

2022-2021 Planning Workshop #1 Briefing Document

Topic 1: New Construction

INTRODUCTION

Historically, savings from new construction represents a relatively small, but impactful portion of the energy efficiency savings in Massachusetts. Incentives help support market development leading to more stringent mandatory building energy codes and improved technologies and building practices that together have increased the efficiency of new buildings over time. However, there are cost-effective opportunities to improve the efficiency of new buildings beyond minimum code requirements.

Constructing a building that does not include high levels of efficiency at the time it is built represents a “lost opportunity” for energy savings. Similarly, selecting a primary heating fuel is a key design decision. In both cases, it will likely be significantly more expensive and challenging to implement efficiency measures or equipment changes once the building is finished than during initial construction. Accordingly, efficient, and electrified new construction is critical for Massachusetts to meet its clean energy and climate goals and transition away from fossil fuels in a cost-efficient manner.

This brief identifies opportunities for improvement related to new construction program offerings in Massachusetts and provides background information to better understand the status of new construction in the State. Although the sections are divided into sections by sector, several cross-sector new construction themes and considerations are discussed. These include the impact of changing baselines on programs, developing all-electric program offerings, and encouraging incentive structures to promote deeper savings. High priority recommendations for Council consideration are numbered and identified by text boxes throughout the sections and summarized in the section below.

SUMMARY OF RECOMMENDATIONS

High priority recommendations related to new construction programs in the residential and C&I sectors are summarized below for ease of reference.

Residential

The recently completed new construction baseline study found significant increases in the efficiency of non-participant homes, which has narrowed the gap between program and non-program homes. The resulting updated Residential New Buildings Program baseline is signaling the need for an increase in program homes performance to maintain above-code savings and cost-effectiveness. Also, although there are multiple pathways to participation in the New Construction Program, there is currently no all-electric new construction offer. Without such an offer, it will be prohibitively expensive to achieve electrification for fossil-fuel heated “legacy” homes until HVAC equipment failure after around 20 years. There are clear opportunities within the program to promote all-electric home offers and to address integration with PVs, storage and active demand reduction (ADR). The section below provides specific recommendations to increase program home performance and capture additional savings opportunities from electrification.

- 1. Continue to grow the pipeline of new multi-family (5+ units) Passive House projects** since the Passive House standard provides a step up in savings.
- 2. Investigate opportunities for promoting zero-energy modular homes.** These efforts may entail working with DOER’s Zero Energy Modular Home Affordable Housing Initiative (ZE-MAHI).¹
- 3. Better characterize the non-energy impacts of fossil-free new construction.** Recent studies have shown significant health impacts from combustion appliances, including the health impacts of gas

¹ <https://ze-mahi.com/about/>

stoves.^{2,3} Properly quantifying and claiming these benefits would likely improve the cost effectiveness of all-electric new construction and or support incentives for electric induction cooktops and ranges. The PAs are starting a new NEI study later this year that will update current RNC measure and program NEIs and investigate additional NEIs, including those that may be attributable to Passive House. Although this recommendation is listed in the residential section of this document, it also applies to the C&I sector.

4. **Develop single family and low-rise multifamily all-electric program offers.** The single-family offer may be informed by similar offers in other states such as Connecticut as well as by Passive House criteria.¹ It would likely entail, at a minimum, a set of stringent prescriptive envelope and HVAC equipment criteria. The MF all-electric offer should leverage the current Passive House activities, which should remain largely unchanged. In concert with their C&I program efforts, the PAs should continue to develop and provide tools and training to promote the use of variable refrigerant flow (VRF) HVAC systems in MF buildings. VRF systems will also have high-rise building applications.
5. **Develop connected home requirements.** This may start as simply as requiring smart, Wifi thermostats or over time it might address requirements for home energy management systems and/or connected equipment such as HVAC and hot water equipment. These efforts should be leveraged by actively recruiting new homeowners to participate in the PAs' ADR efforts. As part of this connected home effort, the PAs should more seamlessly integrate already available storage, EV-charger, and PV incentives into the program. The forthcoming DPU ruling on the CLC's Cape and Vineyard Electrification Offer may further inform whether and how the Program can support PVs.

Commercial & Industrial

Increasing requirements in the energy codes has reduced the opportunity for the C&I New Buildings and Major Renovations Initiative to impact C&I new construction and building energy consumption has *not* trended down as codes have become more stringent. This led to the development of a new EUI baseline methodology for claiming savings that will be used for C&I New Construction Paths 1 & 2, which is in the process of being finalized. A focus on improving the standards for the less comprehensive new construction pathways (3 & 4) should also be a priority, as these are more likely to be smaller projects. There are clear opportunities within the program to promote high-performance HVAC systems, all-electric new construction and integration with distributed generation, storage, and active demand reduction (ADR). Below are specific recommendations to increase C&I new construction performance.

6. **Increase thresholds for participation to ensure significant impacts on building energy use through investments in very high efficiency building envelopes and electrification to avoid more costly future deep energy retrofits.**
 - a. Ensure EUI baselines used for Paths 1 and 2 are stringent enough to drive projects towards the highest efficiency achievable with modern construction practices.
 - b. Emphasize Path 1 (ZNE ready) as often as possible – including with smaller buildings that are motivated to achieve ZNE status. Include bonus incentives for electrification and reduced thermal loads by focusing on high-performance building envelope.

² Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. UCLA Fielding School of Public Health. Department of Environmental Health. April 2020.

³ Health Effects from Gas Stove Pollution. Seal, Brandy Anne and Krasner, Andee. Mothers Out Front, Physicians for Social Responsibility, Rocky Mountain Institute, and Sierra Club.

- c. Address barriers to and find means for consistently shifting new construction to all electric buildings to avoid more costly deep energy retrofits in the future.
- 7. **Run pilot projects with small or mid-size participants in the less comprehensive new construction Paths 3 & 4 that utilize modern building envelopes and high performance HVAC systems such as Variable Refrigerant Flow or Ground Source Heat Pumps paired with Dedicated Outdoor Air Systems. Include commissioning and operator training, and study project impacts on energy and non-energy benefits including:**
 - a. Energy and cost savings
 - b. Carbon emissions
 - c. Operations and maintenance costs
 - d. Indoor air quality and occupant comfort improvements
- 8. **Develop Connected Buildings offerings for all four C&I new construction paths that build ADR capabilities into the design of new buildings.**
 - a. The PAs should leverage controls for end uses like lighting and HVAC in new buildings, which are now required by code in most cases, for active demand reductions (ADR) from early in the design process
 - b. Co-market EE and DR for all customers, not just those who express an interest in ADR, to help ensure all new buildings become flexible grid assets.
 - c. The U.S. Department of Energy has coined the term “Grid Interactive Efficient Buildings”, which integrates technologies ranging from EE, to DR, to distributed generation and EV charging. The PAs should integrate the themes of this concept into the New Construction programs.⁴

RESIDENTIAL NEW CONSTRUCTION

Description

The Residential New Homes and Renovation Initiative, which constitutes the Residential New Buildings Program, provides incentives and technical resources, including training, to the new construction and to the renovations and additions (R&A) markets. The PAs launched the renovations and additions offering in 2018 and a Passive House component in 2019. The Program addresses both market rate and low-income projects.

