Economic Impacts of the NHSaves Programs

Submitted to the New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group

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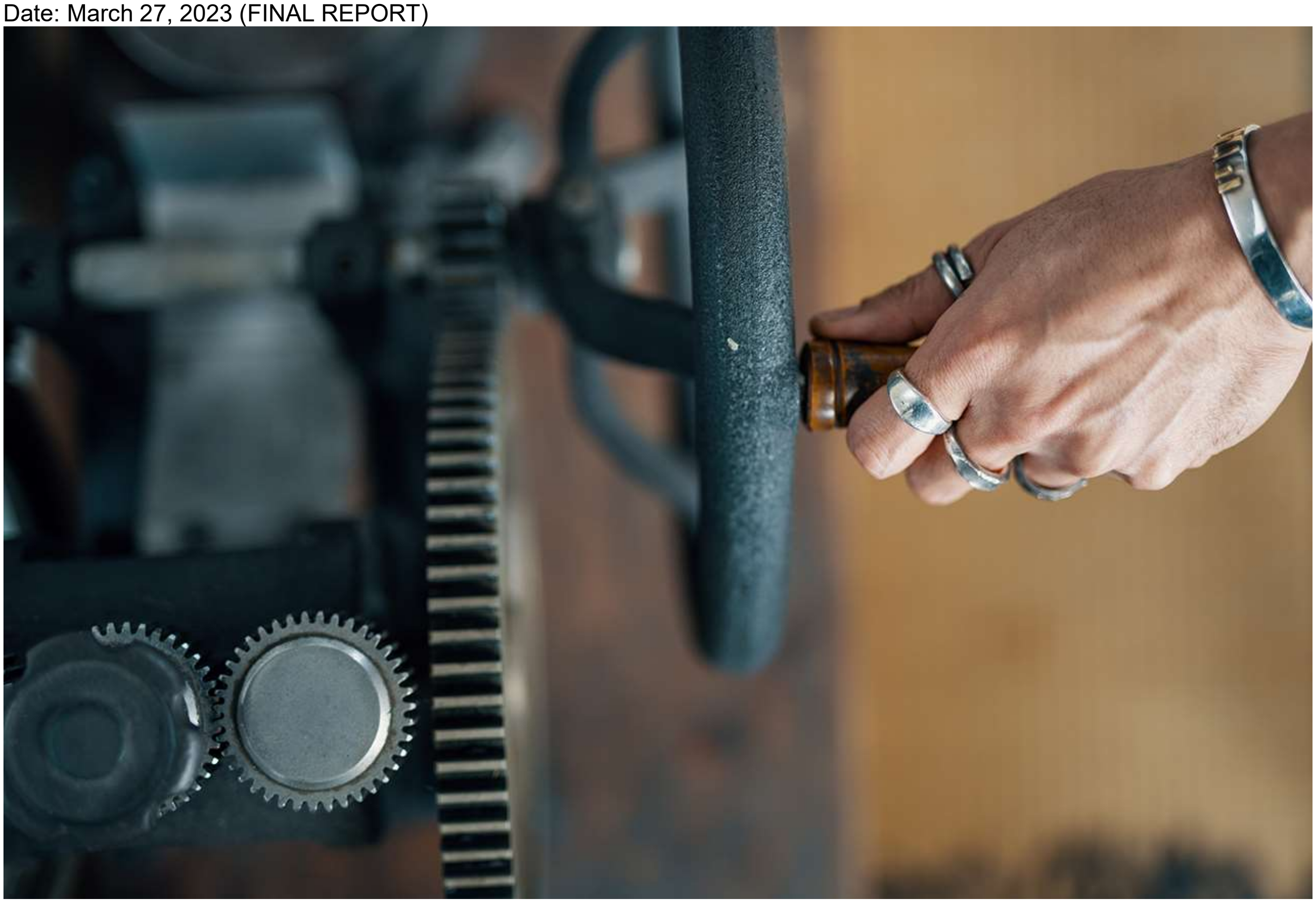

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1 EXECUTIVE SUMMARY

1.1 Background

New Hampshire statutes frequently mention the importance of economic benefits associated with energy policies and programs. For instance, the New Hampshire Revised Statutes on integrated least-cost resource planning state: “The following order of energy policy priorities shall guide the commission's evaluation: energy efficiency and other demand-side management resources; renewable energy sources; all other energy sources. *The Commission must consider potential environmental, economic, and health-related impacts of each option proposed by a utility to meet its customers’ needs*.”[1]

The New Hampshire Public Utilities Commission (the Commission) approved the 2022–2023 NHSaves Plan[2] (the Plan) in an order on April 29, 2022,[3] in which it found that the Plan has the potential to positively impact the New Hampshire economy “through achievement of energy savings and through the long-term multiplier effect of energy efficiency projects on the local economy.” It also directed Eversource Energy, Liberty Utilities, the New Hampshire Electric Cooperative (NHEC), and Unitil (the NH Utilities) to “comprehensively study and report on the 2021 and 2022 Plan’s long-term impact on the New Hampshire economy.” The New Hampshire Evaluation, Measurement, and Verification Working Group (EM&V WG) engaged a team of independent evaluators from DNV and Louisiana State University (LSU) (the evaluation team) to conduct this study in response to these directives.[4] The evaluation team developed a workplan for this study in coordination with the members of the EM&V WG, and independently executed the research according to that workplan.

1.2 Methods

There are two general phases during which energy efficiency programs create economic impacts:[5]

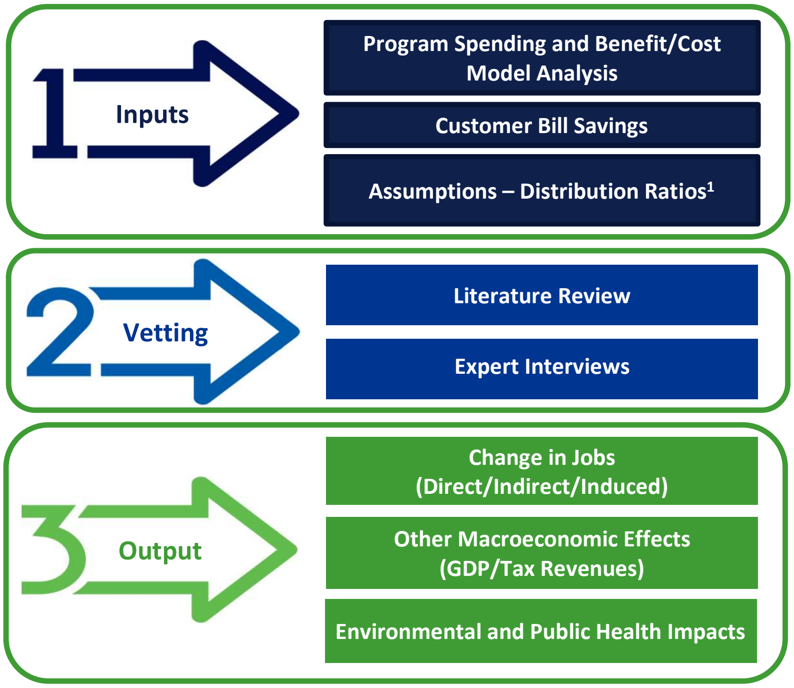
1. The implementation phase, during which economic impacts result from the production and installation of energy efficiency equipment, and
2. The savings phase, after energy efficiency measures are installed and result in energy bill savings that is re-allocated to other spending that creates economic impacts.

The evaluation team used an Input-Output (I/O) modeling approach to analyze the economic impacts from the implementation and savings phases of the 2021 and 2022 NHSaves programs. I/O models allow comprehensive analyses examining industry-wide effects of economic activities and major shifts across sectors,[6] based on economy-wide social accounting matrices that incorporate spending patterns within and across sectors. The evaluation team also estimated the economic value of the health benefits associated with the NHSaves programs, using EPA’s Co-Benefit Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) and Avoided Emissions and Generation Tool (AVERT). Finally, the team interviewed officials at 10 organizations with expertise and knowledge of the NHSaves programs to provide context and insights on the economic impacts of the programs as modeled.

The evaluation team modeled economic impacts using a three-stage approach, summarized in Figure 1-1.

[1] NH Rev Stat § 378:39 (2021)
[2] https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/LETTERS-MEMOS-TARIFFS/20-092_2022-03-01_NH_UTILITIES_NHSAVES-PLAN.PDF.
[3] https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/ORDERS/20-092_2022-04-29_ORDER-26621.PDF
[4] The EM&V WG consists of: (1) representatives from the NH Utilities, (2) staff from the NH Department of Energy (3) independent evaluation consultants under contract to the NH Department of Energy, and (4) an EESE Board member appointed by the Board Chair. This research was conducted under a contract that was competitively procured by the EM&V WG in 2022.
[5] Synapse Energy Economics. New Hampshire Cost-Effectiveness Review, Application of the National Standard Practice Manual to New Hampshire, Oct. 2019.
[6] Miller, Ronald E, and Peter D Blair. 2009. *Input-Output Analysis: Foundations and Extensions*: Cambridge University Press.

Figure 1-1. **Summary of approach for estimating economic impacts**



[1]Distribution ratios reflect the proportions in which program spending is apportioned across different industries/economic sectors.

Key limitation: The economic analyses in this report reflect the overall economic output and employment effects of the NHSaves programs, and are not an accounting of the full costs and benefits of the NHSaves programs. The results presented in this report are complementary to the other gains from energy efficiency projects in New Hampshire as reflected in the Granite State Test (GST),[7] including utility system avoided costs, other fuel and water resource savings, and non-energy benefits such as participants' reduced operations and maintenance costs or improved comfort. Cost-effective energy efficiency programs, by definition, provide a lower-cost alternative to supply-side resources. Even programs with negligible local employment impacts, if cost-effective, have net benefits that ensure they return more to the state's ratepayers in terms of avoided system costs and other energy and non-energy benefits than they cost, regardless of their employment and other economic impacts.

1.3 Results

Table 1-1 summarizes the economic impacts modeled for this study, including their definitions and values. Except where noted, all economic impacts presented in this report reflect impacts on the New Hampshire economy specifically. All employment effects reflect full-time-equivalent (FTE) jobs.[8] Note that employment effects during the implementation phase represent jobs that are created for one program year (2021 or 2022), and so the number of jobs is equivalent to the number of job-years. Employment effects during the savings phase occur in proportion to customer bill savings, over the useful life of the measures installed by the programs. As such, savings phase employment effects represent an aggregate estimate of job years, which are spread out over the life of the program measures for each sector.

[7] The GST is the primary cost-effectiveness test for the NHSaves programs. The NH Utilities calculate the GST using Benefit-Cost models that are filed alongside program plans and reports. The GST was developed through a stakeholder process that culminated in a consensus recommendation to adopt the test, followed by Commission approval of the test. See https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/ORDERS/17-136_2019-12-30_ORDER_26322.PDF The New Hampshire legislature has also established it as the primary cost-effective test for New Hampshire's energy efficiency programs. See https://gencourt.state.nh.us/bill_status/legacy/bs2016/bill_status.aspx?lsr=717&sy=2022&sortoption=&txtsessionyear=2022&txtbillnumber=HB549

[8] FTEs measure total full-time, part-time, and temporary employees, based on the total number of hours worked divided by the number of hours in a full-time schedule.

Table 1-1. Summary of NHSaves' impacts on the New Hampshire economy[1]

Phase	Impact	Definitions	Values
Implementation (program years 2021-2022)	Employment[2]	*Direct effects* accruing to industries involved in production and installation activities	2021: 380.79 jobs (5.09 per $1M) 2022: 359.68 jobs (5.09 per $1M)
		Indirect effects on industries supplying inputs to the sectors benefiting directly	2021: 126.05 jobs (1.68 per $1M) 2022: 118.99 jobs (1.68 per $1M)
		Induced effects, which are second order effects due to increased consumer spending from the income gains made in sectors with direct and indirect effects	2021: 249.13 jobs (3.33 per $1M) 2022: 224.64 jobs (3.18 per $1M)
	New Hampshire gross domestic product (GDP)[2]	Value added reflects the total in-state economic activity generated by the NHSaves programs. It includes direct, indirect, and induced effects. Aggregated across all industries, this value represents the program's contribution to state GDP	Estimated value added associated with the programs was $97 million in 2021, and $87 million in 2022[3]
	Local and state tax revenues	Additional tax revenues generated by the economic activity associated with NHSaves program spending, modeled according to New Hampshire's tax regime	Total estimated tax revenue generation of approximately $3.8 million in 2021 and $3.2 million in 2022
Savings (year of implementation through the end of measures' useful life)	Customer bill savings effects[4]	Gains in employment associated with reduced utility bills, including (1) induced effects from additional disposable household income (e.g., spending on goods and services), and (2) direct, indirect, and induced effects from increased production in the C&I sector	About 1480 total additional job years resulting from long-term bill savings for low-income, residential, and C&I sectors over the lifetime of the program measures
	Public health benefits	Annual monetary value of avoided healthcare costs for New Hampshire citizens from emissions reductions resulting from the NHSaves programs in 2021[5]	Annual benefits range from $68,000 to over $153,000 at a 7% discount rate and from about $76,000 to over $172,000 at a 3% discount rate[6]
		Annual monetary value of avoided healthcare costs for citizens in the contiguous U.S. from emissions reductions resulting from the NHSaves programs in 2021[5]	Annual benefits range from $649,000 to almost $1.5 million at a 7% discount rate and from $727,000 to over $1.6 million at a 3% discount rate[6]

[1] All impacts represent incremental economic effects of each program year independently, relative a no-program counterfactual.
[2] Employment and state GDP effects shown in this table are based on a conservative modeling assumption for the local purchase percentage (LPP), which represents the share of program-rebated materials that are purchased from in-state manufacturers or wholesalers. The team also modeled employment effects with a more aggressive assumption for LPP, as presented in Section 4.1.
[3] These results are generally consistent with other estimates of the impacts of public programs on GDP, which typically find multiplicative effects whereby GDP grows by a factor of 1 or more times the amount of program spending.
[4] Bill savings impacts result from participant energy cost savings, System Benefit Charge costs, and long-term utility system avoided costs. For the NHSaves programs, the net impact of these factors are reductions in overall utility system costs and total customer bills.

[5] Due to limitations in modeling tools and underlying data, the team modeled one year of emissions reductions and associated health impacts from the 2021 programs. The results do not reflect the full emissions and health impacts of 2021 measures over their useful lives.
[6] The range of health impacts estimates reflect the use of different underlying epidemiological studies. The low estimates reflect mortality impacts of PM2.5 as evaluated by the American Cancer society, and the high values reflect results from the Harvard six-city mortality study.

1.3.1 Context for economic impacts

The economic and regulatory context in which the NHSaves programs operate should be considered alongside the quantified economic impacts presented above. In particular, the NHSaves programs experienced uncertainty and funding instability associated with Commission decisions affecting the 2021 and 2022 period modeled in this study.[9] It was not feasible to quantify the economic impacts of these dynamics as part of this study, but based on expert interviews, the uncertainty and funding instability dampened the programs' economic benefits. Interviewees cited the following impacts:

- **Workforce disruption.** Almost all interviewees cited workforce disruptions caused by the decisions. Several noted that the 2021–2023 plan had originally included significant increases in program funding and savings goals, and that despite some uncertainty around the plan due to COVID-19 and other factors, they took steps to prepare for expected funding increases by hiring or otherwise ramping up in advance of the 2021 program year. This ramp-up exacerbated the impact of the subsequent decisions, which in some cases included layoffs of contractors or other staff.
- **Customer impacts.** Most interviewees we spoke with also cited customer impacts caused by the decisions. For customers with projects in progress at the time of the decisions, many of the projects were put on hold, some of them indefinitely. For customers considering participating but without projects in progress, they often did not know if they would be able to participate because the NH Utilities could not tell customers what to expect in terms of funding. Some larger customers faced particular challenges financing projects, such as affordable housing projects that utilize multiple inter-related funding sources, for which predictable timing is important in planning and assembling financing. Similarly, large industrial participants require predictable timing in project funding in order to align with their annual capital planning cycles, and funding uncertainty negatively impacted their ability to install efficient equipment through NHSaves.

The scope of this review included accounting for the NHSaves programs' out-of-state expenditures. The evaluation team took several steps in our I/O modeling to account for inter-state flows of program funding, as described in sections 3.1 and 3.2. The team also interviewed experts for context and insights on the inter-state impacts of the programs, and several themes emerged:

- The vast majority of installation contractors are based in-state, particularly for weatherization projects. However, multiple interviewees noted that NH is a relatively small state with a large population close to the state's borders—particularly with Massachusetts and southern Maine—providing significant opportunities contractors in neighboring states to work in New Hampshire, and vice versa.
- Interviewees said the types of firms most often based out-of-state are specialized firms with expertise in complex custom projects and controls measures, and other equipment types where higher levels of program support and customer adoption in other states have led to growth in the workforce for those technologies (e.g., heat pumps).
- Interviewees said that a key reason NHSaves needs to utilize out-of-state contractors in some cases is that states face competition for workforce, and neighboring states have large, well-funded programs that over time have led to growth in the contractor workforce in those states.

An overarching issue raised in the interviews was that New Hampshire has significant out-of-state expenditures on supply-side resources, and that these expenditures should be considered alongside analyses of out-of-state expenditures on

[9] Specifically, in December 2020, the Commission ordered the 2021 programs to operate at 2020 funding levels rather than the higher levels proposed in the 2021-2023 plan, until the Commission could fully consider the plan. Then, in November 2021, the Commission issued an order denying the 2021-2023 plan and ordering a steady, significant reduction in program funding starting in 2022. Although the funding reductions were partially restored in 2022, the Commission's decision limited the flow of funding and initiation of new projects for much of 2022, impacting workforce and customer decisions. See DE 20-092, Order No. 26,440, December 29, 2020; and DE 20-092, Order No. 26,553, November 12, 2021.

energy efficiency resources. Despite being a net electricity exporter, New Hampshire relies heavily on imports of other sources of energy—particularly fossil fuels for heating and transportation. Specifically, according to EIA data from 2022, New Hampshire does not produce fossil fuels, and over $2 billion flowed out of the state for energy imports across all fuels and end uses.[10]

1.3.2 Comparison of results

I/O models have been deployed in different contexts to assess the employment effects of energy efficiency and other types of energy services programs. A comparison of results from recent studies that used I/O modeling to analyze the employment impacts of regional and state-specific energy programs shows that the employment effects of the NHSaves programs—ranging from about 10 to 14 jobs per $1 million in program investment—are similar to the employment effects found in state-level studies from other jurisdictions. In addition to these implementation period jobs, the team's estimates of employment effects from customer bill savings suggest that the total jobs resulting from the NHSaves programs is at the high end of the range for comparison programs.

1.4 Conclusions and considerations

The 2021 and 2022 NHSaves programs—both residential and commercial and industrial (C&I)—had significant positive economic impacts on New Hampshire's economy, including short-term and long-term employment effects, increased state GDP, state and local tax revenues, and monetized public health benefits. These impacts are complementary to other gains from energy efficiency projects in New Hampshire as reflected in the GST, including utility system avoided costs, other fuel and water resource savings, and non-energy benefits.

It is important to note that these quantified impacts are best estimates, which reflect underlying assumptions and limitations in modeling tools and data. The team documented these assumptions and limitations and presented ranges of conservative and aggressive estimates throughout the report for in-state impacts and other factors. Despite some amount of imprecision, which is inherent in economic modeling, the scale and scope of quantified impacts provides clear evidence of the economic benefits of the programs. In addition, as described in the National Standard Practice Manual,[11] jurisdictions "should account for all relevant, substantive impacts (as identified based on policy goals), even those that are difficult to quantify and monetize. Using best-available information, proxies, alternative thresholds, or qualitative considerations to approximate hard-to-monetize impacts is preferable to assuming those costs and benefits do not exist or have no value."

In addition to quantitative modeling, the team's interviews with officials from multiple organizations with expertise and knowledge of the NHSaves programs validate the importance of the programs in supporting and growing the local workforce and in providing New Hampshire businesses and residents with funding to support energy efficiency investments. The value of the programs can be seen in part by the disruptions to local workforce and customers that occurred when the programs' continuity became uncertain. The programs also provide a tool for workforce recruitment and retention that can help New Hampshire compete with surrounding states that offer similar state-wide energy efficiency programs.

There are several areas of analysis covered in this study that were limited due to schedule and scope constraints, summarized in the list below, which could be explored in greater depth. This could include primary New Hampshire data collected from customers and other market actors via surveys, interviews, or other methods to validate and expand on the team's modeling results, while considering tradeoffs between costs, rigor, and value of additional research.

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[10] EIA data shows total energy expenditures of $4.6 billion, total consumption of 296 trillion Btu, and total in-state energy production of 149 trillion Btu. U.S. Energy Information Administration, New Hampshire State Energy Profile, updated Sept 2022. https://www.eia.gov/state/print.php?sid=NH.

[11] The NSPM is a publication of the National Efficiency Screening Project (NESP), which works to improve cost-effectiveness assessments of customer-funded electric and gas energy efficiency programs. The NSPM includes a set of fundamental principles for cost-effectiveness analysis, which have been applied in multiple jurisdictions nationwide. See NESP, *National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources,* Spring 2017, available at https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf.

- Analysis of inter-state workforce effects of the NHSaves programs, to help quantify the qualitative insights from expert interviews on workforce competition and use of in- and out-of-state contractor workforce
- Updating health impacts analysis for future program years to reflect updated ISO-NE data on electricity generation mix and updated demographic data underlying epidemiological models
- Further analysis of long-term customer bill savings and discount rate sensitivity analyses, to provide additional insight in response to the Commission
- Analysis of secondary energy consumption related to economic activity spurred on by the NHSaves programs—also known as the “rebound effect”—to provide additional insight in response to the Commission.

2 INTRODUCTION

The New Hampshire Public Utilities Commission (the Commission) approved the 2022–2023 NHSaves Plan[12] (the Plan) in an order on April 29, 2022,[13] in which it found that the Plan has the potential to positively impact the New Hampshire economy "through achievement of energy savings and through the long-term multiplier effect of energy efficiency projects on the local economy." It also directed Eversource Energy, Liberty Utilities, the New Hampshire Electric Cooperative (NHEC), and Unitil (the NH Utilities) to "comprehensively study and report on the 2021 and 2022 Plan's long-term impact on the New Hampshire economy, quantifying the factors noted in the 2022–2023 Plan at Bates pages 6 and 7[14] by properly accounting for discounting that reflects ratepayers' time-preference, and by estimating the energy savings to reflect both the energy intensity and the spillover impacts also associated with future incremental economic activity prompted by the Plan." A subsequent order of clarification, issued June 21, 2022,[15] states that "the study and reporting requirement calls for sensitivity analysis using a range of discount rates to demonstrate: 1) the impact of time-preference on benefits and costs, and 2) to account for the impact of economic activity resulting from quantifiable cost savings that will result in future energy consumption." In a separate request issued on November 1, 2022, the Commission directed the NH Utilities to "use existing practices and the best data available to provide calculations that, after adjusting for free-ridership and out-of-state expenditures, provide estimates of the positive economic impacts of the Energy Efficiency Program on NH ratepayers." The Commission ordered this review of economic impacts to be submitted by March 31, 2023.

The DNV team with Dr. Anmol Soni of Louisiana State University (LSU) (the evaluation team), in coordination with the New Hampshire Evaluation, Measurement, and Verification Working Group (EM&V WG), designed this study to be responsive to the Commission's various requests to the greatest extent possible within the given timeframe, as shown in Table 2-1.

Table 2-1. Response to Commission reporting requirements

Commission Reporting Requirement	Source	Research Scope
Comprehensively study and report on the 2021 and 2022 Plan's long-term impact on the New Hampshire economy, quantifying the factors noted in the 2022–2023 Plan	4/29 order	Addressed, results in sections 4.1 and 0
Sensitivity analysis using a range of discount rates to demonstrate the impact of time-preference on benefits and costs, and to account for the impact of economic activity resulting from quantifiable cost savings that will result in future energy consumption.	6/21 clarification order	Partially addressed, results in Section 4.3.3
Use existing practices and the best data available to provide calculations that, after adjusting for free-ridership and out-of-state expenditures, provide estimates of the positive economic impacts of the Energy Efficiency Program on NH ratepayers.	11/1 data request	Addressed, results in sections 4.1, 0, and 4.3.2

[12] https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/LETTERS-MEMOS-TARIFFS/20-092_2022-03-01_NH_UTILITIES_NHSAVES-PLAN.PDF.
[13] https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/ORDERS/20-092_2022-04-29_ORDER-26621.PDF
[14] The factors listed in the plan are (1) customer energy cost savings, (2) continued energy savings, (3) peak demand reduction savings, (4) a strong state economy, (5) a highly trained workforce, and (6) a cleaner environment.
[15] https://www.puc.nh.gov/Regulatory/Orders/2022orders/Documents/26-642.pdf

3 METHODOLOGY

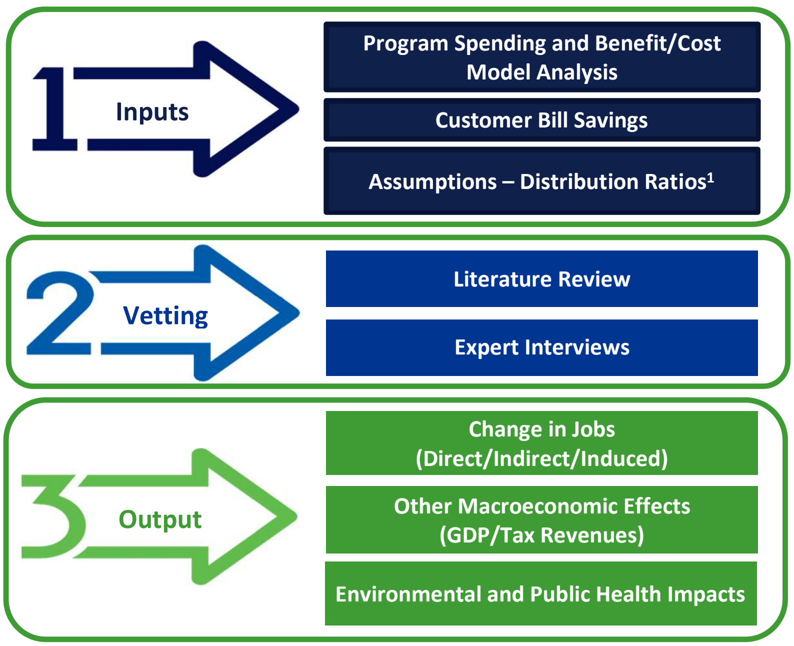
A large body of research has shown that investments in cost-effective energy efficiency have a positive impact on a state's economy. Economic impacts primarily result from direct, indirect, and induced workforce impacts; customer cost savings; public health benefits; and other macroeconomic effects such as increased gross domestic product (GDP) and tax revenues.

