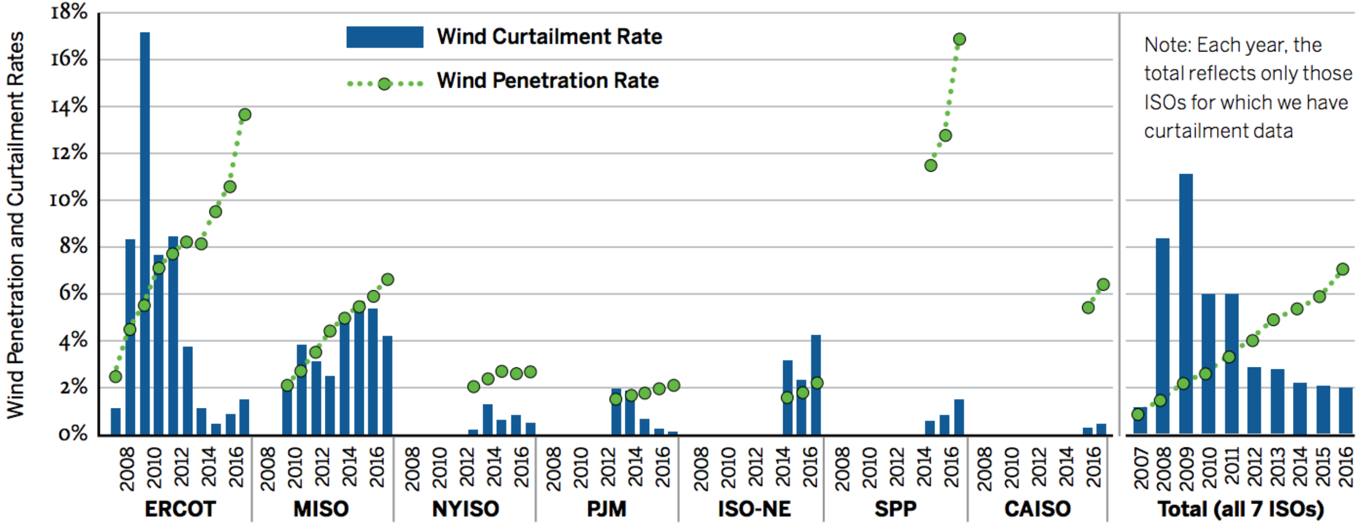
- Top 1% of hours = 9% of total spending

