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Decarbonizing Rhode Island Space Heating in a Managed Carbon Future

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Space Conditioning Energy Use for U.S. Homes (MMBtu/Year)



Space heating is the dominant space conditioning load in all regions. Ratio of heating to cooling is high in northern regions (over 10:1).



Rhode Island power generation is highly reliant on natural gas generators for baseload power.

Natural gas generators are used nearly exclusively to meet seasonal demand increases – for example, for space cooling or heating.

EPA eGRID data shows Rhode Island natural gas power plants have an overall efficiency of 44.6% (HHV basis). Coupled with electric transmission and distribution line losses, delivered electric efficiency is less than 40%.

Note: wind and solar are not seasonally dispatched generation resources.



Rhode Island Power Generation	Baseload
Natural Gas	91.7%
Oil, Coal	0.3%
Nuclear	0.0%
Hydro	0.1%
Wind	3.0%
Solar	1.6%
Other	3.3%





Today a shift to electric heat pumps in Rhode Island would lead to a 79% increase in consumer's space heating annual energy costs with virtually no change in GHG emissions.

Seasonal electricity heating loads and associated peaks, based on today's grid, would largely be met by dispatchable natural gas power generation.

Wind will not able to ramp up in the winter, solar PV output drops substantially during short winter days, and batteries are insufficient to deal with winter heating storage needs for peaks.

Impact of Cold Temperature on Electric Heat Pump Efficiency (and Output)



Cold ambient temperatures lower electric heat pump efficiency (COP) by 30-50% (or more).

Diminished 2015 performance partly attributed to high levels of snow & ice accumulation.

Ductless Mini-Split Heat Pump Impact Evaluation (Cadmus Group, Dec. 2016). Testing conducted on homes in Massachusetts and Rhode Island.

Rhode Island: Seasonal Patterns In Residential Use of Electricity and Natural Gas



Data show monthly peaks. Peak day ratios even higher.



Large Increases In Peak Month Electricity Use Shifting From Natural Gas To Electric Heat Pumps



Switching from gas heating to electric heating would (on average) increase peak residential month electricity 150% in most states.

In Rhode Island, winter month peak with electric heat pumps would be 185% higher than the current summer peak.



Rhode Island All Electric Homes Scenario (Million kWh/month)



Energy Storage Comparison

Natural Gas & Electricity



Energy Storage Realities



Former Secretary of Energy Professor Steven Chu as cited by the Australian on 1-30-18

- While the costs of building battery plants were likely to halve over the next decade, the approach would never be cheap enough to accommodate the big seasonal shifts in renewable power production.
- Batteries could prove viable for storing power produced during the day for use during night hours, and "maybe" up to a week later, but not over seasonal timeframes.
- You need other new technologies to convert cheap renewable energy into chemical fuel when the sun is shining or the wind is blowing, he told *The Australian*. "If you make really cheap hydrogen from renewables and store it underground, then you have something very different."

Source: GTI analysis of DOE EIA data (nominal). Based on underground gas storage and pumped hydro storage data; estimated battery performance assuming 1 GW installed capacity and 25% annual capacity factor.

Natural Gas Low Greenhouse Gas Pathways



Near-Term Thermally Driven Gas Heat Pump Developments 130-140% Efficiency







Residential Low-Capacity Combination Space & Water Heating System (20 kBtu/hr)





Light Commercial Combination Space & Water Heating System (140 kBtu/hr)



Multiple product platforms in development by SMTI, GTI, and partners.

Past, Present, Future Natural Gas Low Carbon Pathways

- The nearly 30% reduction in annual perhome CO₂ emissions is complemented by a nearly 60% reduction in annual methane emissions per home (full-fuel-cycle) since 1990
- Where will be in 2040? Further potential to improve efficiency and lower GHG impacts
 - Gas heat pumps
 - Improved building envelopes
 - Renewables (biomethane, H₂, solar)
 - Lower methane emissions



50.2 million homes 69 million homes XX million homes