

Massachusetts Electric Company
and
Nantucket Electric Company
each d/b/a National Grid

2020 Energy Efficiency
Plan-Year Report

D.P.U. 21-70

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Submitted to:
Massachusetts Department of Public Utilities

Submitted by:
nationalgrid

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National Grid**

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APPENDIX 1

Significant Core Initiative Variances & Cost-Effectiveness

Program Administrator-Specific Narrative Explanations for Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid (together, the “Program Administrator” or the “Company”) are as follows.

I. RESIDENTIAL PROGRAMS

The actual 2020 benefit-cost ratio for the Residential sector is 2.23.

A. RESIDENTIAL NEW BUILDINGS

The actual 2020 benefit-cost ratio for the Residential New Buildings program is 3.56. The projected benefit-cost ratio for the 2019-2021 plan term is 2.97 after accounting for actual results from 2019 and 2020.

1. Residential New Homes & Renovations

a. Significant Variances¹

A significant variance exists between: (1) preliminary and evaluated total resource benefits. Evaluated resource benefits for the Residential New Homes & Renovations core initiative are 34 percent lower than preliminary resource benefits. This decrease represents a reduction in attributable energy savings resulting from two distinct baseline updates from recent evaluation studies.

The *2019 Residential New Construction Baseline and Code Compliance Study* (2019 Plan-Year Report D.P.U. 20-50 Appendix 4D, Study 19-27) updated the User Defined Reference Home (“UDRH”) for new low-rise residential buildings. This study found that program homes are significantly more efficient than non-program homes, but the difference between program and non-program homes has decreased since the previous UDRH update in 2016.

The *Renovations and Additions Market Characterization and Potential Savings Study* (2019 Plan-Year Report D.P.U. 20-50 Appendix 4D, Study 19-6) recommended the

¹ Plan-year core initiative significant variances are defined in the D.P.U. 11-120, Phase II Plan-Year Report Template as: (1) variances between planned and actual core initiative budget of 15 percent or greater; (2) variances between planned and preliminary core initiative total lifetime savings showing a decrease of 15 percent or greater; (3) variances between planned and preliminary core initiative total benefits showing a decrease of 15 percent or greater; and (4) variances between preliminary and evaluated core initiative total resource benefits showing a decrease of 15 percent or greater.

program transition from an “existing conditions” baseline for renovations projects to an Industry Standard Practice (or ISP) baseline starting in 2020. For example, instead of using the pre-existing insulation in a home as the baseline condition for calculating savings, the program now assumes the wall cavities in the renovated area of the home would have been filled to code, regardless of the pre-existing insulation. This categorical baseline change has been applied retrospectively to 2020 projects.

The Program Administrator is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Residential New Homes & Renovations core initiative is 3.56. The projected benefit-cost ratio for the 2019-2021 plan term is 2.97 after accounting for actual results from 2019 and 2020.

B. RESIDENTIAL EXISTING BUILDINGS

The actual 2020 benefit-cost ratio for the Residential Existing Buildings Program is 2.37. The projected benefit-cost ratio for the 2019-2021 plan term is 2.49 after accounting for actual results from 2019 and 2020.

1. Residential Coordinated Delivery

a. Significant Variances

There are no significant variances to report for this core initiative.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Residential Coordinated Delivery core initiative is 2.85. The projected benefit-cost ratio for the 2019-2021 plan term is 3.26 after accounting for actual results from 2019 and 2020.

2. Residential Conservation Services

a. Significant Variances

A significant variance exists between: (1) planned budget and actual expenditures.

Actual expenditures for Residential Conservation Services were 40 percent lower than the planned budget. The primary reason for this was a lower than planned volume of on-premise home energy assessments conducted. This was driven by the COVID-19

pandemic which forced a temporary suspension of all home energy assessments due to customer and staff safety concerns, government-ordered shutdowns and stay-at-home recommendations, and customer policies to limit in-person exposure. In response, protocols were implemented to prioritize customer and contractor safety, which significantly limited the ability to conduct on premise activities. The program shifted to offer virtual home energy assessments and allow some on-premise work to resume, resulting in a substantial volume of home energy assessments, however the total volume fell by 40 percent from 2019 to 2020. In addition, as noted in the 2019 report, the Company had anticipated a change in delivery of home energy assessments that would have increased unit costs for home energy assessments in 2020. A number of factors, including a tight labor market, led the Company to not implement this change.

In response to the above variance, the Company does not plan to make any significant changes to the core initiative during this time. As COVID-19-related restrictions lift, the Company will closely monitor demand for home energy assessments and, if necessary, make changes to marketing strategies to increase volume. The Company will monitor this core initiative's activity for the remainder of the term.

3. Residential Retail

a. Significant Variances

Significant variances exist between: (1) planned budget and actual expenditures.

Actual expenditures for the Residential Retail core initiative were 36 percent higher than planned. There are several reasons for this variance, all of which are attributed to greater than planned participation in this core initiative. First, the fuel optimization effort was launched at the beginning of 2019, which is comprised of higher incentives for heat pumps that displace delivered fuel central heating systems or that replace electric resistance central heating systems. As 2019 was the first year these measures were offered, the Company planned conservatively for all three years of the 2019-2021 term. The Company rebated more fuel optimization measures (electric air source heat pumps) than planned in both 2019 and 2020, which led to higher incentive spending than planned for the electric HVAC measure sub-initiative.

Second, there was a higher than planned quantity of smart thermostat rebates processed for oil and propane heated homes. This higher than planned participation is the result of multiple smart thermostat promotions throughout the program year. Rebate amounts were not increased during these promotions, but manufacturers decreased their prices, leading to a bigger discount and higher customer participation.

Lastly, participation in the residential upstream lighting sub-initiative was higher than planned because the Company incentivized higher than planned lighting measures in

both 2019 and 2020. In 2019, in-store and online sales resulted in increased production, specifically for LED A-Lines and LED Reflectors. Additionally, in 2019 highly effective hyper-targeted marketing through channels such as digital ads, local out of home billboards, and Facebook offer ads contributed to the success of this sub-initiative. These marketing efforts created momentum that carried over into 2020 and led to higher than planned production in the Residential Lighting sub-initiative. In response to the above variance, the Company does not plan to make any significant changes to the core initiative during this time. The Company will monitor this core initiative's activity for the remainder of the plan term.

The Program Administrator is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Residential Retail core initiative is 2.12. The projected benefit-cost ratio for the 2019-2021 plan term is 2.04 after accounting for actual results from 2019 and 2020.

4. Residential Behavior

The Residential Behavior core initiative includes two initiatives – Behavior and Active Demand Reduction.

a. Residential Behavior

i. Significant Variances

There are no significant variances to report for this core initiative.

ii. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Residential Behavior initiative is 2.68. The projected benefit-cost ratio for the 2019-2021 plan term is 2.43 after accounting for actual results from 2019 and 2020.

b. Residential Active Demand Reduction

i. Significant Variances

A significant variance exists between: (1) planned budget and actual expenditures.

Actual expenditures for Residential Active Demand Reduction were 28 percent lower than the planned budget. The main reason for this is that the Company achieved lower than planned participation in its residential battery storage offering. While there are a number of potential contributors to this outcome, the Company had assumed being able to offer a five-year lock on participation incentives to enrolling customers. Because this offering was only approved as a demonstration, the Company could not make this guarantee to customers. Given the capital-intensive nature of storage projects, this affected the Company's ability to recruit participants. Since the Company began offering the storage incentive with a five-year lock, enrollments have increased significantly, but only 187 batteries participated in at least one event during the summer of 2020 which less than half of what was planned in 2020.

In response to the above variance, the Company does not plan to make any significant changes to the core initiative during this time. The current pace of enrollments suggests the Company will meet its targeted battery enrollment for 2021. The Company has also launched and is actively recruiting customers for its electric vehicle demand reduction offering. The Company will monitor this core initiative's activity for the remainder of the plan term.

The Company is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

ii. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Residential Active Demand Reduction initiative is 4.19. The projected benefit-cost ratio for the 2019-2021 plan term is 3.16 after accounting for actual results from 2019 and 2020.

II. INCOME ELIGIBLE PROGRAMS

The actual 2020 benefit-cost ratio for the Income Eligible sector is 2.08.

A. INCOME ELIGIBLE EXISTING BUILDINGS

The actual 2020 benefit-cost ratio for the Income Eligible Existing Buildings program is 2.23. The projected benefit-cost ratio for the 2019-2021 plan term is 2.19 after accounting for actual results from 2019 and 2020.

1. Income Eligible Coordinated Delivery

a. Significant Variances

Significant variances exist between: (1) planned budget and actual expenditures, (2) planned and preliminary lifetime savings, and (3) planned and preliminary total benefits.

Preliminary lifetime savings for Income Eligible Coordinated Delivery were 50 percent lower than planned savings. Preliminary total program costs were 25 percent lower than planned. Preliminary total benefits were 41 percent lower than planned.

There were three primary reasons for the variances in spend, planned versus preliminary lifetime savings and planned and preliminary total benefits. First, COVID-19 pandemic-related customer and staff safety concerns, government-ordered shutdowns and stay-at-home recommendations, and customer policies to limit in-person exposure, led to the implementation of protocols to prioritize customer and contractor safety, which significantly limited the ability to conduct on premise activities. Thereafter, the Company changed program implementation to offer energy assessments by phone or video call. However, fewer than expected income eligible customers moved forward with work because they were disproportionately affected by the pandemic. This was particularly true for multifamily projects, as many income eligible multifamily buildings are for residents who are elderly, have disabilities, or other conditions that make them disproportionately susceptible to COVID-19. As a result, local housing authorities and other owners paused any work on multifamily facilities for most of 2020, including guidelines issued by the Department of Housing and Community Development (“DHCD”) pausing all on-premise work. Second, there were fewer than expected properties suitable for installation of air source heat pumps to replace existing electric resistance heating systems in both 2019 and 2020. Third, a national shortage of large appliances that began in summer of 2020 as a result of the COVID-19 pandemic affected the program’s appliance distributors, who were not able to fulfill orders in a timely fashion.

In response to the above variances, the Company made the following changes in program design/implementation:

The Company worked with its lead vendor to implement remote energy assessments by phone or video call for customers who prefer them and will continue to make use of remote assessments. The Company is also working with its lead vendor to increase outreach to multifamily affordable housing owners, combined with use of assessor’s data, to identify more potential candidates for heat pump installation, as well as to identify further savings opportunities. The Company is working with its lead vendor to identify and address barriers that might prevent building owners from installing heat pumps. Furthermore, the Company is working with its lead vendor and marketing department on additional outreach to single family income eligible customers who would be candidates for heat pumps. The Company is also working with its lead vendor

on additional training for contractors and energy specialists on air source heat pump technologies in order to better promote heat pumps to both single and multifamily customers.

The Company will continue to monitor this core initiative's activity for the remainder of the plan term.

Due to the challenges described above, the Program Administrator is not projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative. However, the Company remains committed to serving the income eligible population and will be redoubling efforts in 2021.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the Income Eligible Coordinated Delivery core initiative is 2.23. The projected benefit-cost ratio for the 2019-2021 plan term is 2.19 after accounting for actual results from 2019 and 2020.

III. COMMERCIAL & INDUSTRIAL ("C&I") PROGRAMS

The actual 2020 benefit-cost ratio for the C&I sector is 2.71.

A. C&I NEW BUILDINGS

The actual 2020 benefit-cost ratio for the C&I New Buildings program is 2.68. The projected benefit-cost ratio for the 2019-2021 plan term is 2.97 after accounting for actual results from 2019 and 2020.

1. C&I New Buildings & Major Renovations

a. Significant Variances

A significant variance exists between: (1) planned budget and actual expenditures.

For 2019 and 2020, total costs for the C&I New Buildings & Major Renovations program exceeded plan by 30 percent. This variance was driven by greater than planned spending in the participant incentive cost category due to increased participation and resultant savings relative to what was planned. In 2019 and 2020, total savings for the New Buildings & Major Renovations program exceeded plan by roughly 25 percent. This increased participation was driven by numerous large commercial projects sold and delivered to customers, including two large Combined Heat and Power ("CHP") projects. At the time the plan was developed one of the CHP projects was projected to be completed in 2018, but an unexpected delay pushed it into

the beginning of 2019. Additionally, the second large CHP project was planned for but outperformed initial expectations and is now saving more energy than planned.

In response to the above variance, the Company does not plan to make any significant changes to the core initiative during this time. The Company anticipates that these increased costs and higher than planned participation will continue throughout 2021 and, as a result submitted a Mid-Term Modification (“MTM”) to the Energy Efficiency Advisory Council (“EEAC”). The MTM was approved by the EEAC on May 26, 2021. The Company will continue to monitor this core initiative’s activity for the remainder of the plan term. The Program Administrator is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the C&I New Buildings & Major Renovations core initiative is 2.68. The projected benefit-cost ratio for the 2019-2021 plan term is 2.97 after accounting for actual results from 2019 and 2020.

B. C&I EXISTING BUILDINGS

The actual 2020 benefit-cost ratio for the C&I Existing Buildings program is 2.81. The projected benefit-cost ratio for the 2019-2021 plan term is 2.85 after accounting for actual results from 2019 and 2020.

1. C&I Existing Building Retrofit

a. Significant Variances

Significant variances exist between: (1) planned budget and actual expenditures and (2) planned and preliminary total benefits.

For 2019 and 2020, total costs for the C&I Existing Building Retrofit program fell short of planned budgets by 30 percent. Additionally, preliminary total benefits were 26 percent below planned values. Overall participation in the Existing Building Retrofit offerings was lower than expected largely due to COVID-19 pandemic-related customer and staff safety concerns, government-ordered shutdowns and stay-at-home recommendations, and customer policies to limit in-person exposure. This led to the implementation of protocols to prioritize customer and contractor safety, which significantly limited the ability to conduct on premise activities. As a result, expenditure on participant incentives reduced, which was the primary driver for the underspend. The government-ordered shutdowns and stay-at-home recommendations, along with customer policies to limit in-person exposure, and the protocols that the

Program Administrator adopted to prioritize contractor and customer safety, significantly reduced the ability to conduct in person meetings to scope, propose, and close projects.

While the Program Administrator is optimistic that it can achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative, and signs of the recovery are promising, there is still considerable uncertainty regarding the pace and scope of the return to previous levels of energy efficiency investment.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the C&I Existing Building Retrofit core initiative is 2.41. The projected benefit-cost ratio for the 2019-2021 plan term is 2.75 after accounting for actual results from 2019 and 2020.

2. C&I New & Replacement Equipment

a. Significant Variances

There are no significant variances to report for this core initiative.

The Program Administrator is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

b. Cost-Effectiveness

The actual 2020 benefit-cost ratio for the C&I New & Replacement Equipment core initiative is 4.43. The projected benefit-cost ratio for the 2019-2021 plan term is 3.00 after accounting for actual results from 2019 and 2020.

3. C&I Active Demand Reduction

a. Significant Variances

There are no significant variances to report for this core initiative.

The Program Administrator is projecting to achieve its savings and benefits goals by the end of the Three-Year Plan term for this core initiative.

b. Program Cost-Effectiveness

The actual 2020 benefit-cost ratio for the C&I Active Demand Reduction core initiative is 3.50. The projected benefit-cost ratio for the 2019-2021 plan term is 4.18 after accounting for actual results from 2019 and 2020.

APPENDIX 2

Benefit-Cost Ratio Screening Tool

Please see the Microsoft Excel file accompanying this report for the Benefit-Cost Ratio Screening Tool.

APPENDIX 3

Statewide Technical Reference Manual – 2020 Report Version

Please see Statewide Appendix 3: Technical Reference Manual – 2020 Report Version, filed under separate cover. The electronic version, the eTRM, is available at:

<http://www.masssavedata.com/Public/TechnicalReferenceLibrary>.

APPENDIX 4

Statewide Evaluation Studies Summary

A. Table of Evaluation Studies

STUDY NAME	STUDY LOCATION AND NUMBER	FUEL	EM&V CONTRACTOR
Residential Studies			
Residential New Construction Non-Program Model Review (MA19R19)	Appendix D, Study 20-1	Electric & Gas	NMR Group, Inc.
Lighting Supplier Insights (MA19R13)	Appendix D, Study 20-2	Electric	NMR Group, Inc.
Passive House Offering Program Theory and Logic Model (MA19R05)	Appendix D, Study 20-3	Electric & Gas	NMR Group, Inc.
Lighting Sales Data Regional Analysis (MA20R22)	Appendix D, Study 20-4	Electric	NMR Group, Inc.
2019 Residential Lighting On-Sites (MA19R15)	Appendix D, Study 20-5	Electric	NMR Group, Inc.
Residential Coordinated Delivery Virtual Home Energy Assessment Study (MA20R26)	Appendix D, Study 20-6	Electric & Gas	Guidehouse Inc.
Renovations and Additions Incremental Cost Study (MA20R27)	Appendix D, Study 20-7	Electric & Gas	NMR Group, Inc.
Comprehensive TRM Review (MA19R17)	Appendix D, Study 20-8	Electric & Gas	Guidehouse Inc.
2019/20 Massachusetts Winter Thermostat Optimization Evaluation	Appendix D, Study 20-9	Electric	Guidehouse Inc.
Eversource Home Energy Report Program Year One Persistence Savings and Decay Rate Study	Appendix D, Study 20-10	Electric & Gas	Guidehouse Inc.
Commercial & Industrial Studies			
Impact Evaluation of PY2019 Massachusetts C&I Upstream Lighting Initiative (MA19C06)	Appendix D, Study 20-11	Electric	DNV-GL
Gross Impact Framework - Decision Guide (MA20C06)	Appendix D, Study 20-12	Electric & Gas	DNV-GL
C&I Lighting Market Characterization Study(MA20C09)	Appendix D, Study 20-13	Electric	DNV-GL

STUDY NAME	STUDY LOCATION AND NUMBER	FUEL	EM&V CONTRACTOR
Impact Evaluation of PY2018-2019 Custom Electric Installations (MA20C04)	Appendix D, Study 20-14	Electric	DNV-GL
Massachusetts Custom Electric CDA (MA20C16)	Appendix D, Study 20-15	Electric	DNV-GL
Steam Trap and Boiler Efficiency Research (MA20C05)	Appendix D, Study 20-16	Gas	DNV-GL
Massachusetts C&I Impact Evaluation of PY2018 Custom Gas Installations (MA20C01)	Appendix D, Study 20-17	Gas	DNV-GL
Franchise Controls Deemed Savings Study (MA20C07-E-DUN)	Appendix D, Study 20-18	Electric	DNV-GL
Ground Source Heat Pump eTRM Measure Review (MA20C15)	Appendix D, Study 20-19	Electric & Gas	DNV-GL
C&I ISP Research and Repository: Food Services Equipment Pre-Research Memo (MA20C02)	Appendix D, Study 20-20	Electric & Gas	DNV-GL
Special & Cross Sector Studies			
Code Promulgation Attribution Study (MA19X07)	Appendix D, Study 20-21	Electric & Gas	NMR Group, Inc.
2013-2017 Residential Customer Profile Study: Stakeholder Summary and Comprehensive Report (MA19X08)	Appendix D, Study 20-22	Electric & Gas	DNV-GL
2018 Commercial and Industrial Customer Profile Study: Stakeholder Summary and Comprehensive (MA20X01)	Appendix D, Study 20-23	Electric & Gas	DNV-GL
Consistent Methodology for Self-Reported Residential Net-to-Gross Measurement (MA19X03)	Appendix D, Study 20-24	Electric & Gas	NMR Group, Inc.
Municipal Partnership Initiative Program Theory and Logic Model Development Memo (MA19X12)	Appendix D, Study 20-25	Electric & Gas	Opinion Dynamics
Demand Response Studies			
2019 Electric Vehicle Supply Equipment Direct Load Control Demonstration - Process evaluation	Appendix D, Study 20-26	Electric	Guidehouse, Inc.
2019 National Grid Behavioral Demand Response Evaluation	Appendix D, Study 20-27	Electric	Guidehouse, Inc.
2019/2020 Residential Energy Storage Demand Response Demonstration Evaluation - Winter Season	Appendix D, Study 20-28	Electric	Guidehouse, Inc.