There are two general phases during which energy efficiency programs create economic impacts:[16]

1. The implementation phase, during which economic impacts result from the production and installation of energy efficiency equipment, and
2. The savings phase, after energy efficiency measures are installed and result in energy bill savings that is re-allocated to other spending that creates economic impacts.

The evaluation team used an Input-Output (I/O) modeling approach to analyze the economic impacts from the implementation and savings phases of the 2021 and 2022 NHSaves programs. I/O models allow comprehensive analyses examining industry-wide effects of economic activities and major shifts across sectors,[17] based on economy-wide social accounting matrices that incorporate spending patterns within and across sectors. The evaluation team modeled impacts on New Hampshire's economy using a three-stage approach, summarized in Figure 3-1 and detailed in the following sections.

Figure 3-1. **Summary of approach for estimating economic impacts**



[1]Distribution ratios reflect the proportions in which program spending is apportioned across different industries/economic sectors.

3.1 NHSaves program data analysis

The first step in developing inputs for the I/O modeling was to gather and analyze information from the NH Utilities on actual and planned program spending and customer bill impacts from the NHSaves programs. As agreed with the EM&V WG, given the timing of the study, the evaluation team based the analysis on 2021 actual spending from the 2021 B/C models used for annual reporting, and 2022 planned spending from the 2022-23 plan B/C models.[18] For customer bill impacts, the

[16] Synapse Energy Economics. New Hampshire Cost-Effectiveness Review, Application of the National Standard Practice Manual to New Hampshire, Oct. 2019.
[17] Miller, Ronald E, and Peter D Blair. 2009. *Input-Output Analysis: Foundations and Extensions*: Cambridge University Press.
[18] Actual 2022 spending for the full program year would not be available until the March 31 deadline for this study.

team used the bill and rate impacts as modeled and filed with the 2022-23 plan, reflecting bill impacts associated with the two years of NHSaves programs as planned. The team collected and analyzed B/C and bill impact models for the four electric and two gas operating companies: Eversource, Unitil, Liberty, and NHEC electric models; and Liberty and Unitil gas models.[19]

3.1.1 B/C model review

The primary source of data used to model the economic impacts from the implementation phase of the NHSaves programs was the NH Utilities' B/C models. The B/C models include six categories of program spending data, as follows:[20]

- **Internal administration**: internal utility costs associated with program design, development, regulatory support, and quality assurance. Costs include employee labor, benefits, expenses, materials, and supplies.
- **External administration**: external costs associated with program administration. This includes contractors and consultants used in support of program design, development, regulatory support, and quality assurance.
- **Customer rebates and services**: Costs associated with incentives that reduce the cost of equipment as well as costs for services to speed adoption. This includes direct rebate dollars paid to distinct participants, as well as indirect incentives for equipment discounts. It also includes services such as technical audits, employee and contractor labor to install measures, expenses, materials, and supplies.
- **Internal implementation services**: Tracking of internal utility costs associated with delivering programs to customers, including labor, benefits, expenses, materials, and supplies.
- **Marketing**: Costs for marketing, advertising, trade shows, toll-free numbers, and NHSaves website. Types of expenses include labor, benefits, consultants, contractors, expenses, materials, and supplies.
- **Evaluation**: Costs for EM&V activities including labor, benefits, expenses, materials, supplies, consultants, contractors, and tracking systems.

The evaluation team compiled spending data from each utility's B/C model and cleaned and analyzed the data to develop inputs for I/O modeling. The spending categories required different levels of analysis and different general assumptions regarding allocation of the funding to labor and materials, as well as to in-state and out-of-state recipients. These assumptions are shown in Table 3-1 and discussed in more detail below.

Table 3-1. NHSaves program spending categories and general assumptions

Spending category		Level of analysis	In-state/out-of-state assumption	Labor and materials assumption
Internal Administration		Program-level	All in-state staff	All labor and overhead[3]
External Administration		Program-level	In-state/out-of-state proportion derived from NH Utilities' filings[2]	All labor and overhead[3]
Customer Rebates & Services	**Rebates**	Measure-level with IMPLAN industry mapping	All in-state recipients	Labor[4] and materials proportion applied at sub-program level based on review of program documents and data, utility staff input, and PERI/IMT research[1]
	Services	Program-level	In-state/out-of-state proportion derived from NH Utilities' filings[2]	All labor and overhead[3]
Implementation Services		Program-level	All in-state staff	All labor and overhead[3]
Marketing		Program-level	In-state/out-of-state proportion derived from NH Utilities' filings[2]	All labor and overhead[3]

[19] The B/C model analysis includes all the NH Utilities, but the customer bill savings analysis includes only the three electric and two gas investor-owned utilities regulated by the Commission. The bill savings analysis does not include NHEC, which offers energy efficiency as part of the NHSaves plan, but is a customer-owned cooperative not regulated by the Commission in the same way as the investor-owned utilities.
[20] See NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Report 5 - Market Barriers

Spending category	Level of analysis	In-state/out-of-state assumption	Labor and materials assumption
Evaluation	Program-level	In-state/out-of-state proportion derived from NH Utilities' filings[2]	All labor and overhead[3]

[1] Political Economy Research Institute & Institute for Market Transformation. Analysis of Job Creation and Energy Cost Savings From Building Energy Rating and Disclosure Policy, March 2012.
[2] Analysis of NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Report 3.1, RR 1-006B. See section below for further details.
[3] Labor was modeled using the IMPLAN code for management of companies and enterprises, which includes both employee compensation and share of overhead costs.
[4] Refers to project installation labor.

As noted, the modeling exercise relied entirely on the program spending values reported in the NH Utilities' B/C models for 2021 and 2022. Overall funding declined by more than $4 million over the two years. The largest absolute change in funding was in the Energy Star Products program, which saw a 22% decline, and the greatest increase was in the residential engagement and C&I customer engagement programs (included in the All Others category in Table 3-2).

Table 3-2. Total program spending, 2021 actual and 2022 planned

Program	2021 (actual)	2022 (planned)	Change
Energy Star Homes (ES Homes)	$3,449,257	$3,979,650	$530,393
Home Performance with Energy Star (HPwES)	$11,263,490	$10,794,370	-$469,121
Energy Star Products (ES Products)	$9,735,295	$7,600,158	-$2,135,137
Home Energy Reports	$555,043	$483,512	-$71,530
Residential Active Demand Response	$159,209	$190,156	$30,947
Home Energy Assistance (HEA)	$14,464,427	$14,066,713	-$397,714
Large Business Energy Solutions (LBES)	$15,892,231	$14,558,651	-$1,333,580
Small Business Energy Solutions (SBES)	$16,471,108	$15,279,584	-$1,191,524
Municipal Energy Solutions (Muni)	$1,879,379	$1,943,528	$64,150
All others	$833,240	$1,561,498	$728,258
Total	**$74,702,678**	**$70,457,819**	**-$4,244,860**

Accounting for participant costs and free-ridership. Customer rebates represent the largest share of program spending by a wide margin and were of particular importance in the I/O modeling. In most cases, program spending on rebates is accompanied by participant contributions toward the cost of energy efficiency upgrades.[21] The B/C models include measure-level total resource cost (TRC) data, which reflects the total incremental cost of an energy efficiency measure relative to the baseline measure—including both the program's and the participant's share. Participant contributions are attributable to some extent to the programs, but the extent of attribution varies by program, measure type, and other factors. New Hampshire has not conducted extensive research on program attribution levels—i.e., free-ridership and spillover—but the NH Utilities' B/C models include free-ridership and spillover estimates for certain measure types and delivery pathways, such as midstream and lighting offerings, taken from neighboring jurisdictions. For this analysis, the evaluation team used these factors to estimate the share of customer contributions that could be attributed to the programs. For example, at the ends of the attribution spectrum, the team assumed programs with 0% free-ridership and spillover (i.e., 100% net-to-gross) can claim 100% of participants' share of project costs as attributable to the program. In contrast, programs with 100% free-ridership and 0% spillover (i.e., 0% net-to-gross) cannot claim any of the participants' share of project costs as attributable to the program. The evaluation team applied these free-ridership and spillover factors to estimate the portion of participant spending attributable to the programs, addressing the Commission's directive to adjust for free-ridership.

[21] The primary exception to this is the low-income Home Energy Assistance program, which does not require any customer co-pay.

Accounting for out-of-state expenditures. Several spending categories include program expenditures for external contractors and consultants that may reside outside of New Hampshire, including spending on customer rebates that is directly paid to contractors but is then passed through to New Hampshire-based customers.[22] To determine the proportion of contractor and consultant spending that flows to out-of-state recipients, the evaluation team reviewed and analyzed cost data from several recent NH Utilities filings.[23] Table 3-3 provides the data from these filings on the NH Utilities' 2021 spending on outside contractors and consultants, including the portion of this spending for rebates—which are required to flow to New Hampshire-based customers—as well as the non-rebate portion—which may or may not ultimately flow to New Hampshire-based recipients.

Table 3-3. NHSaves 2021 statewide contractor and consultant expenses

State/Country[1]	Total Contractor and Consultant Expenses	**Rebate Portion** (100% pass-through to NH customers)	Non-Rebate Portion
NH	**$29,668,388**	**$26,566,101**	**$3,102,286**
CA	$7,034,417	$5,738,082	$1,296,336
MA	$15,713,696	$14,619,373	$1,094,323
TX	$1,101,425	$740,242	$361,183
NY	$396,292	$53,318	$342,974
GA	$1,538,904	$1,239,306	$299,599
RI	$440,426	$165,199	$275,228
IL	$1,451,318	$1,227,080	$224,238
PA	$634,687	$440,885	$193,802
WI	$211,162	$32,300	$178,862
CO	$169,355	$0	$169,355
VA	$141,903	$52,492	$89,411
CT	$360,792	$272,795	$87,997
OH	$63,430	$0	$63,430
NJ	$51,610	$18,898	$32,712
MN	$89,265	$76,065	$13,200
VT	$254,676	$243,935	$10,741
ND	$5,533	$0	$5,533
FL	$105,768	$101,000	$4,768
AZ	$12,050	$9,550	$2,500
ME	$2,006,320	$2,004,220	$2,100
MD	$163,317	$163,317	$0
CANADA	$42,954	$0	$42,954
IRELAND	$9,507	$0	$9,507
INDIA	$1,344	$0	$1,344
Total	**$61,668,540**	**$53,764,159**	**$7,904,381**

[22] Customer rebates, by definition and program rules, are provided only to eligible customers of the NH Utilities who must reside in New Hampshire. Internal administration expenditures are also assumed to be for New Hampshire-based staff for purposes of our analysis.
[23] NHPUC Docket No. IR 22-042 11-01-2022 IR Requests, Attachment RR 1-006B; NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Report 3.1

[1]Based on business address used for payments.
Sources: NHPUC Docket No. IR 22-042 11-01-2022 IR Requests, Attachment RR 1-006B; NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Report 3.1

The team estimated the share of non-rebate spending flowing to out-of-state contractors and consultants using the values in Table 3-3. As the NH Utilities noted in their filings, the business address of a given contractor or consultant does not necessarily reflect the location of the individual(s) working with the programs. The NH Utilities' 2021 data does not track contractor and consultant expenses based on the location of the employees working with the programs, and a comprehensive review of these expenses was not within the scope of this study. However, multiple contractors that are shown in the NH Utilities' filings as being out-of-state businesses based on their corporate address employ New Hampshire-based staff who work for the programs. Based on this review, we modeled several scenarios assessing the sensitivity of the results to the share of contractor and consultant expenses flowing to out-of-state recipients. Table 3-4 shows the share of non-rebate contractor and consultant spending that flows to in- and out-of-state recipients under a range of assumptions about the extent to which non-rebate funding sent to out-of-state business addresses is passed back to New Hampshire-based employees of those businesses. The evaluation team ran a sensitivity analysis of the economic impacts using the middle two assumptions: 25% and 50% of spending on out-of-state business addresses being passed back to New Hampshire-based employees (see Section 4.3.2.)

Table 3-4. Non-rebate contractor and consultant expenses to out-of-state recipients

Assumed share of spending on out-of-state business addresses that is passed through to New Hampshire-based employees	Share of total non-rebate expenses flowing to in-state recipients	Share of total non-rebate expenses flowing to out-of-state recipients
0% passed through to New Hampshire-based employees	39.2%	60.8%
25% passed through to New Hampshire-based employees	54.4%	45.6%
50% passed through to New Hampshire-based employees	69.6%	30.4%
75% passed through to New Hampshire-based employees	84.8%	15.2%

Accounting for labor and materials. For customer rebate spending, the team estimated the share of program spending on the purchase of equipment or materials and the share for labor by installation contractors, technical/engineering vendors, and other project-specific (i.e., non-administrative) labor. Some programs, such as residential weatherization, involve labor-intensive activities installing relatively low-cost materials such as spray foam and weatherstripping, while other programs such as midstream or upstream lighting and appliances involve equipment markdowns or point-of-purchase rebates and do not include program spending for installation or other project-specific labor. The team developed estimates for the share of labor and materials spending based on a review of the programs, discussion with utility staff, and application of labor cost shares from research by the Political Economy Research Institute (PERI), a nationally recognized independent research unit at the University of Massachusetts Amherst.[24]

Table 3-5 below shows the labor and materials assumptions used in modeling.

Table 3-5. Assumptions for labor and material costs, by program

Program/Subprogram	Percent materials[1]	Percent labor[2]	Source
Energy Star Homes (ES Homes)	25%	75%	Estimated based on program review and discussion with utility staff
Home Performance with Energy Star (HPwES)			
HPwES Weatherization	20%	80%	PERI/IMT[3]

[24] Political Economy Research Institute & Institute for Market Transformation. Analysis of Job Creation and Energy Cost Savings From Building Energy Rating and Disclosure Policy, March 2012. PERI is a nationally recognized source of expertise on economic modeling of employment impacts and has been cited in regulatory filings by the NH Utilities and other energy efficiency program administrators throughout the country in estimating the employment impacts of their programs.

Program/Subprogram	Percent materials[1]	Percent labor[2]	Source
HPwES HVAC Systems	70%	30%	PERI/IMT[3]
HPwES 3rd Party Financing	0%	100%	Assumed for financing program
Energy Star Products (ES Products)			
ES Lighting	100%	0%	Estimated based on upstream program design and discussion with utility staff
ES Appliances	90%	10%	Estimated based on midstream program design and discussion with utility staff
ES HVAC Systems	90%	10%	Estimated based on midstream program design and discussion with utility staff
Home Energy Reports	5%	95%	Assumed due to home energy reports program design
Residential Active Demand Response	5%	95%	Estimated based on demand response program design and discussion with utility staff
Home Energy Assistance (HEA)			
HEA Weatherization	20%	80%	PERI/IMT[3]
HEA HVAC Systems	70%	30%	PERI/IMT[3]
Large Business Energy Solutions (LBES)			
LBES Retrofit	69%	31%	PERI/IMT,[3] weighted by spending by end use
LBES New Equipment & Construction	63%	37%	PERI/IMT,[3] weighted by spending by end use
LBES Midstream	90%	10%	Estimated based on midstream program design and discussion with utility staff
Small Business Energy Solutions (SBES)			
SBES Retrofit	66%	34%	PERI/IMT,[3] weighted by spending by end use
SBES New Equipment & Construction	69%	31%	PERI/IMT,[3] weighted by spending by end use
SBES Midstream	90%	10%	Estimated based on midstream program design and discussion with utility staff
SBES Direct Install	70%	30%	PERI/IMT,[3] weighted by spending by end use
Municipal Energy Solutions (Muni)			
Muni Retrofit	65%	35%	PERI/IMT,[3] weighted by spending by end use
Muni New Equipment & Construction	64%	36%	PERI/IMT,[3] weighted by spending by end use
Muni Direct Install	70%	30%	PERI/IMT,[3] weighted by spending by end use

[1] Estimated share of projects' incremental cost attributed to equipment/materials purchased.
[2] Estimated share of projects' incremental cost attributed to labor by installation contractors, technical/engineering vendors, or other project-specific implementation (i.e., non-overhead, non-administrative) labor.
[3] Political Economy Research Institute & Institute for Market Transformation. Analysis of Job Creation and Energy Cost Savings From Building Energy Rating and Disclosure Policy, March 2012.

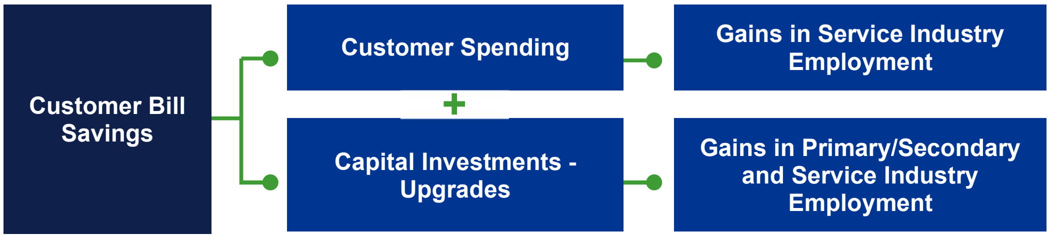
3.1.2 Bill impacts review

The team used the bill and rate impact model results filed by the NH Utilities for the 2022–2023 program years to model the economic impacts of customer bill savings due to the NHSaves programs.[25] The evaluation team incorporated these data in our model to quantify the economic impact during the NHSaves programs' savings phase, which occurs once energy efficiency measures are installed and begin to return savings through reduced energy bills. These bill impacts result from participant energy cost savings, system benefit charge costs, and long-term utility system avoided costs. For the NHSaves

[25] Both the B/C model analysis and bill savings analysis reflect the impacts from 2 program years. However, the bill savings reflects a more recent two-year period (2022-2023), because the NH Utilities estimate and file bill savings for the entire period of their filed plans, not for individual years. As such, the available bill savings values were for either the 2021-23 plan, or the 2022-23 plan update. We used the 2022-23 values for our analysis as they reflect a two, not three-year period, and were more recently updated, following the 2021 funding changes.

programs, the net impact of these factors are reductions in overall utility system costs and total customer bills.[26] The team's I/O modeling accounts for the impacts of bill savings on the economy as depicted in Figure 3-2.

Figure 3-2. Summary of customer bill savings impacts on the New Hampshire economy



The NH Utilities estimated the bill and rate impacts of the 2022–2023 plan using the model developed by Synapse Energy Economics.[27] The evaluation team used the impacts as modeled by the NH Utilities and filed with the plan,[28] rather than separately re-modeling the impacts. Using this model, the NH Utilities estimated that over the life of the measures installed across all programs, the 2022–2023 programs will reduce the revenue requirements of the regulated electric utilities by -0.4% on average, or -$158.8M in total, and reduce the revenue requirements of the regulated gas utilities by -1.0% on average, or -$58.5M in total.[29] Table 3-6 shows the changes in revenue requirements by utility, as filed.

Table 3-6. Long-term revenue requirement changes due to 2022–2023 plan, by utility

Utility	Percent Change	Dollar Change (millions)
Eversource	-0.40%	($135.70)
Liberty Electric	-0.50%	($16.20)
Unitil Electric	-0.10%	($6.90)
Electric Total	**-0.40%**	**($158.80)**
Liberty Gas	-2.00%	($44.80)
Unitil Gas	-0.40%	($13.70)
Gas Total	**-1.00%**	**($58.50)**

Source: NHPUC Docket No. DE 20-092 March 1, 2022 Plan Filing (2022-2023) Attachment M

There are several limitations to the rate and bill impact analysis, as described by the NH Utilities in the 2022–2023 plan.[30] Most significantly for purposes of our analysis of the economic impacts of customer bill savings, the rate and bill model is limited to electric and natural gas system cost savings. The NHSaves programs result in significant customer bill savings

[26] As described in the *National Standard Practice Manual,* energy efficiency resources create both upward and downward pressures on rates, and the net impact on rates will be a result of a variety of factors. Energy efficiency creates upward pressure on rates "as a result of (a) the recovery of efficiency program administration and implementation costs; and (b) the recovery of lost revenues resulting from EE programs." It creates downward pressure on rates "as a result of avoided costs, including reduced generation capacity costs, reduced T&D costs including reduced line losses, reduced environmental compliance costs, reduced utility credit and collection costs, and reduced wholesale market prices from price suppression effects." Bill impacts result from these rate impacts, but vary between participants and non-participants, and depend on the level of savings achieved on a customer basis. See National Efficiency Screening Project (NESP), *National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources, Appendix C*, Spring 2017.

[27] Synapse. New Hampshire Rate, Bill, and Participation Impact Analysis, A User's Guide to the RBP Models, Aug 2020. 20200805-Electric-ME-Report-Guide-To-RBP-Models.pdf (nh.gov)

[28] NHPUC Docket No. DE 20-092 March 1, 2022 Plan Filing (2022-2023) Attachment M

[29] A utility's revenue requirement is the total amount of money it must collect from customers to pay all costs including a reasonable return on investment, and it is approved by regulators as part of a rate case. As detailed in the model user's guide, "to synthesize the rate and bill impacts across the customer sectors, the models estimate the net change in the utility's revenue requirement due to the planned efficiency programs. The change in revenue is dispersed across each rate class differently, depending on the efficiency programs and the rate class structures. Each rate class will experience a different change in revenue and therefore rate impact." Synapse. New Hampshire Rate, Bill, and Participation Impact Analysis, A User's Guide to the RBP Models, Aug 2020. 20200805-Electric-ME-Report-Guide-To-RBP-Models.pdf (nh.gov)

[30] NHPUC Docket No. DE 20-092 March 1, 2022 Plan Filing (2022-2023) Attachment M

from reduced consumption of oil, propane, or other unregulated fuels, particularly among residential customers. These bill savings are not accounted for in the bill and rate impacts filed by the NH Utilities, nor are they accounted for in our analysis. In addition, the values filed by the NH Utilities reflect long-term revenue requirement changes that use the same discount rate assumptions as in the B/C model filed with the 2022–2023 plan (see Section 4.3.3.2). Re-analysis and modeling of the bill and rate impacts of the plan under different discount rate assumptions was not feasible within the timeframe of this study.

3.2 IMPLAN modeling

The core of the economic impact modeling was performed with IMPLAN, which is an industry-standard input-output model developed by the U.S. Forest Service in the 1970s to produce accurate estimates of forest resource economic impacts. IMPLAN allows users to generate three measures of employment changes.[31]

- **Direct employment effects**, which are benefits accruing to industry involved in production and installation activities.
- **Indirect employment effects**, which refer to the changes in industries supplying input to the sectors benefiting directly.
- **Induced employment effects**, which are the second-order effects due to increased consumer spending resulting from the income gains made in the sectors witnessing direct and indirect effects.

In addition to employment impacts, outputs of the IMPLAN model include local, state, and federal GDP impacts and tax impacts associated with the programs. The software accounts for New Hampshire's particular tax regime in the modeling—i.e., no sales tax and limited income tax (interest and dividends income only). The following sections describe the steps the evaluation team took to develop modeling inputs for IMPLAN.

3.2.1 Meta-analysis of energy efficiency I/O literature

The evaluation team began by conducting a search of recent literature on deploying I/O models to estimate the employment effects of energy efficiency programs. The objective of the literature review was to ensure our modeling approach was consistent with other recent research in the field, and we also leveraged the literature to identify certain modeling assumptions such as assumptions for the share of spending on labor and materials across programs.

I/O models have been deployed in different contexts to assess the employment effects of energy efficiency and other types of energy services programs. For example, in its analysis of energy efficiency programs in the state of Colorado—also referenced in prior NHSaves program plans—PERI concluded that every million dollars spent on energy-efficient measures, such as building retrofits, supports 6.2 direct jobs, 2.7 indirect jobs, and 3.3 induced jobs.[32] In a similar analysis in Pennsylvania, $1 million in building retrofits was associated with 6.6 new jobs.[33] Recent studies have also examined the impacts of large scale federal and state level programs on macroeconomic indicators such as GDP and employment. We focused our review on studies in the last five years that used I/O modeling to analyze the employment impacts of regional and state-specific energy programs. Section 4.4 provides a summarized comparison of the results of these studies, and APPENDIX A. LITERATURE REVIEW SOURCES provides the full list of studies the team reviewed and Section 4.4 presents a table with the detailed employment intensity numbers from these other studies.

3.2.2 Distribution ratios and industry code matching

Distribution ratios reflect the proportion in which program spending is apportioned across different industries/economic sectors. The evaluation team reviewed the measure-level program spending data from the B/C models, matching them to

[31] The team modeled employment impacts in terms of full-time-equivalent jobs per year. This is a comparable metric to job-years but allows more granular results that can be separately reported for each year of program impacts, rather than reporting a single job-years value representing multiple years of impacts. Also see Pollin, R., Chakraborty, S., Lala, C., Semieniuk, G. *Job Creation Estimates for Colorado Through Inflation Reduction Act Modeling State-Level Impacts of Climate, Energy, and Environmental Provisions,* at https://peri.umass.edu/economists/shouvik-chakraborty/item/download/1037_fd083b171774ebd2af03bd349aa60ee4

[32] See Pollin, R., Wicks-Lim, J., Chakraborty, S., & Hansen, T. (2019). A Green Growth Program for Colorado. *Amherst: Political Economy Research Institute Research Report, University of Massachusetts Amherst*. Study available at: https://www.peri.umass.edu/publication/item/1168-a-green-growth-program-for-colorado

[33] Pollin, R., Wicks-Lim, J., Chakraborty, S., & Semieniuk, G. (2021). Impacts of the Reimagine Appalachia & Clean Energy Transition Programs for Pennsylvania. *Amherst: Political Economy Research Institute Research Report, University of Massachusetts Amherst*.

industry-specific codes from IMPLAN, which are primarily built on a dataset of 546[34] economic sectors. These sector definitions are based on the North American Industry Classification System (NAICS) codes published by the US Office of Management and Budget.[35] This matching process was used to develop distribution ratios (also referred to as Bills of Goods[36,37,38]) across different industries, reflecting the flow of program dollars to sectors (e.g., construction) and sub-sectors (e.g., materials processing).

Given the level of detail in the NH Utilities' B/C model, the evaluation team was able to allocate measure-level rebate spending to the relevant industries with a high degree of accuracy, for each utility over the two-year period being studied. The ability to deploy information directly from the NH Utilities' B/C models provides this analysis a greater level of detail and depth than most prior I/O modeling-based analyses. Studies typically deploy top-down approaches that either rely on distributing total program spending across industrial sectors based on assumed distribution ratios[39,40] or more recently, with PERI's analysis in Maine[41] that uses target energy intensity numbers to estimate the overall clean energy potential and total required spending on clean energy projects.

