The Economics of Electrifying Buildings

Residential New Construction

Report / December 2022

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About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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Executive Summary

Carbon emission from burning natural gas (herein referred to as gas) is one of the largest contributors to fossil-fuel related climate pollution in the US. In 2020, gas was responsible for around 36% of CO_2 emissions from fossil fuels.[1] Buildings are a major driver of greenhouse gas (GHG) emissions, making up about 11% of total US GHG emissions through the direct use of fossil fuels for space heating, water heating, and cooking.[2, i]

Ambitious action is needed to usher in a future of clean and healthy buildings, and with a recent influx of government funding from the passage of the Inflation Reduction Act (IRA), there has never been a better time to act. States and cities need to reduce emissions from buildings in order to meet climate goals. One place to start is by building all-electric residential new construction.

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To help inform crucial policy and market decisions with clear cost analysis, RMI updated and expanded its 2020 analysis, *The New Economics of Electrifying Buildings*.[3] Due to significant recent changes in gas and electricity rates and evolving construction costs, we have aimed to provide the most up-to-date analysis of these economics. In this update, we examine the economic and climate impacts of building all-electric single-family new construction that relies on electric appliances for space and water heating, cooking, and clothes drying. Compared with the 2020 analysis, we have added two cities to cover a wider range of climate zones, incorporated 2022 standard gas and electricity rates, and made methodology changes to align with local building codes. We look at the direct carbon emissions from the whole building and examine the impact of refrigerant and methane leakage from electric and gas heating and cooling systems.

Our analysis shows that all-electric single-family new construction is more economical to build and operate than a home with gas appliances and has lower lifetime emissions in all nine cities studied.

i The 11% represents only the direct building emissions from burning fossil fuels and excludes noncombustion sources that the US Environmental Protection Agency attributes to the residential and commercial sectors.

Key Findings

The all-electric new single-family home costs less to build and operate than the new mixed-fuel home, resulting in lower net present costs in all cities studied: Austin, Texas; Boston; Columbus, Ohio; Denver; Eugene, Oregon; Las Vegas; Minneapolis; New York; and Seattle.

- In all nine cities, the mixed-fuel home with a gas furnace, gas water heater, air conditioning, gas range, gas dryer, and new gas line has a higher incremental upfront cost than the all-electric home that uses a heat pump for heating and cooling and has a heat pump water heater, induction stove, and electric dryer.
- In all nine cities, the mixed-fuel home has higher annual utility bills (i.e., operating costs) than the all-electric home. Heat pumps used for space and water heating are on average two to four times more efficient than comparable fossil fuel equipment. Recent price spikes in gas rates result in higher operating costs for the mixed-fuel home.
- Net present cost savings over the 15-year period (2022–37) of study range from as low as $1,950 in Boston to as high as $10,775 in New York.

Federal climate policy can drive market transformation and lower upfront costs for low- to moderate-income (LMI) households.

- Federal policies like the IRA can spur the market and heat pump adoption, lower upfront costs, and close the cost gap between electric and gas appliances, resulting in 7% lower upfront costs in Boston and New York, which without the IRA would have comparable mixed-fuel and all-electric construction costs.
- IRA building incentives for LMI households will have an outsize impact on reducing upfront costs in all cities analyzed, and in some cities, they could lower the costs by 70% for low-income and 40% for moderate-income households.

The all-electric home has lower lifetime emissions compared with the mixed-fuel home.

- In all nine cities, the all-electric home has lower lifetime GHG emissions than the home with gas, reducing direct end-use emissions by as much as 50% in New York.
- The emissions advantage of electric heat pumps persists even when accounting for indirect emissions from methane leakage and refrigerants.

The Value of Residential Electrification

In the two years since RMI's 2020 economics of electrifying buildings report, almost 2 million single-family homes have been built in the United States.[4] Of those new homes, roughly 40% were built with an electric air- or ground-source heat pump.[5] However, the states with the largest share of all-electric homes and heat pumps are mostly in the warmer regions of the country that have high cooling needs and less common in colder regions that typically rely on gas, propane, or oil for heating. But this trend is beginning to change due to major technological advancements in heat pumps — which strengthen their potential to reduce operating costs and meet comfort expectations, especially in cold climates — as well as ambitious state and federal policies.

> **Fossil fuels are no longer required or beneficial in new homes across America. Our analysis shows new homes that burn fossil fuels cost more to build and operate and have higher emissions compared with an efficient all-electric new home.**

As of October 2022, over 80 cities and counties across the nation have adopted policies that require or strongly encourage the move off fossil fuels to all-electric new homes and buildings. This national wave of policy action is motivated by the numerous benefits of shifting from fossil fuels to clean, efficient electric appliances, including climate, health, air quality, and economics. For example, California became the first state in the United States to commit to ending the sale of polluting fossil fuel appliances — specifically, furnaces and water heaters — by 2030.[6] And the momentum behind these building electrification policies keeps growing via regulatory proceedings in over a dozen states.

Fossil fuels are no longer required or beneficial in new homes across America. Our analysis shows new homes that burn fossil fuels cost more to build and operate and have higher emissions compared with an efficient all-electric new home. Gas appliances also release harmful air pollutants, including nitrogen dioxide, particulate matter, and carbon monoxide.[7] Exposure to these pollutants can cause a variety of health issues, including respiratory illness and premature death, and disproportionately affect communities of people of color.[8]

Alternative fuels such as biomethane (also called renewable natural gas or RNG) and green hydrogen have been proposed as climate solutions in buildings, but both fuels face significant limitations that prevent them from realistically addressing home heating. Biomethane supplies are sharply limited compared with the scale of today's gas demand, and proposals to expand supply rely on feedstocks with questionable climate benefit. Furthermore, the limited biomethane supply will likely see higher value in harder-to-decarbonize industrial applications. Hydrogen is compatible only with existing gas appliances and pipes at very low concentrations and is expensive, severely limiting its realistic use in homes. Both alternatives also contribute to air pollution and health harms just as fossil gas does today.

The recent infusion of funds through the IRA will have a transformative effect on improving our built environment. The IRA invests over $50 billion in clean energy technologies and improvements, for both residential and commercial buildings, which can lower energy bills and significantly reduce climate pollution. The IRA also prioritizes delivery of new technologies and their benefits to low-income communities and those disproportionately burdened by environmental and public health impacts.