Within the New Construction Program there are multiple pathways to participation depending, in part, on the building type, construction activity, and building size:

- **Low-Rise:** Single Family and low-rise multifamily (three stories and under)
- **High-Rise:** High-Rise (four stories or more), and low-rise multifamily buildings with master metered HVAC systems
- **Passive House:** multifamily (5 units or more)
- **Renovations and Additions**

⁴ <https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings>

The specific incentive payment structures and amounts differ for the different new construction and R&A program components, but all include a pay-for-savings (PFS) component that rewards deeper savings based on modeled energy savings.

Additional bonus incentives are available for ENERGY STAR® certification or for meeting the Department of Energy's (DOE's) Zero Energy Ready Home criteria.⁵ The top tier for 5+ unit multi-family is a Passive House component, with additional incentives provided for design, feasibility studies, energy modeling, pre-certification, and certification. Participation in the Residential New Buildings Program precludes receiving additional downstream Mass Save incentives, most notably those for HVAC and DHW equipment. Additionally, the Program includes a Codes and Standards savings component that works to increase code compliance, accelerate the adoption of more stringent energy code compliance, and promote the adoption of Stretch Codes in the Commonwealth's municipalities.

Background and Current Status

In 2019 savings from the New Buildings Program represented 8% of Residential sector lifetime electricity savings, 10% of Residential sector lifetime gas savings, and 8% of combined Residential sector lifetime MMBtu savings.⁶ The 2019 Residential New Buildings Program expenditures represented 5% of both gas and electric 2019 Residential sector expenditures. The current Residential New Buildings Program consists of four distinct program offerings as noted above: three tied to new construction and one to renovation and additions. Each of these is described in more detail below.

Figure 1 shows the distribution of Program lifetime savings, on a MMBtu base, by fuel and by year. Key takeaways from the Program's savings trends include:

- From 2013 to 2019, annual Residential New Buildings Program lifetime MMBtu savings have varied from 3.0 to 5.5 million lifetime (LT) MMBtus influenced in part by building code and related program baseline updates.

Definitions

All Electric Building (AEB): no combustion occurs in the building, all loads, including heating, are met with electric equipment.

Energy Use Intensity (EUI): measure of the operating efficiency of buildings in in kBtu/Square foot/year (EUI)

Market Effect: a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficient products, services, or practices and is causally related to market intervention(s)

Non-Energy Impacts (NEIs): benefits produced by energy efficiency measures other than energy savings, such as health and safety impacts.

Passive Building: applies the principals of Passive House (PH) to commercial buildings to reduce total loads and achieve ZNE or energy generating buildings.

User Defined Reference Home (UDRH): A home representing the average characteristics of a set of sample homes.

Zero Energy or Zero Net Energy (ZE or ZNE): generates (or acquires from a new off-site source) as much renewable energy as it consumes over a year.

Zero Net Energy Ready (ZNER): reduces energy through energy conservation measures to the point that the remaining energy can be offset with renewable energy.

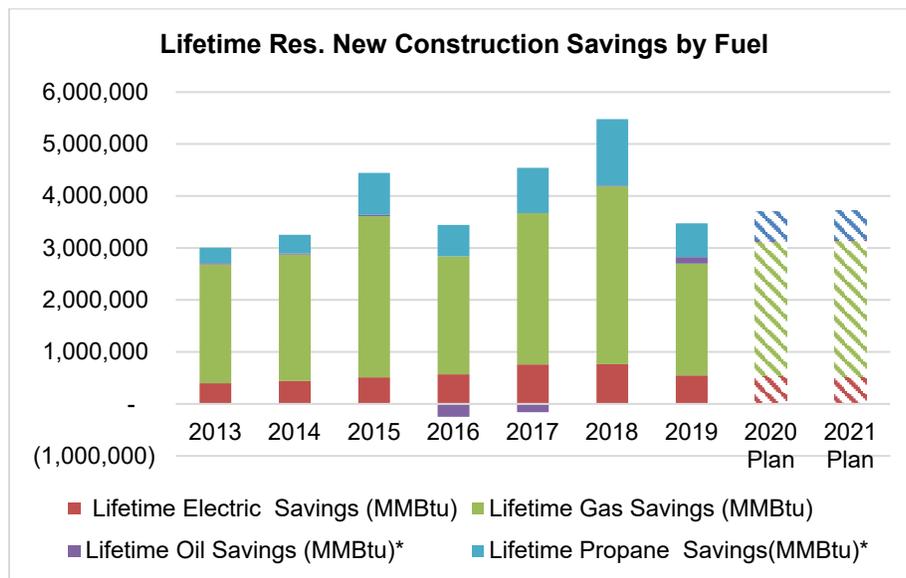
Zero Carbon Building (ZCB): all operational energy use associated with the project must be offset by new on- or off-site renewable energy. All embodied carbon emissions impacts associated with the construction and materials of the project must be disclosed and offset.

⁵ <https://www.energy.gov/sites/prod/files/2019/04/f62/DOE%20ZERH%20Specs%20Rev07.pdf>

⁶ This includes all site fuel savings from Residential programs including electricity, natural gas, oil, and propane.

- Over these seven years, 67% of the program's lifetime MMBtu savings have been from natural gas, 18% from propane, 15% from electricity and -1% from oil. This roughly reflects the market share of each fuel in residential new construction. Unlike existing homes, oil has virtually no market share, and propane and electric heat pumps compete when natural gas is not available.
- Natural gas lifetime savings have fallen from 76% of the total in 2013 to 62% in 2019, while propane savings have increased from 10% in 2013 to 19% in 2019, reaching a peak of 23% in 2018.
- Electricity savings have also increased from 13% in 2013 to 16% in 2019, reaching a peak of 18% in 2016.

Figure 1: Lifetime Residential New Construction Savings by Fuel



Consistent with the increase in program propane savings, the number of propane-heated participants has increased. In 2019 nearly a third of participating projects heated with propane (Table 1).

