New Hampshire Baseline Practices Final Report

FINAL REPORT

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New Hampshire EM&V Working Group

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Glossary

Term	Definition
ACH50	Air Changes per Hour with a 50-Pascal pressure gradient
AFUE	Annual Fuel Utilization Efficiency; higher is better
ASHP	Air-Source Heat Pump; a ducted fixed refrigerant flow heat pump
BTU	British Thermal Unit; a unit of energy. 1,000,000 BTU = 293 kWh
BTUh	British Thermal Units per Hour; a rate of energy consumption
CEF	Combined Energy Factor
CFM25	Cubic Feet per Minute with a 25 Pascal pressure gradient
COP	Coefficient of Performance; a measure of equipment efficiency, usually heating
DHW	Domestic Hot Water
EF	Energy Factor (including CEF, IMEF, MEF and UEF) measures equipment efficiency
HERS	Home Energy Rating System; summarizes a home's efficiency; lower is better
HPWH	Heat Pump Water Heater
HVAC	Heating, Ventilation and Air Conditioning
IECC	International Energy Conservation Code
ISP	Industry Standard Practice
kWh	Kilowatt-Hour; a unit of energy typically used for electricity. 1 kWh = 3,412 BTU
MSHP	Mini or Multi-Split Heat Pump; usually ductless and often variable refrigerant flow
NC	New Construction
R-value	Measure of a material's resistance to the flow of heat, higher is better
RF	Retrofit
RNC	Residential New Construction
ROF	Replace on Failure
TRM	Technical Reference Manual
UDRH	User-Defined Reference Home
VRF	Variable Refrigerant Flow

Abstract

The New Hampshire Baseline Practices Study was designed to support program planning and impact accounting efforts across the New Hampshire energy efficiency portfolio through primary and secondary research into current and future baseline assumptions. The evaluation team worked with the study sponsors to prioritize the most important measures to review, and ultimately carried out a detailed review of eleven residential and nine commercial and industrial measures, as well as a variety of new construction measures. The baselines of the prioritized measures first were benchmarked against those of six comparison areas (Connecticut, Maine, Massachusetts, New York, Vermont, and the Mid-Atlantic states) through a literature review that focused on current technical reference manuals. Measures that required further investigation to determine whether baseline updates were warranted were then prioritized for further research through in-depth interviews of various market actors.

Overall, the study team concluded that baseline updates are warranted for four residential measures (new construction, heat pump water heaters, furnaces, and boilers) and six commercial and industrial measures (new construction, boilers, air compressors, air nozzles, and variable refrigerant flow heat pumps). Further research should be considered for other measures for which conclusive results could not be obtained.

Executive Summary

Background and Study Goals

The New Hampshire Baseline Practices Study was designed to support program planning and impact accounting efforts across the New Hampshire energy efficiency portfolio through primary and secondary research into current and future baseline assumptions. At the time this study was commissioned, New Hampshire was transitioning to a new code based on the 2018 International Energy Conservation Code (IECC) while the Utilities were also considering updates to various baselines used across the portfolio using baseline frameworks and assumptions from comparison states. This research was intended to provide insight regarding which measures and market events would benefit from applying frameworks or assumptions from other states, and where more research was necessary before drawing conclusions.

- Market event types covered in the research included retrofit, replace on failure, and new construction.
- Residential research focused on the new construction market as well as selected measures such as furnaces, boilers, mini-split heat pumps, water heaters, and appliances in existing homes.
- Commercial and industrial (C&I) research also focused on new construction, in addition to lighting and controls, heat pumps, air conditioning, furnaces, boilers, and tankless water heaters in existing buildings.

The study aimed to explore emerging practices, identify areas for improvement within the NHSaves programs, and prioritize future research. This study was launched as New Hampshire was preparing to transition from an energy code based on 2015 IECC to a code based on 2018 IECC with significant weakening amendments such as reduced requirements for building commissioning, testing, and efficiency improvements over listed minimum efficiency requirements.[1,2] The study aimed to explore the relationship between state baselines and the energy code and the prevalence of industry standard practices (ISP) that diverge from code requirements as well as looking at emerging practices, identifying areas for improvement within the NHSaves programs, and prioritizing future research.

Methodology

The study relied on a comprehensive literature review and targeted in-depth interviews (IDIs) to generate findings and recommendations for program baselines in the residential and C&I sectors. The literature review included past New Hampshire studies and research from comparison areas covering market baselines, code compliance, and ISP. Technical reference manuals (TRMs) served as a key source of baseline values and quantification methods from comparison areas. The literature review yielded a narrowed list of priority measures, which were explored further in interviews with market actors such as HVAC contractors, builders, Home Energy Rating System (HERS) raters, and architects. Interview questions were designed to identify the type of design and construction practices

[1] The latest NH State Building Code was adopted by the NH Legislature on July 1, 2022, via House Bill 1681. https://www.energy.nh.gov/renewable-energy/energy-codes

[2] Several amendments to the 2018 IECC were adopted. https://www.nh.gov/safety/boardsandcommissions/bldgcode/documents/summary-of-2018-nh-bldg-code-amendments-rev1-may-19-23.pdf

employed in the market, the prevalence of key equipment types, and how standard practices compare to code requirements.

Recommendations and Future Research Opportunities

This section compiles the recommendations and research opportunities that emerged from this study. Table 1 below provides a summary of the measures chosen for review, the research methods used to assess the baseline for each measure, and the resulting recommendations. Table 8 and Table 22, found in the Residential and Commercial Industrial Results sections respectively, present additional detail on the existing baselines, recommended changes, and suggestions for further research. The study team recommends adopting these changes with the next TRM update.

Residential Recommendations

The recommendations for changes to residential measure baselines resulting from this study are primarily based on the literature review. Performing a side-by-side comparison of multiple TRMs proved to be an efficient way to identify measures that should be updated – for example, where TRMs from comparison areas revealed a general consensus about the baseline or the need for a correction factor. Due to the poor response rate to the in-depth interviews, the interview data was of limited value for recommending specific baseline changes. The interviews did provide indications of where additional research might be targeted. The resulting recommendations and considerations for future research are described below.

Recommendation 1: For lost opportunity heat pump water heaters (HPWHs), the current baseline approach remains the best fit. For direct install HPWHs, consider moving to a baseline of federal minimum efficiency standards to align with most comparison areas and simplify updates.

The literature review revealed a discrepancy between New Hampshire's baseline for HPWHs, which references an older Connecticut study, and the more common federal standards-based baseline used in comparison TRMs. However, the source study incorporates a blended fuel baseline, which is supported by the New Hampshire market actor interviews.

Recommendation 2: For gas furnaces and boilers, adopt a bifurcated baseline approach that applies one of two baseline efficiency values based on the presence of an existing condensing exhaust, like that used in Massachusetts, to support the efficient use of incentive funding. Findings from the literature review and interviews suggest it is defensible to adopt the specific baseline efficiency values used in Massachusetts for each scenario (pre-existing condensing exhaust vs. without) as well, streamlining this process. [3]

Homes with older non-condensing units often incur higher replacement costs, but they also present more significant energy-saving opportunities, potentially justifying higher incentives in a flexible program design that benefits financially constrained customers. New Hampshire already employs Massachusetts' baseline values in certain cases for these measures.

[3] From the Massachusetts eTRM: "For all non-moderate income non-condensing to condensing furnace measures, the baseline efficiency case is an 80% AFUE non-condensing furnace adjusted to 81% AFUE actual efficiency. For all condensing to condensing furnaces, the baseline efficiency is a 93.2% condensing furnace adjust [sic] to 93.4% AFUE actual efficiency. For the non-condensing to condensing boiler, the baseline efficiency case is an 83.2% AFUE non-condensing boiler adjusted to 80.4% AFUE actual efficiency. For the condensing to condensing boiler, the baseline efficiency case is an 94.4% condensing boiler adjusted to 88.8% AFUE actual efficiency." Accessed from: https://etrm.anbetrack.com/#/workarea/home?token=6d6c45766e692f527044

Recommendation 3: For residential new construction, specify User-Defined Reference Home (UDRH) values in the next TRM update that align with the current New Hampshire energy code adopted as of July 1, 2022. Moving forward, we recommend periodic research on practices in the new construction market to continue providing timely updates to the UDRH and assess where, if at all, evaluation-derived ISP values may be more appropriate than UDRH values derived from the energy code.

The current TRM does not specify the UDRH values for residential new construction savings, which can result in confusion for users of the TRM.

C&I Recommendations

Recommendation 1: Update the air compressor measure to align with the methodology outlined in New York's TRM guidelines, particularly for units larger than 75 HP.

NH is currently using a universal deemed savings factor of 0.189 kW/hp, regardless of the unit's size. New York's guidelines utilize the same factor for air compressors between 25 and 74 HP and a higher factor of 0.216 kW/hp for units larger than 75 HP to better reflect market and technology standards.

Recommendation 2: In line with neighboring states' practices for air nozzle measures, adopt a baseline 80-psi default air pressure at the nozzle.

Recommendation 3: Update the baseline efficiency for variable refrigerant flow (VRF) systems in accordance with the recently adopted 2018 IECC standard to the current building energy code in New Hampshire.

Conduct future research including IDIs with different stakeholders to gain a better understanding of potential disparities between real-market VRF efficiency and code requirements.

Recommendation 4: Adopt a standard practice baseline for natural gas hydronic boilers (condensing) in new construction and major renovation that is 15% better than 2015 IECC minimum efficiency.

The study team found a high proportion of condensing units in new construction even in the non-participant case.

Recommendation 5: Adjust the baseline Lighting Power Density (LPD) values by applying a factor of 0.60 for interior and 0.67 for exterior lighting, based on the minimum LPD requirement in IECC 2015.

This recommendation is made consistent with the findings of the MA Non-Residential New Construction ("NRNC") study based on the high prevalence of LEDs in new construction.

Recommendation 6: Adjust the Commercial Heat Pumps IECC 2015 minimum cooling and heating efficiencies by 1% for cooling and 3% for heating based on Massachusetts NRNC study findings.

Recommendation 7: Maintain current baseline efficiencies aligned with code compliance for the following C&I measures: gas furnace, air conditioner, chiller, instantaneous (on-demand) water heater and lighting controls.

Overall Recommendation

Recommendation: Revise the nomenclature used to refer to baseline types (referred to as "Program Type") in the next version of the New Hampshire TRM. Some of the terms currently used (e.g., "lost opportunity" and "retrofit") are imprecise and can lead to confusion.

FUTURE RESEARCH OPPORTUNITIES

Opportunity 1 (Residential): Monitor emerging research from comparison states or related New Hampshire studies to assess whether there are any high priority ISP research needs that should be prioritized for evaluation funding in the short to medium term.

The interviews did not point to any stark differences between standard practice and current baselines, but alternative research methods could be considered if other evidence of an ISP that should be characterized should emerge.

Opportunity 2 (Residential): Consider further research to quantify a blended baseline for water heating measures.

The mixed responses to interview questions and the range of available equipment and fuel types are suggestive of a blended baseline.

Opportunity 3 (Residential): Consider further research to investigate the role of fossil-fuel systems in the mini-split heat pump baseline.

Revisiting this measure in the short to medium term may be warranted as baselines may evolve quickly due to the general push toward electrification in the region and in response to any program design changes that may occur.

Opportunity 4 (Residential): Consider additional research to determine if an update to the residential window replacement baseline is justified. Additional research should focus on the applicable market for window replacements, which at this time is focused on income-eligible customers and homes with single pane windows.

Opportunity 5 (C&I): For variable refrigerant flow heat pump systems, conduct future research including interviews with different stakeholders to gain a better understanding of potential disparities between real-market VRF efficiency and code requirements.

Table 1: Research Methods and Recommended Changes for Prioritized Measures

Measure	Lit Review	In-Depth Interview	Recommended Change
Residential Measures			
New Construction	•	•	Update UDRH where necessary to reflect transition from 2015 IECC (with NH amendments) to 2018 IECC (with NH amendments) as of July 2022.
Gas Instantaneous (On-Demand) Water Heater	•	•	No evidence that updates are needed
Heat Pump Water Heater	•	•	For direct install, consider moving to a federal standards-based baseline to align with most comparison areas and simplify updates.
Gas Furnace	•	•	Adopt a bifurcated baseline for condensing and non-condensing exhaust like that used in MA.
Gas Boiler	•	•	Adopt a bifurcated baseline for condensing and non-condensing exhaust like that used in MA.

Measure	Lit Review	In-Depth Interview	Recommended Change
Window Replacement	•	•	Not enough information to determine whether a baseline change is warranted.
Ductless Mini-Split Heat Pumps	•	•	The code-based baseline should be updated to the new federal standard of SEER2 14.3, HSPF2 7.5. Not enough data to indicate a further baseline change, but further research on the role of fossil-fuel systems in the baseline is warranted based on interview findings.[4]
Central Ducted Air-Source Heat Pump	•		No evidence that updates are needed
Wi-Fi Communicating Thermostat	•		No evidence that updates are needed
Clothes Dryer	•		Change from 3.73 to 3.11 CEF to correct for DOE/ENERGY STAR testing differences (ref. MA, VT, Mid-Atlantic TRMs)
Clothes Washer	•		No evidence that updates are needed
Refrigerator	•		No evidence that updates are needed
Commercial & Industrial (Non-Residential) Measures			
Gas Boilers	•	•	NC: Adopt 15% better than 2015 IECC minimum efficiency ROF: maintain current TRM code compliance baseline
Gas Furnaces	•	•	NC and ROF: maintain current TRM code compliance baseline
Lighting	•	•	NC: Apply a 0.60 factor for interior and 0.67 for exterior lighting to the 2015 IECC lighting power densities (LPD) ROF: Not researched.
Lighting Controls	•	•	NC: Maintain current TRM code compliance baseline ROF: Not researched.
Heat Pumps	•	•	NC: Apply to the 2015 IEEC minimum efficiencies a 1.01 factor for cooling and a 1.03 factor for heating efficiencies ROF: Not researched.
Gas Instantaneous (On-Demand) Water Heater	•	•	NC and ROF: maintain current TRM code compliance baseline
Chillers	•	•	NC: Maintain current TRM code compliance baseline

[4] Note the utilities have already adopted the code-based baseline to the new federal standard of SEER2 14.3, HSPF2 7.5. This adoption is noted in the TRM.

Measure	Lit Review	In-Depth Interview	Recommended Change
			ROF: Not researched.
Air Conditioners	•	•	NC and ROF: maintain current TRM code compliance baseline
Air Compressors	•		NC and ROF factor: 25 to 75 horsepower (hp): 0.189 kW/hp >75 hp: 0.216 kW/hp
Air Nozzles	•		All event types where site-specific pressure is unknown: 80-psi default air pressure at the nozzle
VRF Heat Pumps	•		NC: Adopt 2018 IECC standard efficiencies
Condensing Unit Heaters	•		No evidence that updates are needed
Variable Frequency Drives	•		No evidence that updates are needed

Key: NC = New Construction; ROF = Replace on Failure; RF = Retrofit

• *= Indicates that the research method was used to inform the analysis*

Section 1 Introduction

This report presents the findings of the *New Hampshire Baseline Practices Study,* which was designed to inform current and future baseline assumptions for the NHSaves portfolio of residential and commercial programs. This report was prepared by NMR Group and DNV on behalf of the New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group.

1.1 Background and Objectives

This study was developed to inform future program planning efforts across the New Hampshire portfolio by conducting primary and secondary research to inform current and future baseline assumptions. As this study was launching, New Hampshire was transitioning to a new code based on 2018 IECC while also considering whether various baselines used across the portfolio should be updated using baseline frameworks and assumptions from comparison states. This research was intended to provide insights on which measures and market events would benefit from applying frameworks or assumptions from other states, and where more research would be necessary before drawing conclusions. Within the transition to the new IECC code version, there were questions about the impacts of uneven code enforcement across the state and geographic variability in baseline practices due to differences in climate zone between the northern and southern parts of the state and differences caused by proximity to states with more stringent energy codes (e.g., Massachusetts) where market actors may operate across state lines. The New Hampshire Technical Reference Manual (TRM) was also undergoing updates that would benefit from new data on baseline practices, where available.

Appropriate and accurate baselines help ensure that programs achieve the savings they are targeting. Accordingly, program administrators across the country continue to invest in studies that characterize baseline practices and Industry Standard Practice (ISP). Baseline assumptions used by energy-efficiency program administrators (PAs) can be derived through multiple methods. The prevailing building energy code or equipment standards in each jurisdiction are often assumed to be the baseline for measures offered by energy-efficiency programs. This framework assumes that market actors are most likely to aim for minimum performance requirements in the absence of market forces (e.g., an energy-efficiency program) that induces the market actor to aim higher. Research sometimes finds that actual practices in the market diverge from code and equipment standards on average. Successful energy-efficiency programs that achieve high market penetration are one source of industry standard practices (ISPs) that land beyond code. Equally, industry standard practices may fall below code in markets where codes are not actively enforced. In markets where regulators know or suspect that ISP diverges from code, program evaluations may collect data on ISP to set baseline assumptions that differ from code. Often, a portfolio of programs will use a mix of baseline assumptions that use local codes, federal standards, and local evaluation findings, depending on the characteristics of each measure.

Another method of particular interest in this study is to leverage evaluation findings and frameworks from comparison areas (i.e., typically other states) to set their baselines, where appropriate. This study was designed to help identify and prioritize future baseline research needs by examining baseline assumptions and their sources in New Hampshire and elsewhere to understand where changes are appropriate and how best to arrive at new assumptions. Specifically, the study was launched with the following research objectives:

- Research and recommend best practices for New Hampshire program baselines

- Describe the potential of new approaches to identify program impacts more accurately
- Identify potential impacts on the NHSaves new construction program design, cost-effectiveness, and energy savings
- Recommend additional changes to the baseline approach for NHSaves programs
- Prioritize baseline research for the future

1.2 METHODS OVERVIEW

To achieve the research objectives, the evaluators used two main research methods:

1. For both the residential and commercial sectors, a literature review approach was used to compile and synthesize relevant data and findings for the new construction, add-on, replace on failure, and retrofit markets regarding ISP, code compliance, and measure-level efficiencies from New Hampshire and comparison areas such as Massachusetts and Vermont.
2. For both the residential and commercial sectors, in-depth interviews delivered insights from a variety of market actors including builders, HVAC contractors, HERS raters, and architects who work in New Hampshire, plus a subset who work in both New Hampshire and in neighboring states.

The literature review evolved into two phases: a first phase of broad secondary data collection succeeded by a measure prioritization process designed to streamline data collection within the constraints of the study's budget. The measure prioritization process was conducted over two phases during 2022. In the first phase, measures were prioritized by group consensus, settling on the twelve residential and thirteen C&I measures shown in Table 2. Available baseline data for these measures in TRMs and other reports from comparison states were then reviewed and compared to the current New Hampshire baselines.

In the second phase of prioritization, the group decided which measures merited further investigation through in-depth interviews. After two meetings in September the group came to a consensus on prioritizing the measures shown in bold font in Table 2. Initially only three non-new construction residential measures were recommended for further research, but this list was expanded to include gas furnaces and boilers after it was learned that Massachusetts had instituted separate baselines for homes that did not have an existing condensing exhaust.

Table 2: Measures Prioritized for Detailed Baseline Review

Residential Measures	Commercial & Industrial Measures
New Construction measures	**Gas Boilers**
Gas Instantaneous (On-Demand) Water Heater	**Gas Furnaces**
Heat Pump Water Heater	**Lighting**
Gas Furnace	**Lighting Controls**
Gas Boiler	**Heat Pumps**
Window Replacement	**Gas Instantaneous (On-Demand) Water Heater**
Ductless Mini-Split Heat Pumps	**Chillers**

Residential Measures	Commercial & Industrial Measures
Central Ducted Air-Source Heat Pump	**Air Conditioners**
Wi-Fi Communicating Thermostat	Air Compressors
Clothes Dryer	Air Nozzles
Clothes Washer	VRF Heat Pumps
Refrigerator	Condensing Unit Heaters
	Variable Frequency Drives

Note: Bolded and colored text highlights measures that were addressed through in-depth interviews.

The next phase included market actor interviews to provide further information on the measures prioritized for further research. Due to tracking data limitations and to minimize bias, sample frames were developed through web research and CMD Group's ConstructConnect® service, which aggregates information on construction projects and the teams working on them. While these and similar sources yielded some useful contacts, many were outdated or miscategorized, which led to unproductive recruitment efforts.

For residential baseline practices, the market actors included HVAC and water heating contractors as well as general contractors (collectively, "contractors"), builders, and HERS raters. For C&I, the market actors included builders, contractors, architects, and designers. To assess both residential and commercial energy codes, the study targeted code officials in different regions of the state, contractors who perform code trainings and outreach, and individuals who work on code development.

After extensive recruiting efforts, 29 interviews out of a target of 55 (53%) were completed, as shown in Table 3. Interview recruitment was very challenging due to quality issues with the sample derived from third-party resources as well as a high rate of refusal among both the residential and C&I samples. The small number of completed interviews resulted in lower-than-planned confidence that the findings are representative, and the low response rate introduces the risk of self-selection bias from respondents who are more aware of the NHSaves programs or those that build to code or high-efficiency as standard practice and are thus more inclined to speak about the efficiency characteristics of their work. To ensure we reach the non-program market or those who are not attending code trainings, future baseline research should compare participating contractor data from the Utilities against the sample frames to ensure a reasonable distribution.

Table 3: Completed Interviews

Market Actor Type	Sector	Target Completes	Achieved Completes
Code official	C&I	3	3
Code official	Res	3	3
Builder	C&I	6	2
Builder	Res	6	4
Contractor	C&I	15	7
Contractor	Res	11	6
HERS Rater	Res	5	2

Market Actor Type	Sector	Target Completes	Achieved Completes
Architect	C&I	6	2
Total	All	55	29

Appendix D presents additional details about the methods used for this study.

Section 2 Residential Results

This section presents the results for the prioritized residential measures listed in Table 2. A link to a slide deck summarizing the results and recommendations, which was presented to the EM&V Working Group on May 31, 2023, can be found in Appendix C.

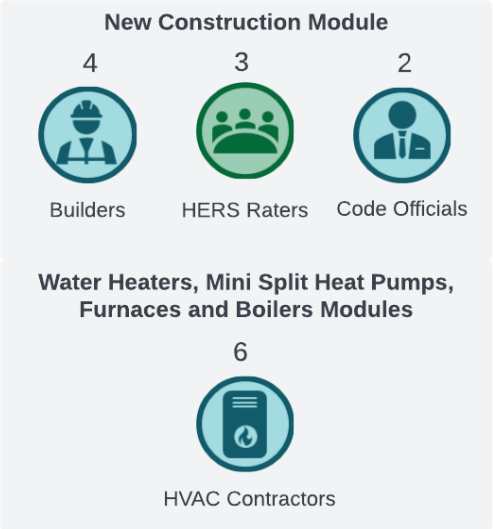
Out of the eleven residential measures that were prioritized for detailed review, five measures were resolved via the literature review and six measures proceeded to the IDI approach. New construction measures were also addressed in the interviews.

2.1 Literature Review and In-Depth Interview Results

The subsequent sections present the findings from both the literature review and interviews. Overall, the interview findings may be taken as suggestive rather than conclusive due to recruitment challenges that led to a smaller-than-planned sample size. See Appendix D.2 for a discussion of the interview recruitment process.

Figure 1 shows the completed interviews by market actor type per study module. The new construction respondents reported working on approximately 300 projects per year in total. For furnaces, boilers, and heat pumps, the interviewees reported a total of approximately 550 projects annually, and for water heaters, approximately 300 projects. Most of the respondents who agreed to complete an interview operate in southern New Hampshire, with some in the central region. Many have experience in neighboring states, including Massachusetts, Vermont, and Maine.

Figure 1: Completed Residential Market Actor Interviews by Study Module



2.1.1 Residential New Construction Findings

Current baseline: Code-based, with some measures representing ISP. The New Hampshire ENERGY STAR Homes program uses energy modeling to compare an as-built home to a UDRH based on 2015 IECC with New Hampshire amendments, and some measures reflect ISP, informed by the most recent New Hampshire RNC baseline evaluation. New Hampshire was transitioning to a new code based on 2018 IECC with amendments as this study launched, so the residential new construction market more broadly was a priority area for further research. A detailed comparison of current and recommended baseline methods is provided for this measure and all other listed in sections 2.2 and 2.3 in Table 8

Research focused on the current code cycle. Interviews were forward-looking, asking respondents to assess practices against the new code that went into effect in July 2022, based on the 2018 IECC.

Interviewees suggest most new homes in New Hampshire are code compliant. NMR completed nine interviews for the New Construction Module. Interviewees included four builders, two code officials, and two HERS Raters. The interviews suggest that code compliance is very high, with limited occurrences of exceeding energy code, but there is not enough evidence to suggest that ISP is currently above code. Because of the difficulties the NMR team encountered in recruiting interview participants, as detailed in Appendix D.2.3, it is possible that recruited interviewees had more favorable opinions of code compliance and therefore more interested in participating in a baseline study.

The following subsections detail the findings for the building systems that were investigated as part of the interviews.

2.1.2 New Construction Building Envelope

Market actors reported that building envelope measures in new homes generally meet or slightly exceed code requirements at the measure level. These measures include insulation, window performance, duct leakage, and air infiltration. Table 8 summarizes these recommendations against the current baseline.

Insulation performance hovers around code requirements. Interviewees reported that new homes consistently meet or sometimes exceed code standards for insulation in above-grade walls, framed floors, basement and crawl space walls, and slab floors. This is noted for both southern and northern New Hampshire, with limited data points for the north. Notably, compliance with the additional code requirement for R-5 continuous insulation in above-grade walls (climate zone 6, with R-20 cavity) was reported to be high where data were available. Additionally, all interviewees confirmed that all the new homes they have worked on meet the code requirement for windows, with rare instances of exceeding the requirement by approximately 5%.

For sloped or cathedral ceiling insulation, the interviews indicated universal compliance with the code requirement of at least R-30, with some homes exceeding this standard with R-values reaching up to R-60. Regarding flat ceilings, insulation reportedly tends to meet the R-49 code requirement, and in some cases, it exceeds this requirement with R-values of R-60. Raised heel trusses with lower R-value insulation were mentioned by one interviewee as a method employed in 20% of homes to meet code requirements – this approach allows builders to use a lower R-value overall because it yields improved insulation performance around the perimeter of the attic space.

Duct sealing, testing, and insulation practices appear to vary; training or enforcement improvements may be needed. Five out of nine professionals reported that most or all new homes

they've worked on undergo duct leakage testing. However, estimates regarding the percentage of homes passing the test (≤ 4 CFM25/100 ft^2 of conditioned floor area) varied from 50% – 100%, with HERS raters providing the lower estimates. Responses regarding duct insulation levels also ranged from 50% – 100% of new homes having ducts insulated to at least R-8 in attics and R-6 in other locations.

Interview responses indicated mixed outcomes and training needs related to air infiltration (ACH50). Most respondents indicated moderate compliance, with 60% – 100% of homes meeting the new requirement of less than 3 ACH50 where testing is performed. However, there was some variation in responses regarding the frequency of testing and the associated requirements for new homes. Six out of nine respondents stated that all or most non-program homes receive a blower door test, while others provided lower estimates or believed there was no testing requirement. Additionally, one respondent was under the impression that the current code requirement remained at 7 ACH50, despite the change to 3 ACH50 in 2022.