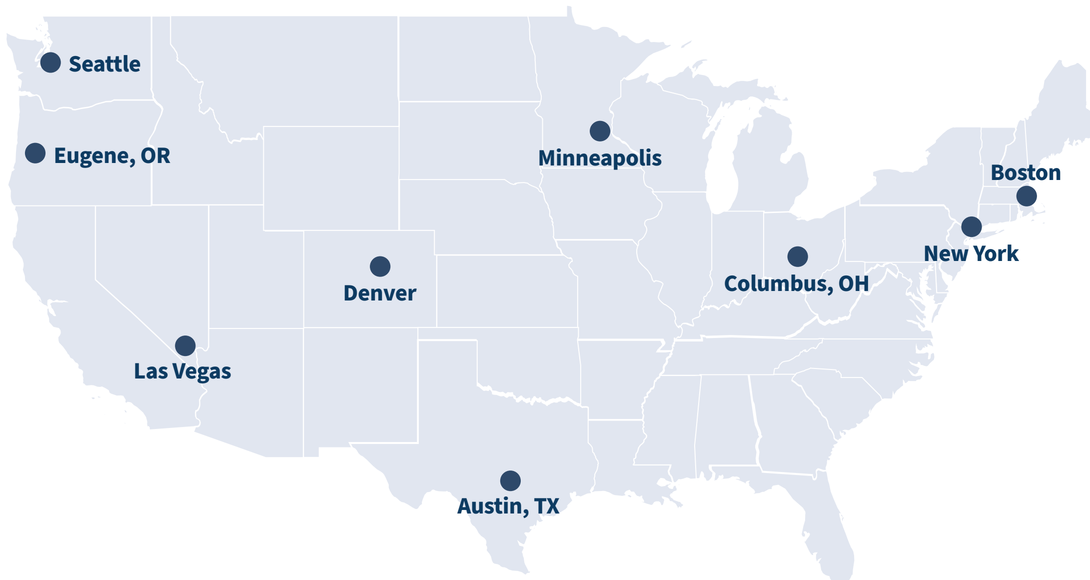
This report provides insights on incremental upfront costs,[ii] operating costs, and lifetime costs and emissions for building all-electric new homes in nine US cities and is an update to our 2020 report.

ii Upfront costs refer to the incremental costs associated with the different gas and electric appliances in the two scenarios and new gas line extensions costs. All other construction costs, including permits and labor, are considered equal across both scenarios and are not included in this analysis.

Results

The all-electric new single-family home has a lower net present cost than the new mixed-fuel home in every city we studied: Austin, Boston, Columbus, Denver, Eugene, Las Vegas, Minneapolis, New York, and Seattle (see Exhibit 1).

Exhibit 1 **The Nine Cities Studied**



Modeled Scenarios

We modeled one year of energy use for a newly constructed, detached single-family home in nine cities to determine the annual GHG impact and the 15-year (2022–37) net present cost of the two scenarios (see Exhibit 2).

Exhibit 2 **Modeled Scenarios and Appliances**

Appliances	Scenario 1: Mixed-Fuel Home	Scenario 2: All-Electric Home
Heating	Ducted central gas furnace (AFUE 0.95)	Ducted multizone air source heat pump (11 HSPF, SEER 19)
Cooling	Central air conditioner (SEER 14)	
Water Heating	Gas water heater 80-gal storage (EF 0.82)	Hybrid electric heat pump water heater 80-gal storage (EF 2.35)
Cooking	Gas cooktop Gas oven	Induction cooktop Electric oven

Note: AFUE is annualized fuel utilization efficiency; HSPF is heating seasonal performance factor; SEER is seasonal energy efficiency rating; and EF is efficiency.

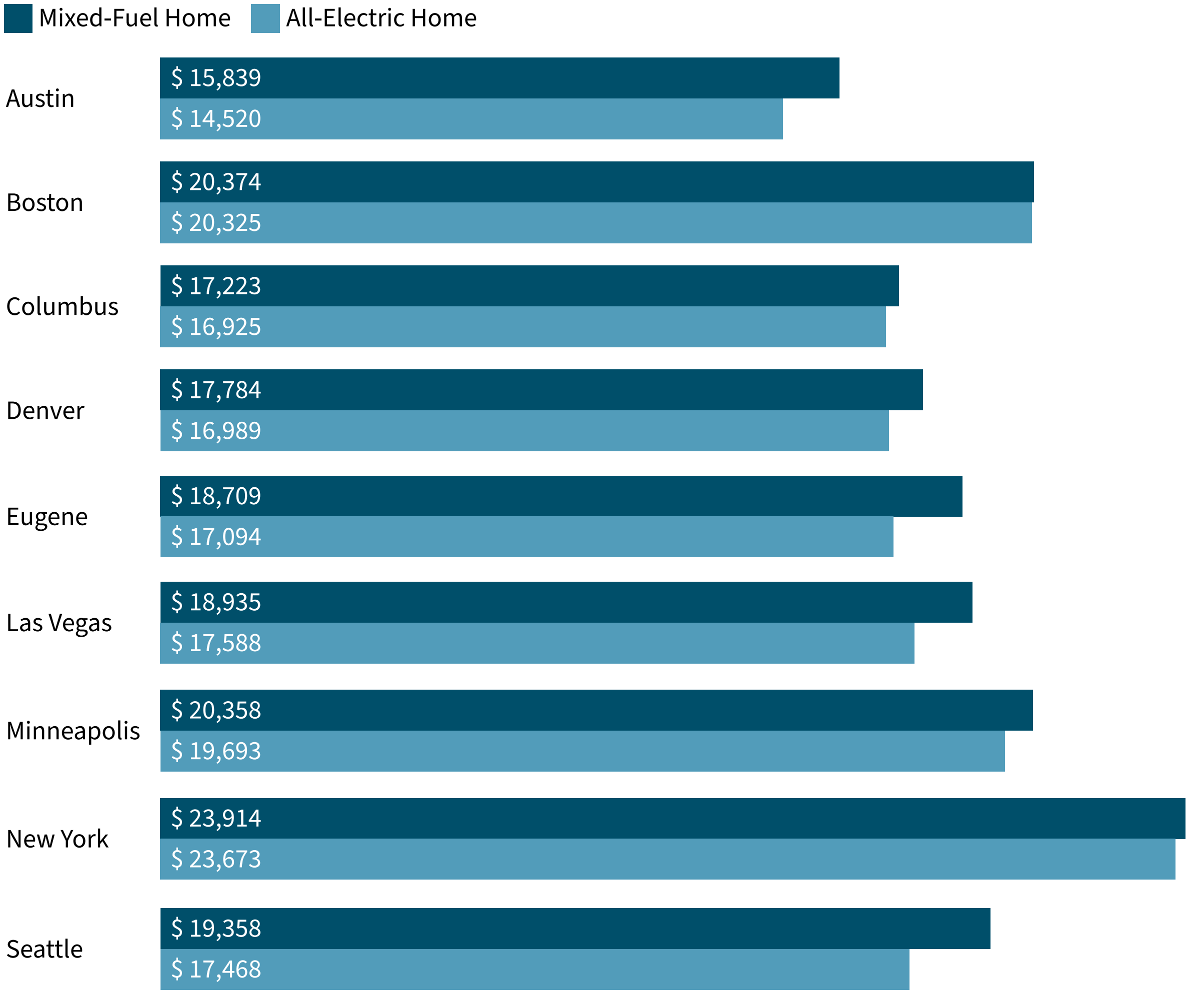
Homes were modeled to align with the International Energy Conservation Code (IECC) of 2018 unless the state or city code was more stringent, in which case the reach code was applied. Scenario 1 simulates a mixed-fuel home that relies on gas for space and water heating, cooking, and clothes drying. Scenario 2 simulates the home in the first scenario except the home relies on electricity for space and water heating, cooking, and clothes drying. See *Appendix: Methodology and Assumptions*, page 20, for more details.