Table 1: 2019 Program Project Counts by Fuel Type

2019 Incentives by Heating Fuel		
Fuel	Project Count	Project Count %
Electric	696	11%
Natural Gas	3,591	57%
Oil	73	1%
Propane	1,951	31%
Wood	2	0%
Total	6,313	100%

In terms of building type participation, there was almost equal participation in the Low-Rise and High-Rise pathways (Table 2). The 11,814-program participating new units represented approximately 70% of new residential units built in 2019: 87% in stretch code municipalities and 50% in base code municipalities.⁷ While the number of 2019 Passive House completions was small (98 units), there are, as of the end of October, 5,417 Passive House units enrolled in the Program. While not all of these may achieve certification, this large number demonstrates the success of the PAs’ efforts to develop their Passive House offer.

Table 2: 2019 Program Participation by Building Type

2019 Units by Building Type		
Fuel	Unit Count	Unit Count %
Low Rise Single-Family	4,657	38%
Low Rise Multifamily	1,250	10%
High Rise	5,809	48%
Passive House	98	1%
Renovations and Additions	409	3%
Total	12,223	100%

RECENT BASELINE CHANGES TO USER DEFINED REFERENCE HOME

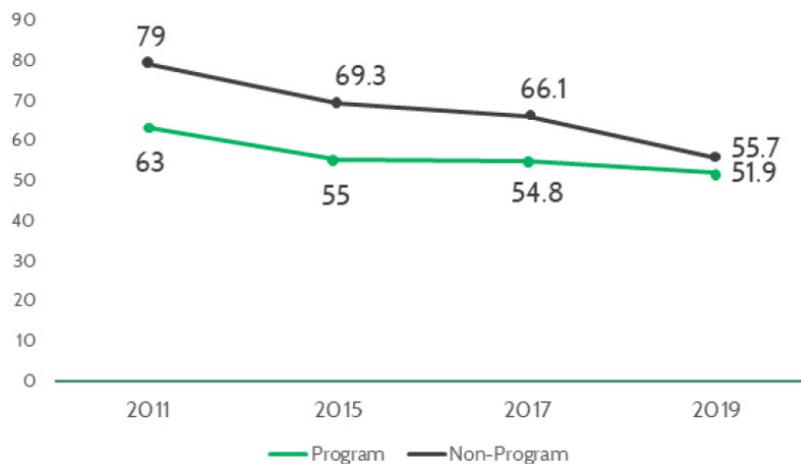
The recently completed new construction baseline study found significant increases in the efficiency of non-participant homes, which has narrowed the gap between program and non-program homes. In turn, this more efficient baseline defines the program’s User Defined Reference Homes (UDRHs) which are used as baselines for energy modeling and savings calculations. Absent any further program changes, these higher baselines will reduce the program’s cost-effectiveness, though lower savings would also be associated with lower costs.

Key findings from the most recent baseline study include:

⁷ 2019 Residential New Construction Baseline/Compliance Study (MA19X02-B-RNCBL). http://ma-eeac.org/wordpress/wp-content/uploads/MA19X02-B-RNCBL_ResBaselineOverallReport_Final_2020.04.01_v2.pdf.

- New non-program homes were 14% more efficient than homes built in 2015
- Program homes are more efficient than non-program homes, but the difference between the two has decreased significantly over the past eight years due to code upgrades and better compliance among nonparticipating homes. The difference in HERS Index scores in 2019 was only 4 points (7%) (Figure 2). The program will need to achieve deeper savings among participating homes to maintain cost-effectiveness and program relevance.

Figure 2: Difference in Non-Program and Program HERS Index Scores⁸



- Among gas and propane-heated homes, attaining program qualification was done mostly through improvements in air and duct leakage and in attic/ceiling insulation. As baseline heating equipment efficiencies were already very high, there was little observed difference in participant vs. nonparticipant heating equipment efficiencies.
- Statewide code compliance has increased to 96%

As a result of this study, the PAs have revised their low-rise modeling baselines (UDRHs). The UDRHs have been both updated to reflect improved construction and compliance practices and to address heating fuel choice. Rather than a single low-rise baseline, the PAs have developed two baselines for the low-rise building type, one for gas heated homes and a blended electric/propane UDRH as electricity and propane “compete” when natural gas is not available. For the electric/propane UDRH, improvements in propane heating equipment efficiencies are limited due to high baseline efficiencies, but there remains the ability for participant homes to install significantly more efficient heat pumps and to achieve higher PFS incentive payments as a result (Table 3).

⁸ http://ma-eeac.org/wordpress/wp-content/uploads/MA19X02-B-RNCBL_ResBaselineOverallReport_Final_2020.04.01_v2.pdf

Table 3: Impact of Heating Fuel Choice on 1-4 Unit Incentives

Space Heating Fuel	New UDRH Baseline	High performance system range	Savings and Incentive level
Electric	HSPF 9.28	HSPF 10-13.5	Significant
Natural Gas	AFUE 93.5	AFUE 95-98	Low
Propane	AFUE 97.1	AFUE 95-98	Basically zero
Heating Oil	AFUE 97.1	AFUE 80-85	None / negative

THE CURRENT PROGRAM HAS NO EXPLICIT ELECTRIFICATION OFFERINGS

PA fuel switching efforts are currently restricted to heating systems and water heating for existing homes that displace oil and propane. There is currently no all-electric new construction offer, though the PAs note that their per unit of energy savings incentive component provides a higher incentive, on a MMBtu basis, for electric savings than for fossil fuel savings. Under the current pay-for-savings incentive structure, electric saving incentives are nearly 3 times higher on a per site MMBtu basis than fossil fuel savings. However, this has not been presented to program participants in the context of energy optimization nor electrification.

For the next Three-year Plan, if not sooner, it will be critical to have a comprehensive and aggressive effort to move new residential construction from fossil fuels to all-electric space and water heating wherever practical. A failure to do so will create fossil-fuel heated “legacy” homes for which future efforts to achieve electrification through retrofit activities will be prohibitively expensive until HVAC equipment failure after around 20 years. Even then, possible initial cost savings from eliminating ductwork at the time of construction cannot be realized in a retrofit EO conversion.

