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EXECUTIVE SUMMARY
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Seasonal Residential Space Heating Opportunities and Challenges

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Executive Summary

There are active policy discussions on future pathways for reducing greenhouse gas (GHG) emissions. To help inform those discussions, this report addresses opportunities and challenges with residential space heating energy use and GHG reductions. The main thrust is: (1) quantifying the magnitude of annual energy use and costs in residential space heating, (2) documenting issues with seasonal electricity generation for space conditioning loads, and (3) quantifying GHG comparisons between gas and electric space heating.

Energy Use

Information in this report covers forty-eight states, reflecting their current residential gas and electric energy use and estimated future peak monthly electricity use under an electrification scenario. For example, Figure 1 shows Illinois data with multi-year residential monthly gas and electricity use (left chart) plus current January and April residential energy use and projected future amounts under an electrification scenario (right chart). These energy use patterns vary by state depending on climate (e.g., heating and cooling degree days) and relative existing market shares for residential gas and electricity space heating.

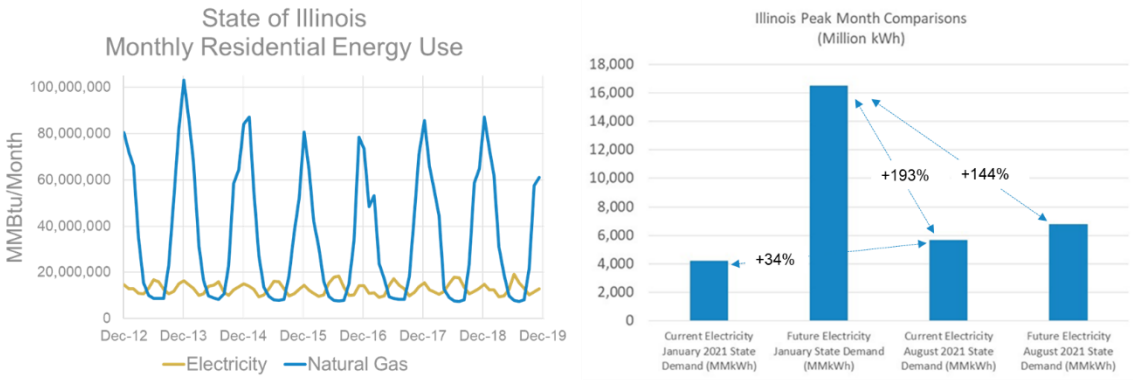

Figure 1: Illinois Residential Energy Use Comparison

A key consideration with electric space heating is the non-linear increase in electricity consumption as temperatures decrease. The issue becomes acute when extreme cold temperatures descend over a region for days or weeks; Figure 2 provides an illustration.

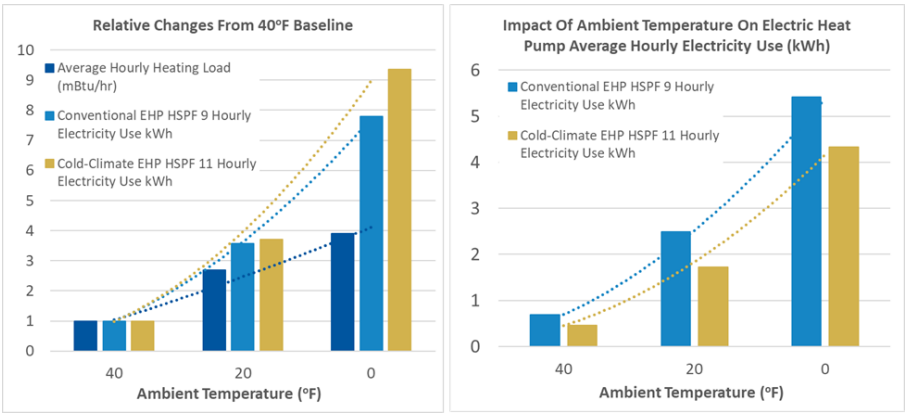

Figure 2: Impact of Ambient Temperature on Electric Heat Pump Electricity Use

Consumer Annual Space Heating Costs

Electric space heating energy results in space heating cost increases of $411 per single-family home (66% average increase) when comparing a 94% efficient gas furnace and an HSPF 9.0 electric heat pump. Thirty-eight of forty-eight states showed an annual operating cost increase (79%). Costs are greatest in regions with considerable Heating Degree Days and/or high electric/natural gas price ratios. Across the US the average ratio of residential electricity to natural gas prices, based on 2021 DOE-EIA data, was 3.8:1.

Seasonal Electricity Generation

The report provides state-level data on three state-specific power generation market metrics:

- Spring Average Generation (e.g.., April, representing nominal Baseload Generation)
- Winter Average Generation (e.g., in January)
- Winter Marginal Generation (e.g., the specific GHG emission attributes of plants used to address January electricity demands from electric space heating)

Figure 3 is an example for Illinois; the report includes data for other states. This graph highlights a pattern seen in over 80% of states: (1) ramp up of dispatchable generation (e.g., gas and/or coal) to meet space conditioning loads in the summer or winter, (2) a decline in wind and solar generation in January, and (3) a higher Winter Marginal Generation Rate (gCO_2/kWh) used to meet electric space heating seasonal energy use.