APPENDIX 4

Statewide Evaluation Studies Summary

B. Summary of the Studies with the Most Significant Effects

The Massachusetts Program Administrators completed 28 evaluation studies for the 2020 Energy Efficiency Plan-Year Report. The studies that produced the most significant results in 2020 were the:

1. Passive House Offering Program Theory and Logic Model
2. Comprehensive TRM Review
3. C&I Lighting Market Characterization Study
4. Custom Impact Evaluations (Impact Evaluation of PY2018-2019 Custom Electric Installations and Massachusetts C&I Impact Evaluation of PY2018 Custom Gas Installations)
5. Code Promulgation Attribution Study

1. Passive House Offering Program Theory and Logic Model

The purpose of this study was to document the Mass Save Residential New Construction program's intention and plan to fundamentally shift building practices in Massachusetts to include passive design practices and super-insulation of building shells. In particular, this study focused on the multifamily Passive House program, as designed and initiated by Mass Save in 2019.

The Program Administrators used NMR's 2019 MA Residential New Construction Passive House Assessment report in designing the Passive House program. This research builds on that study by leveraging interviews with program staff to map the PAs' multifaceted approach to transforming the multifamily construction market. This study identifies the actions taken by the program, including:

- Outreach to market actors in the form of trainings and marketing,
- Incentives and technical support for potential projects from pre-design through occupancy, and
- Post-construction/occupancy data collection to increase transparency on this burgeoning market, highlight best practices for construction, and facilitate future program evaluation.

Additionally, the study isolates the program's stated goals, and identifies the metrics and potential data sources for measuring the success of those goals. These metrics enable the ongoing assessment of program success in meeting short-term objectives (like project enrollment in the

Multifamily Passive House offering) to long-term objectives (such as enabling the transition to more advanced building codes by priming the market to achieve those levels of efficiency).

Future evaluation of these metrics identified in the study will enable the estimation of the program's effect on the overall market. Subsequent research on these market effects will aim to identify attributable and claimable savings and benefits actualized by the program through this market transformation effort. This work is currently being explored in the Passive House Market Effects Baseline Study, scheduled to conclude later this year. A copy of the full Passive House Offering Program Theory and Logic Model study can be found in Appendix 4D, Study 20-3.

2. Comprehensive TRM Review

The purpose of this study was to review the assumptions and values in the Massachusetts Technical Reference Manual ("TRM") to ensure that the TRM assumptions reflect the results of recent residential studies, such as the Residential Baseline Study. The study also assessed the quality of the values in the residential portion of the TRM and conducted analysis, where relevant, to improve these parameters.

The review focused on identifying TRM parameters that were out-of-date, that were based on less relevant data sources (*i.e.*, not Massachusetts or New England-specific), or that have a significant effect on the energy efficiency program's energy, demand, or fossil fuel savings. A scoring methodology was designed and implemented that accounted for these factors and flagged select parameters as a high priority to update. Conversely, parameters from recently published, relevant data sources or that have a low savings impact received a low priority score. The resulting priority scores helped determine which parameters were candidates for updating.

The team reviewed data collected in the Residential Baseline Study and other available data sources to identify newer or more robust data available for updating parameter values. Other data sources include but are not limited to federal standard updates, ENERGY STAR updates, and recent evaluation studies.

This study led to multiple updates in gross savings and lifetime assumptions for residential measures. The study also identified measures and parameters that could be updated through future studies or through additional data collection in future iterations of the Baseline Study. A copy of the complete study can be found in Appendix 4D, Study 20-8.

3. 2020 C&I Lighting Market Characterization

The primary goal of the 2020 Lighting Market Characterization Study was to produce adjusted measure lives ("AMLs") for major commercial and industrial ("C&I") lighting applications using lighting market data collected to improve the Lighting Market Model (the "Model"). As part of updating the Model, the study analyzed market trends in C&I lighting, including saturation (the percentage of fixtures of different types installed across the C&I sector) and market share (the percentage of sales of different lighting types in the C&I sector).

The research conducted during this study focused on three main C&I lighting applications: ambient linear, high & low bay, and building exterior & outdoor lighting. This study also presents AMLs for traditional screw-based lighting categories (a-line, downlight/track, and decorative lighting).

The evaluation team used a variety of methods to research C&I lighting market indicators, which were used to refine the Model's saturation and market share forecasts and the resulting AML calculations. Methods included: onsite lighting inventory assessments via phone interviews, distributor and manufacturer interviews, contractor web surveys, customer surveys, reviewing program tracking data, web scraping, reviewing secondary data sources, and developing a stock turnover model to compare modeled results to national and regional forecasts.

The study found that AMLs for ambient linear LED lighting ranged from 8.5 to 8.8 years for 2020. AMLs for high/low bay LED lighting ranged from 8.2 to 8.6 years for 2020. AMLs for exterior/outdoor LED lighting ranged from 6.9 to 7.4 years in 2020. AMLs for screw-based LED lighting ranged from 3.0 to 6.0 years in 2020. AML values decreased for all lighting types between 2019-2021. When compared to 2019 AML values, the 2020 AMLs are considerably lower. This finding is primarily driven by a change in methodology and effective useful life ("EUL") assumptions serving as the basis for measure life adjustments, rather than differences between previously forecasted and actual adoption of LEDs. Further detail is provided in the report.

The study concluded that the LED C&I Market is continuing to advance, and it will become increasingly difficult to fund opportunities for program savings. With regard to ambient linear lighting, the study found that TLEDs and LED integrated fixtures continue to replace fluorescent technologies at a rapid pace and the market is expected to be largely transformed by 2024. Having said that, the program is steering customers towards higher efficiency products, such as linear LED fixtures, which present future opportunities for controls savings. With regard to high/low bay lighting, the dominant technology type is linear, so the largest opportunity in this market is for TLEDs and LED integrated fixtures to continue to replace the T8s and the T12s that continue to persist in the market. Like the ambient linear submarket, the market is expected to be largely transformed by 2024, though pockets of potential are still expected. With regard to building exterior/outdoor lighting, the diversity of available products is decreasing, and as of 2020 there are few, non-LED options for customers. Consequently, this submarket is transforming rapidly as well. A copy of the complete study can be found in Appendix 4D, Study 20-13.

4. Impact Evaluations of C&I Custom Installations

Two C&I custom impact studies were conducted to verify the savings generated through C&I custom electric and gas installations. Custom installations account for approximately 15% of planned lifetime electric savings and 7% of planned lifetime gas savings. Impact studies for C&I custom installations are conducted on a rolling basis, with updates to the sample of facilities evaluated each year. Impact evaluations produce realization rates, which are used to calibrate savings estimates. These impact evaluations also produced Lifetime Savings Adjustment Factors ("LSAF"), which will be applied for the first time in 2020 to PA reported savings values. In

addition, these evaluations produce recommendations for program improvements, including opportunities to make initial program savings estimates more accurate.

Impact Evaluation of PY2018-2019 Custom Electric Installations

The objective of this impact evaluation is to provide verification or re-estimation of electric energy and demand savings estimates for a sample of custom lighting and non-lighting electric projects through site-specific inspection, monitoring, and analysis.

The study approach involved selecting a representative sample of large C&I custom electric projects from 2018 and 2019. Evaluators then conducted a comprehensive desk review of each sample project to support an independent analysis of achieved gross electric savings realization rates. Where possible, evaluators also conducted a site visit and measurement and verification supported by metering for a subset of sample projects, in accordance with PA pandemic protocols. The site level evaluation results were aggregated using the final adjusted case weights. The sample for the PY2018-19 impact evaluation was generated with the intention of pooling the annual evaluation results with the prior PY2016 and PY2017-18 results to produce a rolling updated result.

The results of this study are realization rates and LSAF for custom lighting and non-lighting electric energy efficiency measures. Realization rates and LSAF were determined at the statewide level as well as separately for Cape Light Compact, Eversource, and National Grid. Statewide, two-year pooled realization rates for gross annual MWh savings were $100\% \pm 5\%$ for custom lighting, and $75\% \pm 6\%$ for custom non-lighting measures. Realization rates are reported at a 90% confidence level. Realization rates for both lighting and non-lighting measures improved from the prior year analysis. Statewide, the improvements in realization rates between the three-year pooled results and the previous two-year pooled results for gross annual MWh are + 0.2% for custom lighting and + 3.1% for custom non-lighting. LSAF values were calculated at both the statewide and PA-specific level. At the statewide level, the LSAF for custom lighting was calculated to be 97.5%, and for custom non-lighting, 101.3%. A copy of the complete study can be found in Appendix 4D, Study 20-13.

Impact Evaluation of PY2018 Custom Gas Installations

The primary objective of this impact evaluation was to verify and re-estimate the energy savings for a sample of statistically selected PY2018 custom gas projects through site-specific inspection, monitoring, and analysis.

The study approach consisted of desk reviews, on-site visits, and metering of a randomly selected sample of projects at participating facilities. The sample for the PY2018 impact evaluation was generated with the intention of pooling the annual evaluation results with the prior PY2016 and PY2017 results to produce a rolling updated result.

The study produced statewide realization rates and LSAF, as well as specific realization rates and LSAF for Columbia Gas, Eversource, and National Grid. The statewide realization rate for the three-year pooled sample (PY2016-PY2018) was $80\% \pm 7\%$ at an 80% confidence level. This

realization rate represented a decrease of 5% compared to the prior year analysis. PA-specific realization rates changed by +7% for Columbia Gas, -15% for Eversource, and -4% for National Grid. LSAF values were calculated to be 103% at the statewide level, 108% for Columbia Gas, 102% for Eversource, and 102% for National Grid. A copy of the complete study can be found in Appendix 4D, Study 20-17.

5. Code Promulgation Attribution Study

The purpose of the Code Promulgation Attribution Study was to develop an attribution factor for PA efforts to promulgate five more stringent energy code requirements into state building energy codes (the code amendments for both the MA residential and commercial portions of the 2018 IECC were approved in 2019 and took effect in November 2020). An additional goal of this study was to estimate the gross technical potential (“GTP”) of the approved code amendments.

To achieve these goals, the evaluators conducted the following research activities:

- Reviewed PA documentation of code promulgation efforts: The evaluators reviewed over 130 documents provided by the PAs that were relevant to their involvement in the 2018 IECC code amendment and adoption process in Massachusetts, as well as all publicly posted materials.
- Conducted code promulgation interviews to help assess attribution: The evaluators conducted in-depth interviews (“IDIs”) with seven stakeholders to gain more perspective on what occurred during the code amendment and adoption process.
- Estimated the GTP savings associated with each of the five 2018 IECC amendments proposed by the PAs that were incorporated into the state-level building energy code.

The study found that it is unlikely that proposals similar to those of the PAs would have been promulgated without the PAs’ efforts. The PAs submitted their proposals late in the code-cycle and were thus able to pick proposals that were not being advanced by other parties. The document review provided evidence of the PAs’ efforts and the lack of any similar efforts from another party. IDI participants also indicated that it was unlikely that another party would have advanced similar proposals.

Based on these findings, the study recommended that the PAs use an attribution factor of 90% for the savings generated from their efforts to promulgate the five approved amendments to the 2018 IECC. The 90% value reflects the fact that it is unlikely, though not impossible, that similar amendments to the PAs’ proposals would have been promulgated without the PAs’ efforts.

In addition, the study estimated the combined electric and gas GTP savings from the amendments as 138,153 MBTU accumulated through 2026. This includes 29,103 MWh of GTP electric savings and 388,574 therms of GTP gas savings, assuming 100% compliance with the PAs amendments. To put these values into context, these savings represent between 1% and 6% of combined electric

and gas 2018 new construction savings annually. Note that the GTP analysis in this report was intended as a forecast rather than an evaluation of actual savings.

The study suggested that the PAs consider developing guidelines for evaluation methods that may be applicable for future codes and standards promulgation efforts, plus consider conducting additional research that will increase the accuracy of GTP estimates during the 2022-2026 program years.

Ultimately, the results of the PAs' code promulgation efforts have implications for other PA new construction programs as they affect the entire new construction market. A copy of the complete study can be found in Appendix 4D, Study 20-21.

APPENDIX 4

Statewide Evaluation Studies Summary

C. Evaluation Study Summaries

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Study 20-1: Residential New Construction Non-Program Model Review (MA19R19-B)

Type of Study:	Market Characterization or Assessment Evaluation
Evaluation Conducted by:	NMR Group
Date Evaluation Completed:	6/6/2020

Study Objective and Summary of Results:

The purpose of this study was to assess the relative merits of using Home Energy Rating System (HERS) data, obtained from Ekotrope Inc., as an additional data source to inform research on the performance of new homes built outside of the Program Administrators' (PAs') low-rise residential new construction (RNC) program. Given the cost and difficulty of collecting data for baseline studies via conventional site visits, alternative methods of data collection, such as registered HERS ratings, could be a valuable source for learning more about how non-program homes are built. These methods might allow for the development of more statistically robust, lower-cost, and/or more frequent updates to the User Defined Reference Home (UDRH), which serves as the RNC program's baseline.

The study provides the following key findings:

- Registered HERS ratings for non-program participant homes are heavily weighted toward stretch code communities.
- HERS ratings are not statistically different between the registered non-program participant sample from Ekotrope and the MA19X02-B-RNCBL baseline sample.
- MA-REC compliance scores are significantly different between the samples.
- Duct leakage to outside (LTO) is not significantly different between the samples.
- Air infiltration is significantly lower in the registered HERS ratings sample than in the baseline sample.
- Baseline audits captured freezers, coolers, and secondary refrigerators absent from the registered HERS ratings sample, representing an additional 361 kWh/yr per home of electric consumption.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential & Income-Eligible
- New Homes & Renovations
- Envelope & HVAC
- Electric & Gas

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

The study does not directly affect program results rather, it explores new methods to conduct future evaluations in a more timely and cost-effective manner.

Overview of Study Method:

Our team made statistical comparisons for numerous measures between 292 Ekotrope non-participant energy models of single-family detached homes and the sample of 100 baseline homes that participated in the MA19X02-B-RNCBL study. This study compared data for all key shell measures, mechanical equipment, lighting, appliances, HERS ratings, and MA-REC compliance.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix D, Study 20-1.

Study 20-2: Lighting Supplier Insights (MA19R13-E)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: NMR Group
 DNV GL

Date Evaluation Completed: 8/14/2020

Study Objective and Summary of Results:

This report summarizes findings from 19 in-depth interviews (IDIs) conducted in 2020 with manufacturers, retail buyers (collectively termed *suppliers*), and advocacy groups with knowledge of the lighting market. The study was designed to provide information on the current state of the market and the regulatory environment to inform whether the Massachusetts Program Administrators (PAs) should make mid-cycle changes to the lighting portion of the Residential Retail Initiative (the program).

The study objectives included the following:

- Estimates of LED market share for 2019 and predictions of market share for 2021 and 2023 (LED market share is the percentage of bulbs sold that are LEDs)
- Opinions on when LEDs would become the dominant bulb type and how suppliers define market dominance
- Insights on how federal and state regulations affect suppliers’ business practices

Key findings in this study include:

Lighting suppliers provided their companies’ estimated 2019 and predicted 2021 and 2023 LED market shares in non-program areas by bulb shape. The average market share estimates were at 66% or higher for all bulb types. Suppliers were asked to estimate the LED proportion of their companies’ light bulb sales in areas of the country without upstream lighting programs for 2019 and to predict those proportions for 2021 and 2023. Importantly, the estimates / predictions focused on each individual company rather than the entire market. Every supplier produces or sells LEDs – some of them exclusively – so their estimates / predictions do not reflect the entire market, which would also include suppliers who do not make or sell LEDs. **Table 1** lists the average shares, which are likely higher than the overall market due towards the bias towards LED suppliers.