A detailed study is currently underway that examines the costs and benefits of new construction Energy Optimization (EO).⁹ Unlike with current EO efforts in existing homes, this study is also examining the economics of electricity compared to natural gas. Draft findings from this study should be available around the end of the year. It is expected that all-electric new homes will compete favorably against both propane and oil from both a cost-effectiveness and customer economics perspective. However, as noted above, there is little, if any, new oil-heated new construction in Massachusetts. The economics of electrification against natural gas are more marginal. Currently, passive house multi-family typically uses electric space heating but natural gas water heating; however, work done by Rocky Mountain Institute shows favorable economics of all electric new construction compared to gas in Providence RI.¹⁰

Recommendations

As discussed more in following sections, the updated Residential New Buildings Program baseline from field evaluations is signaling the need for an increase in program homes performance to maintain above-code savings. Further, there are clear opportunities within the program to promote all-electric home offers and to address integration with PVs, storage and active demand reduction (ADR). The section below provides specific

⁹ Energy Optimization Impact and Process Study. Stage 3 Evaluation Plan. (MA20R24-B-EOEVAL). August 4, 2020.

¹⁰ MA20R23-RNC-EOcost RNC Energy Optimization Cost Study

recommendations to increase program home performance.

ADDRESS THE NEED FOR GREATER SAVINGS AMONG PARTICIPATING HOMES

With higher baselines, savings have dropped significantly among program participants. While this is in part a testament to the success of the program, lower savings also potentially threatens the program's cost-effectiveness. Greater savings will need to be achieved to ensure program relevance and viability, though this will also likely entail higher costs and marginal increases in energy savings may come at a higher cost per incremental unit of saved energy. Fully ascertaining the savings and cost impacts of achieving higher participant savings will require detailed energy modeling and cost estimation that is beyond the scope of this briefing paper.

With those caveats noted, the Consultants' recommendations to the PAs for increased energy efficiency savings are listed below.

High Priority Recommendations

1. **Continue to grow the pipeline of new multi-family (5+ units) Passive House projects** since the Passive House standard provides a step up in savings.
2. **Investigate opportunities for promoting zero-energy modular homes.** These efforts may entail working with DOER's Zero Energy Modular Home Affordable Housing Initiative (ZE-MAHI).¹¹
3. **Better characterize the non-energy impacts (NEIs) of fossil-free new construction.** Recent studies have shown significant health impacts from combustion appliances, including the health impacts of gas stoves.^{12,13} Properly quantifying and claiming these benefits would likely improve the cost effectiveness of all-electric new construction and support incentives for electric induction cooktops and ranges. The PAs are starting a new NEI study later this year that will update current RNC measure and program NEIs and investigate additional NEIs, including those that may be attributable to Passive House. Although this recommendation is listed in the residential section of this document, it also applies to the C&I sector.

Additional Recommendations

- **Consider changes to current program requirements to increase participant savings** for single family and small multi-family buildings, working within the current PFS structure:
 - **Raise the minimum threshold for percent energy savings.** Currently the minimum savings percentage is 5% in the pay-for-saving model for single family and low rise multi-family.
 - **Develop a sliding scale (or tiered structure) for either the percent savings and/or the per unit energy savings incentive components which would reward deeper**

¹¹ <https://ze-mahi.com/about/>

¹² Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. UCLA Fielding School of Public Health. Department of Environmental Health. April 2020.

¹³ Health Effects from Gas Stove Pollution. Seal, Brandy Anne and Krasner, Andee. Mothers Out Front, Physicians for Social Responsibility, Rocky Mountain Institute, and Sierra Club.

savings. Though this will add program complexity and the percent savings component already rewards deeper savings.

- **Work with the design and construction communities to increase the incorporation of Passive House principles in non-certified projects.**
- **Highlight the capital cost savings from achieving very deep savings and being able to avoid the installation of central heating and/or cooling systems and the associated distribution networks, i.e., ducts or pipes.**

PROVIDE ELECTRIFICATION PROGRAM OFFERINGS

The PAs should undertake the following, informed by the final results of the forthcoming Energy Optimization evaluation:

High Priority Recommendation

- 4. Develop single family and low-rise multifamily all-electric program offers.** The single-family offer may be informed by similar offers in other states such as Connecticut as well as by Passive House criteria.¹ It would likely entail, at a minimum, a set of stringent prescriptive envelope and HVAC equipment criteria. The MF all-electric offer should leverage the current Passive House activities, which should remain largely unchanged. In concert with their C&I program efforts, the PAs should continue to develop and provide tools and training to promote the use of variable refrigerant flow (VRF) HVAC systems in MF buildings. VRF systems will also have high-rise building applications.

Additional Recommendations

- **Investigate the economics of geothermal systems in low load buildings and integrate these systems into the program offers as appropriate.** Geothermal systems may be most appropriate for multi-dwelling buildings or complexes, but there is also an emerging market in larger single-family homes.
- **Develop trade ally trainings and other tools to overcome the unfamiliarity and potential reluctance by architects, HVAC contractors, and builders to embrace and promote all-electric new homes.** This effort should include trainings and tools for the R&A market where the application of ductless minisplits may be common. The PAs have developed a robust and successful set of Passive House trainings and tools and should build on these for other building segments. The PAs' efforts should also include working with the next generation of trades peoples through the Commonwealth's vocational schools.
- **Investigate opportunities to use the ZE-MAHI to promote lower cost, all-electric new homes.**
- **Provide trainings and tools to architects, HVAC contractors and builders to pursue electrification during R&A activities.** Consider providing a bonus incentive to promote these outcomes.
- **Develop tools to overcome expected customer resistance to displacement of gas cooking equipment.¹⁴**

¹⁴ Induction Cooktops. Presentation at 2020 ENERGY STAR Partners Meeting. Ali Cafferty. B/S/H/ Home Appliances Corporation. October 2020.

- **Work to accelerate the commercialization of central heat pump water heating systems.**

DEVELOP A NEW CONSTRUCTION PROGRAM OFFER THAT INTEGRATES ENERGY EFFICIENCY WITH ACTIVE DEMAND REDUCTION AND RENEWABLES

The PAs' current RNC program is almost entirely focused on energy efficiency. To better address demand response and resiliency, the program should consider the following:

High Priority Recommendation

5. **Develop connected home requirements.** This may start as simply as requiring smart, Wifi thermostats or it might address, possibly over time, requirements for home energy management systems and/or connected equipment such as HVAC and hot water equipment. These efforts should be leveraged by actively recruiting new homeowners to participate in the PAs' active demand response (ADR) efforts. As part of this connected home effort, the PAs should more seamlessly integrate already available storage, EV-charger, and PV incentives into the program. The forthcoming DPU ruling on the CLC's Cape and Vineyard Electrification Offer may further inform whether and how the Program can support PVs.