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



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

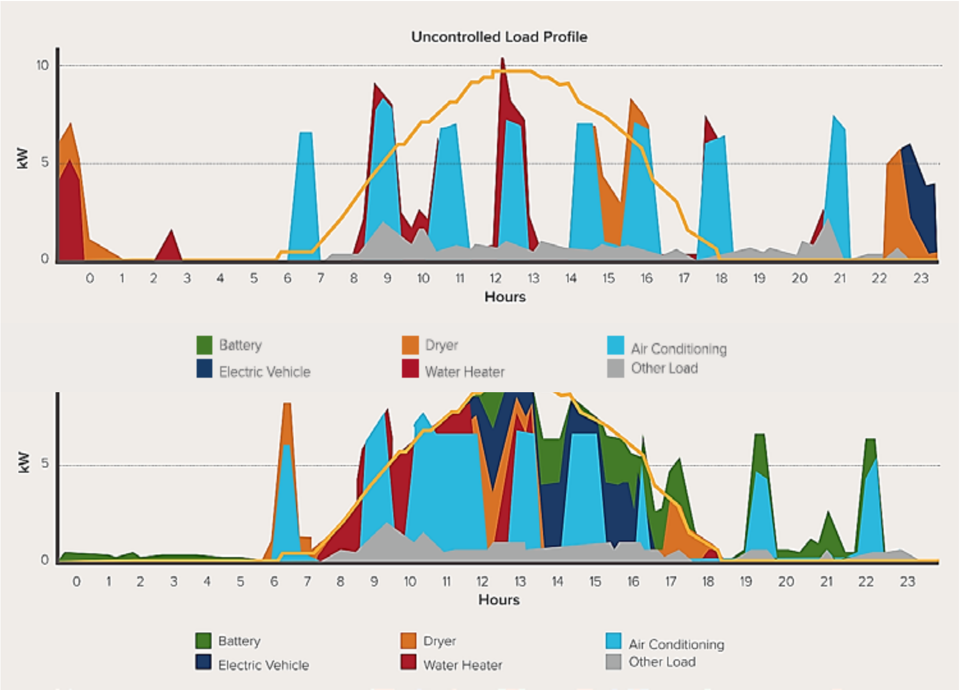
Reducing Renewables Curtailment



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*.

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.

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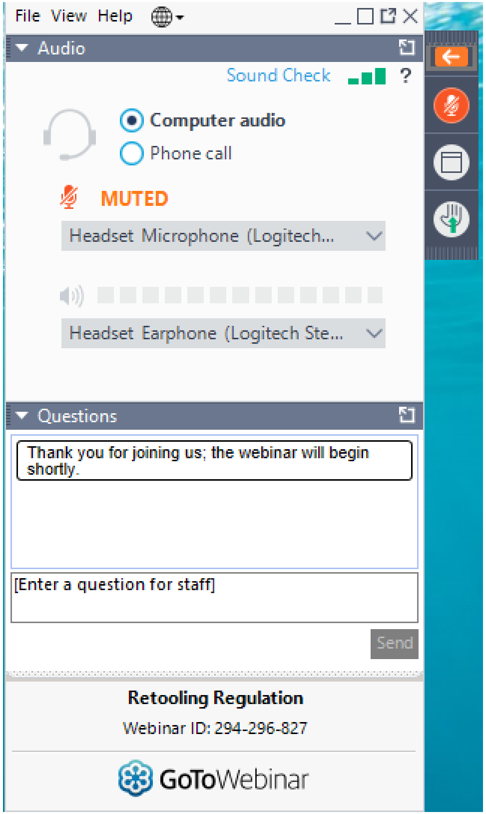