Table 1: Average LED Market Share Estimates / Predictions, 2019 to 2023

(Limited to Respondents’ Companies, all of which make or sell LEDs)

Product	2019	2021	2023
A-line (n=10)	72%	76%	78%
Reflector (n=11)	72%	75%	78%
Specialty (n=10)	66%	66%	70%

Lighting suppliers predicted that standard LEDs would become the dominant bulb technology in 2023, reflectors in 2025, and specialty bulbs in 2026. Suppliers generally defined dominance as achieving 50% to 70% market share. Comparing this range with estimates of suppliers' market share predictions for their companies seems to indicate that the market has achieved dominance already; however, this is not necessarily the case. Unlike market share estimates / predictions, the year of dominance predications reflect the entire market, including the influence of non-LED suppliers. As LED suppliers, respondents believed that their companies' sell a greater proportion of LEDs than found throughout the entire market.

Most suppliers expected little to no impact on their short- or mid-term business practices due to the recent Department of Energy (DOE) decisions. These decision included rescinding the expanded definition of general service lamps (GSLs) and rejecting the 45 lumens per watt (Lm/W) backstop. However, respondents were less certain about the impact of the decisions on their long-term business practices.

Suppliers offered mixed responses when asked whether the uncertainty regarding federal standards affected their bulb ordering / shipment practices. Five of the nine respondents who answered this question said that they did not expect any changes to their practices. Two of the nine who said they did expect changes planned to increase their manufacture and/or stocking of LEDs, while the other two planned to do the opposite and reduce their LED efforts.

Most suppliers reported little variation in stocking practices based on program activity, but three reported differences in LED proportions in program vs. non-program areas. The most commonly mentioned difference in stocking involved ENERGY STAR[®] qualified LEDs: Suppliers argued that retailers carry a greater proportion of ENERGY STAR models in program areas.

Suppliers preferred the consistency of federal regulations for the efficiencies in manufacturing, shipping, and other business practices. Respondents argued that state-specific regulations lead to inefficiencies that ultimately serve to increase product prices.

More suppliers (six) reported that retailers will sell through their remaining stock rather than ship stock to states with lower standards (three), citing logistics and costs and that they would not vary their stocking practices based on state regulations. Shipping products between states creates challenges and increases costs, leading some suppliers to say they would not ship inefficient product from states with regulations to states with others. Other suppliers, however, argued the opposite – that they would ship products between states.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Residential Retail
- Lighting
- Electric Only

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

The study provided insights into the lighting and regulatory market in which the Residential Lighting Initiative is operating, including markets in areas unaffected by programs.

Overview of Study Method:

The evaluation team conducted in-depth interviews over the phone from January to March 2020 with 14 manufacturers and three retailers. These companies manufactured, supplied, or sold lighting products that received upstream incentives from the program from January through October 2019. Collectively, the lighting suppliers interviewed accounted for 67% of total program sales in Massachusetts for the first ten months of 2019. The evaluation team also conducted IDIs with two stakeholders: one representing an energy-efficiency advocacy group and one representing a consumer advocacy group.

The interviews addressed LED market share by bulb shape in non-program areas for each company, when the respondents thought that LEDs would become the dominant bulb on the market and how they defined dominance, and the current and future impact of federal and state lighting regulations on their production, shipping, and stocking practices.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-2.

Study 20-3: Passive House Offering Program Theory and Logic Model (MA19R05)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: NMR Group

Date Evaluation Completed: 6/26/2020

Study Objective and Summary of Results:

The purpose of this study was to follow-up on the MA19R05 Passive House Assessment study and develop a final program theory and logic model (PTLM) for the Passive House program.

The study provides the following key findings:

- A final PTLM for the Passive House program

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- New Homes & Renovations
- All End Uses
- Electric & Gas

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

The results of this study were used to finalize market effects indicators that can be measured over time and used to quantify attributable market effects savings to the PAs efforts in this area. In addition, this study lays out the planned program processes and interactions so that they are easily digestible.

Overview of Study Method:

This study leveraged the results of the MA19R05 Passive House Assessment, along with conversations with program implementation staff, to develop a PTLM of the new Passive House offering.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-3.

Study 20-4: Lighting Sales Data Regional Analysis (MA20R22-E)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: NMR Group

Date Evaluation Completed: 12/2/2020

Study Objective and Summary of Results:

This report describes recent screw-base light bulb market share, shipments, and prices in Connecticut, Massachusetts, New Hampshire, Rhode Island, and program and non-program states. The analyses draw on light bulb sales data compiled by the LightTracker Initiative of the Consortium for Residential Energy Efficiency Data (CREED) and shipment data reported by the National Electrical Manufacturers of America (NEMA). The primary purpose of this study is to characterize the current lighting market and track market share over time. The Massachusetts Program Administrators (PAs) partnered with the Connecticut Energy Efficiency Board, the New Hampshire PAs, and National Grid Rhode Island on this study. The study refers to these four states as the Study States.

The objectives of this study were:

- Examine current market share in the Study States individually, the states with upstream lighting programs, the states without upstream lighting programs, and the entire nation.
- Provide breakdowns of market share by bulb type (i.e., LEDs, CFLs, halogens, and incandescents), shape (A-line, reflector, globes, and candelabras), and ENERGY STAR® status for each of the Study States (individually) and non-program states (collectively).
- Investigate if there are differential growth rates in market shares across areas.
- Create adoption curves of overall market share by bulb technology (inclusive of all shapes) for each Study State and non-program areas from 2009 to 2019.
- Explore trends in NEMA reported quarterly bulb shipment share from 2017 through the second quarter of 2020.
- Assess market share in very low (<310) and very high lumen bins (>2,600), which roughly coincide with ranges that are exempt from Phase 1 of the Energy Independence and Security Act (EISA), which was the original incandescent phase-out that went into effect between 2012 and 2014.
- Compare average prices of LEDs and halogens over time.

Key findings in this study include:

- **In 2019, LEDs made up the majority of light bulb sales in all areas, including non-program states.** Massachusetts (67%) and Rhode Island (68%) had higher market shares than Connecticut (56%) and New Hampshire (60%). LED market share in non-program areas was 54%.
- **Prior to 2018 and in all areas examined, LEDs mainly displaced CFL market share; after 2018, LEDs also displaced halogen shares.** Prior to 2018, LED growth in market share primarily displaced CFL market share. In or after 2018, LED market share began to displace halogen market share as well across all the areas.
- **LED market share differed across retail channels overall and for all shapes.** Overall LED market share in the combined hardware and home improvement stores (non-POS channels) was 59% or higher in all areas, while LED market share in discount, dollar, drug, grocery, mass merchandise, and some membership stores (POS channels) did not exceed 52% in all areas. For every bulb shape and in all areas, LED market shares in non-POS channels exceeded those in POS channels.
- **While reflectors had the highest LED market share in all areas studied, candelabras saw the largest growth in market share between 2018 and 2019. A-line LED market share in non-program areas increased by only 3 percentage points.** As in 2018, reflector market share continued to exceed that of all other shapes, with market shares at 80% or higher in all areas. Candelabra market shares were 46% or higher and had increased by at least 25 percentage points. Market share for globes was 42% or higher and A-lines was 51% or higher.
- **Halogens are the most common alternative to LEDs for A-lines, whereas incandescents are the primary LED alternative to globes and candelabras. For reflectors, consumers across the areas are nearly equally as likely to opt for halogens and incandescents if they do not select an LED.** Halogens made up the second largest market share for A-lines (ranging from 21% to 42% across the areas) and reflectors (4% to 11%) after LEDs whereas incandescents dominated the market for candelabras (31% to 53%) and globes (24% to 42%).
- **LED market share continues to grow in both program and non-program states. Program areas still have higher LED market share, but non-program areas are closing the gap.** LED market share of program states had a nine to ten percentage point lead over non-program states between 2016 and 2017 and a seven percentage point lead between 2018 and 2019. While the percentage difference between program and non-program states has mostly remained unchanged, the relative difference has declined because LED market share increased in non-program states. LED market share of program states had a 37 percent relative lead over non-program states in 2016 and a 12 relative percent lead in 2019.

- **Market share of ENERGY STAR qualified LEDs was at least 66% or higher, including in non-program areas.** ENERGY STAR qualified LEDs accounted for 91% of LED sales in Rhode Island, 88% in Massachusetts and New Hampshire, and 84% in Connecticut. **ENERGY STAR** qualified LED market share in program areas (74%) was still notably higher than non-program areas (66%).
- **LEDs dominated the A-line market in lumen bins most closely associated with 60 Watt incandescent bulbs, but incandescents remained the most common bulb in low and high lumen bins (representing 2% to 6% of the market) in most areas.** Bulbs most closely associated with a 60 watt incandescent bulb have the highest sales volumes. LEDs made up at least 68% of sales in this lumen bin across the four Study States and 62% in non-program areas.
- **Across all channels, LED prices continued to fall in non-program areas, but the pace slowed. In POS channels, LED prices for reflectors in non-program areas fell below those for halogens, but remained higher than incandescents.** LED prices in non-program areas fell from \$4.93 in 2016 to \$2.59 in 2018. At the same time, halogen prices fell from \$1.75 to \$1.43. Both bulbs saw slight upticks in 2019, to \$2.68 for LEDs and \$1.48 for halogens.. Reflector LED prices were \$3.99 in POS channels in non-program areas, compared to \$4.63 for halogens and \$3.18 for incandescents.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Residential Retail
- Lighting
- Electric Only

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

The Study provided valuable context as the PAs continue to monitor the residential lighting market and the impact of the Residential Lighting Initiative. The results suggest that, in 2019, the Residential Lighting Initiative contributed to increased market share and lower shelf prices of ENERGY STAR LEDs, but the impact of the program on the market as a whole appears to be dwindling as the market naturally progresses towards LEDs.

Overview of Study Method:

Using lighting bulb sales data compiled by CREED as part of the LightTracker Initiative (2009 to 2019), shipment data (2011-2020) from NEMA, and program activity data, NMR employed a series of descriptive analysis tasks. The CREED data were generated from point-of-sale (POS) sales data (from grocery, drug, dollar, discount, mass merchandiser, and selected club stores), and National Consumer Panel state sales data (from home improvement, hardware, online, and selected club stores).

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-4.

Study 20-5: 2019 Residential Lighting On-Sites (MA19R15-E)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: NMR Group

Date Evaluation Completed: 12/9/2020

Study Objective and Summary of Results:

The goal of this study was to update estimates of lighting saturation and other critical market indicators in Massachusetts. The data for this study came from on-site lighting inventories conducted in the summer of 2017 and between October 2019 and March 2020 in Massachusetts homes that are a part of the Residential Baseline Study (RES 1).

Evidence from this study suggests the following:

- Light Emitting Diode (LED) saturation in 2020 was 45% in RES1 Baseline homes, an increase from 2017 when saturation was 27% in the Baseline study homes.
- Massachusetts households chose LEDs as replacements for two-thirds (66%) of bulbs replaced since the 2017 visit.
- Over one-third of all installed bulbs (37%) were ENERGY STAR® LEDs, and 92% of all LEDs that households recalled purchasing or obtaining in the last year were verified to be ENERGY STAR-certified.
- Saturation of specialty LED lamps in Massachusetts was highest for reflectors (60%), followed by candelabras (47%) and globes (35%).
- While compact fluorescent lamps (CFLs) and inefficient bulbs (halogens + incandescents) made up about equal proportions of non-LED A-line sockets, inefficient bulbs accounted for nearly all of the non-LED specialty bulbs.
- However, the RES1 Baseline sample includes a disproportionately high number of households verified to have taken part in a direct install program between 2017 and 2020, which has important implications:
 - Some of the observed changes to lighting use reflect program influence. Findings for socket saturation, bulb replacement, and newly purchased or obtained bulbs may be biased towards LEDs as a result.
 - Socket saturation for households not taking part in a direct install program was 39%; therefore, true socket saturation in 2020 was likely between 39% and 45%.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Residential Retail

- Lighting
- Electric Only

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

Estimates of saturation and other market indicators help inform program design, planning, and implementation of the upstream lighting program.

Overview of Study Method:

The data for this study came from on-site lighting inventories of 301 homes in Massachusetts completed between October 2019 and March 2020. Of these, 199 homes had been previously visited in 2017 as part of the RES1 Baseline study. The other 102 homes were visited for the time in 2019/2020. Trained technicians visited the homes and identified all light bulbs installed in sockets or in storage. They noted key characteristics, such as technology, shape, and wattage. They also collected model numbers for LEDs to determine if the bulbs were ENERGY STAR qualified. For homes visited in 2017, the technicians also identified bulbs that had been switched between sockets, removed from storage, or newly brought into the home.

NMR weighted the on-site survey data to reflect the population proportions for home ownership (tenure) and education in Massachusetts based on the American Community Survey (ACS) Five-Year Estimates.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-5.

Study 20-6: Residential Coordinated Delivery Virtual Home Energy Assessment Study (MA20R26-B-VHEA)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: Guidehouse

Date Evaluation Completed: 3/12/2021

Study Objective and Summary of Results:

In March 2020, in response to COVID-19 social distancing requirements, the Massachusetts Program Administrators (the PAs) temporarily replaced the Residential Coordinated Delivery (RCD) initiative's customary in-person home energy assessments (HEA) with virtual (i.e., remote home energy assessments (VHEA). As part of a VHEA, RCD assessors:

- Virtually complete the basic functions of the in-person HEA using common communication software like Zoom and Google Meet/Duo.
- Mail the participant a customized package of instant savings measures (ISMs) for self-installation.
- Develop a scope of work to address any identified air sealing and insulation opportunities and/or mechanical system upgrades.

The PAs expanded the RCD assessment repertoire in July 2020 to include "hybrids". Hybrids, which combined VHEA elements with a shorter follow-up in-person visit, typically occurred for customers with physical limitations, complex properties, those who expressed a strong preference for in-person engagement, or when a VHEA findings were inconclusive (i.e., assessors needed more information to develop recommendations or work scopes).

After nearly a year and more than 20,000 VHEAs, the PAs and Energy Efficiency Advisory Council (EEAC) want to identify lessons learned from the transition to VHEAs and determine how best to interact virtually with customers as part of future initiative cycles.

The key findings are:

1. Most VHEA participants were satisfied with their virtual experience.
2. VHEA-based scopes of work are less accurate, which has adverse implications for contractors.
3. In-service rates are much lower for self-installed measures.
4. VHEAs are a viable, yet imperfect, delivery method.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Weatherization
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation #1 - The evaluation team recommends using the weighted In-Service Rates by measure:

Measure	Weighted ISR (By Assessment Type and Assessor)
LED lightbulbs	87%
Showerheads	66%
Faucet aerators	74%
Smart power strip	73%
Thermostats	79%

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

The study identified lessons learned from VHEAs so the PAs can apply them to future RCD cycles and maximize the value of this new delivery mechanism.

Overview of Study Method:

The methodology was developed to provide the PAs with insights on VHEAs from a variety of perspectives. To provide this, the evaluation team completed the following tasks.

Task 1 | Program Manager Interviews (n=11)

The evaluation team began by interviewing the PA and LV managers that oversee RCD. The evaluation team used these initial interviews to gain program managers' perspectives on the lessons they learned launching VHEAs, as well as their thoughts about the potential role of VHEAs (or other forms of virtual customer interaction) as part of future program delivery. The team spoke with representatives from each PA and LV, in addition to EEAC implementation consultants.

Task 2 | Assessor Interviews (n=22)

Next, the evaluation team conducted 22 interviews—10 with LV Energy Specialists and 12 with HPCs, including HPC technicians and management. The interviews focused on their experience completing VHEAs, the advantages and disadvantages of the approach, technological difficulties, and customer feedback. As with the program manager interviews, the team asked for their perspective on the long-term role for VHEAs in RCD and what, if anything, could be done to streamline VHEA delivery, increase effectiveness, or add value for participating customers.

Task 3 | Participant Surveys (n=332)

Customer's experience with VHEAs was central to this study. To gain this, the team surveyed 332 participants who completed a virtual assessment between May and September 2020. The web-based survey focused on participants' experience conducting the VHEA, their interaction with their ES/HPC, and installation rates for mailed self-install measures. See Appendix A for a list of respondents by PA and the analysis weights the team applied to estimate statewide values.

Task 4 | Nonparticipant Surveys (n=77)

To understand why some customers decided not to proceed with the VHEA, the evaluation team surveyed 77 customers—henceforth referred to as “nonparticipants”—that declined to have a virtual assessment when their in-person assessment was cancelled. The team used the web-based survey to ask nonparticipants why they declined the VHEA, their concerns about the VHEA, and their awareness of the increased insulation incentive.

Task 5 | Contractor Interviews (n=20)

The evaluation team interviewed 20 contractors (14 IICs and 6 HPCs) to determine the accuracy of weatherization scopes based on VHEAs and how, if at all, their business has been impacted by the transition to virtual assessments.

Task 6 | Program Data Analysis

To complement and support Tasks 1-5, the team also analyzed 2019 (HEA only) and 2020 (mostly VHEA) program tracking data. The team explored for potential differences in recommendation rates by measure, participating building types, and renter/landlord participation.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-6.

Study 20-7: Renovations and Additions Incremental Cost Study (MA20R27)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: NMR Group

Date Evaluation Completed: 5/18/2021

Study Objective and Summary of Results:

The purpose of this study was to provide an estimate of the incremental costs associated with participating in the Massachusetts Renovations and Additions (R&A) program. This study applies to single-family homes and low-rise (three stories or less) multifamily housing units that conduct a renovation and/or addition. Incremental costs were calculated on a per square foot of conditioned floor area (CFA) basis to move from baseline construction practices (ISP for renovation and the residential new construction baseline for additions, referred to as the RNC UDRH) to construction practices applied in recent R&A program projects. The study also included a summary of program practices based on the review of 973 participant projects.