To take advantage of the granular, measure-level program spending data, we modeled the effects of each sub-program individually, distributing each measure-level spending value into materials and labor costs (Table 3-1). IMPLAN allows users to model economic impacts in different ways.[42] One of these approaches is setting up each activity as a commodity event. Commodity events are not tied to specific industries and allow for flexibility when estimating the effects of output from different industries. As an example, electricity can be produced from different sources such as fossil fuels, renewable energy, or nuclear energy. Instead of modeling each source of electricity generation separately, by deploying the effect as a commodity event, the study modeled the overall effect of electricity. All material components and labor inputs were modeled as commodity events for the relevant commodity sectors summarized in APPENDIX B. IMPLAN METHODS.

For program rebate spending on materials (e.g., insulation, light bulbs, HVAC equipment, etc.), it is important to account for in- and out-of-state production and purchase of material inputs. To address this, the team modeled two different scenarios for IMPLAN's local purchase percentage (LPP) values. LPP indicates the share of each measure's total economic effect that will be retained within the region being examined (in this case, the state of New Hampshire).[43] Specifically, LPP ratios represent the extent to which the model assumes commodities are purchased from in-state manufacturers or wholesalers. In applying LPP values, users can supply their own estimates or use IMPLAN's internal values. The team modeled two scenarios for LPP—a conservative and an aggressive scenario:

- For the conservative scenario, the team allowed IMPLAN to determine this ratio using the regional purchase coefficient (RPC)[44] included within the software. The regional purchase coefficient values reflect the proportion of total demand in the state that is supplied by local producers. For example, if the RPC of a particular commodity is 50%, that would imply that half the total demand for the commodity is supplied locally. The RPCs included in the version of IMPLAN deployed in this study are estimated econometrically based on economy-wide trade flow data.

[34] https://support.implan.com/hc/en-us/articles/360058813353-546-Industries-Conversions-Bridges-Construction-2019-Data
[35] The only exception to the IMPLAN-NAICS links relevant for this study is the construction sector in IMPLAN which is based on the type of building structures from the Bureau of Economic Analysis' Benchmark Input-Output model. See https://support.implan.com/hc/en-us/articles/115009674668-Sectoring-Schemes and https://support.implan.com/hc/en-us/articles/115009505667-Special-Industry-Definitions
[36] Brown, M. A., Soni, A., & Li, Y. (2020). Estimating employment from energy-efficiency investments. *MethodsX, 7, 100955.*
[37] Brown, M. A., Li, Y., & Soni, A. (2020). Are all jobs created equal? Regional employment impacts of a US carbon tax. *Applied Energy, 262, 114354.*
[38] Baer, P., Brown, M. A., & Kim, G. (2015). The job generation impacts of expanding industrial cogeneration. *Ecological Economics, 110, 141-153.*
[39] Baer, P., Brown, M. A., & Kim, G. (2015). The job generation impacts of expanding industrial cogeneration. *Ecological Economics*, *110*, 141-153.
[40] Pollin, R., Garrett-Peltier, H., Heintz, J., & Hendricks, B. (2014). Green growth: A US program for controlling climate change and expanding job opportunities. *Center for American Progress*, 2.
[41] Pollin, R., Wicks-Lim, J., Chakraborty, S., & Semieniuk, G. (2020). A program for economic recovery and clean energy transition in Maine. *Amherst: Political Economy Research Institute Research Report, University of Massachusetts Amherst*.
[42] https://support.implan.com/hc/en-us/articles/360019638713-Explaining-Event-Types
[43] https://support.implan.com/hc/en-us/articles/115009499327-Local-Purchase-Percentage-LPP-
[44] https://support.implan.com/hc/en-us/articles/115009499527-Regional-Purchase-Coefficient

- To compute more aggressive in-state effects, the study also deployed a 100% LPP with the assumption that all commodities could be purchased from local manufacturers or wholesalers.

For project installation labor, the team redistributed the program spending on labor across the major construction sectors in IMPLAN. For residential programs these include construction, and repair and maintenance of new residential buildings (single and multi-family). For non-residential programs, we split the spending values between construction of new health care, manufacturing, power and communications, and educational and vocational structures and between new construction and maintenance/repair of non-residential structures.

The team also developed distribution ratios for the program-level costs of administration, internal implementation, services, marketing, and evaluation, in alignment with the NH Utilities' accounting definitions for those cost categories. Specifically, we attributed those costs to IMPLAN industry sectors representing management and consulting services. To allow for accurate within state impacts, we modeled these administrative costs as commodity outputs. Since the evaluation team, in consultation with utilities, had established that internal administration and implementation spending remains in-state (Table 3-1), the LPP values for these spending categories were set at 100%. For other administrative expenses (external administration, marketing, evaluation, and services), the study estimated two scenarios—first, where the passthrough to New Hampshire-based employees is 50% and, second, where the pass-through falls to 25%, as shown in Table 3-4. In all cases, the effects are modeled as commodity events allowing us to compute the indirect (material and supplies effects) and the induced effects of additional direct employment in the management and consulting services sectors, which include employee compensation, materials, supplies, and other overhead.

The full table of matched industry codes is provided in APPENDIX B. IMPLAN METHODS.

3.2.3 Modeling bill savings effects

As noted in Section 3.1.2, the team modeled bill savings effects using the bill and rate impact model results filed by the New Hampshire utilities. Since the programs witnessed uncertainties and funding instability in 2021, the team relied on the most up-to-date filings from March 1, 2022, reflecting the 2022-23 plan.[45] The reduction in revenue requirements for the regulated electric and gas utilities due to the 2022–2023 programs was estimated to be $217.3 million in total across all utilities, all customer sectors, and both years of the plan. The impact of customer bill savings varies across customer sectors, due to their different financial circumstances and organizational structures. To apportion these bill savings across the low-income, residential, and C&I sectors, the team apportioned the bill savings for each sector according to that sector's projected lifetime kWh and MMBtu savings for electricity and gas, respectively, from the 2022-23 plan, as shown in Table 3-7.

Table 3-7. NHSaves projected bill savings distributed across sectors

Sector	Share of 2022–2023 lifetime electric savings	Share of 2022–2023 lifetime gas savings	Reallocated electric bill savings	Reallocated gas bill savings	Total bill savings
Low-Income	2.5%	6.7%	$3,917,172	$3,947,093	**$7,864,265**
Residential	20.2%	33.8%	$32,150,545	$19,787,417	**$51,937,961**
Commercial & Industrial	77.3%	59.4%	$122,732,283	$34,765,490	**$157,497,773**
Total	**100%**	**100%**	**$158,800,000**	**$58,500,000**	**$217,300,000**

The bill savings values for each sector were used to compute the employment effects of lower energy spending across the three sectors. It should be noted that these effects will materialize over long periods of time. As noted in the 2022–2023 plan filings, many of these measures last for close to two decades—the average measure life was 12.2 years for 2022 planned electric measures, and 16.6 for planned gas measures—and the total job gains are distributed over the entire period.

[45] NHPUC Docket No. DE 20-092 March 1, 2022 Plan Filing (2022-2023) Attachment M

Residential sector bill savings

The residential sector bill savings impact analysis is based on reapportionment of residential savings across different income categories. IMPLAN's state-level descriptive data includes shares of households by annual income levels. Since the residential programs are available to all types of households, we assume that savings from reduced energy bills are distributed proportionally across the different income levels, as shown in Table 3-8.[46]

Table 3-8. New Hampshire household annual income distribution and bill savings allocation

Income category	Number of households	% of total	Bill savings by household income category
Households <$15k	3,792	7%	$3,455,758
Households $15-30k	58,625	10%	$5,343,840
Households $30-40k	41,089	7%	$3,745,338
Households $40-50k	39,077	7%	$3,562,006
Households $50-70k	78,551	14%	$7,160,102
Households $70-100k	99,079	17%	$9,031,328
Households $100-150k	107,835	19%	$9,829,410
Households $150-200k	52,352	9%	$4,772,035
Households >$200k	55,272	10%	$5,038,146
Total	**569,793**	**100%**	**$51,937,961.38**

Source: IMPLAN demographics data for New Hampshire

As noted earlier, IMPLAN allows for modeling energy bill savings as additional household income, which results in employment gains through induced spending by households. Since bill savings are modeled as gains in income, they only flow through the economy as induced effects and not direct or indirect effects on the economy. Since households do not engage in direct production activity, this "additional" income is then used in induced economic activity (e.g., restaurant services, recreation).

Low-income sector bill savings

The evaluation team modeled low-income customer bill savings based on the share of 2022-23 planned savings for the low-income Home Energy Assistance (HEA) program. HEA is an income-targeted program generally serving participants with household income that is at or below 60 percent of the state median income for their household size.[47] The average household size in New Hampshire is 2.46 persons.[48] For households with three persons, 60% of the state median income equates to $62,950, so we allocated the low-income bill savings for both electricity and gas proportionally among households with annual incomes of less than $70,000 (see Table 3-9). As with residential bill savings, since low-income

[46] This is a simplifying assumption made for purposes of this review. In reality, savings are likely distributed unevenly across income levels, with higher income households seeing greater levels of savings due to higher baseline energy consumption driven by factors such as larger home sizes and more energy-using equipment (e.g., central air conditioning). As a result, this analysis may overstate the impacts of low-income participant bill savings and understate the impacts of higher-income residential participant bill savings. Further analysis of household savings distribution was not possible within the scope and timeline of this study.

[47] Program eligibility requirements also allow for serving customers who are eligible for the New Hampshire Electric Assistance Program, or anyone residing in subsidized housing or municipal or nonprofit organizations serving those in need. See https://www.energy.nh.gov/consumers/help-energy-and-utility-bills/assistance-programs-eligibility for information on program eligibility.

[48] https://www.census.gov/quickfacts/NH

savings accrue directly to households, we modeled them as additional household income, which results in induced economic activity (e.g., services, recreation).

Table 3-9. New Hampshire low-income distribution and bill savings allocation

Income category	Share of households below $70,000 annual income	Program savings share (IMPLAN inputs)
Households <$15k	15%	$1,168,041
Households $15-30k	23%	$1,806,219
Households $30-40k	16%	$1,265,928
Households $40-50k	15%	$1,203,959
Households $50-70k	31%	$2,420,118
Total	**100%**	**$7,864,265**

Source: IMPLAN demographics data for New Hampshire

C&I sector bill savings

The team followed a somewhat different approach for modeling commercial and industrial sector bill savings. As noted above, IMPLAN provides information across 546 industry/commodity sectors, which we used to identify the share of different sectors across the state's economy. The team then apportioned the total C&I savings across different sectors in the same proportion as the share of these sectors in the state's output. We assume that all C&I sector savings are redirected towards additional industry activity, and model these impacts as industry output in the same proportion as the share of these sectors industries in the total output, shown in Table 3-10. IMPLAN defines total output as the monetary value of the total production in any sector. In other words, total output reflects the production for each industry in a given year plus the net inventory changes in the sector. We used output as the basis for reapportioning the total savings across all major sectors/industries since it provides a good picture of the total share of each sector in the state's economy.

Table 3-10. Share of industries in the New Hampshire output[1]

Description	Share of economic output
11 - Agriculture, Forestry, Fishing and Hunting	0.2%
21 - Mining, Quarrying, and Oil and Gas Extraction	0.2%
22 - Utilities	1.7%
23 - Construction	5.5%
31-33 - Manufacturing	15.3%
42 - Wholesale Trade	6.6%
44-45 - Retail Trade	6.1%
48-49 - Transportation and Warehousing	1.5%
51 - Information	3.9%
52 - Finance and Insurance	8.7%
53 - Real Estate and Rental and Leasing	11.7%
54 - Professional, Scientific, and Technical Services	8.3%
55 - Management of Companies and Enterprises	2.9%

Description	Share of economic output
56 - Administrative and Support and Waste Management and Remediation Services	3.5%
61 - Educational Services	1.1%
62 - Health Care and Social Assistance	7.8%
71 - Arts, Entertainment, and Recreation	1.1%
72 - Accommodation and Food Services	4.1%
81 - Other Services (except Public Administration)	2.9%
9A - Government Enterprises	0.8%
9B - Administrative Government	6.0%
Total	**100.0%**

[1]Output = total production + net inventory changes[49]

3.3 Expert interviews

To provide context for the I/O modeling results, the evaluation team interviewed individuals from ten organizations with expertise and knowledge of the NHSaves programs. These interviewees included two vendors and three large, multi-project participants in the NHSaves programs. The interviews covered topics including (1) NHSaves program impacts on workforce and customers, including impacts from recent regulatory decisions and changes in funding levels, (2) the flow of program funding to in-state and out-of-state recipients, (3) local workforce needs and opportunities, (4) how changes in energy bills impact other spending by customers. Table 3-11 provides a list of organizations interviewed for the study.

Table 3-11. Organizations interviewed on NHSaves' economic impacts

Interviewee Organization	Description
ACEEE	Non-profit organization promoting energy efficiency via technical and policy analyses, advisory services, and collaborative partnerships
BAE Systems	Large industrial customer with energy-intensive engineering and laboratory facilities in New Hampshire. *NHSaves participant*
GDS Associates, Inc.	Engineering and energy consulting firm. *NHSaves vendor*
Lake Region Community Developers	Community-based affordable housing development and services non-profit. *NHSaves participant*
NH Business and Economic Affairs	State agency created to enhance the economic vitality of New Hampshire and promote it as a destination for domestic and international visitors
NH Department of Environmental Services, Air Division	State agency created to protect and restore the environment and public health in New Hampshire through wise management of the state's environment
NH Community Development Finance Authority	Quasi-governmental agency providing technical assistance and financing to support community economic development initiatives
NH Department of Energy	State agency created to promote and coordinate energy policies and programs in the state
Resilient Buildings Group	Consulting firm providing energy efficient building management and construction services. *NHSaves vendor*

[49] https://support.implan.com/hc/en-us/articles/360035998833-Understanding-Output

University of New Hampshire Facilities Management	Department providing professional services for University renovation, repair, and new construction projects. *NHSaves participant*

3.4 Health impacts modeling

Energy efficiency programs can offer benefits to individuals, businesses, and society, including lower energy bills and improved grid reliability, as well as a range of public health impacts. These health impacts can include reductions in the frequency and/or severity of health problems caused by emissions and other outputs of fuel combustion and extraction required for supply-side resources. Such health impacts have been widely researched and include reductions in the number of premature deaths, incidences of respiratory and cardiovascular illnesses, and missed days of work and school. There are a range of economic benefits associated with these health impacts, including reduced medical costs, and increased economic productivity of the impacted population.

New Hampshire's energy-related statutes and Commission orders frequently mention public health, and New Hampshire stakeholders previously considered these impacts for purposes of cost-effectiveness testing of the NHSaves programs, although they ultimately decided against including public health impacts in the Granite State Test (GST). As noted above, the economic impacts modeled in this study are additional to program cost-effectiveness.[50]

The evaluation team estimated the economic value of the health benefits associated with the NHSaves programs using EPA's Co-Benefit Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) and Avoided Emissions and Generation Tool (AVERT).

- COBRA is an EPA software tool that produces estimates of public health and associated economic impacts due to changes in air pollution stemming from energy policies and programs. Researchers can model multiple scenarios by specifying increases or decreases in criteria pollutants, as well as discount rates options.[51] COBRA relies in part on epidemiological models for the statistical value of life and changes in adult mortality and non-fatal heart attacks.
- AVERT is an EPA software tool designed to estimate the impact of energy programs and policies on the emissions produced by the power sector. AVERT estimates annual marginal rates of avoided criteria pollutants such as particulate matter (PM2.5), nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon dioxide (CO_2), volatile organic compounds (VOC), and ammonia (NH_3) from electric power plants at a county, state, or regional level.

The team used COBRA to model the economic value of the health benefits associated with emissions reductions caused by the NHSaves programs. For electric programs, the team used AVERT to estimate those emissions reductions, and for gas programs, the team used EPA emissions factors for residential and business end-user combustion to estimate criteria pollutants. See APPENDIX C. AVERT AND COBRA METHODS for more details on the sources and methods used for this analysis.

Limitations. COBRA and AVERT are useful for modeling the overall health impacts of changes in criteria pollutants, but both have limitations that should be considered in applying the results.

- AVERT provides a snapshot of regional electricity dispatch and does not consider changes in dispatch over time due to fuel prices, curtailments, transmission system changes, or other factors. Therefore, the use of AVERT for forward

[50] Cost-effectiveness testing is used to screen programs to determine which have benefits that exceed their costs, and therefore merit using ratepayer dollars to fund. Despite New Hampshire stakeholders' decision to exclude public health impacts from cost-effective testing under the GST, there is clear evidence that energy efficiency programs produce public health benefits that result in economic impacts for the state.

[51] COBRA uses a discount rate to express future economic values in present terms because not all health effects and associated economic values occur in the year of analysis. COBRA assumes changes in adult mortality and non-fatal heart attacks occur over a 20-year period. EPA recommends using both 3% and 7% discount rates. The 3% interest rate corresponds to the interest rate on government backed securities, whereas the 7% interest rate reflects the opportunity costs of capital.

looking scenarios is not recommended.[52] In addition, AVERT models generation dispatch impacts at the regional level, agnostic of the location of electricity reductions. In reality, dispatch decisions are location sensitive.

- COBRA also has limitations in the applicability of its results over time. Each COBRA run represents benefits from emissions reductions in a specific year, based on epidemiological models embedded in the software, which use demographic profiles and other information that reflects impacts for a specific point in time. To analyze multiple years of emissions impacts, the model should be separately run for each year and the results aggregated for each run.

The team modeled the annual emissions reductions and associated health impacts of the 2021 NHSaves programs. It is important to note that these modeling results are based on first year savings only, so they reflect only annual, one-year impacts, and not the full impacts of the savings from the 2021 measures over their useful lives. The limitations noted above should be considered if applying these results to programs' lifetime savings.

[52] For detail, see AVERT User Manual Version 2.3 (epa.gov)

4 RESULTS

4.1 Employment effects

The following section details the employment effects of the 2021 and 2022 NHSaves programs, during both their implementation phase (2021–2022) and savings phase (implementation through the end of measures' useful lives). Except where noted, all economic impacts presented in this report reflect impacts on the New Hampshire economy specifically. All employment effects reflect full-time-equivalent (FTE) jobs. [53] Note that employment effects during the implementation phase represent jobs that are created for one program year (2021 or 2022), and so the number of jobs is equivalent to the number of job-years. Employment effects during the savings phase occur in proportion to customer bill savings, over the useful life of the measures installed by the programs. As such, savings phase employment effects represent an aggregate estimate of job years, which are spread out over the life of the program measures for each sector.

For the implementation phase, as detailed in Section 3.1.1, the team used programs' free-ridership-adjusted total resource cost (TRC) data to estimate the direct, indirect and induced employment effects of program rebates for the 2021 (actual) and 2022 (planned) program years.[54] The team also estimated the effects of internal and external administrative spending on total employment under different scenarios. For the savings phase, the team used the bill and rate impact model results filed by the NH Utilities for the 2022–2023 program years to model the economic impacts of customer bill savings due to the NHSaves programs. Customer bill impacts result from participant energy cost savings, system benefit charge costs, and long-term utility system avoided costs. For the NHSaves programs, the net impact of these factors are reductions in overall utility system costs and customer bills. The following sub-sections describe the findings in greater detail.

4.1.1 Implementation phase

In the conservative LPP scenario,[55] the NHSaves programs generated approximately 756 jobs in 2021 and 703 jobs in 2022—approximately 10 jobs per $1 million in program spending, in both years, as shown in Table 4-1 and Table 4-2. It is important to note that in addition to employment generated from program rebates, the management and implementation of energy efficiency programs is also associated with many local jobs. As described earlier, the study modeled the effects of internal administrative expenses as well as external administration costs including services, marketing, and evaluation. In the conservative scenario, administration and services employment contributes over 40% of the total employment created in 2021. In the aggressive LPP scenario,[56] the share of jobs from program rebates increases, and the share of administration and services-based employment effects decreases to about a third and a quarter of the total jobs generated in 2021 and 2022, respectively.

At the program and sub-program level, there are a range of employment effects, which vary based on two factors.

1. The total number of jobs associated with a program is driven in part by the size of the program budget. For instance, in terms of total jobs, the four programs with the largest budgets—LBES, SBES, HEA, and HPwES—also created the largest number of jobs in both years.
2. The total number of jobs associated with a program is also driven by its employment intensity—that is, the number of jobs created for every $1 million in program spending. At over 14 jobs per million in program spending in 2021 and

[53] FTEs measure total full-time, part-time, and temporary employees, based on the total number of hours worked divided by the number of hours in a full-time schedule.

[54] In most cases, program spending on rebates is accompanied by participant contributions toward the cost of energy efficiency upgrades. The NH Utilities' B/C models include measure-level TRC data, which reflects the total incremental cost of an energy efficiency measure relative to the baseline measure—including both the program's and the participant's share. Participant contributions are attributable to some extent to the programs, but the extent of attribution varies by program, measure type, and other factors. Attribution levels are reflected in the NH Utilities' B/C models via free-ridership and spillover estimates for certain measure types and delivery pathways, such as midstream and lighting offerings, taken from neighboring jurisdictions. For purposes of our analysis, the evaluation team used these factors to estimate the share of customer contributions that could be attributed to the programs.

[55] Where LPP was set equal to RPC, as described in Section 3.2.2. LPP indicates the share of the economic effect of rebated measures that will be retained within the region being examined (in this case, the state of New Hampshire). Specifically, LPP ratios represent the extent to which the IMPLAN model assumes commodities are purchased from in-state manufacturers or wholesalers.

[56] Where LPP was set to 100%.

2022, ES Homes had the highest employment intensity, and HPwES also had high employment intensity at nearly 14 jobs per million in 2021. At the other end of the range, ES Products had the lowest employment intensity in both years, followed by the Home Energy Reports program. These differences are due to programs' different distribution ratios, which reflect the proportions in which program spending is apportioned across different industries/economic sectors. For example, ES Homes and HPwES require relatively more material and local project construction or installation contractors, whereas the Home Energy Reports program primarily involves spending on labor and overhead.

It is important to note that the employment effects of different programs do not reflect a comprehensive accounting of the costs and benefits of the programs. Cost-effective energy efficiency programs, by definition, provide a lower-cost alternative to supply-side resources. Even programs with negligible local employment impacts, if cost-effective, have net benefits that ensure they return more to the state's ratepayers in terms of avoided system costs and other energy and non-energy benefits than they cost. Table 4-1 and Table 4-2 show the employment estimates by sub-program for 2021 and 2022, including jobs from program rebates, administration and services-based jobs, and jobs per $1 million in program spending.

Table 4-1. New Hampshire implementation period FTE employment estimates, 2021 program year (actual)[1]

Program	Sub-program	Total Program Costs	Conservative LPP			Aggressive LPP		
			Rebate Employment	Administration and Services Employment	Jobs per million $ in program costs	Rebate Employment	Administration and Services Employment	Jobs per million $ in program costs
ES Homes		$3,449,257	34.81	13.75	14.08	35.18	13.75	14.18
HPwES	Weatherization	$11,263,490	94.20	62.33	13.99	100.04	62.33	14.67
	HVAC Systems		0.98			2.82		
	3rd Party Financing		0.01			0.01		
ES Products	Lighting	$9,735,295	1.58	36.52	4.78	8.86	36.52	10.39
	Appliances		4.53			23.05		
	HVAC Systems		3.94			32.69		
Home Energy Reports		$555,043	1.52	2.63	7.47	1.73	2.63	10.95
Residential Active Demand Response		$159,209	0.001	1.38	8.71	0.15	1.38	9.65
HEA	Weatherization	$14,464,427	65.45	51.67	9.77	87.23	51.67	12.04
	HVAC Systems		24.15			35.27		
LBES	Retrofit	$15,892,231	77.64	71.48	11.31	159.70	71.48	18.65
	New Equipment & Construction		28.92			55.20		
	Midstream		1.65			10.06		
SBES	Retrofit	$16,471,108	40.32	70.23	9.25	73.50	70.23	15.85
	New Equipment & Construction		20.77			27.35		
	Midstream		12.21			63.61		
	Direct Install		8.83			26.45		
Municipal	Retrofit	$1,879,379	7.04	8.32	10.58	16.06	8.32	18.99
	New Equipment & Construction		3.50			8.24		
	Direct Install		1.03			3.07		
Others[2]		$833,240	0.01	4.58	3.35	2.36	4.58	8.32
Total		**$74,702,678**	**433.07**	**322.90**	**10.12**	**774.35**	**322.90**	**14.69**

[1] All impacts represent incremental effects of each program year independently, relative a no-program counterfactual.
[2] Other programs include C&I active demand and education, residential education, and Energy Rewards RFP.