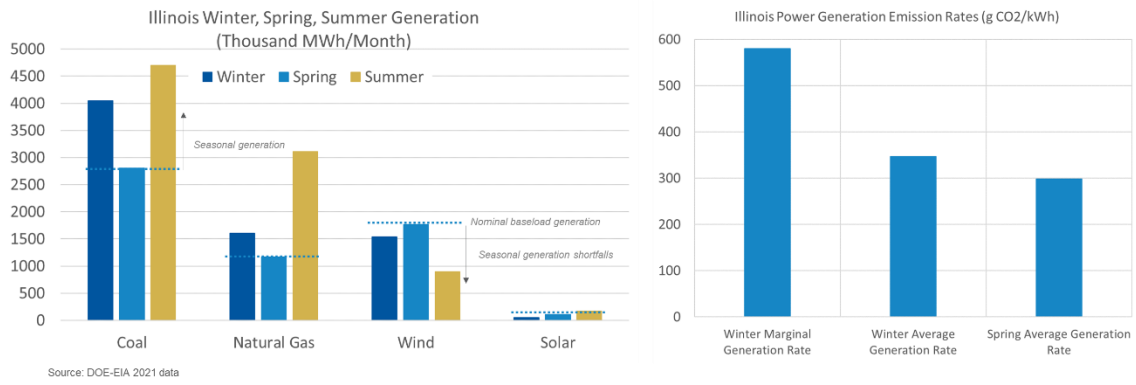

Figure 3: Illinois Winter Marginal, Winter Average, and Spring Average Power Generation and CO_2 Generation Rates

Across the US, the median Winter Marginal Generation Rate results in a 53.5% increase in CO_2 emissions compared to the Spring Average Generation Rate; the amount varies depending on state-specific circumstances.

Greenhouse Emission Reduction Results

The following discussion on GHG emissions from gas and electric space heating options is based on using a 94% efficient gas furnace and an HSPF 9.0 electric heat pump. The report provides state-specific results using different electric generation scenarios (e.g., Winter Marginal versus Winter Average Generation Rates). Because of the unique seasonal nature of electric space heating, it is more appropriate to use the Winter Marginal Generation Rate for CO_2 emissions in a state for the coldest month (e.g., January) to get a real-world estimate of the GHG reduction potential of electric space heating.

Table 1 provides a summary of the GHG impact of switching from residential gas space heating to electric space heating under two different winter power generation emission rates: Winter Marginal and Winter Average. Using the Winter Marginal Emission Rate, the median change in emissions is an increase of 32.8% with higher emissions occurring in 29 states (60% of the 48 states). Using the Average Winter Emission Rate, the median change in emissions is -23.4% with an increase in 16 states (33% of the 48 states). A concerted focus on decarbonizing dispatchable generation such as natural gas combined-cycle plants would substantially alter these findings.

Table 1: Change in Emissions Switching from Gas to Electric Space Heating

CO_2 Emissions Impact of Changes from Gas to Electric Space Heating (48 States)	% Change in Space Heating CO_2 Emissions Using Winter Marginal Rate	% Change in Space Heating CO_2 Emissions Using Winter Average Rate
Median Change (%)	32.8%	-23.4%
Number of States with Emission Increases	29	16

Projected Seasonal Electricity Demand Changes with Statewide Electrification

Across these forty-eight states (Figure 4), the projected future winter peak for residential electricity would be 175% of the future summer peak. Winter peaks would occur in 45 of the 48 states (94%).

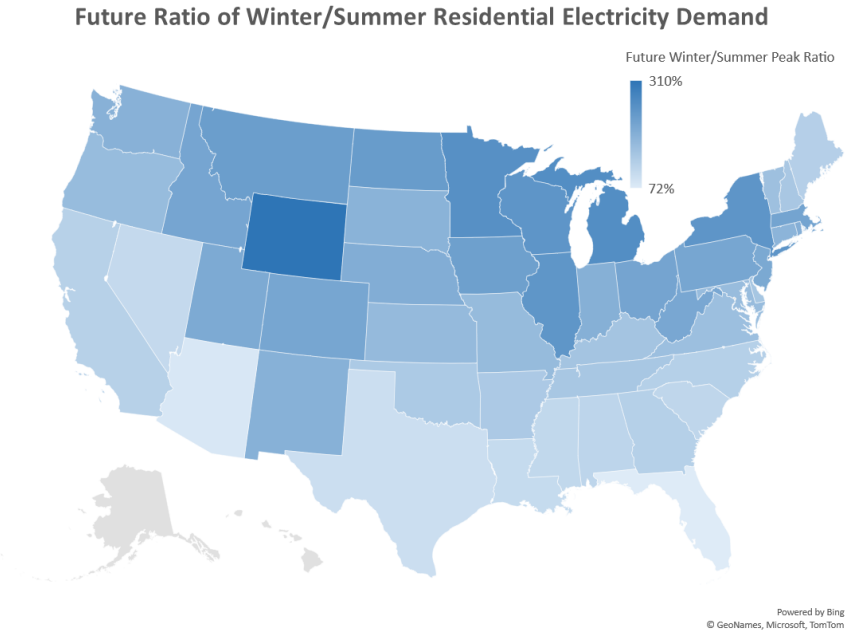

Figure 4: Impact of Electrification on Peak Winter Demand Compared to Summer Demand

Recommendations and Online Information Portal

Specific recommendations are contained at the end of this report. GTI developed an online portal providing state-level summary information for interested energy industry, policy, and regulatory stakeholders. Go to *https://www.gti.energy/residential-space-heating* for more information.