New construction and the future of gas in Massachusetts

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Executive Summary

The Commonwealth of Massachusetts has set greenhouse gas limits that require 50% reductions in greenhouse gas emissions by 2030 and then further reductions over the following decades to achieve net-zero emissions by 2050. The near-elimination of operational emissions in new construction is an important foundational step for achieving these statutory limits—a step emphasized by the Commonwealth's 2050 Decarbonization Roadmap,[1] Clean Energy & Climate Plans,[2,3] and Final Report of the Commission on Clean Heat.[4] Despite recent policy exercises and legislation, the Commonwealth has yet to fully take this foundational action needed to advance the decarbonization of the building sector.

The 2022 update to the Stretch Energy Code included the creation of an Opt-in Specialized Energy Code. While both of these codes position Massachusetts as a leader in new building construction standards that favor electrification, they allow for the continued use of fossil fuels across all building types, including those that can be cost-effectively and readily electrified today. In response to this gap, the State Legislature launched a process to allow ten municipalities to pilot all-electric new construction codes, a program that nine out of ten communities expect to launch in 2024.[5]

In December 2023, the Department of Public Utilities, through its order[6] on the Future of Gas Docket (D.P.U. 20-80), "set forth a regulatory strategy for pursuing an energy future that begins to move the Commonwealth beyond gas and toward its climate objectives." While this statement and a directive to reexamine pipeline extension allowances for new gas connections are remarkable, the order only begins a process for instituting change, and it is not yet clear how fast and consequential such a process will be in limiting emissions from new construction.

While these actions largely favor a steady pivot to electrification, they leave open the door to the continued expansion of fossil fuel demand that challenges the ability of the Commonwealth to achieve its statutory emissions limits. Concerns about the affordability of all-electric new construction have slowed the embrace of all-electric buildings. These concerns

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[1] MA Executive Office of Energy and Environmental Affairs (EOEEA). "Massachusetts 2050 Decarbonization Roadmap", 2020. mass.gov/doc/ma-2050-decarbonization-roadmap/download.
[2] MA EOEEA, "Massachusetts Clean Energy and Climate Plan for 2025 and 2030", 2022. mass.gov/doc/appendices-to-the-clean-energy-and-climate-plan-for-2025-and-2030/download.
[3] MAEOEEA, "Clean Energy and Climate Plan for 2050." mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050
[4] MACommission on Clean Heat "Commission on Clean Heat Final Report." November 30, 2022. https://www.mass.gov/info-details/commission-on-clean-heat-issues-final-report.
[5] MA Department of Energy Resources. "Municipal Fossil Fuel Free Building Demonstration Program," https://www.mass.gov/info-details/municipal-fossil-fuel-free-building-demonstration-program.
[6] MA Department of Public Utilities, "Order on Regulatory Principles and Framework, No. 20-80", December 8, 2023). https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/18297602

have been rooted in a historical understanding of construction and energy costs that is no longer accurate.

This report reviews recent advances in costs and incorporates a forward-looking view of energy costs to demonstrate that concerns about affordability are unfounded and that all-electric new construction offers pathways to more affordability than utility gas. It uses customer cost forecasts developed by the utilities themselves[7] that show rapidly increasing gas costs relative to electricity. The report's major findings are twofold.

First, for many building types, all-electric new residential construction has achieved effective cost-parity—meaning construction costs are within a range of 1% less or more, depending on design considerations with fossil fuel new construction. Ductless air-source heat pumps (ASHPs) avoid the need for ductwork, gas piping, and central AC, while ducted ASHPs incur a small cost premium relative to gas furnaces. Heat pumps are already competitive *before* any cost savings from federal or state incentives and before additional requirements of the Stretch Code on gas construction.

Second, the emergence of cold climate heat pump technology has lowered the operational cost of electric heating to well below that of oil, propane, and electric resistance and is approaching cost-parity with utility gas under current rates and energy prices. Further, all-electric new construction is poised to quickly become much more cost-effective than gas under expected emissions regulations and increasing average gas delivery costs.

The three key drivers behind this inflection in energy costs are the increasing cost of gas pipeline maintenance (largely to manage leak-prone pipe), the declining consumption expected with even modest levels of heating electrification, and potential efforts to regulate emissions. These drive up the cost of gas and delivery to consumers.

By the time average gas costs double in the early 2030s, gas equipment installed today will have reached only half its expected lifespan of 15-20 years. By the 2040s, average customer gas costs will scale even higher and will heavily incentivize remaining gas customers to reduce and abandon their gas consumption. This could be crippling for those with less agency to leave the gas system. Delay in avoiding such an outcome will likely lead to higher customer and taxpayer costs.

As gas costs rise, more affluent customers will convert to electric heating and appliances to avoid the high operational costs. This "retrofit of regret" will require additional capital expenditures and disruption to building occupants to install electric equipment. Costs and

[7] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report--Technical Analysis of Decarbonization Pathways," March 2022. https://thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf.

disruption in these buildings can be avoided if the building is all-electric from the start. Unlike prior studies that have not considered higher future energy costs, this report illustrates the potential costs and burdens of continued fossil-fuel construction and the “retrofit of regret” both analytically and through a household vignette.

Our analysis uses a single-family home as one example to illustrate these points. However, the report’s findings can be extended to other building types where all-electric strategies offer additional or context-specific cost savings and design benefits. Its key point of emphasis is that gas costs are likely to rise to a much greater degree than regulators and project developers have accounted for in prior assessments.

This report offers its readers orientation in a time of uncertainty around infrastructure costs by focusing on long-term dynamics. The recent inflationary post-pandemic environment has resulted in cost spikes for construction and gas system modernization. The acceleration of building decarbonization efforts has added fuel to the fire as more and more building owners—particularly those with the economic ability to do so—embrace electric alternatives.

This period raises an important question: why continue to invest in multiple energy distribution systems when modern technology enables the electric system to increasingly carry the load that has been served by the gas system?

Advancing all-electric new construction today is low-hanging fruit, as all the Massachusetts climate roadmaps have repeatedly emphasized, and an easy and cost-effective way of avoiding significant costs and disruption in the future. Further, as this report shows, concerns around the burden of incremental heating costs of all-electric new construction will be short-lived as gas rates climb. Electric costs can also be managed through electrification-friendly rate design to help smartly allocate costs and encourage load management.

Without all-electric building codes in place, new buildings will consume the carbon budget available to existing buildings and leave little room for existing buildings — which are more costly and difficult to electrify — to meet current building sector targets. **Consequently, building new construction with electricity increases the possibility of achieving mandated emissions targets.**

The Commonwealth faces the pressing and interlinked challenges of reducing greenhouse gas emissions and increasing housing affordability. Both challenges emerged from chronic inaction, resulting in material consequences today. As the Commonwealth, its municipalities, and building developers espouse the need to achieve these goals, this report offers a long-term vision to guide decision-making with the aim of realizing climate, equity, and affordable housing goals.

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Acknowledgments

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Michael J. Walsh, Ph.D.

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Abbreviations and Acronyms

2021 Climate Act	Act Creating a Next-Generation Roadmap for Climate Policy
2022 Climate Act	Act Driving Clean Energy and Offshore Wind
2050 Roadmap	Massachusetts 2050 Decarbonization Roadmap
BPDA	Boston Planning and Development Agency
DEP	Massachusetts Department of Environmental Protection
DOER	Massachusetts Department of Energy Resources
DPU	Massachusetts Department of Public Utilities
EOEEA	Executive Office of Energy and Environmental Affairs
HERS	Home Energy Rating Score

Introduction

The 2021 "Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy"[8] (2021 Climate Act) mandated statewide greenhouse gas reduction targets that require the state to limit and eventually eliminate emissions at a trajectory largely aligned with global climate targets.[9] These greenhouse gas limits aim to reduce emissions relative to 1990 levels by 50%, 75%, and 85% by 2030, 2040, and 2050, respectively (Figure 1). Further, the 2050 target is a net-zero target in which residual gross emissions are to be netted to zero by removals.

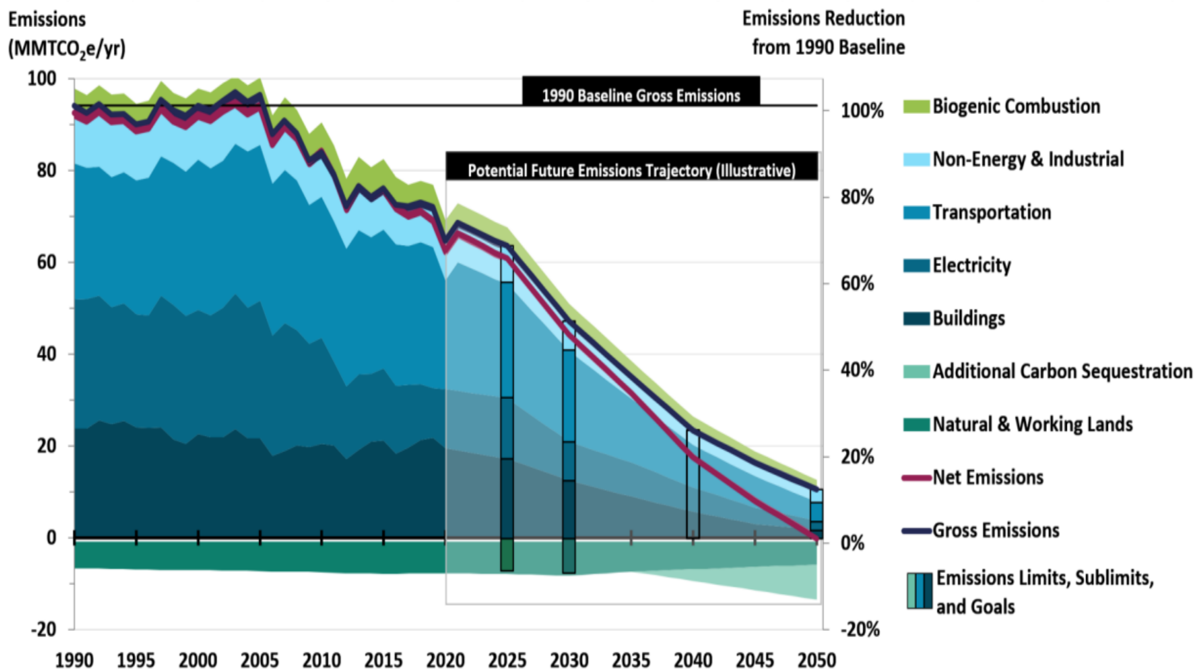

Figure 1. Illustration of Massachusetts historical emissions and projections given statutory limits and sub-limits. Source: Massachusetts 2050 Clean Energy and Climate Plan[10]

While the Commonwealth's greenhouse gas targets are legally binding limits, there remains a substantial disconnect between these limits and the capacity of existing laws and regulations across various sectors to meet them.[11] This report focuses on the gap in one area of greenhouse gas emissions regulation: building energy codes for new construction and major renovations. Specifically, it addresses concerns around cost and affordability that have hindered recent efforts to align building energy codes with the Commonwealth's greenhouse gas limits. **The state of this policy is reviewed in Chapter 1.**

[8] "An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy.". https://malegislature.gov/Bills/192/S9.
[9] "AR6 Climate Change 2022: Mitigation of Climate Change — IPCC." https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/.
[10] "Clean Energy and Climate Plan for 2050." Massachusetts Executive Office of Energy & Environmental Affairs, 2022. mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050
[11] Fitzgerald, Joan, and M. J. Walsh. "The Inaugural Boston Climate Progress Report." Nov. 2023. tbf.org/news-and-insights/reports/2022/november/2022-climate-report-card-20221103.

The emergence of cold-climate air source heat pumps that efficiently provide heat at very low temperatures has made all-electric heating far less carbon-intensive and more efficient than combusting fossil fuels on-site. It has also created a pathway to nearly eliminate greenhouse gas emissions from building heat with increasing levels of carbon-free electricity. **Chapter 2 of this report reviews how all-electric new construction aligns with climate goals while the construction of fossil fuel buildings does not. It notes a gap between current policy and the outcomes needed to achieve statutory emissions limits**.

Chapters 3 and Chapter 4 of this report find that all-electric new construction has achieved effective cost-parity with new gas-fueled buildings on both a construction cost and energy bill basis. We define effective cost-parity to mean that the differences in building construction and operational costs—resulting from comparable design decisions—are close enough that any electrification cost premium is significantly smaller than other factors that influence housing and energy affordability, including design decisions, interest rates, regulatory mechanisms, and market conditions. These factors can be addressed by advancing various regulatory, housing, and energy policy priorities that are addressed throughout this report.

The effective cost parity of all-electric new construction is remarkable because utility gas has historically been associated with low heating bills. **However, as this report demonstrates—*using forecasts developed with the gas utilities themselves*—gas has reached a dead-end on affordability and will become increasingly expensive.**

The report builds on prior studies of the economics of electrification using a novel forward-looking system analysis. Notably, the report considers how future gas system costs will impact buildings built today with gas. It highlights the potential cost of *retrofits of regret*, which occurs when a fossil-fueled household must make expensive and complicated upgrades to electrify before the end of the life of its fossil-fueled appliances to avoid paying exorbitantly expensive gas costs. This insight is valuable to legislators, municipalities, and developers, as each needs to make informed decisions in implementing policies that favor all-electric buildings.

Chapter 5 describes the additional benefits of all-electric construction, while Chapter 6 synthesizes the report's findings through a vignette and concluding summary. An appendix of policy avenues is provided at the end. Ultimately, this report conveys that building codes cannot be designed and promulgated in a vacuum. A forward-looking systems perspective is needed to achieve mandated emissions reductions, affordability, and equitable outcomes.

A list of policy avenues for expanding all-electric new construction is presented at the end of the report. A summary of methodology and data sources for the report's illustrative figures and tables is subsequently presented as an appendix.

Chapter 1: The Current State of All-Electric Construction Policy

The Commonwealth's landmark 2050 Decarbonization Roadmap Study[12] (2050 Roadmap) specifically identified the adoption of all-electric new construction building codes as a practical and cost-effective early action for aligning the state's sectoral regulations with its climate targets. However, the adoption of these important principles into practice has fallen short in the three years since the 2050 Roadmap was published. This chapter reviews the current state of the new construction policy to frame Chapter 2's assessment of its adequacy for achieving emissions limits and Chapter 3's and 4's assessment of cost impacts.

The State of Building Codes in Limiting Emissions from New Construction

The 2008 Green Communities Act[13] established a two-tiered building energy code system consisting of Base and Stretch building energy codes. These codes are updated periodically, with the Base Code largely following the International Energy Conservation Code (IECC). The Stretch Code is designed to achieve higher levels of energy efficiency and energy bill affordability. Three hundred one (of 351) communities in the state, representing 90% of the population, have adopted the Stretch Code as part of their participation in the Green Communities Program,[14] which gives them access to dedicated grants and state resources. As such, the Stretch Code has served as the *de facto* default code for most new construction in the state for the past several years.