4 Strategies for BE Space Heating

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

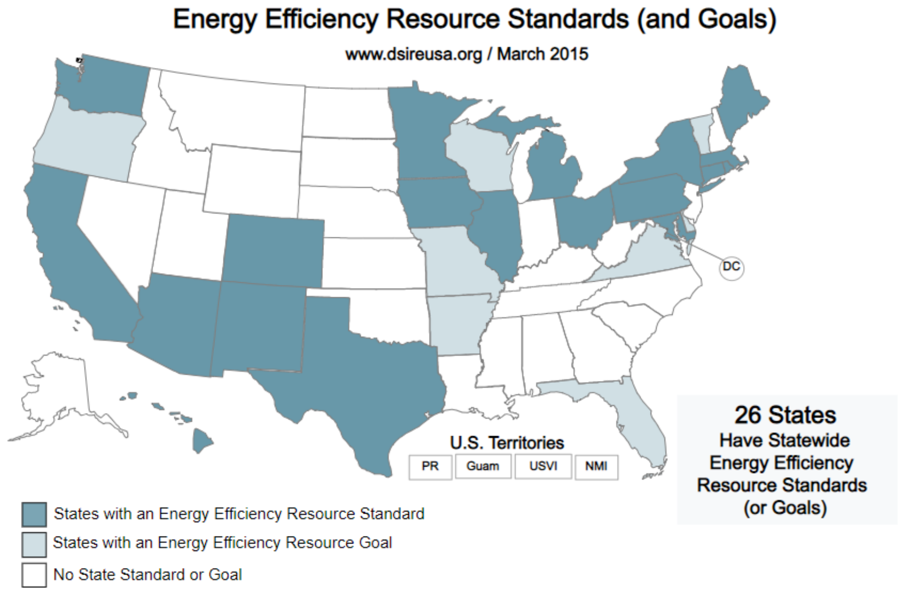
Building Codes

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

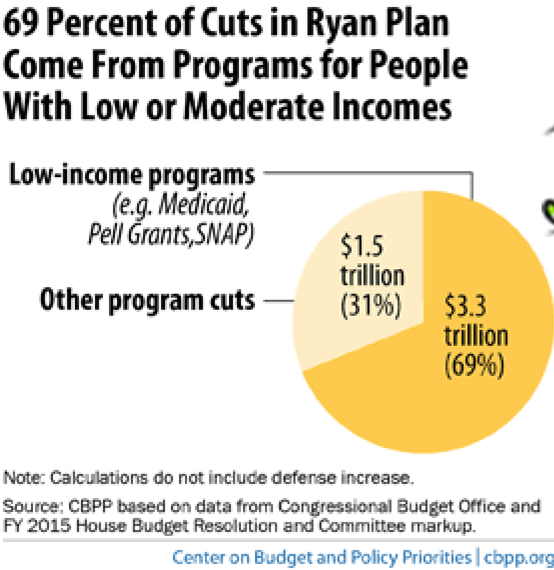
Energy Efficiency Resource Standards

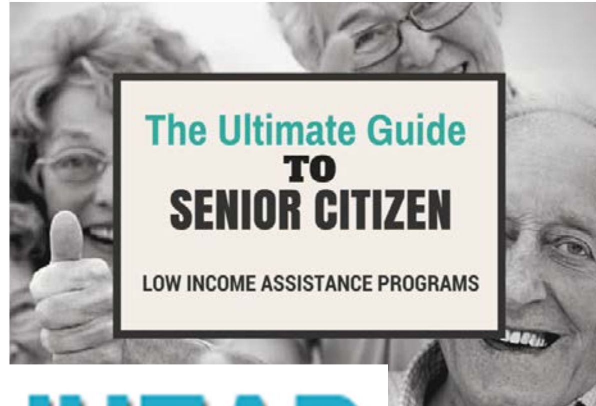
- Adopt a *carve-out* for electrification