2.1.3 New Construction Heating Equipment

Typical efficiencies for furnaces and boilers installed in new homes likely do not exceed the current UDRH value of 90% AFUE and may not quite reach it on average. There was also no indication that the efficiencies of space heating equipment installed in new homes fall outside typical efficiency ranges seen in comparison areas like Massachusetts and Vermont. Because of the small sample sizes and the diverse ranges mentioned in interviews, there is not sufficient evidence at this time to determine whether the current UDRH values are too high.[5]

Gas furnaces. Interviewees reported that 50% – 75% of newly built homes use gas or propane furnaces for heating, with 25% – 50% of those units being condensing units. The typical efficiency of condensing units was reported to range from 90% – 98% AFUE, with most respondents estimating 90%, i.e., the lowest available efficiency for condensing units. For non-condensing gas furnaces, the typical efficiency was reported as 80% AFUE.

Gas boilers. Estimates of the prevalence of gas or propane boiler systems in new homes varied widely among respondents, with estimates ranging from 10% – 75%. The typical efficiency of condensing boilers was estimated at 90% AFUE, i.e., the low end of condensing efficiencies, while new non-condensing units were said to be typically around 85% AFUE.

Recommendation: **For new construction, the UDRH should be detailed in the TRM moving forward.** Updating the UDRH to reflect the 2018 IECC-based code with New Hampshire amendments now in effect will have savings implications for the program if eligibility requirements remain static. Further research on ISP in New Hampshire would help to determine whether a more efficient UDRH is justified by practices in the field. While interviews suggested that compliance with the previous code requirements was high, the low response rate to the interviews prevented the study team from building a detailed picture of the specific practices in the market and the degree to which standard practices have eclipsed code, if at all.

[5] Massachusetts UDRH values form the 2019 Baseline and Code Compliance study are also higher than the NH UDRH for gas heating equipment. Where natural gas is available, the MA UDRH specifies a 93.5 AFUE and where natural gas is unavailable (i.e., where propane is used) the UDRH value is 97.1 AFUE.

2.1.4 New Construction Water Heating Equipment

A wide range of water heating system types and fuels are reported in new homes. Of the seven interviewees who responded to water heating questions, four reported that tank water heaters are most common, while three said that on-demand (tankless) water heaters are most common. Respondents were similarly divided on fuel types, with mentions of gas, electric, and propane as most common. Overall, respondents tended to report significant market shares (10% or greater) for all technologies included in the interview guide: stand-alone electric, stand-alone gas condensing and non-condensing, gas tankless condensing and non-condensing, and indirect water heaters. Only heat pump water heaters were consistently estimated to have a very small market share.

More data is needed to estimate the baseline for water heating in new homes. There was a consensus among interviewees that ENERGY STAR-rated water heaters are highly prevalent in new homes, with an approximate rate of 80%, but they were unable to provide consistent UEF estimates.

2.1.5 New Construction Lighting

Interviewees stated that lighting code requirements are met consistently. Code currently requires 75% of lamps in new homes to be high-efficacy. Of the five interviewees who judged themselves knowledgeable enough about lighting to answer questions on it, interviewees reported that this section of the code is met consistently, and some stated that they see it exceeded by ten to fifteen percentage points.

2.1.6 Additional New Construction Findings

Market actors note the value delivered by the ENERGY STAR Homes Program and see opportunity for greater participation. Interviewees reported that the NHSaves ENERGY STAR Homes Program has positively influenced the energy efficiency of new homes in New Hampshire. However, cost is a significant barrier to constructing more energy-efficient homes. One contractor recounted losing multiple projects because of the financial gap between energy-efficient home costs and client budgets. Additionally, some respondents reported that contractors often prioritize minimal code compliance to maximize profits. Given these insights, the consensus among interviewees is that more substantial financial incentives are needed to promote energy efficiency.

More data is needed to judge whether there are differences in new construction efficiency between single- and multifamily homes or by region. Interviewees were unable to provide specific details regarding compliance rates or variations in equipment efficiency between single- and multifamily homes. In addition, because a large majority of the respondents serve the southern part of the state, there was no conclusive evidence regarding energy-efficiency disparities across different regions of New Hampshire. In order to gauge these differences, a future effort could use more targeted recruiting methods to reach market actors whose offices are in northern New Hampshire. Additionally, market actors with addresses in central New Hampshire may be well-situated to speak to southern and northern New Hampshire regional differences.

2.1.7 Residential Lost Opportunity and Retrofit Findings

The following subsections detail the literature review and IDI results for residential measures installed under lost opportunity/replace on failure and early replacement/retrofit conditions. Note that the New Hampshire TRM primarily uses the terms *lost opportunity* and *retrofit* to denote the market events that are sometimes referred to as *replace on failure/burnout* and *early replacement* in other TRMs. This report strives to align with the TRM but in some instances may use other nomenclature.

2.1.8 Furnaces and Boilers

Current baseline for furnaces: A blended value combining 83% AFUE for early replacement and 85% AFUE for lost opportunity. New Hampshire's TRM values generally align with those of comparison areas, which range from 80% to 88% AFUE as shown in Table 4.

Current baseline for boilers: A blended value combining 84% AFUE for early replacement and 85% AFUE for lost opportunity. New Hampshire's TRM values align with those of comparison areas, which range from 80% to 87% AFUE as shown in **Table 4**.

Table 4 TRM Baseline Values for Residential Gas Furnaces & Boilers

TRM Source	Gas Furnace Baseline Efficiency	Gas Boiler Baseline Efficiency
NH	83% AFUE rated furnace for early replacement and an 85% AFUE furnace for lost opportunity	Early replacement: 84% AFUE Lost opportunity: 85% AFUE
MA	81% AFUE when replacing non-condensing existing unit, 93.4% AFUE when replacing condensing with condensing	80.4% AFUE when replacing a non-condensing existing unit, 88.8% AFUE when replacing a condensing unit.
CT	85% AFUE (gas)	85% AFUE
VT	88% AFUE	86.7% AFUE
Mid-Atlantic	80% AFUE, 81% AFUE (Weatherized)	82% AFUE
ME	87% AFUE	87% AFUE
NY	80% AFUE	80% AFUE (Steam), 82% AFUE (Hot Water)
Study Recommendation	81% AFUE when replacing non-condensing existing unit, 93.4% AFUE when replacing condensing with condensing	80.4% AFUE when replacing a non-condensing existing unit, 88.8% AFUE when replacing a condensing unit.

Furnace baselines may be somewhat higher than the New Hampshire TRM value. Based on interviews with six HVAC contractors, it was reported that approximately 50% – 60% of existing homes had gas or propane furnaces installed. Newly installed non-program condensing furnace units were reported to typically have an AFUE of 92% – 95%, while non-condensing furnace units have an AFUE of 85% or lower. A majority of HVAC contractors (four out of six) reported that over 90% of the gas or propane furnaces they installed in existing homes were condensing units. There is no available New Hampshire HARDI data to verify this finding.

There is less suggestion of a higher baseline for boilers. Six HVAC contractors reported in interviews that about 40% of existing non-program homes have gas or propane boilers. Condensing units typically have an AFUE of 95%, while non-condensing boilers tend to have an AFUE of 85%. Estimates for the prevalence of condensing vs. non-condensing boilers varied among contractors, ranging from 33% – 100% installation frequency for condensing boilers and 40% – 70% for non-condensing units.

The rate of early furnace and boiler replacement is low. Respondents indicated that the replacement rate for units not near failure is very low. For furnaces, four out of six respondents reported a rate of zero, with one estimating less than 2% and another estimating 20%. For boilers, five out of six respondents reported zero early replacements, with one interviewee estimating 20%.

The prevalence of outdoor air temperature sensors is unclear. Interviewees were asked about the prevalence of outdoor air temperature (OAT) sensors for furnaces and boilers. Respondents reported that it is rare for condensing furnace units to have them installed. For boilers, opinions were divided, with half of the respondents stating that OAT sensor installations are very common, and the other half considering them very uncommon.

There is not enough data to detect baseline differences based on region or home type. Based on the limited responses to the interviews, there is no difference in the installation of condensing units observed between different types of homes or different regions of the state for both boilers and furnaces.

Recommendation: **A bifurcated baseline should be adopted for furnaces and boilers.** The interview data suggests that condensing units are frequently installed in non-program homes; adopting a bifurcated baseline would enable New Hampshire to properly account for the savings from these units. The bifurcated baseline approach recently adopted in Massachusetts differentiates the savings that are achieved when a condensing unit replaces a preexisting non-condensing unit from the savings delivered by replacing a preexisting condensing unit. Homes with older non-condensing units often incur higher replacement costs, but they also present more significant energy-saving opportunities, potentially justifying higher incentives in a flexible program design that benefits financially constrained customers. If this shift in the baseline approach is accepted, a comparison of recent baseline findings between New Hampshire and Massachusetts may inform the adoption of similar baseline values in New Hampshire, reducing the need for additional data collection. New Hampshire already employs Massachusetts baseline values for furnaces and boilers in certain market events, as detailed in Appendix C.

2.1.9 Residential Water Heaters – General Findings

The literature review focused on gas instantaneous (tankless) and electric heat pump water heaters and found differing baseline approaches in comparison states, as shown in Table 5.

Contractors estimated that, among the units they recently installed, the proportion of homes opting for an instantaneous gas water heater ranged from <10% to 45%, while the percentage choosing hybrid or heat pump water heaters (HPWH) ranged from 5% to 25%.

Table 5: TRM Baseline Values for Water Heating Systems

Source	Gas Tankless Water Heater Baselines	Heat Pump Water Heater Baselines
NH	Stand-alone tank water heater with a UEF of 0.63. Early retirement portion: Existing 0.58 UEF standalone water heater.	For direct install, a standard efficiency electric resistance storage hot water heater. For lost opportunity retail, “a blended mix of electric and fossil fuel water heating based on study results, used for retail offerings

Source	Gas Tankless Water Heater Baselines	Heat Pump Water Heater Baselines
		where customer-specific baselines are unknown"[6]
MA	0.63 UEF, 0.60 UEF early replacement	Codes and standards-based
CT	0.60 UEF	R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation
RI	0.61 UEF	Codes and standards-based
Mid-Atlantic	0.80 – 0.81 UEF	Codes and standards-based (<55 gallons uses standard electric resistance, >55 gallons uses blended value)
ME	0.62 UEF	50-gallon water heater .945 EF
NY	0.80 – 0.81 UEF	Federal standards (based on volume, draw pattern)

Water heater installations occur mainly on a replace-on-failure basis, also known as "lost opportunity." Regarding the drivers for water heater replacement, respondents reported that a significant proportion of replacements occur when a unit reaches or nears the end of its useful life, with estimates ranging from 75% – 95% across respondents (except for one contractor primarily involved in new construction work). When asked about the percentage of water heater installations that replace a unit not close to failure, respondents indicated that this occurs at a minimal level of approximately five percent.

There is not enough data to detect baseline differences based on region or home type. Interviewees did not report significant variations in the installation of instantaneous or heat pump water heaters based on the type of home. For multifamily homes, interviewees did note that considerations such as flues, gas meters, and space requirements may come into play. Additionally, there were not enough responses from market actors with geographically diverse service areas to detect a difference in the installation of these water heaters between the northern and southern regions of New Hampshire.

Contractors note higher incentives in neighboring states. When comparing the sale and installation of HPWHs in New Hampshire with neighboring states, respondents indicated that Massachusetts and Vermont offer more attractive incentives and rebates. The cost of these water heaters is not thought to be a major concern for homeowners in New Hampshire, according to respondents, although there are some reservations about the upfront expense.

2.1.10 Gas Instantaneous (Tankless) Water Heaters

New Hampshire's current instantaneous water heater baseline is aligned with four out of six comparison area TRMs. The literature review revealed that comparison areas follow two distinct approaches to the baseline for tankless water heaters in comparison areas. New Hampshire follows

[6] R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8.

the practice of using a gas storage water heater as the baseline, aligning with states such as Massachusetts, Connecticut, Rhode Island, and Maine. In contrast, New York and the Mid-Atlantic region employ a baseline based on the federal standard.

According to the six interviewees who provided input on instantaneous water heaters, most or all non-participating gas or propane instantaneous water heaters installed in existing homes in New Hampshire have Uniform Energy Factor (UEF) ratings of 0.87 or higher, with estimates ranging from 80% to 100% across respondents. The most frequently encountered UEF rating for these units is 0.95, as reported by four out of six respondents, while the remaining two respondents cite a most common UEF rating of 0.93.

2.1.11 Heat Pump Water Heaters

The literature review revealed a discrepancy between New Hampshire's baseline for HPWHs and comparison states. New Hampshire cites two different baselines for HPWHs based on the program delivery method: For direct install, the base case is "a standard efficiency electric resistance storage hot water heater," whereas for lost opportunity retail, the TRM cites "a blended mix of electric and fossil fuel water heating based on study results, used for retail offerings where customer-specific baselines are unknown." The retail offering baseline references a metering-based Connecticut study published in 2018.[7] In contrast, comparison area TRMs utilize a codes- and standards-based baseline as shown in Table 5.[8]

Interview data indicates that the baseline includes both electric and fossil fuel systems. The four contractors that had installed heat pump water heaters estimated that approximately 60% of recently installed HPWHs replaced fossil-fuel water heating systems in existing homes, while the remaining 40% replaced conventional electric tank water heating systems. Based on the limited responses, the most common types of fossil-fuel water heating systems replaced by HPWHs in New Hampshire were identified as propane systems, followed by oil systems and gas power-vented tank water heaters.

Recommendation: **For heat pump water heaters, the current baseline approach remains the best fit.** The study that underpins the current lost opportunity retail baseline undertook a rigorous approach incorporating metering and a customer survey to inform baselines.[9] The study also incorporates a blended baseline encompassing electric and fossil fuel systems, consistent with the condition reported by interviewed contractors. Alternatively, the Utilities could undertake further research to finetune the Connecticut study approach to the actual baseline fuel and system types found in New Hampshire. For direct install, the Utilities should consider specifying a federal standards-based baseline to align with most comparison areas and simplify updates.

2.1.12 Window Replacement

Further research will be needed to determine whether a change to the window replacement baseline is warranted. The New Hampshire baseline, defined as a single pane window or jalousie mobile home window, is unique in comparison to nearby states that use approaches based on

[7] Ibid.
[8] Ibid.
[9] R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8.

calculations factoring in glazing area and other variables. The literature review was inconclusive for this measure, leading the study team to prioritize it for IDIs.

With the IDIs, the team aimed to investigate whether the base case and upgrade case of double-pane windows require updating, as well as gaining insights regarding storm windows and interior window inserts. The evaluation team could not obtain interview responses regarding window retrofits from the market actors who agreed to interview, and therefore investigating these questions would require further research. Research in other areas has demonstrated high penetration of double pane windows in existing homes. However, because window replacements through NHSaves are done almost exclusively through the Home Energy Assistance (income-eligible) program, any further research should target this market.

2.1.13 Residential Mini-Split Heat Pumps

The New Hampshire baseline for mini-split heat pumps (MSHPs) is in line with literature review findings for other states. The baseline is defined as a code-compliant 2.2-ton system (SEER 14.0, HSPF 8.2), consistent with most comparison area TRMs as shown in Table 6.[10]

There is evidence that oil- and propane-fired systems should be components of the baseline. The four HVAC contractors that answered a question about the existing fossil-fuel heating systems that are partially or fully displaced reported that the existing heating systems are about 50% propane-fired and 50% oil-fired. The contractors' estimates of the percentage of non-program units that are cold-climate-rated ranged widely, from 40% – 100%. The team did not have access to sales data to validate this finding.

MSHPs are used for both heating and cooling and are typically supplementary to the primary heating system. The interviewed contractors reported that most installations are used for both heating and cooling, with the majority supplementing the systems that are already in place. They reported low rates of customers fully replacing existing heating and cooling systems (five of six respondents estimated between 0% – 15%, with one estimating 50%), and there was consensus that very few customers replaced heating or cooling systems that were near failure with a heat pump system. Respondents also stated that there was a very low rate of customers adding cooling to a space that had no prior permanent cooling.

Table 6: TRM Baseline Values for Mini-Split Heat Pumps

Source	Baseline Efficiency
NH	SEER 14, HSPF 8.2
MA	SEER 15, HSPF 8.2[11]
CT	SEER 14, HSPF 8.2
VT	SEER 14.5, HSPF 8.2 (multi-head)
Mid-Atlantic	SEER 14, HSPF 8.2

[10] As of the timing of this final report, New Hampshire already plans to revise the baseline for lost opportunity heat pumps to SEER2 14.3 and HSPF2 7.5 in 2024 to allow for sell through.

[11] Per the MA eTRM the Ductless Mini-split Heat Pump Quality Installation Verification measure has a different baseline efficiency than the values listed in Table 7, which correspond to the DMSHP, no integrated controls measure. The baseline efficiency for the DMSHP QIV is a follows: 2.3-ton, SEER 19.7, and HSPF 11.2.

Source	Baseline Efficiency
ME	SEER 14, HSPF 8.2
PA	SEER 14 (ROB)/13.5 (ER), HSPF 8.2
RI	SEER 15, HSPF 8.2

Interviewees reported that installation of MSHPs varies between home types (single-family detached, single-family attached, and multifamily). Some of the cited differences for multifamily homes included clearance issues, code differences, and a need for separate systems for each dwelling unit. The contractors didn't believe that finding a contractor who can install heat pumps would be an obstacle in New Hampshire, but they did suggest that larger incentives for heat pumps would help. Contractors have observed that the rebates for multi-split heat pumps (MSHP) in New Hampshire are comparable to those available in Maine. However, they recommend that New Hampshire align its incentive offerings with Massachusetts[12], where a rebate of $350 per indoor head is provided.

2.1.14 The State of Energy Efficiency and Code Enforcement in New Hampshire

To provide broader context to the investigation of baselines, the study team asked interviewees for their opinions on several topics. While the responses do not necessarily consider the laws and regulations that NHSaves must adhere to in running programs, they provide a view onto the day-to-day experiences of trade allies that work with customers.

When evaluators asked builders, code officials, HERS raters, and HVAC contractors what types of program and policy changes they see as most important for increasing the efficiency of buildings in New Hampshire, by far the most common response was that larger financial incentives are important (60%). Interviewees also cited other factors, including larger incentives specifically for heat pumps, expanded energy-efficiency program offerings, higher codes and standards, and increased code compliance. The latter two factors call for regulatory action. More code inspectors to support higher code compliance can be addressed through state or local budget allocations.

Two out of four interviewed builders cited insulation and windows as areas where code enforcement should be stronger, and one HERS rater also pointed to basement and ceiling insulation. One builder identified air sealing as the most important factor needing higher code enforcement and noted that it does not get a lot of attention from most builders. Unfortunately, due to recruitment issues there were no interview responses to the window module and therefore specifics regarding the cited concerns are unavailable.

Two out of three code officials indicated that the code should be better enforced overall and that there should be more education and standardization of best practices.[13] One official also stated that municipal inspectors should be required to be certified by the International Code Council. Notably, one HVAC contractor called for less stringent enforcement of code for ducted systems; another noted that locally there is a dislike of government rules.

[12] Mass Save provides a rebate for qualifying heat pump units of $1,250 per ton, up to $10,000. https://www.masssave.com/en/residential/rebates-and-incentives/air-source-heat-pumps?gad_source=1&gclid=CjwKCAiAgeeqBhBAEiwAoDDhn2AuuUq8WeNRPZxYthdv95AuueYPbTwABfoLX2Uw3Vgr3bYNXAcFqRoCt5wQAvD_BwE.

[13] NHSaves periodically offers codes training for New Hampshire, as noted on the New Hampshire Department of Energy website: https://www.energy.nh.gov/renewable-energy/energy-codes.

When asked for their opinions about which measures are most in need of rebate support, interviewees most frequently cited windows. Notably the study's planned window module was not completed due to recruitment issues, and this finding is derived from a question asked in the New Construction module. Only one code official pointed out that there are no tax credits offered for windows. These interviewees do not primarily work with windows and were unable to specify the details of this need. Heating systems, heat pumps, and water heating systems also were mentioned by several builders, code officials, and HVAC contractors. Heat recovery ventilation systems also received strong support from one builder, and doors and insulation were mentioned by another builder. One HVAC contractor noted that interest-free financing helps some customers to participate.

2.2 Recommendation Summary for Residential Measures

This section addresses the revisions recommended for the TRM followed by recommendations for future research. Recognizing that the Utilities perform an annual review of measure baselines as a regular part of their TRM update process, they should incorporate these recommendations in addition to others that they might identify.

2.2.1 Residential Measures Requiring No Updates

By leveraging the referenced literature review sources, the evaluators determined that no updates are needed to the baselines for the four measures shown in Table 7.

Table 7: Residential Measures Not Requiring Baseline Updates

Measure	Baseline
Central Ducted Air-Source Heat Pump[14]	A code-compliant 2.8-ton, SEER 14, HSPF 8.2 heat pump unit[15]
Wi-Fi Communicating Thermostat	An HVAC system with either a manual or a programmable thermostat[16].
Clothes Washer	Top-loading washer: 1.57 IMEF Front-loading washer: 1.84 IMEF
Clothes Dryer	A new electric resistance dryer that meets the federal standard as of January 1, 2015 (a Combined Energy Factor (CEF) of 3.73, adjusted to 3.11 CEF to account for testing procedure differences between DOE and Energy Star).
Refrigerator	A refrigerator that meets the Federal standard effective September 15, 2014. Specific baseline coefficients and constants by product class are found in the Code of Federal Regulations, 10 CFR 430.32(a).

2.2.2 Recommendations for TRM Revisions

The study produced recommendations for updates to four residential measure baselines. Eleven residential measures, plus several new construction measures, were prioritized for detailed review as part of this evaluation. The conclusions and recommendations are detailed in Table 8.

[14] While there is overlap between ASHP and MSHP the study design and module format treated these measures as wholly separate.
[15] As of the timing of this final report, New Hampshire already plans to revise the baseline for lost opportunity heat pumps to SEER2 14.3 and HSPF2 7.5 in 2024 to allow for sell through.
16 New Hampshire uses deemed savings from a Massachusetts HES impact evaluation for Wi-Fi thermostats, as well as NH baseline findings on equipment type saturations. The deemed values are based on home heating fuel and do not differ based on the type of thermostat (programmable or manual) bring replaced.

Recognizing that the Utilities perform an annual review of measure baselines as a regular part of their TRM update process, they should incorporate these recommendations in addition to others that they might identify. Considerations for additional research are detailed in Table 8 and in the Executive Summary.

The study team additionally recommends that New Hampshire revise the nomenclature used to refer to baseline types in the next version of the New Hampshire TRM. Some of the terms currently used to refer to baseline types, or what are called Program Types in the document (e.g., "lost opportunity" and "retrofit"), are imprecise and can lead to confusion.

Table 8: Residential Measure Research Summary

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recommendations for Further Research
Residential Measures							
New Construction	**Building Envelope, Heating and Water Heating Equipment, Lighting**	Vendor calculated energy savings using a RESNET-accredited Rating Software Tool (REM/Rate) where a user inputs a detailed set of technical data about a project, comparing as-built projected energy consumption to that of a Baseline Home. This process is used to calculate electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes	UDRH Based on 2015 IECC with NH amendments and ISP (air infiltration and heating system efficiencies)	2015 IECC with amendments and 2017 ES Homes evaluation (for ISP)	Literature review, in-depth interviews	UDRH should be detailed in the TRM moving forward. Update UDRH where necessary to reflect transition from 2015 IECC (with NH amendments) to 2018 IECC (with NH amendments) as of July 2022.	Consider further research in the short to medium term to determine how practices in the field align with code updates.
Retrofit/Lost Opportunity	**Gas Instantaneous (Tankless) Water Heater**	Installation of a new high-efficiency natural gas tankless and storage water heaters.	Stand-alone tank water heater with a UEF of 0.63. Early retirement: Existing 0.58 UEF standalone water heater	Unknown	Literature review, in-depth interviews	No change.	Consider further research to quantify blended baseline of water heater types.

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recommendations for Further Research
	Heat Pump Water Heater	Installation of an ENERGY STAR® certified heat pump storage water heater, either through direct installation programs to replace an electric resistance storage water heater, or as a lost opportunity retail offering.	For direct install, a standard efficiency electric resistance storage hot water heater. For lost opportunity retail, a blended mix of electric and fossil fuel water heating based on study results, used for retail offerings where customer-specific baselines are unknown	R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8.	Literature review, in-depth interviews	For direct install, consider moving to a federal standards-based baseline to align with most comparison areas and simplify updates.	Consider further research to quantify blended baseline of water heater types.
	Gas Furnace	Installation of a new high efficiency space heating furnace with an electronically commutated motor (ECM) for the fan.	83% AFUE rated furnace for early replacement and an 85% AFUE furnace for lost opportunity	83% AFUE: New Hampshire Potential Study Volume III: Residential Market Baseline Study 85% AFUE: baseline represents value negotiated in MA for new boilers, which is applied to furnaces in this case.	Literature review, in-depth interviews	Based on our research it is appropriate to adopt a bifurcated baseline for condensing and non-condensing exhaust like that used in MA with the same values.	None
	Gas Boiler	Installation of a new high efficiency forced hot water boiler for space heating.	Early replacement: 84% AFUE Lost opportunity: 85% AFUE	84% AFUE: New Hampshire Potential Study Volume III: Residential Market Baseline Study 85% AFUE: baseline represents value	Literature review, in-depth interviews	Based on our research it is appropriate to adopt a bifurcated baseline for condensing and non-condensing exhaust like that	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recommendations for Further Research
				negotiated in MA for new boilers		used in MA, using the same values.	
	Window Replacement	Replacement of single pane windows or jalousie mobile home windows.	Baseline efficiency is defined as a single pane of jalousie mobile home window.	Unknown	Literature review, in-depth interviews	Not enough information to determine whether a baseline change is warranted.	Additional research focused on the income-eligible market is needed to determine if an update is justified.
	Ductless Mini-Split Heat Pumps	This measure includes the installation of a high-efficiency, ductless, mini-split heat pump unit (DMSHP) to serve the heating and cooling loads of a residential unit.	The lost opportunity baseline is a code compliant 2.2-ton, SEER 14.0, HSPF 8.2 heat pump unit	International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps	Literature review, in-depth interviews	The Utilities have already moved to update the code-based baseline to the new federal standard of SEER2 14.3, HSPF2 7.5. Not enough data to indicate a further baseline change but further research on the role of fossil-fuel systems in the baseline is warranted based on interview findings.	Consider further research to investigate the role of fossil-fuel systems in the baseline, and revisiting measure in short- to medium term as baselines evolve.
	Central Ducted Air-Source Heat Pump	This measure includes the installation of a high-efficiency, central air-source heat pump unit (ASHP) to serve the heating and cooling loads of a residential unit	For lost opportunity or replace on failure, the baseline is a code-compliant 2.8-ton, SEER 14, HSPF 8.2 heat pump unit.	International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps	Literature review	The Utilities have already moved to update the code-based baseline to the new federal standard of SEER2 14.3, HSPF2 7.5.	Consider revisiting measure in 1-3 years as baselines could evolve rapidly given regional push for rapid market adoption.