In 2019, the Town of Brookline, through its Town Meeting, sought to ban the use of fossil fuels in new construction and major renovations.[15] Brookline's initial and revised bylaws were deemed unlawful by the Office of the Attorney General (AGO), which claimed that the town statute was preempted by the Building Code, the Gas Code, and the Department of Public Utilities's regulation of gas service.[16]

Simultaneously, as part of its 2019 Climate Action Plan Update,[17] the City of Boston tasked the Boston Planning and Development Agency (BPDA) to "Strengthen Green Building Zoning Requirements to a Zero Net Carbon Standard." The BPDA subsequently conducted a comprehensive study exploring electrification, on-site renewables, and embodied carbon. Following a comprehensive stakeholder engagement process, the BPDA published its draft

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[12] Executive Office of Energy and Environmental Affairs. "Massachusetts 2050 Decarbonization Roadmap: Summary Report," 2020. mass.gov/doc/ma-2050-decarbonization-roadmap/download.
[13] "Green Communities Division" mass.gov/orgs/green-communities-division.
[14] Massachusetts Department of Energy Resources. "Massachusetts Building Energy Code Adoption by Municipality," December 5, 2223.
https://www.mass.gov/doc/building-energy-code-adoption-by-municipality/download.
[15] "Brookline Tries Again For A Fossil-Free Future | WBUR News." June 3, 2021
wbur.org/news/2021/06/03/brookline-fossil-fuel-natural-gas-ordinance.
[16] Office of the Attorney General. Stretch Code Straw Proposal Comments, 2022 Massachusetts Building Code Regulation. mass.gov/doc/ago-comments-on-doers-stretch-code-straw-proposal/download
[17] City of Boston. "2019 Climate Action Plan Update,"
boston.gov/sites/default/files/embed/file/2019-10/city_of_boston_2019_climate_action_plan_update_4.pdf

policy proposal in September 2022.[18] While this policy did not prohibit fossil-fueled new construction outright, it did create various incentives for all-electric new construction, notably leveraging the framework established by the City's Building Emissions Reduction and Disclosure Ordinance update (BERDO 2.0), which established a declining cap on emissions from large buildings.[19] After the publication of the policy in September 2022, the City of Boston—alternatively—considered participating in the Commonwealth's fossil-fuel-free municipal pilot program. However, in November 2023, the City announced that it would not pursue participation in this pilot.[20] As of the writing of this report, the City appears to be considering its next steps with a possible return to the BPDA net-zero zoning initiative.[21,22]

Recognizing the desire for municipal leadership and the need to advance building codes toward electrification, the Legislature in the 2021 Act on Climate tasked the Massachusetts Department of Energy Resources (DOER) to "develop and promulgate, in consultation with the state Board of Building Regulations and Standards (BBRS), a municipal opt-in specialized stretch energy code that includes, but is not limited to, net-zero building performance standards and a definition of net-zero building, designed to achieve compliance with the Commonwealth's statewide greenhouse gas emission limits and sub-limits."[23]

Adding a third tier to the state's building codes was intended to provide a mechanism for municipalities to align new construction in their jurisdiction with the state's climate targets. Despite the statewide emissions limits, the opt-in mechanism thus effectively leaves out a significant portion of new construction in the state—communities that do not adopt the code. Further, the State Legislature drafted the law in a way that allowed DOER to determine if the code would allow or prohibit the use of fossil fuels.

DOER subsequently developed a code that incentivizes all-electric construction, but still allows the use of fossil fuels in the new Specialized Code. This opt-in code, on approval of the municipal government, requires new construction to be electrification-ready and adds additional efficiency in multi-family housing, pre-wiring for future electrical appliances, and solar requirements for homes built with gas. While these extra requirements are intended to "offset"

[18] Boston Planning & Development Agency. "Proposed Article 37 Zoning Update and ZNC Policy & Standards - DRAFT for Public Comment," September 28, 2022. bostonplans.org/getattachment/708944cf-ff5a-4d68-83a0-29a912bdd8a0.
[19] City of Boston. BERDO 2.0 (2021). boston.gov/sites/default/files/file/2021/12/Final%20Amended%20Docket%200775%20BERDO%202_0.pdf.
[20] Sabrina Shankman "Boston's Plan to Ban Fossil Fuels in New Buildings Goes up in Smoke." *BostonGlobe*, November 12, 2023. bostonglobe.com/2023/11/13/science/boston-will-not-apply-to-ban-fossil-fuels/.
[21] Ryan, Greg. "BPDA 'Net Zero' Proposal Regains Spotlight, with Gas Ban out in Boston." *Boston Business Journal*, November 14, 2023. bizjournals.com/boston/news/2023/11/14/boston-net-zero-proposal-regains-spotlight.html.
[22] Shankman, Sabrina. "Under Pressure from Both Developers and Climate Advocates, Boston Charts a New Path to a Fossil Fuel-Free Future", The Boston Globe." January 16, 2024. bostonglobe.com/2024/01/16/science/boston-green-buildings/.
[23] "An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy.". malegislature.gov/Bills/192/S9. (Section 31, lause 14)

the impact of gas and mitigate future retrofit costs, they fail to recognize the increasing cost of expanding the gas system when long-term declines in consumption and customers are expected. This dynamic will be discussed in Chapter 4.

The Specialized Code builds upon the mechanism of the Stretch Code, which favors electrification by requiring fossil fuel-burning buildings to achieve a lower (more stringent) Home Energy Rating System (HERS) score. A summary of the code is presented in Table 1.

Table 1: Summary of the Residential Stretch and Opt-in Codes. Source: DOER[24]

	All-Electric	**Fossil Fuel**
Stretch	Home Energy Rating Score (HERS) of 45 or Lower	Home Energy Rating Score (HERS) of 42 or Lower
	Prewired for EV Charging Energy recovery ventilation	
Specialized Opt-In	• HERS rating of 45 or lower (same as above)	• HERS rating of 42 or lower (same as above) • Prewiring in place for future electric heating and appliances • On-site solar (when feasible) • Net zero energy (HERS 0) or Passive house certification for new homes over 4,000 ft^2 • Passive house certification for multi-family buildings over 12,000 ft^2

This choice to allow fossil fuels in the Specialized code was made despite the Massachusetts 2050 Roadmap's demonstration of the importance of advancing all-electric new construction. Further, this approach was taken despite guidance from the AGO that the 2021 Climate Act provided that "DOER has the authority to promulgate a specialized opt-in code that includes all-electric requirements."[25]

Following this punt by DOER, the Massachusetts General Court, in its 2022 Climate Act[26] instructed DOER to oversee a ten-municipality fossil fuel-free pilot. Through this program and based on DOER-established guidelines, ten towns and cities may prohibit the combustion of fossil fuels in new construction and comprehensive renovations, essentially by requiring the all-electric pathway in the Specialized Code.

[24] "Summary of Proposed New 225 CMR 22.00 and 23.00." 2023 Stretch Energy Code Update and Municipal Opt-in Specialized Code. Massachusetts Department of Energy Resources, mass.gov/doc/summary-document-explaining-stretch-energy-code-and-specialized-opt-in-code-language.
[25] Office of the Attorney General. Stretch Code Straw Proposal Comments, 2022
[26] "An Act Driving Clean Energy and Offshore Wind." https://malegislature.gov/Bills/192/H5060.

As of the publication of this report, nine of the original ten prioritized communities have been approved by DOER,[27] while two substitute communities are currently competing for the one available final spot in the program.[28] Only one of the prioritized communities, Cambridge, is ranked in the state's top ten most populous cities.

The back and forth has resulted in four overarching energy codes (Table 2) for the Commonwealth.

Table 2 Summary of the Massachusetts building code tiers as of the start of 2024.[29]

Base Code	Stretch Code	Specialized Code	Fossil Fuel Free Code
IECC 2021	2023 Update plus IECC 2021	Stretch plus additional requirements for fossil fuel buildings	DOER 10 municipality fossil fuel free demonstration program
New construction in municipalities not in a Green Community	New construction in Green Community municipalities	New construction in municipalities that vote to opt-in to this code	New construction in 10 municipalities that are approved by DOER
50 municipalities	301 municipalities	32 municipalities (additional pending)	10 municipalities

The State of Gas System Regulation in New Construction

The building code is not the only policy mechanism for advancing all-electric new construction. The Department of Public Utilities, through its regulation of gas distribution systems, can directly and indirectly influence the expansion of the gas system. In its order in the Future of Gas Investigation (DPU 20-80),[30] the DPU explicitly stated that it "seeks to dissuade gas customer expansion and to align rate design with the Commonwealth's climate objectives" as part of a goal to move the Commonwealth "beyond gas."

The rationale for dissuading expansion is premised on aligning the gas system with emissions targets and avoiding additional investment in the gas system, which will see declining customers and consumption, severely challenging the cost recovery of continued ratepayer investment. Current ratemaking practices would severely burden non-migrating gas customers. **This affordability problem, as well as the role of rate design, is discussed in Chapter 4.**

Currently, a new customer is incentivized to connect to the gas system because the serving utility is allowed to cover some portion of the extension cost. This "allowance" is expected to be

[27] Two communities, Newton and Arlington, still need to prove they have fulfilled affordable housing requirements by February 11, 2024

[28] Massachusetts Department of Energy Resources. "Municipal Fossil Fuel Free Building Demonstration Program," https://www.mass.gov/info-details/municipal-fossil-fuel-free-building-demonstration-program.

[29] Massachusetts Department of Energy Resources. "Massachusetts Building Energy Code Adoption by Municipality," December 5, 2023. mass.gov/doc/building-energy-code-adoption-by-municipality/download.

[30] Van Nostrand, Jamie, Cecile Fraser, and Stacy Rubin. Order on Regulatory Principles and Framework, No. 20-80 (Massachusetts Department of Public Utilities December 8, 2023). https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/18297602

paid back by the customer over a period of time via the delivery portion of their gas bill. In many cases, customers are also required to contribute to the cost of the pipeline extension if the cost of the extension is greater than the allowance determined by the utility.

This practice is akin to a down payment and a mortgage, incentivizing customers to join the gas system by covering some of the upfront connection costs. Utilities typically earn a rate of return on the allowance—a rate that is higher than a typical mortgage, usually about 10%.[31]

This practice is meant to ensure that existing customers do not directly subsidize new customers but obscures the true cost of the gas system from new customers by financing it through their expected future bills. The practices for determining the allowances vary by utility and are obscure. A review of filings by Liberty indicates that their customer contributions (the "down payment") are approximately 20% of new connection costs.[32] Such information could not be discerned from other utilities.

This obscurity raises an important concern. Future revenues from a new customer could be lower than what is required to pay back the allowance because the current formula and practice for offering an allowance may not appropriately capture the potential for lower-than-expected demand. Further, unlike a mortgage, it is unclear who would be responsible for paying off these unrecoverable costs.

The evaluation period for ensuring gas sales revenues exceed costs is typically 10-20 years.[33] However, these revenues may be increasingly unrecoverable due to increasing consumer interest in electric alternatives and a 15-year lifespan for new gas equipment—at which point it is likely that customers will electrify, given issues discussed in the following chapters. The DPU, in its 20-80 Order, noted that the current line extension framework should be evaluated and adjusted to align with the Commonwealth's emissions limits and expected trends in gas consumption.

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[31] Seavey, Dorie. "GSEP at the Six-Year Mark: A Review of the Masssachusetts Gas System Enhancement Program," 2021. https://gasleaksallies.org/gsep.

[32] Liberty Utilities "Petition of Liberty Utilities (New England Natural Gas Company) Corp., d/b/a Liberty Utilities for approval of its Revenue Decoupling Adjustment Factors for the 2023 Peak Period, November 1, 2023, through April 30, 2024: Scheudle I" MA DPU #23-78, 2023 https://eeaonline.eea.state.ma.us/DPU/Fileroom/dockets/bynumber/23-82

[33] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals: Regulatory Design." March 14, 2022. https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14633270

The Political Barriers to All-Electric Building Codes

Energy codes and regulations are intended to provide a uniform set of rules to ensure a building is safe, healthy, comfortable, and affordable. While safe, healthy, and comfortable all-electric buildings are already constructed regularly in the Commonwealth, uncertainty among decision-makers about how the climate imperative affects the affordability criterion has led to uncertainty about the future of new construction and a proliferation of codes and efforts to advance building electrification. This uncertainty has its roots in three sets of questions related to the transition from fossil fuels to all-electric buildings in new construction:

1. Does the design of new construction ensure the elimination, eventual elimination, or lock-in of fossil fuels? How does each of these strategies influence the ability of the Commonwealth to achieve its statutory greenhouse gas reduction targets, particularly given higher aggregate and peak electric demand?
2. What are the relative upfront or retrofit costs of these various design outcomes, and how does this influence the pace of new construction?
3. How do these various design outcomes impact customer energy costs?

While these three considerations may seem straightforward, there is significant uncertainty around how each will play out, leading to hesitation around setting ambitious all-electric building codes. This hesitation is rooted in three misperceptions aligned with these questions.

First, there is an expectation that fossil-fuel new construction can be decarbonized later, either through a retrofit or the use of low-carbon fuel. Such an expectation contradicts the State's energy transition research and creates additional emissions that make achieving interim and long-term limits even less likely.

Second, this hesitation is based on an outdated understanding of construction costs. Evolving equipment costs and changing installation practices have resulted in effective cost parity of all-electric and gas systems in residential and many commercial buildings.

Third, for the past two decades, gas has been the cheapest energy source for customers. Research by the state's gas utilities has shown that this will no longer be the case in the future due to the increasing cost of maintaining a gas system with declining throughput. Further, various electric sector regulatory mechanisms can create pathways for all-electric heating in new construction to be even more cost-effective than gas.

The remainder of this report clarifies these misconceptions by taking a broader perspective on the implications of building code decisions than previous studies. The analysis below uses a single-family home to illustrate these points. However, its findings can be extended to other building types where all-electric strategies can offer additional or contextual cost and design benefits.

Chapter 2: All-Electric New Construction is the Lowest Risk Pathway for Meeting Climate Targets

To avoid the worst impacts of climate change, human society needs to both *stop* the flow of emissions into the atmosphere and *limit* the amount of emissions that accumulate in the atmosphere through a rapid decline in emissions. *Stopping* emissions by reaching net zero stops warming. *Limiting* emissions limits the amount of warming to more manageable temperatures for adaptation. These principles are codified in the Commonwealth's climate law, which establishes a net zero emissions target (which stops its contribution to warming) alongside the law's interim 2030 and 2040 targets (which limits its contribution to warming).

Making this distinction may seem pedantic, but distinguishing these two facets of a climate target is important and helpful for emphasizing that all-electric new construction is an immediately impactful policy for limiting and stopping statewide emissions because it avoids fossil fuel infrastructure immediately.

This chapter reviews why heating electrification is essential to achieve immediate reductions in carbon emissions and eventual net zero goals. Then, it reviews the Commonwealth's policy, research, and analysis to establish that continued reliance on fossil fuels presents a clear risk of missing the State's net-zero target and works against interim efforts to limit emissions.

Electrification of Heat is Essential for Net-Zero Emissions Systems

The underlying principles of electrification and efficiency align with national-scale analyses such as the Net Zero America Study.[34] Building electrification eliminates the need for fuel combustion by using low-carbon electricity to power heat pumps. This arrangement works partly due to the high efficiency of modern heat pumps, which consume less energy than they deliver. Heat pumps are so efficient that even when they run with electricity generated from gas, they reduce emissions relative to combusting gas directly for heat in the home, accounting for losses from conversion efficiency (heat rate) at gas power plants (Figure 2, next page).[35]

Electrification in new construction thus *reduces emissions* today and creates a pathway to *eliminate emissions* with the deployment of low-carbon electricity generation that meets growing demand while reducing fossil-based generation.

Cold-climate heat pumps today work at temperatures down to minus 15 degrees Fahrenheit. They work slightly less efficiently at lower temperatures - meaning at a slightly lower COP or coefficient of performance. However, the effect of this is negligible in *new* construction, because the percent of annual new construction is extremely low (and the percent of emissions due to

[34] Larson, Eric, et al. "Net-Zero America." Net-Zero America. https://netzeroamerica.princeton.edu/.
[35] For an illustrative example, see: https://x.com/kevinkircher/status/1672259580410077185?s=20

ASHPs much lower). Additionally, heat pump demand (sizing) performance is optimized in buildings built to the new Stretch Code standards, while performance is maximized due to increased energy efficiency standards.

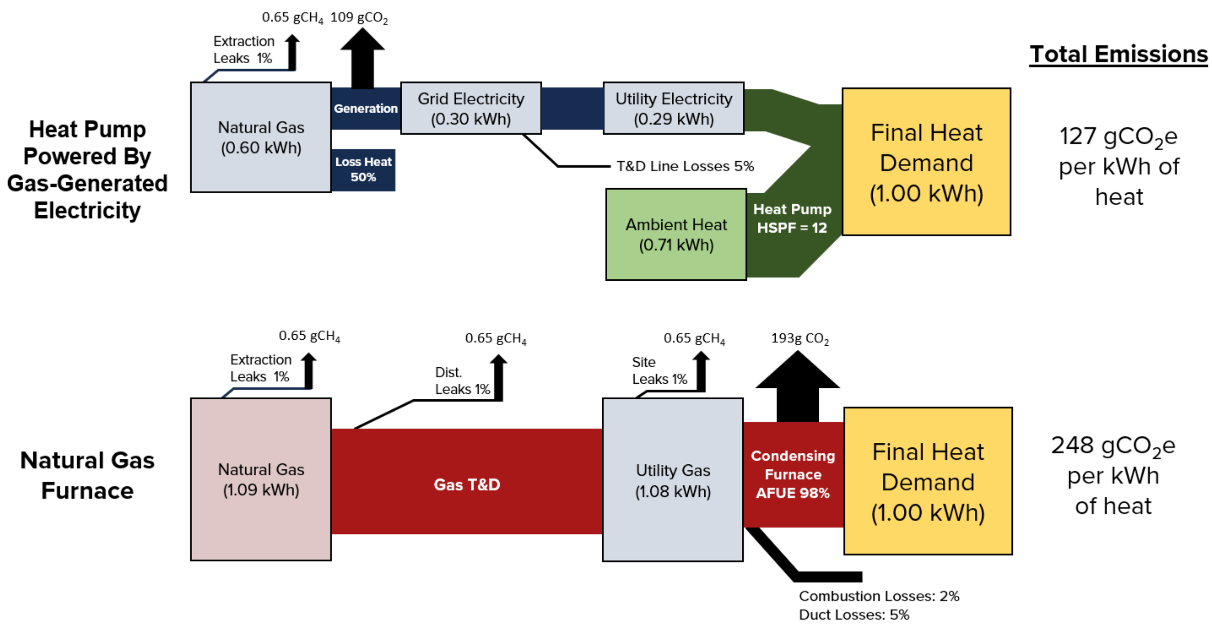


Figure 2. Comparison of energy flows and emissions from a gas furnace and a heat pump powered by electricity from gas generation.