The study provides the following key findings:

- Incremental costs for the renovations portion of the program, using the ISP baseline, were \$3.05 per square foot. The incremental costs for the addition portion of the program were \$1.28 per square foot. The overall cumulative incremental cost for the R&A program is \$2.77 per square foot.
- Only 32% of homes initially conducted air sealing tests before any work was conducted. The homes that did not conduct air infiltration testing applied default efficiency values, making it unclear whether air sealing practices occurred during the renovation.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- New Homes & Renovations
- Envelope & All End Uses
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The savings for the R&A program were recalculated with the ISP baseline; therefore, we recommend using the incremental cost of \$2.77 per CFA for the R&A program retrospectively and prospectively.

Recommendation 2: The program would benefit from an increased focus on air sealing. This may increase the frequency of air infiltration testing during the initial audit and after the work is completed to allow for assessment on savings that are a result of air sealing that occurred on

the project. If air sealing is not being conducted on R&A projects, the program has an opportunity to intervene.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

The findings from this study provide insight into the incremental costs currently faced by contractors or homeowners who decide to participate in the R&A Program. This information is used for cost-effectiveness testing and may inform the incentives offered to participants.

Overview of Study Method:

In this study, NMR leveraged the methodology used in the MA19R18 Residential New Construction Incremental Cost Study to calculate incremental costs. The incremental cost estimates were evaluated against two separate baselines: a renovation baseline (ISP) and an addition baseline (RNC UDRH). The team assessed the measure-level data for 973 projects to determine, at the measure-level, what was a renovation and what was an addition. NMR then assessed costs for recently-renovated program homes against the ISP baseline, to provide an estimate of the incremental costs associated with program participation using two baselines.¹

The study approach relied on cost data from the National Renewable Energy Laboratory's (NREL) National Residential Efficiency Measures Database (NREMD), to construct cost regression models that estimated costs based on efficiency for various measures. The costs were calculated, by measure, for baseline conditions and for the improved conditions, the incremental cost is based on the delta between these estimates.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-7.

¹ The study also included an incremental cost estimate for the previous baseline scenario that the program used, pre-existing conditions, which ultimately was replaced with the ISP baseline to calculate savings for the R&A program. The pre-existing baseline incremental cost results are included in the final report for reference, but are no longer applicable due to programmatic changes.

Study 20-8: Comprehensive TRM Review (MA19R17-B-TRM)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: Guidehouse

Date Evaluation Completed: 3/9/2021

Study Objective and Summary of Results:

The Technical Reference Manual (TRM) documents the calculations used by the state’s Program Administrators (PAs) to claim savings through their energy efficiency programs. It is critical that the TRM use the best available data and that its deemed savings values are based on credible, standardized assumptions. The primary goal of this review was to ensure that relevant data from the Residential Baseline Study and other recent studies are incorporated into the TRM. A secondary goal was to assess the quality of the values in the residential portion of the TRM and to conduct analysis, where relevant, to improve these parameters.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- New Buildings & Major Renovations
- Behavior & HVAC
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Table 1 describes the measure parameters for which the evaluation team recommends the PAs adopt updated TRM values. Table 1 is organized by measure title, with measures presented in the order in which they appear in the 2019-2021 Plan Version of the MA TRM.

Measure Name	Parameter Name	Unit	Existing Value	Proposed Value
	Effective Useful Life (EUL)	Years	20	23
Boiler, Gas Forced Hot Water (RES-HVAC-BGFHW)	Baseline Efficiency, ER	AFUE	80.0% nameplate 77.4% actual	85.5% nameplate 77.4% actual
	Baseline Efficiency, ROF	AFUE	82.0% nameplate 79.3% actual	86.5% nameplate 83.7% actual
	Baseline Efficiency, Oil, ROF	AFUE	83.0%	Through 2020: 83.0% 2021 and on: 86.0%

Measure Name	Parameter Name	Unit	Existing Value	Proposed Value
Boiler, Oil/Propane Forced Hot Water (RES-HVAC-BFHW)	Baseline Efficiency, Propane, ROF	AFUE	82.0% nameplate 79.3% actual	86.5% nameplate 83.6% actual
	Central Air Conditioning (RES-HVAC-CAC)	Baseline Efficiency, ER	SEER	10.0
Central Air Conditioning (RES-HVAC-CAC)	Baseline Efficiency, ROF	SEER	13.0	14.0
	Central Ducted HP Fully Displacing Existing Furnace (RES-HVAC-FSHP)	Baseline Efficiency, Oil, ER	AFUE	78%
Central Ducted HP Partially Displacing Existing Furnace (RES-HVAC-FSHP-P)	Baseline Efficiency, Oil, ER	AFUE	78%	79%
Clothes Dryer (RES-A-CD)	EUL, Electric	Years	12	16
	EUL, Gas	Years	12	17
Combo Condensing Boiler/Water Heater (RES-HVAC-CCBWH)	Baseline % Split of Indirect vs Storage Water Heater (WH)	%	80% Indirect, 20% Storage	24% Indirect, 76% Storage
	Baseline Efficiency, Boiler, ER	AFUE	80.0% nameplate 77.4% actual	85.5% nameplate 77.4% actual
	Baseline Efficiency, Boiler, ROF	AFUE	82.0% nameplate 79.3% actual	86.5% nameplate 83.7% actual
	Baseline Efficiency, WH, ER Blended Medium-, High-Draw	UEF	0.55	0.58
Dehumidifier (RES-PL-DH)	Capacity	Pints/Day	35	Remove
	Efficiency	Liters/kWh	Retirement: 1.0 Baseline: 1.5 Measure: 2.0	Retirement: 1.6 Baseline: 2.8 Measure: 3.3
	Hours of Operation	Hours/Year	Undocumented	Remove
	Dehumidification Load	Liters/Year	n/a	1,520
	Energy Savings	kWh/Year	New: 167.6 Retirement: 152.7	New: 82.3 Retirement: 407.1
	Demand Savings	kW	New: 0.04 Retirement: 0.04	New: 0.02 Retirement: 0.10
	EUL	Years	12	17
ECM Circulator Pump (RES-HVAC-ECMCP)	CF _{WP}	-	0.16	0.53
Furnace, Gas (RES-HVAC-FG)	EUL	Years	18	17
	Baseline Efficiency, ER	AFUE	78.0% nameplate 78.9% actual	85.0% nameplate 81.0% actual
	Baseline Efficiency, ROF	AFUE	85.0%	89.0% nameplate 90.1% actual

Measure Name	Parameter Name	Unit	Existing Value	Proposed Value	
Furnace, Oil/Propane (RES-HVAC-FOP)	Baseline Efficiency, Propane, ROF	AFUE	85.0%	89.0% nameplate 90.1% actual	
Heat Recovery Ventilator (RES-HVAC-HRV)	HRV Gas Savings	MMBtu	7.7	8.6	
	HRV Electricity Savings	kWh	-133	-171	
	HRV Demand Savings	kW	-0.10	-0.02	
	ERV Gas Savings	MMBtu	-	8.8	
	ERV Electricity Savings	kWh	-	-127	
	ERV Demand Savings	kW	-	-0.014	
Insulation (RES-BS-I)	Heating Degree-Days, Cooling Degree-Hours	HDD, CDH	Varies by City, see Table 3-20		
Low-Flow Showerhead (RES-WH-S)	EUL	Years	7	15	
Low-Flow Showerhead with Thermostatic Valve (RES-WH-STV)	EUL	Years	7	15	
	Electric (Single Family)	kWh	372	247	
	Electric (Single Family)	kW	0.08	0.06	
	Gas (Single Family)	MMBtu	1.84	1.22	
	Oil (Single Family)	MMBtu	2.09	1.32	
	Other (Single Family)	MMBtu	1.84	1.22	
	Electric (Multi-family)	kWh	335	183	
	Electric (Multi-family)	kW	0.09	0.04	
	Gas (Multi-family)	MMBtu	1.66	1.41	
	Oil (Multi-family)	MMBtu	1.88	1.44	
	Other (Multi-family)	MMBtu	1.66	1.41	
	Pool Pump (RES-MAD-PP)	Operating Days per Year	Days/Year	91	122
Pool Size		Gallons	20,000 to 23,000	22,000	
Flow Rates		gpm	Baseline: 64 2S: 66 high, 33 low VS: 50 high	Baseline: 97 2S: 97 high, 48 low VS: 77 high, 31 low	
Daily Operating Hours		Hours/day	Baseline: 8.5 2S: 2 high, 12.5 low VS: 2 high, 18 low	Baseline: 5.7 2S: 2 high, 9.5 low VS: 2 high, 15.7 low	
Energy Factor		EF	Baseline: 2.1 2S: 2.0 high, 5.2 low VS: 4.0 high, 8.8 low	Baseline: 2.0 2S: 1.9 high, 5.3 low VS: 2.9 high, 10.5 low	
Energy Savings		kWh/year	2S: 842, VS: 1,062	2S: 639, VS: 1,284	
Demand Savings		kW	2S: 0.87, VS: 1.12	2S: 0.67, VS: 1.35	
EUL		Years	10	6	
Programmable Thermostat (RES-HVAC-PT)		EUL	Years	15	19
		Energy Savings	kWh/year	513	230

Measure Name	Parameter Name	Unit	Existing Value	Proposed Value
Quality Installation with Duct Modification (RES-HVAC-QIDM)	Demand Savings	kW	0.85	0.18
Room Air Cleaner (RES-PL-RAC)	Energy Savings	kWh	391	Varies; see Table 3-28
Room Air Conditioner (RES-PL-ROOMAC)	EUL	Years	8	12
Stand Alone Water Heater (RES-WH-SASWH)	Baseline Efficiency, ER	UEF	Medium Draw: 0.52 High Draw: 0.58 Blended: 0.55	Medium Draw: 0.56 High Draw: 0.60 Blended: 0.58
	EUL	Years	13	10
Thermostatic Valve (RES-WH-TV)	EUL	Years	7	15
Variable Frequency Drive (RES-MAD-VFD)	Energy Savings	kWh/HP	Varies by type; see Table 3-34	
	Demand Savings, Summer	kW/HP _{SP}	Varies by type; see Table 3-34	
	Demand Savings, Winter	kW/HP _{WP}	Varies by type; see Table 3-34	

Recommendation 2: The team identified several measures and parameters for which updated parameter values are not recommended. Table 2 lists these measures and the reasons why this study does not recommend updated parameter values for them.

Measure Names and Codes	Reason for Not Updating
<ul style="list-style-type: none"> Air Source Central Heat Pumps (RES-HVAC-ASHP) Central Air Conditioning (RES-HVAC-CAC), efficient level Ductless Mini-Split Heat Pumps (RES-HVAC-DMHP) 	The PAs use program data to update measure parameters.
<ul style="list-style-type: none"> Central Ducted Heat Pump Fully Displacing Existing Furnace (RES-HVAC-FSHP) Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil (RES-HVAC-FSHP-P) Ductless Mini-Split Heat Pump with Integrated Controls – Fully Displacing Existing Boiler (RES-HVAC-FS-DMSHP) Ductless Mini-Split Heat Pump with Integrated Controls – Partially Displacing Existing Boiler (RES-HVAC-FS-DMSHP-P) 	This study recommends revised measure lifetime values. Revised measure savings values will be informed by a new energy optimization study.
<ul style="list-style-type: none"> Refrigerator/Freezer Recycling (RES-A-RFR) 	Improved data is not available.
<ul style="list-style-type: none"> Faucet Aerators (RES-WH-FA) Pipe Wrap, Water Heating (RES-WH-PW) Early Retirement Clothes Washers (RES-A-ERCW) <ul style="list-style-type: none"> Clothes Dryers (RES-A-CD) Heat Pump Quality Installation Verification (RES-HVAC-HPQIV) Heat Pump Digital Check-up/Tune-up (RES-HVAC-HPDCU) 	Measures represent a small portion of program savings.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

The study identified measure parameters in the TRM for which the evaluate team recommends the PAs adopt.

Overview of Study Method:

The evaluation team's review focused on identifying TRM parameters that were out-of-date, that were based on less relevant data sources (i.e., not Massachusetts or New England-specific), or that have a significant effect on the energy efficiency program's energy, demand, or fossil fuel savings. The team designed and implemented a scoring methodology that accounted for these factors and flagged select parameters as a high priority to update. Conversely, parameters from recently published, relevant data sources or that have a low savings impact received a low priority score. The resulting priority scores helped determine which parameters are candidates for updating.

The team reviewed data collected in the Residential Baseline Study and other available data sources to identify newer or more robust data available for updating parameter values. Other data sources include but are not limited to federal standard updates, ENERGY STAR updates, and recent evaluation studies.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-8.

Study 20-9: 2019/20 Massachusetts Winter Thermostat Optimization Evaluation

Type of Study: Impact Evaluation

Evaluation Conducted by: Guidehouse

Date Evaluation Completed: 10/23/2020

Study Objective and Summary of Results:

The purpose of this study was to estimate energy savings for the winter thermostat optimization program (called Seasonal Savings, hereafter SS) deployed in Cape Light Compact (CLC), Eversource, and (National Grid service territories in winter 2019/20, and to estimate associated energy and demand savings and calculate realization rates.

The study provides the following key findings:

- 47% of ITT thermostats and 61% of qualified ITT thermostats enrolled in the program across all three PAs.
- Enrollment and qualification rates for ITT devices are lower for Cape Light Compact than National Grid and Eversource (63% qualified and 38% of those qualified enrolled for Cape Light Compact versus 78% and 48%, respectively, for National Grid and Eversource combined). Such differences are likely due to different home usage and heating needs on Cape Cod.
- Enrollment rates by PA were similar to 2018/19. Almost two-thirds of devices that enrolled in 2018/19 and were offered the program again in 2019/20 reenrolled.
- Scheduled and actual setpoints and runtime all show evidence of the program effect for the ITT versus control groups. The stay-at-home period from the pandemic does not seem to affect the relative positioning of the ITT and control groups.
- Reviewing scheduled and actual setpoints and runtime based on when customers were treated (2018/19, 2019/20, both, or neither) shows some persistence in setpoints and shows the program effect builds over time.
- Scheduled setpoints for natural gas customers were about 0.25°F lower in the pre-period than in 2018/19. The SS impact on scheduled setpoints was roughly the same as 2018/19 (-0.80°F this year compared with -0.67°F last year).
- Average daily runtime for natural gas customers in the pre-period was similar across the two years (~250 minutes); however, it was lower in the 2019/20 program period (~190 minutes) compared with 2018/19 (~220 minutes), likely driven by milder weather in January to March. The SS impact on runtime was smaller (-4 minutes this year compared with -6 minutes last year).
- Across all three PAs, the program achieved 62,681 MMBtu of fuel energy savings and 319 MWh of electric energy savings (91 MWh on-peak and 228 MWh off-peak) between January 8 and April 30, 2020.
- For natural gas devices, the average energy savings per treated thermostat over the season was 11.6 therms (3.6% of heating load) and 5.4 kWh (3.6% of heating load) between

January 8 and April 30, 2020. This was a decrease of approximately 26% from 2018/19, likely driven by milder weather.

- For non-natural gas devices, average energy savings per treated thermostat over the season were 8.2 therms (2.7% of heating load) and 15.2 kWh (6.0% of heating load) between January 8 and April 30, 2020. This was a decrease of approximately 12% from 2018/19, likely driven by milder weather resulting in lower baseline usage.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- New Buildings & Major Renovations
- Behavior & HVAC
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: In 2019/20, the PAs should claim the fuel and electric savings listed in the following table.

PA	Heating Fuel Type	Measure Life	Participating Thermostats	Verified MMBtu Savings [†]	Verified kWh Savings [†]
Statewide	Natural Gas	1	52,285	60,796	281,641
Eversource	Natural Gas	1	15,977	18,578	86,064
National Grid	Natural Gas	1	36,308	42,219	195,582
Statewide	Non-Natural Gas	1	2,449	1,886	37,167
	Electric	1	32	-	486
Cape Light Compact	Oil	1	700	575	10,624
	Propane	1	228	187	3,460
	Electric	1	46	-	698
Eversource	Oil	1	392	322	5,949
	Propane	1	129	106	1,958
	Electric	1	77	-	1,169
National Grid	Oil	1	644	529	9,774
	Propane	1	201	165	3,050

Recommendation 2: In 2019/20, the PAs should claim electric savings broken down into on-peak and off-peak savings based on the following percentages:

- Natural gas: 28% on-peak, 72% off-peak
- Non-natural gas: 32% on-peak, 68% off-peak

These percentages should be multiplied by the verified kWh savings shown in the table in recommendation 1.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The study found average energy savings of approximately 11.6 therms and 5.4 kWh per treated natural gas thermostat and 8.2 therms and 15.2 kWh per treated non-natural gas thermostat in winter 2019/20. This is the last year SS will be evaluated as Google has integrated it as a standard offering for all Nest thermostats.

Overview of Study Method:

The study relied on thermostat telemetry data and thermostat-level participation data. A total of 145,659 thermostats (98,622 in National Grid's service territory, 41,925 in Eversource's service territory, and 5,112 in CLC's service territory) were included in the study (93% of the 145,659 thermostats in the PAs combined service territories were eligible for savings and approximately 11% were excluded from the analysis due to data quality).

1. An exploratory analysis of the data was performed to:
 - Compare enrollment and reenrollment rates across PAs to assess customer acceptance of the program over multiple years.
 - Analyze setpoints (scheduled and actual) and thermostat heating runtime to assess whether the impact of thermostat optimization was evident in the data.
 - Compare data for devices treated in both 2018/19 and 2019/20 with those treated just one year or the other.
 - Analyze differences between weekdays and weekends.
2. Guidehouse conducted an impact analysis to estimate the energy savings from SS for treated devices. The impact analysis for natural gas devices consisted of a runtime to energy conversion, regression modeling to calculate savings, and a comparison with Google's calculated savings. For non-natural gas devices, Guidehouse applied percentage savings from the 2018/19 evaluation to baseline usage (converted from runtime) for 2019/20.

A regression-based modeling approach was used to estimate energy savings for natural gas devices over the heating season. The SS program uses a randomized encouragement design

(RED) in which all customers in a PA's service territory with a Nest thermostat were randomly assigned into one of two groups. These two groups are the intent to treat (ITT) group, where participants are randomly assigned to receive the program offering, and the control group, where participants are randomly assigned to *not* receive the program offering.²

All qualified customers were provided the program offering on the thermostat itself and through Nest's mobile app. Some portion of ITT customers chose to opt in and enrolled into the program, while others did not. The group of customers that opted in is referred to as the treated group. Thermostats that were part of the ITT group but either did not qualify or did not opt in are referred to as the untreated group.

