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Public Policy for Net Zero Homes and Affordability

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Executive Summary

Climate change is an urgent crisis. Currently more than one-quarter of carbon emissions in Massachusetts come from the building sector, primarily through on-site combustion of oil and methane for the heating of residential and commercial buildings. Achieving net zero carbon emissions in Massachusetts will require achieving net zero carbon emissions from buildings statewide, both by creating more energy-efficient building envelopes and by decarbonizing heating, cooling, and other appliances. At the same time, Massachusetts residents are experiencing a housing cost crisis that disproportionately and negatively affects low- and moderate-income households. Roughly one out of every two renter households (49 percent) and nearly one out of every three (30 percent) homeowner households with a mortgage in Massachusetts were housing cost burdened in 2021, meaning that they were paying 30 percent or more of their income towards housing costs. Today, it is more expensive to build most energy-efficient homes than it is to build conventional homes. Increased construction costs lead to increases in home prices and decreases in housing production. This report identifies a range of effective policy tools that policymakers can use to meet critical goals for climate emissions, housing production, and housing affordability.

This report analyzes and answers three questions:

1. How does the cost of building homes that are compliant with Massachusetts' new municipal opt-in specialized stretch energy code compare to the cost of building similar homes that are compliant with the current stretch code?
2. Based on these cost estimates, how is the opt-in specialized stretch energy code likely to affect housing affordability in Massachusetts?
3. How can public policies simultaneously advance the transition to net-zero housing while also addressing the housing affordability crisis?

Models of single-family home and townhouse construction and surveys of builders of single and multi-family housing indicate that the specialized stretch energy code is likely to increase the cost of construction of single family homes and townhouses by roughly 1.8 to 3.8 percent (approximately $10,000 to $23,000 for the median single family home), depending on the pathway to compliance selected, and increase the cost of construction of large multi-family buildings by roughly 2.4 percent, at least initially. It is important to interpret these numbers in the context of an evolving and diverse marketplace. Labor and material costs have been in flux; low-carbon technologies continue to advance; and builders themselves are still working out the least expensive routes to compliance for diverse projects on diverse sites. Several large non-profit builders of multi-family affordable housing noted that as developers and contractors have become more accustomed to Passive House construction, incremental costs have declined and will continue to decline.

The economic modeling here shows that these increases in construction costs could push the median single-family home in Massachusetts out of reach for between 15,000 and 33,000 households, before taking into account any public financial incentives for green building. The increased energy efficiency of homes will potentially offset some of the increase in construction costs, but not all, as explored below. Some of the increased construction costs will be passed on to homebuyers and renters, while some will be absorbed by builders in the form of reduced profit margins. Increases in construction costs, however, are likely to reduce construction starts overall, as fewer projects pencil out and fewer households can afford new homes, putting further pressure on housing supply and affordability. We find that the increased costs will be felt most by households with low and moderate incomes.

Policymakers have multiple tools to increase housing affordability while advancing the Commonwealth's climate agenda. Since local land use regulations are currently a major driver of the high cost of housing, reform of local land use regulations to facilitate the construction of more housing units should accompany the strengthening of green building standards. Zoning reform can also improve the carbon efficiency of the state's settlement patterns. Other tools to simultaneously improve the energy efficiency of buildings and housing affordability include efforts to streamline the permit process, to restructure financial incentives to keep them in place for longer periods of time, to increase technical assistance for green building, to facilitate use by realtors and appraisers of the Residential Green and Energy Efficient Addendum, to improve underwriting of energy-efficient homes, to expand financing sources through the new Massachusetts Community Climate Bank, to increase support for low-income renters, and to consider new tax classifications and exemptions for highly energy-efficient buildings.

One of the most powerful tools to simultaneously increase housing affordability and decrease carbon emissions is land use policy. Current land use regulations prevalent in municipalities across the Commonwealth require carbon intensive living patterns and drive up the cost of housing. Some of the municipalities adopting the specialized stretch energy code have extensive large-lot, large-unit, single-family land use regulations that mandate energy intensive, environmentally destructive, and unaffordable living patterns. Legislative action tying the adoption of the opt-in specialized stretch code to land use regulations enabling dense and pedestrian-oriented land use patterns, such as smaller minimum lot and unit sizes, larger height limits, and more by-right multi-family zoning could increase the reduction in carbon emissions and simultaneously increase affordability. State legislative action is urgently needed to address local zoning barriers to energy-efficient and affordable housing production.

State and local permitting requirements add substantial time, cost, and uncertainty to current home construction. State efforts to streamline these permit requirements could enable the construction of more affordable energy-efficient homes.

Financial incentives for more energy-efficient construction are an important tool. An obstacle to the effectiveness of some existing incentive programs is lack of certainty about their duration. Explicit commitments by the state as to the durability of these incentives would enable home builders to rely on them in their financing models. The Massachusetts Commission on Clean Heat recently proposed the creation of a Building Decarbonization Clearinghouse to be a single point of contact for all decarbonization programs. The creation of such a clearinghouse as a single point of contact, with a commitment to long-term incentive availability, streamlined application processes, and adjustment of incentives for inflation, would be a beneficial step to advancing housing production, affordability, and decarbonization.

Increased technical assistance and training to small home-builders and subcontractors regarding how to comply with the new specialized stretch energy code would be beneficial. The Massachusetts Clean Energy Center's Passive House Design Challenge and its support for large multi-family builders beginning to build to Passive House standards could serve as a model for smaller builders beginning to comply with or exceed the specialized stretch energy code.

Realtors not only connect buyers and sellers but can play a role in educating buyers and sellers about the value of energy-efficient homes, while appraisers are essential to the underwriting process. Increased use of the Residential Green and Energy Efficient Addendum is necessary to increase home purchasers' awareness of the increased value and decreased utility costs of energy-efficient homes and also to accurately underwrite these homes. Federal action to ensure that energy-efficient improvements and associated utility cost savings are capitalized into property appraisals and that those appraisals will be accepted by the government-sponsored enterprises (GSEs) would simplify the financing of more energy-efficient homes for home buyers. In the interim, it would be helpful for the state to encourage Massachusetts financial community development financial institutions to offer energy-efficient mortgages that accurately underwrite energy-efficient homes and their associated cost savings.

The new Massachusetts Community Climate Bank can facilitate investment in low-carbon, climate-resilient housing. A mission-driven financial institution designed to use public funding to attract private investment to clean energy projects through loans or investment funds, Green Banks can be an important new tool in reducing building carbon emissions and simultaneously increasing affordability.

To the extent that some energy-efficient multi-family buildings may shift some utility costs from landlords to tenants, support for low-income tenants is important to ensure that vulnerable households in the Commonwealth do not disproportionately bear the burden of decarbonization.

The combination of the current climate change and housing affordability crises requires bold action. The Commonwealth's Global Warming Solutions Act of 2008 and the Act Creating a Next Generation Roadmap for Massachusetts Climate Policy of 2021 are fundamental steps to reduce carbon emissions in Massachusetts but will not, alone, reduce carbon emissions from new residential buildings to zero. Housing Choice legislation and the MBTA Communities Act are helpful steps towards reducing some of the obstacles that local land use regulations create to building more energy-efficient and affordable housing, but it falls far short of the changes to land use needed to meet current housing needs and far behind more ambitious legislation other states, such as Oregon, California, and Maine, have recently passed.

In sum, action by the state legislature, by state agencies, and by statewide professional organizations can help move both decarbonization and housing affordability forward together. There are many opportunities to simultaneously reduce carbon emissions associated with the building sector and improve housing affordability at the same time, as suggested below. It is essential to ensure that decarbonization happens in ways that support low- and moderate-income communities and communities of color in the Commonwealth who face pressing issues of housing instability and housing cost burdens.

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1. Introduction

Massachusetts, like the rest of the United States, is currently facing a multi-generational crisis created by climate change and, simultaneously, an ongoing crisis of housing affordability. The changing climate is exacerbating environmental disasters, increasing mortality, and damaging quality of life, while soaring home prices and rents are placing stable housing out of reach for thousands of households in the Commonwealth.

The effects of climate change are already visible in Massachusetts and beyond, from more frequent and severe flooding to longer and more intense heat waves. The Intergovernmental Panel on Climate Change (IPCC) has documented the "widespread, pervasive impacts to ecosystems, people, settlements, and infrastructure [that] have resulted from observed increases in the frequency and intensity of climate and weather extremes, including hot extremes on land and in the ocean, heavy precipitation events, drought and fire" (IPCC WGII Sixth Assessment Report Impacts, Adaptation, and Vulnerability, 2022: 10). The building sector is a significant contributor to global greenhouse gas emissions and thus an important pathway for policy makers to limit those emissions. The IPCC has noted that urban areas can create opportunities to increase resource efficiency and significantly reduce emissions through changes to infrastructure and urban form, as well as (i) reducing or changing energy and material consumption, (ii) electrification, and (iii) enhancing carbon uptake and storage in the urban environment. (IPCC WGII Sixth Assessment Report Mitigation of Climate Change, 2022: 34). The panel has highlighted the potential for the building sector to "approach net zero GHG emissions in 2050 if policy packages, which combine ambitious sufficiency, efficiency, and renewable energy measures, are effectively implemented and barriers to decarbonization are removed" (IPCC WGII Sixth Assessment Report Mitigation of Climate Change, 2022: 35).

In Massachusetts, the Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study on the Buildings Sector noted that on-site fossil fuel combustion in residential and commercial buildings accounted for 27 percent of statewide greenhouse gas emissions in 2017, driven primarily by oil and natural gas combustion for building heating (Office of Energy and Environmental Affairs 2020: 5). The Massachusetts Legislature has taken important steps to address the Commonwealth's greenhouse gas emissions, as discussed below, in the Global Warming Solutions Act of 2008 and the Act Creating a Next Generation Roadmap for Massachusetts Climate Policy of 2021. Achieving net-zero emissions in the Commonwealth by 2050 will require net-zero emissions in the building sector. The long lifetimes of building envelopes and building heating systems mean that buildings built today may have similar energy use profiles for the next 30-40 years or more. It is much less expensive to build a new energy-efficient home at the outset than to retrofit an existing structure. Increasing building energy efficiency and building decarbonization for new construction is thus urgently needed (Office of Energy and Environmental Affairs

2020). To reduce carbon emissions from residential heating and cooling, the Department of Energy Resources (DOER) in 2022 promulgated a municipal opt-in specialized stretch energy code that includes what it has termed net-zero-ready building performance standards.

At the same time, housing affordability is an urgent challenge in Massachusetts and across the nation. Nationally, record low housing inventories are contributing to rapid increases in the cost of housing and worsening cost-burdens for renters (Joint Center for Housing Studies 2021). The National Association of Home Builders estimates that roughly 69 percent of all U.S. households in 2022 are not able to afford a new home priced at the national median of $412,505 (NAHB 2022). Housing affordability in Massachusetts is substantially worse than in the nation as a whole. The cost of the median new home in Massachusetts is the third highest in the nation in 2021 at $608,827 (NAHB 2022). Three out of every four households in Massachusetts could not afford a new home at that median price (NAHB 2022). Roughly one out of ten homeowners in Massachusetts and one out of four renters were already paying more than half of their income to housing costs in 2021 (Boston Foundation 2021). Yet housing production over the past decade in Massachusetts has been roughly half of the level it was in the 1980s and substantially lower on a per capita level than in other major cities, such as Seattle or New York (Boston Foundation 2021). According to U.S. Census Bureau data on permits for privately owned housing, localities in Massachusetts issued permits for the construction of a total of only 18,181 housing units in 2022.[1] Housing is generally households' largest expense. Housing shortages and high costs are forcing Massachusetts residents into longer commutes or even out of state to find housing they can afford.

Legislative efforts to systematically address housing affordability have so far been less successful than legislation reducing carbon emissions. Recent statewide housing legislation includes the passage of the Housing Choice Initiative provision of An Act Enabling Partnerships for Growth (2020), reducing from a two-thirds majority to a simple majority the number of votes required to adopt or change zoning ordinances or bylaws that facilitate housing production and special permits that enable transit-oriented multi-family housing and mixed-use development, as well as the MBTA Communities Zoning Law (part of the Economic Development Bond Bill enacted in January 2021), requiring the municipalities served by the Massachusetts Bay Transportation Authority to have at least one zoning district of reasonable size within half a mile of a transit station where multi-family housing is permitted as of right at a minimum density of 15 units per acre. Important as these changes to the Zoning Act are, they alone will not sufficiently address the pervasive housing affordability crisis in the Commonwealth.

This research analyzes the intersection of the climate crisis and the housing affordability crisis in Massachusetts and the effects of the new net-zero residential building code on housing affordability. It

[1] https://www.census.gov/construction/bps/statemonthly.html

analyzes three main questions. First, how do the costs of building homes compliant with Massachusetts' *new* municipal opt-in specialized stretch energy code compare to the costs of building similar homes compliant with the *current* stretch code? Second, based on these cost estimates, what is the impact of the opt-in specialized stretch energy code on housing affordability in Massachusetts? Third, how should public policies simultaneously advance the transition to net-zero housing while also addressing the crisis of housing affordability?

Climate change is a profound challenge. It is imperative that the Commonwealth and its municipalities act decisively to address climate change and build equity simultaneously. Reducing carbon emissions from residential buildings can create safer, healthier housing but it must also not hinder the sufficient provision of affordable housing. Focusing on housing affordability in conjunction with housing sustainability is essential.

2. Background

Recent Massachusetts legislation related to building energy efficiency

In 2008, the Massachusetts legislature enacted the Global Warming Solutions Act, which required the Executive Office of Energy and Environmental Affairs (EEA) to set economy-wide greenhouse gas (GHG) emission reduction goals for Massachusetts that would reduce 2050 GHG emission levels by at least 80% relative to 1990 levels. To comply with the Global Warming Solutions Act, the Massachusetts Department of Environmental Protection required reporting of GHG emissions by the largest sources and established target emission reductions.

The Massachusetts legislature in 2008 also enacted the Green Communities Act, among other legislation, which required the state to adopt the International Energy Conservation Code as part of the state building code and to update the code as the International Energy Conservation Code is revised. This means that the base energy code in the Commonwealth, as codified by the Massachusetts Board of Building Regulations and Standards, is the International Energy Conservation Code, with Massachusetts specific amendments (see 780 C.M.R.).

Consistent with the Green Communities Act, Massachusetts in 2009 also adopted a stretch energy code, as an appendix to the base code, emphasizing cost-effective construction that had higher levels of energy performance than the base code (see 780 C.M.R. 115 Appendix AA). In 2020, the Board of Building Regulations and Standards clarified that the stretch energy code could be met with either a Home Energy Rating Index Score (HERS) of 55 for new construction (unless there were photovoltaic panels greater than 2.5kW and renewable heating systems) or an equivalent Energy Rating Index (ERI) score (see Section 406.4 of Chapter 11 of 780 C.M.R. 51.00).

In 2021, the Massachusetts legislature enacted Senate Bill 9, An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy. Section 10 of the Act established a statewide emissions limit of at least a 50 percent reduction from the 1990 levels by 2030, at least a 75 percent reduction from the 1990 levels by 2040 and at least net-zero emissions by 2050. The Next Generation Roadmap for Massachusetts Climate Policy Act builds on the Executive Office of Energy and Environmental Affairs' 2050 Decarbonization Roadmap and Clean Energy and Climate Plan for 2030. The 2050 Decarbonization Roadmap was created based on sector specific reports, including a Buildings Sector Report that analyzed sources of GHG emission from the commercial and residential building sectors. The Buildings Sector Report found that on-site combustion of fossil fuels (particularly for heating and hot water) in the more than 2 million individual residential and commercial buildings in the Commonwealth was responsible for 27 percent of statewide GHG emissions in 2017. Electrification of end uses through electric heat pumps or other appliances is likely to be the least-cost strategy for reducing emissions, combined with increasing building energy efficiency overall. The report notes that the "adoption of a high-performance/zero on-site emissions new construction code in 2030 could reduce annual 2050 emissions from residential and commercial new construction by 0.8 MMT CO_2 (54% reduction) and by 1.30 MMT CO_2 (87% reduction) if implemented in 2023," highlighting the importance of early action on a high-performance, net-zero building code (EEA, 2020: 6).

Section 9 of the Act instructed the Executive Office of Energy and Environmental Affairs to establish sub-limits for at least six sectors of the Massachusetts economy: electric power, transportation, commercial and industrial heating and cooling, residential heating and cooling, industrial processes, and natural gas distribution and service. To achieve these sub-limits in residential heating and cooling, Section 31 of the Act instructed the Department of Energy Resources, in addition to the existing base energy code and stretch energy code, to "develop and promulgate, in consultation with the state board of building regulations and standards, 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." Consistent with Section 101 of the Act, the Department of Energy Resources released a specialized stretch energy code proposal on February 8, 2022, and held five public hearings in March to solicit feedback on the proposal. The Department of Energy Resources then released a draft regulation on June 24, 2022, followed by three public hearings in July and August of 2022. It received more than 700 public comments and has submitted final regulations to the Joint Committee on Telecommunications, Utilities, and Energy.

In addition, Massachusetts in August 2022 enacted an Act Driving Clean Energy and Offshore Wind, which enabled 10 municipalities to prohibit fossil fuel connections in new construction or major renovation projects as part of a pilot study of electrification. It also phased out incentives for fossil-fuel based heating and cooling systems and created a Clean Energy Transmission Working Group to analyze major transmission infrastructure upgrades needed to deliver clean energy generation as well as a Grid Modernization Advisory Council to ensure that utilities make proactive and cost-effective transmission upgrades.

Table Review of recent Massachusetts legislation related to building energy efficiency

2008	Global Warming Solutions Act	Required the EEA to set economy-wide greenhouse gas (GHG) emission reduction goals that would reduce 2050 GHG emission levels by at least 80% relative to 1990 levels
2008	Green Communities Act	Required Massachusetts to adopt the International Energy Conservation Code as part of the state building code Consistent with the Act, Massachusetts in 2009 also adopted a stretch energy code, as an appendix to the base code, emphasizing cost-effective construction that had higher levels of energy performance than the base code
2021	Senate Bill 9, An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy	Section 10: Established a statewide emissions limit of at least a 50 percent reduction from 1990 levels by 2030, and at least a 75 percent reduction of 1990 levels by 2040 and at least net-zero emissions by 2050 Section 9: Instructed the EEA to establish sub-limits for at least six sectors of the Massachusetts economy: electric power, transportation, commercial and industrial heating and cooling, residential heating and cooling, industrial processes, and natural gas distribution and service Section 31: To achieve sub-limits in residential heating and cooling, instructs the Department of Energy Resources, in addition to the existing base energy code and stretch energy code, to “develop… 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” Section 101: Consistent with this Section, The Department of Energy Resources released a specialized stretch energy code proposal on February 8, 2022

Massachusetts energy codes

Massachusetts currently has three energy code options that municipalities can adopt: the base energy code, the stretch energy code, and the specialized stretch energy code. As of November 2022, 52 municipalities in Massachusetts were subject to the state's base energy code, slated to be updated in line with the most recent revisions to the International Energy Conservation Code by July 2023. The remaining 299 communities have adopted the state's stretch energy code, slated to be updated by January 2023. Effective December 24, 2022, communities in Massachusetts have been able to opt into the more energy-efficient requirements of the new specialized stretch energy code, by town meeting bylaw or city council vote.

Figure 1: Current Energy Code Options

Base Code (IECC 2021)	**Stretch Code (2023 update)**	**Specialized Code ("Net-Zero")**
• New construction in towns & cities that are not a green community	• New construction in towns & cities that are a green or stretch community	• New construction in towns & cities that vote to opt-in to this code
• 52 communities	• 299 communities	
Expected from BBRS: **July 2023**	Residential: **Jan 2023** Commercial: **July 2023**	Effective date: Typically, **6-11 months** after town/city vote

Source: DOER, https://www.mass.gov/info-details/building-energy-code

The Home Energy Rating System (HERS) Index is the industry standard used to measure a home's energy efficiency. Home energy raters conduct a review of construction plans and then a physical inspection of the home to assess a home's energy performance. A home built to the specifications of the 2006 International Energy Conservation Code scores a HERS Index of 100. Higher scores represent greater energy use and worse energy efficiency. Lower scores represent better energy efficiency and decreased energy use. A score of 0 represents net-zero energy consumption and a score below 0 represents net energy production.

For new construction of residential low-rise buildings (1 & 2 family homes and townhouses), the stretch energy code currently requires a HERS score of 55 or lower, unless it is all-electric or has photovoltaic generation (electricity generation from solar panels) (up to HERS 60) or both (up to HERS 65). As of January 1, 2023, the stretch energy code requires a HERS score of 52 or lower, unless it is all-electric or has photovoltaic generation (up to HERS 55) or both (up to HERS 58). By July 1, 2024, the stretch energy code will require a HERS score of 42 or lower, or HERS 45 for homes that are all-electric. All newly built homes compliant with the stretch code will also be required to have all-electric ready wiring (including a 240 volt, 50-amp circuit per home), wiring for electric car charging, and heat and energy recovery ventilation. There are alternative pathways to comply with the stretch code via meeting the Passive House Institute standard or the Passive House Institute US Core 2021 or Zero 2021 standards. Multi-family residential buildings must meet new limits on heating and cooling demands, measured through thermal energy demand intensity (TEDI) in kBtu per square foot per year, with a limit of 2.8-3.2 kBtu/square foot per year for heating and 15-22 kBtu/square foot per year for cooling.

As set out in the Act Creating a Next Generation Roadmap for Massachusetts Climate Policy, the new opt-in specialized stretch energy code must be designed to achieve the Massachusetts greenhouse gas emission limits and sub-limits every five years from 2025 to 2050 and ensure that new construction is consistent with net-zero emissions in Massachusetts by 2050. The opt-in specialized stretch energy code will have three paths to compliance. The first path is a "mixed-fuel" house with a HERS score of 42 or lower with solar panels, plus wiring for the capacity to be all-electric, or alternatively Passive House certification plus wiring to be all-electric. The second path is an all-electric house with a HERS score of 45 or lower, or a Passive House certification. The third option is a zero-energy home with a HERS score of 0 or a Passive House Institute US Zero certification. Any new homes over 4,000 square feet will have to use one of the second two paths—either all-electric or zero energy. For multi-family buildings greater than 12,000 square feet, Passive House Institute US Core or Passive House Institute certification will be required beginning in January 2024.

Table 2: Review of Massachusetts energy codes

Base energy code	As of November, 2022, 52 communities in Massachusetts were subject to the state's base energy code, slated to be updated in line with the most recent revisions to the International Energy Conservation Code by July, 2023
Stretch energy code	The remaining 299 Massachusetts communities have adopted the state's stretch energy code, slated to be updated by January 2023 Residential low-rise buildings (1 & 2 family homes and townhouses) requirements for new construction

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As of December, 2022: HERS score of 55 or lower, unless it is all-electric or has photovoltaic generation (up to HERS 60) or both (up to HERS 65)
As of January, 2023: HERS score of 52 or lower, unless it is all-electric or has photovoltaic generation (up to HERS 55) or both (up to HERS 58)
By July, 2024: HERS score of 42 or lower, or HERS 45 for homes that are all-electric

Multi-family residential buildings requirements for new construction

New limits on the heating and cooling demands, measured through thermal energy demand intensity (TEDI) in kBtu per square foot per year, with a limit of 2.8-3.2 kBtu/ square foot per year for heating and 15-22 kBtu/ square foot per year for cooling

All newly built homes compliant with the stretch code requirements

All-electric ready wiring (including a 240 volt, 50-amp circuit per home), wiring for electric car charging, and heat and energy recovery ventilation
OR, alternative pathways via meeting the Passive House Institute standard or the Passive House Institute US Core 2021 or Zero 2021 standards

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<tr><td>Specialized stretch energy code</td><td>
As of December, 2022, communities in Massachusetts were able to opt into the more energy-efficient requirements of the new specialized stretch energy code by town meeting bylaw or city council vote.
Designed to achieve:

The greenhouse gas emission limits and sub-limits every five years from 2025 to 2050
New construction consistent with net-zero emissions in Massachusetts by 2050

Three paths to compliance:

A “mixed-fuel” house with a HERS score of 42 or lower with solar panels, plus wiring for the capacity to be all-electric, or alternatively Passive House certification plus wiring to be all-electric
An all-electric house with a HERS score of 45 or lower, or a Passive House certification
A zero-energy home with a HERS score of 0 or a Passive House Institute US Zero certification

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	Any new homes over 4,000 square feet will have to use one of the second two paths—either all-electric or zero energy. For multi-family buildings greater than 12,000 square feet, Passive House Institute US Core or Passive House Institute certification will be required beginning in January 2024.

Definitions of net-zero buildings

The U.S. Department of Energy defines a Net-Zero Energy Building as "a building with net-zero energy consumption, meaning the total amount of energy used by the building on an annual basis is equal to the amount of renewable energy created on the site" (DoE 2015).[2] In parallel with the Department of Energy definition, The Massachusetts Department of Energy Resources has described "a net-zero energy building" as "one that is optimally efficient, and over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite" (DOER n.d.).

For the purposes of the proposed net-zero stretch energy code, the Massachusetts Department of Energy Resources has said that the proposed net zero definition in the code "does not necessitate onsite or offsite renewables, nor the assumption that an individual building is net-zero energy" because buildings built to the proposed net-zero stretch code are either fully electric or pre-wired to be all electric in the future and would have zero carbon emissions when the Commonwealth's electric grid is net zero. This approach to building energy efficiency is sometimes called "net-zero ready." The final version of the opt-in specialized stretch energy code defines a net-zero building as "A building which is consistent with achievement of MA 2050 net zero emissions, through a combination of highly energy-efficient design together with being an all-electric or Zero Energy Building, or where fossil fuels are utilized, a building fully pre-wired for future electrification and that generates solar power on-site from the available Potential Solar Zone Area." According to research by Built Environment Plus the gross square footage of net zero or net zero ready buildings in Massachusetts has more than tripled from the beginning of 2021 to the beginning of 2023, totaling more than 32 million square feet (Built Environment Plus 2023).

[2] Carbon emissions are the primary component of greenhouse gas emissions. Other gases contributing the greenhouse effect include nitrogen oxides, sulfur, and carbon monoxide, among others. The standard measure of greenhouse gas emissions is one metric ton of carbon dioxide equivalent (co2e), the global warming impact of one metric ton of atmospheric carbon dioxide.