Upfront Costs

In all cities analyzed, all-electric new construction costs less to build than a mixed-fuel home that relies on gas for space heating, water heating, cooking, and clothes drying (see Exhibit 3, next page). In Boston and New York, the incremental upfront cost is comparable, and most of the savings is from forgoing a new gas line to the home. The all-electric home costs less, ranging from approximately 0.2% cheaper in Boston all the way up to 9.8% in Seattle. The cost difference between cities is mainly due to climate variation, its impact on equipment sizing, and the city-specific RSMeans construction scaling factor.[iii] (For more information, see *Appendix: Methodology and Assumptions*, page 20.) On average, the overall upfront cost of appliances for space conditioning, water heating, clothes drying, cooking, and their required infrastructure is 5% cheaper for the all-electric home compared with the mixed-fuel home.

iii RSMeans is a database of current construction cost estimates.

Exhibit 3 **Total Upfront Cost Comparison**



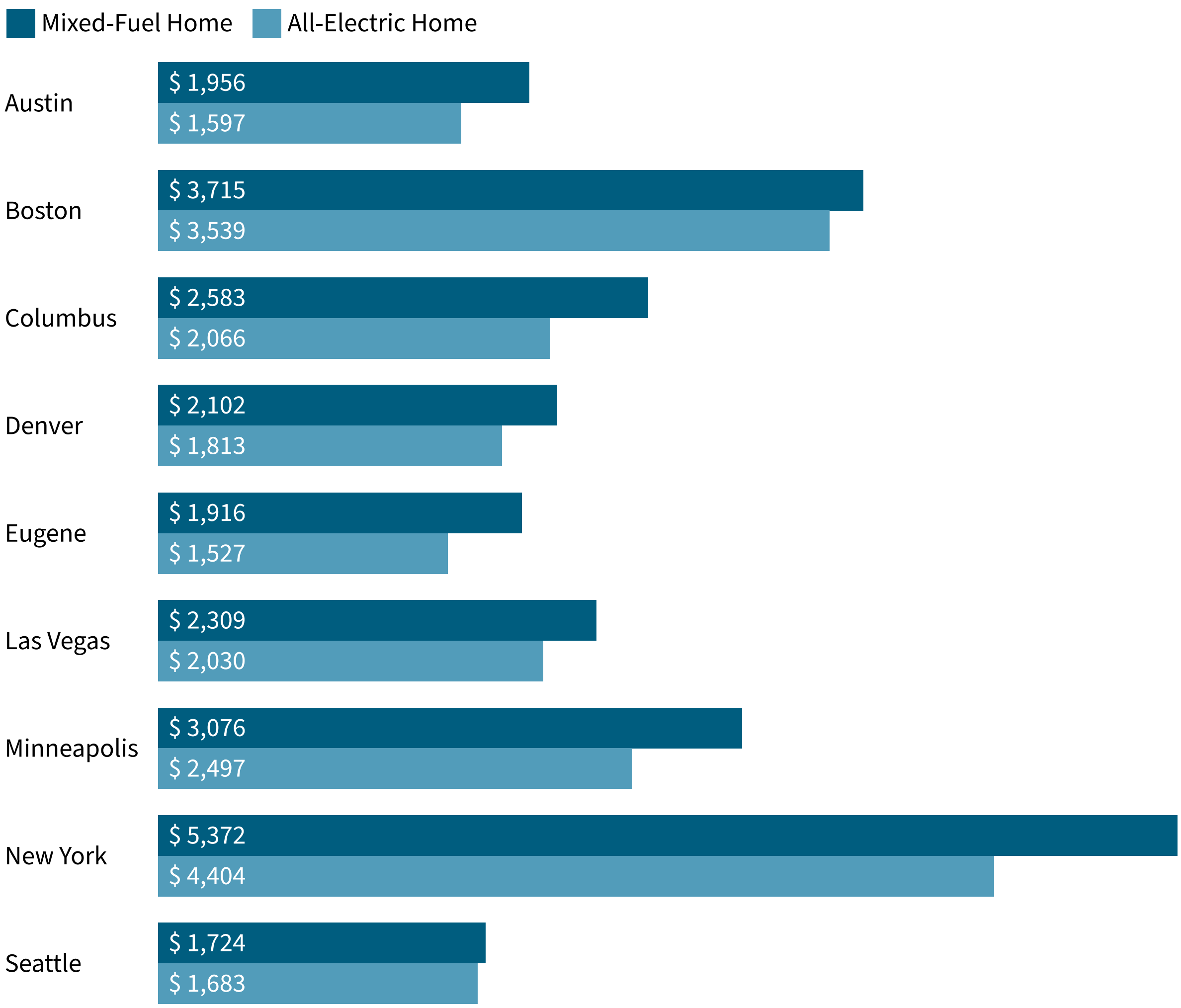
Source: RSMeans Construction Data, RMI Analysis

New housing construction with gas appliances requires a connection to the gas main, a gas meter, lateral service piping between the gas main and meter, and a distribution system within the building, services that increase the upfront cost. Gas utilities typically pay part or all of the cost for these new gas connections based on an expectation of long-term revenue through the customer's gas bills, although standard practice varies widely among utilities. These subsidies, generally called gas line extension allowances, date back decades to when fossil gas was perceived as a cheap and clean alternative to electricity and considered an essential service. All utility customers pay for these allowances, effectively subsidizing the cost of extending service to new customers. But that trend is changing, as states consider ending these gas infrastructure subsidies. For example, California became the first to end subsidies to connect new buildings to the gas system.[9]

Operating Costs

In all cities analyzed, the all-electric home has lower annual operating costs than the mixed-fuel home. This can be attributable to two things. First, heat pumps are two to four times more efficient than a gas furnace, and second, the cost of gas has increased sharply in the last year—which results in higher operating costs for a mixed-fuel home. For this analysis, we used actual local utility rates from 2022 and not statewide averages or forecasts. Exhibit 4 compares the annual utility bills between the all-electric home and the mixed-fuel home and represents all end uses in the homes. In general, all-electric bills are lower by 2% for Seattle and as much as 20% for Columbus. On average, the all-electric home is around 14% less expensive to operate than the mixed-fuel home.