SS savings are evaluated by comparing the ITT group (both treated and untreated thermostats) to the control group using a linear fixed effects (or difference-in-differences) regression model to estimate energy and demand savings. The estimate of savings is then scaled by the program opt-in rate to calculate savings per treated thermostat.

For the 2019/20 season, National Grid and Eversource only offered the SS program to natural gas customers, dramatically reducing the number of customers available to model non-natural gas device savings. In the 2018/19 evaluation, almost 18,000 non-natural gas devices participated in the program compared with less than 2,500 in 2019/20. With so few non-natural gas devices, Guidehouse and Google agreed that regression modeling was unreliable to estimate savings.³

Instead, Guidehouse estimated savings using the same percentage savings as the 2018/19 evaluation and applied them to the 2019/20 usage baselines. Although the same savings were claimed for all non-natural gas devices in the 2018/19 evaluation, the evaluation team used the per fuel type savings to account for the change in mix of non-natural gas devices by fuel type between the two years.⁴

Due to the design of the program, targeted thermostats could not be linked directly to customers and their billing data. Therefore, the study relied exclusively on thermostat telemetry data to estimate impacts after converting thermostat runtime to energy consumption. Based on a combination of geographic location, self-reported heating types, and thermostat wiring, each Nest thermostat was assigned a heating fuel and equipment type. To develop conversion factors for each heating and equipment type, Guidehouse leveraged various data sources to obtain accurate estimates of average capacity and

² For each PA, 80% of thermostats were randomly assigned to the ITT group while the remaining 20% were assigned to the control group.

³ Google did run regressions for non-natural gas devices but found the relative precision at 90% confidence to be 69% of the savings estimate for fuel and 116% for electric (compared with 39% and 55% for 2018/19).

⁴ In 2018/19, 75% of non-natural gas devices were oil, 16% propane, and 10% electric; in 2019/20, the same percentages were 71%, 23%, and 6%. This result shows a shift away from oil and electric and toward propane, which is likely explained by the higher share of Cape Light Compact thermostats among the non-natural gas devices in 2019/20 compared with 2018/19.

operating efficiency, including previous potential studies, the RES 1 Baseline Load Shape Study, past DOE regulatory analyses and the Massachusetts Technical Reference Manual.

Because Guidehouse received daily rather than hourly data from Google this year, electric savings for on-peak, off-peak, and demand periods could not be directly estimated using 2019/20 data. The evaluation team estimated on- and off-peak electric savings using the same percentage of savings these periods made up in the 2018/19 analysis (28% on-peak and 72% off-peak for natural gas devices; 32% on-peak and 68% off-peak for non-natural gas devices). No electric winter demand savings were found in 2018/19, so no demand savings can be claimed for 2019/20.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-9.

Study 20-10: Eversource Home Energy Report Program Year One Persistence Savings and Decay Rate Study

Type of Study: Impact Evaluation

Evaluation Conducted by: Guidehouse Inc.
Illume Advising

Date Evaluation Completed: 2/26/2021

Study Objective and Summary of Results:

The purpose of this study was to determine how savings persisted after the November 2019 discontinuation of the Eversource Home Energy Reports (HER) program. The study identified first year persistence savings realized during calendar year 2020 and final year savings realized between November 2018 and October 2019. Using these findings, decay rates and persistence factors were provided to measure the extent to which savings persisted following termination of program treatment. For calendar year 2020, the persistence factor was defined as the ratio of percentage savings realized in 2020 and the percentage savings realized in the final year of program treatment, and the decay rate was equal to one minus the persistence factor. For a program with savings declining after discontinuation of program treatment persistence factors and decay rates will be between zero and one.

The study provides the following key findings:

- Net savings realized between November 2018 and October 2019:
 - 39,619,661 kWh
 - 873,955 Therms
- Net savings realized between January and December 2020:
 - 37,359,250 kWh
 - 857,253 Therms
 -

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential & Income-Eligible
- Residential Behavior
- Behavior & All End Uses
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: While the savings from the study reflect reasonable statistical significance, the decay rate results indicate that forecasting future persistence may be unreliable. If Eversource claims persistence savings in the future, the evaluation team

recommends periodically updating the study to learn how persistence savings are changing year-over-year, which will allow for more certainty during future planning cycles and filings.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

Evaluation findings will help Eversource understand the persistence savings that exist from the discontinued HER program. The evaluation findings will also help Eversource understand the extent to which savings decay over time.

Overview of Study Method:

To evaluate electric and gas savings during the final year and first persistence year of the HER program, the evaluation team utilized billing data and customer tracking data. A lagged dependent variable (LDV) model was estimated using these data for each electric and gas wave independently, which included program treatment status, monthly fixed effects, and pre-program energy use variables.

Since HER program participation may impart a lift in other program participation (participant uplift), the evaluation team estimated the degree to which this occurred. To conduct uplift analysis the evaluation team utilized program tracking data for all HER waves between 2018 and 2020. These data did not include pre-period program participation for most treatment groups. Therefore, the evaluation team estimated uplift due to suggested actions contained in this HER evaluation period through a post-only differences (POD) approach.

Once uplift savings were estimated, the evaluation team deducted these uplift savings from the savings evaluated via the billing analysis. The result of this difference was program savings net of uplift. These savings are provided above as net savings realized between November 2018 and October 2019 and net savings realized between January and December 2020.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-10.

Study 20-11: Impact Evaluation of PY2019 Massachusetts C&I Upstream Lighting Initiative (MA19C06-E UPLGHT)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 3/5/2021

Study Objective and Summary of Results:

The purpose of this study was to build upon prior research to understand the extent to which program performance is meeting program and policy goals and objectives. Research objectives included updating building-type hours of use (HOU) and compiling space-type HOU; assessing the quality control (QC) process and documenting potential improvements; and surveying, inventorying, and metering customer lighting controls.

The study provides the following key findings:

- Two savings values were calculated for each site in the study: connected demand savings (kW) and energy savings (kWh).
- The 2020 retrospective energy savings realization rate (RR) is 85.8%, ± 15.3 at the 90% confidence level. We recommend the PAs apply these results retrospectively to PY2020.
- The overall short-term ISR is 83.4%, with a precision of $\pm 7.4\%$ at the 90% confidence level, and the long-term ISR is 84.0% with a precision of $\pm 7.4\%$ at 90% confidence.
- The delta watts RRs for evaluation categories 1-5 are all near or over 100%. For high/low bay LEDs, the delta watts realization rate is 57.3%, producing an overall RR of 102.3% with a $\pm 14.5\%$ precision at 90% confidence.
- Connected demand (ISR times delta watts) is 85.4%, with a precision of $\pm 14.3\%$ at 90% confidence.
- The overall demand interactive factor is 1.06, with a precision of ± 9.9 at the 90% confidence level.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- C&I New & Replacement Equipment
- Lighting
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: For retrospective application of results (PY2020), the initiative should use the realization rates provided in the study. We recommend using the overall realization rate of 85.8% that covers all evaluation categories, given the high variance in individual evaluation categories.

Recommendation 2: In 2021, the initiative should use the realization rates of 96.8% for screw-in LEDs and 82.3% for non-screw-in LEDs, which exclude the impact of HOU updates that the PAs already adopted in 2021. Beginning in 2022, the PAs should use the updated impact factors provided in the first section of the study.

Recommendation 3: As with the prior HOU study, if a building type is unknown, use the overall result of 4,569 hours for upstream lighting, which represents the average operating hours of all building types combined.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt and/or are considering some of the recommendations, as described below.

Recommendations 1 and 2 are/will be implemented by PAs. Recommendation 3 is currently being considered by PAs.

How the Study Affects Program Results and Its Significance:

Lighting is an important energy end use in Massachusetts' energy portfolio, and the Upstream Lighting Initiative represents a significant share of C&I savings. Since the Initiative tracks estimated savings based on deemed savings values, the PAs must evaluate the program to determine RRs and update deemed values for future programs.

Overview of Study Method:

This study had four phases of evaluation. In the sample design and sample selection phase, DNV gathered electric account and measure-level population data and developed stratified sample designs by evaluation category and QC or non-QC. In the file and savings reviews, we acquired files supporting savings claims for sampled sites and performed savings reviews with savings validation. For on-site data collection, we recruited 75 in-person and 17 virtual sites; did measure verification, observed operational conditions, and deployed metering, which will remain installed until June 2021. For the site and aggregate savings analysis phase, we made measure-level engineering estimates of connected kWh and kW savings and provided statistical expansion of results and realization rates with precisions.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-11.

Study 20-12: Gross Impact Framework - Decision Guide (MA20C06-B-GIF)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 1/20/2021

Study Objective and Summary of Results:

The purpose of this study was to make decisions related to key processes and issues that the PAs, the EEAC Consultants, and the DNV team have addressed since the publication of the previous Gross Impact Framework – Decision Guide Memo in March 2020, following the implementation of the Gross Impact Evaluation Framework adopted in February 2017.

The memo provides decisions on the following topics:

- Limits on projects per site for evaluations
- Subcategorization of operational differences
- Baseline for Replace on Failure (ROF) projects that involve a change in technology
- Custom express tool adoption
- Lifetime savings and measure life
- Ex-ante review process
- Special considerations of statewide results and prospective evaluation results

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- All End Uses
- Electric & Gas

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

This memo is one iteration of a living document that will continue to be updated with EM&V decisions made in consultation with the PAs and EEAC Consultants.

Overview of Study Method:

All decisions were discussed among the PAs, the EEAC Consultants, and DNV team.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-12.

Study 20-13: C&I Lighting Market Characterization Study (MA20C09-E-LMC)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 3/25/2021

Study Objective and Summary of Results:

The purpose of this study was to update the adjusted measure lives (AMLs) for C&I upstream, prescriptive, and custom lighting program installations. The AMLs are based on market share estimates from the LED Market Model, so to ensure that the model reflects the most up-to-date information, this study also collected data to inform the model forecasts, including saturation, market share, volume of sales, product availability, and jurisdictional comparisons.

The study provides the following key findings:

- The AMLs calculated from the market share forecasts in the program-ending scenario in the LED market model are presented in a table.
- Overall, the LED C&I market is continuing to transform, and it will become increasingly difficult to find opportunities for program savings. COVID-19 had an impact on the uptake of LED technologies in 2020, although it's unclear how long these impacts will last.
- Even in the absence of the program, we expect the ambient linear submarket to be nearly transformed by 2024. However, the program is pushing the market toward higher efficiency LED integrated fixtures, with opportunities for more advanced control capabilities over the more traditional TLED replacements. If the programs continue as-is, we expect to see overall LED saturations near 85% by 2024.
- The high/low bay submarket looks much like the ambient linear submarket in MA, meaning it is dominated by linear technologies trending toward TLEDs and LED integrated fixtures, with the largest growth area in integrated fixtures. By the end of 2024, we estimate that the market saturation of LEDs will be 77% with the program. However, specific segments of the market may have lower saturation, which could provide more targeted opportunities for lighting programs.
- The building exterior/outdoor submarket is already highly saturated with LED technologies, leaving little room for additional market transformation. However, trade allies indicated that lighting programs will be driving a slightly higher percentage of LED market share in the future. There are not as many non-LED products available in the marketplace, so customers will likely be forced to replace non-LEDs with LEDs as equipment burns out or fails.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- Lighting
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: We recommend the PAs adopt the PY2020 retrospective AMLs for all ER and ROF measures reflected in the results table for upstream, prescriptive, and custom lighting program installations. New construction and major renovation measures should continue using the full measure lives rather than the AML.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

While the AMLs were the primary output of this study, it also provides insights into the current state of the C&I lighting market and how it is expected to evolve. These additional research insights are intended to help program planners and evaluators assess how to shape C&I lighting programs in the future.

Overview of Study Method:

The team conducted a saturation survey by doing phone re-visits for 103 sites that had had on-site visits in 2018 and 2019; developed and conducted a web survey of 32 contractors to estimate their market share; conducted in-depth interviews with 21 lighting manufacturers and 16 distributors that participated in the 2019 Upstream Initiative, with the primary goal of understanding how the PAs' programs have influenced all LED sales; developed a web-scraping tool to collect information on the types of products available on manufacturer and distributor websites; and re-calibrated the LED Market Model to reflect observed changes more accurately in the market over time.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-13.

Study 20-14: Impact Evaluation of PY2018-2019 Custom Electric Installations (MA20C04)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 3/17/2021

Study Objective and Summary of Results:

The purpose of this study was to provide verification and re-estimation of energy and demand savings for a sample of statistically selected custom electric projects through site-specific verification, monitoring, and analysis of Project Year 2018/2019 installations.

The study provides the following key findings:

- For almost all energy and peak demand savings parameters, the three-year pooled realization rates improved over the previous two-year rolling results. Statewide, operational effects represents the largest discrepancy adjustment for lighting and baseline the largest for non-lighting.
- Custom non-lighting projects are generally more complex than lighting projects, so the realization rates (RRs) tend to have more variation. However, the programs could gain some ground in some areas. In particular, a large portion of the savings were reduced due to adjusted baselines—something the PAs are committed to improving upon.
- A handful of projects did not claim savings for some portions of the project, possibly to use more conservative tracking savings estimates. Since these have typically been quantified via measurement & verification (M&V), and to stay consistent with past studies, we included these only for sites with full M&V, which was not the case for many of the projects due to impacts of the COVID-19 pandemic on conducting full M&V.
- The lifetime savings adjustment factors (LSAF) reported in this memo represents evaluation changes made to measure event type and measure life selection and does not include the new lighting EUL and adjusted measure life (AML) values from the most recent MA Lighting Market Characterization study. The evaluation found that the claimed custom measure life was typically supported by the documentation provided in the project file.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- Custom
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Apply the results from the Interim Results Memo to the PY2020 tracking savings reported in the 2020 Plan Year Report filed in 2021.

Recommendation 2: Apply the LSAF to the PY2020 lifetime tracking savings reported in the 2020 Plan Year Report filed in 2021.

Recommendation 3: As the application files are not always complete, be diligent in gathering the technical assistance studies, spreadsheets, and models used to define and develop the project and include them in the electronic documentation.

Recommendation 4: Separate fixture replacement and lighting controls savings when calculating annual and lifetime savings estimates. If this isn't possible, a weighted measure life should be applied to better represent early replacement projects with both lighting fixture and control savings.

Recommendation 5: Adopt the recommendation made in the "Memorandum on Dual Baseline Calculation Practices and Assumptions, November 27, 2019" to maximize the accuracy of lifetime savings, and continue to evaluate lifetime savings impacts and calculate a lifetime adjustment factor to be applied to tracking lifetimes.

Recommendation 6: Develop a weighted measure life for multi-measure projects that fall in the same line of tracking data or isolate the individual measure savings into unique lines in the tracking data so that each measure claims an accurate measure life.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The results from this study should be combined with the next round of custom electric impact evaluation, which is expected to be applied to the PY2021 tracking savings and reported in the 2021 Plan Year Report filed in spring 2022. This aligns with the MA impact evaluation framework by maintaining an annual rolling custom electric impact evaluation result.

Overview of Study Method:

Methods used for this year's evaluation were similar to last year's, except for modifications due to the COVID-19 pandemic. The key modifications were an increased scope of desk review tasks, including a more in-depth review of applicants' assumptions and calculation methodology; the use of virtual audits to verify technology, assess HVAC interaction, and validate measure installation; and realization rates based on verified non-operational parameters of the current and PY2016 and PY2017/18 samples, verified operational parameters of the current sample where available and

historical operation adjustments from the past two studies where not available and the pooling of this sample's results with PY2016 and PY2017/18 results.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-14.

Study 20-15: Massachusetts Custom Electric CDA (MA20C16-B-CDA)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 3/23/2021

Study Objective and Summary of Results:

The purpose of this study was to re-analyze the 2018 Custom Comprehensive Design Approach (CDA) energy and peak demand savings realization rates using new standard lighting power densities (LPD) derived from the recent new construction baseline market characterization study as well as current baseline practices used by the program. The analysis also includes adjustments for other non-lighting industry standard practice (ISP) impacts.

The study provides the following key findings:

- For current CDA projects, as well as other performance lighting projects, the lighting baseline depends on the permitting code. For projects permitted under IECC 2015/ASHRAE 90.1-2013, the PAs use a baseline that is 0.8 of code LPD. For projects permitted under IECC 2018/ASHRAE 90.1-2016, the PAs use the Massachusetts Amendments to code. These requirements are documented each year in the Mass Save Baseline Document.
- DNV completed a detailed analysis for each site in the sample. The resulting program-level realization rate, which is the weighted result using the original sample design case weights, is 48% for annual electric energy savings. This is reduced from the 57% realization rate from the prior CDA impact evaluation. However, the removal of the FCU ISP baseline from the revised realization rates brings the result back to 57%.
- DNV applied the same ratio of annual energy savings realization rates between the old study and this study to re-calculate summer and winter on-peak demand savings, producing revised peak demand savings estimates of 58% for summer and 44% for winter.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- New Buildings & Major Renovations
- Custom
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Use RRs from this study to apply retrospectively to CDA projects completed in 2020:

- Gross annual electric kWh savings RR: 57%
- Gross summer on-peak kW reduction RR: 58%
- Gross winter on-peak kW reduction RR: 44%

Recommendation 2: Lighting baselines for new CDA studies should adopt the new LPD adjustment of 0.6 of IECC 2015 code.

Recommendation 3: Upon finalization of the Non-Residential New Construction Baseline study, incorporate any other non-lighting baseline findings to new construction projects going forward.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt and/or are considering some of the recommendations, as described below.

Electric RR recommendations have been employed by PAs retrospectively for 2020. Other recommendations are currently under consideration by the PAs.