The recent Massachusetts legislative and regulatory activities have focused on operational carbon (and not yet embodied carbon), and operational carbon is the focus of this report.[3]

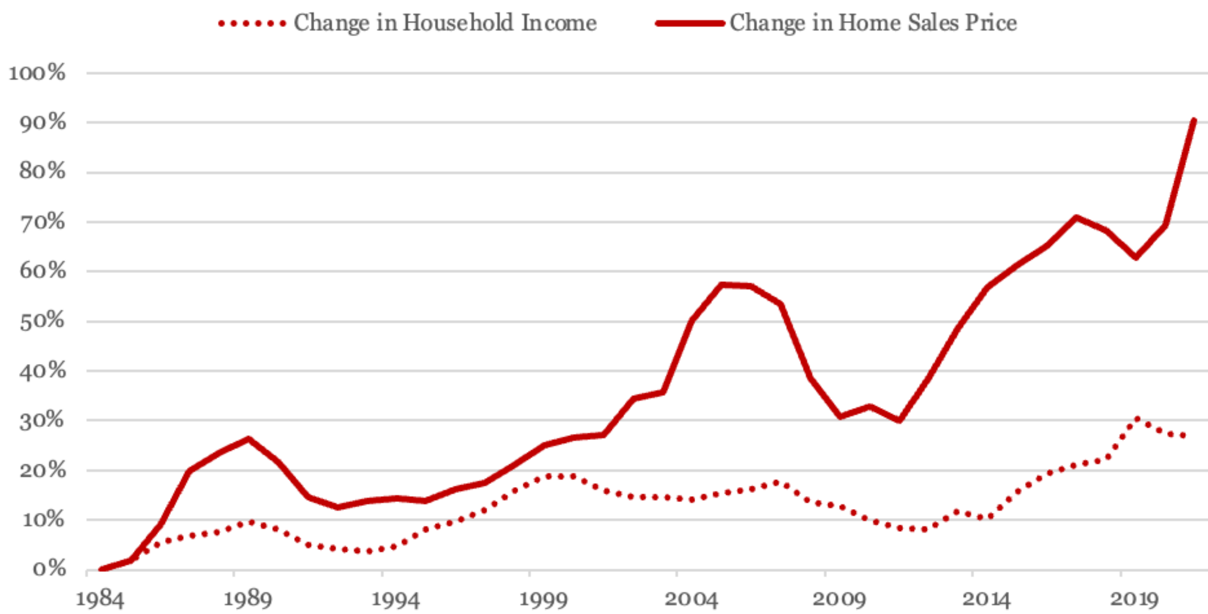
Distinct from, but related to, the definition of a net-zero building are the Passive House standards or certifications, which focus on reducing energy use for space heating and cooling through a well-insulated and air-sealed envelope prioritizing natural light and solar gain as well as efficient HVAC systems. Passive House requirements includes specific standards for airtightness, thermal comfort, space heating and cooling demand, and primary energy demand per square foot. Advances in building energy efficiency enable net-zero carbon or even net-positive energy generation when paired with solar or other renewable power sources. The Passive House Institute (PHI) is an independent research institute that has developed the Passive House concept, Passive House Institute United States (PHIUS) has created regional passive building standards and certifications in the United States, and Passive House Massachusetts is a member-based, non-profit organization that focuses on education, training, outreach, and advocacy for Passive House design across the state.

Dimensions of housing affordability

The affordability of housing for a given household is determined at a basic level by the relationship between household income and the amount that that household pays for their housing in a given period, whether in rent and utilities, for renters, or in mortgage payments, insurance, property taxes, utilities, and other fees for homeowners. Over the past half century, the price of median homes sold has risen faster than median incomes, as seen in Figure 2, leading to a broad decline in housing affordability.

▸ [3] A whole lifecycle approach to carbon emissions includes both the “embodied carbon” (the greenhouse gas emissions associated with building construction, including those that arise from extracting, transporting, manufacturing, and installing building materials on site, as well as those associated with eventual demolition) and “operational carbon” (the greenhouse gas emissions from all energy sources used to for heating, cooling, ventilation, lighting, and power) across the lifecycle of the building from construction to demolition (World Green Building Council 2022). It is estimated that between 2020 and 2050, new buildings will produce around half of their emissions from embodied sources and half from operational sources over their whole lifecycle.

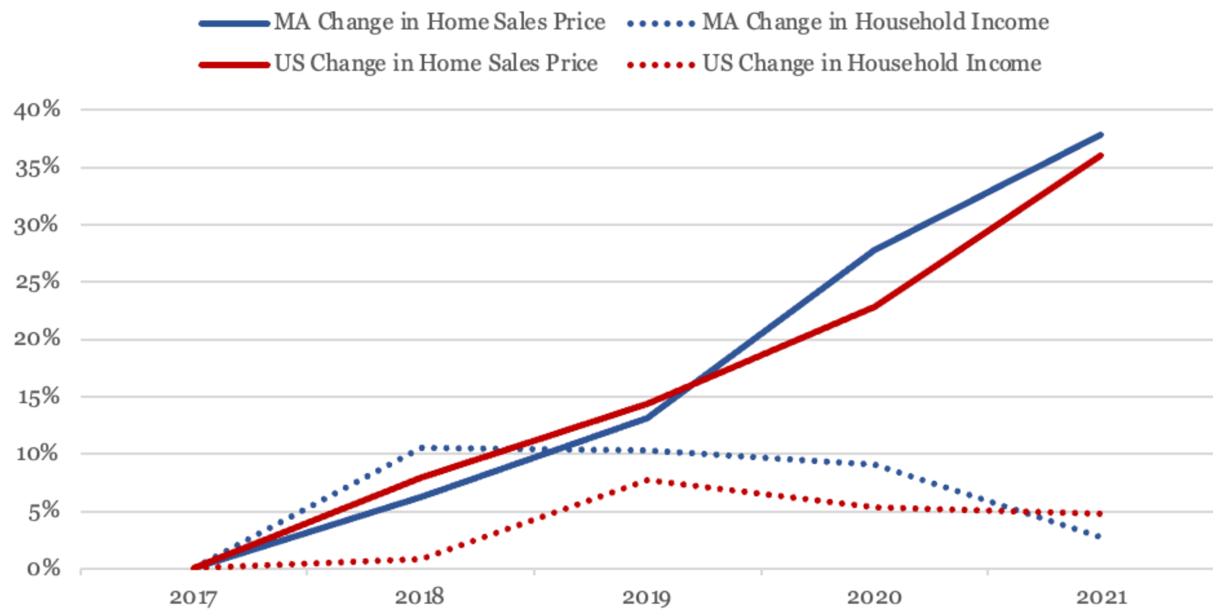
Figure 2: Change in US Home Values Relative to Median Incomes, 1984-2020



Source: U.S. Census Bureau and U.S. Department of Housing and Urban Development, Median Sales Price of Houses Sold for the United States; U.S. Census Bureau, Real Median Household Income in the United States, retrieved from FRED, Federal Reserve Bank of St. Louis

Looking in more detail at the past four years, home prices in Massachusetts and the United States have risen even more rapidly relative to income than over much of the past four decades as seen in Figure 3, further decreasing housing affordability and limiting access to home-ownership.

Figure 3: Change in US and MA Home Values and Median Incomes, 2017-2021



Source: Realtor.com: Housing Inventory: Median Listing Price in Massachusetts, Median Listing Price in the United States; U.S. Census Bureau: Real Median Household Income in the United States, Real Median Household Income in Massachusetts, retrieved from FRED, Federal Reserve Bank of St. Louis

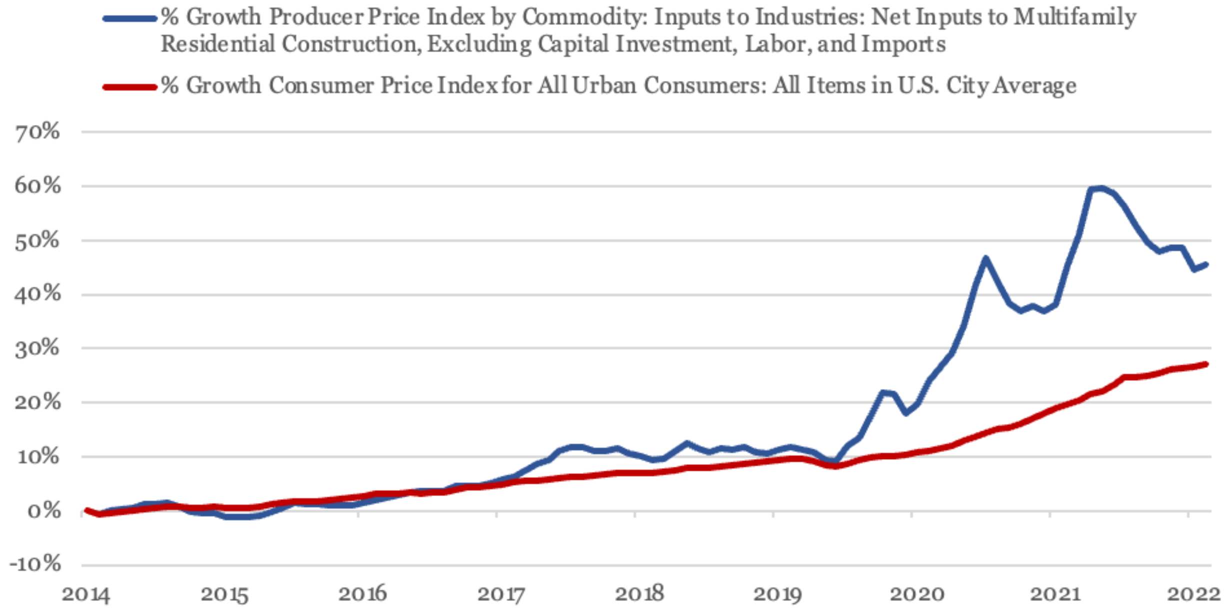
There are many factors that contribute to the rising cost of homes, chief among them growing demand coupled with constrained supply. Principally, this growth stems from increasing population and shrinking household sizes, combined with persistent limitations on supply, particularly from land use regulations. The increasing cost of labor and materials in construction also contribute to increased home prices. In recent months, rising interest rates have had a dramatic effect on housing affordability, substantially increasing monthly mortgage costs for home purchasers. As mortgage rates increase, the maximum home price affordable to a household declines. The decline in purchasing power associated with increasing mortgage rates is especially acute for low- and moderate-income and first-time home buyers. Some of the other factors affecting housing affordability include property taxes, maintenance and operating costs (including utility costs), and the tax treatment of real estate, interest payments, and state and local taxes. Particularly relevant here are utility costs, which may decrease with increasing energy efficiency.

Restrictive local land-use regulations—including large minimum lot sizes, density restrictions, large minimum floor area requirements, minimum parking requirements, and aesthetic rules, among others—decrease the supply of housing and increase housing costs. The effects of stringent restrictions are felt most powerfully by low-income households, who dedicate a higher proportion of their income to housing relative to high-income households. By limiting supply and driving up the cost of housing, these restrictions generally benefit incumbent homeowners at the expense of new home seekers. These land use regulations also encourage environmentally inefficient and destructive use of land, by incentivizing or requiring car-dependent, infrastructure-intensive, and energy-intensive building types and land use patterns.

Construction costs can be broken into two rough portions: costs of labor and of material. As tradable commodities, costs of materials roughly converge across the country (unless there are supply chain disruptions), but costs of labor diverge substantially. Construction wages vary by housing markets, influenced by the cost of living and the different labor market conditions in each region.

In its Producer Price Index data, the Bureau of Labor Statistics measures the price for construction materials (partially processed products such as lumber and plywood) and components (complete commodities purchased for assembly with other commodities such as sinks, windows, and doors). While the costs of materials and components for new residential construction increased only slightly more than inflation between 2014 and 2020, the costs of these materials and components started to increase more quickly than inflation as a result of supply chain disruptions after the outbreak of the COVID-19 pandemic. The Producer Price Index for Residential Construction was 30 percent higher in January 2023 than it had been three years earlier, as seen in Figure 4.

Figure 4: Growth in Producer Price Index for Residential Construction vs Consumer Price Index, 2014-2022

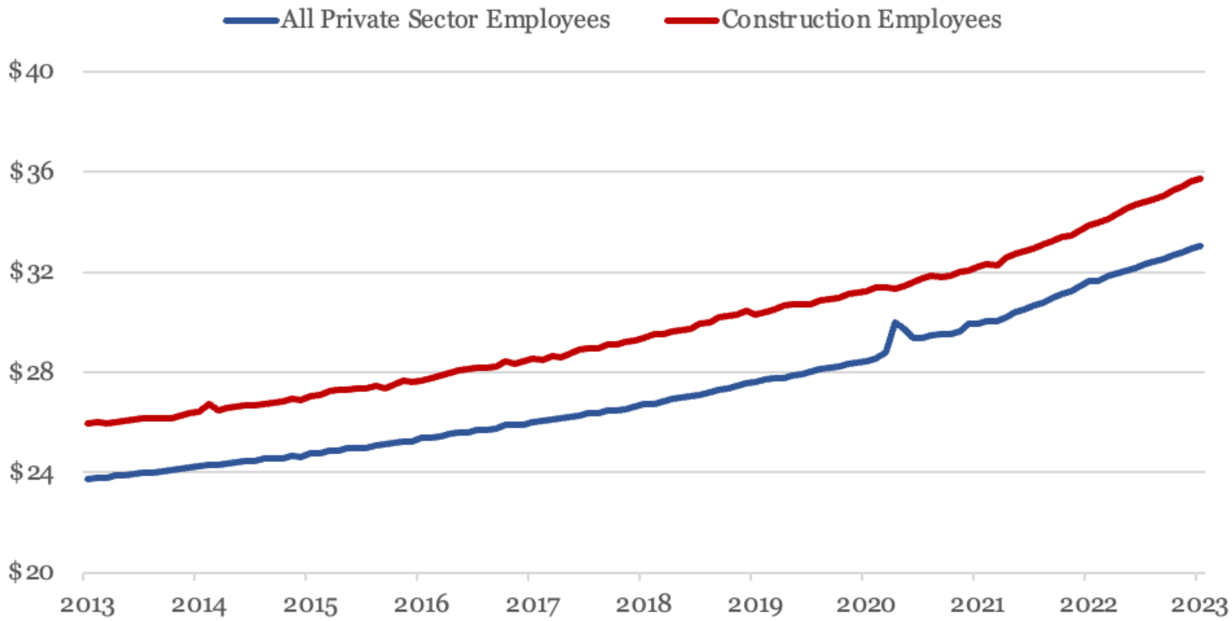


Source: U.S. Bureau of Labor Statistics, BLS Data Viewer [4]

Data from the Bureau of Labor Statistics suggests that, on average, hourly wages in construction have roughly kept pace with hourly wages for all private sector employees, as seen in Figure 5. The cost of construction labor, however, varies substantially by region.

[4] Available at: https://beta.bls.gov/dataViewer/view/timeseries/WPUIP231100;jsessionid=45F1A4D9DF7025DD0F42D9191F9E410B

Figure 5: US Average Hourly Earnings of All Private Sector Employees (Blue) and All Construction Sector Employees, 2013-2023



Source: U.S. Bureau of Labor Statistics, Average Hourly Earnings of All Employees; Average Hourly Earnings of All Employees, retrieved from FRED, Federal Reserve Bank of St. Louis [5]

Of all states, in 2022 Massachusetts had the fourth highest wage for workers in the Construction and Extraction sector, after Hawaii, New Jersey, and Alaska. In 2021 the average wage for those in the Construction and Extraction Sector was $71,290, according the U.S. Bureau of Labor Statistics.[6]

National changes in interest rates are contributing substantially to declining housing affordability over the past year. Figure 6 shows the dramatic rise of the average interest rate for a 30-year fixed-rate mortgage in the United States between January 2022 and January 2023.

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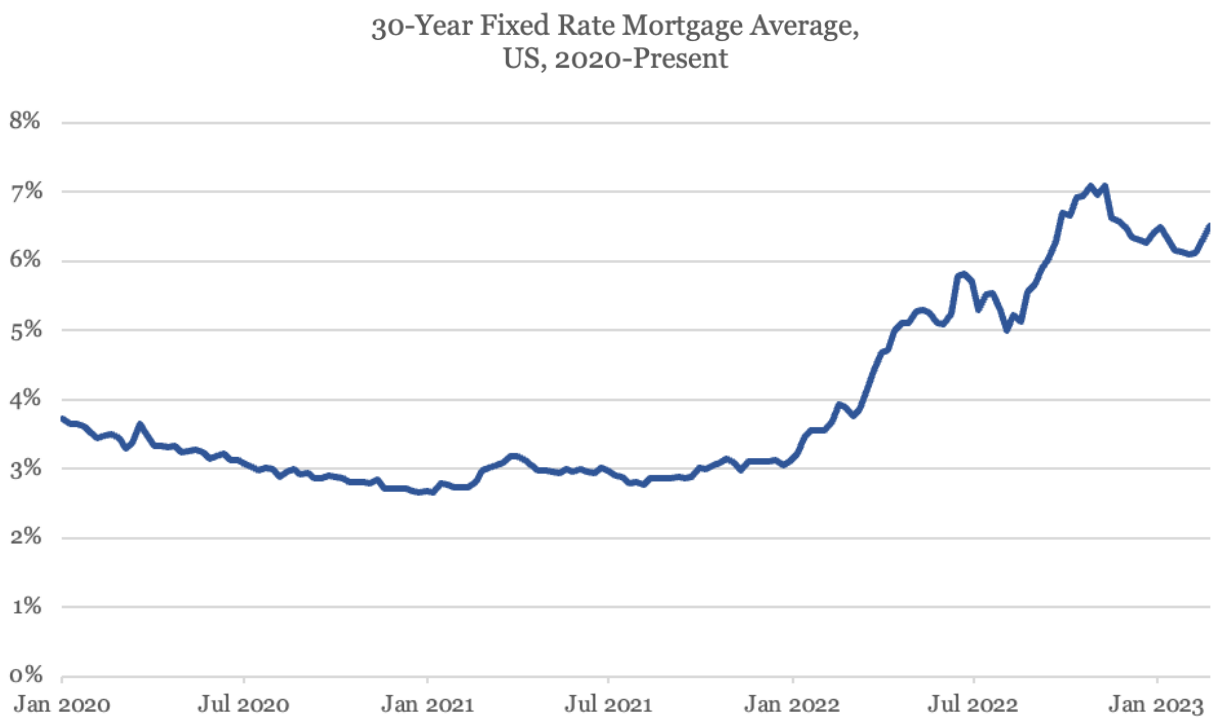
[5] Available at: https://data.bls.gov/timeseries/CES2000000003?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true; https://fred.stlouisfed.org/series/CES0500000003

[6] https://www.bls.gov/oes/current/oes470000.htm

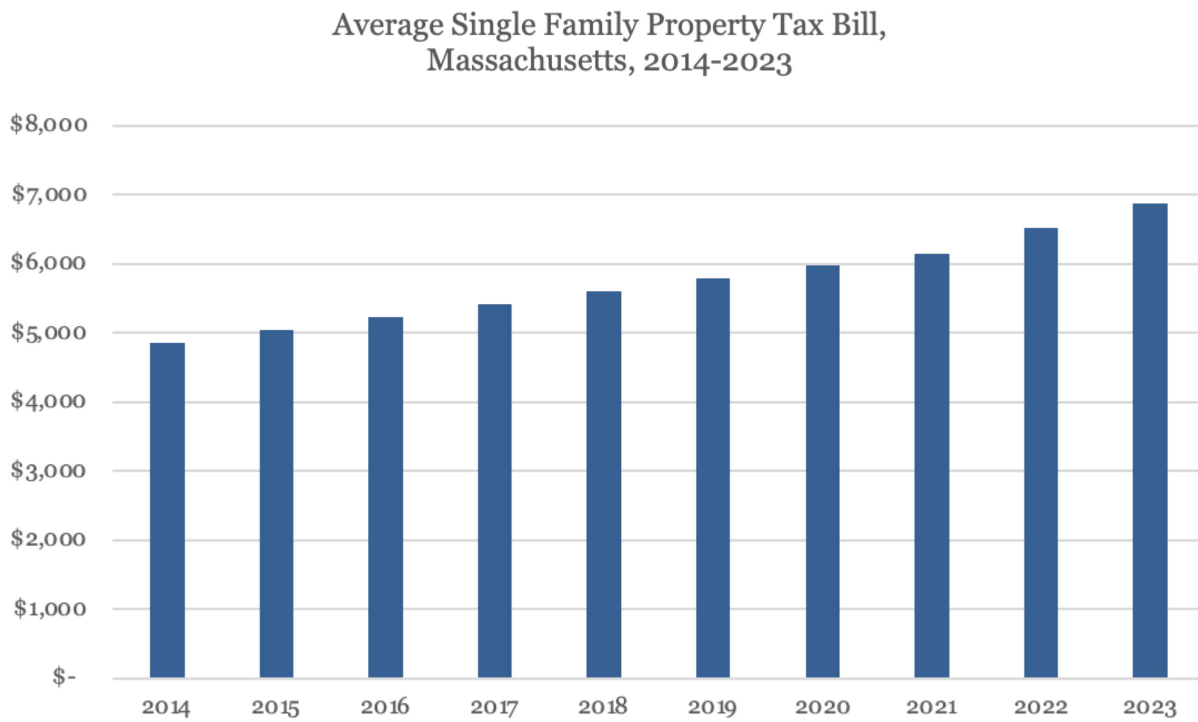
Figure 6: Average 30 Year Fixed Rate Mortgage Rate, January 2020 to January 2023



Source: Freddie Mac, 30-Year Fixed Rate Mortgage Average in the United States, retrieved from FRED, Federal Reserve Bank of St. Louis

As seen in Figure 7, average property tax payments in the state have also been increasing, largely because of increases in home values, contributing to rising housing cost burdens. According to the Massachusetts Department of Revenue, the average property tax bill for a single-family home in the state in fiscal year 2023 is $7,058.

Figure 7: Massachusetts Average Single-family Property Tax Bill



Source: Massachusetts Department of Revenue [7]

Combined with modest income growth in real terms and decreased purchasing power caused by rising interest rates, the increasing cost of construction creates rising housing expenditure shares, which are especially acute for the poor and working class and for wide sections of the middle class (Albouy, Ehrlich, and Liu 2016). Between 2020 and 2022, the price of the median single-family home in Massachusetts increased by 39 percent, from $440,000 to nearly $610,000.[8]

Utility costs are salient in these analyses as the burden of these costs are particularly challenging for low-income households with budget constraints when there are large fluctuations in energy pricing, as experienced with oil, gas, and electricity rates in recent years. Further, homes occupied by households with low incomes are disproportionately less energy-efficient compared to non-poor households, particularly in urban areas where the housing stock is older.

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[7] https://dlsgateway.dor.state.ma.us/reports/rdPage.aspx?rdReport=AverageSingleTaxBill.SingleFamTaxBill_wRange&rdRequestForwarding=Form

[8] https://www.thewarrengroup.com/wp-content/uploads/2022/07/MA-June-2022-Sales.pdf?utm_campaign=Public%20Relations&utm_medium=email&_hsmi=219953320&_hsenc=p2ANqtz--waTVvtcbQdpzET7PPQkvYkfh5CVlBBz9yK5bw_05WOEzv8lZ1gSqDFplEwsxwahxS7lSy3t6yaieW-F6b9c1TWM6i5A&utm_content=219953320&utm_source=hs_email

The affordability of housing is measured as the total cost of housing and associated services relative to a given household's income. For homeowners, the total cost of housing and related services includes principal and interest payments on the mortgage, property taxes, utilities, and insurance. For renters, it includes rent and utilities. The Department of Housing and Urban Development (HUD) characterizes a household spending more than 30 percent of its gross annual income on total housing costs as "housing cost burdened." In 2021, roughly 30 percent of all households in Massachusetts were housing cost burdened.

Each of these dimensions of housing costs—the cost of construction labor, construction materials, mortgage financing, property taxes, and utilities—are crucial to understanding how efforts to advance net-zero residential buildings in Massachusetts will affect housing affordability.

The effects of building code changes on housing affordability

Understanding the net effect of net-zero energy code changes on housing affordability requires understanding both the effects of enhanced energy efficiency requirements on (1) builders' construction costs and how such cost changes will be passed on to housing prices; and (2) their effects on homeowners' or tenants' utility costs. Examining these two dimensions together allows an understanding of how higher monthly mortgage or rent payments associated with increased home prices could be affected by any changes in monthly utility costs. On the one hand, a concern is that enhanced energy efficiency will increase the cost of construction, which would then translate into higher rents and mortgage payments, which will in turn push housing out of reach for some households. On the other hand, enhanced energy efficiency might reduce ongoing utility costs for homeowners and tenants, thus reducing the possible burden of higher rents and mortgage payments on some household budgets. To understand the net effect of the new standards on housing cost burdens, the projected effects on *increased* constructions costs must be compared to the projected effects on *decreased* utility payments. Do high energy efficiency standards actually increase construction costs, and if so, by how much? Do high efficiency standards reduce utility payments, and if so, by how much? In assessing the latter, it is important to note that there is substantial uncertainty about the net effect on utility payments of the combination of increased building envelope efficiency, presumably reducing energy needs, and electrification, for some households entailing a shift to a higher-cost energy source. Adding to this uncertainty are rapid fluctuations in the cost of electricity. According to data from the federal Energy Information Administration, the average residential cost per kWh for electricity in Massachusetts increased by 75 percent between 2010 and 2022, including a 12 percent increase from 2021 to 2022 alone.[9] These rapid changes in the price of electricity are further complicated by uncertainty about

[9] https://www.eia.gov/electricity/data/eia861m/xls/sales_revenue.xlsx

how quickly urgently needed new, renewable energy sources can be brought online and the effect of the growing shift to electrification on prices.

Scholarly work on the effects of building code changes on housing costs is relatively limited (see Listokin and Hattis, 2005 for a review). Building code changes can increase housing costs in a direct, substantive manner by raising construction standards in ways that increase the labor required or the cost of materials. Building code changes can also contribute to increased costs through administrative impediments, if the changes are associated with administrative delays, fees, or conflicts among administrative requirements.

While stringent building codes may add to construction costs and home prices, more energy-efficient code requirements can simultaneously help reduce energy use and residential utility costs. According to the Bureau of Labor Statistics 2021 Consumer Expenditure Survey, the average household spent more than $22,000 on housing each year, amounting to roughly 34 percent of their total annual expenses. The average household spent more than $2,100 annually on electricity, natural gas, and home heating oil, accounting for roughly 9 percent of average housing costs.[10] Data from the American Housing Survey indicates that the average household spends more than 3 percent of their total income on home energy costs (Drehobl et al. 2017). For low-income households, energy costs account for between 7 and 9 percent of total annual income (Drehobl et al. 2017).