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recommendations for Further Research
	Wi-Fi Communicating Thermostat	A communicating Wi-Fi enabled thermostat that allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems.	The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.	Deemed savings based on 2018 MA impact evaluation	Literature review	No change. Updates require new deemed savings from impact evaluation findings.	None
	Clothes Dryer	Clothes dryers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or most efficient.	A new electric resistance dryer with a Combined Energy Factor (CEF) of 3.73, adjusted to 3.11 CEF to account for testing procedure differences between DOE and Energy Star).	Federal standard as of January 1, 2015	Literature review	No change	None
	Clothes Washer	Clothes washers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or Most Efficient.	Top-loading 1.57 IMEF Front Loading 1.84 IMEF	Federal Standards (1.84 IMEF = 2015. 1.57 IMEF = 2018)	Literature review	No change	None
	Refrigerator	Refrigerators exceeding minimum qualifying efficiency standards established as ENERGY STAR®.	A refrigerator that meets the Federal standard effective September 15, 2014. Specific baseline	10 CFR 430.32(a).	Literature review	No change	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recommendations for Further Research
			coefficients and constants by product class found in the Code of Federal Regulations, 10 CFR 430.32(a).				

Section 3 Commercial & Industrial Results

This section presents the results from this study for commercial and industrial measures. Findings based on the literature review are presented first, followed by the results of the in-depth interviews (IDIs). Please refer to Appendix C for the results and recommendations slides presented to the EM&V Working Group on May 31, 2023.

New construction measures were the primary focus of the study, but in some cases, replace-on-failure and retrofit measures were also addressed in the interviews.

3.1 Literature Review and In-Depth Interview Results

The study team carefully analyzed NH's TRM alongside those from other states to determine whether New Hampshire's current baseline for these measures is aligned with current practice in the region. The literature review was essential in capturing the latest market dynamics and technological advancements in energy efficiency. This research included not only new construction/replace-on-failure measures, but also retrofit market events in a few cases.

By leveraging insights from various references, the evaluator determined that the baseline for one measure should remain the same and updates are recommended to the baselines for four measures to ensure they accurately reflect the present landscape and enable targeted and impactful energy savings. During the literature review, it was identified that the baselines for eight C&I measures in existing buildings and new construction merited further investigation through in-depth interviews.

Table 9 shows the number of achieved interviews for different market actors and the number of participating and non-participating projects they worked on in the last 12 months. For contractors, the columns represent the total number of units. However, for other market actor types, the columns represent the total number of projects, which may include more than one measure type.

Table 9: Completed C&I Market Actor Interviews

Market Actor Type	Achieved Interview Completes	Number of Projects/Units (participating)	Number of Projects/Units (non-program participating)
Code official	3	42	50
Builder	2	14	13
Contractor	7	28	176
Architect/Designer	2	17	11
Total	**14**	**101**	**250**[17]

[17] This includes the overlapping equipment among different projects.

By conducting these interviews and collecting relevant data, the evaluator aimed to inform and refine the existing and proposed energy efficiency measures, ensuring the baselines reflect industry practice and regional specifications, thus delivering reliable energy savings estimates in both existing and newly constructed C&I facilities in New Hampshire.

The following section provides details on the interview sample, the collected data, conclusions, and the evaluator's recommendations for each measure.

3.1.1 Compressed Air – Air Compressor with Variable Volume Control

These findings apply to new construction or major renovation and replace-on-failure market event types. Table 10 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 10: TRM Baseline Values for Compressed Air – Air Compressor

Source	Baseline Efficiency / Analysis
NH	0.189 kW reduction per HP
MA	0.189 kW reduction per HP,
CT	0.189 kW reduction per HP
PA	Uses nominal HP to full load kW conversion factors dependent on equipment size.
Mid-Atlantic	Uses nominal HP to full load kW conversion factors dependent on equipment size.
ME	Savings factors depend on equipment size: 16-30 HP: 0.2358 kW/HP 31-60 HP: 0.2154 kW/HP > 60 HP: 0.1861 kW/HP
NY	25-75 HP: 0.189 kW per HP >75 HP: 0.216 kW/HP

This measure covers the installation of oil flooded, rotary screw compressors with variable speed drive or variable displacement capacity control with properly sized air receiver. The potential savings associated with this measure stem from the utilization of efficient air compressors that employ various control schemes to enhance compression efficiencies at partial loads. A typical load/unload compressor represents the current baseline for this measure in New Hampshire. The TRM utilizes a deemed savings factor (0.189 kW/hp) for units ranging from 25 to 75 hp, which is based on an impact evaluation of prescriptive chiller and compressed air installations for the Massachusetts Program Administrators (PAs)[18]. The New York TRM includes values for units greater than 75 hp and is based on a federal Department of Energy study.

[18] DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. Result for VSD 25-75 HP used since "All" result includes savings from load/unload compressors, which are now baseline.

These measure findings apply to both new construction and replace-on-failure events, since any unit equipped with the controls will achieve the estimated savings independent of the underlying equipment efficiency.

Recommendation: Upon reviewing TRMs from neighboring states, the study team agrees with NH's current baseline and deemed saving factor for 25 to 75 hp units. However, the study team recommends considering adopting the expanded size range in New York's TRM[19] incorporating units larger than 75 hp, which uses 0.216 kW/hp as the deemed saving factor.

3.1.2 Compressed Air – Air Nozzle

This finding defines the assumed system pressure for prescriptive measures for all event types. Custom measures should use the same default unless the site-specific system pressure is known.

This measure addresses the installation of engineered air nozzles which provide effective air nozzle action while reducing compressed air system air flow. Currently, the baseline assumption in New Hampshire is a standard nozzle on a compressed air system, with the baseline airflow assumed to be the flow rate at 100 psi when the site-specific operation setting is unknown.

During the comparative analysis of nearby states' TRMs (Connecticut, Pennsylvania, and Maine), it was observed that these states commonly utilize 80 psi as the default air pressure at the nozzle, which is more aligned with practical industrial cases. Table 11 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 11: TRM Baseline Values for Compressed Air – Air Nozzle

Source	Baseline Efficiency / Analysis
NH	CFM at 100 psi if actual CFM is unavailable.
MA	CFM at 100 psi if actual CFM is unavailable.
CT	CFM at 80 psi if actual CFM is unavailable.
PA	CFM at 80 psi if actual CFM is unavailable.
ME	CFM at 80 psi if actual CFM is unavailable.

Recommendation: Based on this finding, the evaluator recommends updating the default air pressure at the nozzle in New Hampshire from 100 psi to 80 psi. This adjustment considers the prevailing industry practices in neighboring states, which the evaluators believe also reflect practices in New Hampshire, and would result in a more accurate reflection of real-world scenarios. For custom projects, the air pressure should be known and used in ex ante savings estimates, but when it is not, the 80 psi default pressure will apply.

[19] https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf, page 556

3.1.3 VRF Systems

These findings apply to new construction or major renovation. Replace-on-failure market event types were not researched.

This measure includes the installation of high-efficiency variable refrigerant flow (VRF) heat pumps. Currently in New Hampshire, the baseline equipment for this measure is based on ASHRAE 90.1 2013 version code compliant VRF systems. Table 12 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 12: TRM Baseline Values for VRF Systems

Source	Baseline Efficiency / Analysis
NH	ASHRAE 90.1-2013
MA	IECC 2018 (must exceed ASHRAE 90.1 by 10%)
CT	ASHRAE 90.1-2019
Mid-Atlantic	ASHRAE 90.1-2013
ME	ASHRAE 90.1-2007

During the literature review, it was discovered that the State Building Code Review Board (BCRB) in New Hampshire had conducted a thorough review and officially adopted the International Energy Conservation Code (IECC) 2018, effective on July 1, 2022, for the commercial sector. This new code updated VRF minimum required efficiencies.

Overtime, replace-on-failure equipment is expected to be like equipment selected for new construction because distributors tend to stock equipment that meets code, phasing-out non-compliant equipment, and code officials may enforce code efficiencies, although ambiguity in the code allows for like-with-like replacement. However, there is no research to indicate where the replace-on-failure market is today.

Recommendation: Considering the revision of the VRF minimum efficiencies, the evaluator recommends updating the baseline efficiency for new construction and replace-on-failure VRF heat pumps in New Hampshire to align with the IECC 2018 standard.

In addition, the evaluator recommends conducting IDIs with different stakeholders in a future baseline study, to gather more insights into any potential discrepancies between the actual market performance and the code requirement for VRF efficiency in the replace-on-failure market.

3.1.4 Commercial Boilers

For this measure, differences in standard practice were found for new construction or major renovation compared to replace-on-failure events. Table 13 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 13: TRM Baseline Values for C&I Boilers

Source	Baseline Efficiency / Analysis
NH	85% AFUE boiler

Source	Baseline Efficiency / Analysis
MA	15% above IECC 2015 code minimum
CT	92% AFUE
VT	82% AFUE (oil); 81% AFUE (propane)
Mid-Atlantic	80-82% AFUE; 77-82% TE
ME	80-82% AFUE; 77-82% TE
NY	80-82% AFUE; 77-84% TE

Condensing boilers have an additional heat exchanger in the combustion exhaust air stream, which extracts enough additional heat to condense the flue gas. This extra heat raises the efficiency of the boiler. Oil-fired unit flue gas is too dirty and steam boiler temperature requirements prevent a condensing design, so condensing boilers are restricted to natural gas or propane hydronic boilers. Condensing boilers operate in a higher combustion efficiency range (90% to 95%) compared to non-condensing boilers (82 – 87%), Building code minimum efficiencies are designed to allow non-condensing boiler designs, thus a high proportion of condensing boilers will lift the market-level baseline efficiency above code.

Summary of Interviews: Eight respondents, including two architects, two code officials, one builder, and three contractors reported boiler installation activity in 70 projects in the previous 12 months. Respondents estimated that only about 5% of the projects were program-participating units, although the rate of condensing boiler installations, thus likely program qualifying installations, was much higher.

Respondents estimate that about 35% of their project activity was in new construction or major renovation, with the balance replace-on-failure. Five respondents (one architect, two code officials and one contractor) reported that condensing boilers are the standard in new construction except for steam or oil-fired boilers, even for non-participating boilers. As one architect noted, “Everyone installs condensing boiler unless they have oil.”

The proportion of condensing boilers in the replacement market (about 65% of the market) is less certain. One contractor who exclusively serves the large boiler replacement market only installs non-condensing boilers. A code official noted that 80% of the replacement market is standard efficiency. A second contractor noted that, while condensing units dominate the replacement market, they still install a smaller number of non-condensing units. In addition, in some cases, existing buildings may face limitations when they come to operating at low enough boiler return temperatures to enable condensing feature.

Three respondents provided detailed data on the size range of condensing boilers installed, with two reporting installation of unit are less than 300 MBH and a third reporting installation of unit in the 1000 – 1700 range. When asked about the efficiency cost premium, two saw it as a moderate or major concern, two as a minor concern, and one said that “the customers are used to the prices – it’s the standard of the industry.”

The respondents did not report any significant differences in boiler practices across the state. Additionally, none of the respondents cited any notable variations in New Hampshire practices

compared to other nearby states. The findings suggest a consistent pattern across New Hampshire and neighboring states in terms of boiler types and efficiencies.

New Construction Boilers

While the number of respondents was limited, their consistent reporting of the dominance of condensing boilers in new construction and their conclusions that New Hampshire was not dissimilar from neighboring states indicates that changes to boiler baselines should be considered. The MA NRNC study discussed in the literature review provides the most robust research of new construction boiler efficiencies in the region. The study includes observations of the rated efficiencies of 89 boilers (including 73 non-program units) in 14 newly constructed sites permitted under IECC 2015 between 2017 and 2019. Like the New Hampshire findings, the Massachusetts study determined that all new construction boilers were condensing boilers except for one steam boiler. That study recommended a standard practice baseline for natural gas hydronic boilers that is 15% better than the IECC 2015 minimum efficiency, a provision that is still in effect.

Recommendation: The evaluator recommends adopting 15% better than the IECC 2015 minimum efficiency adjustment for natural gas hydronic boilers since it is primarily predicated on the high fraction of installed condensing boilers in new construction. This recommendation does not apply to steam or oil-fired boilers, which should continue to use code as the baseline.

Ideally, these factors would be expressed using IECC 2018 efficiencies because New Hampshire has adopted IECC 2018. However, IECC 2018 revises some but not all of the efficiencies, and not in a uniform manner. Applying an average adjustment would impose a change to all efficiencies, even those that remained constant between 2015 and 2018, and would not accurately produce the efficiencies determined through the MA NRNC study, which are derived by accounting for the distribution of equipment by size and configuration in the population.

To avoid any possible confusion, Appendix E.3 provides efficiency references by space type for interior and exterior spaces with the correct adjustment applied.

Replace-on-Failure Boilers

The evidence for a high market share of condensing boilers in the replacement market is mixed with respondents indicating both condensing and non-condensing boiler installations. This is likely due in part to the different installation requirements for the two boiler types, which can complicate the replacement of a non-condensing boiler with a condensing boiler. When an existing building is replacing a condensing boiler, the baseline should also be a condensing boiler to keep the consistence. In Massachusetts, replacement boiler baselines are code.

Recommendation: Due to the evidence of a strong non-condensing boiler market, the evaluator recommends a code baseline for replacement boilers.

3.1.5 Gas Instantaneous (On-Demand) Water Heater

These findings apply to new construction or major renovation and replace-on-failure market events. Table 14 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 14: TRM Baseline Values for Gas Instantaneous Water Heater

Source	Baseline Efficiency / Analysis
NH	0.61
MA	0.71
Mid-Atlantic	0.81
NY	0.80

This measure specifically focuses on the installation of tankless water heaters, which circulate water through a heat exchanger for immediate use, resulting in higher efficiency and energy savings by eliminating standby heat loss associated with storage tanks. During the evaluation process, interviews were conducted with five respondents representing 18 projects. Among these projects, seven were new construction or major renovation projects, while the rest were installations in existing buildings replacing failed or near failed equipment.

The tankless water heaters were reported to be primarily installed in multifamily buildings, dormitories on campuses, restaurants, and labs and industrial facilities where emergency showers were present. Most of these projects utilized water heaters that just complied with, but did not exceed, the minimum required code efficiency in both new construction and replace-on-failure projects. No efficiency difference is reported between southern and northern parts of the state.

Recommendation: Based on the data collected and analyzed, the evaluator recommends maintaining the current baseline efficiency for this measure for both new construction and replace-on-failure. This recommendation is made considering that the reported installations predominantly align with code compliance requirements in both new construction and replace-on-failure events.

3.1.6 New Construction – Commercial Lighting

These findings apply to new construction or major renovation market events, but not to replace-on-failure, which was not researched. Table 15 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 15: TRM Baseline Values for NC C&I Lighting

Source	Baseline Efficiency / Analysis
NH	Compliance with lighting power density requirements as mandated by New Hampshire State Building Code, which currently reflects IECC 2015 with direct reference for compliance to ASHRAE Standard 90.1-2013.
MA	ISP, 60% of the code requirements (IECC 2015) for interior lighting and 67% of the code requirements (IECC 2015) for exterior lighting.
CT	IECC 2021 If a project permit is issued before 2021 IECC code is adopted by the State, the previous code (2015 IECC) should be referenced.
NY	Code LPD shall be taken from chapter C405.3: Interior Lighting Power Requirements (Prescriptive) and chapter C405.4: Exterior Lighting (Mandatory) of the Energy Conservation Construction Code of New York

Source	Baseline Efficiency / Analysis
	State 1182 (ECCCNYS) that are based on IECC 2018. Alternatively, ASHRAE Standard 90.1-2013 may be referenced for compliance.

LED technology provides very high lighting output for a watt of input power (lumens per watt, called the efficacy). The efficacy of linear LEDs is in the 110 – 150 lumens per watt range compared to linear fluorescent technology, which ranges from 75 – 90 lumens per watt. Code maximum allowed lighting power densities (LPD; measured in watts per square foot) are high enough to allow a fluorescent design to meet code, however the same project designed with LEDs will have a significantly lower LPD due to the efficacy advantage. Consequently, a higher proportion of projects installed with LEDs will lower the average market LPD.

Summary of Interviews: Eight respondents (one architect, two code officials, two builders and three electrical contractors) reported working on lighting installation across 172 projects. Respondents estimated that about half of the projects were participating projects. Overall, about 90% of the projects were new construction or major renovation builds. For the remainder of the interview, the evaluator asked respondents to focus on non-program participating new construction and major renovation projects only.

When asked about the percentage of LEDs in new construction, all eight of the respondents reported that LEDs were almost exclusively installed. As one contractor reported, "I haven't put anything else in a very long time – maybe more than 5 years, ... I don't know if you can buy fluorescent troffers anymore." Exceptions were noted for specific applications including ski resort exterior lighting, clean rooms, and some manufacturing.

When the evaluator tried to obtain specific LPD values for different facility types to quantify lighting performance based on the whole building area method, most respondents were unable to provide detailed LPD data but indicated that their projects would meet code. All three of the electrical contractors stated that others engineered the projects, and they were not responsible for or aware of LPD. The architect, someone that would be responsible for code compliance, reported that "across the board, everything is more efficient than code with the exception of cleanroom or manufacturing." The two code officials responded that buildings were code compliant but did not know if they were better than code.

Six of the respondents did not report any significant differences among regions in New Hampshire with respect to new construction lighting practices (the remaining two respondents did not answer this question). One of the contractors noted that there were more differences between designers than between regions within the state. Three responded to the question about how New Hampshire compared to neighboring states: Two contractors reported no differences, while the architect reported that New Hampshire was similar to its neighbors, but Massachusetts "ratchets it up a bit on the code side."

Conclusion: While the number of respondents was limited, their consistent reporting of the dominance of LED technology in new construction and their conclusions that New Hampshire was not dissimilar from its neighboring states indicates that changes to lighting new construction baselines should be considered. This conclusion is also supported by the 2020 New Hampshire

Baseline and Potential Study[20], which found that LED technology had significantly penetrated the New Hampshire commercial market, serving 28% of lighting in existing buildings in 2019. Manufacturers and distributors reported in 21 trade ally interviews that 90% of their lighting product sales were LED (exterior, high/low bay, and ambient) in 2019. Another key conclusion of the study was that New Hampshire lagged Massachusetts in the implementation of LEDs by about two years.

The MA NRNC study discussed in the literature review provides the most robust research of new construction lighting LPDs in the region. The study includes observations of LPDs for 55 buildings (including 20 non-program buildings) permitted under IECC 2015 between 2017 and 2019. Similar to the New Hampshire findings, the Massachusetts study determined that a high fraction (92%) of the new construction lighting was served by LEDs. That study recommended applying a 0.60 LPD factor to derate the code IECC 2015 LPD for interior lighting and a 0.67 factor for exterior lighting, a recommendation that still stands in Massachusetts, although it has since adopted IECC 2018.

Recommendation: The evaluator recommends applying a 0.60 LPD factor to derate the code IECC 2015 LPD for interior lighting and a 0.67 factor for exterior lighting since it is primarily predicated on the high fraction of LEDs in new construction, a conclusion of the IDIs conducted in this study and the 2020 Potential study.

Ideally, these factors would be expressed using IECC 2018 LPDs since New Hampshire has adopted IECC 2018. However, IECC 2018 revises some of the LPDs, but not all and not in uniform manner. Applying an average adjustment will impose a change to all LPDs, even those that remained constant between 2015 and 2018 and will not accurately produce the LPDs determined through the MA NRNC study which are derived accounting for the proportion of space represented in the population.

To reduce any possible confusion, Appendix E provides LPD references by space type for interior and exterior spaces with the correct adjustment applied.

3.1.7 Commercial Lighting Controls

These findings apply to new construction or major renovation. Practices in a replace-on-failure market event were not researched.

This measure encompasses the installation of occupancy sensors or daylighting sensors and controls in new construction or major renovation projects. The types of lighting controls covered by this measure include wall-mounted, ceiling-mounted, fixture-mounted, or integrated controls, as well as Luminaire Level Lighting Controls (LLLCs) or Networked Lighting Controls (NLCs). Table 16 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

[20] https://www.puc.nh.gov/electric/Monitoring_Evaluation_Report_List.htm, item 153, Volume IV, page 7

Table 16: TRM Baseline Values for NC C&I Lighting

Source	Baseline Efficiency / Analysis
NH	Code-compliant controls as mandated by the New Hampshire Building Code, which currently reflects IECC 2015 and ASHRAE Standard 90.1-2013.
MA	Code-compliant controls.
CT	Code-compliant controls.
NY	Code-compliant controls.
PA	Code-compliant controls.

During the interviews, all respondents involved in discussions about new construction lighting also provided feedback on this measure. Contractors and architects highlighted that most customers are not familiar with the specific code requirements, so the decision-making process for lighting design is typically left to the designers. Due to cost concerns, the majority of projects rely on code-compliant controls, with only a few instances of advanced control systems like NLCs being installed in hospitals and university campuses, as reported by one contractor. Additionally, one architect mentioned that advanced control systems are more commonly utilized in cities and hubs located in southern New Hampshire compared to the northern region.

When a control component fails, an owner/operator has the option of replacing the component, likely like-with-like, or leaving the controls in the failed state. Failed lighting controls will typically fail on with manual on/off still working, therefore lighting service is maintained even with control failure. Researching the mix of repair versus failed-in-place which constitutes the replace-on-failure standard practice was beyond the scope of this study.

Recommendation: Based on the information collected, the evaluator recommends maintaining the current baseline of code-compliant controls for this measure for new construction event types. This recommendation takes into consideration the prevailing practice of using code-compliant controls due to cost considerations, the limited adoption of advanced control systems, and the lack of widespread familiarity with specific code requirements among customers. Replace-on-failure event measures were not researched.

3.1.8 Commercial Furnace

These findings apply to new construction, major renovation and replace-on-failure. Table 17 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

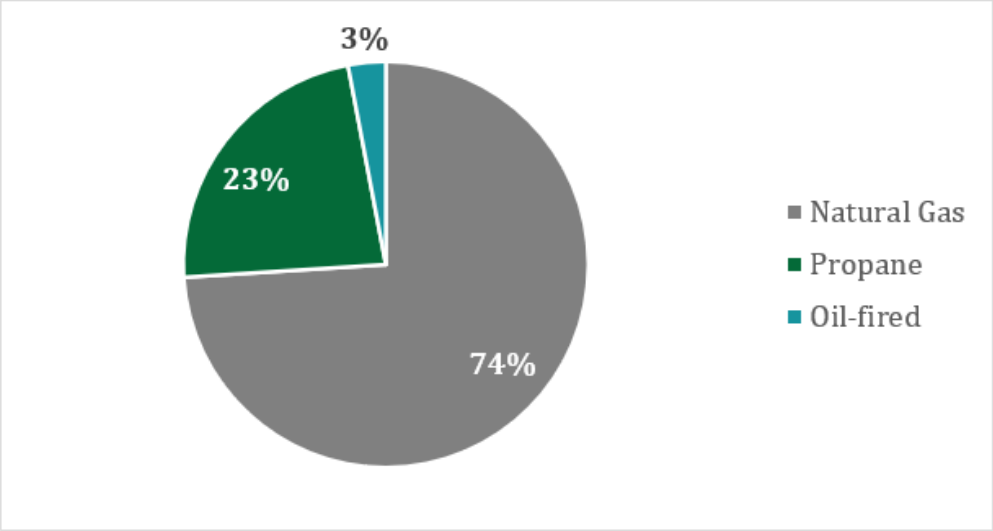
Table 17: TRM Baseline Values for C&I Furnace

Source	Baseline Efficiency / Analysis
NH	85% AFUE furnace.
MA	ISP: 2% above IECC 2015
CT	IECC 2021 If a project permit is issued before 2021 IECC code is adopted by the State, the previous code (2015 IECC) should be referenced.

Source	Baseline Efficiency / Analysis
NY	Gas fired, < 225 kBTU/h: 0.80 AFUE Gas fired, >= 225 kBTU/h: 0.80 Et Oil fired, < 225 kBTU/h: 0.83 AFUE Oil fired, >= 225 kBTU/h: 0.81 Et

During the IDIs, the evaluator collected data from seven respondents on 120 furnaces of which about half were installed in new construction or major renovation projects and half in replace-on-failure projects. About half of the units were estimated to be participating units. The market share for fuels used by the furnaces is shown in Figure 1 below.

Figure 1: Market Share for Furnaces



According to the respondents, **most installed furnace units were below 225 MBH in size, and the overall efficiency was reported to be around 85 – 86% for new construction and replace-on-failure.** This aligns with the current baseline efficiency specified in the NH TRM, which is also set at 85%.

In terms of regional differences within New Hampshire, one contractor noted that natural gas availability is higher in southern New Hampshire compared to the northern region. This regional variation in fuel availability may have an impact on the types and efficiency levels of furnaces installed. However, the data collected does not indicate any significant differences in furnace efficiency or baseline requirements based on regional differences.

Recommendation: Based on the findings, the evaluator recommends maintaining the current baseline efficiency for this measure in the program for both new construction and replace-on-failure, as it reflects the market reality and efficiency levels observed in the field.

3.1.9 New Construction - Commercial Heat Pump

These findings apply to new construction and major renovation. Replace-on-failure was not researched. Table 18 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 18: TRM Baseline Values for C&I Heat Pump

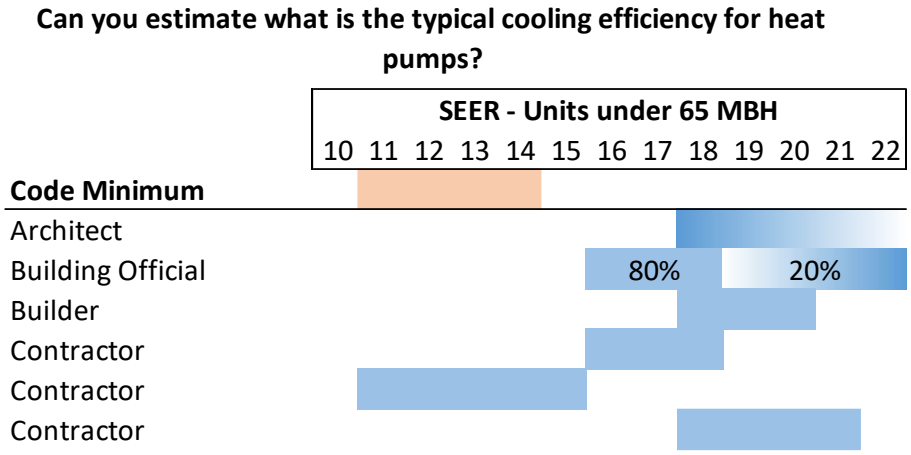
Source	Baseline Efficiency / Analysis
NH	IECC 2015.
MA	ISP, cooling is 3% above IECC 2015, and heating is 6% above IECC 2015
CT	IECC 2021 If a project permit is issued before 2021 IECC code is adopted by the State, the previous code (2015 IECC) should be referenced.
NY	2020 Energy Conservation Construction Code of New York State (ECCCNYS)
ME	IECC 2015
Mid-Atlantic	IECC 2015

Heat pump minimum cooling efficiencies are defined in IECC 2015 using three metrics. For units under 65 MBH, the Seasonal Energy Efficiency Ratio (SEER) ranges between 11 – 14, depending on unit size and configuration. For units larger than or equal to 65 MBH, the Energy Efficiency Ratio (EER) applies to split systems while the Integrated Energy Efficiency Ratio (IEER) applies to packaged units. The range in values for split systems is from 9.3 to 11 EER; the range for packaged units is 9.4 to 12.0 IEER. The EER characterizes peak performance while the IEER characterizes seasonal performance.