How the Study Affects Program Results and Its Significance:

This study found that lighting savings were significantly impacted by the use of the new LPD adjustment factor and by the appropriate application of current baseline practices to the older CDA study results. The opportunity for lighting savings given these new requirements has decreased.

Overview of Study Method:

This study used the same sampled CDA projects as the 2018 study to recalculate electric savings realization rates. For most projects in the impact evaluation sample, ex-ante baselines were defined in accordance with the 8th edition of the Massachusetts Energy Code. This analysis recalculated the custom electric CDA gross annual savings realization rate by applying the new LPD adjustment factor of 0.6 from the current NRNC project to the sample of sites from the prior impact evaluation.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-15.

Study 20-16: Steam Trap and Boiler Efficiency Research (MA20C05-G-STBE)

Type of Study: Technology Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 10/20/2020

Study Objective and Summary of Results:

The purpose of this study was to research factors related to estimating savings for steam traps and the annual heating plant efficiency factor, which is a primary steam trap savings input, and to recommend future research and/or updates to the steam trap tool to improve consistency and accuracy in use of the tool.

The study provides the following key findings:

- Steam trap measures can be identified within the custom population through BCR measure IDs. A steam-trap-specific realization rate (RR) can be integrated into tracking if segmented from the rest of the custom gas measures.
- Stakeholders and tool users are satisfied with the general algorithmic approach of the steam trap tool (STT). However, the Team found variation among the PAs in how some variables are being assessed and input into the tool. PA staff do not believe vendors are systematically overstating hours of operation but have indicated the need for more guidance in the application of parameters, specifically hours. Implementing limits and caps in the tool may prevent gross overstatement but could create other issues. Application reviewers could benefit from built-in tool checks. Calibration of the STT is useful for approximating values of parameters that cannot be measured directly but increases the risk of double-counting some effects.
- While annual heating plant efficiency (AHPE) values vary within a narrow range with respect to firing rate at any site, efficiency values vary more significantly from site to site based on boiler type.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- C&I New & Replacement Equipment
- Custom
- Gas Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Continue current evaluation sample design practices, such as the current practice of reporting all custom gas measures with a single statewide or PA-specific

RR, and reviewing the desk review results from the new calibration projects to further assess PA variability.

Recommendation 2: Modify the STT to clarify inputs and streamline QC review process. Update fields to improve consistency among various users and bolster the review process with a number of automated QC checks.

Recommendation 3: Update STT parameters via billing analysis calibration. Recalibrate using projects from PY2017 and PY2018.

Recommendation 4: Post the STT online with a summary of revisions and communicate updates to vendors and reviewers when the revised STT is rolled out.

Recommendation 5: For measures that reduce the boiler output, **use deemed AHPE values** based on average combustion efficiency measurements representative of typical boilers serving steam trap and insulation measures.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

Steam traps constitute a large share of custom program savings, rely on a single statewide calculator for estimating savings, and have had poorer RRs than other custom measures. These factors raise the question of whether steam trap measures should be evaluated as contributing to overall individual PA custom RRs as they are now, evaluated as a statewide measure, or evaluated in some other way.

Overview of Study Method:

The team researched factors associated with the evaluation of steam trap measures; interviewed experts nominated by stakeholders to gather feedback on the STT and annual heating plant efficiency methods; analyzed past evaluation project data to develop findings related to steam trap discrepancies and factors associated with AHPE methods; and organized five Working Group sessions attended by experts nominated by stakeholders to discuss the findings of each of the three other tasks.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-16.

Study 20-17: Massachusetts C&I Impact Evaluation of PY2018 Custom Gas Installations (MA20C01-G-CUSTGAS)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 2/24/2021

Study Objective and Summary of Results:

The purpose of this study was to verify and re-estimate the energy savings for a sample of statistically selected PY2018 custom gas projects through site-specific inspection, monitoring, and analysis. The study provides the following key findings:

- The three-year pooled statewide precision target was met with an achieved relative precision value better than $\pm 10\%$ at the 80% confidence interval.
- When the results for the most recent three program years were pooled, PA-specific precision targets of $\pm 20\%$ at the 80% were met by Columbia Gas and National Grid, while Eversource achieved relative precision of $\pm 27\%$, which is greater than the target.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- All End Uses
- Gas Only
- Custom installations

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Use the appropriate realization rates. The relative precision of the RRs for National Grid ($\pm 8\%$), and Columbia ($\pm 7\%$) meet the target and each PA had more than ten sites (when PY16, PY17, and PY18 are pooled), therefore their individual PA realization rates will be applied. Eversource will use the statewide (EV) results that achieved a relative precision of $\pm 11\%$. Because fewer than ten sites were evaluated in their territory, Berkshire, Liberty, and Unitil will use the Statewide (BLU) results that achieved a relative precision of $\pm 7\%$.

Recommendation 2: Use the appropriate lifetime savings adjustment factors (LSAFs). Columbia Gas and National Grid will use their individual pooled LSAFs. Eversource will use the Statewide (EV) LSAF value and Berkshire Gas, Liberty, and Unitil will use the Statewide (BLU) pooled LSAF value.

Recommendation 3: Improve the data collection and controls procedures for projects greater than 100,00 therms (large). Pre-project errors (inputs or calculations) had a negative impact of

17% in the PY2018 savings. PAs should continue to improve project-specific pre-installation data collection and enhance the quality control process for large projects to catch errors that affect the program results.

Recommendation 4: Research to gather data on steam trap repair frequencies at participating and non-participating facilities that might result in an update of the steam traps calculator.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The results from this study will be applied to the PY2020 savings in the 2020 term year report filed in 2021. The team will continue to roll the three most recent annual program evaluation results together to determine a realization rate that meets the precision targets.

Overview of Study Method:

The evaluation team's approach was consistent with the procedures and protocols developed during the previous rounds of custom gas impact evaluation conducted for PY2016 and PY2017. The impact evaluation consisted of desk reviews, on-site visits, and metering of a randomly selected sample of projects at participating facilities.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-17.

Study 20-18: Franchise Controls Deemed Savings Study (MA20C07-E-DUN)

Type of Study: Impact Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 1/22/2021

Study Objective and Summary of Results:

The purpose of this study was to develop measure-level deemed savings estimates for a building automation system (BAS) measure offered for small franchise coffee and donut shops, which are often installed with multiple other efficiency measures such as lighting retrofits and refrigeration controls. The measure applies time switch-based scheduling of small individual food service appliances (e.g., toasters and coffee makers), and often HVAC setback and exterior lighting controls. The study leveraged three different recent evaluation studies, where results from those studies were used as a basis to determine the optimal deemed savings estimate for the BAS measure. The recent studies include billing analysis in study P71, and impact evaluation work for PY2017 small business (MA19C03-E-SBIMPCT) and PY2017/2018 custom electric (MA19C07-E-CUSTELEC). To narrow focus on the BAS measure, we isolated five sites that only installed BAS systems that controlled appliances and overlapped in both the M&V and billing analysis samples.

The study provides the following key findings:

- The five sites common to the three studies have similar average impacts, at 9,651 kWh and 9,135 kWh and of the same magnitude when viewed as a percent of consumption.
- Given the DNV team's confidence in the representativeness of the small sample, the methods to develop the measurement and verification (M&V) baseline, and that the billing analysis does not present evidence the M&V savings are incorrect, the team deemed the M&V results reasonable.
- The similarity of savings as a percent consumption between the pre-post billing analysis and M&V savings results among the overlapping subset indicates the two analyses are in agreement regarding individual site-level effects. The full billing analysis, incorporating far more sites and a comparison group, produces a result that is grounded in both more participant data and a consideration of non-program, exogenous trends. Given the parallels between the two analyses, but the ultimate overall strength of the billing analysis result, we recommend using the overall billing analysis study results to inform the deemed savings estimate.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- Existing Building Retrofit
- Food Service
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: Given the similarity of savings as a percent of consumption between pre-post billing analysis and M&V savings results among this subset and the larger billing analysis study, use the overall billing analysis study results to inform the deemed savings estimate.

Recommendation 2: Ensure the appliances planned to be packaged into the BAS are appropriate for the control measure, rather than applying the controls to the eight greatest loads. Appliances such as ice machines, which do not benefit from controls, and appliances that were previously controlled in a similar fashion before the BAS installation should not be included in the BAS package.

Recommendation 3: The overall recommendation for the deemed savings estimate per BAS installed in a franchise site is 5,344 kWh, or 4.0% of site consumption.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The recommended deemed savings estimate for the BAS measure of 5,344 kWh is significantly lower than the current estimate of 18,700 kWh. This decrease is mostly due to less than predicted operational changes impacting hours of use, which are mostly influenced by users overriding the BAS controls to use equipment during periods of lower demand. The change in savings may need to be analyzed through means of cost-effectiveness to determine if the measure should be considered for future energy efficiency implementation.

Overview of Study Method:

To narrow focus on the BAS measure, the DNV team isolated five sites that had only installed BAS and which were in both the M&V and billing analysis samples. In isolating the M&V sites within the billing analysis dataset, the team could then compare the small sample of M&V and billing results and examine the influence of a comparison group on the billing results. Though the selection of these five sites was not representative, they provided a basis to compare the M&V and

billing analysis methods, which provided more confidence that the billing analysis with the control group, which is representative, was the correct value to use.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-18.

Study 20-19: Ground Source Heat Pump eTRM Measure Review (MA20C15-B-GSHP)

Type of Study: Technology Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 1/29/2021

Study Objective and Summary of Results:

The purpose of this study was to determine the accuracy of the values in the Massachusetts Technical Reference Manual (eTRM) for estimating savings for ground source heat pumps (GSHP). The main objectives were to provide guidance to the PAs on possible adjustments to the eTRM savings calculations as they are presented for this measure; the need for estimating whole system savings, as opposed to savings from the heat pump unit only; and measure life estimates, including unit lifetimes vs. whole system lifetime.

The study provides the following key findings:

- The current GSHP offering is sufficient for the limited event type offering. However, it does not accurately reflect the benefits of GSHP installation for wider event types.
- GSHPs are high-performing, supplying 3.1 to 4.1 units of energy to the building as heat for every 1 unit of energy used to power the system.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- HVAC & Hot Water
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: To more accurately reflect savings from this measure, GSHPs should be broken out from air source heat pumps (ASHPs) into their own category offering. This will allow the program to attribute savings, baselines, and lifetimes in a more defensible way.

Recommendation 2: Baseline considerations: The measure should allow baselines to reflect pre-existing and similar code efficiencies to maximize savings for two different event types (new equipment and early replacement/retrofit).

Recommendation 3: Algorithmic considerations: Further algorithms should be considered to include fossil fuel impacts when replacing fossil fuel-fired heating systems. When a

desuperheater is included in the system, domestic hot water impacts should be included for either electric or gas dependent on the hot water heating system on-site.

Recommendation 4: Lifetime considerations: The lifetime of the measure should be updated from 12 years to match the U.S. Department of Energy's expected lifetime of 25 years for the indoor portion of the GSHP.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

Currently, the GSHP measure is lumped into a package with ASHPs. The current methodology, algorithms, and baseline for the new equipment event type are sufficient, though limited in scope, as other event types are not considered. The research suggests that, in reality, most GSHPs replace existing equipment such as boilers, chillers, furnaces, and ASHPs. In such cases, the efficiency of the existing unit or a comparable code efficiency is the better reference savings, though it is recommended that PAs seek secondary research to determine an appropriate baseline for GSHP retrofit event types that fit within the MA C&I baseline framework. Current GSHP methodology only considers electric impacts for cooling and heating supplied by the GSHP. When considering pre-existing conditions, a project may develop gas heating impacts when replacing pre-existing fossil fuel-fired equipment. Domestic hot water benefits are also potentially missed.

Overview of Study Method:

For this study, DNV gathered relevant documents and performed an initial literature review to provide a basis from which we assessed potential modifications to the eTRM measure. Information was collected from industry papers as well as TRMs from other states and jurisdictions that incentivize GSHPs. Interviews were also conducted to collect first-hand information from industry experts and independent engineers on GSHP unit performance and savings. We sought to address issues such as nameplate vs. actual performance, the appropriate baseline for these systems, and whole system savings vs. unit savings alone – which is understanding the impact of the ground source loop system on the ground source heat pump itself.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-19.

Study 20-20: C&I ISP Research and Repository: Food Services Equipment Pre-Research Memo (MA20C02-B-ISP-REPOS)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 9/22/2020

Study Objective and Summary of Results:

The goal of this research was to assess whether we see enough evidence of used food service equipment being purchased and installed to warrant further ISP investigation. The evaluation team conducted pre-ISP study research, including web research and interviews, to determine whether a blended baseline is worth pursuing for food service measures.

The overall outcome of this study was that additional primary research with respect to industry standard practice surrounding kitchen equipment will be valuable to the PAs and the evaluation team.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study. Based on the online research, referring to the TRMs, Food Service Technology Center (FSTC) engineer input, and phone calls with two suppliers, the team found that there is a significant market for used and refurbished food service equipment. The team believes that further research to determine a new baseline for used kitchen equipment will be valuable. The following topics are recommended for inclusion in a full ISP study:

- **Include research on used equipment market prevalence and practices in research.** This may be challenging due to the scattered nature of the used equipment market. Including some interviews with end users may be necessary.
- **Limit ISP research to non-refrigeration equipment.** The interviews and research we conducted suggests that cooking equipment, particularly ovens, griddles, fryers, and ranges, are more likely to last long enough to become part of the used equipment market, and this equipment is not subject to federal efficiency standards in the same way that refrigeration equipment is.
- **Consider differentiating practices by restaurant type.** Fast food, franchised, and chain restaurants may have different standard practices, especially when considering used equipment.

- **Include both gas and electric equipment.** Typical operating efficiencies for cooking equipment differ substantially depending on the fuel used.
- **Note that ongoing impacts due to the coronavirus may drive a change in behavior.** An upswing in the used equipment market may change industry standard practice in the short and long term.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The results from this study do not have a direct impact on retrospective or prospective savings. If additional research is conducted, and the baseline for kitchen equipment is determined to be different from what the program commonly uses this could have savings implications in the future but is not defined at this time.

Overview of Study Method:

Evaluators used a mix of secondary research and a small amount of primary research to arrive at the recommendations. This included web research, online supplier research, a comparison of technical reference manuals and some informal interviews with industry experts.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-20.

Study 20-21: Code Promulgation Attribution Study (MA19X07-B-CDPROMATT)

Type of Study: Impact Evaluation

Evaluation Conducted by: NMR Group

Date Evaluation Completed: 9/15/2020

Study Objective and Summary of Results:

The purpose of this study was to determine an attribution factor to apply to the savings generated from the PAs' efforts to promulgate energy-efficient amendments into the 2018 Massachusetts State Building Code. The study also developed a framework for estimating the gross-technical-potential (GTP) savings resulting from those amendments.

The study provides the following key findings:

- The PAs developed three commercial and two residential amendments that were ultimately adopted into the State's base building energy code. It is unlikely similar proposals would have been adopted without the PAs' efforts.
- The PAs are 90% responsible for the savings resulting from the energy-efficient amendments. This factor was determined by a consensus group of stakeholders, based on a document review and in-depth interviews with participants in the code adoption process.
- The study estimated combined electric and gas GTP savings of 138,153 MMBTU from the amendments through 2026. This includes 29,103 MWh of electric GTP savings, which represent between 3% and 13% of the 2018 new construction electric savings annually. One amendment that reduces interior lighting power density allowances accounts for 95% of the electric GTP savings. The study estimates gas GTP savings at 388,574 therms, representing between -1% and 5% of 2018 new construction gas savings annually (accounting for interactive effects between lighting and gas savings). Commercial and industrial savings comprise 65% of the combined savings and residential savings comprise 35%.
- Using the framework developed in this study, the PAs can calculate more accurate estimations of GTP in the years 2022 through 2026 by replacing assumed values with actual data.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential & Commercial & Industrial
- New Homes & Renovations
- Envelope & HVAC
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: The PAs should use an attribution factor of 90% for the savings generated from their efforts to promulgate the five Massachusetts-approved amendments to the 2018 International Energy Conservation Code (IECC).

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

This study determined that an attribution factor of 90% should be applied to gross savings estimates resulting from the PAs' efforts to promulgate amendments to the 2018 IECC. This will apply to gross savings generated in 2022 through 2026.

Overview of Study Method:

The study included a document review of all documentation of PAs' efforts and all publicly available BBRS proceeding documents. Additionally, NMR conducted in-depth interviews with two PA representatives and five key participants in the code adoption process. The attribution factor was determined using a consensus group, including experts from evaluation, implementation, PAs, and the Department of Energy Resources.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-21.

Study 20-22: 2013-2017 Residential Customer Profile Study: Stakeholder Summary and Comprehensive Report (MA19X08 2017 RESCUSTPRO)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 9/16/2020

Study Objective and Summary of Results:

The principal research objectives of the RCPS comprehensive report is to analyze 2013-2017 customer usage, savings, incentive, and program participation data using charts, tables, and geographic outputs. In addition this report included a location-level analysis (within year, and over time) with aggregated savings and participation rates, by PA, fuel, and geography.

The study provides the following key findings:

- Despite a 4.2% increase in the number of physical locations served by the electric PAs from 2013 to 2017, the residential population's kWh consumption has declined by 1.7%.
- From 2013-2017, approximately 35% of locations participated in a program. This excludes upstream and behavioral programs.
- Housing authorities had a population savings achieved nearly double most other building types.
- The 5-year electric participant location rate is likely much larger than 35%. This is because that figure does not include any locations that purchased lights and other products through the upstream channel. The upstream channel represents 48% of electric program savings annually from 2013-2017.
- The geographic distribution of incentives per kWh at the block group level is relatively uniform, though larger projects can skew this.
- The block group scatterplots show that there are linear trends in savings and participation relative to demographic variables, and that the existence of outlier groups may offer "lessons learned" opportunities for additional savings and participation.
- Since 2015, the Residential Products program, a retail delivery channel, has contributed a proportionally larger percentage of savings, while the Residential Whole House program, which includes home energy audits, has contributed a smaller percentage.
- The electric PAs' quintile population savings ratios have been relatively consistent since 2014, with the first and fifth quintiles averaging around 1.3 to 1.4% savings.
- The gas PAs' quintile population savings ratios are more variable within the ACS attributes.
- Block groups with lower electric participation from 2013 to 2017 appear to be associated with high proportions of delivered heating fuels.
- Rural areas tend not to have access to PA-delivered natural gas and rely on delivered fuels, including oil and propane. These areas may represent opportunities for targeted electrification. Urban areas tend to have choices beyond delivered fuel and are less likely

locations for targeted fuel switching than rural areas, which have a higher percentage of delivered fuel.