Jacobsen and Kotchen (2013) used residential billing data for electricity and natural gas to analyze the effects of a change in Florida's energy code in 2002, comparing consumption across residences constructed just before and just after the change. They found that the code change caused a 4 percent decrease in electricity consumption and a 6 percent decrease in natural gas consumption. A follow up study in 2017 found that the benefits to electricity consumption had diminished, while benefits to gas consumption had increased, yielding a greater than 10% decline in gas consumption (Kotchen 2017). Recent studies using nationwide data on household electricity expenditures have found that occupants of homes built after the first energy codes were adopted spend less on electricity compared to homes built prior to the adoption of these early energy codes, with larger savings in states where energy codes are more stringent and more strictly enforced (Aroonruengsawat 2012; Holian 2020). These increases in energy efficiency and reductions in energy expenditures are in turn capitalized into home values, with studies finding increases in the market value of homes of roughly $20 for every $1 reduction in annual utility bills (Nevin and Watson 1998; Dinan and Miranowski 1989).

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[10] https://www.bls.gov/cex/tables/calendar-year/mean/cu-all-detail-2021.pdf

With these parameters in mind, we move to an analysis conducted by Payam Bakhshi, Ashin Poumokhtarian, and John Cribbs in the Construction Management Department at the Wentworth Institute of Technology (WIT) of the increased cost of net-zero construction under the proposed stretch energy code and subsequently to an analysis of their effects on affordability, followed by a discussion of potential policy tools to address both building energy efficiency and housing affordability.

3. Costs of Net Zero Construction

Methodology

To determine the current cost of net-zero housing construction across the state and its implications for affordability, the WIT principal investigators Payam Bakhshi, Afshin Pourmokhtarian, and John Cribbs, reviewed past studies of the cost premium of high-efficiency (e.g., Net-Zero and Passive House) residential buildings; conducted interviews with architects, engineers, and contractors; identified parameters and developed model houses; performed energy modeling and Manual J calculations to define specifications for the model houses; prepared quote sheets, obtained written prices from subcontractors, and performed cost estimates based on those quote sheets and RS Means data; and analyzed the collected data and calculated the cost implications.

Background

The WIT research sought to identify the incremental construction costs of moderate size new houses including (A) single-family houses, (B) small multi-family houses (2-4 units), across four Home Energy Rating Score (HERS) scenarios of (1) traditional home (HERS 55), (2) all electric, mini-split heat pumps (HERS 45), (3) all electric, central heat pump (HERS 45), and (4) dual fuel, furnace and ducted heat pumps (HERS 42) and (C) large multi-family (5+ units and >12,000 sf) houses considering (1) traditional home, and (2) Passive House standards. The cost study focused on examining the variation in costs (including labor and material) due to different specifications for heating and cooling equipment, water heaters, ventilation systems, insulation, air sealing, electrical wiring, and windows. To assess the existing practices and current experiences with building high performance/Energy-Efficient houses and the anticipated challenges with the new Specialized Opt-In code, the WIT team designed and conducted semi-structured interviews with fourteen experts involved with single-family and small multi-family houses and eleven experts involved with large multi-family houses. Appendices D and E provide the list of questions from the semi-structured interviews and Table 3 summarizes the Specialized Opt-In code requirements for residential buildings. Also, the synopsis and highlights of the relevant past cost implication studies are provided in Appendix C.

Table 3: Specialized Opt-In Code Requirements for Residential Buildings

Building Size	Fuel Type	Minimum Efficiency	Electrification	Minimum EV Wiring	Renewable Generation
Dwelling units up to 4,000 sf	All Electric	HERS 45 or Phius CORE or PHI	Full	1 parking space	Optional
Dwelling units up to 4,000 sf	Mixed- fuel	HERS 42 or Phius CORE or PHI	Pre-wiring	1 parking space	Solar Photovoltaics (PV) (Except shaded sites)
Dwelling units > 4,000 sf	All Electric	HERS 45 or Phius CORE or PHI	Full	1 parking space	Optional
Dwelling units > 4,000 sf	Mixed- fuel	HERS 0 or Phius ZERO	Pre-wiring	1 parking space	Solar Photovoltaics (PV) or other renewables
Multi-family >12,000 sf	All Electric	Phius CORE or PHI	Full	20% of spaces	Optional
Multi-family >12,000 sf	Mixed- fuel	Phius CORE or PHI	Pre-wiring	20% of spaces	Optional

Parameters and specifications for model houses

1) Single-family and Small Multi-family

The purpose of the WIT study was to determine the incremental cost of building at different efficiency levels on the affordability of houses. To this end, size of model homes for single-family and small multi-family (4-units) were determined after thorough literature review, analysis of existing and newly developed typical houses in Massachusetts, and input from Advisory Committee team members. The researchers wanted to select sizes for model homes that are common on the market. Ultimately, the model houses were built upon the analyzed data and professional opinions of the research team members in a way to best represent typical houses in terms of sizes, floor plans, number of floors, bedrooms, and bathrooms.

The single-family model home has two floors, a finished basement, and finished attic. Table 4 and Figure 8 present the detailed parameters and the 3D model of single-family model home, respectively.

Table 4: Parameters of single-family model home

Total Conditioned Area	**2,875 SF**	
Number of Floors	Basement+ 2 Floors+Attic	
Number of Bedrooms	3	
Number of Bathrooms	3.5	
Finished Basement (General Area, 1 Full Bath)	*540 SF*	*3 Windows, 18.0 SF*
Floor 1 (Kitchen, Living & Dining Rooms, 1/2 Bath)	*790 SF*	*8 Windows, 112.7 SF*
Floor 2 (3 Bedrooms, 2 Full Baths)	*1015 SF*	*12 Windows, 116.4 SF*
Finished Attic (General Area)	*530 SF*	*6 Windows, 45.8 SF*

Figure 8: 3D model of single-family model home

The small multi-family model home has 4 units in which the two exterior units (units 1 and 4) are identical and interior units (units 2 and 3) have little difference in their floor plans and square footage. Table 5 and Figure 9 present the detailed parameters and the 3D model of 4-unit multi-family model home, respectively.

Table 5: Parameters of 4-unit multi-family model home

	Unit 1		Unit 2		Unit 3		Unit 4	
Main Floor Living Conditioned Area	1,256 SF		1,115 SF		790 SF		1,256 SF	
Upper Floor Living Conditioned Area	896 SF		1,116 SF		1,044 SF		896 SF	
Total Conditioned Area	**2,152 SF**		**2,231 SF**		**1,834 SF**		**2,152 SF**	
Number of Floors	Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors	
Number of Bedrooms	3		3		3		3	
Number of Bathrooms	3.5		3.5		3.5		3.5	
No./Area of Windows (SF): Basement	0	0	0	0	0	0	0	0
No./Area of Windows (SF): Main Floor	14	110	9	122	3	47	14	110
No./Area of Windows (SF): Upper Floor	8	133	7	83	7	83	8	133
No./Area of Windows (SF): Total	22	243	16	205	10	130	22	243

Figure 9: 3D model of 4-unit multi-family model home

2) Energy Modeling

WIT performed a thorough energy modeling analysis using Ekotrope (RESNET-accredited RATER software) for single-family and all 4 units of small multi-family model homes. The analysis provided detailed specifications for each scenario of both model homes. Specifications were grouped into three categories: insulation and air sealing, mechanical equipment, and lighting and appliances. Table 6 shows the components of each category.

Table 6: Categories of energy modeling analysis

Insulation & Air Sealing	Mechanical Equipment	Lighting & Appliances
Slab	Heating Equipment	Lighting
Foundation Walls	Cooling Equipment	Refrigerator
Garage Ceiling	Water Heater	Dishwasher
Cantilevered Floor	Ducts	Washer
Blockers & Runners	Ventilation System	Dryer
Exterior Walls		
Flat Ceilings		
Cathedral Ceilings		
Windows & Glass Doors		
Air Barrier & Air Sealing Details		

3) Manual J Calculations

The energy modeling resulted in identifying the necessary efficiency levels for the heating and cooling equipment under each scenario and the required load capacity needed to be estimated separately. To this end, Manual J calculations were performed room by room for single-family and all 4 units of small multi-family model homes (total of 20). The Manual J calculation is a formula that identifies the HVAC capacity of a building and proper size for an HVAC unit. Steps for performing Manual J calculations are: (1) Measure the square footage of the building, (2) Evaluate the building's insulation, (3) Consider how the building uses its space, and (4) Determine the BTU of each element of the building.

4) Building Specs for the Model Homes

Following the Ekotrope energy modeling, Manual J calculations, and analysis of the models' outputs, the WIT team identified the key differences in constructing houses built to four different scenarios. Tables 7-10 provide the specifications for both single-family and small multi-family model homes under four selected scenarios.

Table 7: Specifications of single-family model home for four different scenarios

	Projected Rating Results			
	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation & Air Sealing				
Slab	Uninsulated	Uninsulated	R-10 at perimeter and under entire floor	R-10 at perimeter and under entire floor
Foundation Walls	R-10 fire rated foamboard	R-10 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard
Garage Ceiling	R-30 insulation	R-30 insulation	R-30 insulation + R-6 foamboard	R-30 insulation + R-6
Cantilevered Floor	R-30 insulation	R-30 insulation	R-30 insulation + R-6 foamboard	R-30 insulation + R-6
Blockers & Runners	R-21 insulation	R-21 insulation	R-21 insulation + R-9 sheathing	R-21 insulation + R-9 sheathing
Exterior Walls	R-21 insulation	R-20 Insulation + R-6 insulated sheathing	R-20 Insulation + R-9 insulated sheathing	R-21 fiberglass batts + R-9 insulated sheathing
Flat Ceilings	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)
Cathedral Ceilings	R-38 insulation	R-38 insulation	R-38 insulation + R-6 foamboard	R-49 sprayfoam
Windows & Glass Doors	U-Factor = .30	U-Factor = .28	U-Factor = .28	U-Factor = .28
Air Barrier & Air Sealing Details	Maximum blower door test of 3 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50
Mechanical Equipment				
Heating Equipment	54,000 Btuh, 95% AFUE Furnace W/ ECM	32,000 Btuh, 11 HSPF ASHP	33,000 Btuh, 9.5 HSPF ASHP	31,000 Btuh, 10.5 HSPF ASHP with 97% AFUE Propane Furnace Backup
Cooling Equipment	33,500 Btuh, 13.0 SEER Central AC	30,000 Btuh, 20.0 SEER ASHP	35,000 Btuh, 16.5 SEER ASHP	33,000 Btuh, 16.5 SEER ASHP
Water Heater	.95 UEF On-Demand	3.75 UEF Heat Pump water tank	3.75 UEF Heat Pump water tank	3.75 UEF Heat Pump water tank
Ventilation System	2 Continuous Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Lighting & Appliances				
Lighting	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs
Refrigerator	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dishwasher	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Washer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dryer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified

Table 8: Specifications of small multi-family model home for four different scenarios- exterior units (Units #1, 4)

	Projected Rating Results			
	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation & Air Sealing				
Slab	Uninsulated	Uninsulated	Uninsulated	R-10 foamboard at walkout section
Foundation Walls	R-10 fire rated foamboard	R-13 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard
Blockers & Runners	R-21 insulation	R-21 insulation	R-21 insulation	R-21 insulation
Exterior Walls	R-21 fiberglass batts	R-20 dense cellulose + R-6 insulated sheathing	R-20 dense cellulose + R-9 insulated sheathing	R-20 dense cellulose + R-9 insulated sheathing
1st Flat Ceiling	R-38 insulation	R-38 insulation	R-49 insulation	R-38 insulation
2nd Flat Ceilings	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 closed cell foam
Windows & Glass Doors	U-Factor = .30	U-Factor = .28	U-Factor = .28	U-Factor = .28
Air Barrier & Air Sealing Details	Maximum blower door test of 3 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50
Mechanical Equipment				
Heating Equipment	34,000 Btuh, 96% AFUE Furnace W/ ECM	4,500 Btuh, 11 HSPF	27,500 Btuh 10 HSPF	26,500 Btuh, 97% AFUE Furnace W/ ECM
Cooling Equipment	27,500 Btuh, 16 SEER Central AC	21,500 Btuh, 20 SEER ASHP	23,000 Btuh 20 SEER ASHP	22,500 Btuh, 17.5 SEER Central AC
Water Heater	.95 UEF On-Demand	3.5 UEF Heat Pump water tank	3.75 UEF Heat Pump water tank	3.75 UEF Heat Pump water tank
Ventilation System	2 Continuous Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Lighting & Appliances				
Lighting	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs
Refrigerator	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dishwasher	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Washer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dryer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified

Table 9: Specifications of small multi-family model home for four different scenarios- interior unit (Unit #2)

	Projected Rating Results			
	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation & Air Sealing				
Slab	Uninsulated	Uninsulated	R-10 at perimeter and under entire floor	R-15 at perimeter and under entire floor
Foundation Walls	R-10 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard
Garage Ceiling	R-30 insulation	R-38 fiberglass batts	R-38 fiberglass batts	R-42 closed cell foam
Cantilevered Floor	R-30 insulation	R-38 fiberglass batts	R-38 fiberglass batts	R-42 closed cell foam
Blockers & Runners	R-21 insulation	R-21 insulation	R-21 insulation	R-21 insulation
Exterior Walls	R-21 insulation	R-20 dense cellulose + R-6 insulated sheathing	R-20 dense cellulose + R-9 Insulated Sheating	R-20 dense cellulose + R-9 insulated sheating
1st Flat Ceilings	R-38 insulation	R-49 insulation	R-60 loose cellulose (16" deep)	R-60 sprayfoam
2nd Flat Ceilings	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 sprayfoam
Windows & Glass Doors	U-Factor = .30	U-Factor = .28	U-Factor = .28	U-Factor = .26
Air Barrier & Air Sealing Details	Maximum blower door test of 3 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50
Mechanical Equipment				
Heating Equipment	34,000 Btuh, 96% AFUE Furnace W/ ECM	25,000 Btuh, 11 HSPF	28,000 Btuh 10 HSPF	26,500 Btuh, 97% AFUE Furnace W/ ECM
Cooling Equipment	23,500 Btuh, 16 SEER Central AC	18,000 Btuh, 20 SEER ASHP	22,000 Btuh 20 SEER ASHP	22,000 Btuh, 17.5 SEER Central AC
Water Heater	.95 UEF On-Demand	Heat Pump water tank 3.5 UEF	Heat Pump water tank 3.75 UEF	Heat Pump water tank 3.75 UEF
Ventilation System	2 Continuous Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Lighting & Appliances				
Lighting	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs
Refrigerator	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dishwasher	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Washer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dryer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified

Table 10: Specifications of small multi-family model home for four different scenarios- interior unit (Unit #3)

	Projected Rating Results			
	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation & Air Sealing				
Slab	Uninsulated	Uninsulated	R-10 at perimeter and under entire floor	R-15 at perimeter and under entire floor
Foundation Walls	R-10 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard	R-15 fire rated foamboard
Garage Ceiling	R-30 insulation	R-38 fiberglass batts	R-38 fiberglass batts	R-42 closed cell foam
Cantilevered Floor	R-30 insulation	R-38 fiberglass batts	R-38 fiberglass batts	R-42 closed cell foam
Blockers & Runners	R-21 insulation	R-21 insulation	R-21 insulation	R-21 insulation
Exterior Walls	R-21 insulation	R-20 dense cellulose + R-6 insulated sheathing	R-20 dense cellulose + R-9 Insulated Sheating	R-20 dense cellulose + R-9 insulated sheating
1st Flat Ceilings	R-38 insulation	R-49 insulation	R-60 loose cellulose (16" deep)	R-60 sprayfoam
2nd Flat Ceilings	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 loose cellulose (16" deep)	R-60 sprayfoam
Windows & Glass Doors	U-Factor = .30	U-Factor = .28	U-Factor = .28	U-Factor = .26
Air Barrier & Air Sealing Details	Maximum blower door test of 3 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50	Maximum blower door test of 1.5 ACH50
Mechanical Equipment				
Heating Equipment	27,500 Btuh, 96% AFUE Furnace W/ ECM	20,500 Btuh, 11 HSPF	23,000 Btuh 10 HSPF	22,500 Btuh, 97% AFUE Furnace W/ ECM
Cooling Equipment	23,500 Btuh, 16 SEER Central AC	18,000 Btuh, 20 SEER ASHP	23,000 Btuh 20 SEER ASHP	23,000 Btuh, 17.5 SEER Central AC
Water Heater	.95 UEF On-Demand	Heat Pump water tank 3.5 UEF	Heat Pump water tank 3.75 UEF	Heat Pump water tank 3.75 UEF
Ventilation System	2 Continuous Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Lighting & Appliances				
Lighting	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs	100% LED Bulbs
Refrigerator	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dishwasher	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Washer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified
Dryer	Energy Star certified	Energy Star certified	Energy Star certified	Energy Star certified

5) Building Categories for Cost Deltas

To determine the cost deltas among scenarios of each model home, the WIT team identified the differing building elements between scenarios and organized them into the following categories:

- Insulation
- Air barrier/sealing
- Window
- Heating/cooling system
- Water heater
- Ventilation system
- Electrical
- Gas line

These categories are used in calculating and reporting in this study.

6) Subcontractors and Vendors Participation

To accurately calculate the cost deltas among scenarios of each model home, the WIT team involved the following trade contractors in Massachusetts to provide current and accurate market prices:

i. Insulation subcontractors for insulation and air barrier/sealing items
ii. HVAC subcontractors for heating/cooling system, water heater, ventilation system
iii. Electrical subcontractors for all electrical work

The team prepared a long list of contractors for each of these trades and invited them via phone calls and/or emails to participate in the study in three different ways:

i. Interview with the team
ii. Complete and return provided quote sheets
iii. Respond to designed surveys

Appendix F and Appendix G provide the standard email templates for contacting the trade contractors and inviting them to complete the quote sheets or respond to the quote surveys.

Since the energy modeling resulted in windows with different U-factors, the WIT team worked with multiple vendors, suppliers, and manufacturers to obtain quotes for each model home with specific U-factor (e.g., 0.30 or 0.26 for all windows) to make the comparison reasonable. The selection of windows brands was based on common brands available on the market.

The gas line was a small item in both model homes. Therefore, the cost deltas resulting from this item in both model homes were calculated using RS Means.

7) Quote Sheets and Surveys

To facilitate obtaining prices from trade contractors, the team developed quote sheets for each trade and both model homes using an Excel spreadsheet as well as quote surveys using Qualtrics. Appendix H provides a copy of the blank quote sheets.

8) Large Multi-family

The cost delta for the large multi-family project was estimated through studying builders' typical baseline costs versus costs required to meet Passive House standards. The WIT team reached out and invited companies involved with such projects to participate in a newly designed semi-structured interview. Details were collected and cost implications of large multi-family homes were determined after reviewing recently completed projects with Passive House standards.

<u>Collected data and calculated cost implications</u>

1) Data Collection and Analysis

As mentioned earlier, the WIT team invited insulation, HVAC, and electrical subcontractors active in Massachusetts to provide current and accurate prices for identified items in both single-family and multi-family model homes. The quote solicitation process was completed in three different ways: conducting interviews, completing quote sheets, and responding to quote surveys.

The WIT team directly contacted almost 700 trade contractors via phone and/or email to invite them to participate in this study. To expand the study's reach, the team requested Home Builders and Remodelers Association of Massachusetts (HBRAMA), its Net-Zero Committee, and the research Advisory Committee as well as the following professional association to contact their members/connections and encourage them to participate in the study:

- Air Conditioning Association of New England (ACA/NE)
- Boston Chapter of the National Electrical Contractors Association (NECA Boston)
- Builders and Remodelers Association of Greater Boston (BRAGB)
- Massachusetts Electrical Contractors Association (MECA)
- Plumbing, Heating, Cooling, Contractors of Massachusetts (PHCC)

The data collection campaigns collectively resulted in receiving 32 quotes for the single-family model home and 20 quotes for the small multi-family model home. Out of 32 quotes received for the single-family model, there were 10 quotes for insulation, 8 for HVAC, and 14 for electrical. Out of 20 quotes received for the small multi-family model, there were 7 quotes for insulation, 6 for HVAC, and 7 for electrical.

Before incorporating the collected data into the cost analysis, all data points were thoroughly examined to identify outliers and inconsistent data. To determine the cost deltas for scenarios for each model home, the data points were normalized with respect to the base scenario (HERS 55). The next section provides the results.

2) Cost Implication for Single-family Homes

For the single-family model home, the cost delta analysis was performed using the received quotes to generate cost estimates. Tables 11 and 12 provide the results in percentage and dollar value, respectively.

Table 11: Cost delta analysis for single-family model home (%)

	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation	0.0	19.2%	55.4%	61.4%
Air Barrier/Sealing	0.0	16.1%	16.1%	16.1%
Window	0.0	7.6%	7.6%	7.6%
Heating/Cooling System	0.0	-1.3%	11.1%	18.5%
Water Heater	0.0	-23.2%	-23.2%	-23.2%
Ventilation System	0.0	74.2%	74.2%	74.2%
Electrical	0.0	11.9%	7.0%	5.5%
Gas Line	0.0	-100.0%	-100.0%	0.0%

Notes:

(1) The cost estimates, except for the Gas Line, were provided by subcontractors operating in Massachusetts, and they were based on the specifications outlined in Table 7.

(2) These costs encompass both labor and materials, excluding contractor's markup.

Table 12: Cost delta analysis for single-family model home ($)

	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation	$0	$3,239	$9,342	$10,348
Air Barrier/Sealing	$0	$2,902	$2,902	$2,902
Window	$0	$1,791	$1,791	$1,791
Heating/Cooling System	$0	-$434	$3,635	$6,037
Water Heater	$0	-$1,724	-$1,724	-$1,724
Ventilation System	$0	$1,956	$1,956	$1,956
Electrical	$0	$4,395	$2,567	$2,033
Gas Line	$0	-$1,281	-$1,281	$0
Total	**$0**	**$10,846**	**$19,188**	**$23,343**

Notes:

(1) The cost estimates, except for the Gas Line, were provided by subcontractors operating in Massachusetts, and they were based on the specifications outlined in Table 7.

(2) These costs encompass both labor and materials, excluding contractor's markup.

3) Cost Implication for Small Multi-family Home

For the small multi-family model home, the cost delta analysis was performed with the received quotes to generate cost estimates. Tables 13 and 14 provide the results in percentage and dollar value, respectively.

Table 13: Cost delta analysis for small multi-family model home (%)

	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation	0.0	21.3%	39.8%	58.7%
Air Barrier/Sealing	0.0	9.9%	9.9%	9.9%
Window	0.0	9.1%	9.1%	9.1%
Heating/Cooling System	0.0	-10.0%	9.9%	10.5%
Water Heater	0.0	-20.4%	-20.4%	-20.4%
Ventilation System	0.0	70.9%	70.9%	70.9%
Electrical	0.0	10.3%	10.1%	8.0%
Gas Line	0.0	-100.0%	-100.0%	0.0%

Notes:

(1) The cost estimates, except for the Gas Line, were provided by subcontractors operating in Massachusetts, and they were based on the specifications outlined in Tables 8-10.

(2) These costs encompass both labor and materials, excluding contractor's markup.

Table 14: Cost delta analysis for small multi-family model home ($)

	HERS 55	HERS 45 All Electric (Ductless)	HERS 45 All Electric (Ducted)	HERS 42 Dual Fuel (Ducted)
Insulation	$0	$21,757	$40,538	$59,842
Air Barrier/Sealing	$0	$10,550	$10,550	$10,550
Window	$0	$3,102	$3,102	$3,102
Heating/Cooling System	$0	-$14,911	$14,733	$15,515
Water Heater	$0	-$6,082	-$6,082	-$6,082
Ventilation System	$0	$9,295	$9,295	$9,295
Electrical	$0	$16,471	$16,072	$12,814
Gas Line	$0	-$5,952	-$5,952	$0
Total	**$0**	**$34,230**	**$82,257**	**$105,036**

Notes:

(1) The cost estimates, except for the Gas Line, were provided by subcontractors operating in Massachusetts, and they were based on the specifications outlined in Tables 8-10.

(2) These costs encompass both labor and materials, excluding contractor's markup.

4) Cost Implication for Large Multi-family

PHIUS report indicated that Passive House rough general costs results in a premium increase of +2-4% or experienced Passive House contractors, and +5-10% for first time Passive House contractors. A study funded by the City of Boston, Department of Neighborhood Development, leveraged the actual cost data from Passive House projects and other similar efficient buildings in Boston compared to the current energy code in Boston. The studied projects had different numbers of units: 6, 14, 50, and 51. Focusing on projects with 50 and 51 units, the results indicated that the incremental cost on average was 1.56% with a range of 0.91% to 2.21%. The Massachusetts Clean Energy Center (MassCEC) collected cost data to determine incremental cost going from current energy code to PHIUS standards for eight low-income multi-family buildings. They reported incremental costs ranging between 1% and 4.3%.

The WIT team looked at the abovementioned 8 MassCEC projects along with 6 new projects, all large multi-family buildings with unit numbers ranging from 30 to 170. One of the projects (#12) was excluded from the analysis because it was a high-end condo with a 7.5% incremental cost. The cost delta analysis showed that, on average, there was a 2.4% increase in construction costs compared to conventional building (non-Passive House). Incremental cost represents the difference between Passive House requirements and the developer's standard of design, typically IECC 2015, with the Massachusetts Stretch Energy Code Overlay. Considering that the projects selected for this study were all under development or built by experienced contractors, the findings confirm the numbers reported by PHIUS (2-4%). The individual percentage increase for each project is provided in Table 15.