Summary of Interviews: Seven respondents, including one architect, two code officials, one builder and three contractors reported heat pump installation activity in 147 projects in the previous 12 months. Respondents estimated that about a quarter of the projects were program participating units.

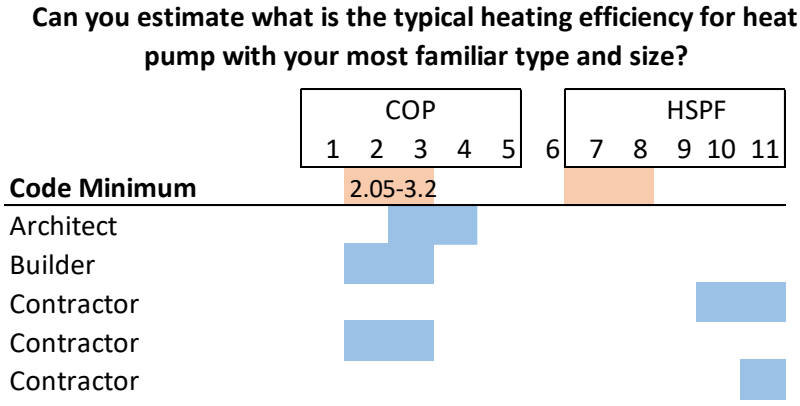
Figure 2 below summarizes the response of the market actors when asked to estimate the cooling efficiency of the typical non-program participating unit installed in New Hampshire new construction or major renovation projects. All the respondents referenced SEER values which is consistent with their characterization of a typical unit as being under 65 MBH. One respondent characterized the typical unit as at or slightly better than code while the other five respondents expected the typical unit to be better than code.

Figure 2: SEER Estimation for Heat Pumps



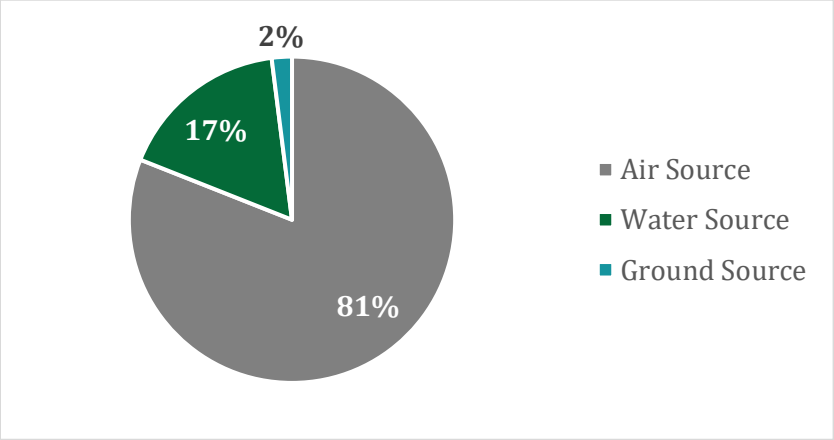
Heat pump minimum heating efficiencies are defined in IECC 2015 using two metrics. The Heating Seasonal Performance Factor (HSPF) ranges between 6.8 and 8.2 and applies to units with a capacity under 65 MBH. A Coefficient of Performance (COP) applies to units greater than 65 MBH and ranges between 2.05 and 3.3. The following figure summarizes the response of the market actors when asked to estimate the heating efficiency of the typical non-program participating unit installed in New Hampshire. Respondents reported using both heating efficiency metrics.

Figure 3: COP and HSPF Estimation for Heat Pump



According to the data, air source heat pumps dominate the market for heat pumps in new construction buildings in New Hampshire due to cost considerations, as depicted in Figure 4. One contractor mentioned that while water source heat pumps are more efficient, they are not as prevalent in the market.

Figure 4: Market Share for Heat Pumps

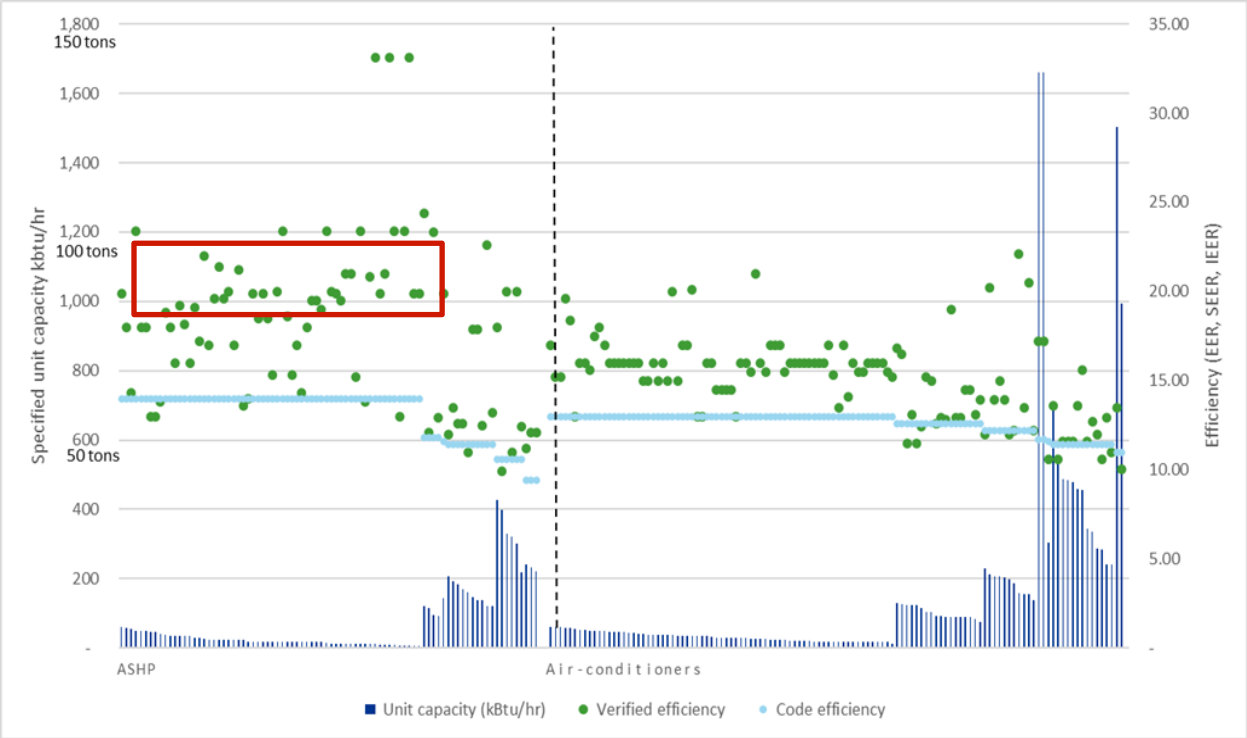


Regional differences within New Hampshire regarding the popularity and adoption of commercial heat pumps were identified during the interviews. Contractors highlighted that heat pumps are more popular in southern New Hampshire compared to the northern region. The colder temperatures in the north pose challenges for heating efficiency, making heat pumps more attractive in the southern part of the state. Contractors noted that in southern New Hampshire, customers are more inclined to invest in heat pumps, likely due to the region's higher average income, which reduces financial barriers to energy-efficient equipment upgrades compared to northern New Hampshire. Furthermore, there is a growing interest in heat pumps among small commercial facilities, indicating a positive trend towards their adoption. However, it was noted that the cost of heat pumps remains a significant concern for customers, particularly if there are no program incentives available to offset the initial investment.

Conclusion

Five of the six respondents reported better-than-code cooling performance and three of five indicated better-than-code heating performance. Unlike the findings for boilers and lighting, there is no transformative technological feature (like condensing or LEDs) that is linked to high efficiency heat pump performance. In Figure 5 below, the left half represents the relationship between unit capacity and the efficiency for heat pumps from the MA NRNC report. The dark blue bar refers to the unit capacity in kbtu/hr, and the green dots refer to the efficiency compared to the light blue line, which shows the code efficiency. This figure graphs all verified SEER values (right y-axis) for a population of new construction heat pumps, ordered by size in dark blue bars. The typical heat pump SEER range reported by New Hampshire respondents (within red outline) overlays this figure. This suggests that while the New Hampshire reported efficiencies are better than code, they may not be as advanced as the Massachusetts population.

Figure 5: Heat Pump Efficiency Distribution



The MA NRNC study discussed in the literature review provides the most robust research of new construction boiler efficiencies in the region. Heat pump efficiencies were verified from 32 new construction sites permitted under IECC 2015 in 2017 and 2019 in Massachusetts. The study verified ratings from 594 individual units configured in 112 systems. About half of the systems were participating systems. This study recommended adjusting the cooling efficiency value by 2% and the heating efficiency by 6% regardless of the heat pump type except for packaged terminal heat pumps. This would increase a SEER of 14.0, for example, to 14.3. While this may seem small, the impact on savings is disproportionate.

Recommendation: Considering the collected information and the discussions above, the evaluator recommends a modest adjustment to the baseline cooling and heating efficiency for new construction heat pumps in the New Hampshire program. The New Hampshire finding supports the conclusion that standard practice is above code, but not robust enough to compute a quantitatively rigorous adjustment. The evaluator proposes to half the adjustment recommended in Massachusetts to 1% for cooling efficiency and 3% for heating efficiency. While halving the Massachusetts value is arbitrary, it reflects the higher reported efficiencies noted by respondents, but is a modest adjustment.

Ideally, these factors would be expressed using IECC 2018 efficiencies because New Hampshire has adopted IECC 2018. However, IECC 2018 revises some but not all the efficiencies, and not in a uniform manner. Applying an average adjustment would impose a change to all efficiencies, even those that remained constant between 2015 and 2018, and would not accurately produce the efficiencies determined through the MA NRNC study, which are derived by accounting for the distribution of equipment by size and configuration in the population.

To avoid any possible confusion, Appendix E.4 provides efficiency references by space type for interior and exterior spaces with the correct adjustment applied.

Replace-on-failure equipment was not researched.

3.1.10 New Construction – Air Conditioners

These findings apply to new construction or major renovation. Replace-on-failure was not researched. Table 19 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 19: TRM Baseline Values for C&I Air Conditioners

Source	Baseline Efficiency / Analysis
NH	IECC 2015.
MA	ISP, IECC 2015
CT	IECC 2021 If a project permit is issued before 2021 IECC code is adopted by the State, the previous code (2015 IECC) should be referenced.
NY	ECCCNYS 2020
ME	IECC 2015

The evaluator conducted interviews with five respondents and obtained data on 188 air conditioners (AC) with sizes ranging from less than five tons to 20 tons. Overall, the reported cooling efficiency for units less than five tons is 13 SEER or above, and for units more than five tons, it is 11 EER or above. These findings align with the current baseline cooling efficiency specified in the measure. Respondents indicated that the main reason for ACs being less efficient than heat pumps is customer cost concerns, as customers who choose AC systems instead of HPs often prioritize affordability over higher efficiency.

The evaluator also gathered additional feedback from the interviewees. One contractor mentioned that the ACs they install in Massachusetts and Vermont may have higher cooling efficiency compared to New Hampshire. Furthermore, respondents highlighted that the return on investment (ROI) for high-efficiency ACs can be negative if there are not sufficient program incentives available.

Recommendation: Based on the collected information and feedback, the evaluator recommends maintaining the current baseline efficiency for new construction measures in the New Hampshire program. The existing baseline efficiency already reflects the market reality, where customers prioritize cost considerations when selecting AC systems.

3.1.11 New Construction – Chiller

These findings apply to new construction or major renovation. Replace-on-failure was not researched. Table 20 lists the comparison between current baseline and savings factor in NH TRM and other nearby states.

Table 20: TRM Baseline Values for Chiller

Source	Baseline Efficiency / Analysis
NH	IECC 2015.
MA	ISP, 1% better than IECC 2015
CT	IECC 2021 If a project permit is issued before 2021 IECC code is adopted by the State, the previous code (2015 IECC) should be referenced.
NY	ECCCNYS 2020
ME	IECC 2015

The evaluator gathered data on 35 non-program participating chillers from four respondents. 80% of the equipment are air-cooled chillers, while 10% are water-cooled screw chillers and another 10% are water-cooled centrifugal chillers. However, the respondents were unable to provide specific information regarding the size or the full load and part load efficiencies of the installed chillers.

Recommendation: Based on the information provided, there are no findings related to New Hampshire chillers performing better than code. Consequently, the evaluator recommends maintaining the current code compliance efficiency as the baseline for new construction chillers in the program.

Table 21: Commercial & Industrial Measures Not Requiring Baseline Updates

Measure	Event Type	Baseline
Air Conditioners	Lost Opportunity and Retrofit	Compliance with the efficiency requirements as mandated by Massachusetts State Building Code[21].
Condensing Unit Heaters	Lost Opportunity	A non-condensing standard efficiency gas fired unit heater with minimum efficiency of 80%.
Variable Frequency Drives	Retrofit	A constant or 2-speed motor.

3.2 Recommendation Summary for Commercial and Industrial Measures

This section addresses the revisions recommended for the TRM followed by recommendations for future research. Recognizing that the Utilities perform an annual review of measure baselines as a regular part of their TRM update process, they should incorporate these recommendations in addition to others that they might identify.

[21] https://www.masssavedata.com/Public/TechnicalReferenceLibrary

3.2.1 Measures Requiring No Updates

During the literature review, the evaluator identified that the baselines for several measures in the NH TRM are consistent with the TRMs of other states and therefore likely reflect the efficiency levels in the current local market. Therefore, there is no need to update the baseline for those measures. These measures are reflected in Table 21.

3.2.2 Recommendations for TRM Revisions

Fifteen commercial and industrial (C&I) measures were prioritized for detailed review as part of this evaluation, yielding recommendations for either maintaining or revising existing TRM baselines. Table 22 summarizes the recommendations identified in Section 3.

The current baseline and study findings for each prioritized measure are shown below.

The study team additionally recommends that New Hampshire revise the nomenclature used to refer to baseline types (referred to as "Program Type") in the next version of the New Hampshire TRM. Some of the terms currently used (e.g., "lost opportunity" and "retrofit") are imprecise and can lead to confusion.

Table 22: Commercial & Industrial Measure Research Summary

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
Commercial Measures							
New construction and replace-on-failure	Compressed Air – Air Compressor with Variable Capacity Control	Installation of oil flooded, rotary screw compressors with variable speed drive or variable displacement capacity control with properly sized air receiver	A typical load/unload compressor.	Deemed savings based on Impact Evaluation of Prescriptive Chiller and Compressed Air Installations in MA.	Literature review	Align with the methodology outlined in NY TRM, to include units larger than 75 hp with 0.216 kW/hp savings.	None
All market event types when site-specific pressure is unknown	Compressed Air – Air Nozzle	Installation of engineered air nozzles which provide effective air nozzle action while reducing compressed air system air flow.	A standard nozzle on a compressed air system, with the baseline airflow assumed to be the flow rate at 100 psi when the site-specific operation setting is unknown.	NH TRM, standard practice.	Literature review	Update the default air pressure at the nozzle in NH from 100 psi to 80 psi.	None
New construction	VRF Systems	High-efficiency variable refrigerant flow (VRF) heat pumps	ASHRAE 90.1 2013 version code-compliant VRF systems. TABLE 6.8.1-9 and TABLE 6.8.1-10.	ASHRAE 90.1 2013	Literature review	Update the baseline efficiency based on IECC 2018 standard.	Conduct future research including IDIs with different stakeholders to confirm New Hampshire specific values
New construction and replace-on-failure	Condensing Unit Heaters	Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.	The baseline efficiency case is a standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting	IECC 2012	Literature review	IECC 2018. The minimum efficiency remains the same (80%).	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
			or an automatic flue damper.				
Retrofit	Variable Frequency Drives	Installation of variable speed drives.	The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats. If the project includes a motor replacement, air or water volume/temperature is controlled using valves, dampers, and/or reheats.	Deemed savings based on: Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR, and Variable Speed Drive Loadshape Project, Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum.	Literature review	No change.	None
Replace-on failure	Replace-on-failure Boilers	High efficiency natural gas fired condensing hot water boiler.	Baseline efficiency is an 85% AFUE boiler.	Deemed savings based on Gas Boiler Market Characterization Study Phase II, 2017.	Literature review, in-depth interviews	IECC 2018, table C403.2.3(5) Minimum Efficiency Requirements: Gas and Oil Fired Boilers	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
New construction	New Construction Boilers	High efficiency natural gas fired condensing hot water boiler.	Baseline efficiency is an 85% AFUE boiler.	Deemed savings based on Gas Boiler Market Characterization Study Phase II, 2017.	Literature review, in-depth interviews	For gas fired hot water boilers, the baseline efficiency is 15% better than IECC 2015, table C403.2.3(5).For steam and oil fired boiler, baseline is IECC 2018, table C403.2.3(5).	None
New construction and replace-om-failure	Gas Instantaneous (On-Demand) Water Heater	Tankless water heaters circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.	A code-compliant gas-fired storage water heater with EF = 0.61.	Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates.	Literature review, in-depth interviews	The efficiency from IECC 2018, table C404.2 Minimum Performance of Water-Heating Equipment: Instantaneous water heaters, gas.	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
New construction	New Construction Lighting	The implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage.	Compliance with lighting power density requirements as mandated by New Hampshire State Building Code. These standards specify the maximum lighting power densities (LPDs) by building type (building area method) and interior space type (space-by-space method). LPDs apply to all new construction and major renovation projects.	IECC 2015 Table C405.4.2(2) Interior Lighting Power Allowances: Space-By-Space Method, and Table C405.5.1(2) Individual Lighting Power Allowances for Building Exteriors.	Literature review, in-depth interviews	Apply a 0.60 LPD factor to derate the code IECC 2015 LPD for interior lighting and a 0.67 factor for exterior lighting.	None
New construction	Lighting Controls	Installation of lighting controls in new construction or major renovation applications.	Code-compliant controls as mandated by the New Hampshire Building Code.	IECC 2015 Section C405.2 Lighting controls (Mandatory)	Literature review, in-depth interviews	IECC 2018.	None
New construction and replace-on-failure	Furnace	High efficiency natural gas warm air furnace with an electronically commutated motor (ECM) for the fan.	The baseline efficiency in an 85% AFUE furnace.	Deemed savings, based on the efficiency of proposed furnace. Recalculation of Prescriptive Program Gas Furnace Savings Using New Baseline, Prepared for National Grid, Massachusetts.	Literature review, in-depth interviews	No change.	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
New construction	Heat Pump	Installation of ductless mini-split, ground source and water source heat pumps to serve the space heating and space cooling loads in a C&I facility.	Code compliant heat pump unit of the same type as the high efficiency unit.	IECC 2015 Table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps	Literature review, in-depth interviews	The baseline heat pump efficiency is 1% better for cooling and 3% better for heating, comparing to IECC 2015 Table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps	None
New Construction	Air Conditioners	Installation of high efficiency unitary air conditioning equipment. This measure applies to air, water, and evaporatively cooled unitary AC systems, both single-package and split systems.	Compliance with the efficiency requirements as mandated by New Hampshire State Building Code.	IECC 2015 Table C403.2.3(1) Minimum Efficiency Requirements: Electrically Operated Unitary Air Conditioners and Condensing Units.	Literature review, in-depth interviews	No change.	None

Market Event	Measure	Description	Current Baseline	Current Baseline Source	Research Methods Used	Proposed Changes to Baseline	Recs for Further Research
New Construction	Chiller	Installation of efficient water-cooled and air-cooled water chilling packages for comfort cooling applications. Eligible chillers include air-cooled, water-cooled rotary screw and scroll, and water-cooled centrifugal chillers for single chiller systems or for the lead chiller only in multi-chiller systems.	Compliance with the efficiency requirements as mandated by Massachusetts State Building Code.	IECC 2015 Table C403.2.3(7) Water Chilling Packages - Efficiency Requirements.	Literature review, in-depth interviews	No change.	None

Appendix A Literature Review Sources

1. AHRI. Monthly Shipments (2023) https://www.ahrinet.org/analytics/statistics/monthly-shipments
2. Connecticut Program Savings Document (2022). https://energizect.com/sites/default/files/documents/Final%202022%20PSD%20FILED%20110122.pdf
3. Durham, NH, Local Ordinances. https://www.nh.gov/safety/boardsandcommissions/bldgcode/documents/DurhamLocalOrdinances.pdf
4. Efficiency Vermont Technical Reference User Manual (2018). https://puc.vermont.gov/sites/psbnew/files/doc_library/Vermont%20TRM%20Savings%20Verification%202018%20Version_FINAL.pdf
5. New Home Construction Program Annual Evaluation Report. Residential New Construction Baseline/Compliance Study (MA19X02-B-RNCBL). https://ma-eeac.org/wp-content/uploads/MA19X02-B-RNCBL_ResBaselineOverallReport_Final_2020.04.01_v2.pdf
6. Maine New Construction Baseline Assessment (2021). https://www.efficiencymaine.com/docs/Maine-New-Construction-Baseline-Assessment-08262021.pdf
7. Maryland/Mid-Atlantic Technical Reference Manual Version 10. https://neep.org/sites/default/files/media-files/trmv10.pdf
8. Mass Save. “Mini-Splits, Big Rewards: Get More from Efficient Heating Technology” (2017) https://www.masssave.com/blog/residential/mini-splits-big-rewards-get-more-from-efficient-heating-technology#:~:text=These%20systems%20are%20gaining%20popularity,expense%20of%20oil%20or%20propane.
9. Massachusetts PAs. eTRM. https://etrm.anbetrack.com/#/workarea/home?token=6d6c45766e692f527044
10. New Hampshire ENERGY STAR Homes Program Impact Evaluation (2014-2015). https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf
11. NEAA (2019-2020). Washington Residential New Construction Code Study. https://neea.org/resources/2019-2020-washington-residential-new-construction-code-study
12. NYSERDA (2019). Single Family Building Assessment. https://www.nyserda.ny.gov/-/media/Project/Nyserda/files/Publications/building-stock-potential-studies/2019-residential-building-stock-assessment-report.pdf
13. NYSERDA. Residential Statewide Baseline Study Volume 1: Single-Family Report. https://www.nyserda.ny.gov/-/media/Project/Nyserda/files/Publications/building-stock-potential-studies/residential-baseline-study/Vol-1-Single-Family-Res-Baseline.pdf
14. NYSERDA. Residential Statewide Baseline Study Volume 5: Methodology and Data Tables. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/building-stock-potential-studies/residential-baseline-study/Vol-5-Methodology-Res-Baseline.pdf

15. Efficiency Maine Technical Reference Manual Version (2022) https://www.efficiencymaine.com/about/library/policies/
16. Pennsylvania Technical Reference Manual. https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/
17. Residential Provisions of the 2015 International Energy Conservation Code. https://codes.iccsafe.org/content/IECC2015/iecc-residential-provisions
18. Vermont Residential Building Energy Code (2011). https://publicservice.vermont.gov/efficiency/building-energy-standards/residential-building-energy-standards

Appendix B In-Depth Interview Guides

B.1 New Hampshire Baseline Practices—Residential Interview Guide

Guide Section	Research Objectives
New Construction Module	Rates of code compliance for measures making up UDRH
	Input on ISP for key measures making up the UDRH
	Geographic trends in compliance and ISP
	ISP comparisons with neighboring states
Water Heater Module	Rates of code compliance for tankless water heaters and HPWHs
	Input on ISP for tankless water heaters and HPWHs
	Geographic trends in compliance and ISP
	ISP comparisons with neighboring states
Gas and Propane Furnaces and Boilers Module	Rates of code compliance for tankless water heaters and HPWHs
	Input on ISP for tankless water heaters and HPWHs
	Geographic trends in compliance and ISP
	ISP comparisons with neighboring states
Ductless Mini-Split Heat Pump Module	General feedback on prevalence, install scenarios
	Identify data gaps for future research
Windows Module	Input on ISP for window replacements
	Geographic trends in ISP
	ISP comparisons with neighboring states

B.1.1 Introduction Module

Greetings. The New Hampshire Utilities, sponsors of NHSaves energy-efficiency programs, have partnered with NMR Group to better understand the equipment and building practices used in both new and existing New Hampshire homes. Your feedback in the areas of your expertise will help ensure that efficiency programs in New Hampshire can effectively support professionals like you moving forward.

This interview may take 30 to 40 minutes to complete. In appreciation of your time, NMR will send a digital $100 Amazon gift card to the email address you provide at the end of the survey or, if you prefer, mail you a gift card. You do not have to accept this incentive. Your responses will be kept confidential and combined anonymously with those of other respondents when reporting the findings of this research to the New Hampshire Utilities.

[Confirm this is a good time for the respondent or reschedule]

1. [Review respondent type and eligible modules recorded during recruitment] I'd like to begin by confirming what we spoke about during recruitment for the study. Is it correct that in the last year you have:
    a) [RNC Builder] Built new homes in New Hampshire *that to your knowledge did not participate in the NHSaves ENERGY STAR Homes Program*?
    b) [HERS Rater] Performed HERS Ratings of new homes in New Hampshire *that to your knowledge did not participate in the NHSaves ENERGY STAR Homes Program*?
    c) [Code Official] Inspected a new home, or reviewing documents such as the plans submitted for a new home *that to your knowledge did not participate in the NHSaves ENERGY STAR Homes Program?*
    d) [HVAC and Water Heating Installer, General Contractor, or Builder] Installed an instantaneous water heater or a heat pump water heater in an existing home *that to your knowledge did not receive a rebate through NHSaves* or working on a home where these measures were installed.
    e) [HVAC and Water Heating Installer, General Contractor, or Builder] Installed a furnace or boiler in an existing home *that to your knowledge did not receive a rebate through NHSaves* or worked on a home where these measures were installed.
    f) [HVAC and Water Heating Installer, General Contractor, or Builder] Installed a ductless mini-split heat pump in an existing home *that to your knowledge did not receive a rebate through NHSaves* or worked on a home where a ductless MSHP was installed
    g) [Builder or General Contractor] Installed new windows in an existing home *that to your knowledge did not receive a rebate through NHSaves* or worked on a home where new windows were installed
    h) [HERS RATERS ONLY] [IF answered "no" to Question 1b] Do you believe you can provide feedback on the typical measures and building practices in new homes that do not participate in the NHSaves ENERGY STAR Homes Program?