Exhibit 4 **Total Annual Operating Cost Comparison**

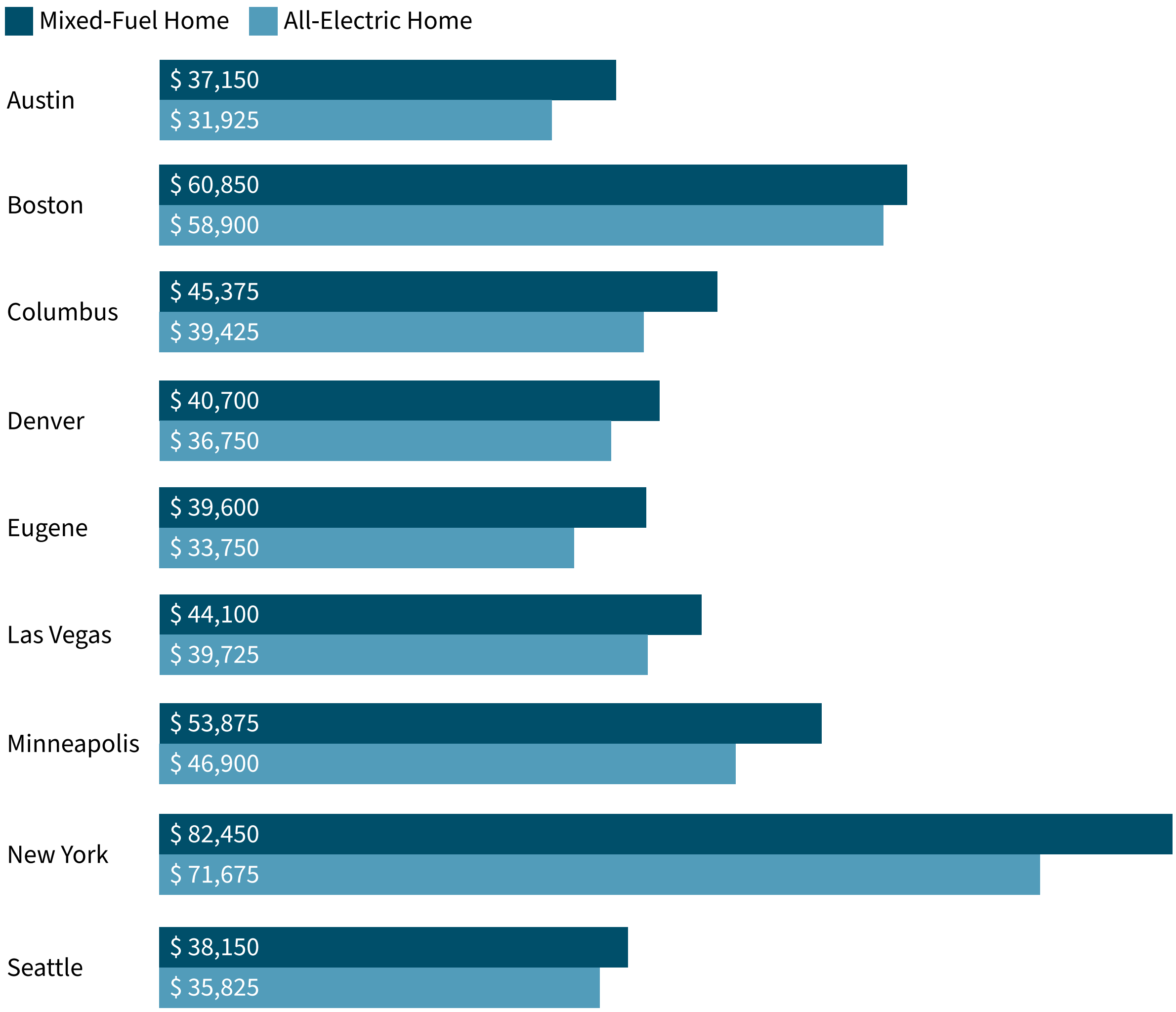


Source: RMI Analysis

Net Present Costs

Exhibit 5 (see next page) shows the 15-year (2022–37) net present cost comparison of the mixed-fuel home and the all-electric home. Fifteen years is the typical life expectancy of a heat pump. The 15-year net present cost of the all-electric home is lower than that of the mixed-fuel home for all cities studied. New York has the highest savings in net present costs, followed by Minneapolis, Columbus, and Eugene.

Exhibit 5 **15-Year Net Present Cost**



Source: RMI Analysis

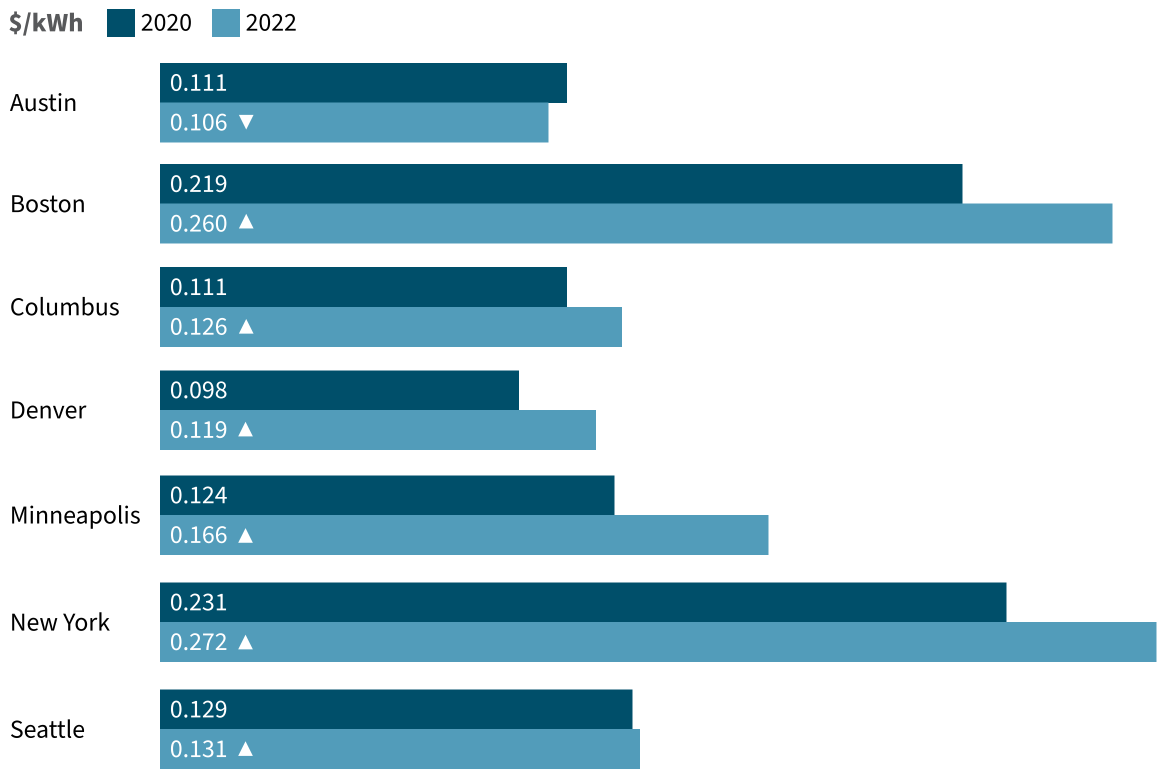
Rising Gas Prices

In almost all cities studied in this analysis,[iv] apart from Austin, electricity and gas prices have increased compared with those in our 2020 report. Our research shows that from 2020 to 2022, gas rates increased sharply, around 35% on average, almost two times more than electricity rates in the same period. Millions of households faced higher-than-average winter heating bills in 2021 due to high gas costs, and this trend is expected to worsen this winter. The National Energy Assistance Directors Association expects the average cost of home heating for 2022–23 will increase by 17.2% and forecasts gas costs to increase 34.4%, compared with the 2021 winter heating season.[10] This would be the second year in a row of high home energy costs, which disproportionately affect low-income families.

Exhibits 6 and 7 (see next page) compare the average electricity and gas rates for the seven cities studied for 2020 and 2022. Minneapolis experienced the highest electricity rate increase (around 34%), whereas Columbus and Denver experienced the highest gas rate increase (around 70% and 62%, respectively).