COMMERCIAL & INDUSTRIAL NEW CONSTRUCTION

Description

The C&I New Buildings and Major Renovations Initiative (here on simply referred to as C&I New Construction initiative) supports energy efficiency in ground-up new construction, major renovation, and additions to commercial and industrial facilities. The C&I New Construction initiative is critically important for achieving high efficiency and electrification of new buildings as the Commonwealth shifts away from fossil fuels to meet climate goals. The C&I New Construction initiative has undergone a substantial redesign that lays the groundwork to shift focus to high efficiency new construction. Effective in the summer of 2020, C&I New Construction initiative includes four pathways¹⁵ (described below) for participation with a goal of moving the market towards ZNE and ZNER buildings and enabling the C&I New Construction initiative to claim savings for moving customers to lower energy HVAC systems such as ground source heat pump or electric heat pump systems.

- **Path 1—Zero Net Energy/Deep Energy Savings:** Works with customers from project concept to set EUI performance targets and supports contracting of design and construction teams charged with delivering a project that meets the target. Incentives are provided on a square foot basis for design, technical assistance, verification, construction, achieved performance and certification (either ZNE or PH/PB). Savings are calculated from either a stipulated EUI or from a project specific EUI based on modeling, potentially enabling savings to be claimed for fuel switching to electric heating sources. Savings are determined at the end of design for base incentives and post occupancy incentives are provided based on achieved EUI using actual performance data. Participants commit to commission the building to levels

¹⁵ https://www.masssave.com/-/media/Files/PDFs/Business/New_Construction_Program_Pathways_Overview.pdf?la=en&hash=E897D6D29C2DAC8B8CDA055C678A1D20A25CC3A0

- equal to LEED Fundamental, Enhanced and Envelope commissioning. (Serves buildings 20,000 square feet and larger.)
- **Path 2—Whole Building EUI Reduction:** Similar to Path 1 without the focus on ZNER or on achieved performance. Incentives are the same as that offered for Path 1 except lower achievement bars are set and there is no incentive available for post occupancy achievement. Savings calculations are the same as Path 1. Incentives are tiered based on EUI savings with the maximum incentive being equal to the base incentive for Path 1. Participants may take advantage of the Verification Incentive offered under Path 1 if they complete LEED Fundamental commissioning. (Serves buildings 50,000 square feet or larger.)
 - **Path 3—Whole Building Streamlined:** Assists customers in designing and building more efficient buildings by providing technical assistance and incentives. Custom and prescriptive incentives are calculated based on measures and savings. The path uses a spreadsheet rather than energy modeling to estimate incremental savings relative to energy code baselines. Similar to prior approaches but streamlined to facilitate faster project turn-around by the PAs and reduce initiative and customer costs. (Serves buildings 20,000 – 100,000 square feet that are not energy intensive.)
 - **Path 4—Systems:** Provides prescriptive incentives for projects installing equipment that exceeds code baselines. Standard incentives and savings are prescriptive based on the TRM. No change from prior offerings. (This path more accurately addresses equipment rather than systems). (Typically serves buildings 20,000 square feet or less and projects that engage late in design or during construction.)

Paths 1 and 2 represent a new approach to supporting new construction projects, focusing on building EUI rather than prescriptive elements of the Energy Code to establish savings. They were developed to move the market towards ZNE and Passive buildings by increasing the familiarity of development, design, construction, and operations professionals with estimating and then verifying the EUI performance of participant buildings. The implementation and evaluation team involved in the program redesign anticipate that the new approaches may result in verifiable market effects in which the at least some of the anticipated market shift to ZNE and Passive buildings will be attributable to the program.

Background and Current Status

Massachusetts has nearly 1.8 billion square feet of existing commercial and industrial buildings. By 2050 new building square footage may increase by 34% over 2019 building area¹⁶ potentially resulting in the addition of over 600 million square feet of new buildings in the State. Massachusetts was estimated to have approximately 79 million square feet of new commercial and institutional space under design and construction between 20017 and 2019.¹⁷ New buildings contribute significantly to greenhouse gas emissions and offer an opportunity for the state to minimize those impacts.

As the energy code has become more stringent, the opportunities for the Massachusetts Program Administrators (PAs) to claim savings and provide incentives for equipment-based efficiency improvements have decreased. Like other offerings, new construction incentives in the past were heavily supported by lighting efficiency improvements. More stringent codes and the fact that LEDs are industry standard practice in new construction have greatly reduced the savings available for lighting efficiency. However, the largest load in most Massachusetts commercial buildings is space heating. Driving down heating and cooling loads and meeting them with more efficient and lower GHG emitting systems are keys to ensuring that new buildings do

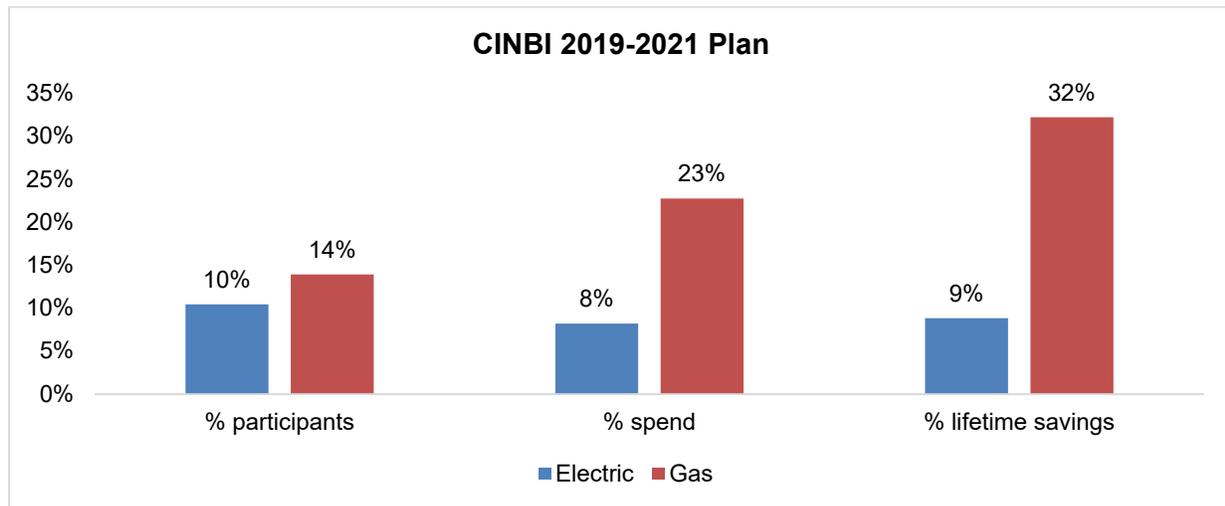
¹⁶ <http://css.umich.edu/factsheets/commercial-buildings-factsheet>

¹⁷ MA NRNC Market Characterization Study, October, 2019, Table 3-3.

not require major retrofits to meet the State's climate goals in the coming decades. Delivering a ZNER Building starting from scratch in new construction will be immensely more cost-effective than returning to a relatively new building for a deep energy retrofit in the future.