Table 15: Cost delta for large multi-family projects (Conventional vs. Passive House)

Project ID	Units	Gross sq. ft	Cost Delta
1	55	51,272	3.5%
2	53	55,538	4.3%
3	48	104,981	4.1%
4	98	111,450	1.4%
5	72	53,675	1.6%
6	30	33,186	1.8%
7	135	178,875	2.0%
8	50	45,031	1.0%
9	170	162,296	1.7%
10	44	49,476	3.1%
11	160	190,000	2.4%
12*	27	N/A	7.5%

4. The Impact of Massachusetts' Net-Zero Energy Code on Housing Affordability

Introduction

How does enhanced energy efficiency impact the affordability of housing? To answer this question, we start with U.S. Census data regarding disaggregated housing costs for current Massachusetts residents, across the state's income distribution. We then use the data from the Wentworth Institute of Technology team in Section 3 to estimate the percentage increase in construction costs to shift from HERS 55 to HERS 42 for different housing typologies and add that to the Census data above in order to estimate the increase in monthly mortgage costs or rent. Next, we use data on the effect of increased energy efficiency of homes in Massachusetts to estimate the effect of the new energy code on utility costs in order to estimate any decrease in monthly utility costs. Together these data enable us to estimate the rough effect of the new building code on housing affordability at different levels of the income distribution, focusing only on the affordability of newly built housing. As a threshold for housing affordability, we use the standard created by the U.S. Department of Housing and Urban Development and the U.S. Census Bureau of 30 percent of a household's gross income. We describe the approach and the findings in more detail below.

Initial analysis of only the increased costs of single-family home construction on housing affordability for all households in Massachusetts

Mathematically, housing affordability can be calculated as total housing costs divided by household income. We begin with household-level data from the most recent publicly available U.S. Census Bureau's American Community Survey Public Use Micro Data (ACS PUMS) five-year sample, looking at household incomes for all households in Massachusetts. Using the NAHB's 2022 median value of a newly constructed single-family home in Massachusetts of $608,827, we estimate monthly housing costs for a household purchasing that median new home (NAHB 2022). Estimating a 10 percent down payment leads to an initial mortgage of $547,944. According to data from the Federal Reserve Bank of St. Louis, the average interest rate for a 30-year fixed-rate mortgage in the United States in 2022 was 5.34 percent.[11] At this interest rate, a self-amortizing 30-year fixed-rate mortgage would have monthly principal and interest payments of approximately $3,056. The average single-family property tax rate across all municipalities in Massachusetts in 2022, weighted by the number of single-family homes in each municipality, was 1.47

[11] Average from data at Federal Reserve Bank of St. Louis, Economic Research Division, 30-Year Fixed Rate Mortgage Average in the United States, Percent, Weekly, Not Seasonally Adjusted. Available at: https://fred.stlouisfed.org.

percent.[12] For the median new single-family home, that would be a monthly property tax bill of $745.81. The most recent publicly available data for insurance premiums in Massachusetts identifies an average homeowner's insurance premium of $1,699, when the median value of all homes in the state was $398,800, suggesting a rate of .00426.[13] That rate applied to the 2022 median home value results in a $2,593.97 annual premium or $216.6 monthly payment. Together, these costs add up to a monthly total of $4,018. To pay these housing costs without spending more than 30 percent of their income would require a total annual gross household income of at least $160,700. Only approximately 16 percent of households in Massachusetts could afford to buy a median-priced, new single-family home at this cost, recognizing that 62 percent of Massachusetts households are already homeowners (possible because they bought lower-cost new or existing homes, secured lower interest rates common in previous years, made larger down-payments, or are paying more than 30 percent of their income to housing costs).

Adding the WIT estimated $10,846 cost to build a HERS 45 all electric ductless home compliant with the new specialized stretch code would reduce the share of Massachusetts households able to afford this home by about one half of one percentage point, or roughly 15,000 households. Adding the WIT estimated $19,188 cost to build a HERS 45 all electric ducted home compliant with the new specialized stretch code would reduce the share of Massachusetts households able to afford this home by just less than one percentage point, or approximately 27,000 households relative to the 2022 baseline. Adding the WIT estimated $23,343 cost to build a HERS 42 dual fuel home compliant with the new specialized stretch code would reduce the share of Massachusetts households able to afford this home by slightly more than one percentage point, or roughly 33,000 households.

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[12] Data on property tax rates is available from the Massachusetts Department of Revenue at https://dlsgateway.dor.state.ma.us/reports/rdPage.aspx?rdReport=AverageSingleTaxBill.SingleFamTaxBill_wRange.

[13] Average value from Massachusetts Division of Insurance. Available at: https://www.mass.gov/doc/the-2020-massachusetts-market-for-home-insurance/download.

Table 16: Estimate of the Increased Costs of Opt-In Specialized Stretch Code Compliance for Single-family Home Construction on Housing Affordability for All Households in Massachusetts

	ACS PUMS SAMPLE	HERS 45 ALL ELECTRIC (DUCTLESS) + $10,846	HERS 45 ALL ELECTRIC (DUCTED) + $19,188	HERS 42 DUAL FUEL (DUCTED) + $23,343
Total number of households	2,861,895	2,861,895	2,861,895	2,861,895
Number of households with housing costs below 30% of income	445,009	429,754	417,936	412,367
Number of households with housing costs above 30% of income	2,137,738	2,152,994	2,164,811	2,170,380
Share of households with housing costs below 30% of income	15.55%	15.02%	14.60%	14.41%
Share of households with housing costs above 30% of income	74.7%	75.2%	75.6%	75.8%
Median home value	608,827	619,673	628,015	632,170
Mortgage	547,944	557,706	565,214	568,953
Monthly mortgage costs	3,056	3,111	3,153	3,174
Monthly median taxes	745.8	759.1	769.3	774.4
Monthly median insurance	216.1	220.0	222.9	224.4
Monthly total housing costs	4,018	4,090	4,145	4,172

As Table 16 indicates, the increased costs of construction compliant with the specialized opt-in stretch code would be likely to push ownership of a newly built single-family home out of reach for between one-half and one percent of households in the Commonwealth, before taking into account any energy cost or other savings or available subsidies. A more detailed analysis could account for possible changes in household energy costs associated with the new energy code and focus in on the actual costs of current homeowners and renters in newly built homes in Massachusetts to estimate the effects more precisely, as explored below.

Analysis of housing costs for homeowners and renters in recently built housing in Massachusetts

Most research about housing affordability sensibly looks at the experiences of either all homeowners or all renters. The new energy efficiency requirements in Massachusetts that are the focus of this research, however, apply only to newly built housing. Newer homes generally cost more and are more energy-efficient than older ones and have higher-income owners or renters relative to older homes. To understand the experiences of homeowners and renters in homes built recently we look at the incomes and housing costs of owners and renters of homes built in Massachusetts since 2010.

Among other questions, the American Community Survey asks respondents about their income, the type of housing they live in, when it was built, when they moved in, the amenities it includes, the fuel used for heating, the cost of electricity, gas, oil, water and sewer, monthly rent or mortgage payments, condominium fees if applicable, real estate taxes, and home insurance.[14] Given our focus on new construction, we focus on those households living in homes that were built after 2010. We limit the analysis to homeowners with a mortgage and with a positive household income. Using these household level data from the weighted sample of all respondents in Massachusetts, we calculate energy costs (electricity, gas, and fuel oil) mortgage payments, real estate taxes, insurance payments, water and sewer payments, and condominium fees as a share of income, by household.[15] The estimates below of the effects of the new specialized stretch energy code take the actual incomes and housing costs of households in Massachusetts who are owners or renters of homes built since 2010 and adjust their housing costs in line with the WIT estimates of increased construction costs and the Resnet HERS estimates of decreased energy costs.

To have a sample size sufficiently large for analysis from the American Community Survey Public Use Microdata Samples, we look at the experiences of owner occupants in their most common building typology, single-family homes, and the experiences of renters in their most common building typology, multi-family buildings with more than 4 units. For the purposes of this study on the impact of the new specialized stretch energy code on the affordability of the newly built housing to which it applies, we focus only on homes built since 2010, although in reality households more commonly purchase existing, older housing that is resold.

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[14] https://www2.census.gov/programs-surveys/acs/methodology/questionnaires/2023/quest23.pdf

[15] We removed values 3 standard deviations above or below the mean for these two new variables (the 0.3% of data at the extremes).

The descriptive statistics in Table 17 are from a representative sample of 5,344 owner occupants of single-family homes built since 2010 surveyed by the U.S. Census Bureau. The data indicate that the median owner-occupant of a single-family home built in Massachusetts between 2010 and 2021 pays $3,076 in monthly housing costs, including $2,464 in first and second mortgage payments and $340 per month in real estate taxes and insurance. The most common heating source in these newly built homes was gas provided by a utility company, with median gas bills costing $87 per month and median electric bills $139 per month. For the median owner of these newly built homes, housing costs added up to 24 percent of their total pre-tax income. However, the cost of housing varied widely across the income spectrum. For those households in the bottom quintile of homeowner's incomes (for homeowners of homes built since 2010 with mortgages and positive income) housing costs on average were 56 percent of total gross income; for those in the second quintile they were 35 percent of total income. For those in the third and fourth income quintiles, housing costs were 26 and 22 percent of total income, respectively, while for those in the highest income quintile, housing costs were only 15 percent of total income.

Table 17: Descriptive statistics of expenses of homeowner costs for new homes constructed in Massachusetts from 2010 to 2021, by income quintile, from the ACS PUMS

UNIT	HOMEOWNERS - NEW CONSTRUCTION (BUILT AFTER 2010)	Median	Median when row variable>0	Mean 0-20% income	Mean 20-40% income	Mean 40-60% income	Mean 60-80% income	Mean 80-100% income
Annual	Household income	154,215	154,215	55,761	108,651	155,379	223,152	443,297
Monthly	Household income	12,851	12,851	4,647	9,054	12,948	18,596	36,941
	Self-reported home value	514,000	514,000	427,687	529,413	574,472	743,334	1,054,853
Monthly	Mortgage costs	2,199	2,199	1,579	1,931	2,272	2,771	3,631
Monthly	Second mortgage	265	265	290	414	297	383	596
Monthly	Real estate taxes	253	257	238	286	355	431	549
Monthly	Home insurance payments	87	90	85	99	99	102	144
Monthly	Electric bill	139	139	138	154	143	168	193
Monthly	Gas bill	91	98	105	120	117	124	144
Monthly	Oil bill	0	133	39	34	36	51	36
Monthly	Water and sewer bill	42	46	44	45	45	57	82
Monthly	Condo fee	0	292	73	52	50	73	53
	Distribution of heating source	-	-	55.2 Utility gas	55.6 Utility gas	55.1 Utility gas	63.3 Utility gas	67.0 Utility gas
Monthly	Housing costs as share of income	23.9%	-	55.8%	34.6%	26.4%	22.4%	14.7%

The descriptive statistics in Table 18 come from a representative sample of 5,135 renter occupants of homes in multi-family buildings with more than four units built in 2010 or after and surveyed by the U.S. Census Bureau. These data indicate that the median renter in a home in a multi-family building with more than 4 units built in Massachusetts between 2010 and 2021 paid $1,875 in monthly housing costs, including $1,796 in rent. The most common heating source in these newly built multi-family homes was gas provided by a utility company, with median gas bills costing $15 per month, followed by electricity, with median electric bills costing $61 per month. For the median renter in these newly built multi-family buildings, housing costs added up to about 35 percent of their total pre-tax income. The affordability of rental housing varied widely across the income spectrum however. For those households in the bottom two quintiles of homeowner's incomes (for households with positive incomes) housing costs on average were 55 percent or more of total gross income. For those in the third and fourth income quintiles, housing costs were 34 and 25 percent of total income, respectively, while for those in the highest income quintile, housing costs were only 13 percent of total income.

Table 18: Descriptive statistics of expenses of renter costs for new homes with more than 4 units constructed in Massachusetts from 2010 to 2021, by income quintile, from the ACS PUMS

UNIT	RENTERS - NEW CONSTRUCTION (BUILT AFTER 2010)	Median	Median when row variable>0	Mean 0-20% income	Mean 20-40% income	Mean 40-60% income	Mean 60-80% income	Mean 80-100% income
Annual	Household Income	63,913	63,913	11,379	32,081	64,692	115,811	254,652
Monthly	Household Income	5,326	5,326	948	2,673	5,391	9,651	21,221
Monthly	Rent	1,796	1,796	1,042	1,356	1,725	2,253	2,691
Monthly	Electric bill	61	67	61	75	77	91	92
Monthly	Gas bill	15	31	24	29	26	40	40
Monthly	Oil bill	0	32	1	1	1	1	1
Monthly	Water and sewer bill	3	24	10	10	18	20	18
	Distribution of heating source	-	-	51.8 Electricity	49.2 Utility gas	48.5 Utility gas	50.7 Utility gas	50.8 Utility gas
Monthly	Housing costs as share of income	35.2%	-	120.0%	55.0%	34.3%	24.9%	13.4%

Estimated effects of the new energy code on energy costs

The Residential Energy Services Network (RESNET) provided data on all homes rated with a HERS Index Score from 2010 to 2022 in the State of Massachusetts. RESNET is a not-for-profit organization founded by the National Association of State Energy Officials and Energy Rated Homes of America to develop a national market for home energy rating systems and energy-efficient mortgages. Its mission is "to make the energy use of all homes transparent, thereby driving residential sector energy use toward net zero."[16] RESNET created and maintains the HERS Index to allow for easy comparison of home energy performance. When a HERS rater evaluates a home, a home energy rater analyzes the home's construction plans and uses an energy efficiency software package to perform an energy analysis of the home's design. The rater then conducts an onsite inspection, typically including a blower door test (to test how tightly insulated and sealed the house is) and a duct test (to test the leakiness of the ducts). Results of these tests, along with inputs derived from the plan review, are used to generate the amount of energy used by the house and the HERS Index score for the home. A home built to 2006 energy efficiency standards (reference home) scores 100 on the HERS Index. The lower the HERS Index number, the more energy-efficient the home is. For instance, a home with a HERS Index Score of 70 is 30% more energy-efficient than a reference home, and a home with a HERS Index Score of 0 means that the home produces as much energy through renewable resources, such as solar panels, as it consumes.

The RESNET data that we use thus has an individualized estimate of each home's energy use and energy costs. We limited our analysis of the RESNET data to newly built homes constructed after 2010 and excluded homes with HERS scores more than 4 standard deviations above or below the mean. Using data obtained from RESNET representing all homes in Massachusetts with HERS ratings, we calculated estimated utility costs for all housing in Massachusetts with HERS scores. We then used these RESNET data to estimate the changes in utility costs as homes move from the current stretch code standard of HERS 55 to the opt-in specialized stretch code standard of HERS 45 or HERS 42. To estimate these effects, we use the following linear regression model:

$$\text{Total Energy Cost}_i = \text{constant} + \text{HERS Index}_i + \text{locational and building characteristics}$$

for 3 different sub-samples (single-family homes, duplex homes, and low-rise multi-family homes), where Total Energy Cost is the sum for annual heating, cooling and electricity costs in USD per square feet and the HERS Index that indicates the HERS score of the property. It is important to be clear that these calculations are not based on actual energy costs but on the HERS raters individualized assessment of the

[16] https://www.resnet.us/about/us/

home's energy efficiency and estimate of expected energy costs. As seen in Table 19, analysis of the RESNET data estimates suggests decreases in estimated utility costs for all housing typologies. Indeed, as a percentage change, the percentage decrease in utility costs (a greater than 20 percent decrease for a single-family home moving from HERS 55 to HERS 42) surpassed the 3.8 percent increase in construction costs to make that shift.

Table 19: Estimated Change in Combined Heating, Cooling, and Electricity Costs per square foot Associated with Decreasing HERS Scores, from all Massachusetts Homes with RESNET HERS Scores

	HERS=55 (USD per sqf)	HERS=42 (USD per sqf)	% change from HERS 55 to HERS 42
Single-Family	1.0263	0.8131	**-20.8%**
Duplex	0.96674	0.74574	**-22.9%**
Multi-Family	1.155	1.1121	**-3.7%**

Estimated net effects of increased construction and decreased utility costs for single-family homeowners

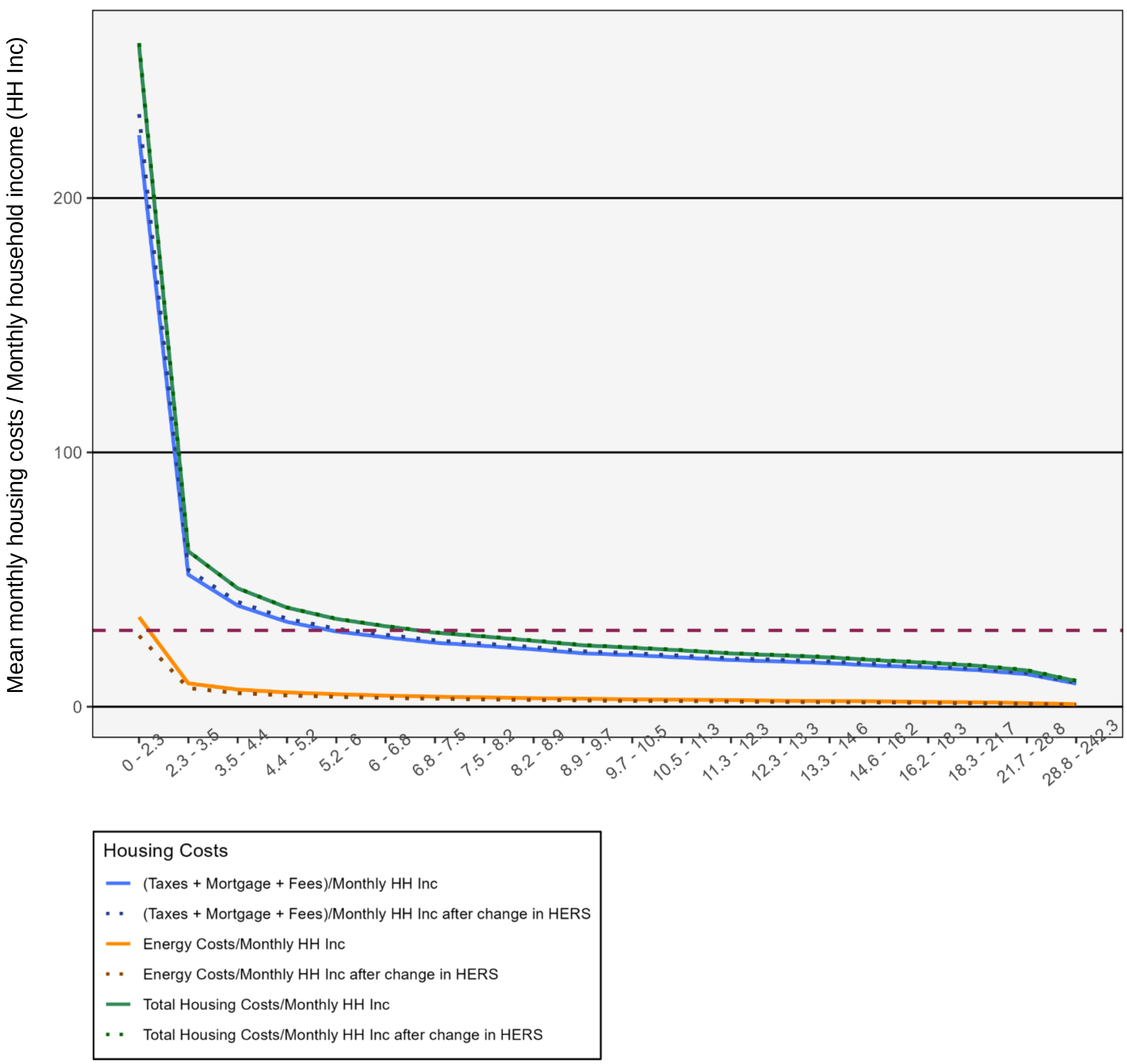
Energy costs represent, on average, roughly 7 percent of the monthly housing costs for homeowners in this sample. Applying the 20.8 decrease in monthly energy costs associated with a decline in HERS scores from HERS 55 to HERS 42 for a single-family home to the average energy costs of single-family homeowners in homes built since 2010 in Massachusetts suggests a $48 monthly energy cost savings. The increased cost of moving to a HERS 42 home as estimated by the WIT team are $23,343. It would take about 43 years for this increased cost to be paid back directly in the estimated energy cost savings. These increased costs for new home buyers also increase mortgage costs, and the increased home value also contributes to proportionate increases in property taxes and some increase in insurance costs. Together the increased monthly costs of the improvements exceed the estimated energy costs saved, for all income quintiles, as seen in Table 20.

Table 20: Estimate of effects of new building code on expenses of homeowners of single-family homes built since 2010 in Massachusetts, by income quartile

UNIT	HOMEOWNERS - SINGLE-FAMILY NEW CONSTRUCTION (BUILT AFTER 2010)	Median	Median when row variable>0	Mean 0-20% income	Mean 20-40% income	Mean 40-60% income	Mean 60-80% income	Mean 80-100% income
Annual	Household income	154,215	154,215	55,761	108,651	155,379	223,152	443,297
Monthly	Household income	12,851	12,851.2	4,647	9,054	12,948	18,596	36,941
Monthly	Housing costs	3,076	3,519	2,591	3,135	3,414	4,160	5,428
Monthly	Estimated additional mortgage costs	94	94	72	90	98	121	162
Monthly	Estimated additional taxes + insurance costs	13	13	12	15	17	20	27
Monthly	Estimated reduced utility costs	48	77	59	64	62	71	78
Monthly	Estimated new total housing costs	3,136	3,550	2,616	3,175	3,468	4,230	5,539
Monthly	Estimated new housing costs as share of income	24.4%	27.6%	56.3%	35.1%	26.8%	22.7%	15.0%

Figure 10 illustrates the two components of housing costs we examine, plus the total housing costs, before and after the specialized stretch energy code. It includes separate lines for (1) taxes, insurance, mortgage payments, and fees such as water, and condominium fees; and for (2) energy costs (electricity, gas, and fuel). It includes a third line for the total housing costs, obtained by summing these two categories. All monetary variables were adjusted to 2019 constant dollars using the adjustment factor provided by the ACS PUMS data.

Figure 10: Changes in Housing Costs for Owner-Occupants of New Single-family Homes in Massachusetts Associated with a Change in HERS Score from 55 to 42, based on 2015-2019 American Community Survey IPUMS Data and RESNET HERS Score Data



In Figure 11, the costs after the implementation of the specialized stretch energy code are represented by the dotted line and are based on (1) the WIT research, applying the respective percentage increase for each housing typology to the taxes, insurance, and mortgage payments; and (2) the RESNET regression above, applying the respective percentage decrease to the energy costs.

Figure 11: Changes in Housing Cost Burden for Owner-Occupants of New Single-family Homes in Massachusetts Associated with a Change in HERS Score from 55 to 42, based on 2015-2019 American Community Survey IPUMS Data and RESNET HERS Score Data

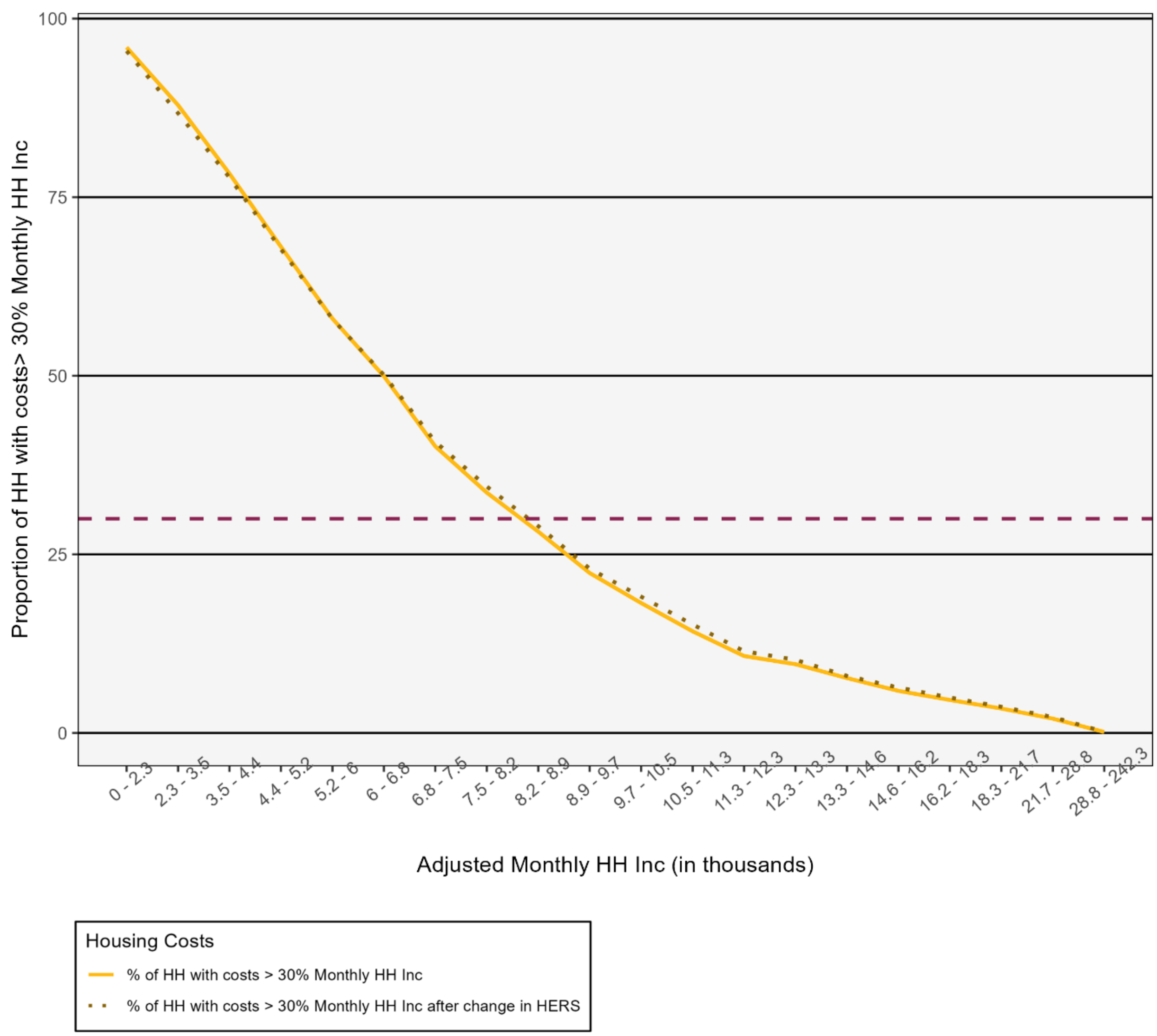


Figure 11 suggests that even though improvements in building energy efficiency are associated with substantial declines in utility costs (estimated at 20.8%) and building energy efficiency improvements can be obtained with roughly 3.8 percent increases in construction costs, utility savings are outpaced by increases in construction costs, especially when those costs are added to the mortgage. In short, building the more energy-efficient homes that the Commonwealth needs will have adverse effects on affordability for low- and especially moderate-income households in Massachusetts. Without policy intervention, these increases in housing costs will push homeownership further out of reach for moderate income households. As seen in Table 20, for those households making between roughly $80,000 and $130,000 it will increase the share of those households unable to afford a home from 41 percent to 47 percent, while for those making between roughly $130,000 and $190,000 it will increase the share unable to afford a home from 19 percent to 22 percent.