-

- [BUILDERS AND CONTRACTORS NEED TO HAVE INSTALLED AT LEAST ONE ITEM; HERS RATERS AND CODE OFFICIALS NEED TO HAVE WORKED ON OR INSPECTED/REVIEWED DOCUMENTS FOR AT LEAST ONE HOME TO QUALIFY; HERS RATERS ALSO QUALIFY IF THEY SAY THEY CAN PROVIDE FEEDBACK ON NON-PROGRAM HOMES]

  [IF ELIGIBLE, MOVE TO THE APPROPRIATE MODULE TO BEGIN]

  [IF THEIR REPSONSE IS INCONSISTENT WITH RECRUITMENT, BUT THEY ARE STILL ELIGIBLE FOR ANOTHER MODULE(S), PROCEED WITH OTHER MODULE(S)]

  [IF NOT ELIGIBLE FOR ANY MODULE] I am sorry; you do not qualify for this interview. Thank you for your time. [END]

B.1.2 New Construction Module

- First, I'd like to ask you some general questions about your work:

1. In a typical year, how many single-family new homes do you [builder: build/ Rater: perform energy audits on/ code official: perform building inspections or plan reviews of]?
    a. To your knowledge, do you work on homes that participate in the NHSaves ENERGY STAR Homes Program?
    b. [If Yes:] Roughly what percentage of your work is homes that participate in this program?
2. Do you also work in multifamily new construction—that is, buildings with more than one dwelling unit that aren't attached townhomes?
3. Can you tell me a bit more about what parts of the state you work in?

[NOTE FOR INTERVIEWER: We are defining southern New Hampshire to consist of the counties of Cheshire, Hillsborough, Rockingham and Strafford; this includes Portsmouth, Manchester, Keene, and Dover. Northern New Hampshire consists of Belknap, Coos, Grafton, Merrimack, Sullivan, and Carroll counties; this includes Concord. Identify if the respondent works in both southern and northern parts of the state, note where separate responses are required for both areas.]

    a. [SKIP FOR CODE OFFICIALS] Do you work in any neighboring states? If so, which additional states do you work in?

- For the remainder of this interview, please consider only newly built single-family homes in New Hampshire *that to your knowledge have not participated in the NHSaves ENERGY STAR Homes Program [If needed: newly constructed homes would be built under the current NH energy code]*. We would like to get your perspective on the building practices and measures installed in the residential new construction market.
- I would like to ask you about insulation in these homes.
- I'm going to ask you about key components of the building shell covered by the energy code, and I'd like to know how non-program homes perform relative to those requirements.
- [TABLE FOR INTERVIEWERS TO RECORD RESPONSES TO QUESTIONS BELOW)

Component	Requirement	% Meeting	% Exceeding	% Below
Above Grade (stud) walls	R-20 cavity (CZ5) or R-20 cavity+R-5 Cont. (CZ6)			
Framed floors	R-30			
Flat ceilings	R-49			
Cathedral/vaulted ceilings	R-30			
Conditioned basement or crawl walls	R-19 cavity or R-15 continuous			
Slab insulation	R-10 2' depth (CZ5) 4' depth (CZ6)			

-

4. [IF WORK IN SOUTHERN NEW HAMPSHIRE] How often would you estimate that above grade wall insulation in new homes meets the code requirement of R-20 for cavity insulation in the southern New Hampshire? [PROBE for proportion of market meeting, exceeding, and failing to meet]
    a) How often do new homes exceed this requirement?
    b) How often do new homes fail to meet this requirement?
    c) [IF THEY SEE WALL R-VALUES THAT EXCEED CODE] By how much does above grade wall insulation typically exceed the code requirements [PROBE for an R-value or percentage]?
    d) [IF THEY SEE WALL R-VALUES THAT DON'T MEET CODE] By how much does above grade wall insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?
5. [IF WORK IN NORTHERN NEW HAMPSHIRE] How often would you estimate that above grade wall insulation in new homes meets the code requirement of R-20 cavity plus R-5 continuous insulation in the northern part of the state?
    a) How often do new homes exceed this requirement?
    b) How often do new homes fail to meet this requirement?
    c) [IF THEY SEE WALL R-VALUES THAT EXCEED CODE] By how much does above grade wall insulation typically exceed the code requirements [PROBE for an R-value or percentage]?
    d) [IF THEY SEE WALL R-VALUES THAT DON'T MEET CODE] By how much does above grade wall insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?
6. How often would you estimate that framed floor insulation meets the code requirement of R-30? [PROBE for proportion of market meeting, exceeding, and failing to meet]
    a) How often do new homes exceed this requirement?
    b) How often do new homes fail to meet this requirement?
    c) [IF THEY SEE R-VALUES THAT EXCEED CODE] By how much does floor insulation typically exceed the code requirements [PROBE for an R-value or percentage]?
    d) [IF THEY SEE R-VALUES THAT DON'T MEET CODE] By how much does frame floor insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?
7. How often would you estimate that the insulation of flat ceilings meets the code requirement of R-49? [PROBE for proportion of market meeting, exceeding, and failing to meet]

a) How often do new homes exceed this requirement?

b) How often do new homes fail to meet this requirement?

c) [IF THEY SEE R-VALUES THAT EXCEED CODE] By how much does flat ceiling insulation typically exceed the code requirements [PROBE for an R-value or percentage]?

d) [IF THEY SEE R-VALUES THAT DON'T MEET CODE] By how much does flat ceiling insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?

8. How often would you estimate that the insulation of sloped or cathedral ceilings meets the code requirement of at least R-30? [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement?

    b) How often do new homes fail to meet this requirement?

    c) [IF THEY SEE R-VALUES THAT EXCEED CODE] By how much does cathedral ceiling insulation typically exceed the code requirements [PROBE for an R-value or percentage]?

    d) [IF THEY SEE R-VALUES THAT DON'T MEET CODE] By how much does cathedral ceiling insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?

9. How often would you estimate that basement or crawl space insulation meets the code requirement of R-19 for cavity insulation or R-15 for continuous insulation? [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement?

    b) How often do new homes fail to meet this requirement?

    c) [IF THEY SEE R-VALUES THAT EXCEED CODE] By how much does basement or crawl space insulation typically exceed the code requirements [PROBE for an R-value or percentage]?

    d) [IF THEY SEE R-VALUES THAT DON'T MEET CODE] By how much does basement or crawl space insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?

10. How often would you estimate that slab insulation meets the code requirement of R-10? [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement?

    b) How often do new homes fail to meet this requirement?

c) [IF THEY SEE R-VALUES THAT EXCEED CODE] By how much does slab insulation typically exceed the code requirements [PROBE for an R-value or percentage]?

d) [IF THEY SEE R-VALUES THAT DON'T MEET CODE] By how much does slab insulation typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?

- Now I would like to ask you about air and duct sealing

11. What portion of homes in the non-program market would you estimate receive blower door tests? [IF LESS THAN ALL, PROBE why are new homes not receiving blower door tests and how much that portion has been impacted by COVID precautions?]

12. [If any portion of homes received blower door testing] What portion of homes in the non-program market pass the blower door test with less than or equal to 3 ACH @ 50 Pascals? [If not all] Please explain why the homes did not pass and how the situation may be remedied. [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement (i.e., have air leakage less than 3 ACH50)?

    b) How often do new homes fail to meet this requirement (i.e., have air leakage higher than 3 ACH50)?

    c) [IF THEY SEE INFILTRATION VALUES THAT EXCEED CODE] By how much do ACH50 values typically exceed the code requirements [PROBE for an R-value or percentage]?

    d) [IF THEY SEE INFILTRATION VALUES THAT DON'T MEET CODE] By how much do ACH50 values typically fall below the code requirements [PROBE for an R-value or percentage]? Why do you think this is [Probe for code enforcement issues]?

13. What portion of homes in the non-program market that had ducts would you estimate received duct leakage tests? [IF LESS THAN ALL, PROBE why are new homes not receiving duct leakage tests?]

    a) What portion of all new homes in the non-program market would you estimate have a forced hot air HVAC system?

14. [If any portion of homes received duct leakage testing] What portion of homes in the non-program market would you estimate meet the total duct leakage requirement with less than or equal to 4 CFM25/100 ft^2 of conditioned floor area? [If not all] Please explain why the homes did not pass and how the situation may be remedied. [PROBE for portions meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement (i.e., have duct leakage less than 4 CFM25/100 ft^2)?

    b) How often do new homes fail to meet this requirement (i.e., have duct leakage higher than 4 CFM25/100 ft^2)?

c) [IF THEY SEE LEAKAGE VALUES BETTER THAN CODE] By how much does total duct leakage typically outperform the code requirements [PROBE for a value or percentage]?

d) [IF THEY SEE LEAKAGE VALUES THAT DON'T MEET CODE] By how much does total duct leakage typically fail to meet code requirements [PROBE for a value or percentage]? Why do you think this is [Probe for code enforcement issues]?

15. What portion of new homes in the non-program market have ducts, have ducts insulated to at least R-8 for ducts in attics and at least R-6 for in other locations? [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement?

    b) How often do new homes fail to meet this requirement?

    c) [IF THEY SEE VALUES BETTER THAN CODE] By how much does duct insulation R-value typically exceed code requirements [PROBE for a value or percentage]?

    d) [IF THEY SEE VALUES THAT DON'T MEET CODE] By how much does duct insulation typically fail to meet code requirements [PROBE for a value or percentage]? Why do you think this is [Probe for code enforcement issues]?

- Now I would like to ask you about windows

16. What portion of new homes in the non-program market have windows that meet the U-factor limit of 0.32? [PROBE for proportion of market meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement; that is, have lower U values for more efficient windows?

    b) How often do new homes fail to meet this requirement?

    c) [IF THEY SEE VALUES BETTER THAN CODE] By how much does window u-factor typically exceed code requirements [PROBE for a value or percentage]?

    d) [IF THEY SEE VALUES THAT DON'T MEET CODE] By how much does window u-factor typically fail to meet code requirements [PROBE for a value or percentage]? Why do you think this is [Probe for code enforcement issues]?

- Now I would like to ask you about lighting

17. What portion of new homes you've observed in the non-program market meet code requirements of having at least 75 percent of the lamps in permanent fixtures be high-efficacy or not less than 75 percent of lighting fixtures containing only high-efficacy lamps? [PROBE for portions meeting, exceeding, and failing to meet]

    a) How often do new homes exceed this requirement?

    b) How often do new homes fail to meet this requirement?

c) [IF THEY SEE VALUES BETTER THAN CODE] By how much does the proportion of efficient lamps typically exceed code requirements [PROBE for a value or percentage]?

d) [IF THEY SEE VALUES THAT DON'T MEET CODE] By how much does the proportion of efficient lamps typically fail to meet code requirements [PROBE for a value or percentage]? Why do you think this is [Probe for code enforcement issues]?

- Now I would like to ask you about HVAC and water heating systems in newly constructed homes

18. What portion of new homes in the non-program home market have gas or propane furnaces? And what portion of these furnaces are condensing units?

    a) What would you say is the typical efficiency of those condensing units?

    b) For non-condensing units, what is the typical efficiency?

19. What portion of new homes in the non-program market have gas or propane boilers? And what portion of these boilers are condensing units?

    a. What would you say is the typical efficiency of those condensing units?

    b. For non-condensing units, what is the typical efficiency?

20. What are the most common types of water heating equipment installed in new, non-program homes?

    c. [FOR EACH TYPE MENTIONED] How efficient are these systems [Probe for a UEF]?

    d. [FOR EACH TYPE MENTIONED] How common are ENERGY STAR-rated units?

21. What portion of new homes in the non-program market have the following water heater types? [READ FROM TABLE BELOW] And what are the typical uniform energy factors associated with them?

Water Heater Type	Proportion of Units	Typical UEF
Stand-alone electric		
Stand-alone gas, non-condensing		
Stand-alone gas, condensing		
HPWH		
Gas tankless, non-condensing		
Gas tankless, condensing		
Indirect		N/A – based on boiler efficiency

-
- Now I would like to ask some more general questions about the energy efficiency of measures in new, non-program homes.
    22. [If indicated they work on MF in Module Question 2] Do compliance rates or equipment efficiency vary between single and multifamily homes? If so, for which measures does it vary and how?
    23. [If indicated they work in more than one area of the state in Module Question 3] In your experience, does the efficiency of homes vary for different parts of the state? If so, which measures drive this variation?
    24. [If indicated they work outside the state in Module Question 3a] How does the overall efficiency of new homes in New Hampshire compare to the overall efficiency of new homes in other states? [PROBE for which states and whether more or less efficient].
        e. What would you say are the key differences between the states?
    25. What, if any, impact do you believe the NHSaves ENERGY STAR Homes Program has had on achieving energy efficiency in the wider residential new construction market? [PROBE for areas that are most affected]
        a. [If not addressed above and if they work on Program homes] How would you say the efficiency of homes participating in the NHSaves program compares with those that do not participate? For which measures or diagnostic tests do you observe differences?
    26. How much of a barrier is the incrementally higher cost of building a more energy efficient home for builders and homeowners? [PROBE if they have customers or know of builders who wanted to incorporate more energy efficient measures in general but could not afford it]?

[WHEN FINISHED WITH NEW CONSTRUCTION MODULE, GO TO CLOSING MODULE]

B.1.3 Water Heater Module

We'd like to know more about [IF APPLICABLE] gas instantaneous water heaters [IF APPLICABLE] and heat pump water heaters installed in existing homes in New Hampshire. As a reminder, existing homes have not been constructed in the last several years and the systems we are talking about have been installed in homes that have previously been occupied.

1. How many existing homes do you work in during a typical year in New Hampshire where new water heaters are installed?
    a. [IF APPLICABLE] What proportion of these homes recently had instantaneous gas water heaters installed?
    b. [IF APPLICABLE] What proportion of these homes recently had hybrid or heat pump water heaters installed?
    c. To your knowledge, do any of the [IF APPLICABLE] gas instantaneous water heaters [IF APPLICABLE] and heat pump water heaters installed in existing homes receive rebates from NHSaves?
2. Do you also work in existing multifamily buildings—that is, buildings with more than one dwelling unit that aren't single-family attached townhomes?
3. Can you tell me a bit more about what parts of the state you work in?

[NOTE FOR INTERVIEWER: We are defining southern New Hampshire to consist of the counties of Cheshire, Hillsborough, Rockingham and Strafford; this includes Portsmouth, Manchester, Keene, and Dover. Northern New Hampshire consists of Belknap, Coos, Grafton, Merrimack, Sullivan, and Carroll counties; this includes Concord. Identify if the respondent works in both southern and northern parts of the state, note where separate responses are required for both areas.

    a. Do you work in any neighboring states? If so, which additional states do you work in?

4. For the next few questions, I would like you to give me rough estimates of the portion of gas or propane instantaneous and/or heat pump water heater installations that fall into the following categories: [AT THE END, ASK RESPONDENT TO ADJUST IF PERCENTAGES DO NOT ADD UP TO 100%]
    a) What portion of these installations were part of new construction?
    b) What portion were part of an addition that required adding a new water heating system?
    c) What portion replaced water heating systems that had failed in existing homes?
    d) What portion replaced water heating systems that were close to the end of their useful life?
    e) What portion replaced water heating systems that were not close to failure?

Installation Category	Gas or Propane Instantaneous Water Heaters	Heat Pump Water Heaters
New construction		
Addition		
Replaced a failed system		
Replaced a functioning system close to failure		
Replaced a functioning system not close to failure		
TOTAL (check to add to 100%)		

-

B.1.4 Gas or Propane Instantaneous Water Heater Module

[IF RESPONDENT HAS DEALT WITH GAS OR PROPANE INSTANTANEOUS WATER HEATERS IN EXISTING HOMES, CONTNUE HERE. IF NOT, SKIP TO HEAT PUMP WATER HEATER SECTION]

5. We are estimating the Uniform Energy Factor (UEF) ratings of gas or propane instantaneous water heaters recently sold and installed in existing homes in New Hampshire that *do not receive a rebate through NHSaves*. Please give me your estimates for the following:
    a) What portion of these units have UEFs of 0.87 or above?
    b) What is the most common UEF of the units installed?
6. [IF RESPONDENT HAS WORKED IN MORE THAN ONE TYPE OF HOME] Does the installation of gas or propane instantaneous water heaters vary by type of home—that is, among single family detached, single family attached, and multifamily homes? If so, how does it vary?
7. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation of gas or propane instantaneous water heaters vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is? [PROBE for the installation rates given the number of homes]
8. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the sale and installation of gas or propane instantaneous water heaters in New Hampshire compare with [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for the installation rates and efficiencies.]
9. How much of an issue is the cost of gas or propane instantaneous water heaters for homeowners in New Hampshire? [PROBE if they have customers who wanted to install gas or propane instantaneous water heaters or become more energy efficient in general but could not afford it]

B.1.5 Heat Pump Water Heater Module

[CONTNUE HERE IF RESPONENT HAS DEALT WITH HEAT PUMP WATER HEATERS IN EXISITNG HOMES. IF NOT, MOVE TO NEXT MODULE OR TO INTERVIEW CONCLUSION]

10. What portion of all the heat pump water heaters recently installed in existing homes fall into the following categories in the New Hampshire market? [AT THE END, ASK RESPONDENT TO ADJUST IF PERCENTAGES DO NOT ADD UP TO 100%]
    a) Replacement of a fossil-fuel *water heating* system in an existing home
    b) Replacement of a conventional electric tank water heating system in an existing home
11. [IF DEALT WITH HEAT PUMP WATER HEATERS THAT WERE PART OF A FOSSIL-FUEL WATER HEATING SYSTEM REPLACEMENT] What is the most common type of fossil-fuel water heating system replaced by heat pump water heaters in New Hampshire? [PROBE FOR GAS/PROPANE/OIL AND CONVENTIONAL OR TANKLESS] And what would be the second most common type?
12. [IF RESPONDENT WORKS IN SINGLE AND MULTIFAMILY MARKETS AND HAS DEALT WITH HEAT PUMP WATER HEATERS] Does the installation of heat pump water heaters vary by type of home—that is, among single family detached, single family attached, and multifamily homes? If so, how does it vary?
13. [IF WORKS IN BOTH PARTS OF THE STATE AND HAS DEALT WITH HEAT PUMP WATER HEATERS] Does the installation of heat pump water heaters vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is? [PROBE for the installation rates given the number of homes]
14. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND HAS DEALT WITH HEAT PUMP WATER HEATERS] How does the sale and installation of heat pump water heaters in New Hampshire compare with [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for the installation rates and efficiencies.]
15. [IF HAS DEALT WITH HEAT PUMP WATER HEATERS] How much of an issue is the cost of heat pump water heaters for homeowners in New Hampshire? [PROBE if they have customers who wanted to install heat pump water heaters or become more energy efficient in general but could not afford it]

B.1.6 Gas and Propane Furnaces and Boilers Module

We'd like to know more about [IF APPLICABLE] gas or propane furnaces [IF APPLICABLE] and gas or propane boilers recently sold and installed in existing homes in New Hampshire. As a reminder, existing homes have not been constructed in the last several years and the systems we are talking about have been installed in homes that have previously been occupied.

1. How many existing homes do you work in during a typical year in New Hampshire where new HVC systems are installed?
    a. [IF APPLICABLE] What proportion of these homes recently had gas or propane furnaces installed?
    b. [IF APPLICABLE] What proportion of these homes recently had gas or propane boilers installed?

c. To your knowledge, do any of the [IF APPLICABLE] gas or propane furnaces [IF APPLICABLE] and boilers installed in existing homes receive rebates from NHSaves?

2. Do you also work in existing multifamily buildings—that is, buildings with more than one dwelling unit that aren't single-family attached townhomes?
3. Can you tell me a bit more about what parts of the state you work in?

[NOTE FOR INTERVIEWER: We are defining southern New Hampshire to consist of the counties of Cheshire, Hillsborough, Rockingham and Strafford; this includes Portsmouth, Manchester, Keene, and Dover. Northern New Hampshire consists of Belknap, Coos, Grafton, Merrimack, Sullivan, and Carroll counties; this includes Concord. Identify if the respondent works in both southern and northern parts of the state, note where separate responses are required for both areas.

a. Do you work in any neighboring states? If so, which additional states do you work in?

We would now like to discuss your experiences with newly sold and installed gas HVAC systems in New Hampshire homes.

1. For the next few questions, I would like you to give me rough estimates of the portion of newly installed furnaces/boilers that fall into the following categories: [READ FOR FURNACES AND BOILERS, AS APPLICABLE; AT THE END, ASK RESPONDENT TO ADUST IF PERCENTAGES DO NOT ADD UP TO 100%]

a) What portion of these installations were part of new construction?

b) What portion were part of an addition that required adding a new heating system?

c) What portion replaced furnaces/boilers that had failed in existing homes?

d) What portion replaced furnaces/boilers that were close to the end of their useful life?

e) What portion replaced furnaces/boilers that were not close to failure?

•

	Gas or Propane Furnace	Gas or Propane Boiler
New construction		
Addition		
Replaced a failed system		
Replaced a functioning system close to failure		
Replaced a functioning system not close to failure		
Total (check to add to 100%)		

•

B.1.7 Gas or Propane Furnace Module

4. What portion of these gas or propane furnaces were condensing units and how many were non-condensing units? [IF NEEDED, a standard, non-condensing furnace only has one heat exchanger; a condensing furnace has two making it more energy efficient]
    a. How common was it for condensing units to have an OAT sensor installed with them?
5. We are estimating the AFUE ratings of gas or propane furnaces currently sold and installed in New Hampshire; *that do not receive a rebate through NHSaves* [IF DEALS WITH NON-CONDENSING UNITS] could you estimate what portion of the non-condensing units have AFUEs of 85 or above? [IF DEALT WITH CONDENSING UNITS] And can you give me the most common AFUE of the condensing units?
6. [IF RESPONDENT HAS DEALT WITH GAS OR PROPANE FURNACES IN MORE THAN ONE TYPE OF HOME; ADUST WORDING DEPENDING ON HOME TYPES] For furnaces, does the installation of condensing units vary by type of home—that is, among single family detached, single family attached, and multifamily homes? If so, how does it vary?
7. [IF WORKS IN BOTH PARTS OF THE STATE] For furnaces, does the installation of condensing units vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is?
8. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] For furnaces, how does the portion of condensing units sold and installed in New Hampshire compare with the portion in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
9. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND DEALS WITH BOILERS] For boilers, how does the portion of condensing units sold and installed in New Hampshire compare with the portion in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
10. How much of an issue is the cost of condensing units for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it] [IF HAS DEALT WITH BOTH FURNACES AND BOILERS] Does this vary for furnaces and boilers? If yes, how so?

B.1.8 Gas or Propane Boiler Module

11. What portion of these gas or propane boilers were condensing units and how many were non-condensing units? [IF NEEDED, a standard, non-condensing boiler only has one heat exchanger; a condensing boiler has two making it more energy efficient]
    a. How common was it for newly installed condensing units to have an OAT sensor installed with them?
12. We are estimating the AFUE ratings of gas or propane boilers recently sold and installed in New Hampshire *that do not receive a rebate through NHSaves*; [IF DEALS WITH NON-CONDENSING UNITS] could you estimate what portion of the non-condensing units have

AFUEs of 85 or above? [IF DEALS WITH CONDENSING UNITS] And can you give me the most common AFUE of the condensing units?

13. [IF RESPONDENT WORKED IN MORE THAN ONE HOME] For boilers, does the installation of condensing units vary by type of home—that is, among single family detached, single family attached, and multifamily homes? If so, how does it vary?
14. [IF WORKS IN BOTH PARTS OF THE STATE] For boilers, does the installation of condensing units vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is?
15. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] For boilers, how does the portion of condensing units sold and installed in New Hampshire compare with [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]

B.1.9 General for Everyone

- How much of an issue is the cost of new condensing units for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it] [IF HAS DEALT WITH BOTH FURNACES AND BOILERS] Does this vary for furnaces and boilers? If yes, how so?

B.1.10 Ductless Mini-Split Heat Pump Module

We'd like to know more about ductless mini-split heat pumps sold and installed in existing homes in New Hampshire. As a reminder, existing homes have not been constructed in the last several years and the systems we are talking about have been installed in homes that have previously been occupied.

1. How many existing homes have you observed in the last year installing ductless mini-split heat pumps?
    a. To your knowledge, do any of the ductless mini-split heat pumps installed in existing homes receive rebates from NHSaves?
2. [IF NOT ALREADY ADDRESSED] Do you also work in existing multifamily buildings—that is, buildings with more than one dwelling unit that aren't single-family attached townhomes?
3. [IF NOT ALREADY ADDRESSED] Can you tell me a bit more about what parts of the state you work in?

[NOTE FOR INTERVIEWER: We are defining southern New Hampshire to consist of the counties of Cheshire, Hillsborough, Rockingham and Strafford; this includes Portsmouth, Manchester, Keene, and Dover. Northern New Hampshire consists of Belknap, Coos, Grafton, Merrimack, Sullivan, and Carroll counties; this includes Concord. Identify if the respondent works in both southern and northern parts of the state, note where separate responses are required for both areas.

    a. Do you work in any neighboring states? If so, which additional states do you work in?

4. For the next few questions, I would like you to give me rough estimates of the portion of ductless MSHP installations that fall into the following categories: [NOTE THAT PERCENTAGES NEED NOT ADD UP TO 100%]
    a) What percentage of these installations were part of a new construction project?
    b) What percentage were cooling only?
    c) What percentage added cooling to a space that had no prior permanent cooling [e.g., a room AC]?
    d) What percentage replaced a primary heating and cooling system in a home (e.g., a furnace and a central AC)
    e) What percentage replaced a central air conditioner that failed or was near failure?
    f) What percentage replaced a central heating system that failed or was near failure
    g) What percentage was installed in addition to a working central HVAC system?

Installation Category	Total
New construction	
Cooling only	
Replaced an operating central system	
Replaced a failed central AC	
Replaced a failed central heating system	
Added alongside a working central HVAC system	

-

5. What portion of these homes with ductless MSHPs had cold-climate rated heat pumps installed? [IF NEEDED, a cold-climate heat pump has a variable speed compressor, powered by an inverter that works well in regions with big differences between the seasons.]
6. [IF DEALT WITH MSHPs and answered 1d or 1g above] In your experience, what is the most common type of fossil-fuel heating system fully or partially replaced by ductless MSHPs in New Hampshire? ? [PROBE FOR GAS/OIL AND FURNACES/BOILERS] And what would be the second most common type?
7. [IF RESPONDENT HAS WORKED IN MORE THAN ONE TYPE OF HOME; ADUST WORDING DEPENDING ON HOME TYPES] Does the installation of ductless MSHPs vary by type of home—that is, among single family detached, single family attached, and multifamily homes? If so, how does it vary?
    a. How does home size impact mini-split installs? Are you seeing any trends in, for example, single-family homes depending on square footage or layout?
8. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation of ductless MSHPs vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is? [PROBE for the installation rates given the number of homes]

9. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the sale and installation of ductless MSHPs in New Hampshire compare with [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for installation rates.]
10. What proportion of HVAC installers in the State of NH would you say are trained and experienced in the installation of ductless MSHPs? [PROBE for differences by part of state ~~it~~]
    a. Are you aware of instances where customers have been deterred from installing MSHPs because they are unable to find a contractor who can do the work?

B.1.11 Windows Module

[We have already confirmed at the recruitment and the start of the IDI, that the respondent has installed windows in an existing home or worked on an existing home where windows were installed]

We'd like to know more about windows installed in existing homes in New Hampshire. As a reminder, existing homes have not been constructed in the last several years and the windows we are talking about have been installed in homes that have previously been occupied.

1. How many existing homes do you work in during a typical year in New Hampshire?
    a. [IF APPLICABLE] What proportion of these homes recently had windows installed?
    b. Have you worked on any manufactured homes in New Hampshire that have had windows installed over the past twelve months? If yes, how many manufactured homes?
    c. To your knowledge, do any of the windows installed in existing homes receive rebates from NHSaves?
2. Do you also work in existing multifamily buildings—that is, buildings with more than one dwelling unit that aren't single-family attached townhomes?
3. Can you tell me a bit more about what parts of the state you work in?