Electrification does result in increasing electricity demand, which prompts two areas of concern. The first has implications for the supply of electricity, while the second impacts distribution systems. In both of these cases, the implications from new construction are negligible or manageable.

With respect to the generation of electricity for new heat demand that would otherwise have been served by gas, it is helpful to consider the implications on electricity supply in both the near term and long term. Electrification of heating loads today increases electricity demand at a time when electricity generation in New England is highly dependent on gas and when peak energy days are regularly met by burning more carbon-intensive oil.[36]

For most of the year, both the dominant and marginal sources of electricity on the New England grid are gas. The oil-fired generation at the margin on cold days in the past few years has resulted from historically unusual gas market dynamics. Gas is more likely to be at the margin in the future with a larger share of clean power on the New England grid. Nevertheless, these dynamics underscore the need for power sector policy that rewards the development of lower

[36] ISO New England. "Resource Mix," https://www.iso-ne.com/about/key-stats/resource-mix/.

cost, cleaner peaking resources, and a diversified mix of clean firm and fast-burst electricity sources on the grid.[37].

Next, there are fair concerns about the impact of heating electrification of *existing buildings* on today's distribution system. There are likely to be areas of the grid that will likely need upgrades as vehicles and buildings are electrified. These must be addressed through strategies such as those recently proposed by the electric utilities in their Electric Sector Modernization Plans.[38] However, new construction is the easiest and most cost-effective place to manage such challenges as well as develop best practices to manage such challenges, as efforts to electrify all buildings ramp up. If parts of the distribution network challenge the ability of new construction to electrify, it is likely that those parts would need upgrading in the near future to support the electrification of existing loads and for resiliency needs.

Energy efficiency and load management measures can also help overcome some of these challenges while making electrification more cost-effective and limiting the need for additional energy infrastructure investment. Air-tight, well-insulated buildings, as built under the new Stretch Code, stay warmer in the winter—(or cooler in the summer)—for longer, increasing their resilience to power outages. This allows them to flexibly operate their heating and cooling systems to avoid emissions-intensive and high-cost grid conditions if smart controls are used.

Some entities have proposed decarbonizing buildings using alternative gasses such as Renewable Natural Gas (RNG). RNG faces high cost and scaling challenges while incurring significant resource tradeoffs in energy and agriculture. It constitutes a sub-optimal use of limited bioenergy resources best used for other sectors or carbon storage. While some renewable delivered liquid fuels that substitute for fuel oil and propane may be available in limited supply, the relatively high cost and limited supply of these fuels means that they will be subservient to building electrification as onsite backup or peaking resources.

Because of these barriers, the Massachusetts Department of Public Utilities, in its order in the "Future of Gas" Docket (D.P.U. 20-80), rejected utility proposals to change gas procurement policy to incorporate RNG into gas supplies.[39] Further, the Department of Environmental Protection, in its draft Clean Heat Standard framework,[40] has not included RNG to achieve compliance with the proposed standard but may reconsider this in 2028.

New buildings pre-wired for electric appliances, as required by the Specialized Code, yet still burning gas, will add to interim emissions, forgoing the opportunity to limit emissions on the way

[37] Sepulveda, Nestor, et al. "The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation." Joule 2, no. 11 (November 2018): 2403–20. doi.org/10.1016/j.joule.2018.08.006.
[38] MA DPU. "Electric Sector Modernization Plan Resources," January 2024. https://www.mass.gov/info-details/electric-sector-modernization-plan-resources.
[39] Van Nostrand, Jamie, Cecile Fraser, and Stacy Rubin. Order on Regulatory Principles and Framework, No. 20-80 (Massachusetts Department of Public Utilities, December 8, 2023).
[40] "Massachusetts Clean Heat Standard Draft Framework." Massachusetts Department of Environmental Protection, November 2023. https://www.mass.gov/info-details/massachusetts-clean-heat-standard.

to stopping emissions. Further, buildings designed to rely primarily on heat pumps but utilizing redundant gas systems for backup may not operate as intended. Such dual-fuel buildings could use more fossil fuel than intended due to the choices—or neglect of the building's operator.

The Commonwealth's Emissions Limits Require Rapid Electrification

Table 3. 2020 Emissions and aggregate sectoral sub-limits for residential and commercial buildings. This table applies the state's combined commercial and industrial percentage sub-limit to commercial buildings. As such, it is assumed that the industrial sector undergoes the same percentage reduction but is outside the scope of this report.

Target	Source	% Reduction	$MtCO_2e$
1990 Actual	*DEP Inventory*[41]	0.0%	23.7
2020 Actual	*DEP Inventory*	17.7%	19.5
2025 Sublimit	*2025/2030 CECP*[42]	31.1%	16.3
2030 Sublimit	*2025/2030 CECP*	49.0%	12.1
2050 Sublimit	*2050 CECP*[43]	93.9%	1.4

Table 3 shows the Commonwealth's sectoral sub-limits for residential and commercial buildings. Sectoral emissions have declined since 1990 despite remarkable growth in the built environment because of the Commonwealth's nation-leading energy efficiency programs and shift from oil to gas heat. However, gas is limited in how much it can reduce emissions relative to other fuels since its use still results in substantial combustion emissions.

[41] MA DEP "Emissions Inventories." mass.gov/lists/massdep-emissions-inventories
[42] MA EEOEA, "Massachusetts Clean Energy and Climate Plan for 2025 and 2030." 2022. mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2025-and-2030.
[43] MA EEOEA, "Massachusetts Clean Energy and Climate Plan for 2025 and 2030." 2022. mass.gov/info-details/massachusetts-clean-energy-and-climate-plan-for-2050

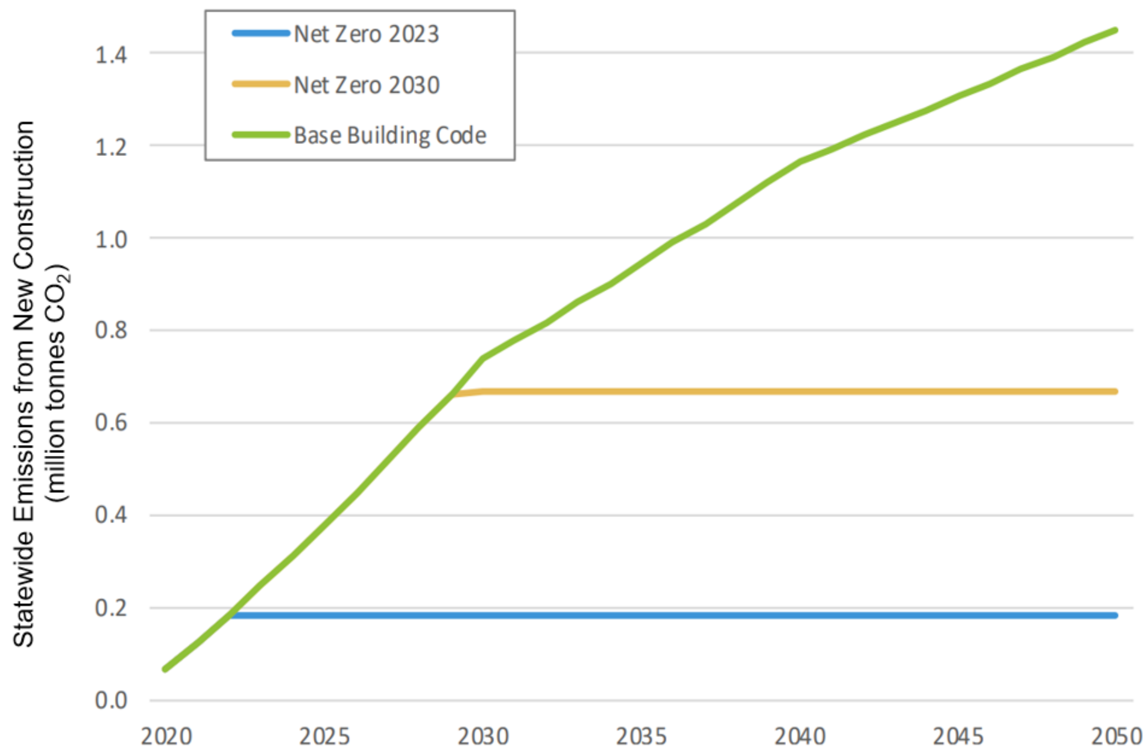
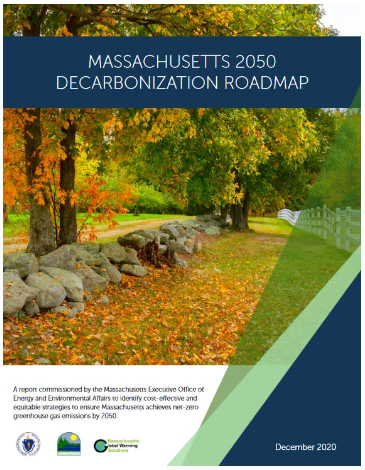
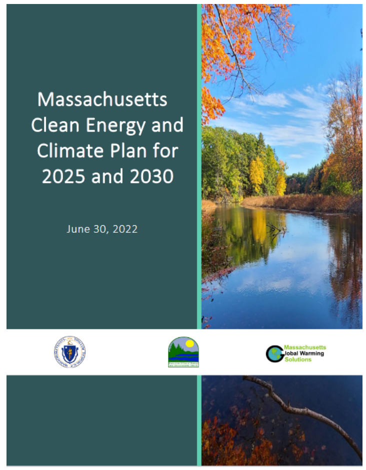
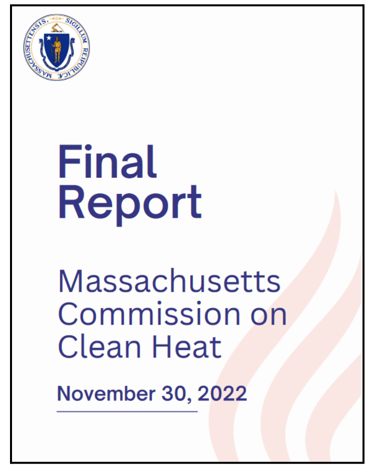


Figure 3. MA 2050 Roadmap illustration of the impact of the timing of a "Net Zero" fossil-fuel-free code achievement on cumulative new construction emissions based on growth projections relative to a "Base" fossil code case. The left axis of this copied figure from the 2050 Roadmap is relabelled for clarity.

The Massachusetts 2050 Decarbonization Roadmap (MA 2050 Roadmap)[44] forecasted that continued reliance on fossil fuels in new construction, even with modest code advancements, could result in the lock-in of nearly 1.5 million tons of combustion CO_2 emissions annually in 2050 (Figure 3). While this represents 2% of the state's current emissions, it is equivalent to the current 2050 sectoral sub-limit (see Table 3) for the commercial and residential sectors—leaving no room for residual emissions from existing buildings.

Based on this analysis, the 2050 Roadmap, along with the 2025/2030 Clean Energy and Climate Plan (referenced above), and the Massachusetts Commission on Clean Heat,[45] unequivocally emphasized the importance of building electrification and energy efficiency — especially concerning new construction — for achieving these limits at the lowest cost and risk:

[44] MA EEOEA "Massachusetts 2050 Decarbonization Roadmap" 2020. mass.gov/doc/ma-2050-decarbonization-roadmap/download.
[45] "Commission on Clean Heat Final Report." Massachusetts Commission on Clean Heat, November 30, 2022. https://www.mass.gov/info-details/commission-on-clean-heat-issues-final-report.

December 2020	June 2022	November 2023
		
"Almost all new buildings can cost-effectively pursue an efficient electric design that increases occupant comfort and pays for itself by reducing heating equipment cost and energy requirements."	"Building standards for new construction represent a critical component of the strategy to promote building electrification."	"If we delay implementing needed policies and programs, the scope of the net zero challenge will increase. There will be more new construction built to outdated standards that must be retrofitted, more gas infrastructure that must be paid for and then strategically retired."

The Commonwealth's energy transition research explicitly emphasizes the importance of electrification in new construction for two reasons. First, all-electric buildings avoid additional building-level emissions when they are built. This aligns with the net-zero principle and statutory requirements to stop and limit additional emissions. Second, new construction is the most cost-effective, least disruptive point for achieving such an outcome. As shown in the next chapters, it can be, in many cases, cheaper than gas. New buildings are the low-hanging fruit of building decarbonization.

While the recent Stretch Code update went further than the projections illustrated by the MA 2050 Roadmap with the Base Building Code line in Figure 3, it still allowed for the use of fossil fuels that challenge these limits by still generating emissions and consuming the carbon budget available to existing buildings.

While a fossil-fuel-free code will not be the only factor influencing whether the state will achieve its statutory emissions targets, additional emissions created by the absence of such a code will increase the challenge of meeting the Commonwealth's legally binding climate targets. The next two chapters will explain why doing so is practical and cost-effective. Through these sections, the reader should remember the greater challenge of decarbonizing existing buildings for context to understand that electrifying new construction is an effective and practical first step on a cost and affordability basis.

Chapter 3: All-Electric Buildings Have Reached Construction Cost Parity With Fossil Fuel Buildings

One barrier to enacting building codes that promote all-electric new construction has been concern about housing and energy costs. This is understandable, as many associate all-electric construction with the short-lived practice of electric resistance heating that was cheap to install but was expensive to operate due to its relatively poor overall efficiency. For a time, heat pump technology was unsuitable for the Northeast or required large, costly systems and costly levels of building energy efficiency. However, the equation has rapidly shifted in recent years due to:

(1) Advances in all-electric cold-climate heat pump technologies, along with other building strategies such as ground source heat pumps and insulation;
(2) Growing contractor familiarity with such equipment and energy efficiency practices; and,
(3) Increasing State and Federal subsidies.

This chapter reviews the recent and current understanding of construction costs, presents an illustrative analysis of costs, and explores the potential costs to retrofit a building that is today built on fossil fuels. Chapter 4 will then address operational energy costs.

Review of Prior Estimates of All-Electric Construction Costs

In 2019, the U.S. Green Building Council of Massachusetts - Built Environment Plus (BE+) - commissioned the Integral Group to examine “Zero Energy Buildings,” defined as electric, high-efficiency buildings supported by on-site or off-site renewables.[46] The report showed that the pathway to cost-effective fossil fuel-free buildings depended on assumptions about future energy costs and the cost premium associated with Zero Energy Buildings. At the time, building all-electric high-performance buildings in the Northeast was relatively new, and electrification typically carried a cost premium depending on the context. An analysis of fossil fuel-free Passive House-certified multi-family in 2017-2018 showed that the cost premium could be around from 1.%-4.1%, with an average of 2.4%[47,] based on actual projects and quotes before incentives were applied. Since then, increased familiarity with Passive House construction by experienced contractors has lowered those cost premiums.