- Adapt metrics to reflect reductions in primary energy use or GHG emissions



Affordability



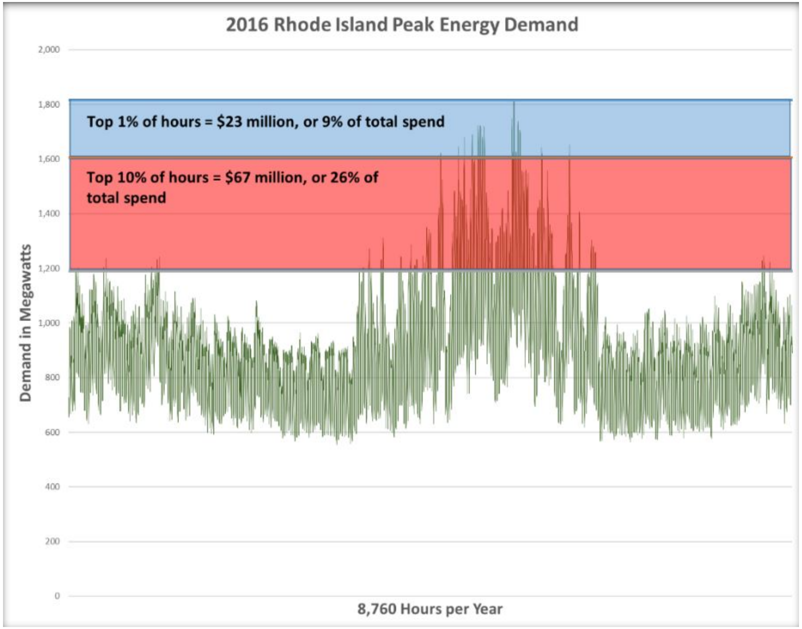


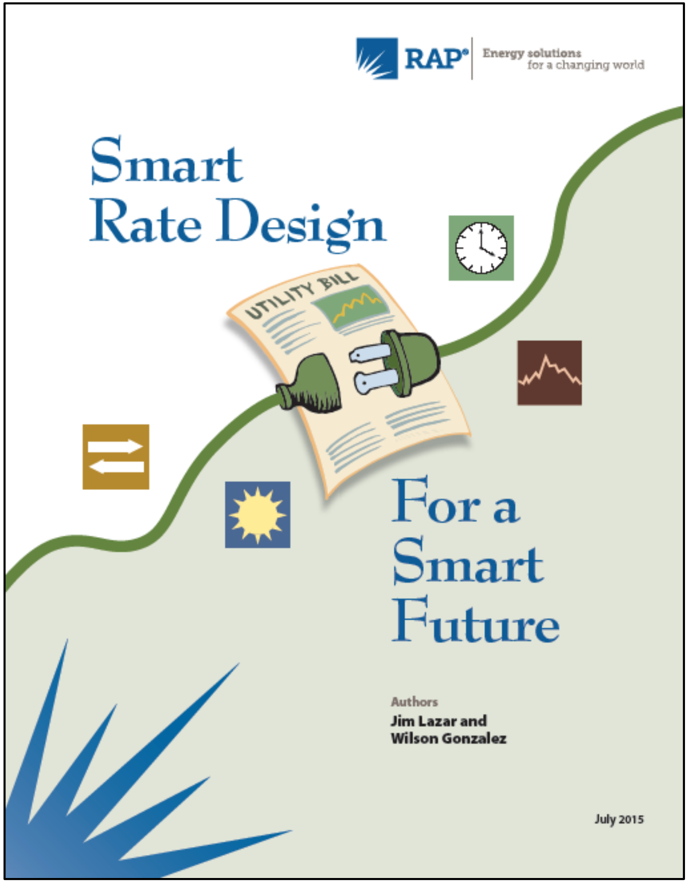
Rate Design

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.