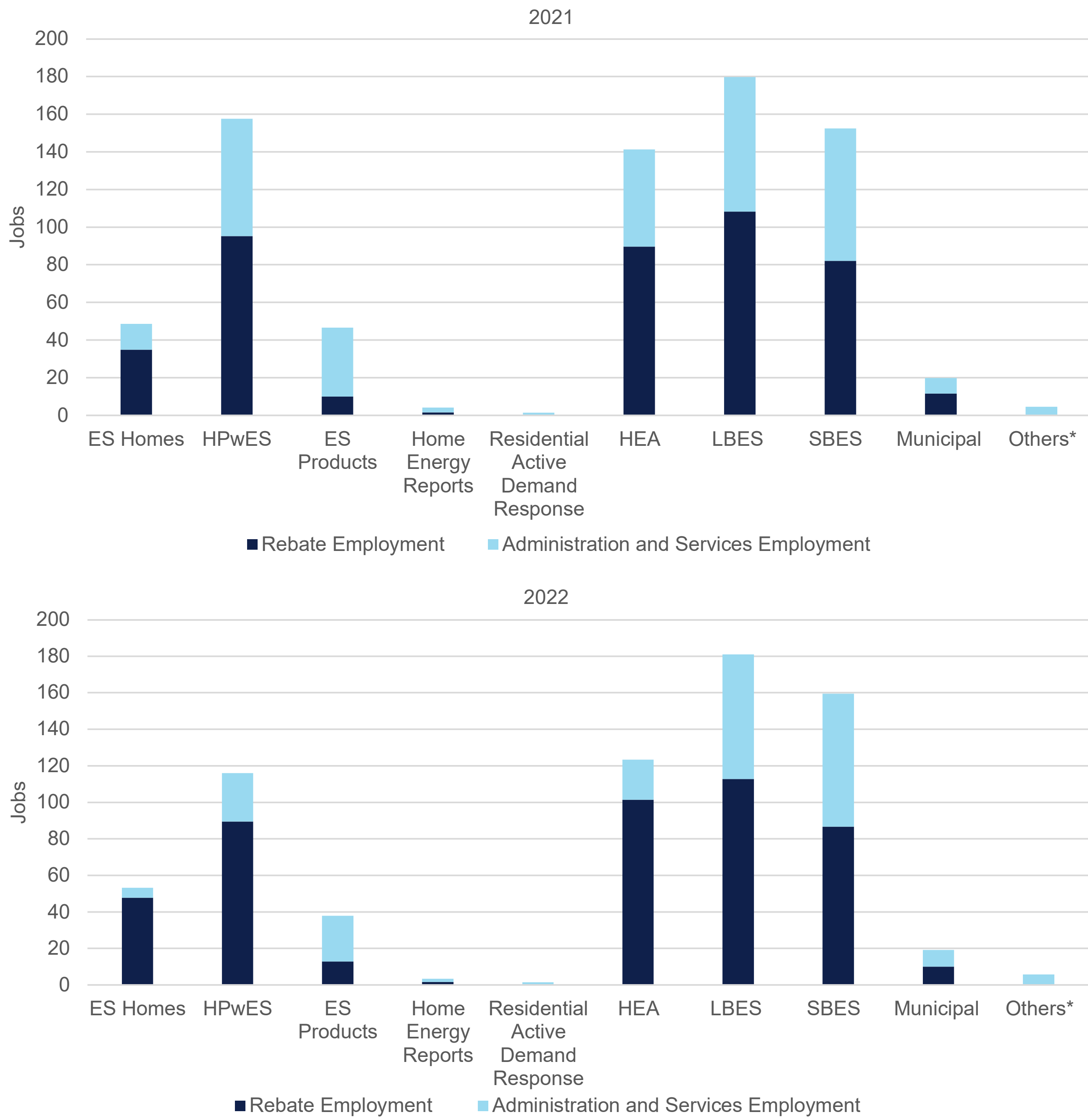
Table 4-2. New Hampshire implementation period FTE employment estimates, 2022 program year (plan)[1]

Program	Sub-program	Total Program Costs	With LPP (Conservative estimates)			Without LPP (Aggressive estimates)		
			Rebate Employment	Administration and Services Employment	Jobs per million $ in program costs	Rebate Employment	Administration and Services Employment	Jobs per million $ in program costs
ES Homes		$3,979,650	47.70	5.44	15.34	48.01	5.44	13.43
HPwES	Weatherization	$10,794,370	88.30	26.53	10.74	93.46	26.53	11.41
	HVAC Systems		1.09			3.11		
	3rd Party Financing		0.03			0.03		
ES Products	Lighting	$7,600,158	0.91	25.02	4.97	2.59	25.02	11.47
	Appliances		5.36			16.22		
	HVAC Systems		6.52			43.38		
Home Energy Reports		$483,512	1.60	1.81	7.04	3.63	1.81	11.24
Residential Active Demand Response		$190,156	0.00	1.47	7.73	0.00	1.47	7.73
HEA	Weatherization	$14,066,713	69.56	21.93	8.77	74.39	21.93	10.53
	HVAC Systems		31.84			51.85		
LBES	Retrofit	$14,558,651	82.66	68.22	12.44	159.17	68.22	19.70
	New Equipment & Construction		28.72			52.92		
	Midstream		1.44			6.05		
SBES	Retrofit	$15,279,584	47.47	72.83	10.44	86.11	72.83	17.69
	New Equipment & Construction		18.75			41.60		
	Midstream		9.33			35.81		
	Direct Install		11.15			33.93		
Municipal	Retrofit	$1,943,528	7.10	9.10	9.85	15.71	9.10	16.22
	New Equipment & Construction		2.94			6.72		
	Direct Install		0.00			0.00		
Others[2]		$1,561,498	0.00	5.70	5.45	0.00	5.70	5.45
Total		**$70,457,819**	**462.46**	**240.84**	**9.98**	**775.15**	**240.84**	**14.42**

[1] All impacts represent incremental effects of each program year independently, relative a no-program counterfactual
[2] Other programs include C&I active demand and education, residential education, and Energy Rewards RFP.

Figure 4-1 shows the total employment results from the 2021 and 2022 NHSaves programs, by program and type of program spending—customer rebate or administration and services spending. As shown, rebate spending is the driver of most employment for all programs, except for ES Products, which due to its midstream/upstream design, involves relatively less project installation labor and therefore lower local employment effects.

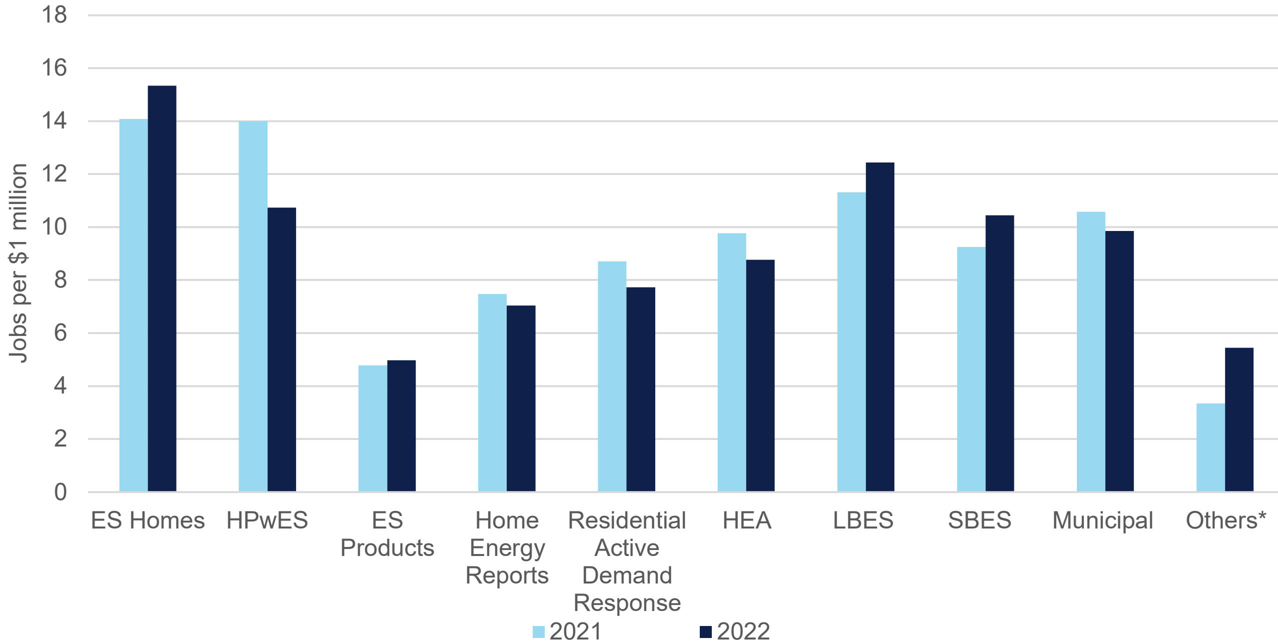
Figure 4-1. Total employment estimates for the 2021 and 2022 NHSaves programs, by program[1]



[1]Results shown for the conservative LPP scenario.

Figure 4-2 shows employment intensity—in terms of jobs per $1 million in program spending—for each NHSaves program in 2021 and 2022. As noted above, ES Homes had the highest employment intensity at over 14 jobs per million in 2021 and 2022, and HPwES also had high employment intensity at nearly 14 jobs per million in 2021.

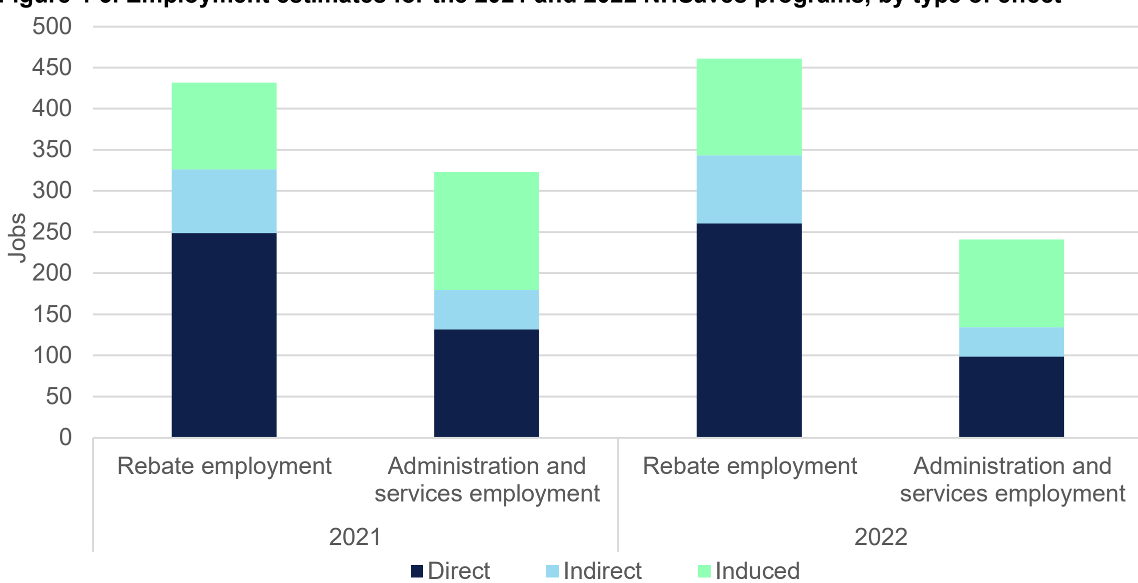
Figure 4-2. Employment intensity estimates for the 2021 and 2022 NHSaves programs, by program[1]



[1]Results shown for the conservative LPP scenario.

Figure 4-3 shows employment estimates for 2021 and 2022 by type of effect—direct, indirect, and induced—and type of program spending. As shown, customer rebates generated the largest share of jobs, primarily through direct employment effects—i.e., employment in industries involved in production and installation activities.

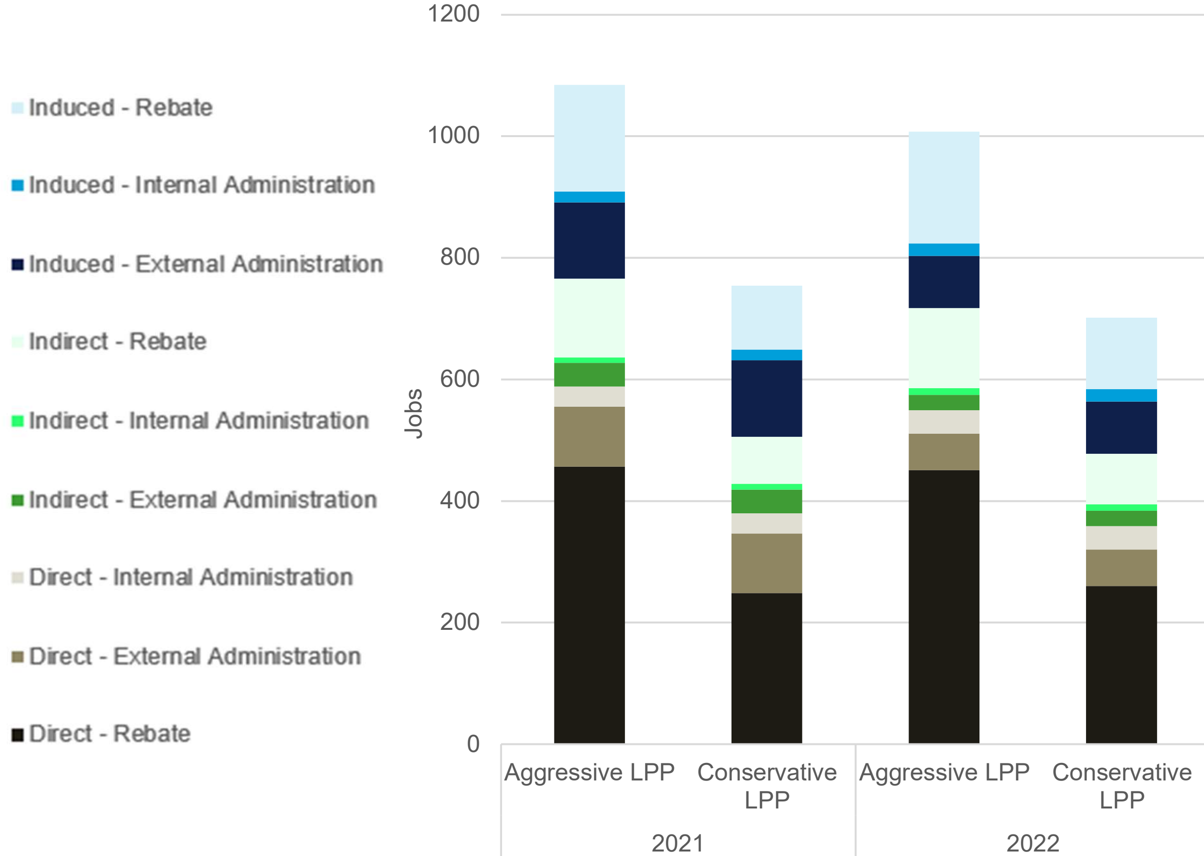
Figure 4-3. Employment estimates for the 2021 and 2022 NHSaves programs, by type of effect[1]



[1]Results shown for the conservative LPP scenario.

Figure 4-4 further breaks out employment, by type of effect, program spending, and LPP scenario (conservative or aggressive). As shown, the increase in jobs between the scenarios is due to increased rebate-generated employment, particularly for direct employment effects.

Figure 4-4. Employment estimates for 2021 and 2022 NHSaves programs, by scenario and type of effect



4.1.2 Savings phase

As shown in Section 3.2.3, the NH Utilities estimated that the 2022–2023 NHSaves programs will result in over $217 million in total customer bill savings over the useful life of the measures installed.[57] These bill savings result in increased customer (e.g., household) spending and industrial investment and outputs, which in turn create employment gains across sectors. The total NHSaves projected customer bill savings for the low-income, residential, and C&I sectors are estimated to result in about 1480 additional job years. (As noted above, savings phase employment effects represent an aggregate estimate of job years, which are spread out over the life of the program measures for each sector.)

The bill savings estimates the team modeled were limited to projected savings in electricity and natural gas bills. New Hampshire households also rely on delivered fuels such as oil and propane, and the NHSaves programs result in significant reductions in delivered fuel consumption, with associated bill savings.[58] Bill savings for those fuels were not included in the

[57] Both the B/C model analysis and bill savings analysis reflect the impacts from 2 program years. However, the bill savings reflects a more recent two-year period (2022-2023), because the NH Utilities estimate and file bill savings for the entire period of their filed plans, not for individual years. As such, the available bill savings values were for either the 2021-23 plan, or the 2022-23 plan update. We used the 2022-23 values for our analysis as they reflect a two, not three-year period, and were more recently updated, following the 2021 funding changes.

[58] According to the 2022-2023 NHSaves Plan, the programs will result in savings of 3.6 million MMBtu from delivered fuels such as oil and propane over the lifetime of the measures installed in 2022 and 2023—compared to projected savings of 5.4 million lifetime natural gas MMBtu.

analysis since the NH Utilities' bill and rate models do not include delivered fuel impacts. As such, the results of this analysis reflect a conservative estimate of the economic impacts of customer bill savings.

The overall increase in jobs for each sector closely mirrors the distribution of bill savings. Because the C&I sector sees both direct, indirect, and induced effects, it has the highest employment intensity at 7.3 job years per $1 million in bill savings. Among households, the low-income sector showed a slightly higher employment intensity (6.06 job years per $1 million) than the residential sector overall (5.45 jobs per $1 million). Table 4-3 shows the modeled bill savings employment effects for the 2022–2023 NHSaves programs.

Table 4-3. Bill savings employment effects, 2022–2023 programs

Sector	Employment (job years generated)				Total bill savings	Job years per million	Share of job years generated	Share of total bill savings
	Direct	Indirect	Induced	Total job years				
Low Income	N/A[1]	N/A[1]	47.67	47.67	$7,864,265	6.06	3.2%	3.6%
Residential	N/A[1]	N/A[1]	283.16	283.16	$51,937,961	5.45	19.1%	23.9%
C&I	697.89	176.37	275.41	1149.67	$157,497,773	7.30	77.7%	72.5%
Grand Total				**1480.49**	**$217,300,000**	**6.81**	**100%**	**100%**

[1]Because residential and low-income bill savings accrue to households which are not engaged in direct production and employment activities, these bill savings result in induced effects but not direct or indirect effects.

4.1.2.1 Residential sector bill savings

Long-term residential sector bill savings (approximately $52 million) were associated with a little over 283 additional job years over the life of the residential program measures. Household bill savings employment effects are modeled as induced effects (e.g., increased household spending on services), and the effects accrue to households in proportion to their share in the state. Households with annual incomes between $70,000-$100,000 contributed the largest number of total induced job years (52.50), in part because they are one of the largest household income brackets in the state, at 17% of all New Hampshire households (see Table 3-8). In terms of employment intensity (job years per $1 million in bill savings), households between $15,000 and $30,000 in annual income showed the highest intensity at 6.5 additional job years per $1 million, while households with over $200,000 in annual income showed the lowest intensity, at 3.37 per $1 million, as shown in Figure 4-5.

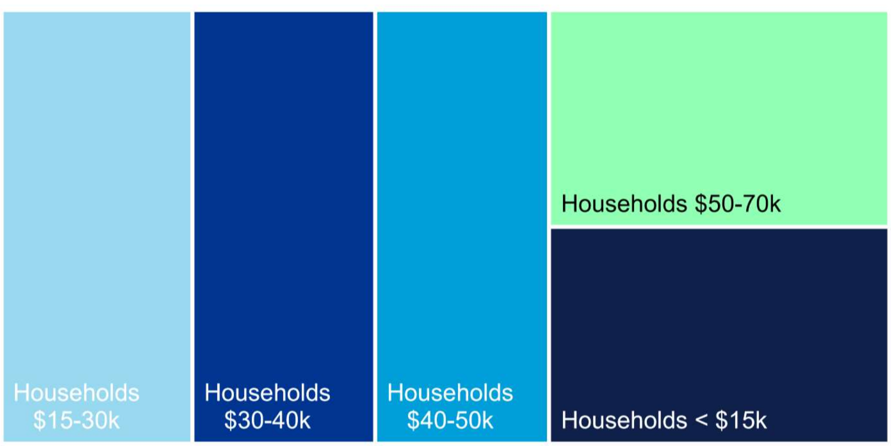
Figure 4-5. Projected employment effects of residential energy bill savings (job years per $1 million)[1]

[1] Residential bill savings were modeled as income gains for households. The figure reflects employment intensity, in job years per $1 million in residential customer bill savings, by annual household income bracket.

4.1.2.2 Low-income sector bill savings

Long-term low-income sector bill savings (approximately $8 million) were associated with a little over 47 additional job years over the life of these program measures. The largest number of total job years accrue to households with annual income between $50,000 and $70,000, again because they represent the largest share of low-income New Hampshire households (31% of low-income households, as shown in Table 3-8). As shown in Figure 4-6, employment intensity is relatively uniform across low-income household income brackets, with all brackets creating 5.8 and 6.5 job years per $1 million in bill savings.

Figure 4-6. Projected employment effects of low-income energy bill savings (job years per $1 million)[1]

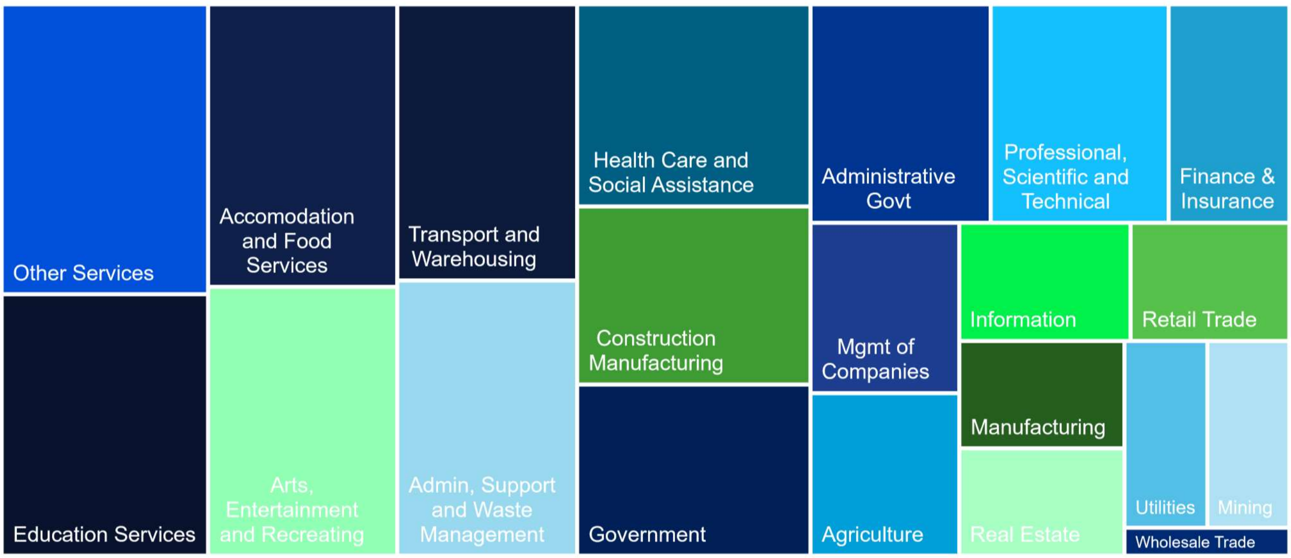


[1] Low-income bill savings were modeled as income gains for households. The figure reflects employment intensity, in job years per $1 million in low-income customer bill savings, by annual household income bracket.

4.1.2.3 C&I sector bill savings

Total C&I sector long-term bill savings of $158 million were associated with nearly 1,150 additional job years during the life of the program measures. Since the commercial and industrial sector savings were modeled as increases in industry production, the employment effects included direct (~698 job years), indirect (~176 job years) and induced (~275 job years) effects. Health care and social assistance sectors had the largest effects, with over 142 job years generated, followed by the professional, scientific, and technical sector and the manufacturing sector at 124 and 104 job years, respectively. In terms of employment intensity, the other services sector had the highest intensity at 14.6 job years per $1 million in savings, followed by the education services sector at 13.17 job years per $1 million. The wholesale trade sector had the lowest intensity at 1.1 job years per $1 million. Figure 4-7 shows the distribution of employment effects across C&I sectors.

Figure 4-7. Projected employment effects of C&I energy bill savings, by sector (jobs per $1 million)[1]



Context and validation

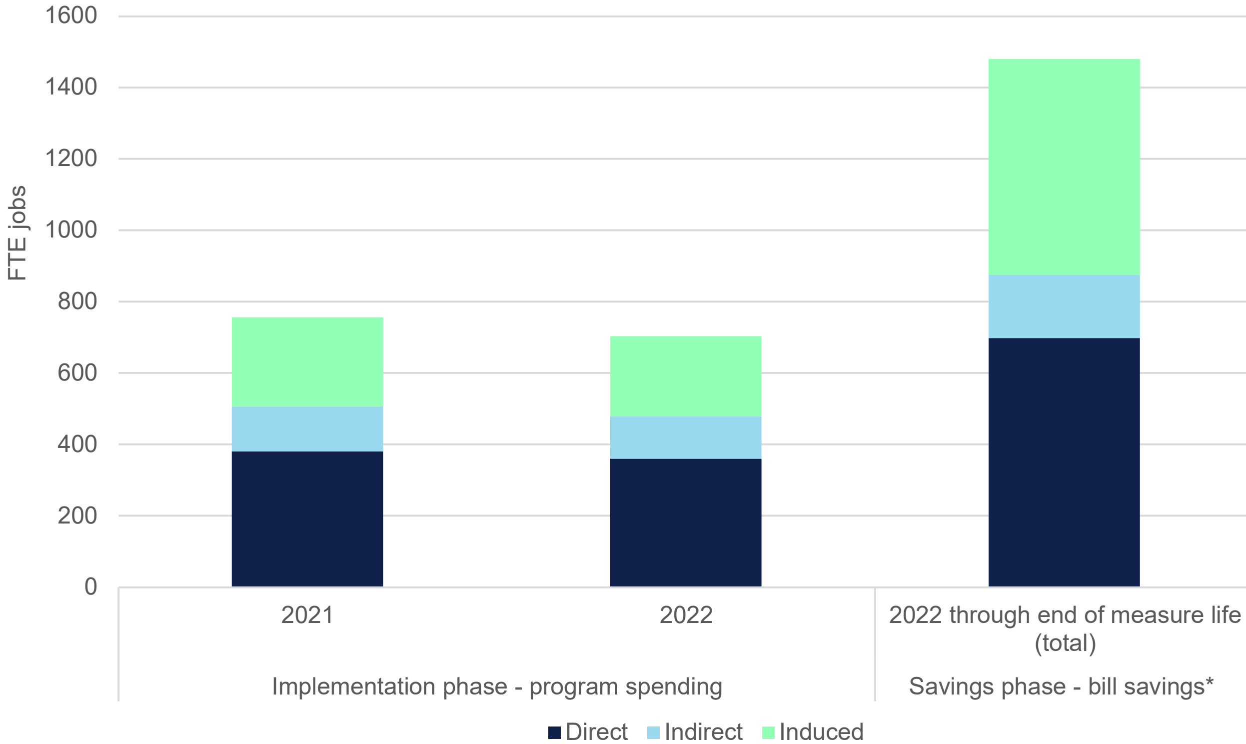
To validate our assumptions about estimating and allocating the economic effects of long-term energy bill savings, we reviewed literature and asked expert interviewees about the topic. Based on the interviews and literature, customer bill savings can get re-allocated in multiple ways, depending on the type of customer and their economic circumstances. Interviewee responses generally corroborate the assumptions and results of our IMPLAN modeling, and help illustrate the financial decisions New Hampshire households and businesses face. According to interviewees:

- Residential bill savings are typically allocated towards other household expenses but given the variability in energy prices and other costs, changing incomes, and changing patterns of home occupancy and working from home, savings from energy efficiency projects may be less noticeable to non-low-income homeowners.
- Low-income bill savings provide added resilience for residents who are resource constrained, and for whom relatively small changes in expenses can have disproportionate impact on daily activities and overall quality of life.
- Large business bill savings may be reallocated towards investment in more energy efficient equipment or toward companies' overall capital, maintenance, or operating budgets.
- Small business bill savings may be reallocated toward hiring or employee compensation, as well as investment in more energy efficient equipment or other budget items. Small business facing financial pressures may also use savings to reduce those pressures and avoid negative financial outcomes.