Since their 2019 report, BE+ has released a series of reports under the title Massachusetts is Ready for Net Zero, documenting the costs of all-electric and net-zero or net-zero-ready buildings. Their 2023 update reported that “of the 7 million GSF with reported cost data, 81% reported a <1% construction cost premium to achieve ‘Net Zero Ready,’” a standard that “promote[s] electrification, but allows flexibility for fossil fuel use where appropriate.”[48]

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[46] Built Environment Plus. “Zero Energy Buildings in Massachusetts: Saving Money from the Start.” https://builtenvironmentplus.org/zero-energy-buildings/.
[47] MassCEC “Passive House Design Challenge” masscec.com/program/passive-house-design-challenge.
[48] Built Environment Plus. “Massachusetts is Ready for Net Zero: Spring 2023 Update.” builtenvironmentplus.org/wp-content/uploads/2023/05/BE_MAisReadyforNetZero_5_23_ReportUpdate.pdf

Construction cost premiums, energy savings, and resulting energy bill impacts from electrification are all sensitive to various structural and heating system design decisions, as well as external factors such as permitting and land use regulations, that reflect market dynamics and policy choices. Rebates and tax incentives can reduce or eliminate any electrification cost premium before it hits consumers' pockets. However, the high degree of optionality in building design creates the potential for diverse outcomes in terms of costs and energy consumption. Rebate amounts in new construction are determined by complex performance-based formulas rather than the measure-specific rebates typically advertised for building retrofits. This high degree of optionality in new building design has challenged the impact of prior studies in this space.

Ideally, cost analyses should be based on empirical evidence. The MassCEC Whole Home Heat Pump pilot data[49] is an ideal example of this with itemized costs and tracking of influential design features, but it (1) has a limited sample size for new construction and (2) does not have any control or counterfactual fossil fuel buildings to be used as a comparison. Similarly, while the BE+ reports keep a comprehensive list of buildings, it does not provide sufficient detail for a robust analysis.

Several studies have used representative building archetypes with estimated costs. This simplifies communication at the cost of nuance, comparability, and the ability to track progress over time. Some studies show absolute costs, while others show incremental costs to a benchmark. Building types, equipment sizes, and efficiency measures vary widely. Comparison of results across studies becomes difficult, if not impossible.

One prominent study attempting to quantify the cost difference between fossil-fueled and all-electric new construction is RMI's "The Economics of Electrifying Buildings," released in 2018[50] and updated in 2020[51] and 2022.[52] The 2022 updated report includes a specific analysis for Boston, showing up-front cost savings for all-electric new homes of $49 (<1%) and long-run decreased energy bills from electrification of $176 (5%) per year, compared to a mixed-fuel home. While the difference is small, the all-electric option appears slightly cheaper.

In 2022, the Massachusetts Department of Energy Resources conducted an analysis[53] of prototypical fully electric and fossil-reliant buildings compliant with the proposed stretch code. Their analysis demonstrated that gas and electric pathways under the stretch code were

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49 "Whole-Home Air-Source Heat Pump Pilot." Massachusetts Clean Energy Center. https://www.masscec.com/program/whole-home-air-source-heat-pump-pilot.
50 Billimoria, Sherri, Leia Guccione, Mike Henchen, and Leah Louis-Prescott. "The Economics of Electrifying Buildings." RMI, 2018. https://rmi.org/insight/the-economics-of-electrifying-buildings/.
51 McKenna, Claire, Shah, and Leah Louis-Prescott. "The New Economics of Electrifying Buildings." RMI, 2020. https://rmi.org/insight/the-new-economics-of-electrifying-buildings/.
52 Tan, Lacey, Mohammad Hassan Fathollahzadeh, and Edie Taylor. "The Economics of Electrifying Buildings: Residential New Construction." RMI, 2022. https://rmi.org/insight/the-economics-of-electrifying-buildings-residential-new-construction/.
53 "Stretch Energy Code Development Support Documentation | Mass.Gov." Accessed October 18, 2023. https://www.mass.gov/lists/stretch-energy-code-development-support-documentation.

cost-effective compared to the base code. However, costs were presented as incremental to unpublished benchmark costs, which made it difficult to interpret key cost drivers.

In July 2023, the Home Builders & Remodelers Association of Massachusetts (HBRAMA) released a report titled Public Policy for Net Zero Homes and Affordability[54]. Using a survey of contractors, the HBRAMA study found that all-electric construction was less expensive than the mixed fuel (gas heating with electric AC) for both ducted and non-ducted heat pumps in both single-family and small multi-family homes under the new Stretch Code.

The study found that all-electric single-family homes were $4,000 to $12,500 cheaper than the mixed-fuel alternative. The projected savings for small multi-family all-electric homes were $22,779 to $70,086 less, respectively, when compared to mixed fuel homes (gas heating with electric AC). This cost differential was largely due to the lower HERS ratingof gas-fired buildings under the new Stretch Code.

Table 4 Summary of regionally-focused cost studies of all-electric new single-family home construction.

	RMI (2022)	MassCEC (2022)	DOER (2023)	HBRAMA (2023)
Methodology	National estimates of installed costs (heat pump costs $1,889/ton) adjusted for localized construction cost indices with RSMeans	Observed cost data from contractors participating in MassCEC Whole Home Heat Pump Pilot program	Building energy optimization modeling to meet MA stretch code for electric and gas	Building energy modeling and survey of contractors for cost estimates
Cost variable analyzed	Difference in up-front costs between new all-electric and mixed-fuel homes in Boston	Median heat pump installed costs for new construction in MA	Difference in up-front costs of heating system in MA base code and Stretch Code all-electric	Difference in up-front costs of heating systems between obsolete MA base code and new Stretch Code
Cost variable estimate[55]	Electric $49 **cheaper** than gas (heat pump $1,889/ton)	Heat pump costs $16,549 (~$6,600/ton)	Electric $2,487 **cheaper** than gas	Depends on benchmark: up to $12,500 **cheaper** than gas
Limitations	National heat pump cost data may not reflect cold-climate designs	No comparable fossil fuel data	No supporting itemized cost data	No supporting itemized cost data

Based on our review of this work (Table 4), along with other datasets from MassSave[56] and national U.S. Energy Information Agency data,[57] we have also found that, on average, electric

[54] Bakhshi, Payam, et al. "Public Policy for Net Zero Homes and Affordability." Home Builders & Remodelers Association of Massachusetts, June 14, 2023. hbrama.com/wp-content/uploads/2023/05/Public-Policy-for-Net-Zero-Homes-and-Affordability-Final-6-14-23.pdf.
[55] Original results have been adjusted for inflation to 2023 values.
[56] Petition of Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid, pursuant to G.L. c. 25, § 21, for approval by the Department of Public Utilities of its Three Year Energy Efficiency Plan for 2022 through 2024., No. 21-128.
[57] "Updated Buildings Sector Appliance and Equipment Costs and Efficiency." Energy Information Agency, March 23, 2023. https://www.eia.gov/analysis/studies/buildings/equipcosts/.

and fossil fuel residential buildings have reached effective cost parity in new construction, even without taking into account the added effect on costs of the Stretch Code's lower HERS requirement for buildings utilizing gas heat. Further, design decisions such as utilizing ductless mini-splits can be incorporated to make all-electric construction even more attractive from a cost standpoint.

Significant federal and state incentives are available to improve the cost-competitiveness of air source and source heat pumps. For example, a program run by MassSave offers rebates of up to $16,000 for whole-home air source heat pumps for income-qualifying customers in existing homes that use fossil or electric resistance heat.[58] Similarly, the federal Inflation Reduction Act (IRA) expanded tax credits for new heat pumps in existing homes up to $2,000 per year (Section 25C Credit).[59] For homeowners in existing buildings considering whether or not to electrify, these incentives have the potential to make a significant difference. However, MassSave and Federal rebates also (as of 2024) apply to some high-efficiency gas, oil, propane, and biomass heating appliances, albeit these incentives are typically less, and some will be phased out in coming years.

State and Federal sources also offer air source heat pump incentives for new construction (there are also significant incentives for ground source heat pumps, which our report does not cover). For low-rise residential construction, the MassSave Pay-For-Savings program offers a formulaic rebate of up to $10,000 per residential unit, with the exact rebate level determined by energy modeling conducted by a HERS rater to estimate savings above a baseline average Massachusetts home.[60] The IRA made available a federal tax credit of up to $5,000 per unit for contractors building new or substantially reconstructed homes that meet the Energy Star home program or DOE Zero Energy Ready Home program requirements (Section 45L Credit).[61] Again, however, Federal incentives are also available for high-efficiency fossil fuel heating systems. The impact of these incentives on the economic realities of electrifying new construction depends on each project's design characteristics and program eligibility factors. Since certain high-efficiency fossil-fueled new buildings may receive state and federal subsidies similar to all new electric buildings, it is difficult to assess how much these incentives affect the economic decision between gas and electric energy sources. For this reason, we have not incorporated incentives like rebates and tax credits in our analysis but have summarized them in Table 5 (next page).

[58]Mass Save "Residential Rebates and Incentives" masssave.com/residential/rebates-and-incentives
[59] Internal Revenue Service, "Energy Efficient Home Improvement Credit" "https://www.irs.gov/credits-deductions/energy-efficient-home-improvement-credit
[60] Mass Save, "Pay for Savings" masssave.com/-/media/Files/PDFs/Save/Residential/Pay-for-Savings.pdf
[61] U.S. Dept. of Energy, "Section 45L Tax Credits for Zero Energy Ready Homes" www.energy.gov/eere/buildings/section-45l-tax-credits-zero-energy-ready-homes

Table 5 *Summary of incentive programs available to new construction.*

	Electric Incentive Requirements	Gas Incentive Requirements
MassSave	Large energy savings % or low HERS score, low infiltration rate (ACH), balanced ventilation systems, and EV readiness. *Up to $15,000* *Or up $25,000 depending on specifications*	Pay-for-Savings calculated based on electricity and fuel (gas, oil, and propane) savings relative to a model of an average MA home. Minimum of 15% savings above baseline required. *Up to $10,000, plus $100 for Energy Star Home designation.*
Federal (IRA)	45L Tax Credit for homes certified under ENERGY STAR or DOE Zero Energy Ready Home program. Requires building shell efficiency plus heat pump or pre-wiring described at right. *Up to $5,000*	45L Tax Credit for homes certified under ENERGY STAR or DOE Zero Energy Ready Home program. Requires building shell efficiency plus high-efficiency gas furnace and specific pre-wiring labeled “For future heat pump.” *Up to $5,000*

More often than not, if any cost premium arises from an all-electric requirement, it would likely fall onto affluent homeowners or renters — the primary market for new construction. From one perspective, this can be seen as a relatively equitable outcome — those with the means absorb the additional costs of decarbonization, if any exist at all.

Illustrative Analysis of HVAC Costs

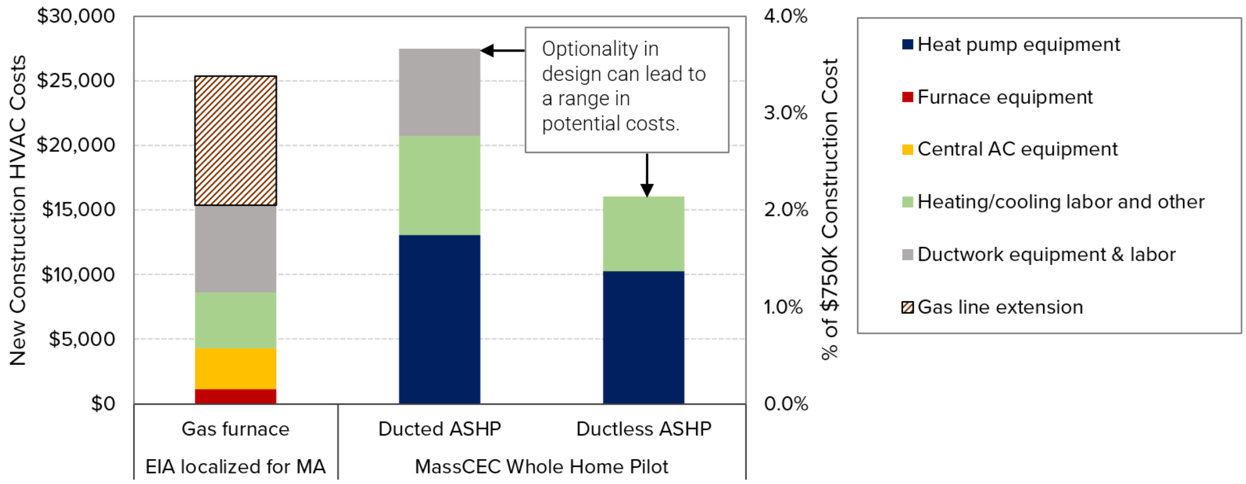

Figure 4. Construction costs for heating systems in a 2,100 sf single-family home, not including additional energy efficiency requirements of the Stretch Code needed to achieve compliance for gas construction, and before incentives. The cost for gas extension is shown with a hatched pattern to denote a greater range of potential variability among projects and the fact that costs can be split between the utility and the customer. Please see the Appendix for the methodology and data sources. The MassCEC (collected between 2019 and 2022, and adjusted for inflation) and EIA data sources (published 2023) each utilize a different methodology. "Other" includes permits and fees.

Our analysis considers three primary space heating scenarios: gas furnaces, ductless electric air-source heat pumps, and ducted electric air-source heat pumps. For new single-family homes in Massachusetts, we estimated the itemized costs of the heating systems (see Figure 4) Figure 4. The single-family home specification was the 2,100 sq.ft., 3-bedroom, "small single-family home" archetype in the 2022 DOER Residential Stretch Code Costs and Benefits Case Studies.[62] For simplicity, our analysis seeks to highlight the primary cost drivers of gas and electric HVAC systems. It excludes costs associated with the additional energy efficiency requirements of the Stretch Code for gas construction for gas construction.

In the gas furnace scenario, the itemized costs include the installed costs of a high-efficiency gas-fired furnace and a central air conditioner (including equipment, labor, permits, and fees), high-efficiency ductwork, and gas line extension fees. We estimated these costs from multiple data sources, including the DOER building code costs and benefits analysis, wholesale cost data, and Northeast US EIA installed cost data.[63] Based on a range of published estimates, we

[62] "Residential Stretch Code Costs and Benefits Case Studies." Massachusetts Department of Energy Resources. mass.gov/doc/residential-stretch-code-costs-and-benefits-case-studies/download.
[63] "Updated Buildings Sector Appliance and Equipment Costs and Efficiency." Energy Information Agency, March 23, 2023. https://www.eia.gov/analysis/studies/buildings/equipcosts/.

assumed a gas line extension cost of $10,000.[64] The gas furnace scenario adds $24,229 (3.2%) to construction costs.

In the electrified scenarios, we estimated installed costs based on data collected from the MassCEC Whole Home Heat Pump Pilot.[65] This data includes itemized cost categories for equipment, labor, ducts (if any), and permits. Furthermore, this data includes specifications about whether each project was new construction, the size of the heating equipment installed, and the size of the conditioned space.

Based on this data, the ductless heat pump scenario adds $16,060 (2.1%) to construction costs, while the ducted heat pump scenario adds $27,493 (3.7%) to construction costs. Our results underscore the cost-competitiveness of all-electric new construction. In our estimate, the ductless heat pump scenario is $8,427 cheaper than the gas furnace scenario – a savings of 1.1% of base construction cost.

These findings are largely consistent with the electrification cost estimates of the DOER[66] and HBRAMA[67] reports. While there are uncertainties surrounding the design specifics of any individual building, our estimate attempts to control for as many variables as possible by using inflation-adjusted public data, controlling for building size and heating equipment capacity, and incorporating a variety of cost items, not just heating and cooling appliance costs. Individual cost items could exhibit substantial future variability, for example, due to changing efficiency regulations and policies,[68] increased price competitiveness and subsidies.

Despite such uncertainty, the reader should take away two things. First, a ductless system avoids the cost of ducts while providing comparable service to a furnace-AC combo. Second, electric systems avoid gas piping and utility connection. Each of these strategies saves sufficient costs to mitigate more complex equipment and labor needs of electric heating strategies. Similar savings are likely to be found in the multi-family segment, whereas other building types may offer other types of opportunities. For example, the new Boston University Data Science Center achieved cost savings by avoiding the space requirements of gas heating equipment.

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[64] Costs range depending on utility territory ($2,286 for Berkshire to $10,404 for National Grid). See Table 13 of Appendix 1: Modeling Framework and Assumptions in DPU #20-80 Independent Consultant Report thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Appendix%201%20(Modeling%20Methodology).pdf

[65] "Whole-Home Air-Source Heat Pump Pilot." Massachusetts Clean Energy Center. Accessed June 30, 2023. https://www.masscec.com/program/whole-home-air-source-heat-pump-pilot.