[NOTE FOR INTERVIEWER: We are defining southern New Hampshire to consist of the counties of Cheshire, Hillsborough, Rockingham and Strafford; this includes Portsmouth, Manchester, Keene, and Dover. Northern New Hampshire consists of Belknap, Coos, Grafton, Merrimack, Sullivan, and Carroll counties; this includes Concord. Identify if the respondent works in both southern and northern parts of the state, note where separate responses are required for both areas.

    a. Do you work in any neighboring states? If so, which additional states do you work in?

1. For the next few questions, I would like you to give me rough estimates of the portion of window installations that fall into the following categories: [AT THE END, ASK RESPONDENT TO ADJUST IF PERCENTAGES DO NOT ADD UP to 100%]
    a) What portion were part of a retrofit that required new windows in a home?

   b) What portion replaced windows that were damaged in existing homes?
   c) What portion replaced windows that were *not* damaged in existing homes?
   •

2. What portion of the new windows installed were double pane vs. triple pane?
3. Approximately what portion of the homes with new windows installed windows with a low e-coating? [IF NEEDED] Low-emissivity (low-e) coatings on glass control heat transfer; they are more expensive but save more energy.
4. Approximately what portion of homes with new windows installed windows that have an insulating gas between the panes (e.g., argon or krypton)?
5. [IF RESPONDENT HAS WORKED IN MORE THAN ONE TYPE OF HOME; ADUST WORDING DEPENDING ON HOME TYPES; ASK ABOUT MANUFACTURED HOMES IF HAS WORKED ON THEM] Does the installation rate of more efficient windows with double or triple panes, low-e coatings and insulating gases vary by type of home—that is, among single family detached, manufactured, single family attached, and multifamily homes? If so, how does it vary?
6. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation rate of more efficient windows with double or triple panes, low-e coatings and insulating gases vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is?
7. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the installation rate of more efficient windows with double or triple panes, low-e coatings and insulating gases in New Hampshire compare with installations in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for the installation rates given number of homes.]
8. How much of a barrier is the higher cost of more efficient windows for your customers? [PROBE if they have customers who wanted to install more efficient windows or become more energy efficient in general but could not afford it]

B.1.12 Closing Module

1. What types of policy changes do you see as most important for increasing the efficiency of homes and equipment in New Hampshire? [PROBE FOR greater code compliance enforcement, for expanded or increased rebates]?
   a. [IF CODE MENTIONED] Are there particular areas of the energy code where enforcement should be stronger? [IF WORKS IN BOTH PARTS OF THE STATE] Does this vary for northern and southern New Hampshire?
   b. [IF REBATES MENTIONED] What equipment types or materials are most in need of rebate support?
2. Those are all the questions I had; is there anything you would like to add that would help us characterize building practices in New Hampshire?

Collect email address for incentive (or mailing address if they prefer that). Double check that the address is correct.

Thank you so much for your time!

B.2 NH Baseline Practices – C&I Interview Guide

The purpose of this survey instrument is to gather information regarding standard practice for certain measures in new construction and retrofit scenarios. The specific objective of the survey is described in the following table:

Measure Type	Objective
Gas-fired ducted hot air heating equipment	Determine the current mix by fossil fuel by number of units installed
	Determine the percent of units installed that are condensing and non-condensing by total installed capacity.
	Determine the typical efficiency of condensing and non-condensing units installed by total installed capacity.
	Determine the minimum efficiency installed.
	Determine other variables that affect equipment selection.
Tankless water heater	Determine the current mix by fossil fuel by number of units installed
	Determine the minimum efficiency installed.
	Determine other variables that affect equipment selection.
Lighting and lighting control	Determine the saturation of LEDs in the C&I new construction and major renovation projects for interior and exterior lighting.
	Determine the practical minimum lighting controls in C&I new construction, major renovation projects and retrofit projects.
Heat Pump	Determine the minimum efficiency installed in C&I new construction and major renovation projects
	Determine other variables that affect equipment selection.
Air Conditioning Unit	Determine the minimum efficiency installed in C&I new construction and major renovation projects.
	Determine other variables that affect equipment selection.
Chiller	Determine the minimum efficiency installed in C&I new construction and major renovation projects.
	Determine other variables that affect equipment selection.

B.2.1 Introduction Module

Good morning/afternoon. The New Hampshire Utilities, sponsors of NHSaves energy-efficiency programs, have partnered with NMR Group and DNV to better understand the equipment and building practices used in both new and existing New Hampshire businesses. Your feedback in the areas of your expertise will help ensure that efficiency programs in New Hampshire can effectively support professionals like you moving forward.

This interview may take 30 to 40 minutes to complete. In appreciation of your time, NMR will send a digital $100 Amazon gift card to the email address you provide at the end of the survey or, if you prefer, mail you a gift card. You do not have to accept this incentive. Your responses will be kept confidential; we will combine them with those of other respondents for the findings and analyses we present to New Hampshire Utilities.

[Confirm this is a good time for the respondent or reschedule]

I will begin with a few general questions.

1. We are going to use the phrase “did you work on” specific types of equipment, like boilers, in the commercial sector. For the purposes of this interview, interpret that to mean whether you or someone else at your firm or organization designed, inspected, approved, sold or installed this type of equipment in 2022 in the commercial sector. With that being said, did you build a newly constructed commercial or industrial building, design a new building, or issue a construction permit to a newly constructed or major renovated commercial or industrial building in 2022?
2. In 2022, have you worked on any of the following in New Hampshire:
    a) Installed lighting or lighting controls or working on/designed lighting retrofit or lighting control measures at a newly constructed, major renovated, or existing C&I facility.
    b) Installed a furnace (ducted fossil fuel-fired unit) or worked on/designed a building where this equipment was installed.
    c) Installed a gas-fired boiler or worked on/designed a building where this equipment was installed.
    d) Installed a gas instantaneous water heater (also called a tankless on-demand water heater) or worked on/designed a pre-exiting building where these measures were installed.
    e) Installed a heat pump or worked on/designed a building where this equipment was installed at a new constructed or major renovated C&I facility. This includes unitary, ducted or ductless mini split system, and water source or ground source heat pump except package terminal heat pumps.
    f) Installed a regular air conditioning unit or worked on/designed a building where this equipment was installed at a new constructed or major renovated C&I facility. This includes unitary, and ducted or ductless mini split system except package terminal air conditioners.
    g) Installed a chiller or worked on/designed a building where this equipment was installed at a new constructed or major renovated C&I facility.
    •

- [FOR BUILDERS AND CONTRACTORS, NEED TO HAVE INSTALLED AT LEAST ONE ITEM; FOR CODE OFFICIALS NEED TO HAVE WORKED ON OR INSPECTED AT LEAST

ONE ITEM TO QUALIFY; FOR ARCHITECTS AND DESIGN TEAMS, NEED TO HAVE DESIGN AT LEAST ONE ITEM]

- [IF DO NOT QUALIFY] I am sorry; you do not qualify for this survey. Thank you for your time. [END]

3. In 2022, what types of commercial or industrial buildings have you worked on? Please tell me approximately the types of facilities.
   - Below is a list of facilities as a reference:
   - Small Commercial: assembly, auto repair, big box retail, dormitory, fast food restaurant, full service restaurant, grocery, light industrial, motel, primary school, religious, small office, small retail, warehouse, other.
   - Large Commercial: community college, high school, hospital, hotel, large office, large retail, university.
4. In the past twelve months, what areas of New Hampshire have you worked in? Please note that, for this interview, we are defining south as Manchester and Portsmouth areas; central as Concord, Keene, Laconia, Lebanon areas; north as Berlin area. [PROBE IF THIS DEFINITION IS ENOUGH FOR THE RESPONDENT TO SAY IF THEIR PROJECTS ARE IN SOUTHERN OR NORTHERN NEW HAMPSHIPE; IF NOT, THEY CAN GIVE THE CITIES OR TOWNS AND WE CAN CLASSIFY THEM.]
5. In the past twelve months, have you done any similar work outside of the state of New Hampshire? If yes, what states have you worked in?

B.3 New Construction and Lighting Module

[If Intro Q2 a) is yes] We would now like to discuss your experiences with lighting and lighting controls.

1. Approximately how many buildings have you worked on throughout the state of New Hampshire over the last twelve months that have had lighting and/or lighting controls sold or installed?
    a. To your knowledge, do you work on projects that participate in the NHSaves new Equipment and Construction Program?
    b. [If Yes:] Roughly what percentage of your work are projects that participate in this program?

For the remainder of this interview, please consider only installations in New Hampshire *that to your knowledge have not participated in the NHSaves New Equipment and Construction Program. We would like to get your perspective on the building practices and measures installed in the non-residential new construction market.*

2. For the next few questions, I would like you to give me rough estimates of the portion of lighting and lighting control sold and installations that fall into the following categories: [AT THE END, ASK RESPONDENT TO ADJUST IF PERCENTAGES DO NOT ADD UP TO 100%]
    a) What portion of these sold and installations were part of a new construction project?
    b) What portion of these sold and installations were part of a major renovation, considered as integrating changes to the physical parameters of the building?
    c) What portion of these sold and installations were part of a retrofit, considered as replacing or upgrading systems in the existing building?

Installation Category	Lighting Fixtures	Lighting Controls
New construction		
Major renovation		
Upgrades or retrofits in existing buildings		
TOTAL		

3. I have a few questions about the new construction market specifically. What percent of the installed lighting fixtures in new construction use LED-based lighting for these applications [ask for percentages for each]?
    a. Exterior lighting:
    b. Interior high/low bay:
    c. Interior linear ambient lighting (as the primary source of light for a certain space):
    d. Interior task lighting (as a light beam illuminated to cover only a tiny area):
    e. Are there significant deviations by any building type?

f. Are there significant deviations between new construction and retrofit?

4. How does the use of LED lighting vary by type of building — that is, among office, hospital, industrial facility, grocery stores, small business and others?

[Open Ended]

5. Talking about the overall market you have seen rather than your own projects, how does code compliance for LPD (lighting power density, in Watts/sq ft) vary by type of building — that is, among office, hospital, industrial facility, grocery stores, small business and others – are there some types of buildings that tend to be much more efficient than code while others are merely compliant? We are talking about the building area method, not space-by-space method. [PROBE TO POPULATE TABLE BELOW]

Building Types	Based on IECC 2015, Building Area Method, LPD, W/ft2	Percent of Sites Just Meeting Code	Percent of Sites More Efficient than Code, with lower LPD	Percent of Sites Less Efficient Than Code, with Higher LPD
Office	0.82			
Hospital	1.05			
Industrial	1.17			
Grocery	1.26			
Restaurant	0.9-1.01			
Hotel	0.87			
University/School	0.87			
Other, please specify				
Other, please specify				
Other, please specify				

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6. [IF ANY SITE PERFORMANCE IS ABOVE CODE] Can you estimate how much approximately in percentage that LPD is lower than the code?

7. Do lighting design practices vary for the northern and southern parts of New Hampshire? If so, how do they differ and how large would you say the difference is? [PROBE for differences between LPD levels and LED saturation levels]

8. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND HAS DEALT WITH LIGHTING] How do the lighting LPD practices compare between New Hampshire and other [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for differences in LPD levels and LED saturation levels]

9. How much of an issue is the cost of the lighting fixtures for your customers? [PROBE if they have customers who wanted lower LPD lighting levels or to become more energy efficient in general but could not afford it]

10. Do you have any other barriers to replacing the fixtures, such as access issue, or operational disturbance?

11. [IF NOT ALREADY COVERED] Rather than the code, are there ostensible/definite differences in ISP (Industry Standard Practice) for lighting LPD, based on the location/building type/industry?

[IF DEALS WITH LIGHTING CONTROLS] We would now like to discuss your experiences with lighting controls.

12. How do lighting controls vary by type of building in new construction or major renovation — that is, among office, hospital, industrial facility, grocery stores, small business and others?

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences between new construction projects and existing building projects?
    a. Occupancy sensor
    b. Daylight dimming control
    c. Integral dual sensor
    d. Networked lighting control
    e. Exterior photocell
    f. Others, please specify

13. Talking about the overall market you have seen rather than your own projects, how does code compliance for lighting controls vary by type of building – that is, among office, hospital, industrial facilities, grocery stores, small businesses, and others – are there some types of buildings that tend to be much more efficient than code while others are merely compliant?

Building Types (NC)	Percent of Sites Just Meeting Code for Lighting Control	Typical Technologies Installed to Meet Code	Typical Technologies Installed Better than Code
Office			
Hospital			
Industrial			
Grocery			
Restaurant			
Hotel			
University/School			
Other, please specify			
Other, please specify			
Other, please specify			

14. What is the typical practice for the commissioning of lighting controls?

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences among new construction, major renovation and existing building projects?

[Open ended]

15. Do the design practices for lighting control selection vary for the northern and southern parts of New Hampshire? If so, where are they most common and how large would you say the difference is? [PROBE for the installation rates given the number of buildings]

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences between new construction projects and existing building projects for the following controls?
    a. Occupancy sensor
    b. Daylight dimming control
    c. Integral dual sensor
    d. Networked lighting control
    e. Exterior photocell
    f. Others, please specify

16. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND HAS DEALT WITH LIGHTING CONTROLS] How do the lighting control practices compare between New Hampshire and other [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for the installation rates given number of buildings.]

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences between new construction projects and existing building projects?

17. How much of an issue is the cost of the lighting control for your customers? [PROBE if they have customers who wanted to install more lighting control but could not afford it]

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences between new construction projects and existing building projects?

18. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP (industrial Standard Practice) for lighting controls, based on the location/building type/industry?

- [IF THE INTERVIEWEE IS CONTRACTOR] Can you specify if there are any differences between new construction projects and existing building projects?

[If Intro Q2 e) is yes]

- Now I would like to discuss your experiences with heat pumps that you installed, designed, or worked at a newly constructed or major renovated facility.
- Please note we are talking about all heat pumps, including air source, water source and ground source except package terminal heat pumps.

19. Approximately how many heat pumps have been installed in the facilities you have worked on throughout the state of New Hampshire over the last twelve months for C&I new construction or major renovation projects?

a. To your knowledge, do you work on projects that participate in the NHSaves new Equipment and Construction Program?

b. [If Yes:] Roughly what percentage of your work are projects that participate in this program?

[IF NEEDED] For the remainder of this interview, please consider only installations in New Hampshire *that to your knowledge have not participated in the NHSaves New Equipment and Construction Program. We would like to get your perspective on the building practices and measures installed in the non-residential new construction market.*

20. What portion of these units were air source, water source and ground source, respectively? [AT THE END, ASK RESPONDENT TO ADUST IF PERCENTAGES DO NOT ADD UP TO 100%]
21. We are estimating the efficiency ratings of heat pumps sold and installed in New Hampshire.
    a. Can you estimate what is the typical cooling efficiency for the heat pump? Are they in SEER, EER or IEER?
    b. If the efficiency varies based on the size of the unit, could you please specify with your most familiar type and size?
    c. If the efficiency varies based on the type of the unit, could you please specify?
    d. Can you estimate what is the typical heating efficiency for the heat pump with your most familiar type and size? Are they in HSPF or COP?
    e. If the efficiency varies based on the size of the unit, could you please specify?
    f. If the efficiency varies based on the type of the unit, could you please specify?
22. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation of heat pump vary for the northern and southern parts of New Hampshire? If so, how are they different and how large would you say the difference is?
23. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the efficiency of heat pumps sold and installed in New Hampshire compare with the efficiency in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
24. How much of an issue is the cost of high efficiency heat pumps for your customers? For ground source heat pump, please specify if it is the incremental cost from standard to high efficiency or the cost from regular heat pump to a ground loop system. [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it]
25. If natural gas is available, will it affect the choice of heat pump used as the main heating source?
26. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP based on location/building type/industry?

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[If Intro Q2 f) is yes]

- Now I would like to discuss your experiences with regular air conditioning units that you installed, designed, or worked at a newly constructed or major renovated facility. This includes unitary, and ducted or ductless mini split system except package terminal air conditioners.
    27. Approximately how many air conditioning units have been installed in the facilities you have worked on throughout the state of New Hampshire over the last twelve months for C&I new construction or major renovation projects?
        a. To your knowledge, do you work on projects that participate in the NHSaves new Equipment and Construction Program?
        b. [If Yes:] Roughly what percentage of your work are projects that participate in this program?

[IF NEEDED] For the remainder of this interview, please consider only installations in New Hampshire *that to your knowledge have not participated in the NHSaves New Equipment and Construction Program. We would like to get your perspective on the building practices and measures installed in the non-residential new construction market.*

28. We are estimating the efficiency ratings of the air conditioning units sold and installed in New Hampshire.
    a. Can you estimate what is the typical cooling efficiency for the heat pump with your most familiar type and size? Are they in SEER, EER or IEER?
29. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation of air conditioning units vary for the northern and southern parts of New Hampshire? If so, are they different and how large would you say the difference is?
30. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the efficiency of air conditioning units sold and installed in New Hampshire compare with the efficiency in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
31. How much of an issue is the cost of high efficiency air conditioning units for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it]
32. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP based on location/building type/industry?

[If Intro Q2 g) is yes]

- Now I would like to discuss your experiences with chillers that you installed, designed, or worked at a newly constructed or major renovated facility.
    33. Approximately how many chillers have been installed in the facilities you have worked on throughout the state of New Hampshire over the last twelve months?
        a. To your knowledge, do you work on projects that participate in the NHSaves new Equipment and Construction Program?

b. [If Yes:] Roughly what percentage of your work are projects that participate in this program?

[IF NEEDED] For the remainder of this interview, please consider only installations in New Hampshire *that to your knowledge have not participated in the NHSaves New Equipment and Construction Program. We would like to get your perspective on the building practices and measures installed in the non-residential new construction market.*

34. What portion of these units were air-cooled chillers? What portions were water cooled rotary screw and scroll chillers? And what portions were water cooled centrifugal chillers? [check that all totals add to 100%]

35. We are estimating the efficiency ratings of the chillers sold and installed in New Hampshire.

    1. Can you estimate what is the typical efficiency for the chiller for each of the categories below? Please focus on the equipment you are most familiar with.
    2. Could you please specify how the efficiency varies based on the size of the unit?
    3. Could you please specify how the efficiency varies based on the type of the unit?

Type of Chiller	Size (ton)	Unit	Path A Full Load	Path A IPLV	Path B Full Load	Path B IPLV
Air cooled	<150	EER				
	>150	EER				
Water Cooled Rotary Screw or Scroll	<75	kW/ton				
	75 – 150	kW/ton				
	150 – 300	kW/ton				
	300 – 600	kW/ton				
	>600	kW/ton				
Water Cooled Centrifugal	<150	kW/ton				
	150 – 300	kW/ton				
	300 – 400	kW/ton				
	400 – 600	kW/ton				
	>600	kW/ton				

36. [IF WORKS IN BOTH PARTS OF THE STATE] Does the installation of chillers vary for the northern and southern parts of New Hampshire? If so, how are they different and how large would you say the difference is?

37. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] How does the efficiency chillers sold and installed in New Hampshire compare with the efficiency in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]

38. How much of an issue is the cost of high efficiency chillers for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it]

39. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP based on location/building type/industry?

B.3.1 Boiler and Furnace Module [Retrofit]

[If Intro Q2 b) is yes]

We would now like to discuss your experiences with ***furnaces or ducted fossil fuel-fired units*** that might be found in a roof-top unit or ductless unit heaters found in a common space. This does not include [IF APPLICABLE] boilers.

[IF THE INTERVIEWEE IS CONTRACTOR, PLEASE ASK THIS AS A FOLLOW-UP FOR EACH QUESTION: Can you specify if there are any differences between new construction projects and existing building projects?]

1. Approximately how many ducted hot air systems have been installed in the facilities you have worked on throughout the state of New Hampshire over the last twelve months? [NUMERIC]
2. For the next few questions, I would like you to give me rough estimates of the portion of ducted hot air systems that were installed or designed that fall into the following categories: [READ FOR FURNACES AND BOILERS, AS APPLICABLE; AT THE END, ASK RESPONDENT TO ADUST IF PERCENTAGES DO NOT ADD UP TO 100%]
    a) What portion of these installations was part of new construction or major renovation?
    b) What potion was part of a major retrofit that required adding a new heating system?
    c) What portion replaced pre-existing units that had failed in existing buildings?
    d) What portion replaced pre-existing units that were close to the end of their useful life?
    e) What portion replaced pre-existing units that were not close to failure?
3. What portion of these units were gas fired units and what portions were propane or oil fired units? [check that all totals add to 100%, and specify if it is propane, or oil (if they worked on non-gas fired unit)]
4. We are estimating the efficiency ratings (in percentage) of furnaces and unit heaters sold and installed in New Hampshire that *do not receive a rebate through NHSaves*.

- [IF DEALS WITH GAS/PROPANE FIRED UNITS] [ASK TWICE FOR NEW CONSTRUCTION OR MAJOR RENOVATION PROJECTS, AND FOR RETROFIT PROJECTS]
    a) Can you estimate what is the percentage of units that are condensing furnaces?
    b) Could you estimate what is the typical efficiency for non-condensing gas/propane-fired units?
    c) And can you estimate what is the lowest efficiency for non-condensing gas/propane-fired units?
    d) If the efficiency varies based on the size of the unit, could you please specify?

    [IF DEALS WITH OIL FIRED UNITS]

    e) Can you estimate what is the percentage of units that are condensing units?
    f) Could you estimate what is the typical efficiency for non-condensing oil-fired units?

g) And can you estimate what is the lowest efficiency for non-condensing oil-fired units?

h) If the efficiency varies based on the size of the unit, could you please specify?

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Type of Furnace	Capacity	% of units that are condensing	Most Common Efficiency for Non-condensing Units	Minimum Efficiency for Non-condensing Units
Gas/Propane fired	<225,000 Btu/h			
	>225,000 Btu/h			
Oil Fired	<225,000 Btu/h			
	>225,000 Btu/h			

5. [IF WORKS IN BOTH PARTS OF THE STATE] For furnaces, does the installation of condensing units vary for the northern and southern parts of New Hampshire? If so, how are they different and how large would you say the difference is?
6. [IF WORKS OUTSIDE OF NEW HAMPSHIRE] For furnaces, how does the portion of condensing units sold and installed in New Hampshire compare with the portion in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
7. How much of an issue is the cost of high efficiency units for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it]
8. [IF NOT ALREADY COVERED] For furnaces, are there ostensible/definite differences in ISP based on location/building type/industry?

[If Intro Q2 c) is yes]

[IF THE INTERVIEWEE IS CONTRACTOR, PLEASE ASK THIS AS A FOLLOW-UP FOR EACH QUESTION: Can you specify if there are any differences between new construction projects and existing building projects?]

We would now like to discuss your experiences with ***boilers***.

1. Approximately how many boilers have been installed in the buildings you have worked on or designed throughout the state of New Hampshire in the last twelve months? Please note that your best estimates of the numbers installed or designed will be fine. [NUMERIC]
2. For the next few questions, I would like you to give me rough estimates of the portion of boilers installed or designed that fall into the following categories: [READ FOR BOILERS, AS APPLICABLE; AT THE END, ASK RESPONDENT TO ADUST IF PERCENTAGES DO NOT ADD UP TO 100%]

a) What portion of these installations was part of new construction?

b) What potion was part of a major retrofit that required adding a new heating system?

c) What portion replaced furnaces/boilers that had failed in existing buildings?

d) What portion replaced furnaces/boilers that were close to the end of their useful life?

e) What portion replaced furnaces/boilers that were not close to failure?

3. [IF RESPONDENT HAS DEALT WITH BOILERS IN MORE THAN ONE TYPE OF BUILDING; ADUST WORDING DEPENDING ON BUILDING TYPES] For boilers, does the installation of condensed units vary by type of facility? If so, how does it vary?

- Below is a list of facilities as a reference:
- Small Commercial: assembly, auto repair, big box retail, dormitory, fast food restaurant, full service restaurant, grocery, light industrial, motel, primary school, religious, small office, small retail, warehouse, other.
- Large Commercial: community college, high school, hospital, hotel, large office, large retail, university.
- Does the installation of condensed units vary by size of facility? If so, how does it vary?

4. What portion of these boilers were gas fired units including natural gas and propane, and what portions were oil fired units? [check that all totals add to 100%]

5. What portions of these boilers were hot water boilers and what portions were steam boilers? [check that all totals add to 100%]

6. [IF DEALS WITH BOILERS] We are estimating the efficiency ratings in percentage or AFUE (Annual Fuel Utilization Efficiency) of gas boilers sold and installed in New Hampshire that *do not receive a rebate through NHSaves*. [ASK SEPARATELY FOR NEW CONSTRUCTION OR MAJOR RENOVATION, AND RETROFIT]

- [IF DEALS WITH HOT WATER GAS BOILER]
  a) Can you estimate what is the percentage of units that are condensing units?

  b) Could you estimate what is the typical efficiency of non-condensing hot water boiler?

  c) Can you give me the most common lowest efficiency of the non-condensing hot water boiler?

  d) If the efficiency varies based on the size of the unit, could you please specify?

- [IF DEALS WITH GAS STEAM BOILER]
  e) Can you estimate what is the percentage of units that are condensing units?

  f) Could you estimate what is the typical efficiency of non-condensing steam boiler?

  g) Can you give me the most common lowest efficiency of the non-condensing steam boiler?

  h) If the efficiency varies based on the size of the unit, could you please specify?

Type of Gas Boiler	Capacity	% of units that are condensing	Most Common Efficiency for Non-condensing Units	Minimum Efficiency
Hot water	<300 MBH			
	300 – 500 MBH			
	500 – 1000 MBH			
	1000 – 1700 MBH			
	>1700 MBH			
Steam	<300 MBH			
	300 – 500 MBH			
	500 – 1000 MBH			
	1000 – 1700 MBH			
	>1700 MBH			

7. [IF WORKS IN BOTH PARTS OF THE STATE AND DEALS WITH BOILERS] Does the installation of boilers vary for the northern and southern parts of New Hampshire? If so, how are they different and how large would you say the difference is?
8. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND DEALS WITH BOILERS] How does the boilers sold and installed in New Hampshire compare with the portion in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine]
9. How much of an issue is the cost of the units for your customers? [PROBE if they have customers who wanted to install an energy efficient unit but could not afford it]
10. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP based on location/building type/industry?

B.3.2 Tankless Water Heater Module [Retrofit]

[If Intro Q2 d) is yes]

We would now like to discuss your experiences with gas tankless water heaters.

1. Approximately how many gas-fired tankless water heaters you have worked on throughout the state of New Hampshire over the last twelve months that have had gas tankless heaters installed?
2. For the next few questions, I would like you to give me rough estimates of the portion of tankless water heater installations that fall into the following categories: [AT THE END, ASK RESPONDENT TO ADJUST IF PERCENTAGES DO NOT ADD UP TO 100%]
    a) What portion of these installations was part of new construction?
    b) What potion was part of a major retrofit that required adding a new water heating system?
    c) What portion replaced water heating systems that had failed in existing buildings?
    d) What portion replaced water heating systems that were close to the end of their useful life?
    e) What portion replaced water heating systems that were not close to failure?

