Introduction to Beneficial Electrification for Buildings

Federal Environmental Symposium

Regulatory Assistance Project (RAP)®

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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
Fuel Choice – 1990

- 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
What is the Opportunity?
Building Emissions Not Declining

Annual CO₂ emissions from electric power and buildings sectors
Million metric tons CO₂, US total, 2007–2019

Electric Power: Down 33% since 2007
Buildings: Up 7% since 2007

Source, EIA; Adapted from slides by Rocky Mountain Institute
Fossil Fuels Still Dominate Space and Water Heating

Final energy use in residential buildings

Source: EIA’s Residential Consumption Survey (RECS) 2015
Fossil Fuels Still Dominate Space and Water Heating

Final energy use in commercial buildings (2020)

Source: EIA 2021 Annual Energy Outlook, Table 5: Commercial Sector Key Indicators and Consumption
The Opportunity of Building Electrification

Efficient, clean, and controllable – cost-effective electric end-use technologies installed in US buildings will produce benefits:

- Cost savings
- Grid flexibility
- Lower emissions
**Beneficial Electrification (BE) - Three Conditions**

1. Saves Customers Money Over Long-Term
2. Reduces Environmental Impacts
3. Enables Better Grid Management
Beneficial Electrification: Ensuring Electrification in the Public Interest

- 6 principles to ensure beneficial to consumers, environment, grid
- Papers for EVs, water heating, and space heating

https://www.raponline.org/BE
1. Put Efficiency First
Efficiency Across Fuel Types

Electrification is (Often) Efficiency

Total energy savings by building type from installing a rooftop heat pump when an existing gas heat packaged system needs to be replaced.
1. Saves Customers Money Long-Term
Consumer Economics: Key Factors

- Efficiency of space heating options
- Climate
- Building type and its thermal efficiency
- Energy intensity of building type
- Operating hours
- Incremental cost of electric options
- Comparative cost of fuel
- Retrofit vs. new construction
### Economics of Space and Water Heating Electrification (Oakland, CA)

<table>
<thead>
<tr>
<th>Heat Pump Type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Heat Pump</td>
<td>$11.5</td>
</tr>
<tr>
<td>Flexible Heat Pump Default Time-of-Use (TOU) Rate</td>
<td>$11.8</td>
</tr>
<tr>
<td>Flexible Heat Pump 3:1 TOU</td>
<td>$10.9</td>
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<tr>
<td>Natural Gas with Existing Air Conditioner (AC)</td>
<td>not applicable</td>
</tr>
<tr>
<td>Natural Gas with New AC</td>
<td>$13.7</td>
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</tbody>
</table>

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

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: PJM Example

2005–2019 PJM Average Emissions Rates

https://insidelines.pjm.com/emissions-continue-to-drop-throughout-pjm-footprint/
National Forecast

Measure Life Matters

- Lighting
- Water Heater
- Space Heater
- Light-Duty Vehicle
- Heavy-Duty Vehicle
- Industrial Boiler
- Power Plant
- Residential Building

2015 to 2050
As the Grid Gets Cleaner, Electric Options Become More Beneficial

![Graph showing emissions over time for different water heater types: Electric Resistance Water Heater, Heat Pump Water Heater, Gas Water Heater. The emissions decrease over time, with electric options showing the lowest emissions.](image-url)
Commercial Building Electrification
Potential Emission Reductions

Estimated GHG emissions reductions by region for RTU replacement with heat pumps

3. Enables Better Grid Management
Water Heater Loads Are Easy to Spot
Grid Management: Grid-Integrated Water Heating

- Water heaters only need to run 2-3 hours/day
- Can store an all-day-long supply
- Can be controlled into low-cost, low-emission hours
- No peak demand impact if managed.
- It’s a place to send excess wind and solar electricity.
Avoid High Cost, High Emission Hours
And Curtailing Renewables
Avoid High Cost, High Emission Hours
And Curtailing Renewables
Things Can Change Quickly

5th Avenue, NYC, Easter 1900
See any automobiles?

Source: Tony Seba
Things Can Change Quickly

Park Avenue, NYC, Easter 1913
See any horses?

Source: Tony Seba
More Info

RAP Beneficial Electrification Papers:
Extras
Grid Benefits: Boost Load Flexibility

<table>
<thead>
<tr>
<th></th>
<th>Generation capacity avoidance</th>
<th>Reduced peak energy costs</th>
<th>System peak related T&amp;D deferral</th>
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</thead>
<tbody>
<tr>
<td>Direct load control</td>
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<td>X</td>
<td>X</td>
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<td>Interruptible tariff</td>
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<td>X</td>
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<td>Demand bidding</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Time-of-use (TOU) rates</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
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Importance of Marginal Emissions on a “Dirty” Day

NEISO July 27, 2016

#/#MWh of Marginal Generating Units

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