- The location data grain is preferable for time series analysis due to its consistency across PAs and fuels, as well as the presence of location in nearly all third-party data.
- Some of the demographic variables of interest in this report appear to be correlated with one another.
- ACS household data and PA location data are complementary, but different grains and should be leveraged with this in mind.
- K-Means clustering of block groups using the combination of factor scores and PAs' tracking data offers an alternative and more comprehensive way than the basic quintile analyses to assess geographic patterns in customer engagement and to aggregate similar block groups for summary statistics.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Income-Eligible
- All Initiatives
- All End Uses
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: *Use third-party information, partner data, and DHCD data to better identify low-income households.* The RCPS has traditionally leveraged PA rate codes to identify low income housing. This approach has the benefits of maintaining consistency across all PAs and leveraging data (the rate code) that is captured as a core element of the billing process. The drawback is that even with the assistance in place through the PAs and other stakeholder groups, not all low-income customers may realize they qualify to be on a low-income rate code. The 2017 RCPS was able to leverage data about housing authorities, but this still leaves a population of privately-owned subsidized housing potentially under-represented in the data. After a review of data available from MA DHCD, DNV believes that a focused effort to identify the most useful datasets and develop a pipeline process to link the to the PAs data – similar to what was done with the tax data – would be a transparent and efficient way to further identify and report on the program engagement of low income customers.

Recommendation 2: *In future iterations of the RCPS, break out multifamily and single-family housing as separate reporting classes and build on the location-level grain to reflect sub-unit participation and savings for all PAs.* The idea arose through working groups with the PAs and EEAC Consultants to add an additional reporting grain identifying single family statistics and multifamily statistics. This grain was not reflected in the 2017 RCPS due to ongoing refinement around identifying multifamily data as accurately as possible. The difficulty of identifying multifamily data is compounded by the fact that while some measures, such as

insulation, impact all accounts, sub-units, and customers within a multifamily building, they might nevertheless be tied to a single record (such as the building's common area meter) or only reflected in the data at the building level. One workaround for this data limitation is to use consumption-weighted participation as done in the MA Residential Non-participant Customer Profile Study; others may include identifying sub-units using tax data or a logic model looking at simultaneously active electric accounts within a location. We suspect that in future studies, the parallel application of different identification systems will allow us to distinguish multifamily from single family sub-reporting grains to better reflect how these customer groups are served.

Recommendation 3: *In the next RCPS, use exploratory factor analysis (EFA) and k-means analyses to determine whether geographic hot spots and/or outliers exist within the landscape.* The application of the EFA and k-means to the geographic data in the 2017 RCPS confirmed that the more detailed classification of block groups leveraging multiple ACS variables yields a more nuanced and interesting geographic landscape than prior methods have yielded. The next RCPS should build on this analysis to not only score the individual block groups, but also identify where geographic clusters of similar block groups exist and if/where there are outliers within these groups or across the greater landscape. This type of analysis addition will facilitate the use of geographic data by implementation and outreach teams through visually focusing on areas of interest, and could become a particularly powerful community outreach tool when integrated into an interactive spatial decision support environment.

Recommendation 4: *Leverage a similar interactive platform for the data presentation along the lines of what the C&I Customer Profile has been migrated to. The RCPS contains a substantial amount of data, and is of interest to a broad array of stakeholders.* Migrating many of the graphics, in particular the geographic analyses, to an interactive platform would support the PAs' focus on continuing to develop and modernize data coordination. The PAs have successfully migrated the C&I Customer Profile Study to an interactive web-based platform; this reduced the report length by over 400 pages, shortened the timeline for making data available to stakeholders by nearly half a year, and based on stakeholder feedback – including the EEAC – greatly increased the data's usefulness by facilitating custom analyses and data summaries.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The 2017 RCPS analyzes and reports on the Massachusetts Program Administrators' (PAs') energy efficiency program tracking and residential customer consumption data to offer diverse views of participation, savings, and geographic dynamics within the PAs' residential customer population. The RCPS assesses the energy efficiency program tracking and billed usage data for

residential gas and electric customers, and identifies and summarizes trends in participation and savings.

Overview of Study Method:

The RCPS dashboard, stakeholder summary and data insights report use PAs' 2017 billing and tracking. This data undergoes a standard extract, transform, and load (ETL) process. Data is prepared for analysis by linking the 2017 tracking and billing data to the historical data along with third-party tax assessor data.

- **Report on unique locations:** DNV reported on the unique locations represented in the PAs' data, replacing the previously reported on account-level analysis grain.
- **Report on unique locations over time:** The 2013-2017 data was used to report on activity at unique locations over time, creating a new analysis lens through which to better understand participation rates and coverage.
- **Report on incentives by geography:** DNV reported on savings, usage, and incentives for customers at the block group level.
- **Add ACS variable groups:** DNV coordinated with the PAs to integrate new ACS block group variables.
- **Link scatterplots, tables and maps:** DNV significantly modified the ACS block group analyses by including newly designed consumption-normalized scatterplots; providing greater transparency and insight into block groups of interest while still protecting customer privacy.
- **Re-cluster ACS block groups:** DNV assessed three clustering options – natural breaks, k-means and principal components analysis (PCA) – as alternatives to the quintile breaks used in prior reports.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-22.

Study 20-23: 2018 Commercial and Industrial Customer Profile Study: Stakeholder Summary and Comprehensive (MA20X01-B-2018CICUSTPRO)

Type of Study: Market Characterization or Assessment Evaluation

Evaluation Conducted by: DNV

Date Evaluation Completed: 2/3/2021

Study Objective and Summary of Results:

The overall goals of the 2018 Commercial & Industrial Customer Profile Study (CCPS) are to analyze, summarize, and report on the energy efficiency program tracking data and billed usage data for all C&I gas and electric customers served by the PAs.

The study provides the following key findings:

- The MA PAs' 2018 energy efficiency programs continued to deliver consistent participation and savings statewide and across a diverse business demographic for Massachusetts C&I customers.
- Gas programs continued to meet statewide savings targets with participation rates consistent with prior years; natural gas prices remain particularly important in customer investment decisions.
- Accounts and locations provide two complementary, but different, views of participation—especially for time series metrics. For several PAs, participation rates nearly double when assessed through the lens of location rather than account.
- In 2018, the share of statewide savings from electric micro and small business accounts was nearly proportional to their share of statewide consumption. Small business gas accounts showed more participant savings achieved, on average, than medium and large accounts.
- Educational Services showed a high degree of measure diversity and high time-series lifetime savings at the location level compared to other segments, suggesting that measure diversity supported this segment's aggregate successes.
- HVAC is an important source of electric and gas savings. Continuing to engage customers in this ubiquitous end use and continuing to support HVAC measures via multiple delivery channels will likely be key to future savings goals.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Commercial & Industrial
- All Initiatives
- All End Uses
- Electric & Gas

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: incorporate broader analytics related to the program planning tools beyond traditional energy efficiency to create a more complete picture for planners and stakeholders, including assessing the performance of the C&I Active Demand Reduction (ADR) Initiative and any other key program or metrics or key performance indicators identified through stated goals in the Three-Year Plan.

Recommendation 2: expand location-level analysis to inform strategic targeting and equity efforts. This would potentially include adding more crosstabs with location comparisons, beyond PA and fuel, to look at location participation and savings across different customer sizes, towns, industry segments, end uses, etc.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The analysis and reporting of the CCPS along with the easily accessible electronic dashboard (<https://www.masssavedata.com/Public/CICustomerProfileDashboard>) accurately quantify and report on time series trends on the Massachusetts C&I energy efficiency programs. The CCPS dashboard and paper report provide detailed data while always maintaining PAs' customer and IT system confidentiality.

Overview of Study Method:

The CCPS dashboard, stakeholder summary and data insights report use PAs' 2018 billing and tracking. This data undergoes a standard extract, transform, and load (ETL) process. Data is prepared for analysis by linking the 2018 tracking and billing data to the historical data along with third-party tax assessor data.

Location-level analysis: New to the 2018 CCPS, DNV created a location analysis grain. This allows for key metrics to be analyzed based on location in addition to, or instead of, account, which has historically been the basis for report findings.

Lifetime savings analysis: the new location grain also allows for a fresh look at program impacts at the site level, where (with relatively rare exception) assets remain constant regardless of account turnover. DNV expanded on this to include time-series contribution ratios utilizing lifetime savings. This new analysis captures a location's contribution to program goals over measure lives and addresses the concern of considering only existing single-year views.

New construction methodology change: to better analyze new construction accounts without prior consumption history, DNV modified the calculation logic to take the current year's extrapolated consumption plus the gross annual energy savings attributed to the new building.

Weather-normalize extrapolated consumption for both gas and electric accounts: for accounts with partial year consumption DNV used time-series data to generate weather-normalized consumption for both gas and electric accounts.

Consumption bin data retention: As part of the CCPS analysis, DNV compared results across customer sizes based on annual consumption. Accounts are broken into four customer size bins for this analysis: micro, small, medium, and large.

DNV updated the results from the 2017 CCPS using 2018 data provided by the PAs and tabulated year-over-year totals the broad groupings of:

1. Statewide by fuel
2. PA and fuel
3. Energy consumption range
4. Geographic region
5. Industry segment
6. End use

When possible, DNV also included breakdowns of these tables for each PA. Analysis of the tracking data by geography was conducted at the town level. The following metrics were used in the analyses:

- Participation
- Consumption-weighted participation
- Population savings achieved
- Participant savings achieved
- Market penetration
- Consumption-weighted penetration rate
- Contribution ratio
- Savings achieved over time

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-23.

Study 20-24: Consistent Methodology for Self-Reported Residential Net-to-Gross Measurement (MA19X03-B-RSRNTG)

Type of Study: Net-to-Gross Evaluation

Evaluation Conducted by: Tetra Tech
NMR Group

Date Evaluation Completed: 5/28/2020

Study Objective and Summary of Results:

The objective of this study is to develop a consistent methodology for determining self-reported (SR) residential downstream net-to-gross (NTG) for Massachusetts that can be adapted to reflect program offerings. This includes recommended survey questions and algorithms to be utilized for program offerings where a SR NTG is feasible.

The study provides the following key findings:

- The Illinois Technical Reference Manual, Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs, and the Energy Trust of Oregon Free-Ridership Methodology are similar in their NTG measurement approach for most residential programs (other than appliance recycling) in that they include a consistent set of core questions asking about influence of the program and customer intent had the program not existed. These frameworks have been in place for multiple program cycles, have been well-tested, and are commonly cited approaches.
- The study team built upon the NTG algorithms previously used in Massachusetts and incorporated commonalities from the Illinois, Pennsylvania, and Oregon frameworks above, including recommended residential batteries of questions and algorithms; questions about influence, timing, efficiency, and quantity; and questions designed to ensure consistency.
- The team created and provided PAs with tables aligned with the Benefit-cost Ratio model (BCR) that identify the residential programs/initiatives for which SR NTG is appropriate.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- All Initiatives
- All End Uses
- Electric & Gas
- Downstream initiatives for which self-reported NTG is appropriate

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: For residential NTG studies of programs for which self-reports from participating end-users or contractors are appropriate, PAs should use the batteries presented in this study, adapting them as appropriate for each evaluation.

Recommendation 2: Appliance recycling NTG evaluations should follow the protocols outlined in the Uniform Methods Project, not the batteries presented in this study.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs plan to adopt the recommendations.

How the Study Affects Program Results and Its Significance:

The study findings have brought consistency to the approaches used to measure NTG from downstream residential programs. This will help ensure that changes in measured NTG from such programs going forward will primarily reflect changes to the measures, programs, and markets in question, not to the NTG measurement methodology.

Overview of Study Method:

With input from an Advisory Group comprising NTG experts from the residential evaluation team, the PAs, and the Energy Efficiency Advisory Council, the study team conducted a literature review. This involved identifying the best ideas for downstream residential self-reported NTG measurement from other jurisdictions and providing a preliminary assessment of the categories or types of programs relevant for consistent SR NTG measurement. With this information, the team created tables aligned with the BCR identifying the residential programs/initiatives for which SR NTG is appropriate. Accounting for each of the categories or types of programs and the different groups that would be expected to self-report NTG, the team developed a SR NTG method, including high-level outlines of algorithms, using questions with enough flexibility to address differences in program types.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-24.

Study 20-25: Municipal Partnership Initiative Program Theory and Logic Model Development Memo (MA19X12-B-PTLMMuni)

Type of Study: Process Evaluation

Evaluation Conducted by: Opinion Dynamics

Date Evaluation Completed: 12/2/2020

Study Objective and Summary of Results:

The purpose of this study was answer to the following research questions:

- What is the core theory behind the Municipal Partnership Initiative?
- What are the anticipated activities that will be undertaken as part of the Initiative?
- What resources and tools are the PAs providing to the municipal leaders?
- What are the outputs of the activities?
- What the intended outcomes of the Initiative?
- What are the key metrics used to assess the Initiative's performance?
- Do the Initiative's activities and outputs vary by target community?

The study provides the following key findings:

- The COVID-19 pandemic is hindering municipalities' ability to reach their participation goals especially for programs that require in person assessments and installations.
- The delayed receipt of execution agreements and some outreach materials also impacted some municipalities.
- Municipalities believe there are opportunities for the PAs to provide increased support in helping them identify target customers groups by providing lists with customer information they can leverage for targeted outreach.
- Municipalities find value in the in opportunities the Initiative affords them to collaborate with not only their PAs and local community-based organizations, but also other municipalities.
- Municipalities are not accustomed to receiving performance-based incentives and would prefer to receive funds in grant form as some struggle with covering the upfront costs of marketing and outreach.
- As the Municipal Partnership Initiative outreach methods are effective for reaching income eligible populations and municipal leaders have expertise in engaging these customers, municipalities believe excluding this group as a target population is a missed opportunity.
- Municipal leaders identified ongoing barriers to engaging Limited English Proficiency customers. They share concerns that these customers are not able to complete the full enrollment and participation journey due to lack of in-language infrastructure and support, this challenge is especially prominent for virtual platforms.

Core Initiatives or End Uses to which the Results of the Study Apply:

- All Sectors
- Residential Coordinated Delivery
- Envelope & HVAC
- Electric & Gas
- Focus on Small Business, Moderate Income, and Limited English Proficiency customers

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: As progress towards participation goals varies for each municipality within each Mass Save program, consider engaging in conversations with each municipality to assess what goals are feasible for 2020 given the impact of the pandemic and adjust goals accordingly.

Recommendation 2: As the COVID-19 pandemic is likely to continue to impact the ability to conduct in person events and interactions in the 2021 calendar year, consider adjusting the 2021 Initiative participation goals as well.

Recommendation 3: Consider re-aligning the performance period with receipt of execution agreements.

Recommendation 4: As data security and privacy constraints allow, consider providing the municipal leaders with access to contact lists pertaining to the target customer populations.

Recommendation 5: Consider hosting a workshop about best practices for reaching small businesses, seniors, and other populations that may be harder to reach due to COVID 19.

Recommendation 6: Continue to provide forums for the municipalities to connect, collaborate, and share experiences, challenges, and implementation ideas.

Recommendation 7: Consider revising the funding structure so less that a smaller percentage of the funds are contingent upon performance and municipalities receive funds earlier in the program year.

Recommendation 8: Consider including income eligible customers as a target customer population for the Initiative.

Recommendation 9: Ensure that customers have in language support through the entire customer journey.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

The PTLM and associated memo are designed to facilitate a common understanding of the Municipal Partnership Initiative design and implementation processes across Initiative stakeholders. These deliverables are also intended to support future evaluation efforts as they include descriptions of key activities, outputs, and outcomes expected from the Initiative and a list of potential performance metrics which the PAs can leverage to determine whether the Municipal Partnership Initiative is being delivered as planned and whether the intended theory of change is occurring.

Overview of Study Method:

The evaluation team approached the development of the PTLM as an iterative and interactive process. We started the process with a review of relevant program materials to develop initial PTLM inputs, which served as the base for in-depth interviews with PA staff. These activities gave us an initial understanding about the theory behind the Initiative and allowed us to develop a draft PTLM. Through interviews with each of the seven municipal leaders, we refined the PTLM and discussed Initiative implementation processes, any setbacks as a result of the COVID-19 pandemic, and identified successes and challenges related to participation. We also held follow-up group interviews with PA staff which allowed us to collect feedback on a draft PTLM and identify variations in program theory across municipalities, address gaps in knowledge, and determine any missing linkages to the PTLM.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-25.

Study 20-26: 2019 Electric Vehicle Supply Equipment Direct Load Control Demonstration - Process /evaluation

Type of Study: Process Evaluation

Evaluation Conducted by: Guidehouse Inc.

Date Evaluation Completed: 7/6/2020

Study Objective and Summary of Results:

This evaluation assessed participant experience with Eversource's Electric Vehicle Supply Equipment (EVSE) Direct Load Control (DLC) demonstration and solicited information on participants' electric vehicle (EV) type, and their driving and charging behavior to inform the scalability of the solution. Additionally, the evaluation summarized key features of managed charging programs offered by utilities in other jurisdictions.

The study provides the following key findings:

Participant Survey Findings

- Survey respondents were generally very pleased with their program experience in 2019, despite events starting late in the evening (7 or 8 p.m.) when home charging is more common (compared to earlier in the day). In terms of program improvements, participant suggestions focused on modifications to program communications (event notification and program information).
- Based on survey feedback, the most common period during which EVs are connected to EVSEs on summer weekdays is between 6 p.m. and 6 a.m. A DLC program that calls events in the afternoon (earlier than 6 p.m.) on summer weekdays may see limited impacts.