Installation Category	Tankless Water Heaters
New construction	
Retrofit	
Replaced a failed system	
Replaced a functioning system close to failure	
Replaced a functioning system not close to failure	
TOTAL	

-

3. We are estimating the Energy Factor (EF) or thermal efficiency (Et) ratings of gas instantaneous water heaters sold and installed in New Hampshire that *do not receive a rebate through NHSaves* for the existing building retrofit projects.
    a. Could you estimate what portion of the units have EFs of 0.61 or above?
    b. And can you give me the most common EF of the gas instantaneous water heaters you come across?
    c. If the efficiency varies based on the size of the unit, could you please specify?
4. [IF RESPONDENT HAS WORKED IN MORE THAN ONE TYPE OF BUILDING; ADUST WORDING DEPENDING ON BUIDLING TYPES AND HAS DEALT WITH GAS INSTANTANEOUS WATER HEATERS] Does the installation of gas instantaneous water heaters vary by type of building — that is, among office, hospital, industrial facility, grocery stores, small business and others? If so, how does it vary?
5. [IF WORKS IN BOTH PARTS OF THE STATE AND HAS DEALT WITH GAS INSTANTANEOUS WATER HEATERS] Does the installation of gas instantaneous water heaters vary by vary for the northern and southern parts of New Hampshire? If so, how are they different and

how large would you say the difference is? [PROBE for the installation rates given the number of buildings]

6. [IF WORKS OUTSIDE OF NEW HAMPSHIRE AND HAS DEALT WITH GAS INSTANTANEOUS WATER HEATERS] How does the installation of gas instantaneous water heaters in New Hampshire compare with installations in [STATE]? [Ask for all states bordering New Hampshire where the respondent has worked over the past year—Massachusetts, Vermont, and Maine; PROBE for the installation rates given number of homes.]
7. How much of an issue is the cost of gas instantaneous water heaters for your customers? [PROBE if they have customers who wanted to install gas instantaneous water heaters or become more energy efficient in general but could not afford it]
8. [IF NOT ALREADY COVERED] Are there ostensible/definite differences in ISP (which is industrial standard practice) based on location/building type/industry?

Appendix C Measure Prioritization Findings and Recommendations

Below are the results and recommendations slides presented to the EM&V Working Group on May 31, 2023.

New Hampshire Baseline Practices

Results Presentation

Calissa Jones, Beth Delahaij, Denisse Manzo Gonzalez – NMR
Shaobo Feng - DNV

May 31, 2023

DNV NMR Group, Inc.

Presentation Outline

NMR Group, Inc.

- C&I Results
  - Measures included in IDIs and literature review
  - Measures not included in IDIs with suggested updates from the literature review
- Residential Results
  - Takeaways for measures included in interviews
- Appendix
  - Measures not included in IDIs with no suggested updates from the literature review

C&I Results

C&I: Measure Summary

No Updates	Condensing Unit Heaters
	Unitary Air Conditioners
	Variable Frequency Drives
Updates from Literature Review	Air Compressors
	Air Nozzles
	VRF Systems
Include in IDIs	Boilers
	Lighting Controls
	Water Heaters (On-Demand Tankless)
	New Construction Measures

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C&I: In-Depth Interviews Summary

Market Actor Role	Completed IDI	Number of Projects/Units (non-program participated only)
Code Official	3	50
Builder	2	13
Contractor	7	176
Architect/Designer	2	11
Total	**14**	**250**

Type of End-use	Completed IDI	Number of Projects/Units (non-program participated only)
NC/Retrofit: Lighting and control	9	NC/Major Renovation: 81; Retrofit: 54
NC: HP	10	142
NC: AC	6	104
NC: Chiller	4	34
NC/Retrofit: Furnace	7	NC/Major Renovation: 83; Retrofit: 84
NC/Retrofit: Boiler	8	NC/Major Renovation: 22; Retrofit: 43
Retrofit: Tankless Water Heater	7	13

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C&I: HVAC – Heating Systems – Boilers

Recommendation: Increase the current baseline efficiency

- For boilers, most respondents (two code officials and two contractors) reported 100% of installations are condensing boilers with one exception from one contractor. Similar as MA market.
- One contractor stated a significant portion of propane boilers were installed to replace the oil ones. Most of them are also condensing units.

- IDI Updates (see details in comments)
- MA updated methodology from a 2021 study to set baseline as 15% above code minimum efficiency.

Current NH Baseline	Literature Review	IDI Survey
85% AFUE boiler (Source: MA Gas Boiler Market Characterization Study, 2017)	MA sets baseline as 15% above code minimum efficiency	Most condensing units

Measure Name	**HVAC – Heating Systems – Boilers**
Program Type	Lost Opportunity
Description	The installation of a high efficiency natural gas fired condensing hot water boiler.
Previous Baseline Efficiency	85% AFUE boiler (Source: MA Gas Boiler Market Characterization Study, 2017)
Baseline Source	DNV GL, NMR, March 2017. Gas Boiler Market Characterization Study Phase II. Prepared for Massachusetts Program Administrators and Energy Efficiency Advisory Council.

Source	Baseline Efficiency/Notes
MA	15% above code minimum
CT	92% AFUE
VT	82% AFUE (oil); 81% AFUE (propane)
Mid-Atlantic	80-82% AFUE; 77-82% TE
ME	80-82% AFUE; 77-82% TE
NY	80-82% AFUE; 77-84% TE

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C&I: Midstream Hot Water – Water Heaters

Measure Name	**Midstream Hot Water – Water Heaters**
Program Type	Lost Opportunity
Description	Includes: HPWHs, Indirect WH, On-Demand Tankless, Volume, Condensing
Baseline Efficiency	The baseline efficiency case assumes compliance with the efficiency requirements as mandated by New Hampshire State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC).
Baseline Source	Compliance with relevant IECC

Source	HPHW	Indirect	Tankless	Volume	Condens.
NH		78% RE	EF = 0.61	80% TE	80% TE
MA		78% RE	EF = 0.71	80% TE	
CT	Algorithm			80% TE	
VT					
Mid-Atlantic	EF = 0.904		EF = 0.81	80% TE	
ME				80% TE	
NY		EF = 0.75	EF = 0.80		

Recommendation: Keep the code compliant efficiency as the baseline

- Only reported in multi-family/dorm, restaurants and emergency shower use in lab and industry facilities.

- IDI Updates (noted this is for downstream tankless only) (see details in comments)

Current NH Baseline	Literature Review	IDI Survey
Code compliance efficiency	Varies based on the type. But all code compliance.	Code

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C&I: Lighting – Controls

Measure Name	**Lighting – Controls**
Program Type	New Construction
Description	This measure includes the installation of lighting controls in both lost-opportunity and retrofit applications.
Baseline Efficiency	The baseline efficiency case for new construction is code-compliant controls as mandated by the New Hampshire Building Code.
Baseline Source	IECC 2015 and ASHRAE Standard 90.1-2013

Source	Baseline Efficiency/Notes
MA	Code-compliant controls
VT	Custom calculation
Mid-Atlantic	Code-compliant controls

Recommendation: Keep the code compliant control as the baseline

- Most customers are not familiar with code, so the decision is normally made by designers and architects.
- Considering the cost impact, most projects are using code compliance controls.

- IDI Updates (see details in comments)

Current NH Baseline	Literature Review	IDI Survey
Code-compliant controls	MA sets baseline as 15% above code minimum efficiency	Code-compliant controls

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C&I: New Construction - Lighting

Recommendation: Consider increasing the baseline with certain percent higher than the code minimum LPD.

- Based on the IDI, most contractors and designers reported that LED were selected in most of the projects, except some labs or manufacturing facilities.
- A code official (county inspector) stated he could not think last time he inspected a project without using LED.
- The conclusion (40% better than code) from MA NRNC study was based on a 92% LED market penetration rate as the figure below, with the combination of IECC 2015 as the state energy code during the study.
- We observed the similar LED penetration in NH through the IDI. Considering NH used IECC 2015 as the code until July 2022, we recommend to increase the baseline LPD.

- Lighting IDI Updates (see details in comments)

Source	ISP % Above Code (MA NRNC Market Characterization Study)
Interior Lighting	40% better than minimum LPD
Exterior Lighting	33% better than minimum LPD
Boilers	15% above minimum efficiency
Warm Air Furnaces	2% above minimum efficiency
Heat Pumps – Cooling	3% above minimum efficiency
Heat Pumps - Heating	6% above minimum efficiency
Chillers	1% above minimum efficiency

End Use	Current NH Baseline	Literature Review	IDI Survey
Lighting	Code	MA: interior LPD is 40% better than code; exterior is 33% better	"code LPD" But All LED

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C&I: New Construction – Boiler and Furnaces

- **Recommendation: Consider increasing the baseline efficiency.**
  - For boilers, most respondents (two code officials and two contractors) reported 100% installation are condensing boilers with one exception from one contractor. Similar as MA market.
  - For furnaces, reported efficiency (85%-86%) is same as the current TRM (85%).

- IDI Updates (see details in comments)

- For boilers, MA updated methodology from a 2021 study to set baseline as 15% above code minimum efficiency.
- For furnaces, MA updated methodology from a 2021 study to set baseline as 2% above code minimum efficiency.

Source	ISP % Above Code (MA NRNC Market Characterization Study)
Interior Lighting	40% better than minimum LPD
Exterior Lighting	33% better than minimum LPD
Boilers	15% above minimum efficiency
Warm Air Furnaces	2% above minimum efficiency
Heat Pumps – Cooling	3% above minimum efficiency
Heat Pumps - Heating	6% above minimum efficiency
Chillers	1% above minimum efficiency

End Use	Current NH Baseline	Literature Review	IDI Survey
Boiler	Code	MA: 15% above code	Most units are condensing units
Furnace	Code	MA: 2% above code	Code

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C&I: New Construction – Heat Pumps, ACs, Chillers

Recommendation:

- **HP: Consider increasing the baseline efficiency**
- **AC and Chiller: Keep the current code compliant efficiency as the baseline**
  - Three of five respondents reported better than code is typical for their projects: 18 SEER or above. One contractor reported code or a little better. One code official reported 20% are hi-efficiency and the balance 'mid-range' efficiency.
  - The overall efficiency for AC and chiller in the non-program participated projects are almost same as code minimum efficiency.

- IDI Updates (see details in comments)

End Use	Current NH Baseline	Literature Review	IDI Survey
HP	Code	MA: cooling is 3% above minimum efficiency; heating is 6% above	Above code
AC	Code	Code	Code
Chiller	Code	MA: 1% above minimum efficiency	Code

Source	ISP % Above Code (MA NRNC Market Characterization Study)
Interior Lighting	40% better than minimum LPD
Exterior Lighting	33% better than minimum LPD
Boilers	15% above minimum efficiency
Warm Air Furnaces	2% above minimum efficiency
Heat Pumps – Cooling	3% above minimum efficiency
Heat Pumps - Heating	6% above minimum efficiency
Chillers	1% above minimum efficiency

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C&I: Compressed Air – Air Compressor

Measure Name	Compressed Air – Air Compressor
Program Type	Lost Opportunity
Description	Covers the installation of oil flooded, rotary screw compressors with Variable Speed Drive or Variable Displacement capacity control with properly sized air receiver.
Baseline Efficiency	The baseline efficiency case is a typical load/unload compressor.
Baseline Source	DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations.

Source	Baseline Efficiency/Notes
MA	DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations.
CT	Uses nominal HP to full load kW conversion factors dependent on equipment size.
PA	Uses nominal HP to full load kW conversion factors dependent on equipment size.
Mid-Atlantic	Uses nominal HP to full load kW conversion factors dependent on equipment size.
ME	Savings factors depend on equipment size. • 16-30 HP: 0.2358 • 31-60 HP: 0.2154 • > 60 HP: 0.1861
NY	For 15-75 HP, same as NH. For > 75 HP, calculated using DOE data.

Recommendation

- Consider aligning with NY methodology to break out units >75 HP

- TRM assumes 0.189 kW reduction per HP
  - Based on VSD 25-75 HP

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C&I: Compressed Air – Air Nozzle

Measure Name	Compressed Air – Air Nozzle
Program Type	Lost Opportunity/Retrofit
Description	Covers the installation of engineered air nozzles which provide effective air nozzle action while reducing compressed air system air flow.
Baseline Efficiency	The baseline efficiency case is a standard nozzle on a compressed air system.
Baseline Source	CFM at 100 psig if actual CFM is unavailable. 0.29 kW/CFM if actual efficiency is unavailable.

Source	Baseline Efficiency/Notes
MA	CFM at 100 psig if actual CFM is unavailable. 0.29 kW/CFM if actual efficiency is unavailable.
CT	CFM defaults by orifice diameter and pressure from US DOE table (August 2004).
VT	1/8" using 26+ CFM
PA	1/8" @ 80 psi = 21 CFM 1/4" @ 80 psi = 58 CFM
ME	1/8" @ 80 psi = 21 CFM 1/4" @ 80 psi = 58 CFM
NY	CFM = 14.485 * D^2 * (psig + 14.7) (https://www.airbestpractices.com/system-assessments/end-uses/compressed-air-savings-nozzles-or-blowers)

Recommendation

– Consider updating default pressure from 100psi to 80psi.

- MA uses 100psi
- Other TRMs use 80psi

C&I: VRF Systems

Measure Name	VRF Systems
Program Type	Lost Opportunity
Description	This measure includes in the installation of high-efficiency variable flow refrigerant (VRF) heat pumps.
Baseline Efficiency	The baseline is a code compliant VRF heat pump unit.
Baseline Source	ASHRAE 90.1-2013

Source	Baseline Efficiency/Notes
MA	IECC 2018 (must exceed ASHRAE 90.1 by 10%)
CT	ASHRAE 90.1-2019
Mid-Atlantic	ASHRAE 90.1-2013
ME	ASHRAE 90.1-2007

Recommendation

– Considering updating baseline to align with MA

Residential Results

Residential: Measure Prioritization Summary

Include in IDIs	Gas Instantaneous (Tankless) Water Heater
	Heat Pump Water Heater
	Window Replacement
	New Construction
	Gas Furnace
	Gas Boiler
Possible IDI Research	Ductless Mini-Split Heat Pump
Do not Include in IDIs	Central Ducted Air-Source Heat Pump
	Wi-Fi Communicating Thermostat
	Clothes Dryer
	Clothes Washer
	Refrigerator

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Residential: Summary of IDI Completes

Module and Response Count	Gas Instantaneous (Tankless) Water Heater (6 Responses)
	Heat Pump Water Heater (4 Responses)
	Window Replacement (No Responses)
	New Construction (7 Responses)
	Gas Furnace (6 Responses)
	Gas Boiler (6 Responses)
	Ductless Mini-Split Heat Pump (6 Responses)
	Closing Module (13 Responses)

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Residential: Tankless Water Heaters

Measure Name	**HVAC – Tankless Water Heaters**
Program Type	Retrofit/Lost Opportunity
Description	Installation of a new high-efficiency natural gas tankless and storage water heaters.
Baseline Efficiency	Stand-alone tank water heater with a UEF of 0.63. Early retirement: Existing 0.58 UEF standalone water heater
Baseline Source	No reference (possibly MA?)

Source	Baseline Efficiency/Notes
MA	0.63 UEF, 0.60 UEF (ER)
CT	0.60 UEF
RI	0.61 UEF
Mid-Atlantic	0.80 – 0.81 UEF
ME	0.62 UEF
NY	0.80 – 0.81 UEF

Recommendation: Maintain current baselines

- Consistent with most comparison areas.
- No evidence from IDIs to support shift to NY/Mid-Atlantic baseline strategy

Supplemental findings

- Majority of units sold have EF > .87
- Most common UEF's of installed systems are 0.95 and 0.93
  - Efficient case is .94 EF unit.

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Residential: Heat Pump Water Heater

Measure Name	HVAC – Heat Pump Water Heater
Program Type	Retrofit/Lost Opportunity
Description	Installation of an Energy Star ® certified heat pump storage water heater, either through direct installation programs to replace an electric resistance storage water heater, or as a lost opportunity retail offering.
Baseline Efficiency	Deemed based on study results
Baseline Source	R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8.

Source	Baseline Efficiency/Notes
MA	Codes and standards-based
CT	R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation
VT	Codes and standards-based
Mid-Atlantic	Codes and standards-based (<55 gallons uses standard electric resistance, >55 gallons uses blended value)
ME	50-gallon water heater .945 EF
NY	Federal standards (based on volume, draw pattern)

Recommendation: Consider moving to standards-based baseline value

- Would align with most comparison areas and simplify updates
- Current baseline ageing and not state-specific

Supplemental findings

- 57.5% of HPWHs replaced a fossil fuel water heating system
- Fossil fuels replaced by frequency: oil systems, then propane, and then natural gas
- 42.5% of HPWHs replaced a conventional electric tank
- The cost of HPWHs is a barrier to their utilization

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Residential: Window Replacement

Measure Name	Window Replacement
Program Type	New Construction, Retrofit
Description	Replacement of single pane windows or Jalousie mobile home windows.
Baseline Efficiency	Baseline efficiency is defined as a single pane of Jalousie mobile home window.
Baseline Source	Don't know

Source	Baseline Efficiency/Notes
MA	**It's complicated** (glazing area plus inputs derived from energy modeling in addition to assumptions about HVAC efficiency)
CT	
VT	
Mid-Atlantic	
ME	
NY	

Recommendation: Additional research to determine if baseline update is needed.

- No interview data for window retrofits.
- Research in other areas has demonstrated high penetration of double pane windows in existing homes.

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Residential: HVAC – Heating Systems – Gas Furnaces

Measure Name	HVAC – Furnaces
Program Type	Retrofit/Lost Opportunity
Description	Installation of a new high efficiency space heating furnace with an electronically commutated motor (ECM) for the fan.
Baseline Efficiency	83% AFUE rated furnace for early replacement and an 85% AFUE furnace for lost opportunity
Baseline Source	83% AFUE: New Hampshire Potential Study Volume III: Residential Market Baseline Study 85% AFUE: baseline represents value negotiated in MA for new boilers, which is applied to furnaces in this case.

Source	Baseline Efficiency/Notes
MA	81% AFUE when replacing non-condensing existing unit
CT	85% AFUE (gas)
VT	88% AFUE
Mid-Atlantic	80% AFUE, 81% AFUE (Weatherized)
ME	87% AFUE
NY	80% AFUE

Recommendation: Consider mirroring the MA condensing exhaust clause for setting a split baseline.

- Current baselines are within range set by comparison areas.
- Split baseline could yield slightly higher savings in sites without an existing condensing exhaust (if implementing a lower baseline)

Supplemental findings:

- HVAC contractors suggested furnaces installed in existing homes are almost always condensing (5/6 respondents said ≥ 90%); new construction respondents (builders, code officials, HERS raters) suggested much lower frequency of condensing units in new homes (30-50%)

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Residential: HVAC – Heating Systems – Gas Boilers

Measure Name	HVAC – Boilers
Program Type	Retrofit/Lost Opportunity
Description	Installation of a new high efficiency forced hot water boiler for space heating.
Baseline Efficiency	Early replacement: 84% AFUE Lost opportunity: 85% AFUE
Baseline Source	84% AFUE: New Hampshire Potential Study Volume III: Residential Market Baseline Study 85% AFUE: baseline represents value negotiated in MA for new boilers

Source	Baseline Efficiency/Notes
MA	80.4% AFUE when replacing a non-condensing existing unit.
CT	85% AFUE
VT	86.7% AFUE
Mid-Atlantic	82% AFUE
ME	87% AFUE
NY	80% AFUE (Steam), 82% AFUE (Hot Water)

Recommendation: As with furnaces, consider adopting the split baseline using the presence of a condensing exhaust.

- Current baseline values are within range set by comparison areas and do not give off red flags.
- IDIs suggest vast majority of units being installed in existing units are condensing, but there was less data on preexisting conditions and presence of a condensing exhaust.
  - This is the case for furnaces as well.

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Residential: New Construction

- **Recommendation: Update UDRH where necessary to reflect transition from IECC 2015 (with NH amendments) to IECC 2018 (with NH amendments) in summer of 2022.**
  - Concurrency period for 2015 and 2018 codes ended in January of 2023
  - IDI data limited but suggests code compliance is very high. Limited occurrences of exceeding code, not enough evidence to suggest ISP is above code.
  - Limited IDI data for northern NH, but two respondents confirmed high compliance with additional AGW requirement (R-5 continuous)
  - Most homes meet general ceiling R-value requirement w/out using raised heel (energy) truss to install a lower R-value
  - Inconsistent application of blower door tests and limited feedback on meeting the updated 3 ACH50 requirement.
    - Similar feedback on duct testing and duct insulation

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Thank You

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Appendix

C&I: HVAC – Heating Systems – Condensing Unit Heaters

Measure Name	**HVAC – Heating Systems – Condensing Unit Heaters**
Program Type	Lost Opportunity
Description	Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.
Baseline Efficiency	The baseline efficiency case is a standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting or an automatic flue damper.
Baseline Source	2015 International Energy Conservation Code

Source	Baseline Efficiency/Notes
MA	Unit savings for the heaters are deemed based on study results, with a deemed savings of 40.9 MMBtu for condensing unit heaters (<=300 mbh).
CT	25% higher than an efficient unit heater of the same heating load.
NY	Baseline efficiency is defined by Code of Federal Regulations (CFR) and subsequently adopted by the Energy Conservation Construction Code of New York State.

Recommendation

– No update. Current baseline is sufficient.

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C&I: HVAC – Unitary Air Conditioner

Measure Name	HVAC – Unitary Air Conditioner
Program Type	Lost Opportunity
Description	This measure promotes the installation of high efficiency unitary air conditioning equipment in lost opportunity applications.
Baseline Efficiency	The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by New Hampshire State Building Code.
Baseline Source	IECC 2018

Source	Baseline Efficiency/Notes
MA	IECC 2018
CT	IECC 2021
Mid-Atlantic	IECC 2012 and IECC 2015
ME	IECC 2015
NY	ECCCNYS 2020

Recommendation

- No update. Current baseline is sufficient.
- Could time update based on adoption of IECC 2021.

- Some minor changes to some baselines in IECC 2021.

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C&I: Motors & Drives – Variable Frequency Drive (VFD)

Measure Name	Motors & Drives – Variable Frequency Drive (VFD)
Program Type	Retrofit/Lost Opportunity
Description	The installation of a high efficiency natural gas fired condensing hot water boiler.
Baseline Efficiency	The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor.
Baseline Source	kWh/HP: Chan, Tumin, 2010. Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR kW/HP: kW/HP estimates derived from Cadmus, 2012

Source	Baseline Efficiency/Notes
MA	Chan, Tumin, 2010. Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR
CT	ASHRAE default performance curves, via ASHRAE 90.1-1989 User's Manual
VT	Cadmus. Variable Speed Drive Loadshape Study. Prepared for Northeast Energy Efficiency Partnership. August 2014
ME	Chan, Tumin, 2010. Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR
NY	Chan, Tumin, 2010. Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR

Recommendation

- No update. Current baseline is sufficient.

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Residential: Ductless Mini-Split Heat Pump

Measure Name	Ductless Mini Split Heat Pump
Program Type	Retrofit/Lost Opportunity
Description	This measure includes the installation of a high-efficiency, ductless, mini-split heat pump unit (DMSHP) to serve the heating and cooling loads of a residential unit.
Baseline Efficiency	The baseline is a code compliant 2.2-ton, SEER 14.0, HSPF 8.2 heat pump unit
Baseline Source	International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps

Source	Baseline Efficiency/Notes
MA	SEER 15, HSPF 8.2
CT	SEER 14, HSPF 8.2
VT	SEER 14.5, HSPF 8.2 (multi-head)
Mid-Atlantic	SEER 14, HSPF 8.2
ME	SEER 14, HSPF 8.2
PA	SEER 14 (ROB)/13.5 (ER), HSPF 8.2
RI	SEER 15, HSPF 8.2

- **Recommendation**
  - Low priority for additional research needed in IDIs. Tied to federal standards/code and in line with literature review findings for other states.
  - Potential research topics: Greater proportion of CCHP use due to climate? Variation across state?
  - Baselines could evolve quickly given rapid market adoption

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Residential: HVAC – Central Air-Source Heat Pumps

Measure Name	HVAC – Central Air Source Heat Pumps
Program Type	Retrofit/Lost Opportunity
Description	This measure includes the installation of a high-efficiency, central air-source heat pump unit (ASHP) to serve the heating and cooling loads of a residential unit.
Baseline Efficiency	For lost opportunity or replace on failure, the baseline is a code-compliant 2.8-ton, SEER 14, HSPF 8.2 heat pump unit.
Baseline Source	International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps

Source	Baseline Efficiency/Notes
MA	SEER 14, HSPF 8.2
CT	SEER 14, HSPF 8.2
VT	SEER 14, HSPF 8.2
Mid-Atlantic	SEER 14, HSPF 8.2
NY	SEER 14, HSPF 8.2
PA	SEER 14 (ROB/NC), 13.5 (ER), HSPF 8.2

- **Recommendation**
  - No further research necessary in IDIs. Uses codes and standards and consistent with comparison areas.

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Residential: HVAC – Wi-Fi Communicating Thermostat

Measure Name	HVAC – Wi-Fi Communicating Thermostat
Program Type	Retrofit
Description	A communicating Wi-Fi enabled thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems.
Baseline Efficiency	The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.
Baseline Source	Deemed savings based on 2018 MA impact evaluation

Source	Baseline Efficiency/Notes
MA	HVAC system with either a manual or a programmable thermostat.
CT	Manual or programmable thermostat
VT	For existing homes, the baseline is assumed to be a mix of programmable and manual thermostats. (67% manual and 33% programmable)
Mid-Atlantic	The baseline equipment is an assumed (defaulted) mix of manual and programmable thermostats.
ME	Existing, non-programmable thermostat
NY	HVAC system using fossil fuel and electricity to provide space heating and cooling controlled by a non-Wi-Fi communicating programmable thermostat.

- **Recommendation**
  - Do not include for additional IDI research.
  - Usually deemed based on impact evaluation findings
    - Updates require new deemed savings from impact evaluation findings.

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Residential: Appliance - Clothes Dryer

Measure Name	Appliance – Clothes Dryer
Program Type	Retrofit/Lost Opportunity
Description	Clothes dryers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or most efficient.
Baseline Efficiency	3.73 CEF
Baseline Source	Federal standard as of January 1, 2015

Source	Baseline Efficiency/Notes
MA	3.11 CEF (adjustment of 3.73 to account for different testing procedures)
PA	3.73 CEF standard (3.27 or 3.61 CEF for compact)
VT	3.11 CEF (electric, see MA explanation) and 2.84 CEF (gas)
Mid-Atlantic	3.11 CEF standard electric; 2.13-3.11 CEF range based on config.
NY	3.73 CEF (standard electric, vented); 2.55-3.73 CEF depending on configuration.