It is possible, however, that not all increased construction costs will be passed on to consumers. To consider this possibility, we conducted a sensitivity analysis at different levels of cost increase and different shares of that cost increase passed on to homeowners across all income levels, as seen in Table 20. In the blank cells of the table there is not a significant adverse price effect.

Given the estimate of incremental construction cost due to increased building energy efficiency, the next question is to what extent this incremental cost will be passed through to housing price. In competitive markets, when the cost of producing a product goes up, there is also generally an increase in price and a decrease in production, with some of the cost increase borne by producers through decreased profits and some by consumers in increased prices. Competition in housing production and consumption is heavily shaped by local land use regulations, in addition to local building regulations as well as other factors. We understand that housing price is composed of housing production cost (land cost plus construction cost) and builder's profit. If we assume that the land cost is independent of the incremental construction cost, the empirical question then becomes, how much of the incremental construction cost will be absorbed by the builder's profit (leading to a decline in profit) and how much will be passed through as a price increase. The basic housing supply and demand model shows that this split is partially a function of local housing market conditions, particularly the relative magnitudes of supply and demand elasticities of housing demand with respect to price. Intuitively, holding demand elasticity constant, in a market with very inelastic supply (very hard to build due to geographic constraints or strict zoning), it is easier for the incremental cost to be passed on to end-users (homebuyers and tenants) but the new construction growth will be slower, and vice versa. On the other hand, holding supply elasticity constant, in a market with very inelastic demand (very attractive locations with job, amenity opportunities, and little land use flexibility), it is also easier for the incremental cost to be passed on to homebuyers and tenants. In this sense, we expect that in most towns in Massachusetts, this pass-through rate will be quite high, which means that the majority of the incremental construction cost will translate into higher housing prices and rents and slower new construction growth, both of which hurt affordability.

Due to data constraints, we are unable to obtain the exact magnitudes of supply and demand elasticities in Massachusetts towns. Therefore, we have conducted a "sensitivity analysis" to allow this pass-through rate to vary. In the meantime, we also understand that our incremental construction cost estimate has a range instead of a constant number, so we add this dimension into our sensitivity analysis. In this way, we can have a 2-dimensional sensitivity analysis tool, to illustrate at different points in the ranges of incremental construction cost and pass-through rate, to what extent this incremental cost increase will be reflected in the housing price increase. Here we only report the positive estimates because it is very unlikely that the overall price effect will be negative.

Table 21: Sensitivity analysis of the estimate of effects of new building code on expenses of homeowners of single-family homes built since 2010 in Massachusetts

Change in % Households > 30% Monthly household income after change in HERS

Construction Cost	**Pass-Through Rate: % Passed on to Homeowners**										
% Increase	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
1.00%											
2.00%											
3.00%											
3.50%											
3.73%											**0.00%**
3.83%											**0.02%**
4.00%											0.07%
5.00%									0.07%	0.18%	0.29%
6.00%								0.12%	0.25%	0.38%	0.52%
7.50%						0.00%	0.18%	0.34%	0.52%	0.69%	0.84%

The sensitivity analysis in Table 21 suggests that if the increase in construction cost is 3.83 percent and all of that cost is passed on to consumers, roughly 0.02 percent of all the households. The actual number of households who currently own single-family homes in Massachusetts that were built since 2010 who would be unable to purchase a new single family home compliant with the specialized stretch energy is sensitive, as the table shows, to variation in the extent of the construction cost increase and in the share of that increase that is passed on to home purchasers.

Estimated net effects of increased construction and decreased utility costs for renters

Energy costs represent a slightly lower share of housing costs for renters than for homeowners in the sample, but the fluctuation in energy costs can create challenges for household budgets, especially for renters with low-incomes. Because multi-family buildings are already more energy-efficient, on average, than single-family homes, the estimated energy cost savings for renters in multi-family buildings associated with a shift to HERS 42 are lower than the savings for single-family homeowners. Applying the 3.7 percent decrease in monthly energy costs associated with a decline in HERS scores from HERS 55 to HERS 42 for multi-family homes to the average energy costs of multi-family renters in homes built since 2010 in Massachusetts suggests a roughly $1 monthly energy cost savings. At that level of energy cost savings, the increase in construction costs, if all were passed on to renters, outpace cost savings as seen in Table 22, Figure 12, and Table 23. As seen in Table 22, the passage of all of the estimated 2.4 percent increase in construction costs to renters would result in roughly 2.17 percent of current renter households in comparable buildings not being able to afford those new units (blank cells in Table 23 have no significant adverse price effects).

Table 22: Estimate of effects of new building code on renter expenses in buildings >4 units in Massachusetts, by income quartile

UNIT	RENTERS - >4 UNITS NEW CONSTRUCTION (BUILT AFTER 2010)	Median	Median when row variable>0	Mean 0-20% income	Mean 20-40% income	Mean 40-60% income	Mean 60-80% income	Mean 80-100% income
Annual	Household income	63,913	63,912.6	11,379	32,081	64,692	115,811	254,652
Monthly	Household income	5,326	5,326.0	948	2,673	5,391	9,651	21,221
Monthly	Housing costs	1,875	1,950	1,138	1,471	1,847	2,405	2,842
Monthly	Estimated additional rent	43	43	25	33	41	54	65
Monthly	Estimated reduced utility costs	1	1	1	1	1	1	1
Monthly	Estimated new total housing costs	1,918	1,992	1,162	1,503	1,888	2,458	2,906
Monthly	Estimated new housing costs as share of income	36.0%	37.4%	122.6%	56.2%	35.0%	25.5%	13.7%

In Figure 12, we show the share of household income that is paid toward housing costs by renters in large multi-family buildings built between 2010 and 2019 at various income levels in Massachusetts for the 2015-2019 period. The orange solid line shows rent and the blue solid line shows energy costs. The green solid line is the total cost computed as the sum of these two. The dotted lines display the same variables after the decrease in the HERS score from 55 to 42.

Figure 12: Changes in Housing Costs for Renters in Massachusetts Associated with a Change in HERS Score from 55 to 42, based on 2015-2019 American Community Survey IPUMS Data and RESNET HERS Score Data

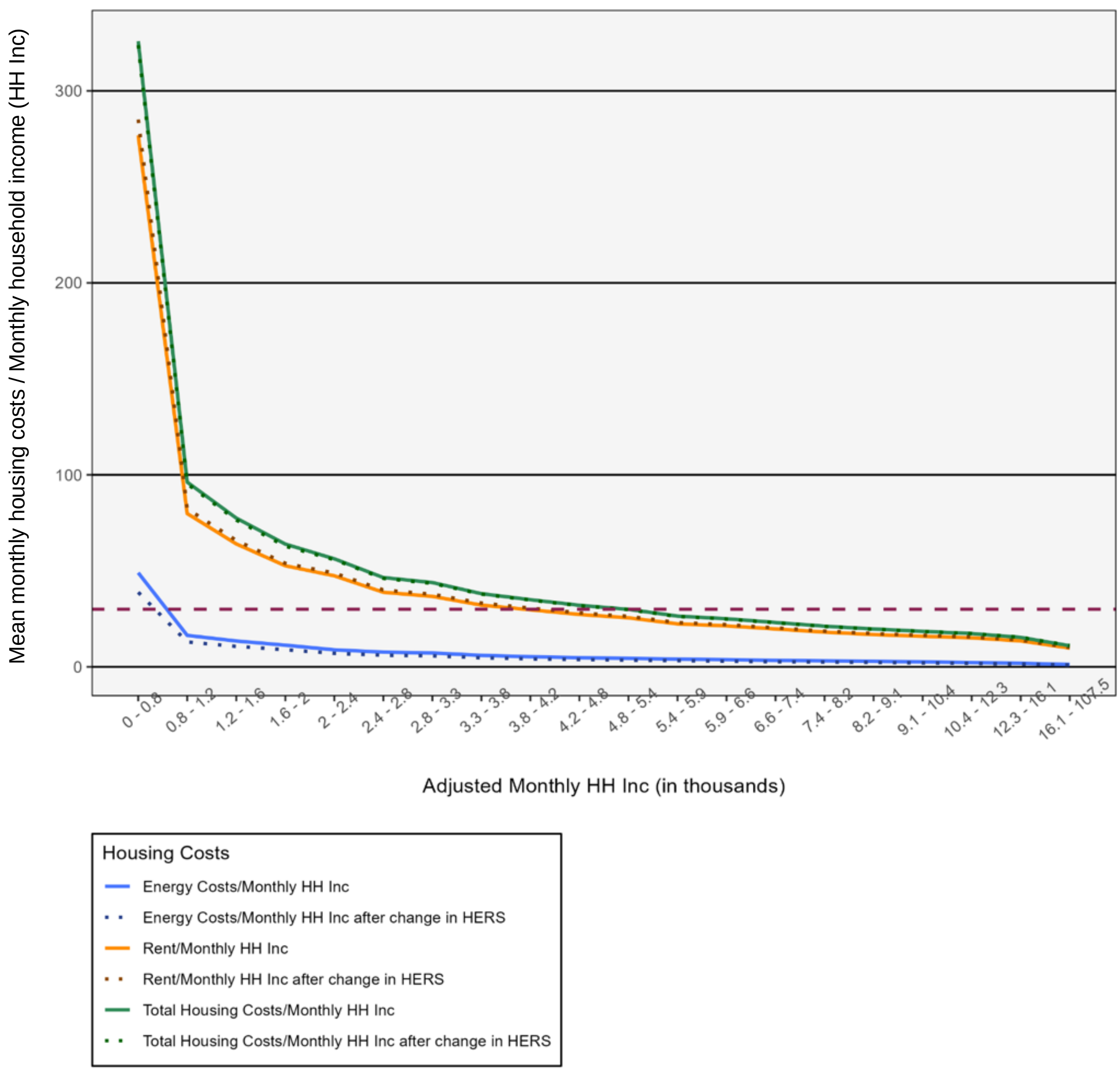


Figure 13: Changes in Housing Costs for Renters in Massachusetts Associated with a Change in HERS Score from 55 to 42, based on 2015-2019 American Community Survey IPUMS Data and RESNET HERS Score Data

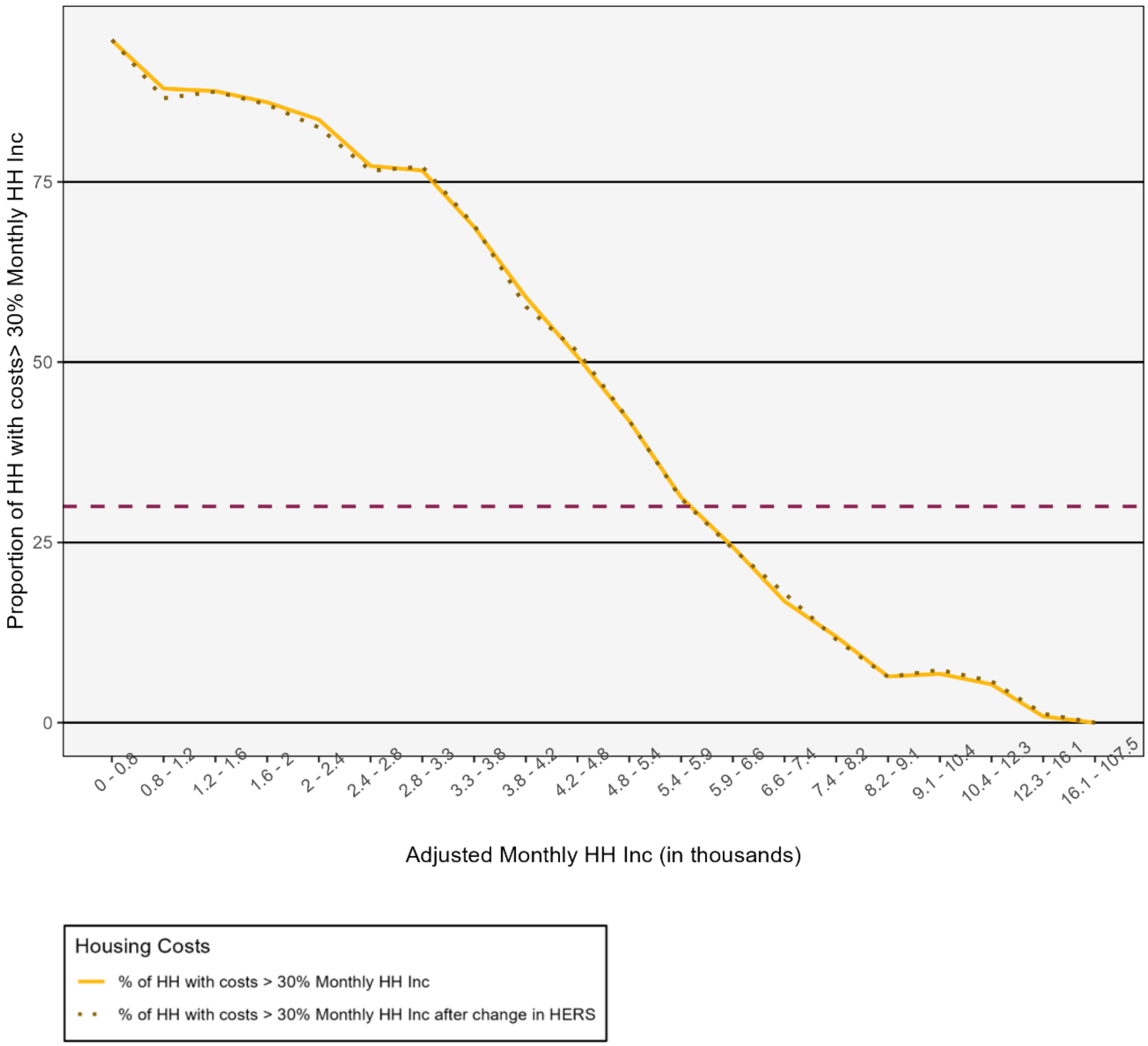


Figure 13 suggests that improvements in building energy efficiency in large multi-family buildings are associated with modest declines in utility costs (3.7%) and that these building energy efficiency improvements can be obtained with roughly 2.4 percent or lower increases in construction costs. Building the more energy-efficient multi-family homes that the Commonwealth needs will have adverse effects on affordability for low- and moderate-income households in Massachusetts. As seen in Table 22, for those renter households making between roughly $20,000 and $50,000 it will increase the share of those households who are cost burdened from 55 percent to 56.2 percent, while for those making between roughly $50,000 and $90,000 it will increase the share of housing cost burdened households from 34.3 percent to 35.0 percent.

As discussed with regard to homeowners above, after estimating the incremental construction cost attributable to increased building energy efficiency and any savings from reduced energy costs, the next question is to what extent this incremental cost will be passed through to housing price (rent). Given the low rental vacancy rate and limitations on building multi-family housing in most municipalities across the state, we expect that in most of the towns in Massachusetts, this pass-through rate will be quite high, which means that the majority of the incremental construction cost will be translated to higher rents and slower new construction growth, both of which will hurt affordability.

Due to data constraints, we are unable to obtain the exact magnitudes of supply and demand elasticities in Massachusetts towns. Therefore, we have conducted a "sensitivity analysis" to allow this pass-through rate to vary. In the meantime, we also understand that our incremental construction cost estimate also has a range instead of a constant number, so we also add this dimension to our sensitivity analysis. In this way, we can have a 2-dimensional sensitivity analysis tool, to illustrate at different points in the ranges of incremental construction cost and pass-through rate, to what extent this incremental cost increase will be reflected in the housing price increase. Here we only report the positive estimates because it is very unlikely that the overall price effect will be negative.

Table 23: Sensitivity analysis of the estimate of the effects of change from HERS 55 to 42 on expenses of renters in multi-family homes built since 2010 in Massachusetts.

Change % Households > 30% Monthly household income after change in HERS

Construction Cost	Pass-Through Rate: % Passed on to Renters										
% Increase	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
0.08%											**0.00%**
1.00%		0.03%	0.13%	0.23%	0.33%	0.41%	0.48%	0.54%	0.64%	0.74%	0.86%
2.00%		0.13%	0.33%	0.48%	0.64%	0.86%	1.08%	1.29%	1.46%	1.62%	1.80%
2.40%		0.18%	0.40%	0.56%	0.80%	1.08%	1.32%	1.54%	1.72%	1.95%	**2.17%**
3.00%		0.23%	0.48%	0.74%	1.08%	1.37%	1.62%	1.90%	2.17%	2.45%	2.71%
3.83%		0.31%	0.62%	1.01%	1.40%	1.71%	2.10%	2.42%	2.82%	3.23%	3.56%
4.00%		0.33%	0.64%	1.08%	1.46%	1.80%	2.17%	2.53%	2.96%	3.37%	3.70%
5.00%		0.41%	0.86%	1.37%	1.80%	2.29%	2.71%	3.29%	3.70%	4.20%	4.63%
6.00%		0.48%	1.08%	1.62%	2.17%	2.71%	3.37%	3.94%	4.46%	4.99%	5.44%
7.50%		0.58%	1.37%	2.03%	2.71%	3.51%	4.20%	4.85%	5.44%	5.99%	6.56%

The sensitivity analysis in Table 23 suggests that if the increase in construction cost is 2.4 percent and all of that cost is passed on to consumers, roughly 2.17 percent of all households who currently rent in large multi-family buildings in Massachusetts built since 2010 would become housing cost-burdened as a result of the increased cost of the specialized stretch energy code. The actual number is sensitive, as the table shows, to variation in the extent of the construction cost increase and in the share of that increase passed on to home purchasers.

Beginning in January 2024, under the opt-in specialized stretch code, new large multi-Family buildings, however, will have to meet the Passive House standard. The Passive House standard does not map directly onto HERS scores. Nevertheless, research on the increased energy efficiency of multi-family Passive House construction estimates reductions in energy use intensity of 40 to 60 percent (Craig, McKneally, and Lino 2022). The one multi-family Boston project built in 2017 that was subject to the City of Boston's Building Energy Reporting Disclosure Ordinance (BERDO) in 2020 reported 63% less energy use per square foot compared to other residential buildings constructed in Boston between 2008 and 2019 and subject to BERDO (because they were residential buildings greater than 35,000 SF and/or thirty-five units) (Craig, McKneally, and Lino 2022). Conservatively estimating a 40 percent reduction in energy use intensity applied evenly to tenants and translated into energy cost savings increases the energy cost savings compared to the HERS 42 standard.

Table 24: Sensitivity analysis of the estimate of the effects of change to Passive House construction (estimating 40% decrease in energy costs) of expenses of renters in multi-family homes built since 2010 in Massachusetts.

Construction Cost	**Pass-Through Rate: % Passed on to Renters**										
% Increase	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
0.08%											
1.00%											
2.00%											
2.40%											**0.17%**
3.00%									0.17%	0.43%	0.72%
3.83%							0.07%	0.42%	0.80%	1.15%	1.51%
4.00%							0.17%	0.54%	0.94%	1.29%	1.73%
5.00%						0.24%	0.72%	1.20%	1.73%	2.18%	2.55%
6.00%					0.17%	0.72%	1.29%	1.92%	2.42%	2.96%	3.47%
7.50%				**0.00%**	0.72%	1.43%	2.18%	2.80%	3.47%	4.09%	4.63%

Improvements in building energy efficiency for large multi-family buildings built to a Passive House standard are associated with substantial declines in utility costs (estimated at 40%) and building energy efficiency improvements can be obtained with roughly 2.4 percent increases in construction costs. Assuming that all of the estimated 2.4 percent increase in construction costs were passed on to tenants in the form of increased rent but tenants saved 40 percent in energy costs, roughly 0.17 percent of the renter households currently in large multi-family buildings built since 2010 would be pushed into a housing cost burdened status, as seen in Table 24.

Conclusion

As the gap between the current average housing cost as a share of income and the average housing cost of the more energy-efficient homes consistent with the opt-in specialized stretch code as a share of income indicates, without additional incentives or financial supports, the increased requirements is likely to increase housing cost burdens for some households, especially home purchasers with incomes between roughly $80,00 and $190,00 and renters with incomes between $20,000 and $90,000.

5. Obstacles to Building More Affordable, Energy-Efficient Housing

In our interviews, home builders identified multiple obstacles to constructing homes that are simultaneously more energy-efficient and more affordable than the current average. High land costs and related land use restrictions, permit delays, lack of clarity about financial incentives available for more energy-efficient construction, lack of experience with new energy-efficient building techniques, and an insufficient valuation by realtors, appraisers, lenders, and purchasers of energy-efficient improvements contribute to the increased cost and difficulty of building energy-efficient homes.

Restrictive land use regulations

The high cost of land and restrictions on development rights are arguably the largest driver of high housing prices in the state. According to a recent paper by the Federal Reserve Bank of Boston's New England Policy Center, local zoning restrictions allow the construction of multi-family housing on only about 16 percent of the land area in Greater Boston (Sood and Chiumenti, 2022). Local regulations limit buildings to three stories or less on almost 70 percent of the developable land area in Greater Boston (Sood and Chiumenti, 2022). For roughly one-quarter of the land, local zoning allows development of only one dwelling unit per acre or less (Sood and Chiumenti, 2022). These land use regulations substantially limit the ability to build new housing that is accessible to households with low and moderate incomes and force builders and purchasers into more environmentally destructive, carbon-intensive building types and land use patterns.

Even where multi-family housing is technically allowed by law, the details of other land use regulations effectively prohibit it in fact (Dain 2019). In some cases, the parcels zoned to allow multi-family dwellings are already built out to the maximum capacity allowed, so no new multi-family buildings are possible. In other cases, local land use regulations require bigger minimum parcel sizes for multi-family buildings than a developer would likely be able to assemble in a given district. In still other cases, the dimensional requirements in the local regulations severely limit how many units can eventually be built on a parcel, making many projects infeasible. Finally, while the use in some jurisdictions may be described as "allowed," it may still require town meeting approval, the difficulty and uncertainty of which will make any project either infeasible or very expensive.

Permitting delays

Another factor that contributes to high housing costs is the time it takes to obtain municipal development approvals and permits. Of the limited land area where multi-family construction is allowed at all, a large portion of that zoning allows multi-family construction only with a special permit or by approval of a town meeting or city council vote. The uncertainty and time associated this requirement is another factor substantially increasing the cost of housing, given the increased costs of financing over the extended development period, the uncertainty regarding whether development applications will be approved, and uncertainty about what the housing market conditions will be if and when the development is finally approved. Builders also mentioned that permits might be delayed because some building inspectors lack knowledge of alternative code-compliant ways to increase energy efficiency using new green technologies or advanced framing that can reduce thermal bridging and increase insulation effectiveness.

Difficulty accessing financial incentives

Builders reported that existing incentives through the Mass Save program are important and beneficial, but insufficient both in their extent and especially because of the certainty of their existence over time. The Mass Save program has created incentives of $15,000 for an all-electric home with a HERS score of 45 and of $25,000 for an all-electric home that has a Passive House certification or a HERS score of 35 or lower.[17] One challenge for developers is that it is not clear how long these incentives will last, and the extent to which developers can count on them in their development pro-forma, especially given the extended time it often takes to obtain development approvals and complete construction. Some small builders also expressed that they faced challenges in making the most of the available incentives when such incentives may require multiple applications to different agencies or departments.

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[17] The Mass Save program is a partnership between the Massachusetts Department of Energy Resources and major energy suppliers in the Commonwealth to use funds from an energy efficiency fee on gas and electric bills to provide a range of energy efficiency services, such as home energy assessments and energy efficiency rebates, to help advance the state's climate goals. The current Mass Save incentive offers $15,000 for new single-family homes that are all electric, have a HERS score of 45 or less, and include the use of heat pumps for space heating and heat and energy recovery ventilation systems, among other requirements (see https://www.masssave.com/residential/rebates-and-incentives/all-electric-home). This incentive supports the construction of homes that roughly meet or exceed the all-electric opt-in specialized code. For homes that are even more energy-efficient and achieve a HERS score of 35 or less and meet additional requirements, up to $25,000 is available. For the construction of new 2–4 unit buildings, reduced per-unit subsidies are available, up to a total of $22,500 for 4 units at the HERS 45 or less level or $40,000 for 4 units at the HERS 35 level. There are also limited subsidies for Passive House construction of 5 units or more, including up to $5,000 for feasibility studies, $500 per unit for energy modeling costs (up to a maximum of $20,000), $500 per unit for pre-certification costs, $2,500 per unit for certification costs, and $7.50 per term performance bonuses.

The federal Inflation Reduction Act (P. L. 117-169) of 2022 also includes extending and expanding tax credits for home energy efficiency. Section 13304 of the Inflation Reduction Act extends the energy-efficient home tax credit in Section 42L of the Internal Revenue Code through 2032, allowing a $2,500 credit for new homes that meet certain Energy Star efficiency standards and a $5,000 credit for new homes that are certified as zero-energy ready homes, as well as allowing tax credits for energy-efficient multi-family dwellings. Section 13301 of the Inflation Reduction Act also extends and expands the energy-efficient home improvement credits in Section 25C of the Internal Revenue Code.

Shortage of technical assistance and skilled labor

As the Commonwealth attempts to rapidly increase the energy efficiency of new construction, one issue builders face now is the lack of skilled labor trained in the increased requirements of more efficient building and Passive House certification. Although some programs provide education and skills development regarding installing energy-efficient heat pumps, there are fewer opportunities for formal training for tradespeople regarding other dimensions of energy-efficient construction such as mitigating thermal bridges, or installing heat and energy recovery ventilation, vapor barriers, and energy-efficient doors, windows, and siding.

Limited public awareness

Builders also expressed concerns about public awareness of the benefits of more energy-efficient construction and the public's lack of willingness to pay for more energy-efficient homes. Of particular concern was the lack of awareness and training among realtors and appraisers of their obligations with regard to energy-efficient homes and the importance of completing the Residential Green and Energy Efficient Addendum as part of the appraisal process and mortgage underwriting process.