[66] MA DOER, "Residential Stretch Code Cost and Benefits Case Studies." 2023 https://www.mass.gov/doc/residential-stretch-code-costs-and-benefits-case-studies/download.

[67] Bakhshi, Payam, et al. "Public Policy for Net Zero Homes and Affordability." Home Builders & Remodelers Association of Massachusetts, June 14, 2023. hbrama.com/wp-content/uploads/2023/05/Public-Policy-for-Net-Zero-Homes-and-Affordability-Final-6-14-23.pdf.

[68] U.S. Department of Energy. "DOE Finalizes Energy Efficiency Standards for Residential Furnaces to Save Americans $1.5 Billion In Annual Utility Bills." Energy.gov, energy.gov/articles/doe-finalizes-energy-efficiency-standards-residential-furnaces-save-americans-15-billion.

These results show that all-electric new construction has reached effective cost parity on a capital expenditure basis. Further, there are design decisions available to all-electric buildings, notably ductless heating and cooling, that can unlock even lower costs.[69]

Retrofits of Regret

Going all-electric today in new construction avoids the significant costs and disruption from retrofitting a building initially designed to use fossil fuels to convert to all-electric in the future. As is the case with existing buildings now, electrifying today's new gas construction in the future will incur costs and practical challenges that are typically larger than those of electrification during initial construction. We call this future expensive electrification retrofit the "retrofit of regret." Meanwhile, today's all-electric new buildings will also require re-investment in the future, for example, to refurbish or replace heat pump equipment, which, like modern gas furnaces and central air conditioners, has an estimated lifetime of approximately 15-20 years.

We cost out three types of future end-of-life retrofits based on our itemized construction cost model for a prototypical single-family home constructed in 2025 (Table 6). Fifteen years later, in 2040, the homeowner must spend money to upgrade or refurbish their heating system, whether gas or electric. For clarity, we assume that inflation-adjusted equipment costs do not change over our time horizon. We have also assumed that the initial mixed-fuel system was ducted (i.e., furnace-based) rather than hydronic (i.e., boiler-based), which would result in a more costly retrofit.

Table 6 Cost estimates of several retrofit scenarios.

2025 Construction	Gas			All-Electric
Retrofit at end-of-life intervention	Gas to Gas	Gas to Ductless Heat Pump	Gas to Ducted Heat Pump	Heat Pump Replacement
Retrofit Steps	Replace high-efficiency gas furnace and central AC equipment	Install whole-home ductless electric air-source heat pumps	Install whole-home ducted electric air-source heat pumps, utilizing existing ducts	Replace existing heat pump system.
Estimated Costs[70]	$8,592	$16,060	$17,098	$8,631

From these results, it is evident that electrifying later in the building's lifetime is a "retrofit of regret," with estimated costs approximately two times higher than same-fuel retrofits. Like-for-like conversions were effectively equal, given similarities between the combined furnace and AC cost and the heat pump.

[69] Hot-water or hydronic heating with gas may also achieve costs that are comparable to the ductless scenario. However, this approach would not provide cooling and was thus not considered in this analysis.
[70] Constant 2023 dollars.

However, the “gas to gas” retrofit faces a significant obstacle that is not captured in this table: much higher gas delivery rates in the future. The next section quantifies this dynamic and illustrates that gas is highly likely to be economically unattractive to all homeowners relative to electrification over the coming decades. It may even prompt a retrofit of regret sooner than the equipment's end-of-life, effectively creating a stranded asset.

Chapter 4: All-Electric Buildings Avoid the Cost Burdens Associated with Rising Gas Costs

For the past quarter-century, natural gas has been the cheapest heating resource for the Commonwealth. However, this paradigm is about to change with significant consequences for the customers who will continue to depend on it for heating. This chapter will explain why this paradigm will not continue and the implications for customer operational costs. This is a novel perspective that synthesizes analyses conducted by both the Commonwealth and gas utilities, the implications of which have largely been overlooked. The chapter finishes by discussing how electric heating costs can be made less burdensome through rate design.

The Future of Gas is Expensive

An underrated aspect of the pending energy transition, and one that underpins this report's rationale, is that the Commonwealth's pipeline gas distribution system faces unprecedented cost increases while at the same time facing unprecedented competition from heating and appliance electrification and efficiency. This has the potential to result in a gas affordability crisis for those who remain on the system.

The state is familiar with energy transitions in home heating. In 1960, fuel oil heated 75.4% of Massachusetts households, while piped natural gas heated 15.6%.[71] By 1990, fuel oil's market share declined to 44% of households, while gas served a growing 38%. Today, 51% of homes are gas-heated compared to 23.5% of oil, while the remainder are largely electric (mostly older resistance systems, at 17.8%) and propane (4.7%).

While gas is cheaper today, it did not become cost-competitive until the late 2000s, following the emergence of domestic hydraulic fracturing. Its growth up to that point was driven by increasing consumer preference. The lack of a tank or need for periodic fuel delivery, combined with aggressive marketing of gas as a "safe and clean" cooking fuel—contrary to the emergence of evidence otherwise[72]—positioned methane gas as a premium product that customers were willing to pay more for.

Regulators encouraged the expansion of gas because it spread the fixed costs of the distribution system across a large and growing customer base. Chapter 1 noted the role of gas system extension allowances which allowed the customer to be subsidized upfront with the expectation that that would be paid back. Estimated average utility capital costs associated with customer additions range from $2,286 for a residential customer in Berkshire territory to $10,254 for a residential customer in Boston Gas territory—commercial connections average

[71] Bureau, US Census. "Historical Census of Housing Tables: House Heating Fuel." Census.gov. https://www.census.gov/data/tables/time-series/dec/coh-fuels.html.
[72] Brady, Jeff. "How Gas Utilities Used Tobacco Tactics to Avoid Gas Stove Regulations." *NPR*, October 17, 2023, sec. Climate. https://www.npr.org/2023/10/17/1183551603/gas-stove-utility-tobacco.

$10,000-$20,000.per customer. Investors in the utility would earn a rate of return (typically around 10%) by providing capital to help cover the upfront cost of new gas connections.[73]

The incentive structure encouraging new gas connections drove growth in customers, which spread the costs of the system around, further keeping rates low and incentivizing more growth. **However, this cycle only works if the customer base and consumption continue to grow and the costs of the gas system can be contained.**

By 2010, gas had cemented its market dominance due to its competitive price, perceived customer benefits, and the promise of lower criteria air pollutants and carbon dioxide emissions. However, in the past several years, these rationales have been upended due to increasing awareness of the health, safety, and climate impacts of methane leaked from pipeline gas infrastructure and increasing evidence that combustion by-products not only create unhealthy air outside buildings[74], but also inside buildings.[75]

Fugitive methane emissions from the state's leak-prone distribution system have also been correlated with increasing tree mortality.[76] Measurements of gas leaked inside the homes have identified numerous carcinogenic volatile organic and carcinogenic compounds.[77] Environmental justice populations are disproportionately exposed to leaks, and such leaks take longer to repair.[78] The 2018 Merrimack Valley gas explosions that resulted in one death, multiple injuries, and $1 billion in damage highlighted the safety challenges of maintaining an old system.[79] Monitoring and modernizing the gas system has subsequently become a priority to support health, safety, and environmental protection goals.

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[73] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report--Technical Analysis of Decarbonization Pathways," March 2022. thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf.
[74] https://www.bc.edu/bc-web/centers/schiller-institute/sites/masscleanair.html#.Ytl9z8zJ770.link
[75] Lebel, Eric D. et al. "Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." *Environmental Science and Technology* 56, no. 4 (February 15, 2022): 2529–39. doi.org/10.1021/ACS.EST.1C04707/ASSET/IMAGES/LARGE/ES1C04707_0004.JPEG.
[76] Schollaert, Clair et al., "Natural Gas Leaks and Tree Death: A First-Look Case-Control Study of Urban Trees in Chelsea, MA USA." *Environmental Pollution* 263 (August 1, 2020): 114464. doi.org/10.1016/j.envpol.2020.114464.
[77] Michanowicz, et al. "Home Is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User." *Environmental Science & Technology*, June 28, 2022. doi.org/10.1021/ACS.EST.1C08298.
[78] Luna, Marcos, and Dominic Nicholas. "An Environmental Justice Analysis of Distribution-Level Natural Gas Leaks in Massachusetts, USA." *Energy Policy* 162 (March 1, 2022): 112778. doi.org/10.1016/j.enpol.2022.112778.
[79] Katcher, Will. "Three Years after the Merrimack Valley Gas Explosions, a Look Back in Photos." masslive, Sept. 13, 2021. masslive.com/news/2021/09/three-years-after-the-merrimack-valley-gas-explosions-a-look-back-in-photos.html.

The 2014 Massachusetts Gas Leaks Act requires utilities to modernize their system by developing and implementing Gas Safety Enhancement Plans.[80] These come with increasing costs. The total cost for replacing all leak-prone pipes in the state (including the upfront capital costs and rate of return) was estimated in 2021 to be $20 billion[81] but has since been revised upward to $34.4 billion based upon growing project costs.[82]

Proposed federal regulations for stepped-up leak detection and repairs from the Pipeline and Hazardous Materials Safety Administration are expected to increase utility operating costs.[83] The impact of these gas network programs on methane emissions is dubious because a significant portion of methane emissions evolve from behind the meter inside buildings, leaking from inactive equipment and pipes and during the ignition cycling of gas equipment.[84]

Simultaneously, consumer attitudes have begun to shift. Growing recognition of the health and safety issues associated with leaks and combustion for cooking inside the home[85] has amplified consumer interest in electric alternatives. So, too, have the climate benefits of building all-electric.

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[80] "GSEPs Pursuant to 2014 Gas Leaks Act" mass.gov/info-details/gseps-pursuant-to-2014-gas-leaks-act.

[81] Seavey, Dorie. "GSEP at the Six-Year Mark: A Review of the Massachusetts Gas System Enhancement Program," 2021. https://gasleaksallies.org/gsep.

[82] Seavey, Dorie. "GSEP's Cumulative Costs" presentation to the Massachusetts GSEP Working Group Oct 20, 2023.

[83] Pipeline and Hazardous Materials Safety Administration. Gas Pipeline Leak Detection and Repair Notice of Proposed Rulemaking, Pub. L. No. 49 CFR Parts 191, 192, and 193, RIN 2137-AF51 (2023). phmsa.dot.gov/sites/phmsa.dot.gov/files/2023-05/Gas%20Pipeline%20Leak%20Detection%20and%20Repair%20NPRM%20-%20May%202023.pdf.

[84] Sargent, Maryann R. et al., "Majority of US Urban Natural Gas Emissions Unaccounted for in Inventories." *Proceedings of the National Academy of Sciences* 118, no. 44 (November 2, 2021): e2105804118. https://doi.org/10.1073/pnas.2105804118.

[85] Lebel, Eric D., Colin J. Finnegan, Zutao Ouyang, and Robert B. Jackson. "Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." *Environmental Science and Technology* 56, no. 4 (February 15, 2022): 2529–39. doi.org/10.1021/ACS.EST.1C04707/ASSET/IMAGES/LARGE/ES1C04707_0004.JPEG.

Table 7. Benefits and potential drawbacks associated with various electric appliances.

Appliance	Consumer Benefits	Potential Drawbacks
Heat pump water heater	Increased efficiency; flexible grid-responsive operation; decreased long-term energy bills; decreased risk of carbon monoxide poisoning from poorly installed or poorly adjusted gas equipment	Increased up-front cost; not really relevant if sized correctly. Some designs exhaust cold air into the surrounding area (may not be suitable for all building designs).
Induction cookstove	Improved indoor air quality, faster boiling, more precision, higher efficiency (less heat wasted to ambient air), easier to clean, safer for children	Short learning curve, not compatible with all cookware.
Heat pump clothes dryer	Significantly increased efficiency, decreased energy bills, no venting required (safer and does not remove heat from the building), gentler on clothes	Marginal increased up-front cost, longer drying times.
Electric fireplace	Improved indoor air quality, reduced risk of fire, more customizable, less maintenance required	Less traditional.

Consumer interest in electric heating and appliances continues to grow, along with the technological advances and flexibility associated with electric heating and cooling equipment (Table 7).

Many electric appliances, such as heat pumps and induction stoves, are inherently more energy-efficient than their gas alternatives. Furthermore, state incentives from MassSave and federal tax incentives from the Inflation Reduction Act are supercharging the adoption of this equipment in new and existing buildings, accelerating a reduction in gas consumption, especially as the Commonwealth considers policies to regulate its future consumption.[86]

[86] "Massachusetts Clean Heat Standard" mass.gov/info-details/massachusetts-clean-heat-standard.

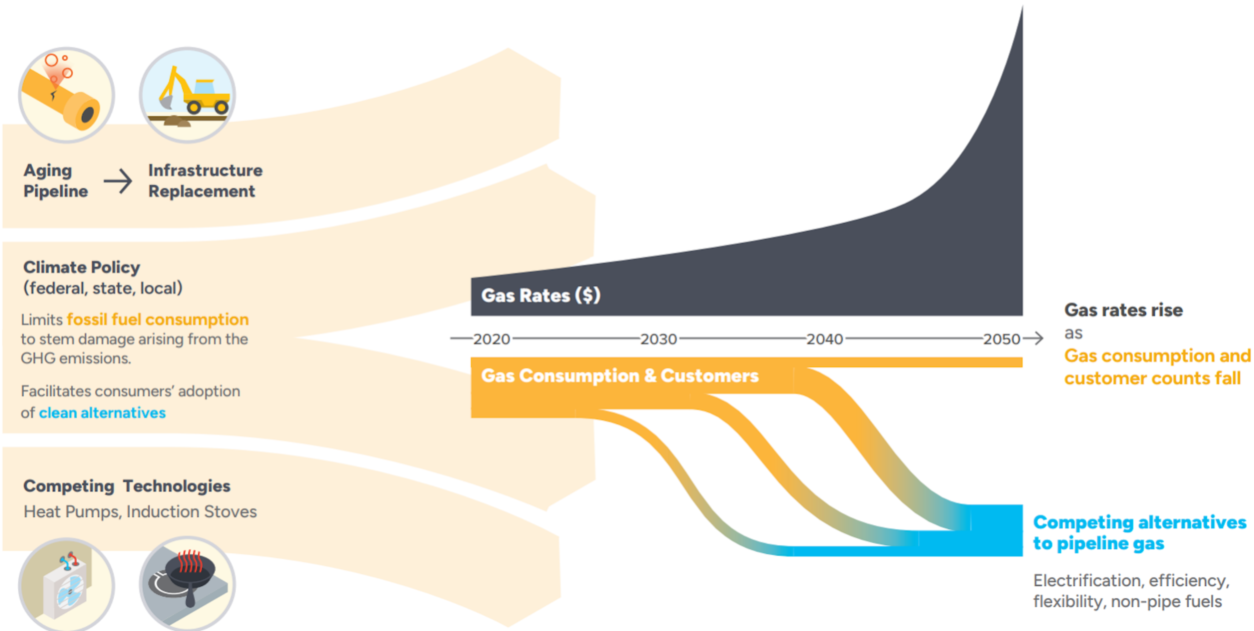

Figure 5 Increase in gas rates driven by increasing pipe costs and declining consumption and customers. Source: "The Future of Gas in New York State".[87]

The cost of pipeline gas delivery, in which customers are incentivized to sign up under the promise of low costs, relies on increasing customers and consumption—something incompatible with climate targets and under threat due to increasing competition. As consumption declines and maintenance costs rise, gas utilities must raise rates to ensure that fixed system costs are paid for (Figure 5). Rate increases drive consumers away—especially those with more agency to leave. Indeed, the Massachusetts 2050 Roadmap,[88] highlighted the implications of the decline in customers and consumption:

> *"A future increase in the price of pipeline gas together with increasing reductions in costs associated with heat pumps could result in a significant cost-driven market advantage for heat pumps that, regardless of policy, leads to a large, uncontrolled customer exit from the gas system…there are risks and challenges in implementing even a controlled or planned exit from widespread, primarily residential, use of the gas system. The potential for an uncontrolled exit driven by market economics raises significant additional equity concerns."*

The "additional equity concerns" refer to the fact that low-income households lack both the capital and agency (as renters) to mitigate their exposure to increasing gas rates.