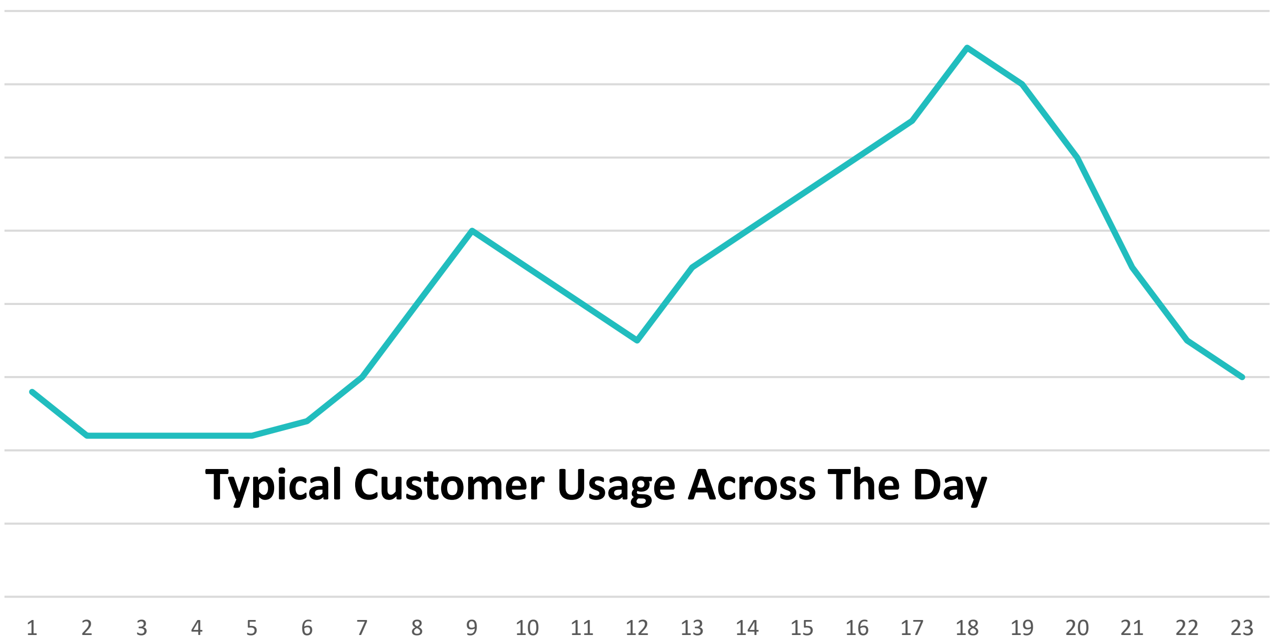



RAP®
Energy solutions
for a changing world
Smart
Rate Design
UTILITY BILL
For a
Smart
Future
Authors
Jim Lazar and
Wilson Gonzalez
July 2015

Key Elements of TOU Rates: Fort Collins, Colorado

	Summer	Winter
Customer Charge	$6.16	$6.16
Off-Peak	$.066	$.065
On-Peak	$.235	$.211
Tier Charge All Usage Over 700 kWh	+$.017	+$.017

A TOU Rate Does Not Mean A Higher Bill For Typical Residential Consumers



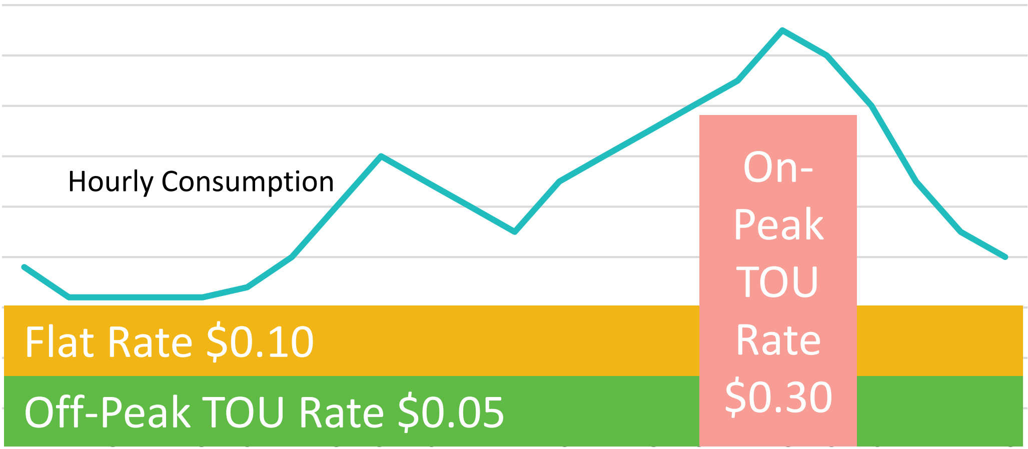
A TOU Rate Does Not Mean A Higher Bill For Typical Residential Consumers

