



Proposal for Research submitted to

Home Builders & Remodelers Association of Massachusetts

Public Policy for Net Zero Homes and Affordability

Updated Jan 18th, 2022

by MIT and WIT

Housing affordability and climate change are two of the most prominent and urgent challenges faced by the Commonwealth of Massachusetts. The Home Builders & Remodelers Association of Massachusetts (HBRAMA) is initiating academic research on policy strategies that could simultaneously advance environmental sustainability and housing affordability. Such research would not only address the state's most critical challenges, but also garner widespread attention from political leaders and the general public. The research would have immediate impact.

Background

The proposal is an initial research plan in response to the Proposal for Research released by the Home Builders and Remodelers Association of Massachusetts (HBRAMA). The HBRAMA request for proposals outlined the following research questions:

- 1) *In Massachusetts, how do the costs of building net zero and net zero ready homes compare to similar conventional homes built to the current building code? How do the costs compare for projects of different sizes, including single family and multi-family developments? This analysis would include consideration of which building reforms would be optimal (cost efficient) for the transition to net zero.*
- 2) *To the extent that costs are higher for net zero buildings, what would the impact of net zero mandates have on the affordability of housing in Massachusetts? What would the impact be on housing production and the housing shortage? The analysis would also consider the affordability of new housing built under current (baseline) regulations, pre-reforms.*
- 3) *What kinds of public policies -- local, state, and federal -- would advance the transition to net zero without fueling further price escalations and exacerbating the housing shortage?*

In 2008, the Massachusetts legislature enacted the Global Warming Solutions Act, requiring 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.

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 an emissions limit of at least a 50% reduction from 1990 levels by 2030, and at least a 75% reduction of 1990 levels by 2040 and at least net zero emissions by 2050. Section 9 of the Act instructed the EEA to establish sublimits 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 sublimits in residential heating and cooling, Section 31 of the Act instructs the Department of Energy Resources 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 sublimits.” Section 101 of the Act further instructs that in order to develop the stretch energy code, the Department of Energy Resources must hold at least 5 public hearings throughout the commonwealth, representing rural, suburban, and urban communities, including at least one hearing in a community with a high percentage of low-income households. The stretch energy code must be promulgated within 18 months.

The Next Generation Roadmap for Massachusetts Climate Policy Act builds on the EEA’s 2050 Decarbonization Roadmap and Clean Energy and Climate Plan for 2030. The 2050 Decarbonization Roadmap draws on sector specific reports, including a Buildings Sector Report, analyzing 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% 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 CO₂ (54% reduction) and by 1.30 MMT CO₂ (87% reduction) if implemented in 2023,” highlighting the importance of early action on a high-performance, net-zero building code (EEA, 2020: 6).

What this existing work fails to analyze is how much these increased efficiency requirements will cost and how they will affect housing affordability for Massachusetts households. At this time, the Massachusetts legislature is in the process of stakeholder engagement on the Net Zero stretch code for new and renovated homes with promulgation planned for 2022 or 2023. The MIT Center for Real Estate (MIT CRE) and Wentworth Institute of Technology (WIT) believe that this research project is an important opportunity to shape both housing affordability and climate policy in Massachusetts. We are excited to work with HBRAMA and other stakeholders on this research and to advance best practices in both housing development and climate mitigation. We hope that this research could become a national roadmap for these critically important issues.

Research Framework

1. Cost Comparisons

We will begin by conducting a literature review for the cost calculation. Multiple studies have been conducted around the country on the upfront cost premium of net zero buildings as well as potential cost-savings over time. We will build on these earlier studies, and generate cost estimates to reflect industry progress and technological advancement. We will then conduct interviews with builders and other stakeholders to understand the most up-to-date construction practices and opportunities and challenges on the ground for a net-zero building code. After performing a thorough literature review and conducting interviews, we are planning to create two model buildings for each typology where one meets the “anticipated” requirements of new net-zero code, and the other one is in compliance with the current code. For the items that differ among two models within each typology, we will prepare bid packages and solicit bids from 2-3 subcontractors for each proposed geographical location. Upon receiving the proposals for each bid package, a bid leveling process is performed to ensure accuracy and completeness, and the final construction cost for the package is determined. For the items that are in common among both models, we may either follow the same process or estimate their costs using cost databases such as RSMeans as the cost impact of the new net-zero code is the focus of this study. While the bids are location specific, to calculate the final construction cost for each scenario, the costs will be adjusted for time and location as needed.



