



Decarbonizing residential space heating with heat pumps in the United States

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Highlights

- We examine policies to promote heat pump adoption using national bill and usage analysis.
- Heat pump adoption would reduce bills for electric, propane, or oil users by up to \$3000.
- Where bills fall, policies should focus on financing and incentives for multi-unit homes.
- For most natural gas users, about half of U.S. heating demand, bills would rise by up to \$1500.
- Electricity price reform and solutions like time-of-use rates and thermal storage are needed.

Abstract

Heat pumps are a critical technology for decarbonizing the buildings sector, but adoption rates remain low in the United States. Here, we examine policies to promote widespread heat pump uptake based on a national-scale analysis of the impact of heat pump adoption on consumer heating bills and patterns of heating usage across the contiguous United States. At current fuel prices, we show that heat pump adoption would widely reduce heating bills in households using electric resistance, propane, or oil. Drawing on residential energy consumption data, we highlight that for these households, policy interventions should focus on overcoming barriers associated with financing and include incentives for landlords to implement heat pump upgrades in multi-unit dwellings reliant on electric heating. However, for approximately half of U.S. residential heating energy demand—households using natural gas in northern regions with cold winters—our analysis shows that heat pump adoption would significantly raise annual heating bills. In these regions and households, policies should prioritize lowering the price of electricity, such as through time-of-use pricing structures, paired with technologies like thermal storage that allow households to shift heating to lower-cost periods. More generally, targeting high electricity prices will be essential to promoting electrification across all sectors in these regions.

Introduction

Electrification of space heating using heat pumps is likely to be the most technologically scalable and cost-effective solution for decarbonizing the buildings sector, relative to other options such as hydrogen or biogas. As heat pumps use electricity to move heat at high efficiencies, they can offer greater energy efficiencies than fossil-based systems (natural gas, oil, or propane) and conventional electric resistance heating. Despite a steady increase in heat pump sales—including surpassing gas furnace sales in recent years (Rosenow et al., 2022; AHRI, 2025)—overall market penetration remains low, averaging only 14% of U.S. households, with substantial regional variability (EIA, 2024a; EIA, 2024b). Low adoption rates in colder northern states, which account for roughly half of U.S. energy demand for space heating (EIA, 2024c), may be a result of high electricity prices relative to other heating fuels like natural gas, creating an economic disincentive for switching (Davis, 2024).

Here we conduct a high-resolution analysis of the impact of heat pump adoption on space heating operating costs (i.e. consumer bills). Specifically, we determine how air- and ground-source heat pump retrofits would change heating bills for the average-sized household across different climates, fuel types, and energy prices in the contiguous United States. Additionally, we draw on data from the EIA Residential Energy Consumption Survey (RECS) to analyze broader trends in heating fuel use, energy demand, and household characteristics, highlighting economic barriers and opportunities—particularly where subsidization should be prioritized. We also discuss the implications of our results in the context of overall cost-effectiveness of investments, but do not perform detailed calculations of net present value or payback times, given the extreme variability in upfront costs of heat pumps. Finally, we examine proposed technologies and policies for enhancing

the cost-effectiveness of heat pumps, such as heat pump water heaters, time-of-use electricity pricing, and carbon pricing.

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Section snippets

Change in annual household heating bills

To examine the impact of heat pump adoption on annual household heating bills across the United States, we calculated the change in annual heating costs for the average-sized household by primary heating fuel (eq. (1)), mapping the annual cost difference (ΔC_{annual}) relative to the baseline fossil system. All data variables are shown in Table 1.
$$\Delta C_{\text{annual}} = \left(\frac{E_{\text{heat}}}{\text{SCOP}} \cdot C_e \right) - \left(\frac{E_{\text{heat}}}{\eta_{\text{ff}}} \cdot C_{\text{ff}} \right)$$

Although our analysis focuses on the change in heating bills for the average-sized household (by state), household ...

Trends in space heating usage and fuel types

In 2020, approximately 1,180 TWh of energy was consumed for space heating in the United States (EIA, 2024g), representing about 40% of total household energy consumption, although this varies regionally. Energy consumption for space heating is greatest across northern states, where winters are colder and longer, as illustrated by the greater number of heating degree days (Fig. 1). In these regions, up to 60% of annual household energy consumption is used for space heating. To a lesser extent, ...

Policy implications

Current state- and national level policies to promote heat pump adoption focus overwhelmingly on overcoming the high upfront costs associated with their purchase and installation, typically through tax rebates or direct subsidies (Mass Save, 2025; NYSEG, 2025). However, as shown in this analysis and others (Wilson et al., 2024), heat pump uptake also impacts operating costs, with the effect on consumer bills varying across the diversity of climate, fuel costs, and heating types of the United ...

Conclusions

The economic impact of heat pump adoption varies across the United States based on existing heating systems, climate, and, most importantly, the price of electricity relative to other heating fuels. Here we show that based on current fuel prices, heat pump adoption would reduce heating bills in households using electric resistance, propane, or oil across many parts of the country. However, in these households, the time to repay the upfront costs of installation with savings in utility bills may ...

CRedit authorship contribution statement

Roxana T. Shafiee: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Daniel P. Schrag:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, ...

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

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