6. Policy Tools to Facilitate the Production of More Energy-Efficient and Affordable Housing

The combination of the current crises of climate change and housing affordability require bold action. The Commonwealth's Global Warming Solutions Act of 2008 and the Act Creating a Next Generation Roadmap for Massachusetts Climate Policy of 2021 are crucial steps to address carbon emissions in Massachusetts but will not, alone, reduce carbon emissions from new residential buildings to zero. The Housing Choice legislation and MBTA Communities legislation are helpful steps towards reducing some of the obstacles that local land use regulation pose to building more energy-efficient and affordable housing, but fall short of the changes to land use needed to meet current housing needs and behind more ambitious legislation other states have recently passed, such as Oregon, California, and Maine.[18] In short, more action is necessary to increase energy efficiency and reduce the carbon emissions of new homes, especially in those municipalities that have not adopted the stretch energy code. Additionally, more action is necessary to increase housing affordability, especially in those municipalities that have adopted these more stringent standards.

<u>Land use changes that reduce carbon emissions and increase affordability</u>

One of the most powerful tools to increase housing affordability and decrease carbon emissions simultaneously is land use policy. As discussed above, current land use regulations prevalent in municipalities across the Commonwealth require carbon intensive living patterns and drive up the cost of housing. Some of the municipalities advocating for stringent building energy efficiency requirements are laggards in housing affordability and also in overall energy-efficient land use patterns. Municipalities that have extensive large lot, large unit, single-family land use regulations that mandate energy-intensive, environmentally-destructive, and unaffordable living patterns are seeking to adopt policies that will have only modest impacts on climate emissions compared to loosening their restrictive land use regulations but will worsen affordability.

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[18] Oregon's House Bill 2001 of 2019 allows duplexes in areas zoned for single-family homes in all municipalities with populations greater than 10,000 and four-unit buildings in cities with populations greater than 25,000. California's Senate Bill 9 of 2021 allows single-family lots to be split and existing homes to be converted to duplexes or new duplexes built. California's Senate Bill 10 of 2021 allows zoning ordinances enabling the construction of up to ten units near transit to be exempt from environmental review under the California Environmental Quality Act. Other recent California legislation provides additional density bonuses, limits restrictions on lot coverage and floor area ratios, facilitates the construction of accessory dwelling units, streamlines housing approvals, and takes other steps to facilitate housing development. Maine enacted L.D. 2003 in 2022, An Act To Implement the Recommendations of the Commission To Increase Housing Opportunities in Maine by Studying Zoning and Land Use Restrictions, allowing the construction of duplexes or accessory dwelling units on single-family lots or up to 4 units per lot for those parcels in designated growth areas, allowing affordable housing construction at 2.5 times existing local zoning density, and establishing regional housing production goals that municipalities are required to achieve.

Recent legislation in other states has sought to change these exclusionary land use policies. Oregon's House Bill 2001 of 2019 allows duplexes in areas zoned for single-family homes in all municipalities with populations greater than 10,000 and four-unit buildings in cities with populations greater than 25,000. California's Senate Bill 9 of 2021 allows single-family lots to be split and existing homes to be converted to duplexes or new duplexes built. Senate Bill 10 of 2021 allows zoning ordinances enabling the construction of up to ten units near transit to be exempt from environmental review under the California Environmental Quality Act, and other recent California legislation provides additional density bonuses, limits restrictions on lot coverage and floor area ratios, and facilitates the construction of accessory dwelling units, streamlines housing approvals, and takes other steps to facilitate housing development. Maine enacted L.D. 2003 in 2022, An Act to Implement the Recommendations of the Commission to Increase Housing Opportunities in Maine by Studying Zoning and Land Use Restrictions, which allowed the construction of duplexes or accessory dwelling units on single-family lots or up to 4 units per lot for those parcels in designated growth areas, allowing affordable housing construction at 2.5 times existing local zoning density, and establishing regional housing production goals. The Terner Center for Housing Innovation and the Urban Institute recently reviewed 144 different state laws designed to encourage or require municipal action to increase housing production and reduce housing costs.[19] The Massachusetts legislature could learn from these varied policies setting standards for local housing production and affordability, creating penalties for localities that fail to meet those targets or offering streamlined approvals for projects that meet affordability or other goals, facilitating the production of accessory dwelling units, and putting forth state standards to increase density for affordable housing projects, among other approaches.

After years of effort, the Massachusetts legislature in 2020 and 2021 enacted two pieces of legislation, commonly referred to as Housing Choice and MBTA Communities Zoning legislation.[20] These bills made several amendments to Chapter 40A of the Massachusetts General Laws, often referred to as the state Zoning Act. First, the Housing Choice legislation reduced from a two-thirds majority to a simple majority the number of votes required to adopt or change zoning ordinances or bylaws that facilitate housing production and special permits that enable transit-oriented multi-family housing and mixed-use development. Second, the MBTA Communities legislation required the 175 municipalities served by or abutting communities served by the Massachusetts Bay Transportation Authority to have at least one zoning district of reasonable size within half a mile of a transit station (if one is present) where non-age-restricted multi-family housing is permitted as of right at a minimum density of 15 units per acre. On the

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▸ [19] https://ternercenter.berkeley.edu/research-and-policy/state-pro-housing-law-typology/

▸ [20] https://malegislature.gov/Laws/SessionLaws/Acts/2020/Chapter358; https://malegislature.gov/Bills/191/H5250 top of local agendas to improve affordability and reduce emissions should be full implementation of the MBTA Communities law. Full implementation is an important first step, and further zoning reform at the state and local levels will need to follow.

The Massachusetts legislature could take similar actions and tie those actions to higher levels of building energy efficiency in order to simultaneously increase housing affordability and reduce carbon emissions. For instance, the legislature could require that adoption of the opt-in specialized stretch code be combined with improvements to land use regulations that will have a greater impact on carbon emissions and also increase affordability, such as allowing smaller minimum lot and unit sizes, larger height limits, and/or more by-right multi-family zoning. The legislature could also require density bonuses for more energy-efficient homes, similar to what the City of Somerville has done by reducing minimum unit sizes for energy-efficient multi-family buildings. The state legislature could also create land use improvements for building projects that meet or exceed the requirements of the opt-in specialized stretch code even in municipalities that have not opted into its requirements. Further state legislative action to address local zoning barriers to housing production is urgently needed. To offset the costs of increased energy efficiency, zoning liberalization is a central tool and can simultaneously support more energy efficient living patterns, more carbon neutral construction, and greater affordability.

<u>Streamlining permitting and reducing utility connection delays</u>

Another powerful tool to advance green building and housing affordability is streamlining or expediting state and local permits. For instance, where existing local zoning requires multi-family proposals to obtain a special permit, the legislature could enact legislation to waive those requirements for proposals that meet or exceed the requirements of the opt-in specialized stretch code. The legislature could also create a requirement that adoption of the opt-in specialized stretch code be combined with expedited permits, in a program similar to the current Chapter 43D expedited local permit process that seeks to provide a transparent and efficient process for municipal permits and guarantees local permit decisions on priority development sites within 180 days, in turn giving participating municipalities priority consideration for several state funding streams.

Localities could also act on their own, such as Boston’s recent effort to streamline and speed affordable housing permits. In all cases, action is needed by the state Board of Building Regulations and Standards to ensure that building inspectors are knowledgeable about the variety of ways energy efficiency can be increased while simultaneously fulfilling the different existing codes in Massachusetts.

Relatedly, reducing utility connection delays can help housing be built faster and reduce financing costs and uncertainty. Already, builders are reporting rising delays in obtaining utility connections especially in large projects. The U.S. Department of Energy’s SunShot Initiative Rooftop Solar Challenge provides a model for how the Massachusetts Department of Energy Resources could work with city, county, and state officials, regulatory entities, local utilities, and others to focus on reviewing permit processes, changing zoning bylaws, addressing electric interconnection challenges, identifying new financing tools, and generally reducing the soft costs of increased energy efficiency.

Restructuring financial incentives and tax credits

Financial incentives have played a crucial role in increasing renewable electricity generation in Massachusetts, particularly through the installation of rooftop solar panels on homes and commercial buildings in the state. Incentives like these will be an important inducement to increase building energy efficiency and to ensure that the benefits of more energy-efficient homes reach moderate and low-income households in the Commonwealth.

One obstacle of some existing incentive programs is lack of certainty about their duration—explicit commitments by the state as to the durability of these incentives would enable home builders to rely on them in their financing models. A streamlined application process for climate-related incentives would benefit builders and homeowners, especially smaller builders with limited capacity to identify disparate subsidies and limited time to complete multiple applications for programs including Mass Save, Massachusetts Clean Energy Center incentives, Solar Massachusetts Renewable Target (SMART) rebates, Alternative Portfolio Standards, Renewable Portfolio Standards, and other incentives.

The Massachusetts Commission on Clean Heat recently proposed the creation of a Building Decarbonization Clearinghouse to act a single point of contact for all decarbonization programs. The creation of such a clearinghouse as a single point of contact, with a commitment to long-term incentive availability and the ability to adjust incentives for inflation, would be a beneficial step to advance housing production, affordability, and decarbonization.

Tax rebate programs, in conjunction with other financial incentives, have been very successful in Massachusetts in expanding rooftop solar projects. The combination of federal Renewable Energy Tax Credits with Massachusetts personal income tax credits and the Department of Energy Resources Solar Massachusetts Renewable Target incentives have led to rapid growth in rooftop solar expansion. The creation of state income tax credits for investments in other dimensions of energy-efficient construction could help reduce the costs to consumers and facilitate more production of the energy-efficient homes that the commonwealth needs. For instance, creating something like the Residential Energy Credit codified in 830 CMR 62.6.1 for energy saving technology, instead of just energy production technology, could create new incentives that would increase the affordability of more energy-efficient homes.

Increased technical assistance for green building

As efforts to increase building energy efficiency and reduce building sector carbon emissions gain momentum, smaller builders are limited by a lack of training and technical assistance in meeting these new requirements. The Massachusetts Clean Energy Center's Passive House Design Challenge could serve as a model.

Developers and others have expressed concerns that more training is needed to overcome limited industry knowledge regarding Passive House standards, that required building envelope upgrades increase costs, that Passive House projects expose them to increased financial risk, and that the public lacks awareness about energy-efficient buildings. To address these concerns, the Passive House Design Challenge made awards of up to $4,000 per unit for eight new-construction, affordable housing developments that were eligible for Massachusetts Low Income Housing Tax Credits (LIHTC). The funding allowed developers to hire a Passive House consultant, to upgrade their design from the existing stretch code to Passive House, and to seek Passive House certification.

From the challenge, participants learned that projects with more project team members with Passive House training and architects with more experience with Passive House projects had lower costs (Simmons, Craig, McKneally, Lino 2022). The assessment of the challenge following its first cycle led to a number of recommendations: 1) keeping incentive programs simple and providing incentives accessible at different project milestones; 2) supporting design phase incentives so developers can explore Passive House feasibility and energy modeling in the early stages; 3) providing flat rate incentives that are predictable and easily understood to help reduce developers' perceived financial risks; and 4) supporting education, training, and workforce development for design and construction professionals.

The program proved effective at helping several large affordable housing developers increase their internal capacity for Passive House development and helped large contractors and subcontractors increase their skills in energy-efficient construction. Continuing and expanding the program or another like it to include different housing typologies and smaller builders could help further diffuse the knowledge and skills necessary to deliver more energy-efficient and affordable homes to Massachusetts, as could further investments in workforce training and education focused on these energy-efficient construction techniques.

Enhancing the knowledge and skills of realtors and appraisers, improving green underwriting

Realtors not only connect buyers and sellers but can play a role in educating buyers and sellers about the value of energy-efficient homes, the importance of completing the Residential Green and Energy Efficient Addendum, and the benefits of green mortgages, which are structured to consider the increased value and decreased utility costs of energy-efficient homes. The National Association of Realtors has a

Green Designation for realtors that enables access to marketing tools and market research. The Massachusetts Association of Realtors should require that all of its members obtain this Green Designation. The Massachusetts Board of Registration of Real Estate Brokers and Salespersons could also act to strengthen the role of real estate brokers in educating home purchasers and sellers about green buildings through changes to the Code of Massachusetts Regulations Title 254 that governs real estate brokers.

Similarly, the Massachusetts Board of Registration of Real Estate Appraisers could encourage or require that licensed real estate appraisers be familiar with and offer the Residential Green and Energy Efficient Addendum. These steps would help ensure that realtors and appraisers are informed about the benefits of energy-efficient construction and their professional obligations to their clients with regard to these homes. The Massachusetts Department of Energy Resources or another state agency could also set up a website and database to store these Green Building Addenda where builders, contractors, home energy raters, and owners could upload and store relevant supporting data for them—this would make completing the Addendum easier for all involved and could provide the Department of Energy Resources with a more comprehensive picture at a house by house level of progress towards energy efficiency, enabling interventions targeted at particular local or sectoral roadblocks.

Lack of clear guidance from the Federal National Mortgage Association (Fannie Mae), the Federal Home Loan Mortgage Corporation (Freddie Mac), the Federal Housing Administration (FHA), the U.S. Department of Veterans Affairs (VA), and the U.S. Department of Agriculture regarding how to take energy efficiency into account in property valuations is a challenge to financing the purchase of energy-efficient homes. Ensuring that energy efficiency improvements and associated utility cost savings are capitalized into property appraisals and that those appraisals will be accepted by the GSEs would make financing more energy-efficient homes easier for home buyers. Currently, the Uniform Residential Appraisal Report includes a line for "Additional features (special energy-efficient items, etc.)" and a line for the description of "Energy-efficient Items" in sales comparisons (Freddie Mac Form 70; Fannie Mae Form 1004). The Residential Green and Energy Efficient Addendum augments the appraisal report, but adoption of the Addendum has been limited. Specific property valuation guidance for energy-efficient properties and comprehensive requirements from Fannie Mae and Freddie Mac for how energy efficiency should be incorporated into appraisals and underwriting is needed to facilitate market growth of energy-efficient construction.

Freddie Mac conducted a study of the effect of high levels of energy efficiency on residential home values and loan performance, using data from RESNET HERS ratings and Department of Energy Home Energy Scores (Argento, Bak, and Brown, n.d.). After accounting for property characteristics in a regression analysis, RESNET-rated homes sold for 4.3 percent more than all unrated homes and 2.7 percent more than comparable unrated homes. More energy-efficient RESNET-rated homes sold for 3-5 percent more than RESNET homes with low-energy efficiency ratings. RESNET-rated homes had lower delinquency rates than unrated homes overall, and for households with debt-to-income ratios of 45 percent and above, RESNET-rated homes had statistically lower delinquency rates than their unrated peers.

There are special energy-efficient mortgages to cover the cost of energy efficiency improvements or clean energy improvements in a single primary mortgage in the purchase or refinance of residential real estate. These energy-efficient mortgages are usually tax-deductible and expand underwriting to take into account both increased cash flow from renewable energy installation or savings from energy-efficient improvements. Fannie Mae offers the Fannie Mae HomeStyle Energy Mortgage Program to support borrowers in increasing a home's energy efficiency and reducing utility costs by financing efficiency upgrades during a home purchase or refinance. The Federal Housing Administration and Veterans Administration also offer energy-efficient mortgages. Other entities, such as the Vermont State Employees Credit Union, also provide financing for projects that improve energy efficiency in a home, enabling more energy-efficient construction or renovation at a low monthly cost. It would be helpful to support or encourage community development financial institutions in Massachusetts to offer energy-efficient mortgages. This could occur in conjunction with a Green Bank as discussed below.

Expand financing sources

The new Massachusetts Community Climate Bank or Green Bank can facilitate investment in low-carbon, climate-resilient housing. A green bank is a mission-driven financial institution designed to use public funding to attract private investment in clean energy projects through loan or investment funds. States, including California, Connecticut, Hawaii, New York and Rhode Island, have created green banks, as have municipal governments, such as the New York City Energy Efficiency Corporation and the Montgomery County Green Bank in Maryland. Governor Healey just launched the Massachusetts Community Climate Bank within MassHousing to work in partnership with the Massachusetts Clean Energy Center and MassDevelopment to identify, develop, finance, and execute clean energy projects, starting with affordable housing.

Green banks can use public funds to catalyze larger private investments through multiple tools. They can reduce risks and administrative burdens for private investors by aggregating small, decentralized projects. They can provide credit enhancements through loan loss reserves or loan guarantees to reduce financial risks for innovative projects with long payback periods. Green banks can provide market-rate or below market-rate loans directly, through revolving loan funds. They can also invest directly in energy-efficient, affordable housing developments to reduce the risk and equity needed to start development. A green bank can also issue environmental impact bonds to capitalize on clean energy projects. Through these tools, green banks can also focus on market gaps in access to financing, for instance providing low-interest loans or lease financing for low- and moderate-income households seeking greater building energy efficiency.

The Inflation Reduction Act created a Greenhouse Gas Reduction Fund and allocated $27 billion to the Environmental Protection Agency to provide competitive grants to states, local governments, tribes and eligible non-profit financing institutions (such as community development financial institutions) to leverage private capital for clean energy and climate projects that reduce greenhouse gas emissions. It makes sense for Massachusetts to make the most of these funding opportunities Community Climate Bank and using it, among other things, to expand financing for the creation of homes that are more energy-efficient and more affordable than the current stretch code.

Support for low-income renters

As more and more homes switch from gas to electricity, housing advocates have expressed concern that electricity costs (already high in Massachusetts relative to other states) could rise further. These concerns are especially pressing for low-income households with fixed incomes, such as seniors and those with disabilities. As large multi-family buildings shift to distributed air-source heat pumps for both cooling and heating, some landlords may shift from heating through one large collective boiler or furnace with costs paid by the landlord to individual units with heating costs paid by individual tenants. Doing so will expose tenants to greater fluctuation in electricity prices. Low-income renters then may need expanded support from the state's LIHEAP program to meet their utility costs or other approaches to reduce their exposure to price fluctuation. The Maine Public Utilities Commission, for instance, has approved different rate structures for households that use heat pumps for all of their heating and cooling needs.

New tax classifications and exemptions

Given the benefits that highly energy-efficient homes provide to the Commonwealth, including their decreased need for state and local energy capacity and infrastructure, the State Department of Revenue could explore the creation of a new property tax classification for highly energy-efficient housing or a new exemption for highly energy-efficient housing. These potential property tax reductions could reduce the cost of highly energy-efficient homes and create a powerful and durable incentive that would facilitate increased production of more energy-efficient and affordable housing.

7. Conclusion

Increasing the energy efficiency of new residential construction in Massachusetts is an urgent imperative for the health and well-being of all Massachusetts residents. Increasing the affordability of housing in Massachusetts is also an urgent imperative for economic growth in the Commonwealth and for the health and well-being of the state's residents. These two imperatives exist in some tension with each other, but there are opportunities to advance both.

Action by the state legislature, by state agencies, and by professional organizations can help move both decarbonization and housing affordability forward together. Especially important is state and local legislative action to enable the construction of more multi-family housing and of smaller housing on smaller parcels. The ability to construct smaller homes on smaller parcels and to build more multi-family units will simultaneously create more climate friendly housing and more affordable housing. Also important are efforts at the state and local levels to streamline the permit process, so that the energy-efficient housing the Commonwealth needs can be built more quickly and more affordably. Expanded and more durable financial incentives can facilitate the production of more energy-efficient housing that is also more affordable. Additionally, increasing opportunities for smaller builders and contractors to access technical assistance regarding energy-efficient construction techniques, enhancing the knowledge of realtors and appraisers regarding green buildings, creating new financing sources through the new Community Climate Bank, increasing support for utility costs for low-income renters, and considering new tax classifications or exemptions for highly energy-efficient buildings will move Massachusetts towards achieving its decarbonization and affordability goals.

Appendix A: Participants

We thank all of the people and companies who contributed in some way to the work described in this report by sharing their experience and expertise:

- Air Conditioning Association of New England (ACA/NE)
- Ack-Air Duct LLC
- Alternative Creative Energy
- Anderson Insulation
- Auburndale Builders
- Boston Chapter of the National Electrical Contractors Association (NECA Boston)
- BrightBuilt Home
- Builders and Remodelers Association of Greater Boston (BRAGB)
- CapeBuilt Construction
- Cranshaw Construction
- Dakota Partners
- Dellbrook|JKS
- Donovan Electrical Service
- Dimeo
- Done & Done Insulation
- D R Hattin Electric
- Driscoll Electric Co., Inc.
- Ekotrope
- EZ CLIMATE HVAC Inc
- Frehill Insulation Co., Inc
- Foley Electric LLC
- FX Automation
- Green Insulation
- Greenstamp
- Homans Associates
- Home Builders & Remodelers Association of Central Mass
- Home Energy Remedies LLC
- Installations Plus, Inc.
- James Driscoll Electric
- Jones Boys Insulation
- Kaplan Thompson Architects
- London and Sons Electrical LLC
- Lowe's
- Lynch & Fierro LLP
- M. Duffany Builders
- Massachusetts Clean Energy Center (MassCEC)
- Massachusetts Department of Energy Resources (DOER)
- Massachusetts Electrical Contractors Association (MECA)
- Matthew B McCue Electrician
- Mike Malone Electric Inc
- Mitsubishi Electric Heating and Air Conditioning
- Motti Electric Co.
- National Association of Home Builders (NAHB)
- National Grid
- NEI General Contracting
- Passive House Massachusetts
- Planning Office for Urban Affairs (POUA)
- Plumbing, Heating, Cooling, Contractors of Massachusetts (PHCC)
- Smolak & Vaughan LLP
- Suffolk Construction
- SunPower Corporation
- Sullivan & McLaughlin Companies
- Symes Associates
- The Home Depot
- Toll Brothers
- Victory HVAC
- Vigil Electric
- Villano Electric
- Woodside Development
- Youssef HVAC
- ZeroEnergy Design

Appendix B: Committee Members and Research Team

The Net-Zero Committee

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- Ben Fierro, Partner, Lynch & Fierro LLP
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- Larry Kady, Managing Director, Jay Corp.
- Joe Landers, State Executive Officer, Home Builders & Remodelers Association of Massachusetts
- Mark Leff, Sr. Vice President - Construction Loan Officer, Salem Five Bank
- Russ Leonard, President, Leonard Electric Co.
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- Parlin Meyer, Director, BrightBuilt Homes
- Michael Moore, Sr. Development Analyst - Toll Brothers
- Jeff Rhuda, Business Development Manager, Symes Associates
- Guy Webb, Executive Officer, Home Builders & Remodelers Association of Central Mass.

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- Akrisht Pandey, Graduate Student, MSRED and MCP
- Rebecca Glasgow, Graduate Student, MSRED and MCP
- Maria Jimena Muzio, Graduate Student, MCP

Appendix C: Cost Implication Case Studies

Case Study 1:

Title: Is Cost the Barrier to Passive House Performance? A Look at First Costs for Sixteen Multi-family Buildings (Barry, 2021)

This study, which was conducted in 2021, looked at 16 Passive House certified multi-family buildings that were in the design phase or under construction to determine if cost was a contributing factor. These buildings were traditional mixed-use multi-family units with the exception of two buildings that were university dormitories. The costs of these buildings are very close to the actual cost as the buildings are working within detailed construction cost estimates. The only cost that is not included is the final total cost of the project are any changes or other cost escalations. This study found that the cost increase due to Passive House building was on par with other green building certifications such as LEED. The observed cost increase ranged from a 1 to 8 percent increase, which is similar to that for LEED certified buildings, which is 2.5 to 8.5 percent (Barry, 2021). This study found that the industry lacks experience in building using Passive House methods; importantly, the largest impact on total cost was the project design team's experience.

Case Study 2:

Title: City of Boston – Department of Neighborhood Development 2020 Guidebook for Zero Emission Buildings (City of Boston, 2020)

This report, which focused on the affordability of Zero Emission Buildings (ZEBs), stated that construction cost increases before rebates ranged from 0 to 2.5 percent (City of Boston, 2020). Additionally, with rebates and incentives, construction costs decrease along with operational costs. The costs within this study were broken into different categories based on building elements. The areas of focus were heat recovery ventilation (HRV), domestic hot water system, heating system, roof R-value, wall R-value, and floor R-value. These areas are considered key areas for the success of ZEBs. ZEBs require a high level of quality as energy efficiency relies heavily on air tightness. Tighter buildings result in fewer air changeovers per hour, which in turn reduces the heating load as the conditioned air is maintained inside the building. This study focused on small to large multi-family buildings. The study concluded that through the use of key strategies, ZEBs could be highly efficient. First, a simple shape allows for simple details to ensure a tight envelope. Orientation is a critical factor to maximize passive heat gains from the sun and natural light; it is important that the longest side of the building face the south in order to maximize solar heat gain. Another key area is to build high density of units within the building. Building design also plays a key role. This includes a reduction of glazing to 15 to 18 percent of total wall area and facing the largest window areas south, followed by east and west, while minimizing windows area facing north. Minimizing the number of windows reduces the need for highly efficient windows which helps reduce costs. Another design aspect is to remove thermal bridging from the building design and to ensure continuous insulation around the interior and exterior components. This can be accomplished either through continuous exterior insulation behind the exterior skin or using double-studded walls. Double-studded walls do not allow hot or cold air to pass through building components such as framing. Increasing the required insulation R-value across all assembly locations is also required, with the highest R-value located in the attic and the lowest under slab. Lastly, air tightness is critical, which can be accomplished through simplified designs and higher oversight during construction and coordination among different trades. The minimal cost increase is accomplished through a variety of means such as simplified buildings that pose fewer construction challenges and the reduction of glazing requirements, resulting in less glazing and a tighter envelope.

Case Study 3:

Title: Cost and Other Implications of Electrification Policies of Residential Construction (Home Innovation Research Labs, 2021)

This study examined the cost of switching from gas to all electric homes, including heating methods and household appliances. Heating and appliances are the areas that have the most visible change when switching to an all-electric home. A region's location is a direct determinant of owner heating costs and this study showed an increase in the cost of heating associated with more northern climates due to the increased cost of heating with electricity (Home Innovation Research Labs, 2021). The study used a cost database, price indexes, and manufacturers' costs to perform their calculations. This study highlighted the cost increase associated with switching to all electric and the increase in operating costs.