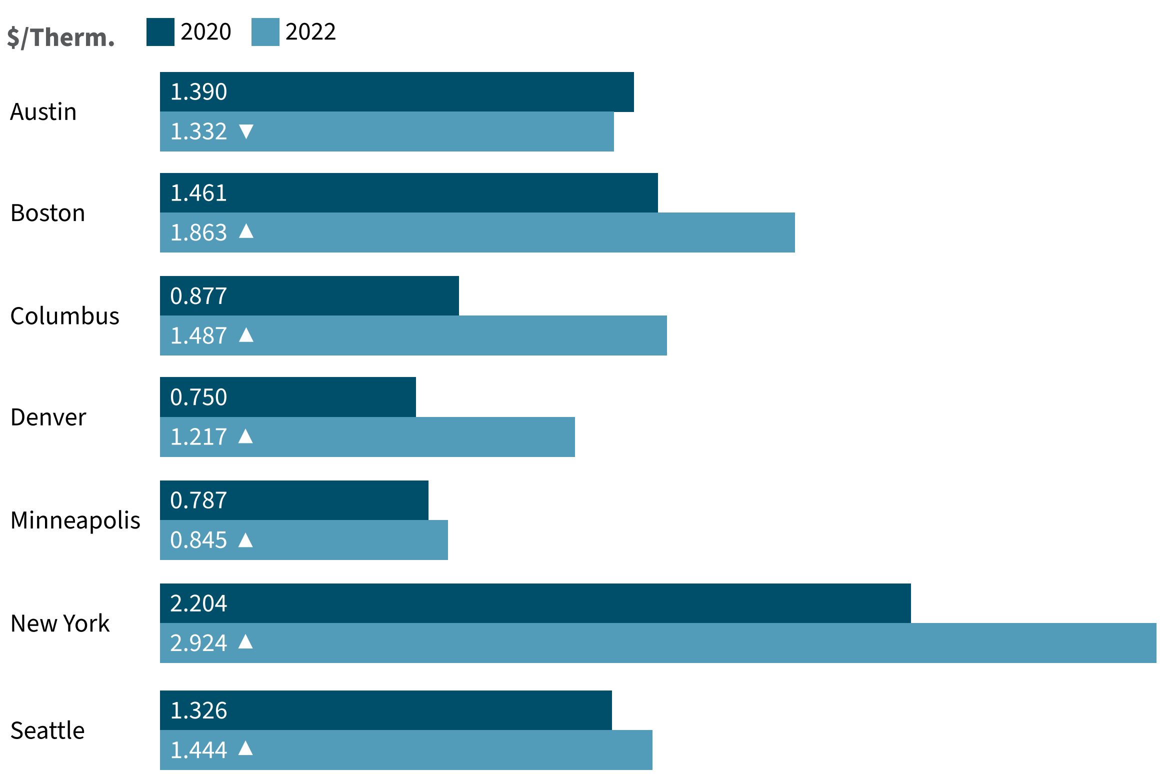
iv Eugene and Las Vegas are excluded in the rates analysis as these cities were not included in the 2020 analysis.

Exhibit 6 Average Electricity Rates in 2020 vs. 2022



Source: RMI Analysis

Exhibit 7 Average Gas Rates in 2020 vs. 2022



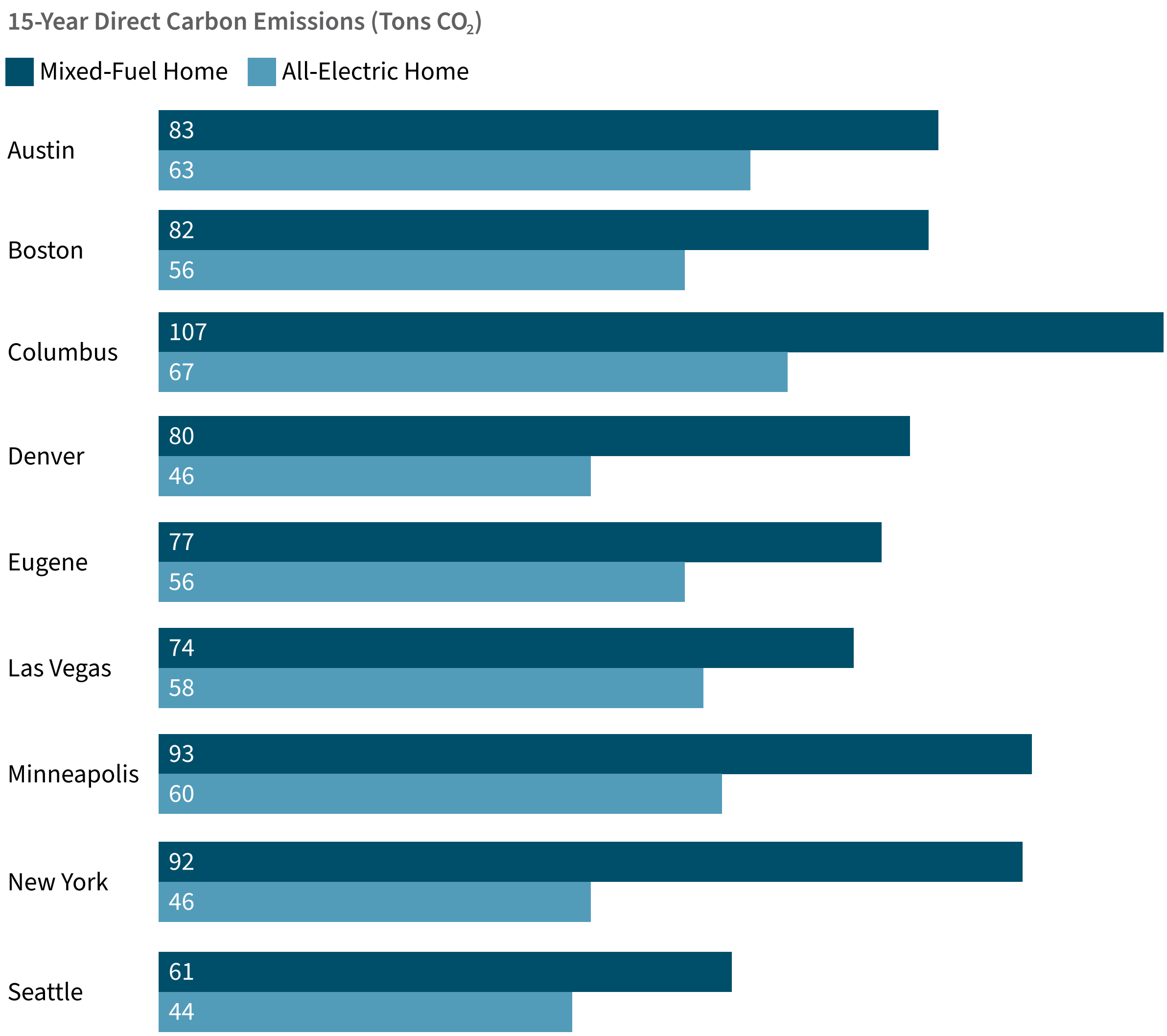
Source: RMI Analysis

Climate Impacts: GHG Emissions

Residential buildings contribute to emissions directly and indirectly. Direct emissions primarily come from burning fuels such as gas and oil for space heating, water heating, and cooking. Indirect emissions come from power plants that burn fuel to generate electricity, which then is distributed to homes and businesses. We looked at the direct emissions of all appliances in both scenarios using the National Renewable Energy Laboratory's (NREL) Cambium tool long-run marginal emission rate (LRMER)[11] and the US Environmental Protection Agency's (EPA) emission factors.[12]

Exhibit 8 shows the 15-year (2022–37) carbon emissions comparison of mixed-fuel and all-electric homes. The 15-year CO_2 emissions of all-electric homes are significantly lower than those of mixed-fuel homes for all the studied cities, even the cities that still rely on gas for electricity.