Across all sectors, interviewees told us that increased energy costs have shifted focus from proactively pursuing energy efficiency for environmental or other reasons toward reactively responding to increasing energy bills by looking for ways to reduce costs. This dynamic does not necessarily change how bill savings are allocated, but rather affects customers' motivations for seeking out and participating in energy savings programs.

Figure 4-8 provides a summary of the employment estimates for both phases (implementation and savings) analyzed in the study. The small decrease in program spending over the two years of the implementation period is reflected in the decline in program-related jobs. The aggregate bill savings would add another projected 1480 jobs over the savings phase, based on total customer bill savings over the useful life of the measures installed, per the NH Utilities' 2022-2023 plan filings.

Figure 4-8: Summary of Employment Estimates for NH Saves Programs and Bill Savings



*Savings phase employment effects represent total FTE job-years, estimated using the 2022 net present value of customer bill savings over the useful life of the energy efficiency measures installed through the NHSaves across two program years.

4.2 Other economic impacts

4.2.1 New Hampshire gross domestic product

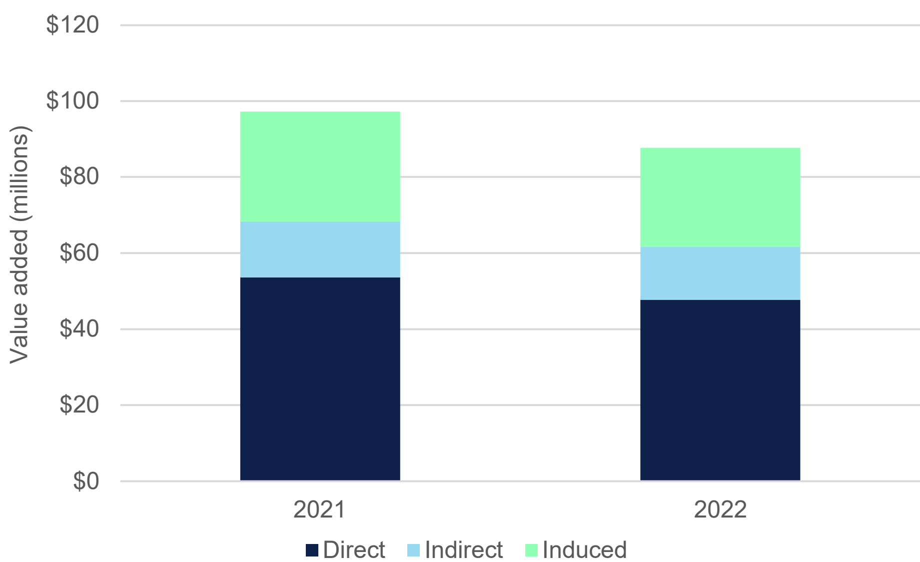
The total economic impact of NHSaves programs modeled in this study can be measured through the changes in value added estimates generated by IMPLAN. Value added reflects the programs' contribution to GDP[59] and is calculated as the total output net of intermediate inputs. As noted in the methodology section, we modeled each sub-program as a combination of output events which reflect direct effects accruing to a particular industry (e.g., spending flowing to HVAC manufacturers or wholesalers), which are then passed through different sectors in the form of indirect effects involving business-to-business transactions (e.g., spending on motors, wiring, etc. for HVAC equipment). Finally, the direct and indirect effects have associated induced effects in the form of increased consumer spending (e.g., restaurant meals, grocery purchases). The total value added reflects the cascading effects of all three levels of spending resulting from the programs.

It is important to note that value added is one way to measure GDP, and it is intricately interlinked with the other impacts measured in this report, including employment. These different metrics reflect the same underlying economic activity, which is the effect of the NHSaves program spending. The NHSaves programs overall added just over $97 million to state GDP

[59] Value added serves as a measure of contribution to the GDP. It is calculated as the total output net of all intermediate input costs. For more please see: https://support.implan.com/hc/en-us/articles/360017144753-Understanding-Value-Added-VA-

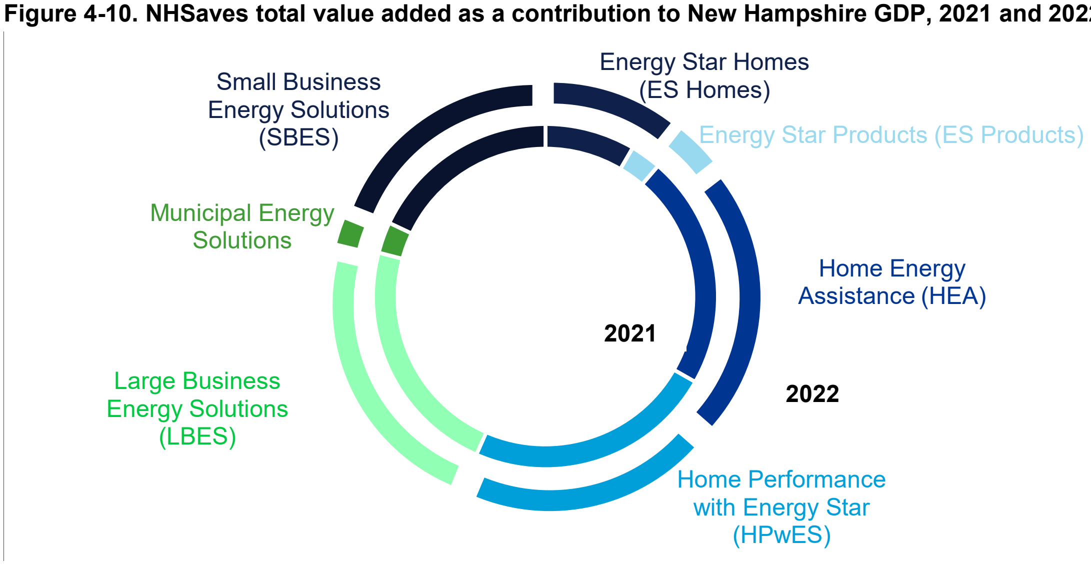
through their total direct, indirect, and induced effects in 2021, and over $87 million in 2022, as shown in Figure 4-9. These estimates reflect the conservative LPP scenario for the share of NHSaves-rebated equipment being purchased from in-state wholesalers and manufacturers. The value added amounts are 1.3 times the program spending in 2021 and 1.2 times the program spending in 2022. These results are generally consistent with impacts of other public programs on GDP, which typically have multiplicative effects whereby GDP grows by a factor of 1 or more times the amount of program spending.

Figure 4-9. NHSaves total value added as a contribution to New Hampshire GDP, 2021 and 2022



Since value added is a function of economic output across sectors, the total effect of each program is directly related to each program's budget, as well as the team's assumed material and labor cost distribution ratios for given programs. In both 2021 and 2022, the HPwES, HEA, and LBES programs had the largest contribution to the state's GDP, as shown in Figure 4-10.

Figure 4-10. NHSaves total value added as a contribution to New Hampshire GDP, 2021 and 2022, by program[1]



[1]2021 values are shown in the inner circle and 2022 values are in the outer circle.

4.2.2 State and local tax revenues

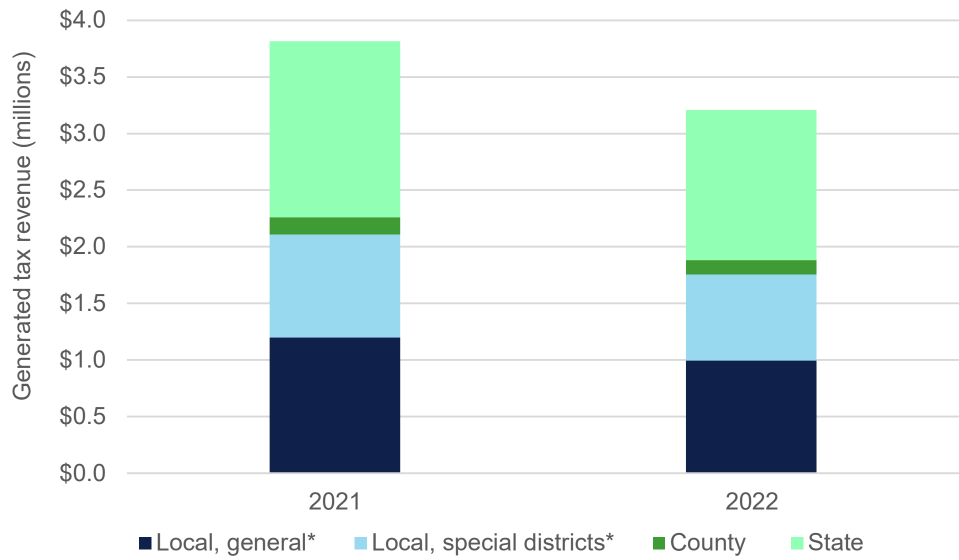
The team's I/O modeling also generated estimates of additional state and local tax revenues generated by the economic activity associated with NHSaves program spending, which are modeled according to New Hampshire's tax regime (e.g., no sales tax, limited income tax). Economic activity generated by the NHSaves programs and detailed in the above sections, such as increased industrial production, employee compensation, or business income, are in many cases taxable. The evaluation team focused on the state and local tax estimates generated for the sub-county, county, special districts, and state governments, and did not model federal tax revenues given the New Hampshire-specific scope of this study. It is important to note that the results for each level of government do not necessarily reflect the governments that levy the tax, but rather they reflect the governments to which the tax dollars ultimately flow.

The total estimated tax revenue generation for all NHSaves programs was about $3.8 million in 2021, and just over $3.2 million in 2022, as shown in Figure 4-11. These estimates reflect the conservative LPP scenario for the share of NHSaves-rebated equipment being purchased from in-state wholesalers and manufacturers. Of these total tax revenue amounts, rebate spending is responsible for approximately $900,000 in 2021 and just over $1 million in 2022, and administrative spending is responsible for the remainder. Administrative expense categories lead to a larger share of direct and indirect tax revenues than rebate spending for two reasons. First, administrative expenses are relatively more human capital-intensive than rebate spending because they reflect spending on managing and implementing programs, whereas rebate spending includes a larger portion of material spending. In addition, a larger share of administrative expenses are incurred in-state, relative to rebate spending. Since rebate spending includes material and out-of-state leakages, the tax revenue from rebates occurs through indirect and induced impacts.

Given New Hampshire's unique taxation structure, most of the tax gains arise from indirect and induced effects. This is because the largest transactions flowing from program funding are the direct purchases of materials (e.g., HVAC measures), and New Hampshire has no sales tax on those transactions, which would show up as direct effects. Primary categories of tax revenues include employer and employee contributions to social insurance taxes, and property taxes.[60] Some of the other tax categories modeled in the software such as taxes on production and imports are applicable but are tied to indirect effects transactions. Other tax categories, such as property taxes, apply to programs' induced effects. For example, property taxes reflected the largest share of tax revenues from the LBES program. Figure 4-12 shows the tax revenue generated by NHSaves at each level of government, by program.

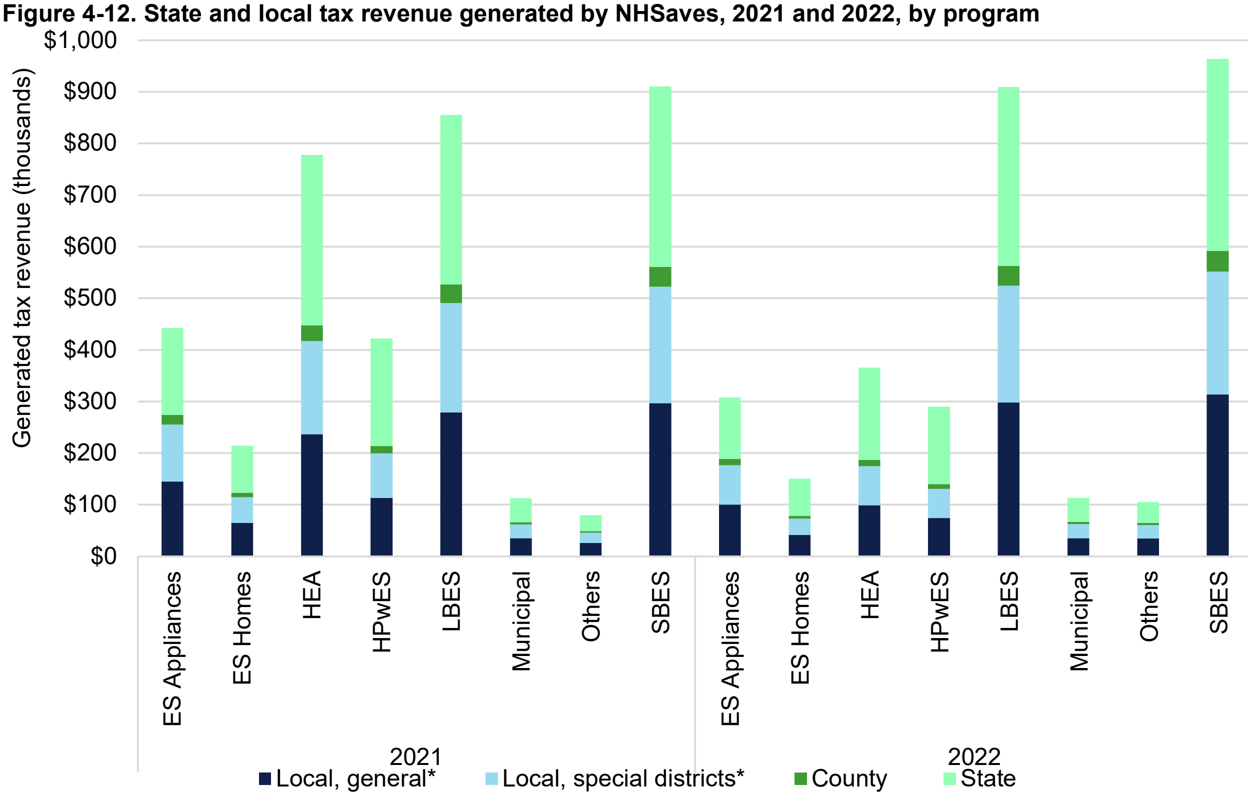
[60] Social insurance taxes include taxes for state government retirement programs, state unemployment taxes, workers' compensation, Medicaid, as well as other federal programs (not modelled in the results presented here), such as Federal Insurance Contributions Act, the Children's Health Insurance Program, Federal Insurance Contributions Act, Federal Unemployment Tax Act, Medicare, military medical, Old Age, Survivors and Disability Insurance, and others. Please see: https://support.implan.com/hc/en-us/articles/360041584233-Taxes-Where-s-the-Tax-

Figure 4-11. State and local tax revenue generated by NHSaves programs, 2021 and 2022



*Local reflects all sub-county level taxes, including general municipal taxes and special districts such as those related to water or transportation infrastructure or other public services.

Figure 4-12. State and local tax revenue generated by NHSaves, 2021 and 2022, by program



*Local reflects all sub-county level taxes, including general municipal taxes and special districts such as those related to water or transportation infrastructure or other public services.
**Other programs include C&I and residential active demand response, education, and behavior (Home Energy Report) programs.

4.2.3 Value of health benefits

The team modeled the estimated monetary value of avoided healthcare costs for New Hampshire citizens from emissions reductions resulting from the NHSaves programs in 2021, as shown in Table 4-4. COBRA outputs a low and high estimate, each at a 3% and 7% discount rate. The low and high estimates reflect the use of different underlying epidemiological studies, particularly on the mortality impacts of PM2.5.[61] The total value ranges from just over $68,000 to over $153,000 at a 7% discount rate and approximately $76,000 to just over $172,000 at a 3% discount rate.

Table 4-4. Estimated annual monetized NH benefits in 2021 (NH only)

Program[1]	Monetary Value (dollars, annual)			
	Low (3%)	High (3%)	Low (7%)	High (7%)
NHSaves Electric Programs	$40,867	$92,260	$36,458	$82,258
NHSaves Gas Residential Programs	$29,059	$65,622	$25,927	$58,510
NHSaves Gas Commercial Programs	$6,393	$14,433	$5,704	$12,868
Total	**$76,319**	**$172,315**	**$68,089**	**$153,636**

[1]Electric program benefits are based on reduced emissions from grid electricity, regardless of the type of end user. In contrast, gas program benefits result from end use combustion, which differs by the type of end user (residential or C&I).

Air pollution does not stop at state boundaries, so the evaluation team also analyzed the avoided healthcare costs for citizens in the entire contiguous United States resulting from emissions reductions attributable to the NHSaves programs. The majority of these benefits would be experienced by citizens of neighboring states; the effects of pollution decreases the farther away from the source one travels. These estimates are substantially greater than the NH-only estimates because many more people would be affected. The savings at a 7% discount rate range from just under $649,000 to almost $1.5 million. The savings at a 3% discount rate range from $727,000 to over $1.6 million.

Table 4-5. Estimated annual monetized NH benefits in 2021 (contiguous US)

Program[1]	Monetary Value (dollars, annual)			
	Low (3%)	High (3%)	Low (7%)	High (7%)
NHSaves Electric Programs	$613,199	$1,383,382	$547,166	$1,233,551
NHSaves Gas Residential Programs	$92,249	$208,245	$82,314	$185,693
NHSaves Gas Commercial Programs	$21,558	$48,669	$19,236	$43,399
Total	**$727,006**	**$1,640,296**	**$648,716**	**$1,462,643**

[1]Electric program benefits are based on reduced emissions from grid electricity, regardless of the type of end user. In contrast, gas program benefits result from reduced end use combustion, which differs by the type of end user (residential or C&I).

It is important to note that these modeling results reflect the impacts of one year of savings from the measures installed during the 2021 program year. As noted in the 2022–2023 plan filings, many of these measures last for close to two decades—the average measure life was 12.2 years for 2022 planned electric measures, and 16.6 for 2022 planned gas measures. The modeling results do not reflect the full impacts of the savings from those measures over their useful lives, which would be significantly larger than the values shown for 2021. However, due to the limitations in the AVERT and COBRA models described in Section 3.4, the team presents the one-year annual values only.

More detailed breakouts of the health benefits are provided in APPENDIX C. AVERT AND COBRA METHODS AND DETAILED RESULTS.

[61] The low estimates are based on the mortality impacts of PM2.5 evaluated by the American Cancer society, whereas the high values reflect the results from the Harvard six-city mortality study. Rather than using an average, the model presents results from both studies. See Fine particulate matter and mortality: a comparison of the six cities and American Cancer Society cohorts with a medicare cohort - PubMed (nih.gov).

4.3 Context and sources of uncertainty

4.3.1 Regulatory and funding uncertainty

The NHSaves programs experienced uncertainty and funding instability during the 2021 and 2022 period modeled in this study. The evaluation team did not quantify the associated economic impacts in the I/O modeling presented in this study, but based on expert interviews, the program uncertainty and instability in funding levels dampened the economic benefits of the programs. Specifically, in December 2020, the Commission ordered the 2021 programs to operate at 2020 funding levels rather than the higher levels proposed in the 2021–2023 plan, until the Commission could fully consider the plan.[62] Then, in November 2021, the Commission issued an order denying the 2021-2023 plan and ordering a steady, significant reduction in program funding starting in 2022.[63] Although the funding reductions were partially restored in 2022, the Commission's decision limited the flow of funding and initiation of new projects for much of 2022, impacting workforce and customer decisions.

The evaluation team interviewed officials at 10 organizations with expertise and knowledge of the NHSaves programs to provide context and insights on the impacts of these decisions. Several key themes emerged from these discussions:

- **Workforce disruption.** Almost all interviewees cited workforce disruptions caused by the decisions. Several noted that the 2021–2023 plan had originally included significant increases in program funding and savings goals, and that despite some uncertainty around the plan due to COVID-19 and other factors, they prepared for anticipated increases by hiring or otherwise ramping up in advance of the 2021 program year. This ramp up exacerbated the impact of the subsequent decisions, which, according to the interviewees, in some cases, led to unanticipated layoffs of contractor or other staff, most notably in the low-income programs. One interviewee noted that the disruptions were more acutely felt by vendors specializing in energy-efficient equipment—e.g., weatherization and LED lighting providers—and less acutely felt by HVAC or other vendors who provide equipment that customers need regardless of whether there is an energy efficient version available. The disruptions also created ongoing challenges in business planning and investment decisions. As one vendor we interviewed noted, contractors need advance knowledge of program funding levels and goals so they can deliver them consistently throughout the year, and uncertainty undermines trust between the trade ally workforce and the program administrators. Several interviewees also noted that firms are recovering from these disruptions but that it takes longer to recover than it did to lose workforce.
- **Customer impacts.** Most interviewees we spoke with cited customer impacts caused by the decisions as well. For customers with projects that were in progress at the time of the decisions, many of the projects were put on hold, some of them indefinitely, according to interviewees. Additionally, in the absence of consistent and reliable funding availability, the NH utilities could not recruit or enroll customers who would have otherwise considered participating in NHSaves programs. As one interviewee said, “It was almost impossible for the utilities to be out there promoting and selling programs, because they didn’t know what they were selling.” The impacts varied depending on the types of projects and customers as follows, according to interviewees.
    - **For small businesses pursuing projects with the promise of program funds**, they often may have had to stop projects such as lighting retrofits, possibly indefinitely. For HVAC or other project types, such customers may have gone ahead with standard efficiency models, rather than high efficiency models.
    - **Large customers can face project financing challenges** due to their multi-layered financing arrangements and capital planning processes. For instance, interviewees involved in developing affordable housing and community buildings for economic development projects said that they use a combination of NHSaves incentives along with

[62] DE 20-092, 2021-2023 NEW HAMPSHIRE STATEWIDE ENERGY EFFICIENCY PLAN, Order Approving Short-Term Extension of 2020 Energy Efficiency Programs and System Benefits Charge Rate, Order No. 26,440, December 29, 2020

[63] DE 20-092, 2021–2023 Triennial Energy Efficiency Plan Order on 2021–2023 Triennial Energy Efficiency Plan and Implementation of Energy Efficiency Programs, Order No. 26,553, November 12, 2021

grant funding, tax subsidies, loans, and other sources to fund projects. These funding sources are inter-related and predictable timing is very important in planning and assembling financing for these projects. For instance, one interviewee said they apply for competitive public funding for affordable housing, and promised funding from NHSaves improves their chances of getting selected. In other cases, grant or other sources require applicants to assess energy savings opportunities and/or identify matching funds for energy improvements, which NHSaves provides. If they think they have this funding and then it falls through, they can end up with a large hole in the budget that risks the overall project's success. One interviewee that develops such projects estimated that 23 (about half) of their ongoing projects, involving a total of over $1 million in incentives, were moderately or significantly impacted by the 2021 decision. A large industrial participant we interviewed said that they fund projects during their annual capital planning season, and having uncertainty or lack of program funding available during that period means they must forgo savings opportunities and lose out on rebates. They estimated that the recent decisions caused them to lose out on over $200,000 in rebates.

Since the period of these decisions, legislation was enacted providing greater stability and certainty regarding the continued funding of the NHSaves programs.[64] However, a subsequent Commission investigation into NHSaves planning, programming, and evaluation raised concerns among stakeholders and trade allies that they would see continued uncertainty and instability in levels of program activity.[65] In addition, the NH Utilities noted that program vendors are still hesitant to commit to program activities in some cases because, although the Utilities understand that the legislation provides more certainty going forward, the vendors do not necessarily believe that to be the case. Further attempts to estimate the economic impacts of the NHSaves programs will require careful analysis of how these ongoing regulatory activities influence workforce and customer expectations and decisions.

4.3.2 In-state and out-of-state impacts

In response to the Commission's directive to adjust for out-of-state expenditures in estimating the economic impacts of the NHSaves programs, the evaluation team reviewed and analyzed data on the NH Utilities' 2021 spending on outside contractors and consultants obtained from recent filings,[66] as described in Section 3.1.1. Using these data, the team estimated the share of non-rebate spending flowing to out-of-state contractors and consultants (rebate spending is assumed to flow solely to NH customers, per program requirements), based on their business address provided by the NH Utilities. However, as the NH Utilities noted in their filings, the business address of a given contractor or consultant does not necessarily reflect the location of the individual(s) working with the programs, and multiple contractors that receive significant program funding and are listed as being out-of-state businesses based on their corporate address employ New Hampshire-based staff who work for the programs.

To account for this in the I/O modeling, the evaluation team ran a sensitivity analysis of economic impacts using two assumptions for the share of program spending that flows from businesses with out-of-state corporate addresses back to New Hampshire-based employees of those businesses: 25% and 50%, as shown in Table 4-6. It is important to note that the far more influential factor for modeling the in- and out-of-state flows of program funding is the LPP.[67] As the results presented in Section 4.1.1 show, the modeled job intensity of the NHSaves programs with conservative LPP assumptions was about 10 jobs per $1 million in 2021 and 2022, but over 14 jobs per $1 million in both years under the more aggressive

[64] HOUSE BILL 549, Signed by Governor Sununu, Feb. 24, 2022
[65] IR 22-042, Investigation of Energy Efficiency Planning, Programming, and Evaluation ORDER OF NOTICE, Aug 10, 2022
[66] NHPUC Docket No. IR 22-042 11-01-2022 IR Requests, Attachment RR 1-006B; NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Report 3.1
[67] LPP indicates the share of the economic effect of rebated measures that will be retained within the region being examined (e.g., New Hampshire). As detailed in Section 3.2.2, LPP ratios represent the extent to which the IMPLAN model assumes commodities are purchased from in-state manufacturers or wholesalers.

LPP assumption. In contrast, the assumed percentage of pass-through to New Hampshire-based employees changes job intensity by less than 1 job per $1 million between the two scenarios modeled and presented in Table 4-6.

Table 4-6. Non-rebate contractor and consultant expenses to out-of-state recipients[1]

Assumed share of out-of-state spending passed through to New Hampshire-based employees	2021		2022	
	Total jobs generated	Jobs per $1 million in program costs	Total jobs generated	Jobs per $1 million in program costs
25% passed to New Hampshire-based employees	698.59	9.35	664.35	9.43
50% passed to New Hampshire-based employees	755.97	10.12	703.30	9.98

[1]Employment effects in this table are modeled with a conservative LPP (=RPC) assumption. See Section 3.2.2 for details.