In the current plan the New Construction initiative comprises less than 10% of the electric participants, spending and savings and nearly a third of the gas savings.

Figure 3: C&I New Buildings and Major Renovations Initiative 2019-2021 Planned Participants, Spending, and Savings



C&I New Construction initiative investments and savings are a function of the amount of new construction occurring in the market and ability of the energy efficiency programs to engage the market to design, build and operate low energy consuming buildings. The Massachusetts Energy Code establishes a baseline for energy efficiency that dictates minimum efficiencies with generally increasing requirements over time. The Energy Code historically has permitted tradeoffs that enable developers to significantly exceed the maximum allowed glazing area requirements by installing more efficient HVAC and lighting systems to offset the energy use due to extensive glass facades. These options remain in the International Energy Conservation Code (IECC) 2018 update that takes effect this November. The 2018 Code increases energy efficiency requirements by about 8% over the current code, limits trade-offs to require minimum building envelope requirements, and will be implemented effective November 7, 2020.¹⁸

Analyses of energy use intensity (EUI) for new construction projects in Massachusetts completed between 2010 and 2019 found that EUIs trends did not correlate with increased energy efficiency requirements in the Energy Code¹⁹ (i.e. building energy use is not going down as codes become more stringent). A study of participants in the Comprehensive Design Assistance offering found that participant buildings typically had higher EUIs than existing buildings constructed to less rigorous energy codes.²⁰ While building energy codes

¹⁸ The MA amended IECC Commercial Energy Code was planned to go into effect 2/7/20 with a concurrency period through 8/7/20, however, due to COVID-19/MA State of Emergency, the Board of Building Regulations and Standards (BBRS) voted to extend the concurrency period by 3 months. It will be effective November 7, 2020.

¹⁹ MA NRNC EUI Revised Results - MA19C12-B-NCEUIBSLN page 6

²⁰ http://ma-eeac.org/wordpress/wp-content/uploads/MA_CIEC_Stage5_Report_P56_Custom_CDA_Final-Report_180514.pdf, Figure 4-5 Page 25.

create more stringent criteria for new construction in terms of design efficiency, modern commercial buildings may provide a greater amount of building services and have higher occupancy rates compared to older building stock. Many older commercial buildings deliver what would be considered below-code ventilation by current standards and may have fewer plug loads. This can create challenges for an apples-to-apples comparison of buildings across different vintages.

Looking to the future of the C&I new construction market, we expect a shift to Zero Net Energy buildings and ultimately the inclusion of carbon accounting for the building construction in addition to operations. Tools already exist to assess, minimize, and offset the greenhouse gas impacts of construction.²¹ This type of accounting would move the market to developing Zero Carbon Buildings which are net carbon sinks, including the construction impacts, over the life of the building. Efficiency programs will have an important role to play in this transition and should account for how changing construction practices may impact program delivery.

BASELINE

As discussed above, increasing requirements in the energy codes has reduced the opportunity for the C&I New Construction initiative to impact C&I new construction and building energy consumption has *not* trended down as codes have become more stringent. This led to the development of a new EUI baseline methodology for claiming savings that will be used for C&I New Construction Paths 1 & 2. Considerable research and development has gone into establishing the baselines for Paths 1 and 2 including initial data compilation and analysis using billing and tax data for new buildings constructed in Massachusetts from 2010 to 2018 to establish EUI ranges by building type.²² A working group including PA representatives, EEAC consultants and evaluation professionals was convened to develop baseline EUIs for use in Paths 1 & 2. A draft memo has been published but is still under review by the PAs at this time. The current recommendation is for EUI baselines as follows:²³

Table 4: Recommended EUI Baselines

Building Type	Recommended Site EUI Baseline (kBtu/ft ²)
Multifamily	45
Offices	65
Medical Office	65
Hotel	75
Supermarket/Grocery Store	200
Library	80
Fire/Police Stations	108
K-12	65

Until the baselines and approach are finalized for Pathway 1 and 2, participants will likely use a project specific baseline, generated from building models to calculate savings.

There are challenges with establishing baseline system types. The Energy Code stipulates baseline system

²¹ <https://living-future.org/zero-carbon-certification/>.

²² Report will be available on EEAC website.

²³ Draft MA20X02-B-EUIBASE_Interim Memo_2020.10.01

types that one should use in modeling energy savings for buildings. In the past the C&I New Construction initiative has not claimed savings for changes in system type. This means that if a building is designed with a high efficiency heat pump system, the C&I New Construction initiative has claimed savings for the incremental improvement in efficiency within that system type, even if C&I New Construction initiative helped to guide the customer away from the more traditional fossil fuel heating and industrial chiller or direct expansion cooling systems to a more efficient, low/no carbon system. Using an EUI baseline approach will address these issues.

A critical baseline consideration is whether the C&I New Construction initiative should be using site or source EUI. Source EUI attempts to capture the losses associated with the generation and transmission of electricity and the transmission of natural gas. Natural gas is considered a primary energy source and its source EUI does not address the energy consumed in mining, transporting, and refining crude products; it simply accounts for the losses once the natural gas is in the pipeline.²⁴ In addition, Massachusetts is working to transform its electric grid meaning that the source conversion factors of the future will be significantly different from the current model.

The C&I New Construction initiative will use site energy consumption in establishing EUIs for the customer, who is primarily interested in performance at the building. The use of site energy for customer analysis and reporting will support the electrification of new construction consistent with MA climate and energy goals. A broader discussion on whether site or source energy will be used to claim savings will be part of future EEAC planning discussions focused on 2022-2024 goals.

In jurisdictions that prohibit new natural gas service connections, the baseline fuel will be electric and EUI site baselines will be adjusted to reflect electric only baselines (which are typically lower than electric/fossil site EUIs).