Flat Rate

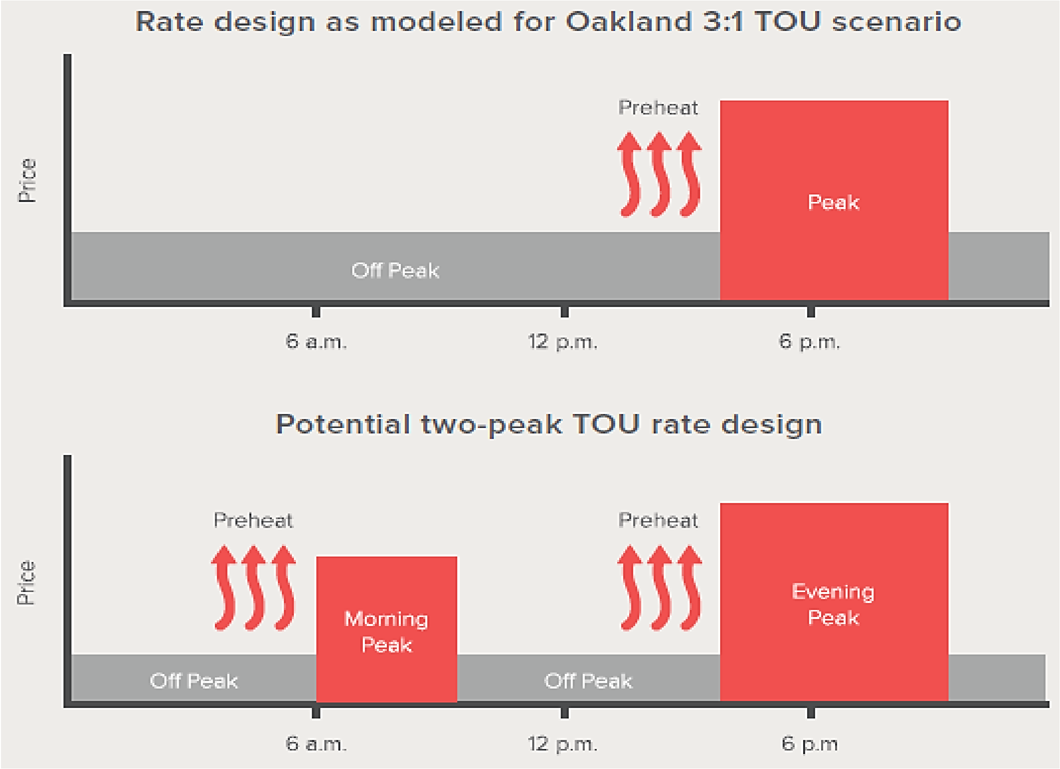
1,000 kWh @ $0.10 = $100

TOU Rate

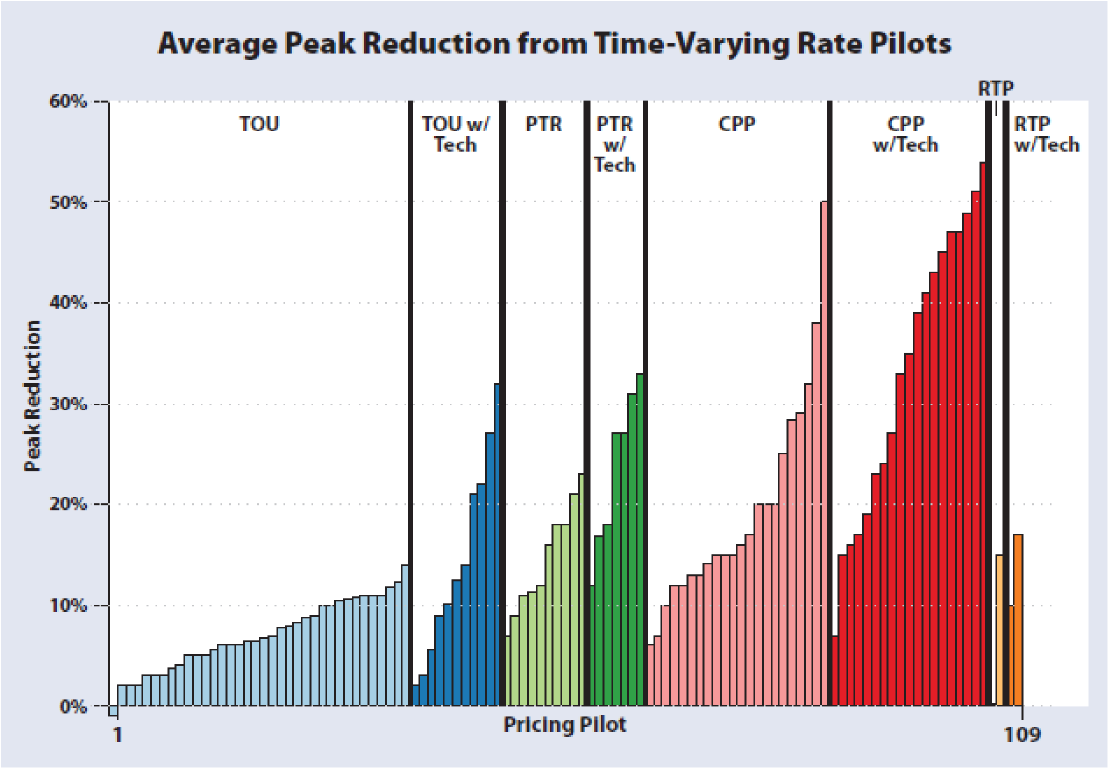
800 kWh @ $.05 off-peak
+ 200 kWh @ $.30 on-peak
= $100