To determine the current cost of net zero housing construction across the state and its implications for affordability, we propose to analyze multiple dimensions of construction costs at multiple levels of affordability. We propose looking at multiple typologies representing different levels of baseline housing market costs, different land use typologies and urban forms, different levels of carbon reduction, and different levels of affordability.

First, we believe it is important to look at different housing submarkets within the state in order to understand how housing costs and affordability are shaped by the costs of land and construction. Accordingly, we propose analyzing two different regions or submarkets across the state 1) a strong market, e.g. Greater Boston, and 2) a weak market, e.g. Springfield.

Second, we believe land use regulations, permitting processes, and the cost of labor are also important dimensions of housing cost and affordability that relate to the urban form. Accordingly, for both submarkets, we propose examining two categories of location, defined as A) urban (e.g. Boston or Springfield) and B) suburban or exurban (e.g. Lexington or Agawam).

Third, given uncertainty as to how the Commonwealth will define net zero for the purposes of building codes and the importance of increasing building energy efficiency, we propose to examine two types of building code improvements. First, a scenario (i) that primarily requires the elimination of on-site carbon generation through full electrification. Second, a scenario (ii) that increases building energy efficiency (including increased building envelope air-tightness, opaque envelope R-Values, enhanced glazing, etc) and requires energy generation, aiming for building sector energy production to meet building energy demand state-wide. As more information becomes available about the EEA's proposed Net Zero stretch code, we will tailor either the electrification or high-efficiency scenario to match it (whichever is closer to the actual code proposed).

Fourth, given the differing implications of these different definitions of net zero for different building types, we believe it is important to examine the effects on at least three different building types. There are roughly 2.9 million housing units in the Commonwealth of Massachusetts. Fifty-seven percent of those units are single-family homes, (52.1% detached homes and 5.3% attached homes). Approximately 21 percent of housing units in the Commonwealth are in 2-4 family buildings, and 21 percent in buildings with 5 or more units (including 10 percent in 5-19 unit buildings, and 11 percent in 20 or more unit buildings). Accordingly, we propose to examine construction costs in 3 building typologies:

- a. single family,
- b. small multifamily buildings (2-4 units),
- c. large multifamily buildings (5 or more units)

Together, this yields 24 combinations of housing submarkets (strong/weak), land use forms (urban/suburban or exurban), energy standards (electrification/high-efficiency), and building types (single family/small multifamily/large multifamily). Not all of these combinations will be feasible in all locations given land use regulations and market conditions and we will likely simplify this structure as we come to better understand the drivers of variation in the cost of implementing new energy efficiency regulations.

2. Impacts on housing production and affordability

To begin our analyses of the effects of these requirements on housing production and affordability, we will conduct interviews with any of the 18 members of the public policy committee of the Home Builders & Remodelers Association of Massachusetts to better understand their insights into how best to model these effects and what additional considerations to take into account. We will also review the literature on how previous building code changes and increased energy efficiency requirements have affected housing production and affordability.



We will review leading efforts to calculate affordability, such as the National Association of Realtors Housing Affordability Index for home purchasers and the National Low-Income Housing Coalition’s calculations for renters, among others. Based on these reviews, we expect to construct a model that estimates effects on housing production and housing affordability by examining the relationship of monthly housing expenses to monthly income. For renters, monthly expenses are primarily monthly rent and utilities, both of which will be affected by electrification as well as increased building energy efficiency. For home purchasers, affordability is shaped by the opportunity cost of a down payment, plus monthly expenses driven by the monthly mortgage payment, plus monthly property tax and insurance payments, plus utilities. In addition to calculating the incremental upfront cost of net zero housing we will also calculate how electrification and increased building energy efficiency will affect monthly housing costs and affect affordability, recognizing that lower-income households with less discretionary income are more sensitive to these expenses.