Exhibit 8 **15-Year Whole Home GHG Emissions**



Source: NREL Cambium tool, EPA, RMI Analysis

Refrigerants and Methane

Significant debate exists over whether installing a heat pump today makes sense from a climate perspective given the global warming potential (GWP) of refrigerants and potential leaks.

Air conditioners (ACs) and heat pumps use hydrofluorocarbons (HFCs) as refrigerants or heat transfer agents. HFCs are powerful heat-trapping pollutants when they leak from equipment. Most current heat pumps use refrigerant R-410A with a global GWP of 2,088 over 100 years.[13,v] Current refrigerants have climate impacts when they leak into the air, but alternative refrigerants have less than 1% the climate impact of R410-A, which is why they are being phased out. This analysis confirms that the climate benefits of installing a heat pump today, even accounting for refrigerant leakage, are positive. What's more, these benefits will improve over time as HFCs are replaced with more climate-friendly alternatives.[14]

Residential heat pumps, in place of gas furnaces, have the potential to significantly reduce operational GHG emissions under a wide range of geographic and climatic conditions. This is true even in regions that still rely on gas for electricity production.

We analyzed the emissions of a heat pump and a gas furnace plus AC,[vi] including:

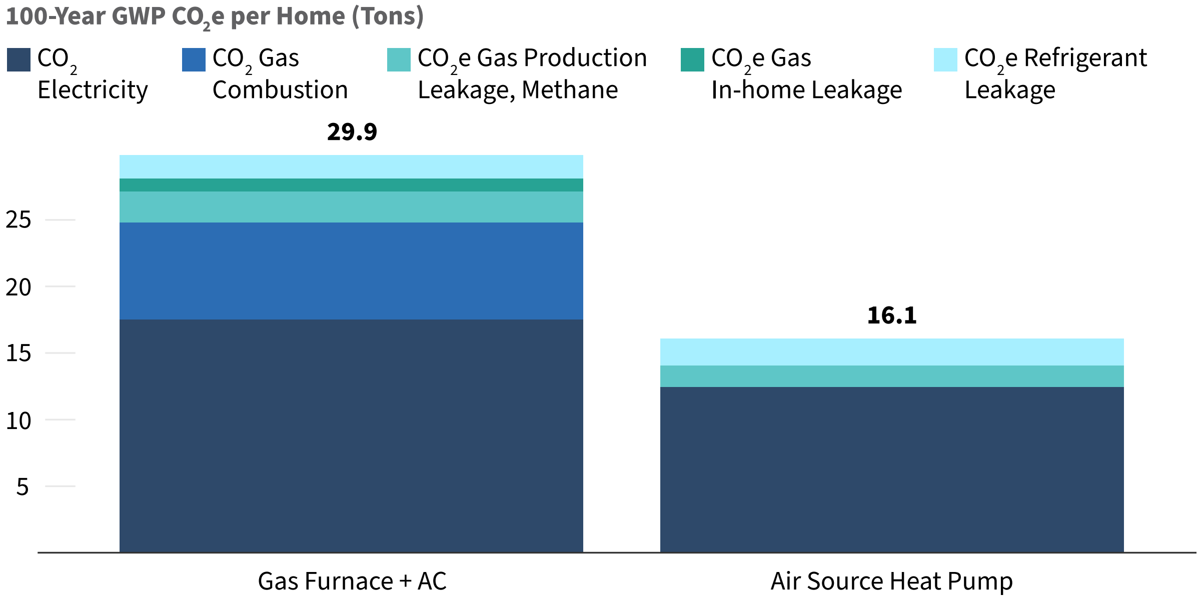
- Long-run marginal emissions from the electric grid predicted by NREL's Cambium tool (2022–37)
- Emissions from gas combustion in homes
- Gas leaks during production for electricity generation and furnace heat
- Methane and refrigerant leaks on an annual basis and end-of-life disposal

For simplicity's sake, the analysis was narrowed down to two cities with different contexts (see Exhibits 9 and 10, next page). Las Vegas is a predominately cooling climate with a high dependence on electricity with high grid emissions today and for the next 15 years (2022–37). Seattle, by contrast, uses less cooling relative to Las Vegas and has a more significant dependence on heating energy in both mixed-fuel and all-electric cases but also has lower grid emissions today and over the next 15 years. This analysis does not represent a comprehensive assessment of all potential climate or grid emissions dependencies but provides a useful sample showing that even in the wider context of indirect emissions from the gas and electric equipment, electric equipment has a lesser climate impact.

v GWP was developed to allow comparisons of the global warming impacts of different gases and specifically is a measure of how much energy the emissions of 1 ton of gas will absorb over a given period of time, relative to the emissions of 1 ton of CO_2.

vi Methodology and assumptions followed the approach outlined in the University of California, Davis, study *Greenhouse gas emission forecasts for electrification of space heating in residential homes in the US*. (See **https://www.sciencedirect.com/science/article/pii/S0301421522000386**.)

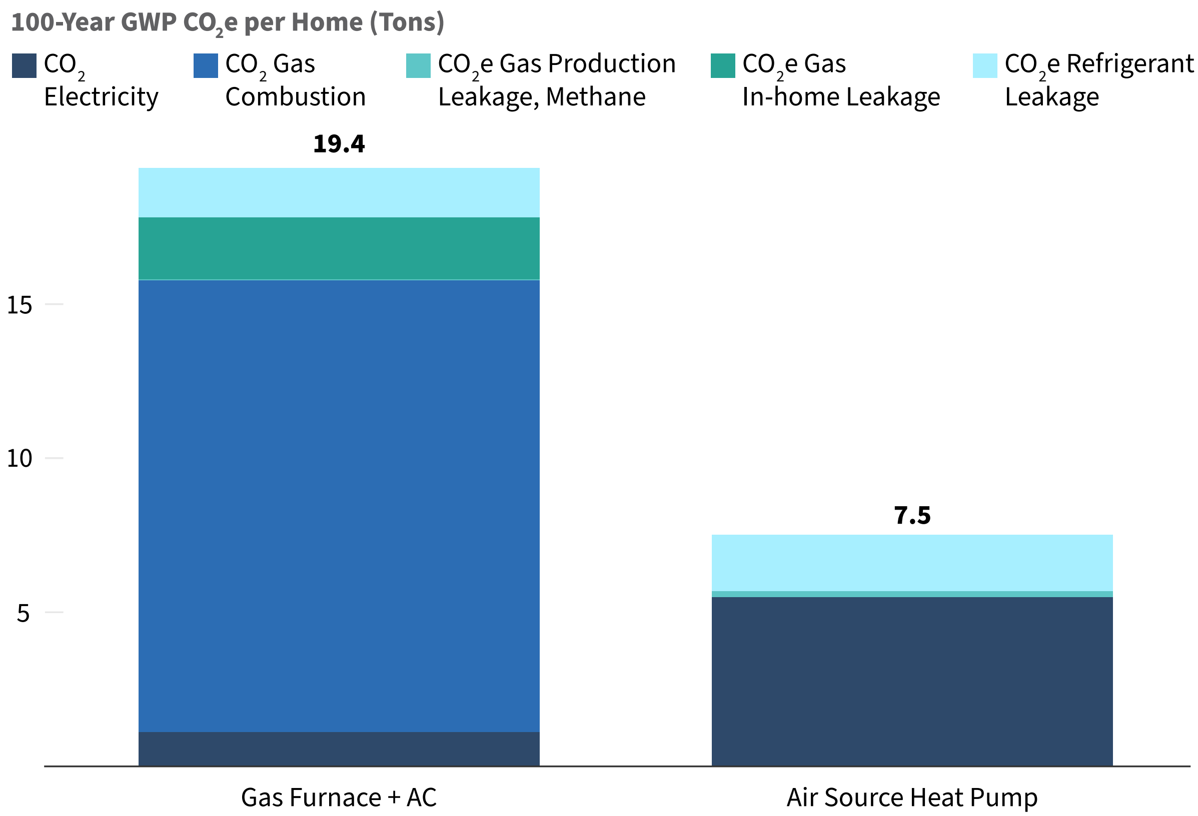
Exhibit 9 Las Vegas CO_2-Equivalent Emissions



Note: All CO_2e emissions for methane and refrigerant are representative of a 100-year GWP. The refrigerant represented in this calculation is R-410A.