Two-Peak Rate Design



Advanced Pricing Helps Grid Flexibility



Incentive Programs

- Run by utilities, states, and third parties
- May enable or obstruct beneficial electrification

Multi-zone ductless heat pump

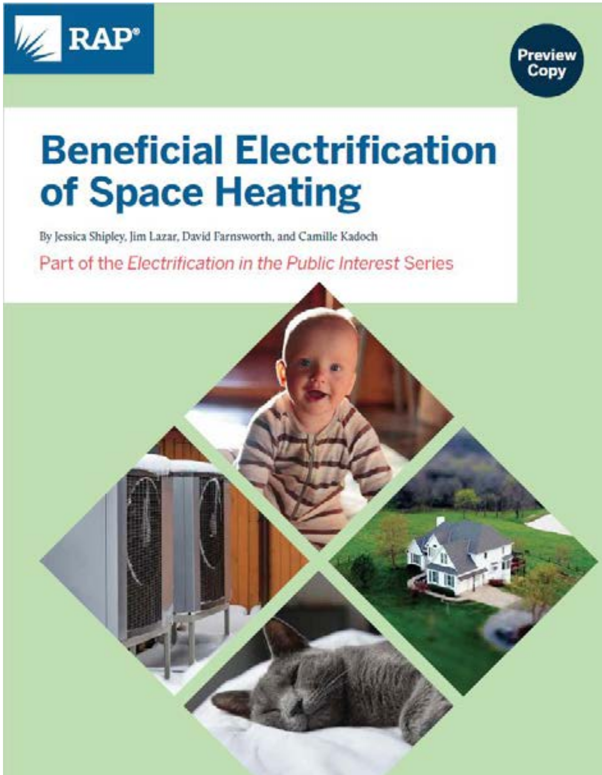
- Tend to reward switching to a more efficient appliance that uses the ***same fuel***
- Many explicitly disallow **fuel switching**
- Programs may be working at cross-purposes to BE

Energy Star certified gas furnace

Sources for images: www.mitsubishicomfort.com and www.americanstandardair.com

Final Thoughts

- *Beneficial Electrification* is a framework to help decision-makers
  - Opportunities will vary
  - Analyze for local circumstances
  - ID and remove barriers
  - Revisit electricity rates and program incentives.
  - Is there value in
    - Developing infrastructure and a market,
    - Educating consumers, and
    - Contractors?



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 will follow in the next few months.

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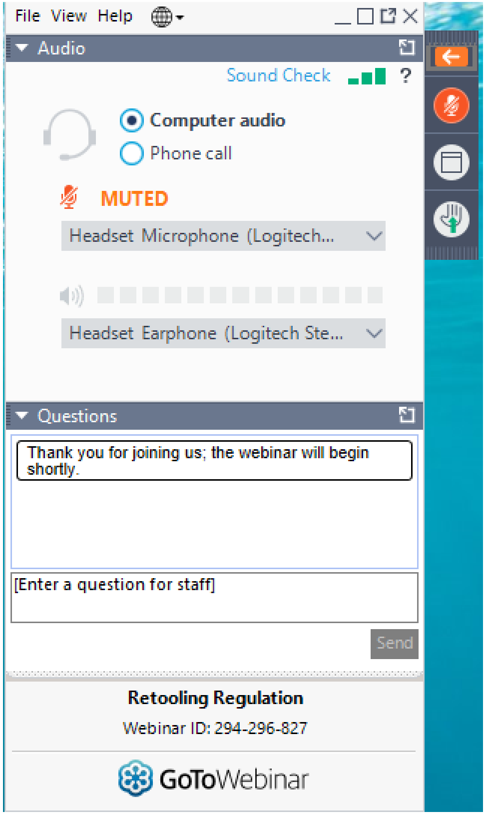