We will also seek to conduct case studies of the financing of recent net-zero construction in Massachusetts, such as the Bunker Hill Housing Redevelopment in Charlestown, which will be built to a Passive House standards and use cross-laminated timber. We will learn from the 25 projects that the Massachusetts Department of Energy Resources already funded through its Pathways to Zero Net Energy Program, focusing on the residential buildings and using the data in the Northeast Sustainable Energy Association Case Studies to better understand both costs and savings as well as rebates and financial incentives.

Based on those interviews, literature reviews, and case studies, we will formulate a sensitivity analysis of the above 24 typologies’ (or fewer once we better understand the level of variation) housing cost increases on affordability in 3 tiers, which we currently expect will be: 30-60% AMI (Area Median Income); 60%-100% AMI; 100% of AMI or greater. We will then calculate the affordability sensitivity in the typologies. This level of granularity will help identify the different affordability issues a net-zero building code may face for low and moderate income renter and home-purchaser households in different types of municipalities in different parts of the state and be useful in specifying appropriate policy responses.

We plan to focus on low and moderate-income households with incomes between 30 percent and 120 percent of AMI as that is where affordability pressures are highest. This broad range of incomes will enable us to examine the implications of increased cost on both prospective renters and home-purchasers in both market-rate workforce housing and housing subsidized through the Low-Income Housing Tax Credit or other funds, as well as housing that meets the requirements of Chapter 40B.

Diagram: Housing Affordability Sensitive Analysis Metrics

	Strong Urban Electrification Single family	Strong Urban Electrification Small multi	Strong Urban Electrification Large multi	Strong Urban High-efficiency Single family	Strong Urban High-efficiency Small multi	Etc.
100-120% AMI						
60-100% AMI						



30-60%
AMI

We will analyze different estimated housing costs in relation to varying income distributions of residents in the areas studied and the Commonwealth overall, with a focus on the income distribution of recent home purchasers to understand how increased costs might affect housing production and affordability. There are substantial uncertainties at the current moment in estimating both construction costs and housing affordability, including but not limited to dramatic changes in the costs of construction materials caused by pandemic related changes in supply and demand as well as changes in inflation and interest rates. We will do our best to incorporate this uncertainty into the analyses and range of estimates we produce.

It should be noted that producing a precise estimate of a statewide housing production impact as a function of construction cost increase is out of the scope of this proposal as housing production can be affected by numerous factors other than construction costs. Ideally, if we can find some estimates from literature about the elasticity of housing production with respect to housing costs, then we can directly multiply this elasticity with the costs estimated in Part # 1 of this research framework to get the outcome on housing production change. However, this elasticity is from literature with many assumptions.

3. Public Policy Analysis

To better understand what policy interventions might be able to simultaneously support progress toward a net zero residential building sector and improvements to housing affordability, we will conduct interviews with for-profit and non-profit home-builders beginning with the public policy committee of the Home Builders & Remodelers Association of Massachusetts and extending to include other stakeholders such as Community Development Corporation staff, public housing authority directors, and public officials in the Massachusetts Department of Housing and Community Development (DHCD) and MassHousing, among others. We will also seek to interview interested elected officials at the local and state level to better understand their sense of the strengths and weaknesses of different potential policy tools. These interviews will inform the public policy analysis and recommendations regarding the costs and benefits of various mitigative measures, as well as their different effects on affordability at different income levels.

Given that the Next Generation Roadmap for Massachusetts Climate Policy only requires the creation of a municipal opt-in stretch energy code that includes net-zero building performance standards, the report will also consider what policy incentives might encourage net zero construction even where local governments have not chosen to adopt the net zero code. At least until the Commonwealth makes net zero building part of the statewide base building code, incentives for net zero construction will likely be required to achieve compliance with the commonwealth’s statewide greenhouse gas emission limits.

We expect that some of the tools that could either mitigate increased costs of net zero construction or incentivize net zero construction where it is not required could include state and local tax credits, low interest loans, rebates, improvements to the Mass Save program, and potentially zoning changes or changes to other state or local housing policies, such as Chapter 40b or the Community Preservation Act. Once we have been able to analyze the role of potential policy interventions and create a draft report, we will conduct at least one workshop with the Home Builders & Remodelers Association of Massachusetts and other key stakeholders to gather feedback on our preliminary findings. We plan to invite local and state elected officials and staff to this workshop as well, to discuss the preliminary research findings and share their insights and concerns. We believe this public engagement will both



publicize some of the crucial tensions and opportunities at the intersection of building energy efficiency and housing affordability, and also help strengthen the final report by gathering broad input. We will then incorporate the lessons learned and finalize the report.