- **Recommendation**
  - Do not include for additional baseline research through IDIs
  - Mimic correction for DOE/ENERGY STAR testing differences (3.73 -> 3.11)

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Residential: Clothes Washer

Measure Name	Appliance - Clothes Washer
Program Type	Retrofit/Lost Opportunity
Description	Clothes washers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or Most Efficient.
Baseline Efficiency	Top-loading 1.57 IMEF, Front Loading,1.84 IMEF
Baseline Source	Federal Standards (1.84 IMEF = 2015. 1.57 IMEF = 2018)

Source	Baseline Efficiency/Notes
MA	1.57 IMEF (Top Loading)
PA	Top-loading 1.57 IMEF, Front Loading,1.84
VT	Top-loading 1.57 IMEF, Front Loading,1.84
Mid-Atlantic	Top-loading 0.84 IMEF, Front Loading,1.0 IMEF; Top-loading 1.57 IMEF, Front Loading,1.84 (split based on measure life assumptions)
ME	1.29 IMEF top loading 1.84 front loading
NY	Top-loading 1.57 IMEF, Front Loading,1.84

- **Recommendation**
  - Do not include for additional baseline research through IDIs
  - Tied to codes and standards, consistent across comparison areas.

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Residential: Refrigerator

Measure Name	Appliance – Refrigerators
Program Type	Retrofit/Lost Opportunity
Description	Refrigerators exceeding minimum qualifying efficiency standards established as ENERGY STAR®.
Baseline Efficiency	Ra refrigerator that meets the Federal standard effective September 15, 2014. Specific baseline coefficients and constants by product class found in the Code of Federal Regulations, 10 CFR 430.32(a).
Baseline Source	10 CFR 430.32(a).

Source	Baseline Efficiency/Notes
MA	Federal standards based on configuration
CT	Federal standards based on configuration (references VT TRM)
VT	Federal standards based on configuration
Mid-Atlantic	Federal standards based on configuration
ME	Federal standards based on configuration
NY	Federal standards based on configuration

- **Recommendation**
  - Do not include for additional research in IDIs.

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Residential: Other Findings from In-Depth Interviews

- **Takeaways**
  - Most respondents had a positive sentiment towards the EE program
  - Respondents would like to see changes toward insulation code, the expansion of the EE program, and code compliance
- **Recommendations**
  - Offer interest free financing
  - Require municipal inspectors to be ICC certified
  - Stronger enforcement of insulation code, window standards, and air sealing standards
  - Offer rebate support for window and HP measures

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Appendix D Methods

The study used a literature review and a series of in-depth interviews (IDIs) with market actors to generate recommendations on the baseline assumptions used by the NHSaves portfolio of programs:

3. For both the residential and commercial sectors, the team compiled and synthesized relevant data and findings for the new construction, add-on, replace on failure, and retrofit markets regarding ISP, code compliance, and measure-level efficiencies from New Hampshire and comparison areas such as Massachusetts and Vermont.
4. For both the residential and commercial sectors, the team conducted in-depth interviews with a variety of market actors including builders, HVAC contractors, HERS raters, and architects who work in New Hampshire, plus a subset who work in both New Hampshire and in neighboring states.

The literature review evolved into two phases: a first phase of broad secondary data collection followed by a measure prioritization process designed to narrow the scope of data collection into something manageable within the study budget. This was necessary given the interest in assessing current baselines across the portfolio and the time constraints of primary data collection with busy market actors. Assessing baselines for both the residential and commercial new construction markets were priorities for the New Hampshire utilities and each sector covers a wide array of measures (e.g., the suite of measures that comprise the User-Defined Reference Home (UDRH) for residential new construction), so measure prioritization was used to narrow down the retrofit measures covered in IDIs. Below the evaluators summarize the initial secondary data review, the measure prioritization process, and the process of designing and fielding the IDIs.

D.1 Literature Review Summary

The literature review served all research objectives of the study, covering the Northeast and other jurisdictions where a history of evaluation findings around baseline practices, ISP, and other relevant topics were available. Specific topics covered in the literature review included:

- New construction practices in New Hampshire
- New construction practices in neighboring states (Massachusetts, Vermont, Maine, and Connecticut)
- Baselines, industry standard practice (ISP), and methods used to evaluate them in neighboring states
- Baseline practices and evaluation methods in other leading regions and states (e.g., the Pacific Northwest or California)
- Options for baseline characterization and associated trade-offs

The team began a review of evaluation findings for New Hampshire programs as part of project planning and covered foundational resources including the 2020 New Hampshire Potential Study, recent new construction evaluations, and the New Hampshire technical reference manual (TRM). For other jurisdictions the primary targets of the review were TRMs published by regulators and

program administrators along with evaluation reports establishing measure baselines for various market events. While reviewing these resources the evaluation team compiled measure baseline values and reviewed the methods by which baseline values were developed. As part of this process, the sources of baseline values were assessed based on several factors, including the use of federal standards or state codes and various attributes of evaluation studies if they were used as a source, including the age, location, and sample sizes of the study. Table 23 summarizes the types of documents included and the geographic coverage of the literature review. Appendix A also includes a list of references.

Table 23: Literature Review Source Summary

State	Documents Reviewed	Market Events Covered
New Hampshire	TRM, RNC Baseline Evaluation, Potential Study	All
Massachusetts	TRM, RNC Baseline Evaluation, NRNC Market Characterization Study[22], Gas Boiler Market Characterization Study[23], MA ISP Repository	All
Vermont	TRM, RNC Baseline Evaluation, NRNC Market Characterization Study	All
New York	TRM, Residential Baseline Evaluation, Energy Conservation Construction Code of New York State (ECCCNYS)	All
Maine	TRM, RNC Baseline Evaluation	All
Mid-Atlantic	TRM	All
Connecticut	TRM, Residential Appliance Saturation Survey, RNC Baseline Evaluation	All
Rhode Island	TRM, Residential Appliance Saturation Survey, RNC Baseline Evaluation	All
Pennsylvania	TRM	All
Michigan	RNC Evaluation (Non-baseline)	New Construction
Washington	RNC Baseline Evaluation	New Construction

[22] https://ma-eeac.org/wp-content/uploads/MA19C08-B-NRNCMKT-NRNC-Market-Characterization-Study-Final-Report.pdf
[23] https://ma-eeac.org/wp-content/uploads/Gas-Boiler-Market-Characterization-Study-Phase-II-Final-Report.pdf

As the evaluation team compiled baseline values and their sources, they flagged measures for which patterns emerged, for example a consistent use of federal standards or code-based values across jurisdictions. They also compiled findings from the *Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023* (the NH Potential Study) [24] to assess which measure types were estimated to be the largest source of future savings in the New Hampshire portfolio.

D.1.1 Measure Prioritization

Once all relevant foundational data had been compiled and reviewed, the team began the measure prioritization process. The potential study findings were used to prioritize measures based on their expected contribution to portfolio energy savings over the three-year period after the report was released (2021 – 2023). Total projected annual and lifetime savings were factored in, as was the savings trajectory, whether that measure was projected to contribute to portfolio savings over time. The team then used a review of TRM sources and their understanding of baseline quantification to narrow down the high-savings measures into a final set of recommended measures for deeper research. For example, envelope upgrade measures (e.g., adding attic insulation) represent high-savings measures but the baseline is tied to existing conditions at a site, so further research for retrofit baselines was not necessary. The measure prioritization process ultimately binned measures into three categories:

1. Measures for which current baselines are sufficient
2. Measures for which current baselines could be updated using the literature review results
3. Measures for which current baselines should be informed through in-depth interviews

Table 24 shows an example of the prioritization process (with logic moving left to right) for three residential measures. Both refrigerators and heat pump water heaters (HPWHs) are projected to contribute significantly to residential portfolio electric savings, but while refrigerators consistently used federal standards to set baselines in New Hampshire and comparison areas, HPWHs showed a more diverse set of baseline values. Several nearby states (Massachusetts, Vermont, New York, and states that use the Mid-Atlantic TRM) use federal standards to set the baseline for HPWHs, whereas New Hampshire continues to leverage evaluation findings from Connecticut that are roughly five years old. The combination of projected savings, differences in baseline methodologies, and the age of the baseline source fueled a recommendation to include HPWHs in the IDIs. Wi-Fi communicating thermostats are another measure projected to deliver significant gas and electric savings, but baselines are often deemed values set through impact evaluations, making this measure difficult to assess through qualitative data collection.

[24] 20201016-NHSaves-Potential Study-Final Report-Volume I.pdf

Table 24: Example of Measure Prioritization Process

Measure	Potential savings	NH baseline	Comparison baselines similar?	Comparison baselines appropriate?	Baseline updates out of scope?	Prioritized for IDI research?
Refrigerator	High	Federal Standards	Yes	Yes (standards-based)	No	**No**
Wi-Fi Thermostat	High	Deemed based on impact evaluation	Yes	Yes (high-rigor evaluation)	Yes (requires new impact findings)	**No**
Heat Pump Water Heater	High	Evaluation based	No	Yes (standards-based)	No	**Yes**

D.2 IN-DEPTH INTERVIEWS

Once the measure prioritization process was complete, the team moved to conducting IDIs to collect market actor feedback on the measures of interest.

D.2.1 Sample Development

Initially, the team planned to use program tracking data to secure part of the interview sample but learned that market actor contact information was limited. In addition, there was concern about biasing the results by relying too heavily on participating market actors. The team developed sample frames through web research and CMD Group's ConstructConnect® service, which aggregates information on construction projects and the teams working on them to facilitate connections between subcontractors and project leads. Web research covered an array of resources including organizations representing market actors like the American Institute of Architects (AIA) and the Northeast Sustainable Energy Association's (NESEA) partner directory. While these and similar sources yielded some useful contacts, many were outdated or miscategorized, which led to unproductive recruitment efforts.

For residential baseline practices, the market actors included HVAC and water heating contractors as well as general contractors (collectively, "contractors"), builders, and HERS raters. For C&I, the market actors included builders, contractors, architects, and designers. To assess residential and commercial energy codes, the team targeted code officials in different regions of the state, contractors who perform code trainings and outreach, and individuals who work on code development. Some of the key points the team considered when identifying the market actors for IDIs included:

- Size of the firm

- Markets served (new construction, replace on failure, early replacement, and/or add-on)
- Regions served (northern and southern New Hampshire, other neighboring states, etc.)

Table 25 provides a breakdown of interview targets for each market actor type, in addition to the research topics to be covered with each group. The team targeted 25 IDIs for the residential sector and 30 IDIs for C&I with the goal of achieving geographic representation across the state of New Hampshire.

Table 25: Market Actor Interview Targets and Research Goals

Research Topics	Code Officials	Builders	HERS Raters	Contractors	Architects
# of interviews (*n*)	*Res: 3; C&I: 3*	*Res: 6; C&I: 6*	*Res: 5*	*Res: 11; C&I: 15*	*C&I: 6*
Compare baseline policies to actual ISP in the field	☑	☑	☑	☑	☑
Isolate where ISP differs	☑	☑	☑	☑	☑
Compare ISP to code	☑	☑	☑	☑	☑
Considerations for properly characterizing ISP		☑	☑	☑	☑
Impact of legislative changes in NH that have decentralized the administration of code enforcement.	☑	☑	☑	☑	☑
Impact of the NH ES Homes program on the wider RNC market	☑	☑	☑	☑	☑
Recommended updates to RNC & NRNC program requirements (e.g., minimum HERS score) to ensure savings relative to market		☑	☑	☑	☑
Differences in ISP by geography or customer segment	☑	☑	☑	☑	☑
Differences in ISP among residential (SF attached/ detached, MF) and commercial sub-sectors	☑	☑	☑	☑	☑
Impacts in NH of adopting baseline characterization procedures from other states		☑	☑		☑
Impacts of ISP changes on last-to-adopt and cash-strapped population		☑	☑	☑	☑
Recommendations for additional changes to baseline approach beyond new construction			☑	☑	
Priorities for additional ISP research for EE programs		☑	☑	☑	☑

D.2.2 Interview Recruitment

During sample development the team collected all available phone and email contact information for companies and specific contacts, where available. Recruitment began with an email blast to all market actors, after which phone calls were made wherever a phone number was available. All contacts were emailed and called multiple times. Respondents were offered a $100 electronic gift card in response for participation. During sample development, the team identified the measures that each respondent would likely be able to answer based on available information. During recruitment, the team confirmed that the respondent had the relevant experience to answer for multiple measures of interest before scheduling the interview.

During recruitment, the team attempted to strike a balance between market actors that work both in New Hampshire and neighboring states and those that work only within New Hampshire. Market actors working in New Hampshire and neighboring states were intended to help provide some perspective on neighboring state baseline practices and how those might differ from New Hampshire. Because market actors working in multiple states could be concentrated in larger firms and/or only work in more populated areas of New Hampshire, the team also targeted market actors that work only within New Hampshire to better represent smaller firms and cover more remote regions of the state.

D.2.3 Recruitment Results

The team completed 29 interviews out of a target of 55 (53%), as shown in Table 26.

The team found interview recruitment to be challenging. As mentioned earlier, there were some quality issues with the sample derived from third-party resources. In addition, many of the market actors the team was able to speak with were unwilling to participate, with most citing schedule constraints. These issues manifested among both the residential and C&I samples. After multiple contact attempts by phone and email, the team ceased recruitment and began analysis to provide findings in time for the utilities' reporting needs.

Table 26: Completed Interviews

Market Actor Type	Sector	Target Completes	Achieved Completes
Code official	C&I	3	3
Code official	Res	3	3
Builder	C&I	6	2
Builder	Res	6	4
Contractor	C&I	15	7
Contractor	Res	11	6
HERS Rater	Res	5	2
Architect	C&I	6	2
Total	All	55	29

D.2.4 Interview Guides

Interview guides were designed to be modular, allowing respondents to provide information only on measures with which they were familiar. Separate modules were developed for residential and C&I new construction as well as a variety of retrofit and lost-opportunity measures. Appendix B contains the full interview guides for reference.

Appendix E C&I Baseline Efficiency Tables

This part lists the specific minimum efficiency requirements for some C&I measures discussed in Section 3.

E.1 BASELINE LPD FOR INTERIOR LIGHTING

The NH Baseline LPD values are defined by Industry Standard Practice (ISP), which differs from IECC 2018. The baseline LPD values are defined using 0.60 adjustment factor applied to the IECC 2015 values. The IECC 2015 values are provided below for reference.

Table 27: New Construction Interior Lighting Baseline Values (Building Area Method)

Building Type	NH ISP	IECC 2015
Automotive facility	0.48	0.8
Convention center	0.61	1.01
Courthouse	0.61	1.01
Dining: bar lounge/leisure	0.61	1.01
Dining: cafeteria/fast food	0.54	0.9
Dining: family	0.57	0.95
Dormitory	0.34	0.57
Exercise center	0.5	0.84
Fire station	0.4	0.67
Gymnasium	0.56	0.94
Health care clinic	0.54	0.9
Hospital	0.63	1.05
Hotel/Motel	0.52	0.87
Library	0.71	1.19
Manufacturing facility	0.7	1.17
Motion picture theater	0.46	0.76
Multifamily	0.31	0.51
Museum	0.61	1.02
Office	0.49	0.82
Parking garage	0.13	0.21
Penitentiary	0.49	0.81
Performance arts theater	0.83	1.39
Police Station	0.52	0.87
Post office	0.52	0.87
Religious building	0.6	1

Building Type	NH ISP	IECC 2015
Retail	0.76	1.26
School/university	0.52	0.87
Sports arena	0.55	0.91
Town hall	0.53	0.89
Transportation	0.42	0.7
Warehouse	0.4	0.66
Workshop	0.71	1.19

Table 28: New Construction Interior Lighting Baseline Values (Space-by-Space Method)

Common/Building Specific	Space Type	NH ISP	IECC 2015
Common Space types	Audience seating area - In a convention center	0.49	0.82
Common Space types	Audience seating area - In a gymnasium	0.39	0.65
Common Space types	Audience seating area - In a motion picture theater	0.68	1.14
Common Space types	Audience seating area - In a penitentiary	0.17	0.28
Common Space types	Audience seating area - In a performing arts theater	1.46	2.43
Common Space types	Audience seating area - In a religious building	0.92	1.53
Common Space types	Audience seating area - In a sports arena	0.26	0.43
Common Space types	Audience seating area - In an auditorium	0.38	0.63
Common Space types	Audience seating area - OTHERWISE	0.26	0.43
Common Space types	Banking activity area	0.61	1.01
Common Space types	Classroom/lecture hall/ training room - In a penitentiary	0.8	1.34
Common Space types	Classroom/lecture hall/ training room - OTHERWISE	0.74	1.24
Common Space types	Computer Room	1.03	1.71
Common Space types	Conference/meeting/multipurpose room	0.74	1.23
Common Space types	Copy/Print Room	0.43	0.72
Common Space types	Corridor - facility for visually impaired (not primarily used by staff)	0.55	0.92
Common Space types	Corridor - In a hospital	0.47	0.79
Common Space types	Corridor - In a manufacturing facility	0.25	0.41
Common Space types	Corridor - OTHERWISE	0.4	0.66
Common Space types	Courtroom	1.03	1.72
Common Space types	Dining area - facillity for visually impaired (not primarily used by staff)	1.14	1.9
Common Space types	Dining area - In a penitentiary	0.58	0.96

Common/Building Specific	Space Type	NH ISP	IECC 2015
Common Space types	Dining area - In bar/lounge or leisure dining	0.64	1.07
Common Space types	Dining area - In cafeteria or fast food dining	0.39	0.65
Common Space types	Dining area - In family dining	0.53	0.89
Common Space types	Dining area - OTHERWISE	0.39	0.65
Common Space types	Electrical/mechanical	0.57	0.95
Common Space types	Emergency vehicle parking	0.34	0.56
Common Space types	Food preparation	0.73	1.21
Common Space types	Guest room	0.28	0.47
Common Space types	Laboratory - In or as classrooms	0.86	1.43
Common Space types	Laboratory - OTHERWISE	1.09	1.81
Common Space types	Laundry/washing area	0.36	0.6
Common Space types	Loading dock, interior	0.28	0.47
Common Space types	Lobby - facility for visually impaired (not primarily used by staff)	1.08	1.8
Common Space types	Lobby - for an elevator	0.38	0.64
Common Space types	Lobby - In a hotel	0.64	1.06
Common Space types	Lobby - In a motion picture theater	0.35	0.59
Common Space types	Lobby - In a performing arts theater	1.2	2
Common Space types	Lobby - OTHERWISE	0.54	0.9
Common Space types	Locker room	0.45	0.75
Common Space types	Lounge/breakroom - In a healthcare facility	0.55	0.92
Common Space types	Lounge/breakroom - OTHERWISE	0.44	0.73
Common Space types	Office - enclosed (<=250 sqft)	0.67	1.11
Common Space types	Office - enclosed (>250 sqft)	0.67	1.11
Common Space types	Office - open plan	0.59	0.98
Common Space types	Parking area, interior	0.11	0.19
Common Space types	Pharmacy area	1.01	1.68
Common Space types	Restroom - facility for visually impaired (not primarily used by staff)	0.73	1.21
Common Space types	Restroom - OTHERWISE	0.59	0.98
Common Space types	Sales area	0.95	1.59
Common Space types	Seating area, general	0.32	0.54
Common Space types	Stairwell	0.41	0.69
Common Space types	Storage room	0.38	0.63
Common Space types	Vehicular Maintenance area	0.4	0.67

Common/Building Specific	Space Type	NH ISP	IECC 2015
Building Specific Space Types	Convention center - exhibit space	0.87	1.45
Building Specific Space Types	Dormitory - living quarters	0.23	0.38
Building Specific Space Types	Facility for visually impaired - In a Chapel (not primarily used by staff)	1.33	2.21
Building Specific Space Types	Facility for visually impaired - In a rec room (not primarily used by staff)	1.45	2.41
Building Specific Space Types	Fire Station - sleeping quarters	0.13	0.22
Building Specific Space Types	Gymnasium/fitness center - In a playing area	0.72	1.2
Building Specific Space Types	Gymnasium/fitness center - In an exercise area	0.43	0.72
Building Specific Space Types	Healthcare Facility - In a medical supply room	0.44	0.74
Building Specific Space Types	Healthcare Facility - In a nursery	0.53	0.88
Building Specific Space Types	Healthcare Facility - In a patient room	0.37	0.62
Building Specific Space Types	Healthcare Facility - In a physical therapy room	0.55	0.91
Building Specific Space Types	Healthcare Facility - In an exam/treatment room	1	1.66
Building Specific Space Types	Healthcare Facility - In an imaging room	0.91	1.51
Building Specific Space Types	Healthcare Facility - In a nurse's station	0.43	0.71
Building Specific Space Types	Healthcare Facility - In an operating room	1.49	2.48
Building Specific Space Types	Healthcare Facility - In a recovery room	0.69	1.15
Building Specific Space Types	Library - In a reading area	0.64	1.06
Building Specific Space Types	Library - In the stacks	1.03	1.71
Building Specific Space Types	Manufacturing - In a detailed manufacturing area	0.77	1.29
Building Specific Space Types	Manufacturing - In a high bay area (25-50-foot floor-ceiling height)	0.74	1.23
Building Specific Space Types	Manufacturing - In a low bay area (<25-foot floor-ceiling height)	0.71	1.19
Building Specific Space Types	Manufacturing - In an equipment room	0.44	0.74
Building Specific Space Types	Manufacturing - In an extra high bay area (>50-foot floor-ceiling height)	0.63	1.05
Building Specific Space Types	Museum - In a general exhibition area	0.63	1.05
Building Specific Space Types	Museum - In a restoration room	0.61	1.02
Building Specific Space Types	Performing arts theater - dressing room	0.37	0.61
Building Specific Space Types	Post office - sorting area	0.56	0.94
Building Specific Space Types	Religious building - In a fellowship hall	0.38	0.64
Building Specific Space Types	Religious building - In a worship/pulpit/choir area	0.92	1.53
Building Specific Space Types	Retail - In a dressing/fitting area	0.43	0.71
Building Specific Space Types	Retail - In a mall concourse	0.66	1.1
Building Specific Space Types	Sports arena - playing area - For a Class I facility	2.21	3.68

Common/Building Specific	Space Type	NH ISP	IECC 2015
Building Specific Space Types	Sports arena - playing area - For a Class II facility	1.44	2.4
Building Specific Space Types	Sports arena - playing area - For a Class III facility	1.08	1.8
Building Specific Space Types	Sports arena - playing area - For a Class IV facility	0.72	1.2
Building Specific Space Types	Transportation facility - At a terminal ticket counter	0.48	0.8
Building Specific Space Types	Transportation facility - In a baggage/carousel area	0.32	0.53
Building Specific Space Types	Transportation facility - In an airport concourse	0.22	0.36
Building Specific Space Types	Warehouse - storage area - For medium to bulky, palletized items	0.35	0.58

E.2 BASELINE LPD FOR EXTERIOR LIGHTING

The NH Baseline LPD values are defined by Industry Standard Practice (ISP), which differs from IECC 2018. The baseline LPD values are defined using 0.67 adjustment factor applied to the IECC 2015 values. The IECC 2015 values are provided below for reference. Only tradable surfaces LPDs (uncovered parking areas, building grounds, building entrances, exits and loading docks, canopies and overhangs, and outdoor sales areas may be traded) are adjusted based on this study.

Table 29: New Construction Exterior Lighting Baseline Values

	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (base allowance may be used in tradable or non-tradable surfaces)	500 W	600 W	750 W	1300 W
Uncovered Parking Areas				
Parking areas and drives	0.03 W/ft2	0.04 W/ft2	0.07 W/ft2	0.09 W/ft2
Building Grounds				
Walkways less than 10 ft wide	0.5 W/linear foot	0.5 W/linear foot	0.5 W/linear foot	0.7 W/linear foot
Walkways 10 ft wide or greater, plaza areas Special feature areas	0.09 W/ft2	0.09 W/ft2	0.11 W/ft2	0.13 W/ft2
Stairways	0.50 W/ft2	0.67 W/ft2	0.67 W/ft2	0.67 W/ft2
Pedestrian tunnels	0.10 W/ft2	0.10 W/ft2	0.13 W/ft2	0.20 W/ft2
Building Entrances, Exits, and Loading Docks				
Main entries	13 W/linear foot of door width	13 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
Other doors	13 W/linear foot of door width	13 W/linear foot of door width	13 W/linear foot of door width	13 W/linear foot of door width
Entry canopies	0.17 W/ft2	0.17 W/ft2	0.27 W/ft2	0.27 W/ft2
Sales Canopies				

	Zone 1	Zone 2	Zone 3	Zone 4
Free standing and attached	0.40 W/ft2	0.40 W/ft2	0.54 W/ft2	0.67 W/ft2
Outdoor Sales				
Open areas (including vehicle sales lots)	0.17 W/ft2	0.17 W/ft2	0.34 W/ft2	0.47 W/ft2
Street frontage for vehicle sales lots in addition to "open area" allowance	7 W/linear foot	7 W/linear foot	7 W/linear foot	20 W/linear foot

E.3 Baseline Efficiency for C&I Boilers

For replace-on-failure event, the baseline efficiency follows IECC 2018 table C403.2.3(5).

For new construction, the baseline efficiency for gas fired hot water boiler is 15% better than IECC 2015 table C403.2.3(5); for the other types of boilers, the baseline efficiency follows IECC 2018 table C403.2.3(5).

Table 30: Baseline Efficiency for C&I Boilers – Hot Water

	Replace-on-failure (ROF)	New Construction (NC)		
Capacity (Input, MBH)	Gas-fired	Oil-fired	Gas-fired	Oil-fired
< 300	82% AFUE	84% AFUE	92% AFUE	84% AFUE
≥ 300 and ≤ 2,500	80% Et	82% Et	92% Et	82% Et
> 2,500	82% Ec	84% Ec	82% Ec	84% Ec

Table 31: Baseline Efficiency for C&I Boilers – Steam

	ROF and NC			
Capacity (Input, MBH)	Gas-fired	Gas-fired all, except natural draft	Gas-fired, natural draft	Oil-fired
< 300	80% AFUE	N/A	N/A	82% AFUE
≥ 300 and ≤ 2,500	N/A	79% Et	77% Et	81% Et
> 2,500	N/A	79% Et	77% Et	81% Et

E.4 Baseline Efficiency for NC Heat Pumps

For new construction air source heat pump, the baseline efficiency is 1% better for cooling and 3% better for heating, comparing to IECC 2015 Table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps.

Table 32: Baseline Efficiency for NC Air-Cooled Heat Pumps

Equipment Type	Type Size (MBH)	Minimum Efficiency
Air cooled	< 65	Split: 14.1 SEER, 8.4 HSPF Packaged: 14.1 SEER, 8.2 HSPF

Equipment Type	Type Size (MBH)	Minimum Efficiency
Through the wall	≤ 30	Split: 12.1 SEER, 7.6 HSPF Packaged: 12.1 SEER, 7.6 HSPF
Single-duct high-velocity	< 65	Split: 11.1 SEER, 7.0 HSPF
Air cooled	≥ 65 and < 135	11.1 EER & 12.1 IEER (electric heat or no heat) 10.9 EER & 11.9 IEER (other heat) 3.4 COP (47°F db/43°F wb) 2.32 COP (17°F db/ 15°F wb)
Air cooled	≥ 135 and < 240	10.7 EER & 11.7 IEER (electric heat or no heat) 10.5 EER & 11.5 IEER (other heat) 3.3 COP (47°F db/43°F wb) 2.11 COP (17°F db/ 15°F wb)
Air cooled	≥ 240	9.6 EER & 10.7 IEER (electric heat or no heat) 9.4 EER & 9.5 IEER (other heat) 3.3 COP (47°F db/43°F wb) 2.11 COP (17°F db/ 15°F wb)