Literature Review Findings

- Utilities across the US are experimenting with a variety of managed charging solutions (including direct load control and pricing-based solutions) to achieve goals for peak load reduction or load shifting. No single program design or technology platform has been identified as the model that will ultimately become the industry favorite.
- Early EVSE Demand Response (DR) pilots have shown promising potential, but challenges related to equipment connectivity and asset availability will need to be addressed before these programs can achieve the scale and dispatchability that utilities may ultimately want.
- Many utilities are planning for or are deploying managed charging-capable infrastructure with the intent of offering future DR programs.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Residential Behavior

- Other
- Electric Only
- Electric Vehicle Supply Equipment Direct Load Control

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A

How the Study Affects Program Results and Its Significance:

The evaluation begins to inform which managed charging solutions will be offered by the PAs in the future.

Overview of Study Method:

This evaluation assessed participant experience with the solution and solicited information on participants' EV types and driving and charging behavior. Additionally, the evaluation summarized key features of managed charging programs offered by utilities in other jurisdictions. The key elements of the study method include the following:

Participant Survey: Guidehouse administered an online survey with 2019 EVSE DLC demonstration participants. The evaluation team designed the survey instrument and had it reviewed by Eversource and the Energy Efficiency Advisory Council (EEAC) EM&V consultant before fielding the survey. The survey was administered online via the Qualtrics platform from December 16 through December 23, 2019 to the 74 customers enrolled in the demonstration as of October 31, 2019. Ultimately, 53 participants completed the survey.

Literature Review: Guidehouse performed a literature review to collect and synthesize information about EV managed charging programs being offered by other utilities around the US. The evaluation team collected information about program design and delivery, technology trends, and the overall experience that other utilities have had when attempting to manage EV charging by means of customer programs. In total, Guidehouse reviewed 14 programs in 12 jurisdictions.

Application of Results: Prospectively

A copy of the complete study can be found in Appendix 4D, Study 20-26.

Study 20-27: 2019 National Grid Behavioral Demand Response Evaluation

Type of Study: Impact Evaluation

Evaluation Conducted by: Guidehouse

Date Evaluation Completed: 4/28/2020

Study Objective and Summary of Results:

The objective of this study was to estimate demand reductions from National Grid's 2019 behavioral demand response (BDR) program via a literature review and an analysis of a subset of National Grid Massachusetts customers with interval utility metering.

The estimated event savings were not statistically significant across a variety of models. It is possible that an evaluation with access to a larger group of participants, or with a randomized control trial (RCT), may detect statistically significant savings in the future. Likewise, should National Grid have access to AMI data for more customers, the program design could be improved with customer-specific, post-event communications. An improved program design could lead to increased savings in the future.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Existing Building Retrofit
- Active Demand Reductions & Other
- Electric Only

Evaluation Recommendations:

No formal recommendations were made in this evaluation.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

N/A (no formal recommendations were made in this evaluation)

How the Study Affects Program Results and Its Significance:

The estimated event savings were not statistically significant across a variety of models. It is possible that an evaluation with access to a larger group of participants, or with a randomized control trial (RCT), may detect statistically significant savings in the future. Likewise, should National Grid have access to AMI data for more customers, the program design could be improved with customer-specific, post-event communications. An improved program design could lead to increased savings in the future.

Overview of Study Method:

Guidehouse utilized AMI data from customers in the SES pilot to estimate impacts from the BDR program in 2019. Since the SES pilot ran from 2014 to 2018, with its own demand response events, it was not possible to estimate 2018 BDR savings with this dataset.⁵

Because there is no random control group for the BDR program, Guidehouse first utilized a within-subject analysis to estimate 2019 BDR savings. The within-subject analysis utilizes only BDR program participants and constructs counterfactual usage (i.e., usage in the absence of a BDR event) based on participant's usage during other hot days of the 2019 summer. The difference between the predicted baseline usage and actual usage during BDR events is the BDR program savings. We estimated the average treatment effect (ATE) which represents demand savings for all households called to participate in the BDR event.⁶

Guidehouse selected event-like non-event days to construct the counterfactual baseline usage for each event. The weekday event was matched to non-event, non-holiday weekdays and the weekend event was matched to non-event weekends or holidays. We chose non-event days that minimize the sum of the squared Euclidean distance in the temperature across the 14 hours of the day from 8 am to 10 pm, excluding days with unusual weather patterns (e.g. passage of cold fronts after thunderstorms).

Guidehouse then applied a linear regression framework using the event and selected non-event days to estimate the savings during each event. The regression model fits energy use as a function of a customer-specific fixed effect, events for participants, weather, and hour of the day. The model also captures up to 2 hours of (manual) precooling before the event starts and up to 3 hours of snapback after the event.

This model yields per participant average demand savings (or dissavings) during each hour of precooling, the event, and snapback. The values can be used to determine demand savings for the population during each hour of the event and energy savings for the day across precooling, the event, and snapback.

Guidehouse observed that the weather on event days was considerably hotter than the weather on the best matched control days. Therefore, in addition to the within-subject model, Guidehouse explored a regression specification that utilized the SES participants without email addresses as a quasi-control group for the BDR participants. The Level 1 Passive group from the SES pilot was the only group with enough non-BDR participants to serve as an adequate control group (3,646 quasi-controls compared to 4,896 treatment customers). Even for this group, there were not enough

⁵ As the effect would be confounded with that from the SES pilot.

⁶ We cannot estimate a treatment effect on the treated as we do not know who responds to the BDR emails by making changes to their usage and who does not.

non-BDR participants to conduct participant matching. Instead, Guidehouse used the entire non-BDR group as the quasi-control group.

Guidehouse applied a linear regression framework using the BDR and non-BDR participants on the event and selected non-event days to estimate the savings during each event. Like the within-subject model, the regression model fits energy use as a function of a customer-specific fixed effect, events for participants, weather, and hour of the day. The model also captures up to 2 hours of (manual) precooling before the event starts and up to 3 hours of snapback after the event.

Like the within-subject model, this model yields per participant average demand savings (or dissavings) during each hour of precooling, the event, and snapback. The values can be used to determine demand savings for the population during each hour of the event and energy savings for the day across precooling, the event, and snapback.

Application of Results: Retrospectively and Prospectively

A copy of the complete study can be found in Appendix D, Study 20-27.

Study 20-28: 2019/2020 Residential Energy Storage Demand Response Demonstration Evaluation - Winter Season

Type of Study: Pilot Evaluation and Demonstration Projects

Evaluation Conducted by: Guidehouse

Date Evaluation Completed: 9/21/2020

Study Objective and Summary of Results:

The purpose of this study was to assess the technical feasibility of using residential energy storage systems (battery) to reduce peak demand for National Grid and to flatten the solar output curve for Unitil as part of their broader active demand response initiatives. This study confirmed this feasibility; however, it has not looked at whether that control will be cost-effective for the electric system, program administrators, and/or customers. National Grid provided a performance incentive to customers in exchange for control of their existing battery as part of a “Bring Your Own Battery” demonstration, while Unitil provided each participant with a battery at no cost to them. National Grid called two events for participating customers⁷ during the winter season: one on December 19, 2019 and the other on February 14, 2020. Between January 1 and February 29, 2020 Unitil called events every day from 5 p.m. to 7 p.m. for 4 participating customers.

The study provides the following key findings for National Grid:

- Events called by National Grid during the winter season saved 559 kW per 2-hour event on average, with an average of 80 successfully participating battery devices.
- Battery devices that successfully participated in 2-hour events saved an average of 6.9 kW per unit.
- On average, called events had 72% of the expected maximum impact given the maximum expected discharge of the batteries operational at the time of the event.
- 119 devices were available for analysis, out of 148 devices that were enrolled in the program prior to the final event of the season.
- 102 of 119 devices successfully performed in at least one event this season.
- Successfully participating devices dispatched at a constant rate for the length of the event.
- The conventions (e.g., sign, time zone) associated with the telemetry data varied across manufacturers. While data consistency was largely improved since the original summer 2019 analysis, Guidehouse made a couple informed corrections to further align the telemetry data for all devices into a single convention.

The study provides the following key findings for Unitil:

- The battery output could not maintain a high level of discharge for the whole event. The batteries were successful at exceeding battery output targets for 30 minutes for 68% of events; however, no battery achieved its target for longer than 1.5 hours on any event day.

⁷ As of February 13, 2020, 148 customers enrolled in the program in Massachusetts.

- The average total output from the battery storage during the 2-hour events was 8.3 kW and 16.5 kWh.
- The average total battery discharge measured by PCS was 20.3 kWh, while the battery discharge calculated from power output averaged 16.5 kWh. The calculated battery discharge was approximately 82% of the battery's change in energy.

Core Initiatives or End Uses to which the Results of the Study Apply:

- Residential
- Existing Building Retrofits
- Active Demand Reductions
- Electric Only

Evaluation Recommendations:

The following recommendations were made by the evaluators conducting this study.

Recommendation 1: National Grid to encourage EnergyHub to work with manufacturers and/or integrators to align all details of the telemetry data so the data fields are consistent.

Explain Whether or Not the PAs Decided to Adopt the Recommendations from the Study:

The PAs are considering all recommendations for adoption at this time. The PAs have not formally adopted or rejected any recommendations that require changes to program design and operations.

How the Study Affects Program Results and Its Significance:

Regarding energy storage system performance, the study found that most batteries successfully performed in the majority of called events. This implies that daily dispatch is a viable option for consistent peak reduction or load shifting. National Grid should further explore the factors behind why the per-event average fleet performance was 72% of the maximum expected impact, which includes underperformance of selected devices. National Grid should also confirm that batteries are operational prior to joining program, in order to have accurate battery counts and impact estimations, and monitor batteries and potentially troubleshoot batteries that are consistently not performing. Depending on program objectives, Unutil should consider different approaches to increase event success—for example, reduce the duration of events from 2 hours to 1.5 hours or reduce the targeted output of the battery so batteries discharge through the entire period of winter events.

Overview of Study Method:

The study relied on several methods:

1. Impact analysis was performed using whole-home, solar PV, and energy storage system telemetry data along with event participation data. Interval data was collected for all

participating devices during the winter season. This was used to calculate the energy storage system dispatch during each called event and to assess the shape of the combined solar and battery output.

Application of Results: Retrospectively

A copy of the complete study can be found in Appendix 4D, Study 20-28.

APPENDIX 4

Statewide Evaluation Studies Summary

D. Evaluation Studies

Please see Statewide Appendix 4D: Evaluation Studies, filed under separate cover.

APPENDIX 5

Performance Incentives

Please see the attached Performance Incentive calculation tables for calculations of performance incentives based on 2019 and 2020 achievement.

Please note that on February 19, 2019, the Program Administrators petitioned the Department of Public Utilities (“Department”) for clarification and reconsideration of certain limited findings in the Department’s 2019-2021 Three-Year Plans Order, D.P.U. 18-110 through D.P.U. 18-115 and D.P.U. 18-117 through D.P.U. 18-119. Specifically, the Program Administrators sought: (1) clarification that the new cost-effectiveness standard for performance incentives requires that the Companies remove performance incentives based on actual performance associated with non-cost-effective core initiatives only if the respective program is not cost-effective over the full term; and (2) reconsideration of the application of the Department’s new cost-effectiveness standard to the value component of the performance incentive model. To date, the Department has not ruled on the Program Administrators’ Motions.

All of the Program Administrator’s core initiatives were cost-effective in 2020. Accordingly, the new cost-effectiveness standard for standard for performance incentives is not implicated.

National Grid Electric
2020 Energy Efficiency Performance Incentives (PI)
(\$2019)

Line #	Performance Incentive Component	Total	Comment
ENERGY EFFICIENCY SAVINGS COMPONENT			
1	Plan Energy Efficiency (EE) Benefits (excludes active demand)	\$ 959,740,607	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
2	Threshold EE Benefits	\$ 719,805,455	Line 1 * 75%
3	Evaluated EE Benefits	\$ 813,835,164	Cost-Effectiveness (2019\$): Total Evaluated Benefits
4	EE Savings Payout Rate 2019-2021	\$ 0.0104207	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
5	Plan EE Savings Incentives	\$ 10,001,153	Line 1 * Line 4
6	Cap on EE Savings Incentives	\$ 12,501,441	Line 5 * 125%
7	Evaluated EE Savings Incentives	\$ 8,480,718	Line 3 * Line 4 if Line 3 is greater than or equal to Line 2. Otherwise, \$0.
8	Claimed EE Savings Incentives	\$ 8,480,718	Minimum of lines 6 and 7.
ACTIVE DEMAND REDUCTION SAVINGS COMPONENT			
9	Plan Active Demand Reduction (ADR) Benefits	\$ 31,667,565	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
10	Threshold ADR Benefits	\$ 23,750,674	Line 9 * 75%
11	Evaluated ADR Benefits	\$ 26,747,565	Cost-Effectiveness (2019\$): Total Evaluated Benefits
12	ADR Savings Payout Rate 2019-2021	\$ 0.0277721	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
13	Plan ADR Savings Incentives	\$ 879,474	Line 9 * Line 12
14	Cap on ADR Savings Incentives using ADR Savings Payout	\$ 1,099,342	Line 13 * 125%
15	Evaluated ADR Savings Incentives	\$ 742,835	Line 11 * Line 12 if Line 11 is greater than or equal to Line 10. Otherwise, \$0.
16	Evaluated ADR Benefits In Excess of ADR Cap	\$ -	Line 11 - (Line 9 * 125%)
17	EE Savings Payout Rate 2019-2021	\$ 0.0104207	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
18	Percent of EE + ADR Savings Components Earned	85%	(Line 8 + Line 15) / (Line 5 + Line 13)
19	Incremental ADR Savings Incentives at EE Savings Payout	\$ -	Line 18 * Line 17
20	Claimed ADR Savings Incentives	\$ 742,835	Minimum of lines 14 and 15 plus line 19
VALUE COMPONENT			
21	Plan Program Costs (2019\$)	\$ 284,671,742	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
22	Plan Net Benefits (Benefits - Program Costs) (2019\$)	\$ 706,736,430	(Line 1 + Line 9) - Line 21
23	Threshold Net Benefits (Benefits - Program Costs) (2019\$)	\$ 530,052,323	Line 22 * 75%
24	Actual Program Costs (2019\$)	\$ 254,399,084	Cost-Effectiveness (2019\$): Total Program Costs
25	Evaluated Net Benefits (Benefits - Program Costs) (2019\$)	\$ 586,183,645	(Line 3 + Line 11) - Line 24
26	Value Payout Rate 2019-2021	\$ 0.0087126	D.P.U. 18-110 through 18-119, Exh. Comm-1, App. R (updated February 19, 2019)
27	Plan Value Incentives	\$ 6,157,495	Line 22 * Line 26
28	Cap on Value Incentives	\$ 7,696,868	Line 27 * 125%
29	Evaluated Value Incentives	\$ 5,107,169	Line 25 * Line 26 if Line 25 is greater than or equal to Line 23. Otherwise, \$0.
30	Claimed Value Incentives	\$ 5,107,169	Minimum of lines 28 and 29.
31	Total Planned Performance Incentive	\$ 17,038,121	Line 5 + Line 13 + Line 27
32	Total Claimed Performance Incentive	\$ 14,330,723	Line 8 + Line 20 + Line 30
33	Percent Earned	84%	Line 32 / Line 31
34	Total Planned Performance Incentive (nominal\$)	\$ 17,435,109	Inflating to 2020\$ using 2.33% discount rate --- Line 31 * (1+2.33%)
35	Total Claimed Performance Incentive (nominal\$)	\$ 14,664,629	Inflating to 2020\$ using 2.33% discount rate --- Line 32 * (1+2.33%)

APPENDIX 6

2020 Miscellaneous Implementation Update

A. Renter, Income, and Language data

See below for additional data related to renters, income level, and language.

Program Pathway	Renters Served			Notes
	2019	2020	2021	
Innovation - Tailored Energy Savings Packages	5	3		1
Residential Coordinated Delivery	6,655	4,074		2
Income Eligible Coordinated Delivery	4,601	2,100		
Total	11,261	6,177	-	
C&I, Residential End Use	4,607	3,383		3

- 1) Tailored Energy Savings Packages were made available to renters in 2019 as an easy way for them to access program savings. This number represents the number of customers receiving kits.
- 2) This number includes renter units in SF and legacy MF buildings who received at least one measure; renters who only received an audit are not counted.
- 3) This number represents the total number of units served through this pathway, not just renters. For large multifamily buildings, it is typically not possible to individually verify which units are occupied by a renter. However, it is likely that these buildings are predominantly occupied by renters.

Income Level	Renters Served			Notes
	2019	2020	2021	
Non-Income-Verified (Standard Program Participation)	6,655	3,997	-	1
Moderate Income Qualified (Weatherization Offer)	5	80		2
Income Eligible	4,601	2,100	-	
Total	11,261	6,177	-	

- 1) The vast majority of customers who participate in the PAs' programs do not undergo any income screening. The PAs are therefore unaware of their income status. All income screenings are voluntary.

2) This number only includes moderate-income-qualified renters who participated in the special insulation offer. In April of 2020, in response to the COVID-19 pandemic, the PAs began offering 100% incentives for insulation to all customers. There was therefore no reason for moderate income customers to undertake the voluntary income-qualification process and *tracked* moderate income participation appears low as a result. This is not a representation of the total number of moderate-income customers served. The customer profile studies issued annually contain information about participation in census blocks with high levels of moderate-income residents.

Language Data (Statewide)	Mass Save Hotline Selection			MassSave.com Page Views		
	2019	2020	2021	2019	2020	2021
English	137,156	128,383		5,154,923	4,874,548	
Mandarin	158	1,399		N/A	N/A	
Portuguese	313	368		9,603	18,304	
Russian	212	761		N/A	N/A	
Spanish	2,900	3,039		44,195	31,927	
Total	140,739	133,950	-	5,208,721	4,924,779	-