[87] Walsh, Michael, and Michael Bloomberg. "The Future of Gas in New York State." Building Decarbonization Coalition, March 16, 2023. buildingdecarb.org/resource/the-future-of-gas-in-nys.
[88] Page 51, Massachusetts Executive Office of Energy and Environmental Affairs. "Massachusetts 2050 Decarbonization Roadmap," 2020. mass.gov/doc/ma-2050-decarbonization-roadmap/download

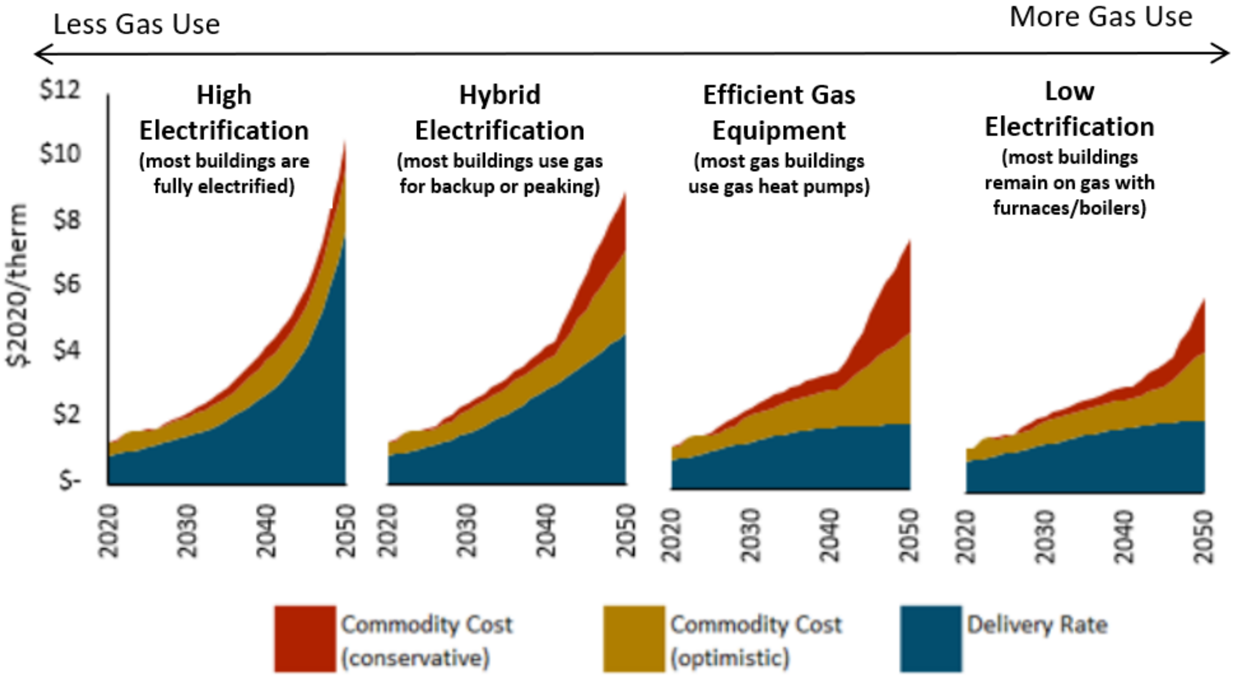

Figure 6: The impact of several gas transition scenarios on customer rates adapted from the independent consultant report for the gas utilities in the MA DPU 20-80 Investigation. Note: The gas heat pump in the Efficient Gas Equipment scenario uses pipeline gas (rather than electricity) to power a heat pump cycle.

The consultant for the state's local gas distribution companies detailed how this dynamic will evolve as part of their research (the Independent Consultant Report)[89] in the Department of Public Utilities' "Future of Gas" investigation (D.P.U. 20-80[90]). Figure 6 shows the impact of several of the examined gas transition scenarios on customer rates, assuming the continuation of current ratemaking practices.[91]

The red and gold areas show a range of increasing costs for the gas supply, reflecting the tenuous assumption that increasing levels of blending of renewable natural gas and hydrogen would be necessary to achieve emissions compliance with emissions limits. The blue area illustrates the impact of the dynamics described above on the rates associated with gas delivery.

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[89] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report--Technical Analysis of Decarbonization Pathways," March 2022. thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf.

[90] Massachusetts Department of Public Utilities. "Docket #20-80 "Investigation into the Future of Gas." https://eeaonline.eea.state.ma.us/DPU/Fileroom/dockets/bynumber/20-80.

[91] These forecasts assume that rate design continues as it does today under unprecedented levels of demand reduction that are likely to result in unacceptable and inequitable outcomes. It is difficult to imagine that policymakers would let rates rise so high without intervention, but one could envision those who remain on the system being subject to some degree of rate increases and emissions compliance costs that increase the cost of gas significantly, even with efforts to limit the impact of these costs.

The four scenarios shown reflect a decreasing amount of electrification (from left to right) evaluated by the gas utilities. The Low Electrification scenario reflects a similar number of customers relative to today, with modest efficiency gains but minimal transitions to all-electric homes. The Efficient Gas Equipment scenario reflects a modest decline in gas demand driven by building energy efficiency and the adoption of gas-powered heat pumps. The Hybrid Electrification scenario reflects a dual fuel approach where gas is used as a peaking resource on the coldest days, while heat pumps are used at moderate temperatures. The High Electrification scenario represents an approximate 90% reduction in gas consumption due to widespread whole-building electrification. The cost increases across these scenarios are driven by three key factors.

First, in all scenarios, supply rates (commodity costs) increase because pipeline gas is expensive to decarbonize. The 20-80 Independent Consultant report provided by the utilities in the 20-80 Docket report modeled the blending of RNG into the gas system. RNG can cost as much as ten times the current supply rates. Alternatively, pipeline gas can be decarbonized by using (likely-to-be-expensive) allowances with fossil gas under a future emissions control structure, such as Boston's BERDO 2.0[92] or DEP's proposed clean heat standard.[93]
Second, in all scenarios, the impact of continued investment (e.g., GSEP) into the gas system increases utility revenue requirements. The average customer cost per therm of gas delivered will almost double over the next 15 years even if customer counts remain the same. However, such cost increases and climate policy will incentivize customers away. This leads to the third driver, that average customer costs will increase multifold as expected customer departures accelerate and consumption declines. All scenarios reflect a decline in gas consumption and customers to varying degrees. As described above, this reduction will increase average customer costs to meet the increasing revenue requirements.

These forecasts reach similar conclusions to those conducted in New York by National Grid[94] and independently by the authors of this report.[95] **All future scenarios—including those evaluated by the gas utilities—find gas to be expensive.**

The consequence will be significant, especially for those who lock in gas infrastructure in their homes over the coming years. By the time customer costs double around the mid-2030s, gas equipment installed today will reach half its expected lifespan. By the early 2040s, rates could spiral to consequential levels if customer costs were allocated in the manner they are today.

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[92] City of Boston. BERDO 2.0 (2021) boston.gov/sites/default/files/file/2021/12/Final%20Amended%20Docket%200775%20BERDO%202_0.pdf
[93] "Massachusetts Clean Heat Standard Draft Framework." Massachusetts Department of Environmental Protection, November 2023. https://www.mass.gov/info-details/massachusetts-clean-heat-standard.
[94] National Grid CLCPA Study Draft Report, 12/21/2022 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BFD7B3008-F3CC-49CD-858C-471ACD6F47E3%7D.
[95] Walsh, Michael, and Michael Bloomberg. "The Future of Gas in New York State." Building Decarbonization Coalition, March 16, 2023. https://buildingdecarb.org/resource/the-future-of-gas-in-nys.

Even under the most optimistic scenario, costs would rise high enough to incentivize customer attrition that follows the narratives of the deeper electrification scenarios.

Future electricity costs are expected to be more stable but depend on various factors. For example, the Massachusetts 2050 Decarbonization Roadmap Energy Pathways Report and Independent Consultant Report commissioned by the utilities found that customer electric costs would likely increase by roughly 0-20% in total over 30 years under most scenarios. Such modest growth is notable compared to the projected multifold increase in gas costs.

The reason for this is straightforward: while there will be more investment in the electric system, there will also be more sales due to beneficial electrification and economic growth. The costs of new generation, transmission, and distribution infrastructure are spread across increasing demand that will more than double. Further, flexible electric load management can help to keep cost increases down by maximizing the utilization of grid assets. In the near term, the distribution grid generally has sufficient capacity to handle increased heating loads as the grid is largely sized for historically higher summer loads. For an illustrative reference across the entire grid, ISO-NE's largest summer peak ever was 28,130 MW on August 2, 2006. The highest winter peak ever occurred on January 15, 2004, at 22,818 MW. Electrification of heating systems will *eventually* result in winter peaks in the early 2030s per various state and utility projections.[96] If parts of the distribution system are challenged by the addition of efficient all-electric new construction, those parts of the system are also likely going to require upgrading anyways to handle increased electrical loads from vehicles and adoption of heat pumps in existing buildings.

[96] MA DPU. "Electric Sector Modernization Plan Resources," January 2024. https://www.mass.gov/info-details/electric-sector-modernization-plan-resources.

The Implications of the Future of Gas on New Construction

Right now, assuming *average* gas and electric rates across the Commonwealth, heating an all-electric home is slightly more expensive than heating a gas home with the same heating demand profile - approximately $150/annually as shown in Figure 8 below for new construction. This is because the ratio of average gas to electric rates is low relative to the efficiency gains of a heat pump.[97] This energy bill analysis examines the impact of the cost changes highlighted in the previous section, assuming rates are determined in a similar manner to today. It forecasts the energy costs of a new, high-efficiency single-family home to be constructed in 2025 that is faced with the choice of installing a modern efficient (>95% AFUE) condensing gas furnace with a separate electric AC system or a whole-home electric air-source heat pump arrangement providing both heat and AC.

Returning to the core design choices being considered—gas, ducted heat pumps, and ductless mini-splits—there are important considerations in how these systems operate that need to be factored in when estimating energy consumption and bill impacts.

While most gas furnaces in existing buildings have efficiencies ranging around 80%, the recent building code updates will likely result in the installation of new construction Energy Star-rated furnaces with efficiencies ranging from 95-99%. While these furnaces reduce gas demand overall, their highly efficient cycles can cause higher instantaneous demand, which can pose a challenge for some older or over-subscribed gas distribution systems.

Electric air-source heat pumps are intrinsically more efficient than gas furnaces. A heat pump with an efficiency rating of 12 HSPF, which would likely be installed under the new Stretch Code (as identified in the DOER case studies), has an average efficiency of 350% across the heating season, meaning that for every unit of electrical energy from the grid, the heat pump produces 3.5 units of heat.

Ductwork adds the potential for energy losses that reduce these ultimate efficiencies. However, in new construction, these should be minimal (~5%), and this small loss in efficiency applies to ducted gas systems as well. Ductless mini-split heat pump designs, which use refrigerant lines to transfer heat between outdoor condenser (evaporator) units and indoor air handler heads, offer the advantage of avoiding those potential losses.

Again, new buildings constructed under the current Stretch Code are remarkably efficient compared to existing buildings, therefore leading to reduced energy bills under today's rates.

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[97] For present-day rates, this analysis benchmarks its data on Massachusetts residential average electric and gas rates from the US Energy Information Administration. These rates include supply and delivery costs. However, there is significant variability in the actual rates facing customers across the state. For example, some customers of municipal utilities (e.g. Holyoke Gas and Electric) or community choice aggregators (e.g. Cambridge Community Electricity Program) may pay rates that differ significantly from the statewide average.

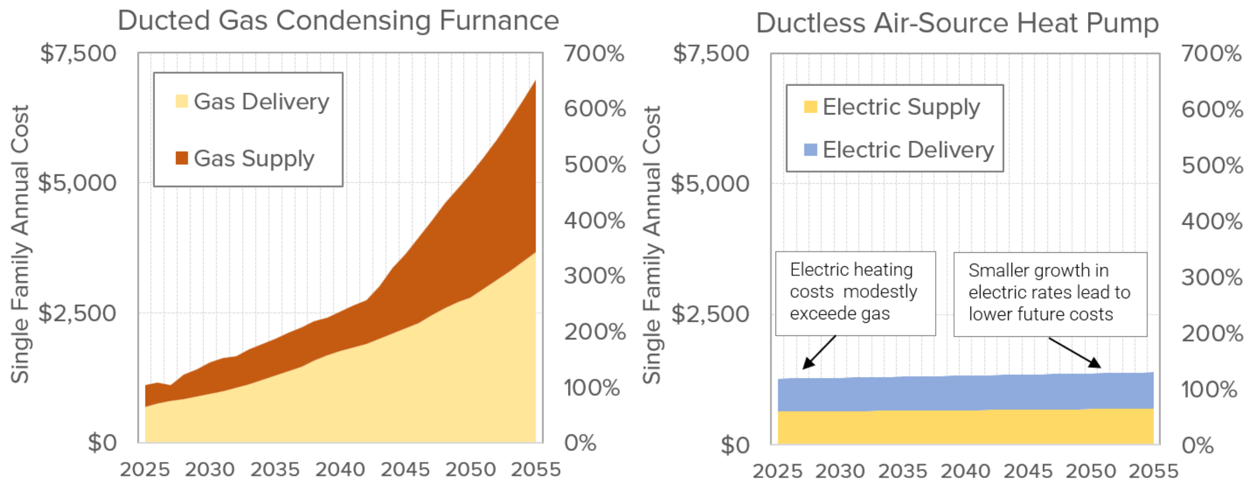

Figure 7. Forecasts of typical annual gas and electricity costs for heating a single-family home built to the standards of the 2023 Stretch Code with an estimated annual final heat demand of 60 mmBtu. Projected gas rates were obtained from the Hybrid Electric Scenario in the gas utilities' Independent Consultant Report.[98] Electric rates assume a gradual 10% increase in real terms over the time period consistent with the modeling in that report as well as the Massachusetts 2050 Decarbonization Roadmap Energy Pathways Report.[99] Percentages are indexed to the Ducted Gas Condensing Furnace 2025 cost.

The result of this analysis of building energy demand and long-term rate dynamics are visualized in Figure 7. As described above, increases in gas rates are driven first by increasing infrastructure investment (e.g., GSEP or the Gas System Enhancement Plan) in the ten years from 2025 to the 2035, when gas costs double. After this point, rates escalate steeply due to the increasing cost of compliance with emissions targets (e.g., renewable fuel blending as modeled by the gas utility analysis or a compliance payment), along with declining customer counts that force utilities to raise rates to meet their revenue requirement.

In comparison, these studies show that electric rates remain relatively stable, with a relatively modest 10-20% constant-dollar increase over the next 30 years. Here, increasing investment in generation and distribution is spread over increasing demand and system utilization from vehicle and heating electrification.

[98] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report--DRAFT, Part I: Technical Analysis of Decarbonization Pathways," February 15, 2022. https://thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf.

[99] Massachusetts Executive Office of Energy and Environmental Affairs. "Massachusetts 2050 Decarbonization Roadmap," 2020. https://www.mass.gov/info-details/ma-decarbonization-roadmap

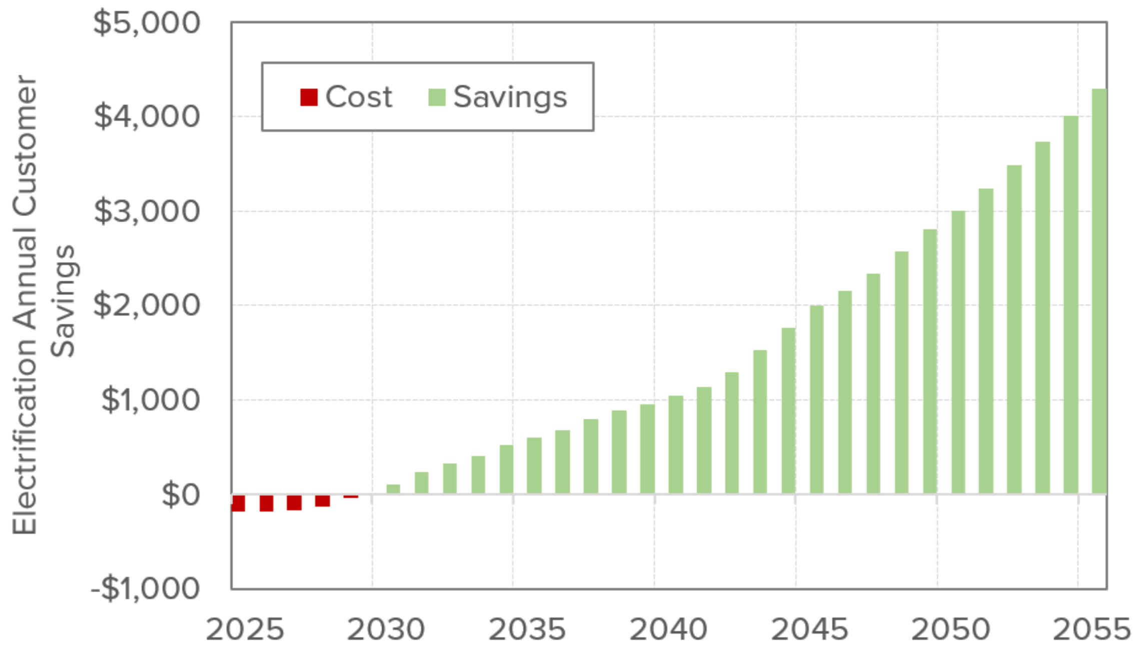

Figure 8 Net annual energy bill savings from heating electrification.