Case Study 4:

Title: Residential New Construction Incremental Cost Update (NMR Group, Inc., 2020)

This report provided a range of estimated cost increases based upon survey responses and experiences of building professionals. This range was anywhere between a 0 to10 percent increase, with an average of 5 percent increase as an agreeable amount (NMR Group, Inc., 2020). These ranges were retrieved through an in-depth interview process. Additionally, this research used data from Passive House multi-family units being constructed in Pennsylvania. Their review of the final construction cost data showed that Passive House units had a lower square foot cost as well as per unit cost. The study suggested that this was a result of Passive House units having a basic, simple box-like design. It is important to note that the cost comparisons were not for the same design but a comparison of similarly-sized multi-family housing projects. The cost for the projects can vary greatly based upon design, target tenants, and a host of other factors. The projects studied within this report were for low-income housing multi-family units, which are different from single-family houses. The design target in this case study is a specific end-user focusing on affordability and would not match the same design furnishes of a market rate complex.

This report examines the drivers of the cost increase and addresses the most common sources found through literature review. This includes the tighter or less air infiltration building envelope, costs associated with certifications and the modeling required to assess energy efficiency, and increased costs for mechanical ventilation. Assessing mechanical ventilation of Passive Houses for maintaining proper and healthy indoor air quality is an important area in the certification process. Unlike in other types of construction, in Passive House construction, air change doesn't occur incidentally through leaky building envelopes; instead, this process must be engineered through the mechanical system. The major deficiencies of this study are a lack of a detailed cost analysis of the proposed building; additionally, it lacks a cost comparison of increases for identical buildings with same floor plans, finishes, and common features when moving from base code to Passive House standards. Ideally, this cost comparison would include the modification of the required systems and materials to allow the design to reach the Passive House level while maintaining the features of the original design.

<u>Case Study 5:</u>

Title: The Economics of Zero-Energy Homes: Single-family Insights (Peterson, et al., 2019)

This report highlights the benefits of building new construction homes that are Zero-Energy (ZE) or Zero-Energy Ready (ZER). ZE represents a home that produces enough renewable energy to satisfy all its energy consumption needs. In contrast, a ZER is a home that is built to the same efficiency standards but does not produce enough renewable energy to meet its consumption needs, which can be due to a variety of reasons. The cost increases for building homes like this are 6.7 to 8.1 percent and 0.9 to 2.5 percent for ZE and ZER, respectively (Peterson, et al., 2019). These price increases are from building the entire structure to high efficiency standards. This includes highly efficient electric heating and cooling systems such as heat pumps and electric water heaters. The building envelope is also built to a higher standard for insulation with a solar ready roof.

<u>Case Study 6:</u>

Title: NAHB Priced-Out Estimates for 2022 (Zhao, 2022)

This article provides a breakdown of how price increases affect the number of households that can afford housing. The overall cost of housing, including the loan, insurance, and taxes, should not exceed 28 percent of an individual's income in order to be deemed affordable. Estimates for 2022 show an increase to the median new home price ($412,505) of $1,000 would price out 117,932 households (Zhao, 2022). In addition to the number of households that would be priced out with a $1,000 increase, 87.5 million houses or 69 percent of U.S. households are currently priced out of home purchase given the current cost of the average new home.

Appendix D: Interview Blank Form for Single-Family and Small Multi-Family Houses

Q1 Single-family & 2-4 Unit Multi-family Houses

You are invited to participate in a research study about impacts of the new Specialized Opt-in code (Net-Zero code) on housing costs and affordability. This interview should take about 30-40 minutes and aims to collect information about your current experience with building high performance/energy-efficient houses and the anticipated challenges with the new Net-Zero code. Your participation and sharing your opinions are very important for our research and are greatly appreciated. Please be advised that all publicly released results will be anonymized.

Thank you very much for your time and willingness to participate! Would you like to start the interview now?

○ YES

○ No

Skip To: End of Survey If Single-family & 2-4 Unit Multi-family Houses You are invited to participate in a research study a... = No

---

Q2 Interviewer(s):

____

Q3 Interviewee Information:

- ◯ Full Name ____
- ◯ Company's Name ____
- ◯ Job Title ____
- ◯ Email ____

Q4 Please estimate the percent of projects your company undertakes that are new construction versus remodeling: *

________ New Construction
________ Remodeling

Q5 Please estimate the percent of your company's projects in the following categories: *

________ Single-family
________ Small Multi-family (2-4 units)
________ Other (specify)

Q6 Please indicate the typical size of your projects that your company undertakes (Select all that apply):

- ◯ Under 1,000 SF
- ◯ 1,000-2,000 SF
- ◯ 2,000-3,000 SF
- ◯ 3,000-4,000 SF
- ◯ Above 4,000 SF

Q7 What sector of the home purchase market do you primarily build for?

- ◯ Publicly Subsidized
- ◯ Workforce
- ◯ Market Rate
- ◯ Luxury
- ◯ Other (Specify) ____

Q8 Please indicate the typical number of projects that you complete annually:

____

Q9 Please indicate the counties or cities in Massachusetts in which your company works:

____

____

Q10 Please indicate the typical energy sources in your projects (Select all that apply):

- ○ Heating Oil
- ○ Natural Gas
- ○ Propane
- ○ Electricity
- ○ Other (specify):

Q11 What is the typical HERS score for your projects? (Select all that apply)

- ○ Above 55
- ○ 55-51
- ○ 50-46
- ○ 45-41
- ○ Below 40

Q12 Targeting to achieve the HERS score of 42-45, how would this affect your current building processes? Please describe.

Q13 What are the most common features clients want that make it a challenge to achieve a low HERS score or to implement sustainable features?

Q14 To achieve HERS score below 45, which components of the building do you mainly focus on (e.g., walls, windows, roof, etc.)?

Q15 What are the top three (3) challenges in achieving HERS score below 45?

Q16 If you have completed all-electric homes, what are limiting factors and challenges that you faced?

____

____

Q17 Please indicate the percentage of homes that have heat pumps in your projects over the past 3 years.

	0	50%	100%
Air source heat pump (ASHP)			
Ground source heat pumps (GSHP)			
None			

Q18 If you installed heat pumps in any of your projects, what were the challenges that you faced (e.g., lack of skilled labor, limited selection, long waiting time, etc.)?

____

____

Q19 Please indicate the percentage of your projects that included EV chargers in the past 3 years.

____

Q20 Please indicate the percentage of your projects that have PV panels or built as solar ready.

____

Q21 Are you familiar with the proposed Massachusetts code updates and the new Specialized Opt-in code (Net-Zero code)?

- ◯ Extremely familiar
- ◯ Very familiar
- ◯ Moderately familiar
- ◯ Slightly familiar
- ◯ Not familiar at all

Q22 If you are familiar with the proposed Massachusetts code updates and the new Specialized Opt-in code (Net-Zero code), how do you expect these to impact your business and market?

____

____

Q23 How do you think the supply of skilled labor might affect implementation of the opt-in code? Please explain.

____

____

Q24 Have you built a Passive House? If yes, please indicate the number of projects over the past 3 years.

____

____

Q25 Do you take advantage of existing incentive programs for energy-efficient homes offered at federal and state levels? If yes, please explain which programs and how often.

____

____

Q26 What are motivating factors to pivot toward building with HERS score below 45 or Passive House besides mandatory code requirement?

____

____

Q27 What incentives or subsidies have your projects received? (e.g., MassSaves)

____

____

Q28 What local or state law or policy change would do the most to increase the affordability of your projects?

____

____

Q29 Would you mind sharing your typical profit margin and explaining what direction that profit margin moves in homes with higher levels of energy efficiency?

____

____

Q30 Is there anything else that you would like to add?

____

____

End of Block: Questions

Appendix E: Interview Blank Form for Large Multi-Family (5+ Unit) Houses

Q1 Large Multi-family (5+ Unit) Houses

You are invited to participate in a research study about impacts of the new Specialized Opt-in code (Net-Zero code) on housing costs and affordability. This interview should take about 30-40 minutes and aims to collect information about your current experience with building high performance/energy-efficient houses and the anticipated challenges with the new Net-Zero code. Your participation and sharing your opinions are very important for our research and are greatly appreciated. Please be advised that all publicly released results will be anonymized.

Thank you very much for your time and willingness to participate! Would you like to start the interview now?

◯ YES

◯ No

Skip To: End of Survey If Large Multi-family (5+ Unit) Houses You are invited to participate in a research study about impacts... = No

---

Q2 Interviewer(s):

____

Q3 Interviewee Information:

- Full Name ______________________________
- Company's Name ______________________________
- Job Title ______________________________
- Email ______________________________

Q4 Please indicate the typical project size (number of units) that your company undertakes.

____

Q5 Please indicate number of sustainable certifications that your projects received (out of total number of projects) over the past 3 years.

- BREEAM ______________________________
- Energy Star ______________________________
- Green Globes ______________________________
- LEED ______________________________
- Passive House ______________________________
- WELL ______________________________
- Other (Please specify) ______________________________

Q6 Are you familiar with the proposed Massachusetts code updates and the new Specialized Opt-in code (Net-Zero code)?

- ◯ Extremely familiar
- ◯ Very familiar
- ◯ Moderately familiar
- ◯ Slightly familiar
- ◯ Not familiar at all

Q7 Does your company have a sustainability department? Please explain.

____

____

Q8 Does your company have any incentives for personnel to become Passive House certified?

____

____

Q9 We have heard that requirements for sustainability certifications like Passive House can dissuade companies from bidding on projects. Is that your experience? If so, why? Can you comment on that?

____

____

Q10 Is it harder to estimate and prepare a bid for a large multi-family Passive House compared to conventional house? If so, why? Can you comment on that?

____

____

Q11 When preparing the bid for a large multi-family Passive House project, do you increase the construction contingency compared to traditional similar-size projects? If yes, what percentage do you add?

____

____

Q12 Have you ever been involved in a Passive House project? If yes, please describe differences, challenges, and lessons learned.

____

____

Q13 When awarding subcontractors on Passive House (PH) projects, does their past PH experience matter? If so, please describe your selection process.

____

____

Q14 What are the cost implications and challenges for Passive House (PH) projects? Do you have data about the cost variation of your PH projects compared to their conventional versions that you could share with us?

____

____

Q15 If natural gas were to be ruled out on all future projects, what issues do you foresee?

____

____

Q16 Is there anything else that you would like to add?

____

____

End of Block: Questions

Appendix F: Outreach for Completing Quote Sheets

Below is the standard email template for contacting HVAC, insulation, and electrical trade contractors and asking them to complete the quote sheets.

Dear ______,

My name is _________. I am a Construction Management student and a Research Assistant at Wentworth Institute of Technology (WIT) and contacting you today to ask your help for a research project.

The Home Builders and Remodelers Association of Massachusetts (HBRAMA) has engaged academic teams at the Massachusetts Institute of Technology (MIT) and Wentworth Institute of Technology (WIT) to conduct a landmark study on the costs of building to a net-zero standard, the impacts of the added costs on housing affordability, and policy recommendations for mitigating the cost impacts. The researchers are looking for reliable, up-to-date cost estimates for various items including HVAC, insulation, and electrical for a model single-family house, and a model small multi-family building designed to HERS 55, HERS 45 all electric (ductless), HERS 45 all electric (ducted), and HERS 42 dual fuel (ducted).

WIT research team is hoping to leverage your knowledge and experience in pricing __________ costs for these model homes. To this end, the team has created separate Excel spreadsheets for the single-family and 4-unit multi-family model homes that are attached. Your participation is very important for this research and is greatly appreciated. **Please be advised that all publicly released results will be anonymized and your company will be acknowledged in the final research report.**

If you have any questions, please do not hesitate to contact me or WIT Professors, Dr. Payam Bakhshi (bakhship@wit.edu and 617-989-4635) and Dr. Afshin Pourmokhtarian (pourmokhtariana@wit.edu and 617-989-4138).

Thank you so much again for your time and participation!

Appendix G: Outreach for Responding to Quote Surveys

Below is the email template for inviting HVAC, insulation, and electrical trade contractors to respond to the quote surveys.

Hello,

On behalf of Wentworth, MIT, and the Homebuilders and Remodelers Association of Massachusetts, we invite you to participate in a landmark study of the cost of residential construction and carbon regulation in Massachusetts.

The Healey Administration, state legislature, and policy advocates are looking forward to using the results of the study to develop actionable policy reforms to advance housing production, affordability, and sustainability.

This is a **paid research study**. For submission of complete responses, you will receive a **$100 Visa card for every response ($200 in total)** which will be e-mailed to the address included in the survey within 2 weeks. Please submit your responses by **Thursday, March 9th**.

The two surveys are at the following links:

Single-family: https://wentworth.az1.qualtrics.com/jfe/form/SV_4ZLJvGnkzixlelo

Small Multi-family: https://wentworth.az1.qualtrics.com/jfe/form/SV_b72MleuYDbfvWoC

About the Survey: This survey should not take more than 20-30 minutes. The purpose of the survey is to determine the prices (labors and materials) of certain building components of homes that meet varying energy efficiency levels (i.e., HERS scores of 55, 45, and 42). The survey asks contractors to estimate costs for those components – based on specifications for model homes designed (on paper) by the research team. Please note that parameters of the model homes along with the specs of building elements are included in the surveys.

Please be advised that all publicly released results will be anonymized and your company will be acknowledged in the final research report.

Point of Contacts: Should you have any questions about this research and survey, please do not hesitate to contact the WIT research team, **Dr. Payam Bakhshi** (bakhship@wit.edu and 617-989-4635), **Dr. Afshin Pourmokhtarian** (pourmokhtariana@wit.edu and 617-989-4138), or **Dr. John Cribbs** (cribbsj@wit.edu and 617-989-4909).

Thank you for your time and consideration!

Best regards,

Payam Bakhshi, Associate Professor of Construction Management, Wentworth Institute of Technology (WIT)

Justin Steil, Associate Professor of Law and Urban Planning, Massachusetts Institute of Technology (MIT)

Joe Landers, Executive Officer, Home Builders and Remodelers Association of Massachusetts (HBRAMA)

Appendix H: Quote Sheets

Project: Single Family Model Home
Project Location: Massachusetts
Bid Package: HVAC/Mechnical Systems

Company: ______________
Estimator: ______________
Date: ______________

Using the below information, please estimate the cost of HVAC and Mechical Systems for this single family model home under four different scenrios.
Please note that the project specs varying among the scenarios are provided in the below table.

Total Conditioned Area	**2,875 SF**	
Number of Floors	Basement+ 2 Floors+Attic	
Number of Bedrooms	3	
Number of Bathrooms	3.5	
Finished Basement (General Area, 1 Full Bath)	*540 SF*	*3 Windows, 18.0 SF*
Floor 1 (Kitchen, Living & Dining Rooms, 1/2 Bath)	*790 SF*	*8 Windows, 112.7 SF*
Floor 2 (3 Bedrooms, 2 Full Baths)	*1015 SF*	*12 Windows, 116.4 SF*
Finished Attic (General Area)	*530 SF*	*6 Windows, 45.8 SF*

Note: Please do not include any electrical work in your price. If you are including any additional work, please mention it in the "Note" box.

	Scenarios											
	Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
	Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Heating Equipment	Heating: 54,000 Btuh, 95% AFUE Furnace W/ ECM			Heating: 32,000 Btuh, 11 HSPF ASHP			Heating: 33,000 Btuh, 9.5 HSPF ASHP			Heating: 31,000 Btuh, 10.5 HSPF ASHP with 97% AFUE Propane Furnace Backup		
Cooling Equipment	Cooling: 33,500 Btuh, 13.0 SEER Central AC			Cooling: 30,000 Btuh, 20.0 SEER ASHP			Cooling: 35,000 Btuh, 16.5 SEER ASHP			Cooling: 33,000 Btuh, 16.5 SEER ASHP		
Water Heater	.95 UEF On-Demand Water Tank			3.75 UEF Heat Pump Water Tank			3.75 UEF Heat Pump Water Tank			3.75 UEF Heat Pump Water Tank		
Ventilation System	2 Continuous Exhaust Fans			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)		
Total Cost												

Project: 4-Unit Multi Family Model Home
Project Location: Massachusetts
Bid Package: HVAC/Mechanical Systems

Company: ______________
Estimator: ______________
Date: ______________

Using the below information, please estimate the cost of HVAC and Mechical Systems for each unit of this 4-unit multi family model home under four different scenrios.
Please note that the project specs varying among the scenarios are provided in the below table.

	Unit 1		*Unit 2*		*Unit 3*		*Unit 4*	
Main Floor Living Conditioned Area	1,256 SF		1,115 SF		790 SF		1,256 SF	
Upper Floor Living Conditioned Area	896 SF		1,116 SF		1,044 SF		896 SF	
Total Conditioned Area	**2,152 SF**		**2,231 SF**		**1,834 SF**		**2,152 SF**	
Number of Floors	Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors	
Number of Bedrooms	3		3		3		3	
Number of Bathrooms	3.5		3.5		3.5		3.5	
No./Area of Windows (SF): Basement	0	0	0	0	0	0	0	0
No./Area of Windows (SF): Main Floor	14	110	9	122	3	47	14	110
No./Area of Windows (SF): Upper Floor	8	133	7	83	7	83	8	133
No./Area of Windows (SF): Total	22	243	16	205	10	130	22	243

Note: Please do not include any electrical work in your price. If you are including any additional work, please mention it in the "Note" box.

Units 1, 4 (Identical) *Price Per Unit*	Scenarios											
	Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
	Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Heating Equipment	Heating: 34,000 Btuh, 96% AFUE Furnace W/ ECM			Heating: 24,500 Btuh, 11 HSPF			Heating: 27,500 Btuh 10 HSPF			Heating: 26,500 Btuh, 97% AFUE Furnace W/ ECM		
Cooling Equipment	Cooling: 27,500 Btuh, 16 SEER Central AC			Cooling: 21,500 Btuh, 20 SEER ASHP			Cooling: 23,000 Btuh 20 SEER ASHP			Cooling: 22,500 Btuh, 17.5 SEER Central AC		
Water Heater	.95 UEF On-Demand			Heat Pump water tank 3.5 UEF			Heat Pump water tank 3.75 UEF			Heat Pump water tank 3.75 UEF		
Ventilation System	2 Continuous Exhaust Fans			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)		
Total Cost												

Unit 2	Scenarios											
	Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
	Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Heating Equipment	Heating: 34,000 Btuh, 96% AFUE Furnace W/ ECM			Heating: 25,000 Btuh, 11 HSPF			Heating: 28,000 Btuh 10 HSPF			Heating: 26,500 Btuh, 97% AFUE Furnace W/ ECM		
Cooling Equipment	Cooling: 23,500 Btuh, 16 SEER Central AC			Cooling: 18,000 Btuh, 20 SEER ASHP			Cooling: 22,000 Btuh 20 SEER ASHP			Cooling: 22,000 Btuh, 17.5 SEER Central AC		
Water Heater	.95 UEF On-Demand			Heat Pump water tank 3.5 UEF			Heat Pump water tank 3.75 UEF			Heat Pump water tank 3.75 UEF		
Ventilation System	2 Continuous Exhaust Fans			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)		
Total Cost												

Unit 3	Scenarios											
	Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
	Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Heating Equipment	Heating: 27,500 Btuh, 96% AFUE Furnace W/ ECM			Heating: 20,500 Btuh, 11 HSPF			Heating: 23,000 Btuh 10 HSPF			Heating: 22,500 Btuh, 97% AFUE Furnace W/ ECM		
Cooling Equipment	Cooling: 23,500 Btuh, 16 SEER Central AC			Cooling: 18,000 Btuh, 20 SEER ASHP			Cooling: 23,000 Btuh 20 SEER ASHP			Cooling: 23,000 Btuh, 17.5 SEER Central AC		
Water Heater	.95 UEF On-Demand			Heat Pump water tank 3.5 UEF			Heat Pump water tank 3.75 UEF			Heat Pump water tank 3.75 UEF		
Ventilation System	2 Continuous Exhaust Fans			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)			Heat Recovery Ventilator (HRV)		
Total Cost												

Center for Real Estate | HBRA Home Builders & Remodelers Association MASSACHUSETTS | Wentworth INSTITUTE OF TECHNOLOGY

Project Type: Single Family Model Home
Project Location: Massachusetts
Bid Package: Electrical

Company: _______________
Estimator: _______________
Date: ___________________

Using the below information, please estimate the electrical cost of this single family model home under four different scenrios.
Please note that the electrical components varying among the scenarios are provided in the below table.
All other electrical items are assumed identical among the scenarios.

Total Conditioned Area	**2,875 SF**	
Number of Floors	Basement+ 2 Floors+Attic	
Number of Bedrooms	3	
Number of Bathrooms	3.5	
Finished Basement (General Area, 1 Full Bath)	*540 SF*	*3 Windows, 18.0 SF*
Floor 1 (Kitchen, Living & Dining Rooms, 1/2 Bath)	*790 SF*	*8 Windows, 112.7 SF*
Floor 2 (3 Bedrooms, 2 Full Baths)	*1015 SF*	*12 Windows, 116.4 SF*
Finished Attic (General Area)	*530 SF*	*6 Windows, 45.8 SF*

Components	**Scenarios**			
	Traditional Home (HERS 55)	**All Electric (Mini-Split Heat Pumps) (HERS 45)**	**All Electric (Central Heat Pump) (HERS 45)**	**Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)**
Heating Equipment	Gas Furnance	Heat Pump Condenser with Wall Mounted Fans	Heat Pump Condenser with Air Handlers	Gas Furnance, and Heat Pump Condenser
Cooling Equipment	Central AC			
Water Heater	On-Demand Water Tank	Heat Pump Water Tank	Heat Pump Water Tank	Heat Pump Water Tank
Ventilation System	2 Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Range Appliance	Gas Range	Eletric Range	Electric Range	Gas Range
Total Electrical Cost	0			
Note				

Project: 4-Unit Multi Family Model Home
Project Location: Massachusetts
Bid Package: Electrical

Company:
Estimator: ________________
Date: ____________________

Using the below information, please estimate the electrical cost for each unit of this 4-unit multi family model home under four different scenrios.
Please note that the electrical components varying among the scenarios within each unit are provided in the below tables.
All other electrical items for each unit are assumed identical among the scenarios.

	Unit 1		*Unit 2*	
Main Floor Living Conditioned Area	1,256 SF		1,115 SF	
Upper Floor Living Conditioned Area	896 SF		1,116 SF	
Total Conditioned Area	**2,152 SF**		**2,231 SF**	
Number of Floors	Basement+ 2 Floors		Basement+ 2 Floors	
Number of Bedrooms	3		3	
Number of Bathrooms	3.5		3.5	
No./Area of Windows (SF): Basement	0	0	0	0
No./Area of Windows (SF): Main Floor	14	110	9	122
No./Area of Windows (SF): Upper Floor	8	133	7	83
No./Area of Windows (SF): Total	22	243	16	205

Components Units 1, 4 (Identical) *Price Per Unit*	**Scenarios**			
	Traditional Home (HERS 55)	**All Electric (Mini-Split Heat Pumps) (HERS 45)**	**All Electric (Central Heat Pump) (HERS 45)**	**Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)**
Heating Equipment	Gas Furnance	Heat Pump Condenser with Wall Mounted Fans	Heat Pump Condenser with Air Handlers	Gas Furnance, and Heat Pump Condenser
Cooling Equipment	Central AC			
Water Heater	On-Demand Water Tank	Heat Pump Water Tank	Heat Pump Water Tank	Heat Pump Water Tank
Ventilation System	2 Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Range Appliance	Gas Range	Eletric Range	Electric Range	Gas Range
Total Electrical Cost				
Note				

Components Unit 2	**Scenarios**			
	Traditional Home (HERS 55)	**All Electric (Mini-Split Heat Pumps) (HERS 45)**	**All Electric (Central Heat Pump) (HERS 45)**	**Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)**
Heating Equipment	Gas Furnance	Heat Pump Condenser with Wall Mounted Fans	Heat Pump Condenser with Air Handlers	Gas Furnance, and Heat Pump Condenser
Cooling Equipment	Central AC			
Water Heater	On-Demand Water Tank	Heat Pump Water Tank	Heat Pump Water Tank	Heat Pump Water Tank
Ventilation System	2 Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Range Appliance	Gas Range	Eletric Range	Electric Range	Gas Range
Total Electrical Cost				
Note				

Components Unit 3	Scenarios			
	Traditional Home (HERS 55)	All Electric (Mini-Split Heat Pumps) (HERS 45)	All Electric (Central Heat Pump) (HERS 45)	Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)
Heating Equipment	Gas Furnance	Heat Pump Condenser with Wall Mounted Fans	Heat Pump Condenser with Air Handlers	Gas Furnance, and Heat Pump Condenser
Cooling Equipment	Central AC			
Water Heater	On-Demand Water Tank	Heat Pump Water Tank	Heat Pump Water Tank	Heat Pump Water Tank
Ventilation System	2 Exhaust Fans	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)	Heat Recovery Ventilator (HRV)
Range Appliance	Gas Range	Eletric Range	Electric Range	Gas Range
Total Electrical Cost				
Note				

Project: Single Family Model Home
Project Location: Massachusetts
Bid Package: Insulation & Air Sealing

Company: ______________
Estimator: ______________
Date: ______________

Using the below information, please estimate the insulation cost of this single family model home under four different scenrios.
Please note that the project specs varying among the scenarios are provided in the below table.

Total Conditioned Area	**2,875 SF**	
Number of Floors	Basement+ 2 Floors+Attic	
Number of Bedrooms	3	
Number of Bathrooms	3.5	
Finished Basement (General Area, 1 Full Bath)	*540 SF*	*3 Windows, 18.0 SF*
Floor 1 (Kitchen, Living & Dining Rooms, 1/2 Bath)	*790 SF*	*8 Windows, 112.7 SF*
Floor 2 (3 Bedrooms, 2 Full Baths)	*1015 SF*	*12 Windows, 116.4 SF*
Finished Attic (General Area)	*530 SF*	*6 Windows, 45.8 SF*

	Quantity (SF)	Scenarios											
		Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
		Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Slab	633	Uninsulated			Uninsulated			R-10 at perimeter and under entire floor			R-10 at perimeter and under entire floor		
Foundation Walls	904	R-10 fire rated foamboard			R-10 fire rated foamboard			R-15 fire rated foamboard			R-15 fire rated foamboard		
Garage Ceiling	219	R-30 insulation			R-30 insulation			R-30 insulation + R-6 foamboard			R-30 insulation + R-6		
Cantilevered Floor	150	R-30 insulation			R-30 insulation			R-30 insulation + R-6 foamboard			R-30 insulation + R-6		
Blockers & Runners	350	R-21 insulation			R-21 insulation			R-21 insulation + R-9 sheathing			R-21 insulation + R-9 sheathing		
Exterior Walls	2315	R-21 insulation			R-20 Insulation + R-6 insulated sheathing			R-20 Insulation + R-9 insulated sheathing			R-21 fiberglass batts + R-9 insulated sheathing		
Flat Ceilings	494	R-60 loose cellulose (16" deep)			R-60 loose cellulose (16" deep)			R-60 loose cellulose (16" deep)			R-60 loose cellulose (16" deep)		
Cathedral Ceilings	602	R-38 insulation			R-38 insulation			R-38 insulation + R-6 foamboard			R-49 sprayfoam		
Air Barrier & Sealing	Lump Sum	ACH50: 3.0			ACH50: 1.5			ACH50: 1.5			ACH50: 1.5		
Total Cost													

Project: 4-Unit Multi Family Model Home | **Company:** _______________
Project Location: Massachusetts | **Estimator:** _______________
Bid Package: Insulation & Air Sealing | **Date:** _______________

Using the below information, please estimate the insulation cost of this 4-unit multi familymodel home under four different scenrios.
Please note that the project specs varying among the scenarios are provided in the below table.