We aim to release the final report to sponsors at the end of 2022 and to the public at the beginning of 2023. MIT CRE and WIT will present research findings at the annual meeting of the National Association of Home Builders (NAHB).

Statement of Work for MIT Team

MIT CRE research team will work with WIT on the overall research design. MIT CRE is responsible for delivering the #2 and #3 part of research framework tasks.

#2 Impacts on housing production and affordability

- collaborate with WIT to organize and facilitate the kickoff meeting.
- conduct interviews with any of the 18 members of the public policy committee of the Home Builders & Remodelers Association of Massachusetts
- review the literature on how previous building code changes and increased energy efficiency requirements have affected housing production and affordability
- construct a model that estimates effects on housing production and housing affordability by examining the relationship of monthly housing expenses to monthly income
- conduct case studies of the financing of recent net-zero construction in Massachusetts
- analyze different estimated housing costs in relation to varying income distributions of residents in the areas studied and the Commonwealth overall, with a focus on the income distribution of recent home purchasers

#3 Public Policy Analysis

- conduct interviews with for-profit and non-profit home-builders, public housing authority directors, public officials in the Massachusetts Department of Housing and Community Development (DHCD) and MassHousing, interested elected officials, and other stakeholders.
- analyze the role of potential policy interventions and create a draft report, we will conduct at least one workshop with the Home Builders & Remodelers Association of Massachusetts and other key stakeholders to gather feedback on our preliminary findings.

Other Tasks:

- Organize research workshops with MIT and WIT teams
- Writing preliminary and final report
- Present research findings at the annual meeting of the National Association of Home Builders

Statement of Work for WIT Team

Wentworth research team will work with MIT CRE on the overall research design. WIT is responsible for delivering the #1 part of the research framework tasks.

1 Cost Comparisons



- collaborate with MIT CRE to organize and facilitate the kickoff meeting.
- conduct a literature review for the upfront cost premium of net zero buildings as well as potential cost-savings over time.
- build on these earlier studies, and generate cost estimates to reflect industry progress and technological advancement.
- conduct interviews with builders and other stakeholders to understand the most up-to-date construction practices and opportunities and challenges on the ground for a net-zero building code.
- create two model buildings for each typology where one meets the “anticipated” requirements of new net-zero code, and the other one is in compliance with the current code. For the items that differ among two models within each typology, prepare bid packages and solicit bids from 2-3 subcontractors for each proposed geographical location.
- determine the final construction costs. For the items that are in common among both models, the intent is to follow the same process or estimate their costs using cost databases such as RSMMeans as the cost impact of the new net-zero code is the focus of this study.
- work with MIT CRE to produce sections of the preliminary and final reports related to the #1 part of the research framework tasks, and present joint research findings at the annual meeting of the National Association of Home Builders.

Other Tasks:

- Organize research workshops with MIT and WIT teams
- Writing preliminary and final report
- Present research findings at the annual meeting of the National Association of Home Builders

Project Timeline

Jan/Feb 2021	Project contract, defining detailed research framework and start recruiting research associates
Jan – April 2022	Kickoff workshop, interviews and initial cost estimates, housing affordability sensitivity study, policy study, monthly update meeting with stakeholders
May 2022	Preliminary report
June-August 2022	Municipal workshop with key stakeholders to collect feedback from the preliminary report
Sep-Dec 2022	Continue research with feedback from key stakeholders



Jan 2023

Final report and presentation at the annual meeting of the National Association of Home Builders

Project Deliverable

The research team will lead meetings to engage with project sponsors about the ongoing research efforts:

1. **Preliminary Report:** MIT CRE and WIT will share the findings with the sponsors, get feedback to extend the depth of knowledge and understanding to expand/improve research.
2. **Municipal Workshop:** With the initial findings from the preliminary report, the MIT CRE and WIT research teams will work with HBRAMA to hold a net zero workshop or roundtable to discuss net zero building code implications for cities and towns in the state. The workshop is a platform for state and local staff, elected officials, housing experts and researchers to come together to learn and share about the research findings and questions. All the responses and feedback from the workshop will be recorded and summarized to be incorporated in the next phase of the research. This will help inform the modeling results and the policy recommendations covered in the preliminary report.
3. **Final report and presentation:** MIT CRE will prepare to publish the final report to sponsors as well as the general release to the industry in Jan 2023. MIT CRE and WIT will present joint research findings at the annual meeting of the National Association of Home Builders in Feb 2023.
4. **Shared Thought Leadership:** The project will maintain an online platform with general information about the ongoing projects to further disseminate the research findings with building industry leaders, researchers, state and municipal agencies, and the innovative businesses in Massachusetts and beyond. This will include visualizations, indices, results, summaries. Massachusetts is already a national leader and is uniquely positioned to take the next step and show the world how net-zero housing can generate big climate impact without sacrificing housing affordability.

Research Team- MIT

Principle Investigator: Prof. Justin Steil

Co-Principal Investigator: Prof. Siqu Zheng

Project Manager: Zhengzhen Tan, Research Scientist

Research Assistant: 1 Master level research associate to be recruited

Graduate Student: 1 Graduate Student to be recruited – 50%

Research Team- WIT

Principle Investigator: Prof. Payam Bakhshi

Co-Principal Investigator: Prof. Afshin Pourmokhtarian

Co-Principal Investigator: Prof. John Cribbs

Research Assistant: 2-3 Students from Construction Management Major



MIT Research Budget

	2/1/2022 - 2/1/2023
Personnel	
Summer Faculty - 1.5 month	\$31,660.83
Research Scientist 50% for 4 months	\$20,600.00
Research Assistant (1)	\$15,859.71
Graduate Student – hourly (50%)	\$10,729.36
Total Salary	\$78,849.90
Other Direct Costs	
Material and Services (website, report, workshop)	\$5,000.00
MITemp hourly employee	\$12,241.57
Tuition - RA	\$19,529
Total Other Costs	\$36,770.57
Total Direct Cost	\$115,620.47
EB+Vacation Accrual	\$14,752.88
MIT Overhead	\$16,626.65
Total	\$147,000.00

Notes:

- MIT fully supports the academic year salary of professors, associate professors and assistant professors, but makes no specific commitment of time or effort to any individual research project.
- MIT FY22 Overhead rate is 55.10% (recovery OH 15% from Dean’s office)
- Fringe Benefits and Vacation Accrual – Fringe Benefits are charged as direct costs and include Employee Benefits (EB) and Vacation Accrual (VA). Fringe Benefit rates are set by MIT at the current negotiated rates for budgeting purposes. (FY22 fixed rates: on-campus EB 24.80%, VA 8.70%). MIT charges actual rates to awards. EB is applied to total salary expenses, excluding students; VA is applied to total salary expenses, excluding faculty and students.
- The RA stipend is not subject to Employee Benefits. RA stipend is \$3,200/month for a SM student and \$3,488/month for a PhD student in FY22. Annual inflation is budgeted at 3% for all salaries.

WIT Research Budget

Description of Item	Amount	Amount Requested from	Amount Covered by
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		HBRAMA	WIT
<i>Personnel</i>			
Faculty Course Releases	\$43,750	\$43,750	
Faculty Fringe Benefits	\$11,900	\$8,604	\$3,296
Graduate Student Wages	\$12,000	0	\$12,000
Graduate Student Fringe Benefits	\$960	0	\$960
Undergraduate Student Wages	\$4,500	0	\$4,500
Undergraduate Student Fringe Benefits	\$360	0	\$360
Subtotal Personnel	\$73,470	\$52,354	\$21,116
<i>Non-Personnel</i>			
Workshops	\$1,500	0	\$1,500
Travel for Research/Professional Development	\$5,000	0	\$5,000
Subtotal, Non-Personnel	\$6,500	0	\$6,500
Total Project Budget	\$79,970	\$52,354	\$27,616