Figure 8 again demonstrates that the favorability of natural gas under these trends will not last for long. By 2040, again assuming no change in rate design, gas bills result in customer heating costs that are equivalent to oil and propane. At this point, a home constructed in 2025 will reach the expected end of life for its condensing gas furnace and water heater. The cost of this "retrofit of regret" will be significant, but under such increasing gas costs, its payback will be short. Over the past two decades, such cost differentials have been a driver of oil-to-gas conversions.

While the implications of the expensive future of gas are increasingly discussed in the context of existing buildings, such an understanding is not reflected in any prior analysis of new construction strategies, which largely assume that gas costs will remain relatively consistent with their recent levels.

Again, policy action will likely avoid such rate increases beyond 2040, but how this will play out remains a pressing and difficult question. Such policy action will require concerted management by regulators and utilities to stop growth, avoid reinvestment, and rightsize the gas system to meet net-zero targets and a dwindling gas customer base.

The first step is to stop the growth of the gas system in new construction, which has the following benefits:

1. It avoids locking in additional gas infrastructure incompatible with the state's net zero climate targets, which instead continues to generate additional emissions for the foreseeable future.
2. It avoids additional investment in a gas system that will be increasingly underutilized and at risk of burdening its remaining customers.
3. It protects the ratepayers from increasing gas system costs.

Rate Design Can Unlock More Affordable Electrification

Although gas rates are expected to spiral upward in the coming decades, under current average rates and prevailing rate designs, gas remains slightly more affordable today on an energy bill basis. However, such an advantage can be addressed by plausible alternative rate designs that encourage affordable electrification.

One approach to alternative rate designs for electrification involves balancing fixed and volumetric charges in electric rates. Although most of the costs of electric transmission and distribution utilities like those in Massachusetts are fixed costs (i.e., they do not vary with kWh), most of those utilities' revenue is recovered through volumetric (i.e., per kWh) charges. Altering rate designs to recover more revenue through fixed charges and less through volumetric charges makes electrification more affordable for all customers and all end users. This can be done on an opt-in or opt-out basis by creating an optional rate designed for electrification or changing the fixed/volumetric balance of default residential rates.

Regulators in other states have actively pursued innovative rate designs that favor building electrification. For example, utilities in Maine offer several different optional rates intended to encourage the affordable adoption of heat pumps and other electric technologies. Central Maine Power offers an “Electric Technology” rate that effectively provides a discount for high users by shifting the fixed/volumetric rate design balance.[100] The same utility also offers a “Seasonal Heat Pump” rate that adds an additional discount for winter months (in exchange for a higher rate in the summer), resulting in an overall delivery rate per kWh for the winter that is over 20 times lower than the default residential delivery rate.[101]

Another approach to rate design for affordable electrification involves special rates for lower-income customers. In a rate case filed by National Grid in November 2023,[102] the utility is proposing to give customers a discount of between 32 and 55 percent based on their income levels.[103] In addition, all customers would receive a 10 percent discount if they increase electricity usage by electrifying their home heating or buying an electric vehicle. This represents an expansion of existing programs to assist low-income ratepayers in Massachusetts, including similar (though not as large) discounts to gas rates.

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[100] Central Maine Power. “Electric Technology Rate.” Accessed November 21, 2023. https://www.cmpco.com/account/understandyourbill/newelectrictechnologyrate.

[101] Central Maine Power. “Seasonal Heat Pump Rate.” Accessed November 21, 2023. https://www.cmpco.com/account/understandyourbill/newseasonalheatpumprate.

[102] Petition of Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid, pursuant to G.L. c. 164, § 94 and 220 CMR 5.00, for Approval of a General Increase in Base Distribution Rates for Electric Service and a Performance-Based Ratemaking Plan. Docket #23-150

[103] Jon Chesto, “National Grid Is Raising Rates to Cover Power-Line Maintenance, Expansion Costs” Boston Globe, Nov. 17, 2023. bostonglobe.com/2023/11/17/business/national-grid-raise-rates/.

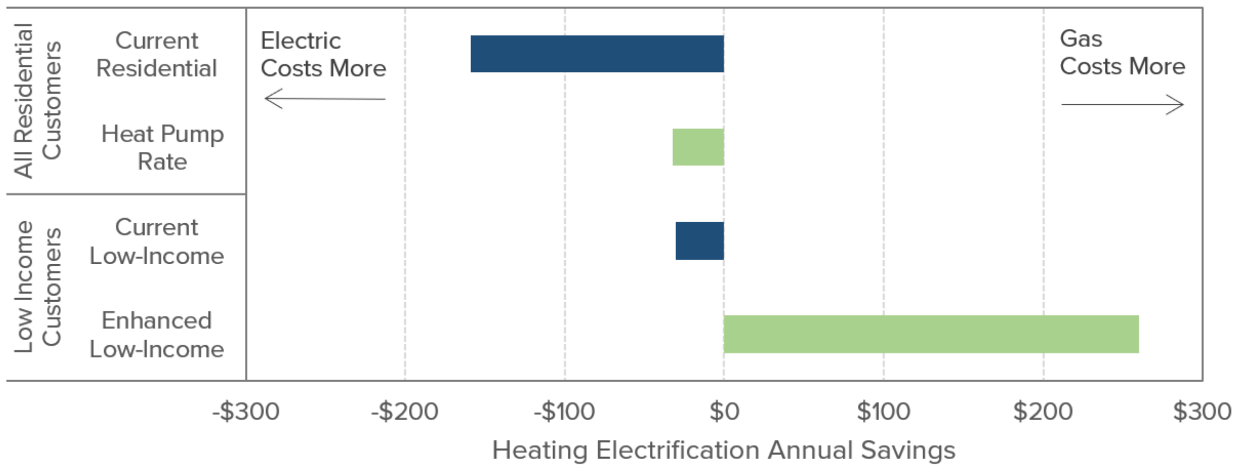

Figure 9. Net annual savings from heating electrification for all residential customers under a conventional rate compared to a heat pump rate; and for low-income customers under new proposed discount rates. Both scenarios are based on recent rate structures proposed by National Grid.

Figure 9 shows the impact of National Grid's proposed rate designs for conventional and low-income customers. For a conventional customer under average current rate structures (top blue), gas heating is approximately $150 per year cheaper than electric using *average costs* across the State. Under the discounted electrification rate (top green), the cost difference between electric and gas heating is substantially reduced, although gas is still cheaper by $32 per year. Low-income households already on a discount rate currently (bottom blue) would only pay $30 more per year for electric heating, but under the new rate design (bottom green), the lowest-income customers would save $260 annually from electrification.

As is evident from this figure, rate design has the potential to "close the gap" between gas and electric heating costs in the short term. In the long term, the upward spiral of gas rates continues to dominate and create significant savings for electric heating.

These Findings Can Be Extended to Other Building Types

Although this work focuses on new single-family residential construction, its findings apply to other building types.

First, it is more cost-effective to heat new buildings (large and small) with electric heat pumps today than with oil and propane. This is primarily due to the relatively high price of delivered oil and propane compared to electricity. Although these fuels do not face the same long-term potential cost pressures associated with pipeline gas delivery, their high carbon intensity of heat production exposes them to increasing emissions compliance costs in the long run.

Second, these lessons can be extrapolated to other building types. The rapid decline in emissions needed to achieve the state's climate targets necessitates limiting fuel combustion across all new construction. New construction is well suited for various technologies, including geothermal, thermal storage, and integration of novel district energy approaches that may see favorable implementation cases in larger and more complicated buildings with distinctive energy loads.

Notably, several large office buildings have recently been built to all-electric standards. Boston University recently commissioned a data science center that uses over 30 geothermal wells to meet the building's heating and cooling needs, achieving net-zero construction with a less-than two-year payback.[104] One of the reasons why such a building was cost-effective was that the geothermal system avoided the space needed for combustion equipment. Amazon's new Seaport office (630,000 sf) will also be all-electric.[105,106]

Where combustion still may be needed for backup requirements or peaking needs in certain buildings with high ventilation requirements (e.g., hospitals and laboratories), at least until more technological advancement, a limited amount of onsite fuel combustion may be compatible with climate targets. In some complex building types, some auxiliary combustion-based heating may obviate the need for oversized all-electric heating systems. Nonetheless, the electrification of most loads will allow such buildings not to be reliant on the gas system.

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[104] Boston University Sustainability. "Center for Computing & Data Sciences | Sustainability." Accessed November 20, 2023. https://www.bu.edu/sustainability/projects/center-for-computing-data-sciences/.
[105] Boston Business Journal. "Amazon, WS Pledge Net-Zero Carbon at New Seaport Office," May 6, 2021.bizjournals.com/boston/news/2021/05/06/amazon-ws-pledge-net-zero-carbon-at-new-seaport.html.
[106] Approximately 77,000 square feet of ground floor retail space will still have gas connections.

Chapter 5: Additional Considerations

Catalyzing Change Across the Building Sector at Time of Uncertainty

The Commonwealth's largest challenge in decarbonization is retrofitting over two million buildings, each with its own specific challenges. Accelerating change in new construction—at the top of the market—positions all-electric strategies as a desirable, premium brand. Electric heat pump heating allows for more zonal control and precise temperature and humidity settings, analogous to what consumers have grown to expect from the HVAC system in modern cars. Induction stoves cook faster and are cleaner, more responsive, and more efficient than gas. In short, electrification offers increasing options to create consumer value. Demonstrating this in new construction will spark consumer interest in electrifying existing homes.

Likewise, more electric adoption increases familiarity with electric technologies across the workforce. The tradespeople with these new skills gained in new construction will in turn, bring their experience into the existing building sector.

Improved Public Health

The COVID-19 pandemic has brought the need for healthy buildings to the forefront. Improved air quality can deliver considerable benefits in terms of reduced mortality, hospitalizations, and incidences of respiratory and cardiac disease, as well as enhanced productivity and general well-being. In aggregate, these benefits are considerable — for both occupants and society. While this study does not monetize the social costs of air pollution, both outdoor and indoor air pollution from fossil fuel combustion is well-documented, and is a substantial burden to Massachusetts residents, disproportionately affecting environmental justice communities.[107]

A growing body of evidence highlights the impact of building design on air quality in influencing health and wellbeing.[108] The continued use of gas in new construction should be considered a probable and significant health risk, given observations of leaks and pollutant levels in existing buildings. Sources of pollutants from pipeline gas include combustion by-products,[109] including air pollutants like carbon monoxide and nitrogen dioxide, and volatile organic compounds like

[107] Tessum, C. W., et al. (2021). PM2.5 polluters disproportionately and systemically affect people of color in the United States. Science Advances, 7(18), eabf4491. https://www.science.org/doi/10.1126/sciadv.abf4491

[108] Mannan, Mehzabeen, and Sami G. Al-Ghamdi. "Indoor Air Quality in Buildings: A Comprehensive Review on the Factors Influencing Air Pollution in Residential and Commercial Structure." *International Journal of Environmental Research and Public Health* 18, no. 6 (March 22, 2021): 3276. https://doi.org/10.3390/ijerph18063276.

[109] Lebel, Eric D. et al.. "Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." *Environmental Science and Technology* 56, no. 4 (February 15, 2022): 2529–39. https://doi.org/10.1021/ACS.EST.1C04707/ASSET/IMAGES/LARGE/ES1C04707_0004.JPEG.

benzene, some of which are carcinogenic, in pipeline gas. These compounds are released from both operating and inactive equipment.[110]

Modern air-tight buildings require sufficient mechanical ventilation to maintain healthy indoor air quality and comfort. The 2022 code update is notable for its requirement of ventilation. However, such equipment may not mitigate all risks associated with gas use and equipment. Energy recovery ventilation is likely insufficient to mitigate plumes from intense sources such as a stove undergoing ignition cycling or operation, and cooking ventilation fans are not consistently utilized by occupants. Ventilation also appears to have a limited impact on NO_x concentrations.[111]

Equity Implications

There are two overall areas of concern with respect to equity when considering fossil fuel-free new construction and the future of utility gas. The first has to do with implications for existing ratepayers who financially backstop new gas connections. The second involves the implications for the residents and occupants of the building.

Implications of Continued Gas System Expansion

Chapter 1 described the role of pipeline extension allowances for new gas connections. Here, the cost of connecting a new customer to the gas system is covered by the utility with the expectation that the customer will pay it back plus a rate of return over a specified time horizon. There are three concerns regarding the current allowance framework:

1. Continued gas system expansion under historical trends is incompatible with the Commonwealth's emissions limits.
2. The new Stretch Code will significantly reduce the amount of gas consumed for new connections, thus reducing the amount of potential recoverable revenue for both the line extension and the existing system.
3. Prewiring homes for electrification could allow rapid conversion of this new building stock away from gas. Given changing consumer preferences and equipment lifecycles, the timing of such conversions could occur before revenue for the gas connection is recovered.

Historically, new customer additions allowed for growth in revenue, which allowed the costs of distribution to be spread more broadly. Now, future revenue from such customers is tenuous. This becomes both explicitly unfair and inequitable if the cost of connecting the new customers, who are more likely to be higher income, becomes unrecoverable and is passed on to existing ratepayers. Imagine the utility-incurred cost of $10,000 for connecting a new customer, but this customer leaves the gas system halfway through a 20-year recovery period. Approximately

[110] Michanowicz, et al. "Home Is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User." *Environmental Science & Technology*, June 28, 2022. https://doi.org/10.1021/ACS.EST.1C08298.
[111] "Studying the Optimal Ventilation for Environmental Indoor Air Quality." National Center for Healthy Housing, April 2022.

$7,500 would need to be recovered from customers remaining on the gas system when factoring in a utility's rate of return (typically 10%). This is clearly unfair to remaining customers. It becomes inequitable for two compounding reasons:

1. New gas customers tend to be more affluent than existing customers, and
2. Non-migrating customers remaining on the gas system are likely going to be those with less agency to leave the system (lower/middle-income, fixed-income, renters).

The DPU has directed the investor-owned gas utilities to evaluate these policies in its order for the "Future of Gas" docket, a docket which was initiated in 2020 and is still ongoing.[112] This investigation will provide further insight into the cost recovery mechanisms for pipeline extension allowances and should consider ways to make such mechanisms more fair and equitable under declining consumption.

Implications for Building Occupants

Most new construction is typically geared to the higher end of the market, with the cost of developing a new housing unit ranging from $500,000 to $600,000[113] with single-family homes in Greater Boston costing $900,000.[114] When affordable new construction is built, it is often in the context of an "inclusionary housing" policy that sets aside units for income-eligible residents at below-market rates. Such units are typically a part of multifamily developments and, as such, begin with lower energy demands under the updated Stretch Code as well as the Specialized Code..

In such buildings, electric ductless mini-splits avoid the need for and cost of gas piping and heating equipment. This keeps construction costs low with the effect of moderating purchase costs or rent and allowing for more units to be constructed overall. However, such impacts will likely be small relative to other policies that remove barriers to housing production, such as zoning and permitting reform.