Source: NREL Cambium tool, UC Davis, RMI Analysis

Exhibit 10 Seattle CO_2-Equivalent Emissions



Note: All CO_2e emissions for methane and refrigerant are representative of a 100-year GWP. The refrigerant represented in this calculation is R-410A.

Source: NREL Cambium tool, UC Davis, RMI Analysis

Market Transformation: Inflation Reduction Act

With the IRA signed into law, the buildings sector can now anticipate a flood of over $50 billion in building decarbonization provisions. The IRA's building provisions include rebates, tax credits, loans and grants, and other funding. These provisions could accelerate the nation's shift to all-electric homes.

We examined two provisions that apply to new construction: (1) the 45L tax credit,[vii] which provides a credit up to $2,000 for new homes that install an efficient heat pump, and (2) the High-Efficiency Electric Home Rebate Act (HEEHRA), which includes $4.5 billion in direct rebates for LMI households that install new, efficient electric appliances.[viii]

The 45L tax credit will help lower the cost gap between heat pumps and gas furnaces, and recent analysis finds that the bill could result in 650,000 newly constructed energy-efficient homes.[15] We looked at two cities, Boston and New York, where the upfront cost differential between building all-electric and mixed-fuel homes is comparable and found that the tax credit could help persuade builders and homebuyers to install a high-efficiency heat pump for space heating and cooling (see Exhibit 11).

Exhibit 11 **Impacts of 45L on Upfront Costs in New Construction**

City	Mixed-Fuel	All-Electric	Percent Difference	Mixed-Fuel with Tax Credit	All-Electric with Tax Credit	Percent Difference
Boston	$20,375	$20,325	(0.2%)	$19,775	$18,325	(7%)
New York	$23,925	$23,675	(1%)	$23,325	$21,675	(7%)

The HEEHRA provides rebates for LMI households that install new, efficient electric appliances such as heat pumps. It covers 100% of electrification project costs for low-income households and 50% of costs for moderate-income households.[ix] It offers a maximum rebate of $14,000, which includes as much as $8,000 for a heat pump for space heating, $1,750 for a heat pump water heater, $840 for a heat pump clothes dryer, and $840 for an induction stove or cooktop.[x] Our analysis shows these incentives could have an outsize impact on the upfront costs of all-electric new construction, and in some cities, they could lower the costs by as much

vii The tax credit also applies to gas-powered heat pumps, which are very rare and not examined in this report. We included the $600 federal tax credit for efficient gas furnaces in the mixed-fuel costs.

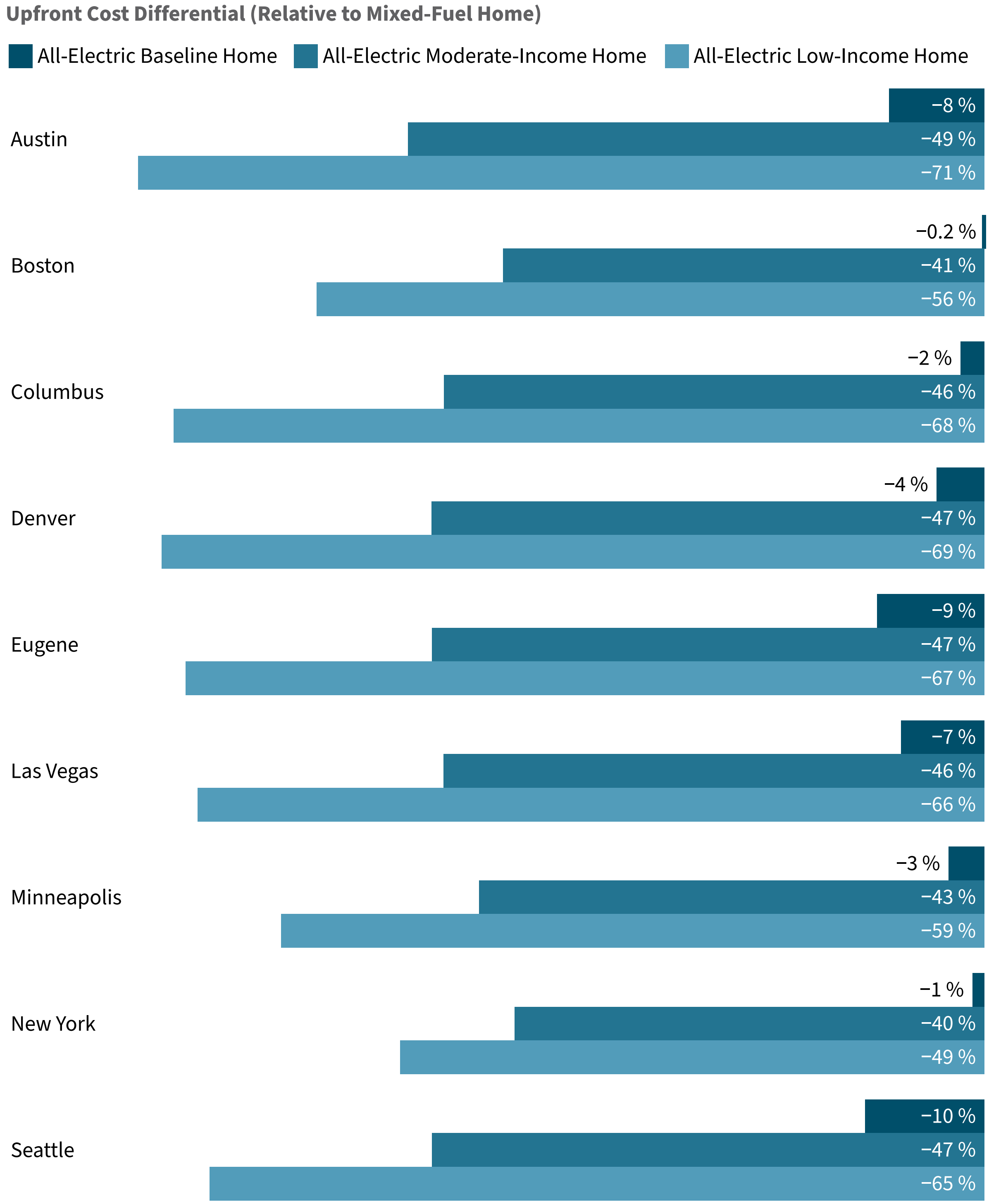
viii Also applicable to existing housing and retrofits.

ix Low-income is defined as a household below 80% of area median income (AMI), and moderate-income applies to a household between 80% and 150% AMI.

x The HEEHRA includes additional incentives for panel upgrades, electrical wiring, and insulation, ventilation, and sealing, but is more applicable to existing buildings and retrofits and thus excluded from this analysis.

as 70% for low-income and 49% for moderate-income households (see Exhibit 12). These cost savings allow developers to produce more market-rate and affordable housing units and endure other price fluctuations.