4.3.2.1 Context and explanatory factors

In addition to the modeling results, the experts interviewed provided context and insights on the inter-state impacts of the programs. One overarching issue raised in the interviews was that New Hampshire has significant out-of-state expenditures on supply-side resources, and that these expenditures should be considered alongside any analysis of out-of-state expenditures on energy efficiency resources. Despite being a net electricity exporter, New Hampshire relies heavily on imports of other sources of energy—particularly fossil fuels for heating and transportation. Specifically, according to EIA data from 2022, New Hampshire does not produce fossil fuels, and over $2 billion flowed out of the state for energy imports across all fuels and end uses.[68] Further analysis of the in- and out-of-state economic impacts of energy supply expenditures would provide context for the results of our analysis but was not feasible within the timeframe of this study.

With regard to local workforce, interviewees said that the vast majority of installation contractors are based in-state, particularly for weatherization projects. However, multiple interviewees noted that NH is a relatively small state with a large population close to the state's borders, providing significant opportunities for neighboring states' contractors to work in NH, and vice versa. There were several recurring themes on the use of out-of-state contractor workforce by the programs, as follows:

- **Sources of out-of-state contractor workforce.** Program vendors and large customers we interviewed said that Massachusetts is the largest source of out-of-state workforce (and materials) for the NHSaves programs, and that it has a substantial and well-trained energy efficiency workforce that includes specialized firms not always available in-state. Other jurisdictions providing workforce for NHSaves mentioned by interviewees include Maine (particularly near the Seacoast area) and Canada, where contractors are drawn to NH because the exchange rate is highly favorable for working in the U.S. and getting paid in dollars.
- **Types of firms coming from out-of-state.** According to the experts interviewed, the types of firms that are most frequently New Hampshire-based include weatherization contractors, construction management firms, and general contractors. The types of firms most commonly based in other states are specialized firms with expertise in complex custom projects and controls measures. Interviewees also said that there is a relatively large population of in-state contractors for small business projects, but there are many regional firms providing commercial lighting, HVAC, and refrigeration as well. They also said larger industrial equipment often comes from out-of-state.
- **Drivers of out-of-state contractor workforce**. Interviewees said that a key reason for the need for out-of-state contractors is that states face competition for workforce, and neighboring states have larger, more well-funded programs that over time have led to growth in the contractor workforce in those states. They also said that there are certain equipment types where higher levels of program support and customer adoption have led to growth in the workforce for those technologies neighboring states. For instance, one interviewee said that NH has a large base of

[68] EIA data shows total energy expenditures of $4.6 billion, total consumption of 296 trillion Btu, and total in-state energy production of 149 trillion Btu. U.S. Energy Information Administration, New Hampshire State Energy Profile, updated Sept 2022. https://www.eia.gov/state/print.php?sid=NH.

HVAC contractors, but that contractors with expertise in heat pumps often come from neighboring states with more widespread heat pump adoption.

Interviewees mentioned several other issues related to the flow of workforce and program spending between states.

- **The NH workforce benefits from other states' programs**. One interviewee who is currently an NHSaves vendor had previously worked for the Mass Save programs while living in NH, during which time he completed numerous training courses and earned a BPI certification. This education and training were largely funded by the MA programs but provided a foundation for the interviewee's current work for NHSaves.
- **NHSaves can enhance local workforce recruitment**. One agency official we interviewed said that when recruiting businesses to move to New Hampshire, particularly from Canada, they are often concerned by the state's high energy costs. He said that programs such as NHSaves that can help businesses manage energy costs are a key part of the business recruitment "sales pitch."

4.3.3 Long-term impacts

As noted in the New Hampshire Cost Effectiveness Review,[69] I/O modeling is best suited for relatively short-term analysis. Longer term economic impacts (beyond 5 years) are highly uncertain due to a variety of factors, and I/O models as well as EPA's COBRA and AVERT models are based on current economic and energy structures. Large government programs can lead to potential shifts in industry structures which cannot be factored into current I/O matrices. Other structural changes could include, for example, pandemics such as COVID-19 leading to fundamental shifts in building usage affecting the impact of residential and commercial energy efficiency investments, as well as international economic disruptions and military conflicts affecting energy markets. Such changes are highly difficult to anticipate, predict, and model.

However, the evaluation team conducted several analyses that shed light on the Commission's directive to assess the impact of different discount rate assumptions, and to account for the economic activity and energy consumption resulting from future cost savings. These impacts occur specifically during the savings phase of the programs, after energy efficiency measures are installed and result in (1) energy use reductions and corresponding health benefits as discussed in Section 4.2.3, and (2) bill savings that is re-allocated to other spending, creating economic impacts as discussed in Section 4.1.2.

4.3.3.1 Rebound effects

The evaluation team's IMPLAN modeling accounted for the economic activity resulting from future cost savings, as part of the bill savings modeling task as detailed in Section 3.2.3. Specifically, the team's modeling of long-term bill savings treated residential savings as additional household income, which results in employment gains through induced economic activity (e.g., household spending on services, recreation). Modeling of C&I sector bill savings assumed those savings are redirected towards additional industry activity, resulting in additional economic output.

However, the modeling did not account for secondary energy consumption related to this additional economic activity—also known as the "rebound effect" or "'macroeconomic growth effect." As described by Gillingham et al (2015), "the basic premise is that an increase in the efficiency of energy-consuming durables may spur economic growth—and that economic growth requires additional energy consumption."[70] There are multiple theoretical pathways through which this effect occurs, but empirical estimates of its effect are limited and there are steep challenges in developing such estimates. A review of research on the topic described such challenges:[71]

> "For the last century, we have seen large increases in both energy use and the energy efficiency of many durable goods. But in order to claim a causal relationship between energy efficiency and energy use, it must be shown that energy

[69] https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/LETTERS-MEMOS-TARIFFS/17-136_2019-10-31_STAFF_NH_COST_EFFECTIVENESS_REVIEW.PDF
[70] Gillingham, K, Rapson, D, and Wagner, G. (2015, September 25). The Rebound Effect and Energy Efficiency Policy, Review of Environmental Economics and Policy, Yale University and the National Bureau of Economic Research. Retrieved March 1, 2023, from https://resources.environment.yale.edu/gillingham/GillinghamRapsonWagner_Rebound.pdf
[71] Ibid

consumption has not increased due to some other factor. …In fact, it is extremely difficult, if not impossible, to separate the effect of energy efficiency improvements from exogenous economic growth and the simultaneous dramatic improvements in energy services."

Similarly, a PERI study of clean energy investments in Maine noted that although increased energy efficiency can result in rebound effects, these effects are likely to be modest in advanced economies where there is already high saturation in energy-using equipment. For example, the study notes that homeowners are not likely to clean dishes more frequently because they have more efficient dishwashers, and although consumers may heat and cool their homes and drive their cars somewhat more given higher levels of efficiency, these increases are modest in advanced economies.[72] In another example, research on the Massachusetts Home Energy Services weatherization program found little evidence of rebound, with about half of participants reporting no changes in cooling and heating setpoints following weatherization of their homes. Among those who did change setpoints, the vast majority reported doing so in a way that would reduce consumption (i.e., higher cooling and lower heating setpoints).[73] Attempting to quantify the rebound effect for the NHSaves programs would require more rigorous analysis that is beyond the scope of this review.

4.3.3.2 Discount rate assumptions

For the customer bill savings analysis, the team relied on the bill impacts values as filed by the utilities. As noted in Section 3.1.2, the values reflect long-term revenue requirement changes that use the same discount rate assumptions as in the B/C model filed with the 2022–2023 plan, shown in Table 4-7. Re-modeling the bill and rate impacts of the plan under different discount rate assumptions was not feasible within the timeframe of this study.

Table 4-7. Discount rate assumptions for customer bill savings analysis

Rate	Value	Source
Nominal Discount Rate	3.25%	Updated October 18, 2021. Based on the June 2021 Prime Rate in accordance with the Final Energy Efficiency Group Report, dated July 6, 1999 in DR 96-150
Inflation	2.03%	Updated October 18, 2021. Based on the inflation rate from Q1 2020 to Q1 2021, per the Federal Reserve Bank of St. Louis
Real Discount Rate	1.19%	Real Discount Rate = [(1 + Nominal Discount Rate)/(1 + Inflation Rate)] – 1

Source: NH Utilities' B/C and Bill and Rate Impacts models for 2022-2023 plan.

For health impacts analysis, we applied the 3% and 7% discount rates built into COBRA, which are reflected in the results as presented in Section 4.2.3. Further discount rate sensitivity analysis for health impacts was also not feasible within the timeframe of this study.

Implementation phase impacts, including employment and other economic impacts, are generally incurred in the same period as the program dollars were spent (2021 and 2022), and the team determined that discounting was not appropriate for these impacts. The team assumes dissipation of these impacts once those years' dollars are spent, an assumption that was validated by our interviews with experts, who widely cited direct workforce disruptions resulting from program funding reductions.

Although comprehensive sensitivity analyses of discount rate assumptions were not feasible within the timeframe of this study, the results suggest that modelled program impacts are less sensitive to discount rate assumptions than to other underlying assumptions. For instance, the value of the health impacts presented in Section 4.2.3 above decrease by about 11% when moving from a 3% discount rate to 7% discount rate. By comparison, the value of the health impacts presented above increases by about 125% between the "low" and "high" scenarios that reflect the two different underlying

[72] Pollin, R., Wicks, J., Chakraborty, S., & Semieniuk, G. (2020, August 27). PERI - A Program for Economic Recovery and Clean Energy Transition in Maine. Political Economy Research Institute. Retrieved February 14, 2023, from https://peri.umass.edu/component/k2/item/1339-a-program-for-economic-recovery-and-clean-energy-transition-in-maine

[73] Navigant. Massachusetts Home Energy Services Realization Rate Assessment (RES 39), Mar. 2020 https://ma-eeac.org/wp-content/uploads/MA-RES-39-HES-RR-Assessment-Executive-Summary_FINALwES_19MAR2020.pdf

epidemiological studies on the mortality impacts of PM2.5.[74] Similarly, the NH Utilities' filings[75] of B/C model results under different discount rate assumptions show that statewide, the programs' GST benefits decrease by about 12% when moving from the 1.41% real discount rate used in the plan to a 3% real discount rate, and they decrease by 15% when moving from a 3% to 5.5% real discount rate. Other sensitivity analyses presented in this report, such as employment effects under conservative and aggressive LPP scenarios, show larger changes in results due to differing assumptions.

4.4 Results comparison

I/O models have been deployed in different contexts to assess the employment effects of energy efficiency and other types of energy services programs. Studies have also examined the impacts of large scale federal and state level programs on macroeconomic indicators such as GDP and employment. For example, a 2020 study by PERI[76] estimates the effects of economic stimulus measures in the US economy and concludes that investments of about $600 billion per year over 10 years would create 4.6 million jobs per year in infrastructure and 4.5 million jobs in the clean energy sector. In addition, the study also concludes that public investments in these programs will stimulate private investments worth $300 billion which would result in another 4.5 million jobs. In a similar analysis in the state of Maine, the group concludes that an average annual investment of $2.2 billion in the state would create 15,000 jobs per year.[77]

Table 4-8 provides a comparison of results from recent studies that used I/O modeling to analyze the employment impacts of regional and state-specific energy programs. Differences in scope, jurisdiction, and the type of programs analyzed should be considered in comparing results.[78] For instance, most nationwide studies reflect a higher job intensity compared to region- or state-specific studies. Nationwide studies in the US have typically estimated job intensities in the range of 10 to 15 jobs per $1 million in program investment, as shown Table 4-8. In state-specific studies, these numbers range from about 6 to 12 jobs per million. The results of the team's analysis of the NHSaves programs—around 10 jobs per million in 2021 and 2022 in the conservative LPP scenario—are closer to the higher end of the range of results of state specific analyses. In the more aggressive LPP scenario, the numbers are higher at over 14 jobs per million in both years—closer to the estimates from nationwide studies.

[74] The low estimates are based on the mortality impacts of PM2.5 evaluated by the American Cancer society, whereas the high values reflect the results from the Harvard six-city mortality study. Rather than using an average, the model presents results from both studies. See Fine particulate matter and mortality: a comparison of the six cities and American Cancer Society cohorts with a medicare cohort - PubMed (nih.gov).

[75] NHPUC Docket No. IR 22-042 2021 Program Year Compliance Filing Order No. 26,621, Attachment RR 1-001C, December 16, 2022.

[76] Pollin, R., & Chakraborty, S. (2020). Job creation estimates through proposed economic stimulus measures. *Political Economy Research Institute (PERI)*. Available at https://peri.umass.edu/publication/item/1297-job-creation-estimates-through-proposed-economic-stimulus-measures

[77] Pollin, R., Wicks-Lim, J., Chakraborty, S., & Semieniuk, G. (2020). A program for economic recovery and clean energy transition in Maine. *Amherst: Political Economy Research Institute Research Report, University of Massachusetts Amherst*

[78] In addition, the evaluation team's analysis presented in this report reflects the most granular, measure-specific review of energy efficiency program economic impacts among the literature we reviewed. The analyses in comparison studies were largely conducted at the aggregate economy level. Most studies do not examine the effects of specific program measures in the way this analysis does.

Table 4-8. Comparison economic impact studies[79]

Title	Authors	Year	Publisher/ Journal	Jurisdiction	Approach	Industry	Jobs per $1 million	URL
Job Creation Estimates for Colorado Through Inflation Reduction Act	Pollin, R., Chakraborty, S., Lala, C., Semieniuk, G.	2022	PERI	Colorado	IMPLAN		9.2	Link
State-Level Employment Projections for Four Clean Energy Technologies	Truitt, S., Elsworth, J., Williams, J., Keyser, D., Moe, A., Sullivan, J. Wu, K.	2022	NREL	USA	IMPLAN		6.04	Link
Employment Impacts of Proposed U.S. Economic Stimulus Program: Job Creation, Job Quality, and Demographic Distribution Measure	Pollin, R., Chakraborty, S., Wicks-Lim, J.	2021	PERI	USA	IMPLAN	Building Retrofits	13.4	Link
						Industrial Efficiency	14.2	
A Program for Economic Recovery and Clean Energy Transition in California	Pollin, R., Wicks-Lim, J., Chakraborty, S., Kline, C., Semieniuk, G.	2021	PERI	California	IMPLAN	Building Retrofits	7.7	Link
						Industrial Efficiency	5.7	
						Grid Upgrades	5.1	
Impacts of the Reimagine Appalachia & Clean Energy Transition Program for Pennsylvania	Pollin, R., Wicks-Lim, J., Chakraborty, S., Semieniuk, G.	2021	PERI	Pennsylvania	IMPLAN	Building Retrofits	8.8	Link
						Industrial Efficiency	6.7	
						Grid Upgrades	6.9	
Impacts of the Reimagine Appalachia & Clean Energy Transition Program for West Virginia	Wicks-Lim, J., Robert, P., Chakraborty, S., Semieniuk, G.	2021	PERI	West Virginia	IMPLAN	Building Retrofits	7.7	Link
						Industrial Efficiency	3.6	
						Grid Upgrades	4.6	
Estimating employment from energy-efficiency investments	Brown, M., Soni, A., Li, Y.	2020	*MethodsX*	USA	IMPLAN	Residential	12.55	Link
						Commercial	12.64	
Energy Efficiency 2020	IEA	2020	IEA	USA	Publicly available data	Building Retrofits	14.8	Link
						Efficient New Buildings	15	
						Industry Efficiency	10	

[79] Natanael Pabon-Trinidad, an MPA student in the Department of Public Administration at Louisiana State University contributed in compiling this Table.

Title	Authors	Year	Publisher/ Journal	Jurisdiction	Approach	Industry	Jobs per $1 million	URL
A Program for Economic Recovery and Clean Energy Transition in Maine	Pollin, R., Wicks-Lim, J., Chakraborty, S., Semieniuk, G.	2020	PERI	Maine	IMPLAN	Building Retrofits	11.8	Link
						Industrial Efficiency	8.1	
						Grid Upgrades	6.9	
Impacts of the Reimagine Appalachia & Clean Energy Transition Program for Ohio	Pollin, R., Wicks-Lim, J., Chakraborty, S., Semieniuk, G.	2020	PERI	Ohio	IMPLAN	Building Retrofits	9.7	Link
						Industrial Efficiency	7.6	
						Grid Upgrades	7.4	
Maryland Benefits: Expanding the Results of EmPOWER Maryland through 2015	Baatz, B., Barrett, J.	2017	ACEEE	Maryland	Publicly available data		13.2	Link
Green versus Brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model	Garrett-Peltier, H.	2017	*Economic Modeling*	USA	I-O Models	Weatherization	8.21	Link
						Home Weatherization	7.41	
						Commercial Retrofits	7.26	
						Industrial Energy Efficiency	7.41	
						Smart Grid	6.76	
The job generation impacts of expanding industrial cogeneration	Baer, P., Brown, M., Kim, G.	2015	*Ecological Economics*	USA	IMPLAN	Industrial Cogen	14.48	Link
Verifying Energy Efficiency Job Creation: Current Practices and Recommendations	Bell, C., Barrett, J., McNerney, M.	2015	ACEEE	USA	IMPLAN		5 to 11	Link
Green Growth: A U.S. Program for Controlling Climate Change and Expanding Job Opportunities	Pollin, R., Garrett-Peltier, H., Heintz, J., Hendriks, B.	2014	Center for American Progress/PERI	USA	IMPLAN		14.6	Link
Analysis of Job Creation and Energy Cost Savings From Building Energy Rating and Disclosure Policy	Burr, A., Majersik, C., Stelberg, S.	2012	PERI/IMT	USA	IMPLAN	Multifamily Capital Upgrades (weighted)	13.41	Link
						Commercial Capital Upgrades (weighted)	12.94	

Title	Authors	Year	Publisher/ Journal	Jurisdiction	Approach	Industry	Jobs per $1 million	URL
Employment Estimates for Energy Efficiency Retrofits of Commercial Buildings	Garrett-Peltier, H.	2011	PERI	USA	IMPLAN		13.6	Link
The Economic Benefits of Investing in Clean Energy: How the economic stimulus program and new legislation can boost U.S. economic growth and employment	Pollin, R., Heintz, J., Garrett-Peltier, H.	2009	PERI/Center for American Progress	USA	IMPLAN	Building Retrofits	11.9	Link
						Smart Grid	8.9	

5 CONCLUSIONS AND CONSIDERATIONS FOR NEW HAMPSHIRE

Based on the analysis and results presented above, the 2021 and 2022 NHSaves programs had significant positive economic impacts on New Hampshire's economy, including short-term and long-term employment effects, increased state GDP, state and local tax revenues, and monetized public health benefits.

It is important to note that these quantified impacts are best estimates, which reflect underlying assumptions and limitations in modeling tools and data. The team documented these assumptions and limitations and presented ranges of estimates throughout the report that include conservative and aggressive assumptions for in-state impacts and other factors. Despite some amount of imprecision, which is inherent in economic modeling, the scale and scope of quantified impacts provides clear evidence of the economic benefits of the programs. In addition, as described in the National Standard Practice Manual,[80] jurisdictions "should account for all relevant, substantive impacts (as identified based on policy goals), even those that are difficult to quantify and monetize. Using best-available information, proxies, alternative thresholds, or qualitative considerations to approximate hard-to-monetize impacts is preferable to assuming those costs and benefits do not exist or have no value."

In addition to quantitative modeling, the team's interviews with officials from multiple organizations with expertise and knowledge of the NHSaves programs validate the importance of the programs in supporting and growing the local workforce and in providing New Hampshire businesses and residents with funding to support energy efficiency investments. The value of the programs can be seen in part by the disruptions to local workforce and customers that occurred when the programs' continuity became uncertain. The programs also provide a tool for workforce recruitment and retention that can help New Hampshire compete with surrounding states that offer similar state-wide energy efficiency programs.

5.1 Further research

There are several areas of analysis covered in this study that were limited due to schedule and scope constraints, summarized in the list below, which could be explored in greater depth. This could include primary New Hampshire data collected from customers and other market actors via surveys, interviews, or other methods to validate and expand on the team's modelling results, while considering tradeoffs between costs, rigor, and value of additional research.

- Analysis of inter-state workforce effects of the NHSaves programs, to help quantify the qualitative insights from expert interviews on workforce competition and use of in- and out-of-state contractor workforce
- Updating health impacts analysis for future program years to reflect updated ISO-NE data on electricity generation mix and updated demographic data underlying epidemiological models
- Further analysis of long-term customer bill savings and discount rate sensitivity analyses, to provide additional insight in response to the Commission
- Analysis of secondary energy consumption related to economic activity spurred on by the NHSaves programs—also known as the "rebound effect"—to provide additional insight in response to the Commission.

[80] The NSPM is a publication of the National Efficiency Screening Project (NESP), which works to improve cost-effectiveness assessments of customer-funded electric and gas energy efficiency programs. The NSPM includes a set of fundamental principles for cost-effectiveness analysis, which have been applied in multiple jurisdictions nationwide. See NESP, *National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources,* Spring 2017, available at https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf.

APPENDIX A. LITERATURE REVIEW SOURCES

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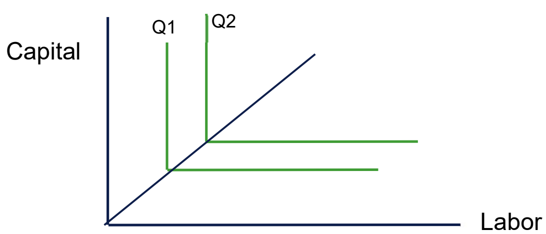
APPENDIX B. IMPLAN METHODS

Input-output (I-O) modeling provides a snapshot view of the economy and is often used to assess how changes in one sector impact the entire economy. I-O modelling has been deployed extensively to estimate the effects of environmental programs including the impacts on GDP, employment, and other economy-wide indicators.[81,82]

The I-O approach relies on exchange among different industries in an economy. The entire economy is represented using a matrix of inputs used to produce outputs known as the Leontief Inverse Matrix. The analysis begins with the n x n matrix A that represents the economy. Each element of the matrix A, aij = xij/xj, represents the inputs needed from industry i to produce one unit of output for industry j. In the symmetric Leontief Inverse Matrix ((I-A)-1), the rows represent the inputs to produce the outputs represented in columns. The coefficient matrix is then post-multiplied by a final demand vector that represents (∆Y)—the change in output for different industries owing to the increase in investments.

IMPLAN deploys a social accounting matrix (SAM) that represents the economy-wide transactions between and within industries, institutions, and households. The SAM is an extension of an I-O matrix as explained in the following paragraphs. The software is based on 546 industries and 536 commodities. Each industry/commodity is, in turn, represented by a Leontief production function (Q = Min(aK, bL))—i.e., the inputs are used in fixed proportions and the resulting isoquants (the relationship between inputs and outputs) are at right angles implying that different inputs are always deployed in fixed proportions to manufacture a commodity (Figure B-1).

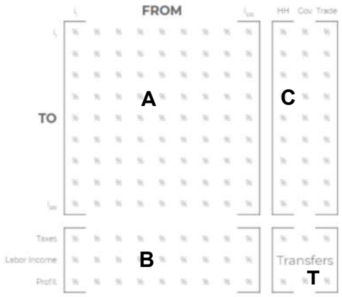
Figure B-1:Representation of a typical Leontief Isoquant Map



The underlying data for a region in each year represents the backward linkages within industries. These linkages include the intermediate inputs, employee compensation, proprietor income (i.e. profits) and taxes.[83] In Figure B-2, for example, block A represents the payments (for intermediate inputs) from each of the 536 industries (in the columns) to all the industries (in the rows). As an illustration, moving down each row in the first column, each cell represents the share of payments from industry 1 to industries 1 through 536. To account for the imports of each commodity from outside the region being examined, the model also weighs the transfers by the regional purchase coefficient of each industry. This is the Input-Output component of the overall SAM.

[81] Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge University Press.
[82] Garrett-Peltier, H. (2017). Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model. *Economic Modelling*, *61*, 439-447.
[83] https://support.implan.com/hc/en-us/articles/360035967274-Industry-Leontief-Production-Functions-in-IMPLAN

Figure B-2: Illustration of the underlying structure of the SAM in IMPLAN[84]



In addition to the input-output relation based on the production relations presented above, the social accounting matrix also includes information on the total value added (block B) measured through the tax on production and imports, labor income, and profits earned by proprietors. These values are based on the region-specific data contained in IMPLAN. The social accounting matrix also incorporates the flow of payments from household income, government spending and inter-regional trade flows through different forms of spending to each industry (block C). Finally, the SAM also accounts for the transfers from households, government, and inter-region trade in the form of taxes, labor income (that accrues to households and business), and profits to businesses (block T).

Computing Employment Effects in an I-O set-up

To generate the employment effects, the team starts with the economy-wide 1xn vector e of employment multipliers where each element e_i represents the employment needed to generate one unit of output for industry *i*. The post-multiplication product $(e(I-A)^{-1})$ provides the total employment effects of investments in the economy. The analysis generates three types of effects – direct, indirect, and induced, as described below.

- ***Direct effects*** represent the total impact on sectors that get affected by direct spending due to the creation of a new industry. In energy efficiency programs, the direct effects relate to production and installation activities.
- ***Indirect effects*** primarily include the materials and industry demand. These effects accrue to industries supplying inputs to the sectors benefiting directly.
- ***Induced effects*** reflect the second order effects realized in the form of increased spending on consumer goods and services by those earning higher incomes due to the direct and indirect effects.

Distribution ratios and industry code matching

To take advantage of the granular, measure-level program spending data in the NH Utilities' B/C models, we modeled the employment effects of each sub-program individually, distributing each measure-level spending value into materials and labor costs. All material components and labor inputs were modeled as commodity events for the relevant commodity sectors. Table B-1 below provides the list of IMPLAN industries matched against each energy efficiency measure in the NH Utilities' B/C model.