All-electric affordable housing new construction is increasingly prevalent. Notably, the City of Boston has been advancing such practices. For example, the development at 475-511 Dorchester Avenue[115] in South Boston is slated to be all-electric, with 1,460 residential units on top of commercial space. Of the residential units, 284 will be income-restricted, and 94 will house seniors. The building will be rated as Passive House and LEED Platinum and incorporate resiliency features. In 2020, the Mayor's Office of Housing (MOH) (then the Department of Neighborhood Development) adopted a zero-emissions building standard requiring developers

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[112] MA Department of Public Utilities, "Order on Regulatory Principles and Framework, No. 20-80", December 8, 2023). https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/18297602

[113] Logan, Tim, et al. "Boston Construction: How Sky High Costs Drive the Housing Crisis." Boston Globe, 12/22/23 apps.bostonglobe.com/2023/10/special-projects/spotlight-boston-housing/construction-costs/.

[114] Brinker, Andrew, et al. "A Housing Crisis in Massachusetts: A Look at Single Family Homes." Boston Globe 10/22/23 https://apps.bostonglobe.com/2023/10/special-projects/spotlight-boston-housing/single-family-zoning/.

[115] Boston Planning & Development Agency "475-511 Dorchester Avenue (On the Dot) PDA" https://www.bostonplans.org/projects/development-projects/475-511-dorchester-avenue-on-the-dot-pda.

who received funding from the MOH to build to this standard.[116] Separately, Mayor Wu announced in 2023 that any current properties managed by the Boston Housing Authority undergoing major renovations must be retrofitted to be fossil fuel-free by 2030.[117,118]

With respect to both of these facets, building all-electric new construction allows building owners to avoid increasing the costs of a gas system in decline without slowing the pace of construction and positioning occupants for lower long-term energy costs.

[116] City of Boston Department of Neighborhood Development. "Guidebook for Zero Emissions Buildings" 2020. https://www.boston.gov/sites/default/files/file/2020/03/200306_DND%20book_FOR%20WEB.pdf
[117] Noor, Dharna. "Boston's Public Housing Is Getting a Green Makeover" The Boston Globe https://www.bostonglobe.com/2023/01/26/science/bostons-public-housing-is-getting-green-makeover/.
[118] Boston Housing Authority, "Sustainability at Boston Housing Authority," bostonhousing.org/en/Departments/Planning-and-Real-Estate-Development/The-BHA-and-Sustainability-(1).aspx.

Chapter 6: Synthesis

<u>Vignette: Karen and Kamilah's Retrofit of Regret</u>

Karen and Kamilah Black-Smith and their three-year-old son are a typical Massachusetts family. In 2026, they bought a brand new townhouse in Boroborough. The townhouse is part of a development close to Borobough's commuter rail station. The Black-Smiths are grateful that Boroborough's adoption of the MBTA Communities Act requirements enabled this home to be built and affordable to them.

However, the Boroborough Town Meeting was hesitant to adopt the Specialized Code at the same time that it made an affordable housing policy push. As a result, the development was built to include gas heating, cooking, hot water, and dryers. The Black-Smith's realtor emphasized the luxury feel of gas heat and cooking—which included a gas range. While Karen had some worries about potential health impacts, Kamilah grew up with a gas stove and thought it was fine. The family enjoys a couple of years of low energy bills made possible by the 2022 DOER update of the stretch code.

In the 2030s, the family notices an uptick in gas costs. They learn that this is due to rising gas pipeline infrastructure costs. At first, they think little of this, as the impact is small and within their budget. Around the same time, they hear a news story about how the Commonwealth has missed its 2030 climate target. By 2040, they will pay $1,000 more per year in gas bills than they did when they moved in. With their son about to go to college, this cost starts to pinch their budget.

In December 2040, their condensing gas furnace breaks down. It's winter, and they cannot go without heat. Since they moved in, other homeowners across the state have updated their homes with electric appliances. The declining gas demand and lack of state action have forced gas utilities to raise rates to levels where gas costs are comparable to oil. The state is considering mechanisms to limit gas rates, but gas rates will still be high relative to electricity.

The sticking point is they will have to go through a retrofit, and they need heat now. The stove, dryer, and hot water heater still work but may need updates soon. Electrifying these will require new electric wiring to each piece of equipment, as well as custom installation of heat pump equipment and refrigerant lines. The cost is $12,000 after rebates, compared to $6,000 to replace the gas furnace. At current rates, payback will take a couple of years. This cost is incurred at the same time as their first college tuition bill is due.

The Black-Smiths can afford this, but need to adjust their budget. They appreciate that they are doing this part to reduce their emissions given the increasing impacts of climate in Massachusetts and worldwide. Still, they wish they weren't in this position and wished their home was all-electric when they first moved in.

In the worst case scenario, if there were a modest cost premium (such as $5,000) to going electric from the start, the monthly impact on the Black-Smith's finances would have been less than $50 per month in the first year and declining after that due to the increasing favorability of electric rates, ultimately reaching net cost savings around 2033. A formal net present value analysis would indicate that it takes until 2040 for that pessimistic $5,000 electric premium to be paid off. While the payoff may seem long, the cost here is relatively small compared to other aspects of housing. Most importantly, it positions the Black-Smiths to be at the forefront of climate mitigation for, at worst, $1.50 a day and mitigates an additional cost and disruption when their kid goes off to college. The foresight of an all-electric building code would have served the Black-Smith's throughout their life.

It also would have served the other gas ratepayers who remain on the system in 2040. An early departure implies that the utility was probably unable to fully recover the cost of the Black-Smith's connection in a fair and equitable manner. The non-migrating customers, which are likely to be disproportionately low-income, would be burdened by this. Both middle and low-income customers have higher gas rates as a result.

All-Electric New Construction and Climate & Housing Urgency

This study encourages decision-makers to go beyond the cacophony of assumptions and the number of back-and-forth studies that have now converged to say that the relative difference in new construction is small. **The question at hand is: why continue to invest in multiple energy distribution systems when modern technology enables the electric system to increasingly carry the load that has been served by the gas system, *especially with new construction*?**

Climate policy cannot be developed in a vacuum. Neither can housing policy. Unfortunately, proposals to electrify new construction are often considered in isolation along a narrow cost-effectiveness test absent a broader context.

The Black-Smith's middle-income predicament in 2040 results from cascading decisions made in information isolation by the State Legislature, the Department of Energy Resources, the fictional town of Boroborough, and even the Black-Smiths.

Our analysis and Black-Smith's story demonstrate that all-electric new construction has reached effective cost parity with those buildings built with gas. This is remarkable given the historically unique and temporarily low cost of gas. Further, all-electric new construction unlocks pathways to greater affordability than gas. However, the magnitude of relative cost savings of those pathways depends largely on the design and implementation of complementary policies to keep upfront costs and bills low.

The 2023 Greater Boston Housing Report Card[119] listed several long-standing challenges that have slowed the pace of housing construction and led to skyrocketing living costs. The Report Card attributed these challenges to local transportation and zoning policies that have prioritized sprawl and created barriers to affordable housing. Municipalities and the Commonwealth have begun to take action to roll back these policies through mechanisms such as the MBTA Communities Act. This report echoes the value of these actions in the section titled "Policy Avenues for Meeting Climate and Housing Goals in the Policy Appendix. However, given these challenges in implementing such policy and the time it takes for such policy to have an impact, it is understandable that decision-makers and advocates want to ensure that new requirements for buildings to be fossil fuel-free do not impact affordability.

This assessment should alleviate those concerns. First, because of the potential pathways to greater affordability that all-electric new construction unlocks, especially when supported by broader affordable energy policy. Second, other barriers to new construction have had a far greater impact on housing affordability—it is clearly within the means of state and municipal policymakers to alleviate some of those drivers. And thirdly, because of the long-term costs of the gas system and costs and disruption of retrofits of regret.

This study encourages decision-makers to go beyond the cacophony of assumptions and the number of back-and-forth studies that have now converged to say that the relative difference in new construction is small. **The question at hand is: why continue to invest in multiple energy distribution systems when modern technology enables the electric system to increasingly carry the load that has been served by the gas system, *especially with new construction*?**

The Commonwealth's nation-leading climate mitigation research emphasized the need to enact immediate and bold systemic changes to achieve climate targets while keeping the energy transition affordable for all. All-electric new construction remains an important, cost-effective, but yet-to-be-achieved first step.

[119] Kennedy, Aja, Peter Ciurczak, and Luc Schuster. "2023 Greater Boston Housing Report Card." The Boston Foundation, November 2023. https://www.tbf.org/news-and-insights/reports/2023/november/2023-greater-boston-housing-report-card.

Policy Avenues for Meeting Climate and Affordability Goals

Advance All-Electric Building Codes and Incentives for New Construction *Responsible parties:* Legislature, Municipalities	In 2023, New York State and the United Kingdom—both cold-climate jurisdictions—advanced all-electric new construction policies. These policies typically exempt certain industries and building classes. The MA State Legislature could advance all-electric new construction via a target date for all-electric new construction in certain sectors similar to the approach used in New York State. The Legislature could also expand the number of communities allowed in the current fossil fuel-free demonstration program. Municipalities can adopt the Specialized Code to advance all-electric new construction in their communities.
Address Gas Line Extension Policy *Responsible parties:* Department of Public Utilities, Legislature	Some of the costs of pipeline connections are covered by the utility for new connections. However, such revenue is currently at risk of being unrecoverable as customers switch to electric alternatives. In the 20-80 order, the DPU has requested the gas utilities to review their existing practices related to new service connections. Further, the Legislature could repeal Section 3 of the 2014 Gas Leaks Act which was implemented to encourage the growth of the gas system.
Simultaneously Address Housing Affordability and Climate Challenges *Responsible parties:* All-of-government action by both the Commonwealth and municipalities.	The Commonwealth and its communities can pursue both greenhouse gas elimination and housing affordability by embracing all-electric new residential buildings alongside policies that achieve climate goals through smart growth strategies and making it easier to build housing. EEA's 2050 Roadmap and Clean Energy and Climate Plans lay out many of these strategies. These typically include: - Densification and transit-oriented development - Reduce municipal barriers to the construction of new multifamily housing - Streamlining state and local permitting and financial incentives - Zoning and land use regulation reform Like Boston, the Commonwealth could require any developer receiving grants for affordable housing to build it all-electric

Keep Electricity Prices Low and Adopt Heat-Pump Friendly Rate Design *Responsible parties:* DOER, Department of Public Utilities	First, low electricity system costs and rates are essential for an affordable and equitable energy transition. The Commonwealth should pursue strategies that keep electricity generation, transmission, and distribution costs low. Heat pump-friendly rate design is helping to encourage heat pump adoption in Maine primarily by spreading electric heating costs across the season. National Grid has proposed a 10% discount for customers using electric heat. Heat pump-friendly rates may take other forms, and the exact design of these is outside the scope of this study, but they largely involve increasing fixed customer charges and lowering volumetric rates. Over the next decade — before the region shifts to winter peaking — the rapid rise in heating electrification increases the utilization factor of the distribution system. The Commonwealth could evaluate potential strategies, learn from other states, and move to implement new tariffs.
Advance Building Electrification Practices Using Data Responsible parties: Energy Efficiency Advisory Council & DOER (in its municipal fossil fuel-free pilot)	This report and its predecessors were challenged by data availability on the cost and energy implications of various building energy design strategies. The MassCEC Whole Home Heat Pump Pilot data set is a remarkable resource for how much data it provides, but it is limited in scope and has become dated. With increasing public investment (Mass Save, IRA) into building electrification, it is reasonable and beneficial to increase data collection, performance evaluation, and dissemination of results. Information on energy interventions and their cost (including detailed breakdowns of material, labor, permitting, etc.) can help drive performance improvements and cost reductions. The Energy Efficiency Advisory Council should consider expanding its data collection and evaluation activities. The legislation establishing the municipal fossil fuel-free pilot program also requires DOER to collect, analyze, and disseminate energy and cost data relevant to this program. Such data collection should be focused on evaluating the employed construction strategies and their impact on energy consumption patterns. DOER should design its study to collect data from similar towns and buildings not participating in the pilot.

Appendix: Summary of Analytical Approach

The purpose of the modeling exercise in this report is to illustrate the major upfront capital expenditure drivers and energy bill implications of home energy decisions in new residential construction under long-term forecasted gas and electric rates. A summary of data sources and key assumptions is provided in the table below.

Several studies have evaluated the cost implications of new construction energy and efficiency standards in Massachusetts. This report builds on those previous studies by examining the long-term forecasts of gas and electric rates. This methodology draws on findings and estimates of other work but adjusts and harmonizes inputs from this work for inflation and differences between these resources. While it makes adjustments for inflation where appropriate, the recent volatility in materials and labor costs challenges the accuracy of any estimate here. As such, upfront capital costs should be viewed in the context of an evolving marketplace.

The core thesis of this work is that forecasts of future gas rates—based on findings of the utility Future of Gas investigation (D.P.U. 20-80)—will be so large that even highly efficient buildings constructed under today's energy code will face challenges heating with gas. The magnitude of these gas rate increases is so significant that specific building component design decisions or marginal policy changes cannot close the long-run cost gap between gas and electric buildings.

Building energy consumption assumptions under both gas and electric scenarios were obtained from DOER's Stretch Code case study, as this study was used as the basis for policy development and has high familiarity among stakeholders. This work was reviewed and compared to similar work focused on Massachusetts. While each study had different approaches and presentations of results, our review observed consistency in the magnitude of key design decisions associated with electric versus gas implementation. Cost assumptions for air source heat pumps and ductwork were ultimately benchmarked to the MassCEC Whole Home Heat Pump Pilot dataset due to its relative robustness and stakeholder familiarity. However, we note that this leading database does have limitations and that improved data collection should be a priority for the Commonwealth as it advances building electrification. Gas equipment costs were sourced from the 2023 EIA Appliance Cost Database and were adjusted for system size.

Finally, while multiple building types were reviewed by the project team and considered for presentation, the high costs associated with future gas delivery will result in similar cost implications across the building stock: buildings that stay on gas are exposed to dramatically increasing energy costs, whereas all-electric buildings experience comparatively minuscule impacts to their energy costs.

Table 1. Summary of data sources and assumptions used for this study.

Data	Source	Notes
Building characteristics	MassDOER Stretch Code Costs & Benefits Case Studies[120]	2,100 sf detached single-family home 3 bedrooms, 60 MMBtu annual heat demand
Future electric rate projections	MA DPU 20-80: Independent Consultant Report[121] and MA 2050 Roadmap[122]	Hybrid Electrification scenario rate projections used for bill impact model (see Figure 6)
Future gas rate projections	MA DPU 20-80: Independent Consultant Report	Hybrid Electrification scenario (see Figure 6)
Heat pump efficiency	MassDOER Stretch Code Costs & Benefits Case Studies[123]	Ductless, HSPF 12, SEER 20 36,000 Btu capacity
Heat pump costs	MassCEC Whole Home Heat Pump Pilot Projects Database[124]	Data used for econometric modeling of cost components
Gas furnace efficiency	MassDOER Stretch Code Costs & Benefits Case Studies	High-efficiency condensing furnace 98% AFUE
Gas furnace costs	EIA Appliance Cost Database[125] crosschecked with wholesale appliance cost database	Data used for estimation of cost components. Northeast region.
Central air conditioner costs	EIA Appliance Cost Database cross-checked with wholesale appliance cost database	Data used for estimation of cost components. Northeast region.

[120] Residential Stretch Code Cost and Benefits Case Studies." Massachusetts Department of Energy Resources. mass.gov/doc/residential-stretch-code-costs-and-benefits-case-studies/download.
[121] Energy+Environmental Economics and Scott Madden Management Consultants. "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals, Independent Consultant Report--Technical Analysis of Decarbonization Pathways," March 2022. thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf.
[122] "Massachusetts 2050 Decarbonization Roadmap: Summary Report." Massachusetts Executive Office of Energy and Environmental Affairs, 2020. mass.gov/doc/ma-2050-decarbonization-roadmap/download.
[123] "Residential Stretch Code Cost and Benefits Case Studies." Massachusetts Department of Energy Resources. mass.gov/doc/residential-stretch-code-costs-and-benefits-case-studies/download.
[124] "Whole-Home Air-Source Heat Pump Pilot." Massachusetts Clean Energy Center. 2023. masscec.com/program/whole-home-air-source-heat-pump-pilot.
[125] "Updated Buildings Sector Appliance and Equipment Costs and Efficiency." Energy Information Agency, March 23, 2023. https://www.eia.gov/analysis/studies/buildings/equipcosts/.