	Unit 1		*Unit 2*		*Unit 3*		*Unit 4*	
Main Floor Living Conditioned Area	1,256 SF		1,115 SF		790 SF		1,256 SF	
Upper Floor Living Conditioned Area	896 SF		1,116 SF		1,044 SF		896 SF	
Total Conditioned Area	**2,152 SF**		**2,231 SF**		**1,834 SF**		**2,152 SF**	
Number of Floors	Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors		Basement+ 2 Floors	
Number of Bedrooms	3		3		3		3	
Number of Bathrooms	3.5		3.5		3.5		3.5	
No./Area of Windows (SF): Basement	0	0	0	0	0	0	0	0
No./Area of Windows (SF): Main Floor	14	110	9	122	3	47	14	110
No./Area of Windows (SF): Upper Floor	8	133	7	83	7	83	8	133
No./Area of Windows (SF): Total	22	243	16	205	10	130	22	243

	Quantity (SF)	Scenarios											
		Traditional Home (HERS 55)			All Electric (Mini-Split Heat Pumps) (HERS 45)			All Electric (Central Heat Pump) (HERS 45)			Dual Fuel (Furnance and Ducted Heat Pump) (HERS 42)		
		Description	Price	Note	Description	Price	Note	Description	Price	Note	Description	Price	Note
Slab	5,333	Uninsulated			Uninsulated			R-10 at perimeter and under entire floor			R-15 at perimeter and under entire floor		
Foundation Walls	2,344	R-10 fire rated foamboard			R-15 fire rated foamboard			R-15 fire rated foamboard			R-15 fire rated foamboard		
Garage Ceiling	538	R-30 insulation			R-38 fiberglass batts			R-38 fiberglass batts			R-42 closed cell foam		
Cantilevered Floor	94	R-30 insulation			R-38 fiberglass batts			R-38 fiberglass batts			R-42 closed cell foam		
Blockers & Runners	1,623	R-21 insulation			R-21 insulation			R-21 insulation			R-21 insulation		
Exterior Walls	6,665	R-21 insulation			R-20 dense cellulose + R-6 insulated sheathing			R-20 dense cellulose + R-9 Insulated Sheating			R-20 dense cellulose + R-9 insulated sheating		
1st Flat Ceilings	4,837	R-38 insulation			R-49 insulation			R-60 loose cellulose (16" deep)			R-60 sprayfoam		
2nd Flat Ceilings	4,170	R-60 loose cellulose (16" deep)			R-60 loose cellulose (16" deep)			R-60 loose cellulose (16" deep)			R-60 sprayfoam		
Air Barrier & Sealing	Lump Sum	ACH50: 3.0			ACH50: 1.5			ACH50: 1.5			ACH50: 1.5		
Total Price													

Appendix I: Description of Relevant Programs by Building Type and Actor

Single-family/apartment homeowner

Massachusetts currently offers homeowners property tax exemptions and rebates for installing energy-efficient equipment for their homes. Residents also have access to federal programs such as Energy-Efficient Mortgages and Residential Renewable Energy Tax Credits.

Tools available in Massachusetts:

1) Energy-Efficient Mortgages[21]

   The federal government supports energy-efficient mortgages through the Federal Housing Authority and Veterans Affairs programs to increase home buying power with the purchase of a new energy-efficient home.

2) Residential Renewable Energy Tax Credit – Single-family[22]

   The federal government allows a taxpayer who owns and lives in a single-family dwelling to claim a credit for a renewable energy system.

3) Renewable Energy Property Tax Exemption[23]

   Massachusetts law provides that solar energy systems and wind energy systems used as either a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of taxable property are exempt from local property tax for a 20-year period.

Tools used elsewhere that could be implemented in Massachusetts:

1) Washington State - Energy Spark Home Loan[24]

   The Washington State Housing Finance Commission offers qualified buyers of new construction energy-efficient homes a 0.25% interest rate reduction on their home loan. Eligibility is restricted to household incomes of less than $145,000 and homes must exceed state energy standards by at least 15%.

▸ [21] https://www.hud.gov/states/massachusetts/homeownership/energy

▸ [22] https://www.mass.gov/regulations/830-CMR-6261-residential-energy-credit

▸ [23] https://www.mass.gov/doc/84-209pdf/download

▸ [24] https://www.wshfc.org/EnergySpark/

Single-family developers

Massachusetts helps incentivize construction of single-family homes aimed at low or moderate-income households in low density communities through the Community Scale Housing Initiative and Commonwealth Builder programs.

Tools available in Massachusetts:

1) Mass Save Residential New Home Construction Incentives[25]

   Mass Save promotes construction of new energy-efficient homes that are three stories or less. To be eligible, the site must be based within a territory serviced by a qualified energy provider. The building must also achieve Energy Star certification and be at least 5% or more efficient than an average home.

2) Community Scale Housing Initiative (CSHI)[26]

   The CSHI is a joint initiative of the Department of Housing and Community Development (DHCD) and MassHousing that provides funding in the form of 50-year zero interest loans for small scale projects that are between five to twenty units in municipalities with a population of no more than 200,000. 20% of the total units of the project are officially required to be below 80% AMI, although this requirement is often expected to extend to a minimum of 50% of total units. In addition, the design features must promote green building standards and increased accessibility. Note that loans are available for both single-family and multi-family developers.

3) CommonWealth Builder Program[27]

   The CommonWealth Builder Program provides market-based subsidies to support the construction of new, moderately priced single-family homes and condominiums located in Gateway Cities, the City of Boston, and other Qualified Census Tracts throughout the Commonwealth. The program subsidizes the production and purchase of homes restricted to moderate-income first-time home buyers. Income restrictions are set between 70% - 120% AMI for a minimum of seven units regardless of project size.

▸ [25] https://www.masssave.com/saving/residential-rebates/new-construction

▸ [26] https://www.mass.gov/service-details/community-scale-housing-initiative-cshi

▸ [27] https://www.masshousing.com/en/developers/commonwealth-builder

Tools used elsewhere that could be implemented in Massachusetts:

1) Washington State (WA) - Sustainable Energy Trust[28]

   The Washington State Housing Finance Commission offers low interest loans for energy efficiency or renewable energy projects through the Sustainable Energy Trust. This includes the construction of high efficiency single-family homes that exceed 15% of WA's Energy Code. Financing ranges from a preferable minimum of $50,000 to $1 million in the form the construction loans and are only available to housing developers.

<u>Multi-family developers</u>

Massachusetts offers a variety of financial incentives in the form of loan interest loans, tax credits, and/or density bonuses mostly for the construction of sustainable affordable housing projects.

Tools available in Massachusetts:

1) Massachusetts Housing Partnership's (MHP) Green Building Certification Financing (GBC)

   Designed for new and existing projects, GBC offers reduced interest rates, reimbursement for commissioning costs up to $15,000 for most certification programs, and free energy performance benchmarking services for the first two years after loan closing. Revised in 2021, GBC now offers a new tier of 40-basis point discounts for zero energy certifications. Incentives for pursuing Passive House certification line up with incentives offered by Mass Save.

2) MHP Healthy Housing Financing (HHF)[29]

   HHF offers reduced interest rates and reimbursement for the costs of obtaining healthy housing certification from the Fitwel multi-family certification program. All new construction or substantial rehabilitation multi-family projects seeking MHP financing are eligible for Healthy Housing Financing benefits.

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[28] https://wshfc.org/energy/

[29] https://www.mhp.net/writable/resources/documents/MHP-Healthy-Housing-Financing-FINAL-5-10-19.pdf

3) MHP's Climate Ready Housing Program[30]

The 2021 Commonwealth's Economic Development Bond Bill allocated $10 million to support sustainable and climate resilient affordable housing efforts over the next five years. In the first year, the program will support two to three highly rated projects that represent achievable and replicable approaches to very low carbon emissions focused on existing building renovations. New construction projects may be included in future years.

4) Mass Save Passive House Incentive[31]

The qualified utility companies of Mass Save offer incentives and assistance to support the construction of Passive House multi-family buildings (which include five or more units) with deep energy savings. Certification and performance incentives are available to assist builders and developers in achieving Passive House certification or similar levels of efficiency.

5) Mass Save Residential New Home Construction Incentives[32]

To qualify for incentives, the home must have a minimum of 5% total energy savings per unit above that of the average home. Residential new construction homes that are three stories or less are eligible if located within a Sponsor's service territory in Massachusetts.

6) Inclusionary Zoning (Somerville and Cambridge)[33] [34]

Somerville provides increased residential density for apartment buildings meeting the definition of a Net Zero Ready Building. However, note that the City of Cambridge's zoning ordinance provides an incentive for inclusionary housing, but not energy. Cambridge is also looking at eliminating single and dual family zoning.[35]

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[30] https://www.mhp.net/rental-financing/climate-ready-housing

[31] https://www.masssave.com/saving/residential-rebates/passive-house-incentives

[32] https://www.masssave.com/saving/residential-rebates/new-construction

[33] https://www.somervillema.gov/departments/programs/inclusionary-housing-program

[34] https://www.cambridgema.gov/CDD/housing/inclusionaryhousing

[35] https://www.cambridgeday.com/2022/01/05

7) Low Income Housing Tax Credit[36]

DHCD is undergoing a new draft of their Qualified Allocation Plan for the 2022-2024 affordable housing financing awards. In the current draft, Passive House projects are eligible to receive an additional five points in the category of Certified Exemplary Energy Performance.

8) Multi-family As-of-Right Zones in Massachusetts Bay Transportation Authority (MBTA) Communities[37]

In the 176 communities served by the MBTA, the state zoning law requires cities and towns to adopt as-of-right multi-family zoning ordinances or bylaws that allow for at least one multi-family district as-of-right. This requirement could potentially be expanded to include sustainable housing projects.

Tools used elsewhere that could be implemented in Massachusetts:

1) Seattle City Light – Multi-family New Construction Rebate Program[38]

Provides incentives for builders, developers, and architects who construct energy-efficient multi-family buildings.

2) Colorado Solar and Wind Easements and Rights Law[39]

Colorado's solar access laws render void any covenants, restrictions, or conditions that prohibit "renewable energy generation devices" or "energy efficiency measures". Renewable energy generation devices include solar energy devices and wind-electric generators that meet the state's interconnection standards. Energy efficiency measures include awnings, attic fans, energy-efficient lighting, and clotheslines, among other technologies.

3) City of Boulder Green Points Building Program[40]

The Boulder Green Points Building Program is a mandatory residential green building program that requires a builder or homeowner to include a minimum amount of sustainable building components based on the size of the proposed structure. New construction must be 14%-64% more

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[36] https://www.mass.gov/doc/2022-2023-qap/download

[37] https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities

[38] http://seattle.gov/city-light/construction-services/building-for-energy-efficiency

[39] https://www.cleanenergyauthority.com/solar-rebates-and-incentives

[40] https://bouldercolorado.gov/services/energy-conservation-code

efficient than 2012 IECC levels depending on building type and square footage (i.e., HERS score of 60 to 25).

4) City of Boulder Solar Grant Program[41]

The Solar Grant Program provides grants for PV and solar water heating installations on income-qualified homes, site-based non-profit organizations, and low- to moderate-income housing owned and/or developed by a non-profit organization. Individual grant amounts cannot exceed 50% of the total out-of-pocket costs for the project after all other incentives are subtracted.

5) Evergreen Sustainable Development Standard for Affordable Housing[42]

The Washington State Department of Commerce created the Evergreen Sustainable Development Standard, which is a set of green building criteria that are required for any affordable housing project applying for state funds through the Washington State Housing Trust Fund. The standard is based on a point system which awards points for a variety of sustainable building practices including:

- Site location and neighborhood planning
- Water conservation
- Energy efficiency and the incorporation of renewable energy technologies
- Environmentally conscious construction practices, building materials and improved indoor-air quality

New construction and rehabilitation projects must also earn a minimum of 50 points and 40 points from the optional measures respectively.

6) Burbank Water and Power - LEED Certification Incentive Program[43]

To help offset the cost of constructing environmentally friendly buildings, Burbank Water and Power offers a rebate program ranging from $15,000 to $30,000 depending on the level of LEED Certification a building receives.

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[41] https://bouldercolorado.gov/services/solar-grants

[42] https://www.commerce.wa.gov/building-infrastructure

[43] https://www.burbankwaterandpower.com/conservation/commercial-programs-rebates/leed-incentive-program

7) The City of Seattle Priority Green Expedited Program[44]

The program shortens the time to get a construction permit by 50% in exchange for meeting green building certification and other criteria. The program sets goals for energy efficiency, embodied carbon, indoor air quality, resource conservation, and lead hazard reduction.

Single-family/apartment renters

Massachusetts provides rebates for Energy Star appliances through various residential energy efficiency programs across the state. Renters are also eligible for tax credits and tariff-based incentives for the installation of a renewable energy and solar system on their primary residence, respectively.

Tools available in Massachusetts:

1) Residential Energy Efficiency Rebate Program - Reading Municipal Light Department[45]

Reading Municipal Light Department offers rebates to residential customers who install Energy Star appliances in eligible homes. The offer is limited to one rebate per appliance or a maximum of two rebates for programmable thermostats. Additionally, rebates are offered for energy assessments, lawn equipment, and heat pumps. Incentive amounts range from $25 to $1,000 depending on the appliance. Energy assessments are free.

2) Residential Renewable Energy Income Tax Credit[46]

Massachusetts allows a 15% credit of up to $1,000 against the state income tax for the net expenditure and installation of a renewable energy system on a primary residence. If the credit amount exceeds a resident's income tax liability, the excess credit amount may be carried forward to the next succeeding year for up to three years. Eligible technologies include solar, water and space heating, photovoltaics, and wind energy systems. The system is expected to remain in operation for at least five years.

3) SMART Program - Low Income Generation Units[47]

The Solar Massachusetts Renewable Target (SMART) Program is the state's Department of Energy Resources' (DOER) incentive program established to support the development of solar in

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44 https://www.seattle.gov/sdci/permits/green-building/priority-green-expedited-overview

45 https://www.rmld.com/my-residence/pages/residential-rebates

46 https://www.sunrun.com/solar-by-state/ma

47 https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program

Massachusetts. The tariff-based incentive is paid directly by the utility company to the system owner following the appropriate approvals of the application. Eligible units include low-income solar tariff generation units with an AC rated capacity of less than or equal to 25 kW that serve low-income customers.

Tools that can be implemented in Massachusetts:

1) New York (NY) Sun Loan Program[48]

The NY-Sun loan program is part of the broader NY-Sun Initiative to accelerate the use of solar PV across the state. In addition to cash incentives, NY-Sun Initiative also provides state sponsored low-interest financing options to install solar PV systems. Residential customers can qualify for $1,500, or up to $25,000 loans with higher cost-effectiveness standards. The repayment periods can be 5, 10, or 15 years and should be within the expected life of the installation.

2) Residential Solar Tax Credit[49]

Administered by the New York State Department of Taxation and Finance, this personal income tax credit originally applied to expenditures on solar-electric (PV) equipment used on residential property. The credit is equal to 25% percent of the cost of equipment and installation and includes solar-thermal equipment. The credit is capped at $3,750 for solar-energy systems placed in service before September 1, 2006 and capped at $5,000 for solar-energy systems placed in service on or after September 1, 2006.

Additional tools

In addition to financial incentives and policy tools, there are technical assistance grants, informational resources, and educational funds that support developers and homeowners in areas that indirectly help to achieve their sustainability goals in Massachusetts.

1) Office of Grants and Technical Assistance[50]

The Executive Office of Energy and Environmental Affairs' Office of Grants and Technical Assistance serves as a first stop for constituents seeking any sort of funding assistance.

▸ 48 https://www.nyserda.ny.gov/All-Programs/ny-sun

▸ 49 https://www.tax.ny.gov/pit/credits/solar_energy_system_equipment_credit.htm

▸ 50 https://www.mass.gov/orgs/eea-office-of-grants-and-technical-assistance

2) Office of Technical Assistance and Technology (OTA)[51]

This is a non-regulatory agency within the Executive Office of Energy and Environmental Affairs. OTA provides free, confidential, onsite technical assistance to Massachusetts businesses and institutions.

3) Real Estate Services (RES) Technical Assistance[52]

MassDevelopment works with municipal officials, planners, local stakeholders and others to provide technical assistance aimed at addressing site-specific and/or district-wide economic development challenges

4) Solar Technical Assistance Retrofit (STAR) Program[53]

Program is designed to remove barriers and dramatically increase the adoption of solar PV for affordable housing developments across the Commonwealth.

Resources

Resources for homeowners

Massachusetts has supported home buyers through resources such as the My Mass Mortgage[54] and First Time Home Buyer[55] programs. In addition, the Commonwealth Energy Tool for Savings[56] lists all the energy savings tools available to residents in Massachusetts.

Resources for developers

Community One Stop for Growth[57] is a single application portal and collaborative review process of community development grant programs that make targeted investments based on a Development Continuum. This process streamlines the experience for the applicant and better coordinates economic development programs and staff on engagement and grant making.

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51 https://www.mass.gov/orgs/office-of-technical-assistance-and-technology-ota
52 https://www.massdevelopment.com/what-we-offer/real-estate-services/technical-assistance/
53 https://www.lisc.org/boston/our-work/green-homes/star
54 https://www.mymassmortgage.org/
55 https://www.mass.gov/service-details/first-time-home-buyer-fthb
56 https://www.mass.gov/guides/massachusetts-energy-rebates-incentives#-commonwealth-energy-tool-for-savings-(energycents)-
57 https://www.mass.gov/guides/community-one-stop-for-growth

Appendix J: Listing of Relevant Incentives

Program	Tool Type	Applicable to	Description	Source
Low Income Housing Tax Credit	Tax Credit	Multi-family Rentals 2a. Subsidized	In exchange for providing development funds, the investors receive a stream of tax credits.	https://passivehousema.org/policy https://www.mass.gov/service-details/low-income-housing-tax-credit-lihtc
Residential Renewable Energy Income Tax Credit	Tax Credit	Homes for Purchase 1a. Single-family 1b. Apartments; Multi-family Rentals 2a. Subsidized 2b. Non-subsidized	The credit is available to any owner or tenant of residential property. For a newly constructed home, the credit is available to the original owner/occupant. Joint owners of a residential property shall share any credit available to the property under this subsection in the same proportion as their ownership interest.	Malegislature.org
Residential Renewable Energy Tax Credit	Tax Credit	Homes for Purchase 1a. Single-family	A taxpayer may claim a credit for a system that serves a dwelling unit located in the United States that is owned and used as a residence by the taxpayer.	http://www.energystar.gov/taxcredits
Renewable Energy Property Tax Exemption	Tax Abatement	Homes for Purchase 1a. Single-family 1b. Apartments Multi-family Rentals 2a. Subsidized 2b. Non-subsidized	Massachusetts law provides that solar energy systems and wind energy systems used as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of taxable property are exempt from local property tax for a 20-year period.	http://www.mass.gov/dor/local-officials/
PACE Financing	Financing	Multi-family Rentals (5 or more units) 2a. Subsidized 2b. Non-subsidized	Property-Assessed Clean Energy (PACE) financing effectively allows property owners to borrow money to pay for energy improvements. The amount borrowed is typically repaid via a special assessment on the property over a period of years.	https://www.massdevelopment.com/what-we-offer/key-initiatives/pace/

Program	Tool Type	Applicable to	Description	Source
Energy-Efficient Mortgages	Financing	Homes for Purchase 1a. Single-family 1b. Apartments (up to two units)	Homeowners can take advantage of energy efficient mortgages (EEM) to either finance energy efficiency improvements to existing homes, including renewable energy technologies, or to increase their home buying power with the purchase of a new energy efficient home.	Energystar.org
Residential Energy Efficiency Rebate Program - Reading Municipal Light Department	Financing	Homes for Purchase 1a. Single-family 1b. Apartments; Multi-family Rentals 2a. Subsidized 2b. Non-subsidized	Reading Municipal Light Department (RMLD) offers rebates to residential customers who install Energy Star appliances in eligible homes.	https://www.rmld.com/my-residence/pages/residential-rebates
Holyoke Gas & Electric - Residential Energy Conservation Program	Financing	Homes for Purchase 1a. Single-family 1b. Apartments (up to 4 units);	The Holyoke Gas & Electric (HG&E) Residential Energy Conservation Program provides residential customers with loans to help make energy saving improvements to eligible homes.	http://www.hged.com/customers/save-energy-money/for-home/residential-energy-conservation/default.aspx
Mass Save - HEAT Loan Program	Financing	Homes for Purchase 1a. Single-family 1b. Apartments (up to 4 units);	This financing is available to all residential customers who own and reside in a one to four family residence, obtain a Home Energy Assessment through the Mass Save Program, and install the recommended energy efficiency improvements.	Mass Save Heat Loan
MHP Green Building Certification Financing (GBC)	Financing	Multi-family Rentals (Min. 5 Units) 2a. Subsidized	Designed for new and existing projects, GBC offers reduced interest rates, reimbursement for commissioning costs up to $15,000 for most certification programs, and free energy performance benchmarking services for the first two years after loan closing.	https://www.mhp.net/rental-financing/green-healthy-financing
MHP Green Retrofit Financing (GRF)	Financing	Multi-family Rentals (Min. 5 Units) 2a. Subsidized	GRF offers increased loan proceeds, free energy audits, reduced interest rates, and free benchmarking services for the	https://www.mhp.net/rental-financing/green-healthy-financing

Program	Tool Type	Applicable to	Description	Source
			refinance and rehabilitation of multi-family projects that invest in property improvements that reduce energy and water consumption by a combined 30 percent.	
MHP Healthy Housing Financing (HHF)	Financing	Multi-family Rentals (Min. 5 Units) 2a. Subsidized	HHF offers reduced interest rates and reimbursement for the costs of obtaining healthy housing certification from the Fitwel® multi-family certification program.	https://www.mhp.net/rental-financing/green-healthy-financing
MHP's Climate Ready Housing Program	Financing	Multi-family Rentals 2a. Subsidized	The Commonwealth's Economic Development Bond Bill of 2021 included $10 million to be used to demonstrate how to support sustainable and climate resilient affordable housing over the next five years.	Commonwealth's Economic Development Bond Bill of 2021 (H5250)
Mass Save Passive House Incentive	Financing	Homes for Purchase 1b. Apartments (5 or more units); Multi-family Rentals (5 or more Units) 2a. Subsidized 2b. Non-subsidized	The Sponsors of Mass Save® offer incentives and assistance to support the construction of Passive House multi-family buildings (five units or more) with deep energy savings. Certification and performance incentives are available to assist builders and developers in achieving Passive House certification or similar levels of efficiency.	https://www.masssave.com/en/saving/residential-rebates/passive-house-incentives/
Mass Save Residential New Home Construction Incentives	Financing	Homes for Purchase (3 floors or less) 1a. Single-family 1b. Apartments; Multi-family Rentals (3 floors or less) 2a. Subsidized 2b. Non-subsidized	To calculate incentives, HERS raters create a whole-house, energy-use model of your home and compare it against a model of an average Massachusetts home. To qualify for incentives, your home must have a minimum of 5% total savings per unit above the average home.	https://www.masssave.com/en/saving/residential-rebates/new-construction
Residential & Small-Scale Biomass	Financing	Homes for Purchase 1a. Single-family	The Massachusetts Clean Energy Center offers rebates for installing small-scale central wood pellet heating systems in	http://www.masscec.com/get-clean-

Program	Tool Type	Applicable to	Description	Source
Heating Program		1b. Apartments; Multi-family Rentals 2a. Subsidized 2b. Non-subsidized	residential, commercial, public, and non-profit buildings.	energy/residential/biomass-heating
SMART Program - Low Income Generation Units	Financing	Multi-family Rentals 2a. Subsidized	The Solar Massachusetts Renewable Target (SMART) Program is DOER's incentive program established to support the development of solar in Massachusetts.	
Somerville - Net Zero Zoning Overlay district	Zoning / Land-use	Homes for Purchase 1b. Apartments; Multi-family Rentals 2a. Subsidized 2b. Non-subsidized	The permit increases residential density for apartment buildings meeting the definition of a Net Zero Ready Building.	

Appendix K: HBRAMA Stakeholder Interviews

The research team conducted interviews with the Net Zero Committee members, including:

- Dave Bauer: Division President, Massachusetts Division, Toll Brothers
- David Buckley: Director, Massachusetts Division, Toll Brothers
- Michael Moore: Senior Development Analyst, Massachusetts Division, Toll Brothers
- Brian Lupien: Vice President of Finance and Operations, Pulte Homes of New England
- Jim McCabe: President, New England Division, Pulte Homes of New England
- Rob Brennan: Managing Partner, CapeBuilt Companies
- Mike Browne: HERS Rater, Advanced Building Analysis, LLC
- Emerson Clauss III: Allegiance Construction & Development
- Russel Cole: Home Energy Remedies LLC
- Ben Fierro: Partner, Lynch & Fierro LLP
- Joe Landers: State Executive Officer, Home Builders & Remodelers Association of Massachusetts,
- Guy Webb: Executive Officer, Home Builders & Remodelers Association of Central Mass,
- Chris Flanagan: Executive Officer, Home Builders & Remodelers Association of Cape Cod
- Aaron Gornstein: President and CEO, POAH
- Julie A. Klump: Vice President - Design and Building Performance, POAH
- Ashley Stolba: Undersecretary, Executive Office of Housing and Economic Development
- William H. Grogan: President, Planning Office for Urban Affairs
- Mary Wambui: Asset Manager, Planning Office for Urban Affairs
- Hank Keating: President, PHMassachusetts Board
- Rob Dietz: Senior Vice President and Chief Economist, National Association of Home Builders

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