IMPACT OF CODE ADVANCEMENT ON PROGRAM

Massachusetts is one of several states working to establish ZNE minimum standards under their Energy Codes.²⁵ The Massachusetts Board of Building Regulation and Standards is currently reviewing a commercial code proposal that would require any combination of on-site and off-site renewable energy purchases to achieve either net-zero energy or net-zero emissions, and the same proposal is an optional appendix in the forthcoming IECC2021 commercial energy code. While achieving net-zero implies increases in energy efficiency, the renewable and efficiency components of the code are separable, and likely to be treated differently by Mass Save programs. As the codes increase in stringency and the market transforms, the C&I New Construction initiative would no longer have an opportunity to provide incentives and claim savings. However, a shift to renewable energy supply would not necessarily drive efficiency improvements absent program incentives. The market effects framework established under the C&I New Construction initiative's redesign will attempt to give the C&I New Construction initiative credit for its contribution to shifting the market to enable successful adoption and implementation of greater energy efficiency within ZNE codes. However, if the C&I New Construction initiative essentially follows the market, working with innovators and early adopters and failing to move the majority to adoption of ZNE and Passive Building practices before these practices are mandated by Code, the C&I New Construction initiative will likely have minimal opportunity to claim market

²⁴ <https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf>, Page 4

²⁵ MA is one of several states and cities participating in an ICC hosted sub-committee on net-zero codes.

effects.

Figure 4: Market Adoption Curve



 riable.com/adoption-curve

Market adoption curve, Diffusion of Innovation

MARKET EFFECTS

Market effects are measurable changes in the market that occur over time caused by program activities. Ideally the C&I New Construction initiative would support the transformation of the new construction market to a ZNE standard practice over the next decade. In seeking to achieve such a change, the PAs are effectively working themselves and energy efficiency out of a role in C&I New Construction. Measuring the impact of the C&I New Construction initiative on the market enables measurement and attribution of the benefits generated by the C&I New Construction initiative beyond those derived from direct participants. The establishment and quantification of market effects require a framework at inception that includes:

- Creating a program logic model indicating the program activities and their intended effects on both participants and the broader market, establishing causal pathways for effects.
- Assessing the baseline for the planned effects at the start of program activities. This includes surveys of market actors expected to be impacted by the program to establish current practices, awareness, and knowledge.
- Evaluating changes in current practices over time and assessment of the impact of the C&I New Construction initiative on those changes, again through surveys of market actors.
- Quantifying the impact of the program intervention on practices that delivery energy savings for an appropriate period of time.

Market effects will be evaluated in the short, mid and long term. Some expected effects from the program include:

- Short term: increased understanding of EUI, reduced EUI in participant buildings, improvement in market actor practices
- Mid-term: reduced EUI in market overall, increased number of ZNE/Passive building, improved building resiliency to outages
- Long term: changes in building codes, emissions reductions, market transformation

A study to establish baselines for these market effects is currently underway.

Recommendations

The updated C&I New Construction program redesign and implementation needs to account for rapidly changing building practices, code enhancements and a need to decarbonize the built environment. There are clear opportunities within the program to promote high-performance HVAC systems, all-electric new construction and integration with distributed generation, storage, and active demand reduction (ADR). The section below provides specific recommendations to increase C&I new construction performance.

High Priority Recommendations

- 6. Increase thresholds for participation to ensure significant impacts on building energy use through investments in very high efficiency building envelopes and electrification to avoid more costly future deep energy retrofits.**
 - a. Ensure EUI baselines used for Paths 1 and 2 are stringent enough to drive projects towards the highest efficiency achievable with modern construction practices.
 - b. Emphasize Path 1 (ZNE ready) as often as possible – including with smaller buildings that are motivated to achieve ZNE status. Include bonus incentives for electrification and reduced thermal loads by focusing on high-performance building envelope.
 - c. Address barriers to and find means for consistently shifting new construction to all electric buildings to avoid more costly deep energy retrofits in the future.
- 7. Run pilot projects with small or mid-size participants in the less comprehensive new construction Paths 3 & 4 that utilize modern building envelopes and high performance HVAC systems such as Variable Refrigerant Flow or Ground Source Heat Pumps paired with Dedicated Outdoor Air Systems. Include commissioning and operator training, and study project impacts on energy and non-energy benefits including:**
 - a. Energy and cost savings
 - b. Carbon emissions
 - c. Operations and maintenance costs
 - d. Indoor air quality and occupant comfort improvements
- 8. Develop Connected Buildings offerings for all four C&I new construction paths that build ADR capabilities into the design of new buildings.**
 - a. The PAs should leverage controls for end uses like lighting and HVAC in new buildings, which are now required by code in most cases, for active demand reductions (ADR) from early in the design process
 - b. Co-market EE and DR for all customers, not just those who express an interest in ADR, to help ensure all new buildings become flexible grid assets.
 - c. The U.S. Department of Energy has coined the term “Grid Interactive Efficient Buildings”, which integrates technologies ranging from EE, to DR, to distributed generation and EV charging. The PAs should integrate the themes of this concept into the New Construction programs.²⁶

ALL ELECTRIC BUILDINGS

A significant step in reducing the impact of buildings on greenhouse gas emissions is to eliminate the

²⁶ <https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings>

combustion of fossil fuels on site. To meet climate goals, the electrification of commercial buildings and even industrial processes²⁷ must accelerate as the grid shifts to renewable fuels. In the new construction market building electrification is a cost-efficient method of achieving ZNE and Passive buildings. The approach includes optimizing the performance of the building envelope to reduce heating and cooling loads, reducing interior loads by installing efficient process equipment such as computers and decoupling ventilation from heating and cooling in the HVAC system design. In traditional commercial construction, the ventilation system distributes fresh air and heats and cools spaces. Air is the least efficient means for transferring heat in buildings and the combustion of fossil fuels for heating generally ranges from 70-90% efficiency.

The HVAC approaches used in Passive and ZNE buildings typically include heat pump systems including ground source, air source and variable refrigerant flow systems. These systems efficiently address the heating and cooling loads in a space using refrigerant or water as the distribution medium, which has a much greater ability to transfer heat than air or steam-based traditional HVAC systems. Additionally, heat pump water heaters and on demand electric water heaters are applicable for many commercial applications.

The addition of Paths 1 & 2 to the C&I New Construction initiative is a step towards leading the market to new, more efficient construction practices. That said, there is already considerable market activity by innovators and early adopters in the ZNE and Passive building sphere. The Massachusetts Green Building Council recently published a report on the barriers to ZNE Buildings in Massachusetts²⁸ that included recommendations to address the barriers and included examples of some of the existing ZNE buildings. The report includes analysis of the financial breakeven point for achieving ZNE for six different building types. It also identifies barriers to ZNE buildings, some of which the redesigned C&I New Construction initiative are intended to address such as first cost challenges and lack of market familiarity with ZNE approaches. Other opportunities for evolution in C&I New Construction initiative are outlined below.