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Beneficial Electrification Resources from RAP

- 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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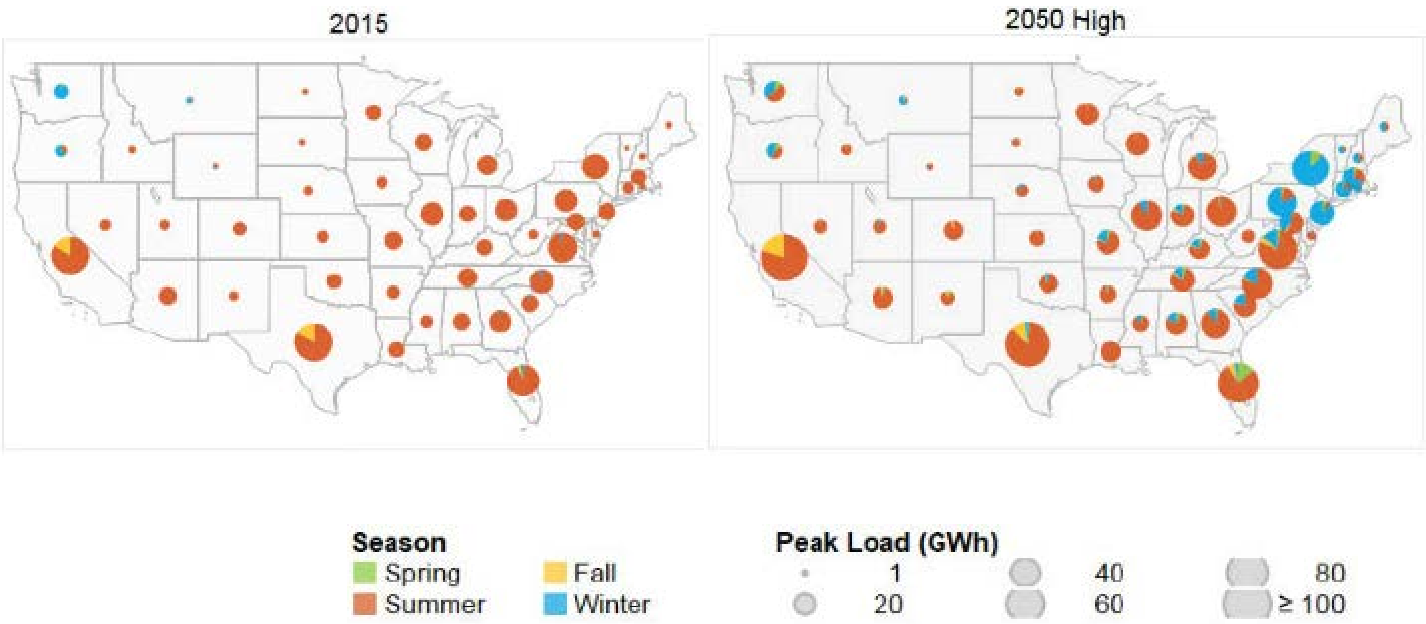
Learn more about our work at raponline.org

Grid Management



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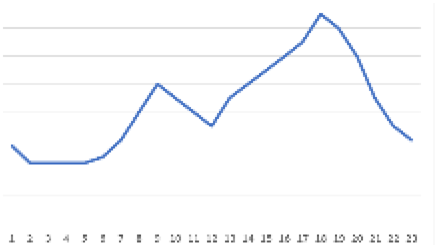

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