[84] Figure sourced from IMPLAN: https://support.implan.com/hc/en-us/articles/360035967274-Industry-Leontief-Production-Functions-in-IMPLAN

Table B-1. IMPLAN industry and B/C model measure matching

IMPLAN Industry Name	Measures
Air and gas compressor manufacturing	Air compressors, air nozzles, compressor storage, custom compressor measures
Air conditioning, refrigeration, and warm air heating equipment manufacturing	Air conditioning, chillers, furnaces, heat pumps, other HVAC, refrigeration measures, ice machines, circulator pumps, VRFs, VFDs
Air purification and ventilation equipment manufacturing	Dehumidifiers, air purifiers, demand control ventilation, fan motors
All other industrial machinery manufacturing	Large custom measures
All other electrical equipment and component manufacturing	Advanced power strips
Architectural, engineering, and related services	Comprehensive design, code compliance, Home Energy Raters
Automatic environmental control manufacturing	Boiler controls, RTU controls, energy management systems, lighting controls, hood controls, thermostats
C&I machinery and equipment repair and maintenance	Retro-commissioning
Community food, housing, and other relief services	Workforce development and training
Construction of new multifamily residential structures	EnergyStar Homes measures (multifamily)
Construction of new single-family residential structures	EnergyStar Homes measures (single family)
Electric lamp bulb and part manufacturing	LED lighting (lamps)
Environmental and other technical consulting services	Energy audits, quality assurance, technical assistance
Food product machinery manufacturing	Ovens, fryers, griddles, hot food holding cabinets, steam cookers
Heating equipment (except warm air furnaces) manufacturing	Boilers, circulator pumps, infrared heaters, condensing unit heaters
Household cooking appliance manufacturing	Residential dishwashers
Household laundry equipment manufacturing	Clothes washers, clothes dryers
Household refrigerator and home freezer manufacturing	Freezers, refrigerators, refrigerator recycling
Lighting fixture manufacturing	Lighting fixtures, custom lighting, performance lighting
Maintenance and repair construction of residential structures	Air sealing, duct sealing, contractor fees
Management of companies and enterprises	Administrative and vendor fees, rebate processing, 3rd party financing
Metal window and door manufacturing	Insulated doors
Mineral wool manufacturing	Envelope insulation, duct insulation
Motor and generator manufacturing	Custom motors, case motors, ECM motors
Newly constructed single-family residential structures	Residential code compliance
Other commercial service industry machinery manufacturing	Commercial water heaters, commercial dishwashers
Other major household appliance manufacturing	Residential water heaters
Other plastics product manufacturing	Window inserts
Plumbing fixture fitting and trim manufacturing	Showerheads
Polystyrene foam product manufacturing	Pipe insulation, pipe wrap
Pottery, ceramics, and plumbing fixture manufacturing	Faucet aerators
Pump and pumping equipment manufacturing	Pool pumps
Sheet metal work manufacturing	Heat recovery ventilators
Small electrical appliance manufacturing	Vending misers
Valve and fittings, other than plumbing, manufacturing	Steam traps, pre-rinse spray valves
Water, sewage and other systems	Wastewater treatment facility measures
Wood windows and door manufacturing	Window replacements

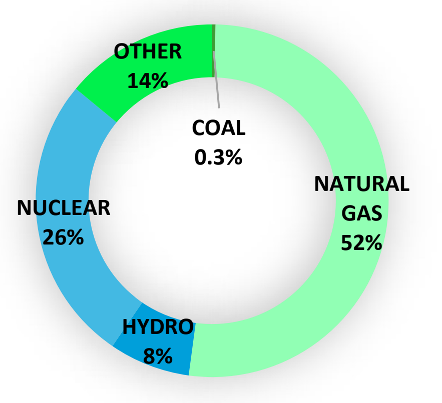
APPENDIX C. AVERT AND COBRA METHODS AND DETAILED RESULTS

Electric generation

The analysis of the NHSaves electric programs' emissions and health impacts is based on the programs' reductions in demand during peak hours.[85] According to Energy Information Administration data, nuclear energy is the main source of electricity generated in New Hampshire.[86] However, during peak hours, fossil fuel generators act as marginal power plants. Power plants operated on fossil fuels, especially coal, are one of the major sources of the criteria pollutants. The NHSaves programs result in savings during ISO New England peak hours, thereby reducing the need for these plants and in turn reducing criteria pollutants. The model also assumes that there are no imports or exports, hence the regions are self-sufficient when it comes to electricity.

In this study, we used AVERT along with COBRA to estimate the health benefits arising from the energy efficiency programs in the power sector. It should be noted that from 2001 to 2020, air emissions from the regional generators in New England have declined drastically. According to ISO New England, the decline can be attributed to decrease in generation from coal and oil powered generation and an increased penetration of renewable resources in the generation fleet. Low emitting gas resources now make up 52% of all electric generation in New England and 98% of the fossil-fueled generation (Figure C-1).

Figure C-1. ISO New England electric generation mix by fuel type, 2022



Source: ISO New England, 2022

End-use combustion

For analysis of the NHSaves gas programs, DNV estimated criteria pollutants using the emission factors provided by the EPA,[87] following the methodology laid in the COBRA user manual.[88] The EPA emission factors report units of pollution (lbs) per million cubic feet (MMcf) of natural gas. To use these emission factors, we converted the savings from MMBtu to MMcf, using the following steps:

- Converted MMBTU to therms by multiplying it by 10
- Converted therms to cubic feet by dividing by 0.01037, per the EIA (In 2020, the U.S. annual average heat content of natural gas delivered to consumers was about 1,037 Btu per cubic foot. Therefore, 100 cubic feet (Ccf) of natural gas equals 103,700 Btu, or 1.037 therms)

[85] See ISO-NE, https://www.iso-ne.com/about/key-stats/electricity-use/ and https://www.iso-ne.com/about/key-stats/air-emissions.
[86] See https://www.eia.gov/state/analysis.php?sid=NH
[87] See EPA document AP-42, Compilation of Air Emission Factors
[88] See https://www.epa.gov/sites/default/files/2021-03/documents/cobra-fact-sheet-natural-gas.pdf

- Converted cubic feet to MMcf by dividing by 1,000,000
- Multiplied the MMcf of fuel savings by the EPA emission factors for residential and C&I users defined in EPA AP-42
- Divided by 2,000 to convert pounds to tons.

We estimated benefits from residential and commercial gas programs separately given the difference in the emission factors and end uses for those sectors. For the residential sector in particular, end-use combustion fuels include propane, kerosene, wood pellets, and fuel oil. However, modeling end-use combustion for each fuel type was not feasible due to data and project timeline limitations. Therefore, the study assumed all end-use combustion used natural gas. Because combustion of other fuels (particularly oil, kerosene, and wood pellets) creates more criteria pollutants than combustion of natural gas, this assumption resulted in a conservative estimate of the health effects of the programs due to changes in end-use combustion.

Detailed health benefits results

The tables in this section show the detailed breakdown of the health benefits stemming from the 2021 energy savings attributable to the NHSaves program, both for New Hampshire only, as well as the contiguous United States, each at a 3% and 7% discount rate. The tables present both low and high estimates, reflecting the use of different underlying epidemiological studies, particularly on the mortality impacts of PM2.5.[89] The tables illustrate that most of the benefits are attributed to avoided mortality due to the decrease in PM2.5, and the remaining results from effects on morbidity. EPA uses the value of statistical life (VSL) to calculate estimates of mortality benefits.

New Hampshire only, electric

This section documents the detailed COBRA outputs for electric program savings when the pollution effects are limited to New Hampshire only.

Table C-1. Estimated annual monetized benefits from electric savings in 2021, New Hampshire, 3% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.004	0.008	$40,296	$91,160
Nonfatal Heart Attacks *	0	0.004	$64	$593
Infant Mortality	0	0	$127	$127
Hospital Admits, All Respiratory	0.001	0.001	$32	$32
Hospital Admits, Cardiovascular **	0.001	0.001	$46	$46
Acute Bronchitis	0.004	0.004	$2	$2
Upper Respiratory Symptoms	0.066	0.066	$3	$3
Lower Respiratory Symptoms	0.046	0.046	$1	$1
Emergency Room Visits, Asthma	0.002	0.002	$1	$1
Asthma Exacerbation	0.07	0.07	$5	$5
Minor Restricted Activity Days	2.388	2.388	$209	$209
Work Loss Days	0.399	0.399	$80	$80
Total Health Effects			**$40,867**	**$92,260**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks.

[89] The low estimates are based on the mortality impacts of PM2.5 evaluated by the American Cancer society, whereas the high values reflect the results from the Harvard six-city mortality study. Rather than using an average, the model presents results from both studies. See Fine particulate matter and mortality: a comparison of the six cities and American Cancer Society cohorts with a medicare cohort - PubMed (nih.gov).

Table C-2. Estimated annual monetized benefits from electric savings in 2021, New Hampshire, 7% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.004	0.008	$35,891	$81,195
Nonfatal Heart Attacks *	0	0.004	$60	$555
Infant Mortality	0	0	$127	$127
Hospital Admits, All Respiratory	0.001	0.001	$32	$32
Hospital Admits, Cardiovascular **	0.001	0.001	$46	$46
Acute Bronchitis	0.004	0.004	$2	$2
Upper Respiratory Symptoms	0.066	0.066	$3	$3
Lower Respiratory Symptoms	0.046	0.046	$1	$1
Emergency Room Visits, Asthma	0.002	0.002	$1	$1
Asthma Exacerbation	0.07	0.07	$5	$5
Minor Restricted Activity Days	2.388	2.388	$209	$209
Work Loss Days	0.399	0.399	$80	$80
Total Health Effects			**$36,458**	**$82,258**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

New Hampshire only, gas

This section documents the detailed COBRA outputs for gas program savings when the pollution effects are limited to New Hampshire only.

Table C-3. Estimated annual monetized benefits from residential gas savings in 2021, New Hampshire, 3% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.003	0.006	$28,624	$64,808
Nonfatal Heart Attacks *	0	0.003	$46	$425
Infant Mortality	0	0	$104	$104
Hospital Admits, All Respiratory	0.001	0.001	$23	$23
Hospital Admits, Cardiovascular **	0.001	0.001	$33	$33
Acute Bronchitis	0.003	0.003	$2	$2
Upper Respiratory Symptoms	0.052	0.052	$2	$2
Lower Respiratory Symptoms	0.037	0.037	$1	$1
Emergency Room Visits, Asthma	0.002	0.002	$1	$1
Asthma Exacerbation	0.055	0.055	$4	$4
Minor Restricted Activity Days	1.805	1.805	$158	$158
Work Loss Days	0.302	0.302	$61	$61
Total Health Effects			**$29,059**	**$65,622**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-4. Estimated annual monetized benefits from residential gas savings in 2021, New Hampshire, 7% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.003	0.006	$25,495	$57,724
Nonfatal Heart Attacks *	0	0.003	$43	$398
Infant Mortality	0	0	$104	$104
Hospital Admits, All Respiratory	0.001	0.001	$23	$23
Hospital Admits, Cardiovascular **	0.001	0.001	$33	$33
Acute Bronchitis	0.003	0.003	$2	$2
Upper Respiratory Symptoms	0.052	0.052	$2	$2
Lower Respiratory Symptoms	0.037	0.037	$1	$1
Emergency Room Visits, Asthma	0.002	0.002	$1	$1
Asthma Exacerbation	0.055	0.055	$4	$4
Minor Restricted Activity Days	1.805	1.805	$158	$158
Work Loss Days	0.302	0.302	$61	$61
Total Health Effects			**$25,927**	**$58,510**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-5. Estimated annual monetized benefits from C&I gas savings in 2021, New Hampshire, 3% discount rate

Health End Point	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.001	0.001	$6,300	$14,258
Nonfatal Heart Attacks *	0	0.001	$10	$92
Infant Mortality	0	0	$22	$22
Hospital Admits, All Respiratory	0	0	$5	$5
Hospital Admits, Cardiovascular **	0	0	$7	$7
Acute Bronchitis	0.001	0.001	$-	$-
Upper Respiratory Symptoms	0.011	0.011	$-	$-
Lower Respiratory Symptoms	0.008	0.008	$-	$-
Emergency Room Visits, Asthma	0	0	$-	$-
Asthma Exacerbation	0.012	0.012	$1	$1
Minor Restricted Activity Days	0.388	0.388	$34	$34
Work Loss Days	0.065	0.065	$13	$13
Total Health Effects			**$6,393**	**$14,433**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-6. Estimated annual monetized benefits from C&I gas savings in 2021, New Hampshire, 7% discount rate

Health End Point	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.001	0.001	$5,611	$12,699
Nonfatal Heart Attacks *	0	0.001	$9	$86
Infant Mortality	0	0	$22	$22
Hospital Admits, All Respiratory	0	0	$5	$5
Hospital Admits, Cardiovascular **	0	0	$7	$7
Acute Bronchitis	0.001	0.001	$-	$-
Upper Respiratory Symptoms	0.011	0.011	$-	$-
Lower Respiratory Symptoms	0.008	0.008	$-	$-
Emergency Room Visits, Asthma	0	0	$-	$-
Asthma Exacerbation	0.012	0.012	$1	$1
Minor Restricted Activity Days	0.388	0.388	$34	$34
Work Loss Days	0.065	0.065	$13	$13
Total Health Effects			**$5,704**	**$12,868**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Contiguous US, electric

This section documents the detailed COBRA outputs for electric program savings when the pollution effects are estimated for the entire contiguous United States.

Table C-7. Estimated annual monetized benefits from electric savings in 2021, contiguous US, 3% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.055	0.125	$603,516	$1,365,606
Nonfatal Heart Attacks *	0.006	0.057	$976	$9,070
Infant Mortality	0	0	$2,542	$2,542
Hospital Admits, All Respiratory	0.013	0.013	$495	$495
Hospital Admits, Cardiovascular **	0.013	0.013	$658	$658
Acute Bronchitis	0.065	0.065	$40	$40
Upper Respiratory Symptoms	1.184	1.184	$51	$51
Lower Respiratory Symptoms	0.832	0.832	$22	$22
Emergency Room Visits, Asthma	0.032	0.032	$18	$18
Asthma Exacerbation	1.248	1.248	$93	$93
Minor Restricted Activity Days	39.426	39.426	$3,456	$3,456
Work Loss Days	6.657	6.657	$1,333	$1,333
Total Health Effects			**$613,199**	**$1,383,382**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-8. Estimated annual monetized benefits from electric savings in 2021, contiguous US, 7% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.055	0.125	$537,542	$1,216,323
Nonfatal Heart Attacks *	0.006	0.057	$917	$8,521
Infant Mortality	0	0	$2,542	$2,542
Hospital Admits, All Respiratory	0.013	0.013	$495	$495
Hospital Admits, Cardiovascular **	0.013	0.013	$658	$658
Acute Bronchitis	0.065	0.065	$40	$40
Upper Respiratory Symptoms	1.184	1.184	$51	$51
Lower Respiratory Symptoms	0.832	0.832	$22	$22
Emergency Room Visits, Asthma	0.032	0.032	$18	$18
Asthma Exacerbation	1.248	1.248	$93	$93
Minor Restricted Activity Days	39.426	39.426	$3,456	$3,456
Work Loss Days	6.657	6.657	$1,333	$1,333
Total Health Effects			**$547,166**	**$1,233,551**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Contiguous US, gas

This section documents the detailed COBRA outputs for gas program savings when the pollution effects are estimated for the entire contiguous United States.

Table C-9. Estimated annual monetized benefits from residential gas savings in 2021, contiguous US, 3% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.008	0.019	$90,794	$205,483
Nonfatal Heart Attacks *	0.001	0.009	$158	$1,465
Infant Mortality	0	0	$364	$364
Hospital Admits, All Respiratory	0.002	0.002	$77	$77
Hospital Admits, Cardiovascular **	0.002	0.002	$101	$101
Acute Bronchitis	0.01	0.01	$6	$6
Upper Respiratory Symptoms	0.176	0.176	$8	$8
Lower Respiratory Symptoms	0.124	0.124	$3	$3
Emergency Room Visits, Asthma	0.005	0.005	$3	$3
Asthma Exacerbation	0.185	0.185	$14	$14
Minor Restricted Activity Days	5.94	5.94	$521	$521
Work Loss Days	1.002	1.002	$201	$201
Total Health Effects			**$92,249**	**$208,245**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-10. Estimated annual monetized benefits from residential gas savings in 2021, contiguous US, 7% discount rate

Health Endpoint	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.008	0.019	$80,869	$183,020
Nonfatal Heart Attacks *	0.001	0.009	$148	$1,376
Infant Mortality	0	0	$364	$364
Hospital Admits, All Respiratory	0.002	0.002	$77	$77
Hospital Admits, Cardiovascular **	0.002	0.002	$101	$101
Acute Bronchitis	0.01	0.01	$6	$6
Upper Respiratory Symptoms	0.176	0.176	$8	$8
Lower Respiratory Symptoms	0.124	0.124	$3	$3
Emergency Room Visits, Asthma	0.005	0.005	$3	$3
Asthma Exacerbation	0.185	0.185	$14	$14
Minor Restricted Activity Days	5.94	5.94	$521	$521
Work Loss Days	1.002	1.002	$201	$201
Total Health Effects			**$82,314**	**$185,693**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-11. Estimated annual monetized benefits from C&I gas savings in 2021, contiguous US, 3% discount rate

Health End Point	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.002	0.004	$21,222	$48,020
Nonfatal Heart Attacks *	0	0.002	$38	$351
Infant Mortality	0	0	$85	$85
Hospital Admits, All Respiratory	0	0	$18	$18
Hospital Admits, Cardiovascular **	0	0	$24	$24
Acute Bronchitis	0.002	0.002	$1	$1
Upper Respiratory Symptoms	0.04	0.04	$2	$2
Lower Respiratory Symptoms	0.028	0.028	$1	$1
Emergency Room Visits, Asthma	0.001	0.001	$1	$1
Asthma Exacerbation	0.042	0.042	$3	$3
Minor Restricted Activity Days	1.352	1.352	$119	$119
Work Loss Days	0.228	0.228	$46	$46
Total Health Effects			**$21,558**	**$48,669**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Table C-12. Estimated annual monetized benefits from C&I gas savings in 2021, contiguous US, 7% discount rate

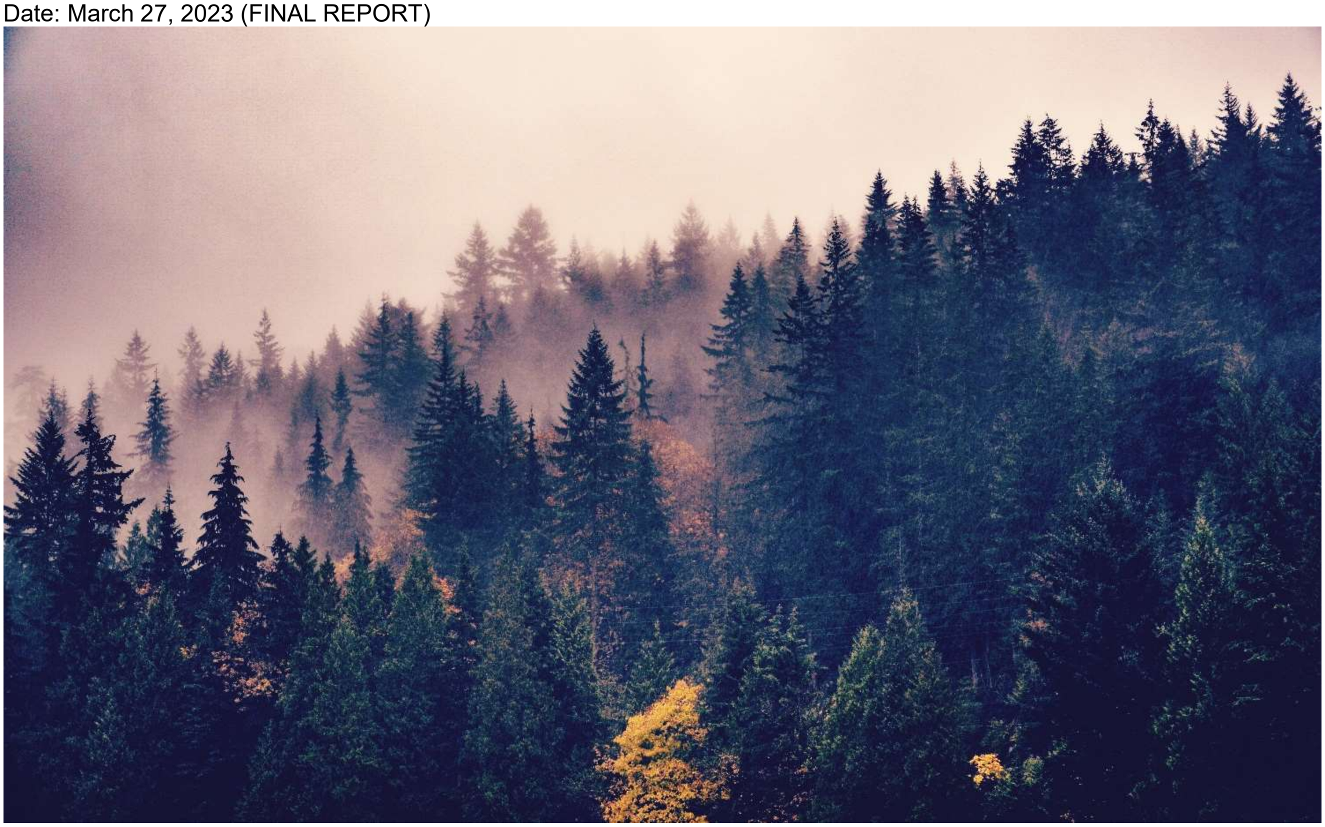
Health End Point	Changes in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.002	0.004	$18,902	$42,770
Nonfatal Heart Attacks *	0	0.002	$36	$330
Infant Mortality	0	0	$85	$85
Hospital Admits, All Respiratory	0	0	$18	$18
Hospital Admits, Cardiovascular **	0	0	$24	$24
Acute Bronchitis	0.002	0.002	$1	$1
Upper Respiratory Symptoms	0.04	0.04	$2	$2
Lower Respiratory Symptoms	0.028	0.028	$1	$1
Emergency Room Visits, Asthma	0.001	0.001	$1	$1
Asthma Exacerbation	0.042	0.042	$3	$3
Minor Restricted Activity Days	1.352	1.352	$119	$119
Work Loss Days	0.228	0.228	$46	$46
Total Health Effects			**$19,236**	**$43,399**

* The low and high values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM2.5 on mortality in the United States.
** Except heart attacks

Market Barriers to Energy Efficiency

Submitted to the New Hampshire Evaluation, Measurement, and Verification (EM&V) Working Group

Prepared by: DNV
Date: March 27, 2023 (FINAL REPORT)



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1 EXECUTIVE SUMMARY

New Hampshire statute establishes several principles for the state's energy efficiency programs, including that "*utility sponsored energy efficiency programs should target cost-effective opportunities that may otherwise be lost due to market barriers*."[1] The statute does not establish a specific definition of market barriers, or related terms such as cost-effectiveness. However, in the 2022–2023 NHSaves Plan, the NH Utilities provided a list of the key barriers the programs are designed to overcome. The New Hampshire Public Utilities Commission (the Commission) approved the 2022–2023 NHSaves Plan[2] in an order on April 29, 2022,[3] in which it found that the "further inquiry and a more in-depth identification of market barriers to energy efficiency and the Plan's ability to remove those barriers going forward is necessary." It directed Eversource Energy, Liberty Utilities, the New Hampshire Electric Cooperative (NHEC), and Unitil (the NH Utilities) to identify and quantify the market barriers addressed by the NHSaves programs.

DNV conducted this review in response to the Commission's directives, in coordination with the New Hampshire Evaluation, Measurement, and Verification Working Group (EM&V WG). The primary objectives of the review were to (1) identify and detail the market barriers addressed by the NHSaves programs, (2) assess the extent to which selected energy efficiency programs such as those in New Hampshire have overcome such barriers, and (3) identify how New Hampshire's programs could continue to do so going forward.

To achieve these objectives, DNV reviewed foundational literature on barriers to energy efficiency broadly, to distill key concepts and research findings that have provided a basis for program interventions since the early days of energy efficiency programs. In addition, DNV identified five selected energy efficiency program offerings for case studies, conducted via a literature review, assessment of NHSaves program offerings and evaluation results, and analysis of NHSaves spending and savings data.[4] This review included analysis of future potential savings opportunities for case study program offerings, based on the 2021–2023 New Hampshire Potential Study.[5]

1.1 Barriers overview

There is a substantial body of literature on barriers to energy efficiency spanning back to the 1990's and earlier. The literature includes several variations of definitions for market barriers, but consistently finds a basis in evidence for the existence and impact of such barriers, and for justification for program interventions to address them. A distillation of the literature suggests the following simplified definition of general barriers: *factors that inhibit adoption of otherwise cost-effective energy efficient technologies and behaviors, resulting in a sub-optimal level of investment in energy efficient technology*.[6] There are several important factors to consider in more specifically defining and assessing market barriers.

1. **The market is complex and heterogenous, and so are barriers**. The market for energy efficiency includes a multitude of technologies, customers, contractors, distributors, manufacturers, and other market actors. Market barriers represent a "complex web of micro-level considerations and constraints that differ greatly by customer group and end use,"[7] and must be "addressed in a highly disaggregate fashion, considering the workings of individual markets."[8] Within a given market, suppliers from upstream manufacturers to midstream distributors to downstream installation contractors

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[1] RSA 374-F:3, X. https://www.gencourt.state.nh.us/rsa/html/XXXIV/374-F/374-F-3.htm.
[2] NHSaves, *2022-2023 New Hampshire Statewide Energy Efficiency Plan,* 2022, https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/LETTERS-MEMOS-TARIFFS/20-092_2022-03-01_NH_UTILITIES_NHSAVES-PLAN.PDF.
[3] NH PUC, *Order No. 26,621,* 2022. https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/ORDERS/20-092_2022-04-29_ORDER-26621.PDF.
[4] In order to accommodate the March 31 deadline, the EM&V WG chose a case study approach based on secondary research. In addition, without explicit direction from the Commission to invest in primary research via surveys and interviews, the EM&V WG preferred the lower-cost secondary research approach.
[5] Dunsky. New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023, Oct. 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf
[6] In investigatory Docket No. IR 22-042, the NH Utilities provided several similar definitions for market barriers, including "the factors behind the so-called "efficiency gap" – the differential between the level of energy efficiency actually achieved the level judged to be cost-effective at prevailing prices" (LBNL 1992); and "a real or perceived impediment to the adoption of energy efficient technologies or energy efficiency behavior by consumers" (Iowa Administrative Code).
[7] Lawrence Berkeley National Laboratory and National Association of Regulatory Commissioners. *Least-Cost Utility Planning Handbook for Public Utility Commissioners, Volume 2, the Demand Side: Conceptual and Methodological Issues*, December 1988.
[8] Golove, William H. and Joseph H. Eto. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, March 1996. https://www.osti.gov/biblio/270751.

each face a unique set of financial and operational circumstances, and each confronts a different mix of barriers. Among end use customers, heterogeneity in the population means that technologies that are cost-effective on average may not be cost-effective for certain groups of customers.