High-performance building envelopes include optimized levels of insulation and reduced air infiltration enabling heating and cooling system capacity to be reduced increasing cost effectiveness and enabling air-source heat pumps to meet the winter heating loads on the coldest days of the year. In addition to addressing envelope, HVAC loads can be lowered by decoupling ventilation and space conditioning, for example by using a dedicated outdoor air system (DOAS) to deliver fresh air for occupants and heat pump systems for heating and cooling. DOAS systems include energy recovery to capture the heat or cool from the exhaust air stream and use it to precondition the intake air.

Path 1 of the C&I New Construction initiative will likely include participants that incorporate many of the elements described above. Case studies and promotion of these buildings, including benefits and costs will assist the New Construction initiative in educating the market and increasing adoption of high-performance building practices. Most recommendations regarding electrifications are covered in high-priority recommendations, additional consideration should be given to the following recommendation:

- **Work with participants in Paths 2-4 to increase adoption of these practices to accelerate market change and increase savings for the C&I New Construction initiative.**

PERFORMANCE VERIFICATION

While Path 1 requires a significant level of commissioning, the current program design does not effectively promote building commissioning. The commissioning authority can be a strong ally to energy efficiency if engaged as part of the team supported by incentives. High quality, independent commissioning is a critical part of the solution for achieving verifiable savings and transforming the new construction market.

²⁷ <https://www.cnbc.com/2019/12/07/first-us-steel-plants-powered-by-wind-solar-energy-are-coming.html>

²⁸ <https://builtenvironmentplus.org/wp-content/uploads/2019/09/ZeroEnergyBldgMA2019.pdf>

Commissioning services that provide the in-depth verification of designs, construction, programming and operation of complex systems can be difficult to find. In other regions (NY, VT, CA, Chicago, WA for example) establishing and developing the commissioning market has been a key focus of C&I new construction programs. By explicitly focusing on and promoting commissioning, EE programs can establish a solid market for the services and enable commissioning firms to develop the resources that enable the growth and quality of services delivery over time.

By using the language “commissioning” and educating the market, both providers and customers, as to its meaning, the C&I New Construction initiative can accelerate its market effects. Commissioning providers work on many more projects in a year than design engineers or contractors, making them an excellent vector for disseminating best practices. For Path 1, designating the commissioning provider as the verification entity provides an independent party to ensure results are valid and transparent. The New Construction initiative should provide robust commissioning incentives from concept through operations and consider including performance bonuses for commissioning providers. Effective Mechanical, Electrical and Plumbing (MEP) Commissioning of most major new construction projects to LEED Enhanced level typically costs between \$75,000 and \$200,000 with approximately a 60% adder for envelope commissioning²⁹.

Building envelope commissioning is essential to the performance of our commercial building stock, just as Home Energy Rating System (HERS) raters are essential to ensuring the performance of residential building envelopes. Building envelope commissioning should be the norm for new construction projects completed in the 2020s and beyond. It is much less expensive to make the building envelope work correctly when one is in design and construction than it is to go back and fix buildings after the fact.

Monitoring-based commissioning includes a detailed monitoring plan, design of an energy monitoring and reporting system, establishment of performance benchmarks, commissioning the system to ensure it operates correctly and regular performance benchmarking and tuning over the life of a building. This approach will ensure sustained savings over the long-term and will help operators identify and correct performance faults.

Because savings are claimed based on estimates (and verified performance in Path 1), the PAs do not have a direct claimable benefit from supporting commissioning. However, in some initiatives the PAs claim less than 100% of savings and attribute the final 10-20% of savings to commissioning. Incorporating these commissioning recommendations will improve savings realization rates, increase customer satisfaction, accelerate market education, and propagate market effects. These benefits are all targets of the EE funding.

Specific recommendations include:

- **Recognize and promote the value of quality third party MEP and envelope commissioning.** Opportunities to support commissioning include providing education/training, establishing clear standards, providing incentives for commissioning and working directly with the industry and customers to increase recognition of quality third party commissioning.
- **Support monitoring-based commissioning including planning, infrastructure and implementation.**

FINANCIAL INDUSTRY RISKS AND REWARDS

The current financing paradigm for new construction does not typically support the development of ZNE buildings. Lenders use industry comparisons to establish the \$/square foot market value of the property under

²⁹ Estimate by Jennifer Chiodo, PE who has 15 years' experience managing a commissioning services firm. Numbers vary widely by project.

development and provide construction financing based on those figures. There is a lack of comparable ZNE, Passive and ZNER buildings on the market and the real estate industry assigns no value to on-site renewable energy generation.

Life cycle costs are not considered, so even if investment in ZNE is cash flow neutral or even positive, the cash flow is not typically considered in the lending determination. Construction financing requires highly compressed project timelines. Lender imposed schedules fail to consider the benefit of adequate time to conceptualize, analyze and optimize projects. It is extremely common to have large commercial new construction projects go out to bid before the Mechanical, Electrical and Plumbing design is complete and for buildings to be turned over before they are commissioned due to these compressed schedules.

To overcome these barriers, the PAs should:

- **Work with financial institutions to recognize the benefits of ZNE/ZNER and passive buildings and provide favorable lending for these projects, including allowing for adequate design, construction, and M&V periods.**

MARKETING

The market is moving towards resiliency and responsibility regarding contributions to climate change; C&I New Construction initiative web pages and materials should create pull towards ZNE practices as a means for building a resilient and sustainable future. The current approach seems to invite those who have already set ZNE building as a goal to participate. To truly influence the market, the C&I New Construction initiative will have to aggressively pursue participation by those who hadn't started out planning to go the ZNE route. Building envelope improvements can help increase resiliency by maintaining stable internal building temperatures during times of power outages. These features should be promoted as an added benefit of ZNE buildings. To increase participation, the PAs should:

- **Invest in effective marketing including promotional materials that appeal to researched market drivers such as increased occupancy satisfaction, lower operating costs, low vacancy rates and contributions to sustainability and resiliency often associated with high performance, sustainable buildings.** Marketing should appeal to the underlying customer motives, creating pull towards the program offering. Conduct post occupancy studies to understand, quantify and document the benefits of participant approaches.

From the MASS SAVE Website 10/13/20 Under Path 1:

“...If you are planning a ZNE commercial or industrial building project, receive the highest level of incentives to offset project costs, as well as resources and tools to help you achieve a very low energy use intensity (EUI) and ultimately, zero-net energy success...”