Exhibit 12 HEEHRA Impacts on New Construction Upfront Costs



Source: NREL Cambium tool, RMI Analysis

Conclusion

Our analysis shows that building all-electric new construction makes economic and climate sense today compared with building a new home that uses gas appliances. Reducing our reliance on fossil fuels in buildings can make energy costs more affordable over time, especially if gas prices remain at today's elevated levels or rise higher. The buildings provisions in the IRA have the potential to close the cost gap between gas and electric appliances, lowering upfront costs and making it more affordable to build all-electric and install all-electric appliances, especially for LMI households.

These findings support policies that incentivize or require all-electric residential new construction and eliminate gas infrastructure subsidies for new buildings. Our buildings are long-lived investments that will remain standing for decades. Now that we can meet nearly all their energy needs with electricity from an increasingly low-carbon grid, we can establish a cost-effective pathway to meeting climate goals by eliminating direct fossil fuel use in buildings and not expanding the gas distribution system. This also avoids harmful health impacts, high costs, and safety challenges associated with fossil fuel use and infrastructure.

Appendix: Methodology and Assumptions

Energy Modeling

Annual hourly energy modeling is conducted for each city using the US Department of Energy's EnergyPlus whole building energy modeling tool (v 9.2). The Pacific Northwest National Laboratory's (PNNL) single-family detached home is utilized as the baseline for modeling, and the inputs are adjusted for each city considering the local building codes and/or IECC of 2018. If the local building code is more stringent (e.g., Seattle), the PNNL baseline is modified to meet local code recommendations. Otherwise, IECC 2018 is used. Typical meteorological year 3 (i.e., TMY3) weather files are used to provide insights on local climate and weather conditions in a typical year. The energy modeling results for each scenario with the inputs described above are calibrated to energy use intensity and gas/electricity fuel split with the latest available data by climate region from the US Energy Information Administration's Residential Energy Consumption Survey.[16]

Upfront Costs

For the two scenarios discussed in this study, the upfront costs of the building envelope, infrastructure, and general construction are assumed to be the same for both all-electric and mixed-fuel scenarios, so they are not included in the first cost analysis. Only the first costs associated with the different appliances and their primary fuel are examined. All costs associated with a new residential home are considered equal, except between the appliances that operate with only electricity (heat pump, heat pump water heater, electric cooking range, and electric dryer) and those that operate with gas and electricity (gas furnace, air conditioning, gas cooking range, and gas dryer). Electric panel upgrades are assumed unnecessary for new construction as they are part of the building code; however, new gas infrastructure costs are assumed to be applicable for the mixed-fuel building.

Exhibit 13 **Average National Appliance Costs**

	Mixed-Fuel Home		All-Electric Home	
	Equipment	**Cost**	**Equipment**	**Cost**
Space Heating	Gas furnace	$731/ton	Air source heat pump, ducted	$1,889/ton
Space Cooling	Air conditioning, central	$1,051/ton		
Water Heating	Gas water heater	$1,798	Heat pump water heater	$3,336
Cooking	Gas range	$884	Electric range	$1,927
Clothes Drying	Gas dryer	$1,195	Electric dryer	$1,515
Gas Infrastructure	New connections, new line from street	$1/sq. ft.	NA	NA

The added cost of new gas infrastructure on any given project can vary widely based on site conditions, utility practices, local labor costs, and municipal regulations. The representative costs for gas infrastructure are primarily based on available data from major investor-owned utilities across multiple states. Our research shows the cost for new gas infrastructure ranges from $1,800 to $10,000 per home.[17]

Exhibit 13 (previous page) provides average appliance costs for mixed-fuel and all-electric homes before applying the RSMeans construction cost factors to account for location-specific variability as well as climate variability in heating and cooling equipment.

Operating Costs

Annual hourly energy modeling data is used to calculate the operating costs for each city. Standard 2022 residential rates are used for the utilities in each city. The original version of our *The New Economics of Electrifying Buildings* analysis (EEB), published in 2020, used the 2020 rates; however, rates have changed significantly in recent years, which made updating the rates necessary. Average electricity ($/kWh) and gas rates ($/therm) are compared for 2020 and 2022 for the seven cities analyzed in the 2020 report.

Emissions

Emissions are calculated using NREL's Cambium tool for LRMER and the EPA's emission factors. The Cambium tool provides the hourly cost, emissions, and operational data for modeled future scenarios of the US electricity sector in two-year increments (2022–50). Cambium projections are conservative forecasts based on state-level legislation passed as of June 30, 2020. The NREL Cambium 2021 Standard Scenario was used, 95% electrification by 2050, which accounts for changes in generation and transmission infrastructure investments as a direct result of electrification policies and adoption. The LRMER is a long-term estimate of the rate of emissions that would either be avoided or induced by a change in the electrical demand in the long term. This version of EEB considers the emissions of all end-use and whole-building energy demand. However, the 2020 version of EEB accounts only for the emissions of the heating systems.

Refrigerants and Methane

Methodology and assumptions used to determine the refrigerant and methane emissions align with the University of California, Davis, (UC Davis) study *Greenhouse gas emission forecasts for electrification of space heating in residential homes in the US*.[18] Refrigerant charge is assumed to be 0.28 kg/kW for the air-conditioning unit modeled and 0.34 kg/kW for the heat pump. Refrigerant volume is then translated to CO_2 equivalent emissions based on a 2% annual leakage rate,[xi] and a GWP of 2,088, representing the 100-year GWP of R-410A, the refrigerant most used in American heat pumps and ACs, is applied. Methane end-use consumption was determined based on Cambium data, and emissions associated with the methane consumption were calculated consistent with the UC Davis methodology.

xi Based on the US Green Building Council credit for refrigerant management. (See **https://www.usgbc.org/credits/ea7**.)

Endnotes

1 "U.S. Energy-Related Carbon Dioxide Emissions, 2020," US Energy Information Administration, December 5, 2022, **www.eia.gov/environment/emissions/carbon**.

2 "Inventory of US Greenhouse Gas Emissions and Sinks," US Environmental Protection Agency, 1990–2020, **https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks**.

3 Claire McKenna, Amar Shah, and Leah Louis-Prescott, *The New Economics of Electrifying Buildings*, RMI, 2020, **https://rmi.org/insight/the-new-economics-of-electrifying-buildings**.

4 "New Residential Construction," US Census Bureau and US Department of Housing and Urban Development, August 16, 2022, **https://www.census.gov/construction/nrc/index.html**.

5 "Residential Energy Consumption Survey (RECS)," US Energy Information Administration, 2020, **https://www.eia.gov/consumption/residential/data/2020/**.

6 Leah Louis-Prescott and Alexandra Maxim, "California Becomes the First State to Commit to Ending the Sale of Polluting Heaters by 2030," RMI, September 28, 2022, **https://rmi.org/california-commit-ending-sale-of-polluting-heaters/**.

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