2. **The market is ever-changing, and so are barriers**. All markets are dynamic, and the market for energy efficiency is especially so given the broad range of variables—from energy prices, to equipment supply chains, to public policies—that impact market actors and customers. As stated in foundational literature on barriers, "technological and institutional change is an enduring feature of energy service markets. Public policies must be constantly scrutinized for their continuing appropriateness in view of technological advances and the emergence of new market institutions."[9] Chief among these factors is energy prices, which are generally more volatile than other commodities, due in part to customers' limited ability to substitute other fuels when the price of one fuel increases.[10]
3. **Cost-effectiveness is integral to evaluating market barriers**. Market barriers are defined relative to a threshold for cost-effectiveness, above which rational market actors not facing barriers would implement energy efficiency. Any assessment of the extent and magnitude of market barriers must be anchored to a defined threshold for cost-effectiveness. There are multiple perspectives from which to consider the cost-effectiveness of energy efficiency investments, including (1) the perspective of a customer faced with a decision of whether to adopt energy efficiency measure(s), (2) the perspective of society as a whole, in weighing whether the total societal benefits of energy efficiency investments outweigh the total societal costs, and (3) the perspective of regulators within a jurisdiction, who must consider costs and benefits according to the applicable policy goals established in that jurisdiction.[11] Unless otherwise noted, references to cost-effectiveness in this report reflect the customer perspective.

Literature on market barriers consistently identifies a set of specific types of barriers to the adoption of energy efficiency. As with the overall definition of barriers, there are variations in the framing and organization of barrier types throughout the literature, due to inherent subjectivity and overlap in categories. However, the literature we reviewed includes a sufficiently consistent set of barriers to support a general classification into the following categories:

- **Financial** – barriers associated with end users' financial costs of adopting energy efficiency, including limited access to financing, internal competition for capital resources, and transaction costs such as time and labor for project installation
- **Informational** – barriers associated with obtaining information or lacking sufficient information, such as limited awareness of savings potential or limited access to information to assess and verify vendor claims of performance
- **Organizational** – barriers associated with the structure or practices of end-user organizations, including split incentives whereby owners or landlords decide whether to install efficient equipment, rather than occupants who pay energy bills
- **Supply and provision** – barriers associated with energy efficiency suppliers' resources and practices, including workforce capacity and training limitations, and limited product availability
- **Behavioral** – barriers associated with the behavioral patterns of end users, which can include factors such as end user habits, skepticism or lack of trust in the benefits of energy efficiency, or social group dynamics limiting adoption
- **Public policy** – barriers associated with public policies (or lack thereof) causing distortion in market prices or behaviors, including externalities or costs that are associated with transactions, but are not reflected in the transaction price (e.g., the potentially harmful consequences of economic activities on the environment)

The literature also identifies multiple underlying barriers within each category. This deeper understanding of barriers allows for fine-tuning program interventions. For instance, informational barriers in general might be addressed through increased

[9] Ibid.
[10] U.S. Energy Information Administration, *Volatility*, https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2003/10_23/Volatility%2010-22-03.htm.
[11] Cost-effectiveness principles and perspectives are described in more detail in the National Standard Practice Manual (NSPM). The NSPM is a publication of the National Efficiency Screening Project (NESP), which works to improve cost-effectiveness assessments of customer-funded electric and gas energy efficiency programs. The NSPM includes a set of fundamental principles for cost-effectiveness analysis, which have been applied in multiple jurisdictions nationwide. See NESP, *National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources,* Spring 2017, available at https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf.

marketing, but if the key underlying barrier for a technology is performance uncertainties (e.g., for emerging technologies with a relatively shorter record of operational performance), an intervention that focused on equipment performance, such as warranties, demonstrations, or certification and labeling, would be more effective.

Market barriers as described in this report are not necessarily market failures as defined in classical economics. Market barriers may slow the adoption of cost-effective efficient technologies, and programs may intervene to circumvent these barriers for individual customers or eliminate them market-wide. In contrast, without such interventions, markets may experience market failures as traditionally defined—that is, situations in which the allocation of resources is economically inefficient, resulting in a net loss of economic value.[12]

1.2 Program interventions

To overcome barriers, programs use a range of interventions that are as varied and targeted as the barriers they are intended to address. The most common types of program interventions are financial—e.g., rebates and financing—and informational—e.g., marketing and educational campaigns.[13] However, successful programs tend to use multi-pronged approaches that include several forms of interventions targeting the same set of customers or technologies. Such approaches acknowledge that customers and suppliers often face multiple barriers and overcoming or reducing one barrier will not always be sufficient to induce participation. For instance, a customer who is unaware of a particular technology (informational barrier) may be informed via advertising, but the advertisement will not be sufficient to induce adoption if they cannot access financing or otherwise afford to install energy saving equipment. Even if informational and financial interventions are effective, customers will be unable to install energy saving equipment if there are no installation contractors available or customers lack the time or expertise to procure and oversee contractors.

Well-designed program interventions are based on careful analysis and insights from customers and suppliers about the barriers they face, ideally drawn from first-hand relationships or primary research. Successful interventions “must be based on a sound understanding of the market problems they seek to correct…[which] can only emerge from detailed investigations of the current operation of individual markets.”[14] Table 1-1 provides general categories of program interventions, and the types of information that can support effective design.

Table 1-1. Types of program intervention and information supporting effective design

Intervention Type	Description	Information Supporting Effective Design
Financial incentives	Rebates, discounts, or other incentives (including financing) paid to customers, contractors, distributors, or manufacturers	Data on equipment and project costs, research on customer price sensitivity, access to and preferences for financing
Information and promotion	Marketing and educational materials or campaigns targeting customers, manufacturers, distributors, and retailers. This can also include product assurance via warranties, certifications, labeling, etc.	Market research, program and technology awareness studies, media and audience research
Technical assistance	Engineering, design, and other technical support services, often provided to assist customers with large, complex projects	Research on technological barriers, customers’ technical capabilities and limitations, technical assistance vendor capabilities and limitations

[12] See Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* 1996; Eto, Prahl, and Schlegel, *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*, 1996; New South Wales Government (2017). “A guide to categorising market failures for government policy development and evaluation.” New South Wales Department of Industry.

[13] Eto, Prahl, and Schlegel, 1996. The study notes that “if a market barrier is lowered, market adoption of energy-efficient products, services, or practices will increase. We recognize, however, that reducing any one market barrier may not lead to increases in adoption because other barriers may remain or be reinforced, or new barriers may be introduced.”

[14] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* 1996.

Training and trade ally support	Educational and informational resources, training and technical support, joint promotion and advertising support provided to contractors or other trade allies	Technological and engineering expertise, workforce capacity research, market research

1.2.1 Resource acquisition and market transformation programs

Energy efficiency programs generally fall into two broad categories, based on their objectives and design:

- **Resource acquisition programs** are designed to target specific sets of customers and market actors, and specific purchasing decisions. The general objective of these programs is to engage participants by circumventing individual customer barriers to achieve discrete project-level savings typically measured against short-term (e.g., annual) goals.
- **Market transformation programs** are designed to create long-term changes in the structure and function of markets. The general objective of these programs is to eliminate market-level barriers to the supply of energy efficiency, creating widespread changes in markets that persist after program interventions have been removed.

In general, the NHSaves programs are designed to be resource acquisition programs, not market transformation programs.[15] As such, they generally aim to circumvent specific customer or market actor barriers through individual transactions, rather than aiming to eliminate barriers to a particular technology market-wide by achieving systematic changes to the market.

1.3 Barriers and opportunities for selected case study topics

DNV, with input from the EM&V WG, selected topics for case studies that collectively cover all barriers listed in the 2022–2023 NHSaves Plan. These include a range of program offerings, from those with long histories of market transformation, such as retail lighting, to more recently emerging offerings facing steeper barriers, such as advanced lighting controls. The programs and measure types featured in the case studies were selected in part based on their prominence in the NHSaves portfolio, both in terms of their share of recent years' savings and their importance to future program savings opportunities.[16] While there are several markets covered by the NHSaves programs that are not included in our case studies, in general the types of program interventions and the nature of the barriers has broad applicability beyond the selected case study topics.

Some barriers, such as physical health and safety barriers to weatherization projects (e.g., the presence of mold or asbestos preventing blower door-guided air sealing), are unique to specific measures and markets covered in our case studies. Similarly, barriers such as customer skepticism of the performance and savings of new technologies are more prominent in certain areas, such as advanced C&I lighting controls. Other barriers, such as financial barriers, appear in different forms across most markets, and programs consistently offer interventions—i.e., incentives—targeted to the specific customers and market actors involved. Predominant across nearly all markets are overarching barriers related to workforce. Workforce barriers are driven by economy-wide labor supply and demand dynamics, which reach beyond the purview of the NHSaves programs and beyond the geographic boundaries of New Hampshire. In this landscape of diverse and far-ranging barriers, programs including those in New Hampshire have found ways to intervene and circumvent barriers, though there were few areas we reviewed where barriers had been fully eliminated.

Table 1-2 provides a summary of the barriers to adoption of the energy efficiency measures included in each case study topic, and the future opportunities for savings with continued program intervention.

[15] A more detailed explanation of how the NHSaves programs align with these categories was submitted by the NH Utilities in IR 22-042 Investigation of Energy Efficiency Planning, Programming, and Evaluation, Joint Responses to Commission inquiries by NH Utilities, Nov. 30, 2022.
[16] More detail on case study selection criteria is presented in Table 3-1.

Table 1-2. Summary of market barriers and program opportunities for case study topics

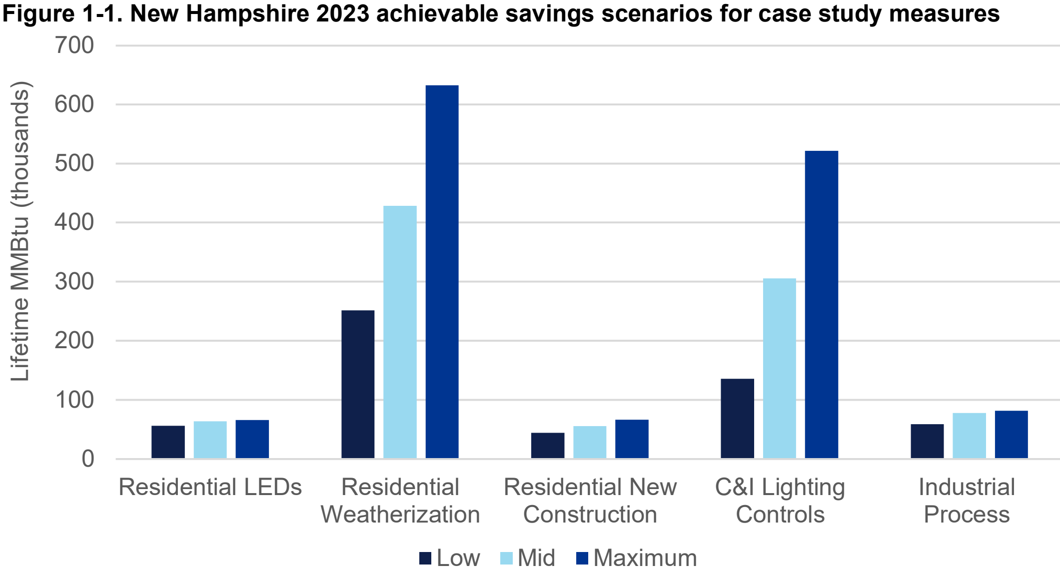
Case study topic	Market barriers characterization	Program opportunities summary
Residential retail lighting	There are minimal remaining market barriers in the retail LED market. It is largely transformed, due in part to significant historic program interventions including incentives and federal lighting standards to eliminate key barriers: • financial barriers (upfront incremental cost of LEDs) and • informational barriers (awareness of savings and performance of LEDs)	There are minimal remaining savings opportunities, limited to the hard-to-reach market (e.g., dollar and discount stores)
Residential weatherization	The weatherization market has faced and continues to face a wide range of barriers that programs have long worked to circumvent, with mixed results. Key types of market barriers include: • financial barriers (upfront cost) • technical and physical barriers (health and safety barriers) • organizational (split incentive between landlords and tenants in rental market) • supply and provision barriers (contractor workforce shortages)	There are significant remaining savings opportunities, primarily for fossil fuel savings. Programs can achieve some amount of savings with financial and other interventions, but may be limited by persistent, widespread workforce barriers, which are driven by broader labor market dynamics that utility programs have limited ability to influence
Residential new construction	Key types of market barriers to efficient residential construction include: • financial (upfront incremental cost of efficient construction); • organizational (split incentive between developers who incur the costs of energy efficient construction and future owners who benefit from savings), and • supply and provision (lack of workforce trained in energy efficient practices)	There are moderate savings opportunities via increased incentives and other interventions to circumvent builder and customer barriers, if programs maintain sufficiently high efficiency requirements relative to the continually advancing construction market and building codes
C&I lighting controls	Advanced C&I lighting controls are in the early stages of market adoption. Key types of market barriers for these technologies include: • financial barriers (upfront incremental cost of controls technology and high transaction costs); • informational barriers (customer awareness and understanding); and • supply and provision barriers (lack of workforce education and awareness)	There are significant remaining savings opportunities if programs and market actors can circumvent these barriers, but the pace of LED replacements means shrinking opportunities if replacements do not include controls
Industrial process	The industrial sector is highly heterogenous and faces a diverse set of barriers. Key types of market barriers include: • financial (upfront costs, access to capital, payback period requirements) • organizational (internal competition for funding, complexities of internal decision making, internal planning cycles) • informational (lack of internal expertise or resources to hire outside experts; lack of information to support program development), • supply and provision (lack of specialized workforce and equipment availability)	There are significant remaining savings opportunities via customized interventions to circumvent barriers on a customer-by-customer basis, particularly enabling strategies such as technical assistance and project planning support

Primary New Hampshire-based research on market barriers has generally been limited. However, the 2021–2023 New Hampshire Potential Study estimated the theoretical impact of barriers on savings opportunities for the NHSaves portfolio using quantitative modeling techniques.[17] To estimate the effect of NHSaves program interventions in overcoming market barriers, the evaluation team re-analyzed the savings opportunities originally modeled for the study. Specifically, the study modeled several achievable savings scenarios that assumed different levels of barriers and included different levels of program incentives and enabling strategies for overcoming barriers—such as contractor training and support, targeted marketing, and financing offerings. The scenarios used to model achievable savings for the 2021–2023 period were:

- **Low achievable savings:** incentives and enabling strategies at the levels of the 2018–2020 NHSaves Plan
- **Mid achievable savings:** incentives raised to a minimum of 75% of incremental cost, and increased enabling strategies
- **Maximum achievable savings:** incentives raised to 100% of incremental cost, and the same enabling strategies as the mid scenario[18]

Using these scenarios, the impact of market barriers on energy efficiency adoption can be estimated based on the growth in savings when moving from the low, to mid, to maximum achievable potential scenarios. This analysis provides an estimate of the scale of savings that barriers are preventing and helps identify what savings programs may be able to achieve by circumventing or eliminating them. Figure 1-1 shows the increase in modeled savings moving from low to maximum achievable potential scenarios for the measures in each case study topic. Larger increases in savings between the scenarios reflect a greater impact from increased incentives and enabling activities to overcome barriers. In other words, greater increases reflect programs or measures where barriers are preventing larger amounts of potential savings from being achieved. In contrast, small increases in savings imply there are few barriers that programs can address. Among case study measures, residential weatherization sees the greatest savings increase—in both percentage and absolute terms—from increased incentives and enabling activities to circumvent barriers. LEDs, in contrast, show a relatively minor increase in savings across the achievable potential scenarios. This pattern is consistent with an assumption of a largely transformed market for retail lighting due to the elimination of barriers for most of the market.

Figure 1-1. New Hampshire 2023 achievable savings scenarios for case study measures



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

[17] Potential studies help inform energy efficiency program planning by establishing guideposts for the amount of savings programs might achieve, as well as more detailed information on savings opportunities for specific customer segments and measure types. Potential studies quantify savings opportunities by obtaining data on existing energy using equipment and building stock, referred to as baseline data. The baseline data is entered into a model with data on efficient equipment and associated savings, costs, customer and market barriers, and other inputs. This model is used to develop various scenarios of potential savings that programs can achieve depending on the level of incentives and other program interventions.

[18] Incremental costs are foundational to energy efficiency program planning and cost-effectiveness testing. They represent the difference in cost between baseline, standard efficiency technologies and the energy efficient measures the programs offer.

On their own, the modelled results from the New Hampshire Potential Study are not definitive evidence of the state of market transformation or elimination of market barriers for the case study measures. However, when considered alongside other indicators, the achievable savings results help identify program areas where market barriers have been largely eliminated, and a market exit strategy should be considered for the programs. Among case studies in our review, retail lighting had the most consistent evidence of market transformation—including studies showing minimal price differences between LEDs and baseline lighting products, and LEDs capturing an overwhelming share of the retail lighting market, even in states without retail lighting programs. In other cases, the Potential Study shows relatively small increases in achievable savings from increased incentives and enabling strategies, but other indicators and research show that customers and market actors continue to face barriers. For instance, our case study of residential new construction found that, despite small increases in achievable savings in the Potential Study, residential new construction programs can continue to achieve savings by increasing program efficiency requirements to ensure participating homes stay ahead of the broader new construction market.

1.4 Conclusions and considerations

Market barriers addressed by the NHSaves programs

Market barriers incorporate a broad and diverse set of obstacles to energy efficiency adoption that vary across customers, technologies, and other dimensions. As stated in the foundational literature , "there is no single market for energy services; instead, the "market" consists of hundreds of end-uses, thousands of intermediaries, and millions of consumers. As a result,…these issues must be addressed in a highly disaggregate fashion, considering the workings of individual markets."[19] The NHSaves programs cover the full spectrum of technologies and customer types, and as such, the programs confront a broad range of barriers. By the same token, they face a wealth of potential savings opportunities from circumventing or eliminating those barriers.

Some barriers, such as physical health and safety barriers to weatherization projects, are unique to specific measures and markets covered in our case studies. Other barriers, such as financial barriers, appear in different forms across most markets, and programs consistently offer interventions—i.e., incentives—targeted to the specific customers and market actors involved. Predominant across nearly all markets are overarching barriers related to workforce, which are driven by economy-wide labor supply and demand dynamics that extend beyond the purview of the NHSaves programs.

Progress in overcoming barriers and transforming markets

In this diverse landscape of barriers, programs including those in New Hampshire have found ways to intervene and circumvent barriers for certain customers and market actors, though there were few areas we reviewed where barriers had been fully eliminated. A key question facing program administrators, stakeholders, and regulators is as follows: in what areas have market barriers been eliminated, if not market-wide, then for a large enough share of customers and market actors whereby program intervention is no longer justified? To definitively answer this question, it is important to have multiple sources of evidence pointing toward the same conclusion.

Our review found that programs vary in the extent to which they have circumvented or eliminated barriers. For retail lighting, it is clear from a preponderance of evidence that programs have helped eliminate market barriers, and program interventions are no longer needed in most cases—and the NH Utilities are discontinuing their offerings in response to this market transformation. However, the other NHSaves programs and offerings covered in our case studies all still face a range of barriers and savings opportunities that justify continued program intervention, with weatherization and C&I lighting controls presenting the greatest opportunities in New Hampshire. In addition, given the ever-changing market for energy efficiency and the continual progress of technological advancement, newer, more efficient technologies are always arising

[19] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* 1996.

which often face a new set of financial, informational, behavioral and other barriers. These advances present opportunities for program intervention even as other opportunities diminish due to market transformation.

Considerations for program interventions in evolving markets

There are clear and significant remaining opportunities for program savings across the markets covered in our case studies. The scope and depth of our analysis does not allow for definitive conclusions about targeting and designing NHSaves program interventions, nor how programs should prioritize resources across programs or among the different types of interventions (e.g., financial, informational, training, etc.). Ultimately barriers are best understood, circumvented, and eliminated through direct interactions between programs, market actors, and the customers they serve. The first-hand knowledge of program implementers and trade allies is critical in this process. As a complement to this expertise, research can provide insights reflecting a broader view, through methods such as surveys, focus groups, or market data analysis.

Due to the scope and timeline of the Commission's requests, the team's case study approach could not comprehensively address all areas of inquiry on market barriers—particularly those such as quantifying end-user costs of addressing barriers and directly quantifying the extent to which New Hampshire programs have removed them. As part of this review, we identified gaps where primary New Hampshire-based research such as customer surveys, market actor interviews, sales data analysis, or other methods would allow for a fuller assessment of the Commission's questions, as shown in Table 1-3. New Hampshire may consider pursuing such research, while weighing the tradeoffs between its costs, rigor, and value to the NHSaves programs and customers in understanding and overcoming barriers.

Table 1-3. Information to support further assessment of barriers and refinement of program interventions

Case Study Topic	Information gaps
Residential retail lighting	Due to high levels of market share and limited remaining savings opportunity, additional research is not recommended for retail lighting
Residential weatherization	Primary research on: • upfront weatherization costs residents are willing to incur, by customer class and measure type, and single family vs. multifamily • workforce capacity, knowledge, and skills gaps • coordination of program offerings and other funding sources to address health and safety barriers
Residential new construction	Primary research on: • homebuyer awareness of and preferences for energy efficient homes, and developer perception of market demand for energy efficiency • incremental costs of energy efficient construction • ENERGY STAR® Homes attribution (NTG) and market penetration
C&I lighting controls	Primary research on: • workforce capacity, knowledge, and skills gaps regarding controls • contractor and customer research on barriers and opportunities for integration of controls into LED retrofit projects • customer research on awareness and perception of controls technologies and persistence of savings
Industrial process	Primary research on: • Industrial stock in New Hampshire • Customer research on internal and external financing processes and sources

2 INTRODUCTION

The New Hampshire Public Utilities Commission (the Commission) approved the 2022–2023 NHSaves Plan[20] in an order on April 29, 2022,[21] in which it found that the "further inquiry and a more in-depth identification of market barriers to energy efficiency and the Plan's ability to remove those barriers going forward is necessary." It directed Eversource Energy, Liberty Utilities, the New Hampshire Electric Cooperative (NHEC), and Unitil (the NH Utilities) to quantify the market barriers. In a subsequent order of clarification, issued June 21,[22] the Commission stated that the intention of their directive was to comprehensively enumerate the end-users' costs of addressing identified market barriers and quantify as many costs as possible and provide a narrative explanation of the non-quantifiable costs. In a separate request issued on November 1, 2022, the Commission sought information on market barriers related to the scope of this review, including for the Joint Utilities to identify areas where New Hampshire energy efficiency program funds have enabled a technology or practice to become market competitive.[23] Per the Commission's order, this review of market barriers was due by March 31, 2023.

DNV, in coordination with the New Hampshire Evaluation, Measurement, and Verification Working Group (EM&V WG), designed this review to respond to the Commission's requests to the extent feasible within the given timeframe. DNV presented several options for study approaches, including several approaches that would fully address Commission requests via primary data collection and analysis, but would require longer timelines. These approaches included methods such as general population surveys for selected customer segments, interviews with participating and non-participating distributors, retailers, and contractors, analysis of historical program data, and participant surveys and interviews. In order to accommodate the March 31 deadline, the EM&V WG chose a case study approach based on secondary research.[24]

As shown in Table 2-1, the selected case study approach addresses or partially addresses the Commission's directives. As part of this review, throughout the report we have noted gaps where primary New Hampshire-based research would allow for a fuller assessment and response to the Commission's directives, such as quantifying the end-user costs of addressing barriers or directly quantifying the extent to which New Hampshire programs have removed them.

Table 2-1. Response to commission reporting requirements

Commission reporting requirement	Source	Case study approach
Identify and quantify market barriers listed in the 2022–2023 NHSaves plan	4/29 order, 11/1 data request	Partially addressed: identification and description of barriers, but not quantification
Assess the ability of plans to remove barriers in the future	4/29 order	Addressed, for selected case studies
Enumerate and quantify costs of addressing barriers	6/21 clarification order	Partially addressed: enumeration of costs, but not quantification
Identify previously existing barriers partially or totally removed by programs	11/1 data request	Addressed, for selected case studies
Identify where programs enabled a technology or practice to become market competitive	11/1 data request	Addressed, for selected case studies

[20] NHSaves, *2022-2023 New Hampshire Statewide Energy Efficiency Plan,* 2022, https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/LETTERS-MEMOS-TARIFFS/20-092_2022-03-01_NH_UTILITIES_NHSAVES-PLAN.PDF.

[21] NH PUC, *Order No. 26,621*, 2022. https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/ORDERS/20-092_2022-04-29_ORDER-26621.PDF.

[22] NH PUC, *Order No. 26,642*, 2022. https://www.puc.nh.gov/Regulatory/Orders/2022orders/Documents/26-642.pdf.

[23] NH PUC, *IR 22-042,* 2022. https://www.puc.nh.gov/Regulatory/Docketbk/2022/22-042/ORDERS/22-042_2022-11-01_NHPUC_PROC-ORDER-RE-RECORD-REQUESTS.PDF.

[24] The EM&V WG also preferred the case study approach due to its lower cost compared to conducting primary research via surveys and interviews. Survey and interview methods require a larger research budget and more staff hours for tasks such as statistical sampling, instrument design, survey and interview fielding, and data analysis, as well as incentives to encourage survey and interview responses. Without explicit direction from the Commission to invest in such research, the EM&V WG decided to pursue a lower-cost approach.

3 METHODOLOGY

The primary objectives of this review were to (1) identify and enumerate the market barriers addressed by the NHSaves programs, (2) assess the extent to which selected energy efficiency programs such as those in New Hampshire have overcome such barriers, and (3) identify how New Hampshire's programs could continue to do so going forward.

To achieve these objectives, DNV identified five selected energy efficiency program offerings for case studies, conducted via a literature review and consultation with internal subject matter experts.[25] The selected case studies document known market and customer barriers, program interventions used to overcome those barriers, and trends in adoption of energy efficient technologies and behaviors. The case studies also provide context on New Hampshire's existing programs and future opportunities for achieving savings by addressing market barriers. In addition to the case studies, DNV reviewed foundational literature on barriers to energy efficiency broadly, to identify and distill key concepts and research findings that have provided a basis for program interventions since the early days of energy efficiency programs.

Further details on these methods are described below, and sources for the literature review are provided in APPENDIX B.

3.1 Case study topic selection

DNV, with input from the EM&V WG, selected case studies that collectively cover all barriers listed in the 2022–2023 NHSaves Plan. These include a range of program offerings, from those with long histories of market transformation, such as retail lighting, to more recently emerging offerings facing steeper barriers, such as advanced lighting controls. The programs and measure types featured in the case studies have been selected in part based on their prominence in the NHSaves portfolio, both in terms of their share of recent years' savings and their importance to future program savings opportunities. Case study topics were selected based on the following tasks.

3.1.1 Review of New Hampshire program documents and data

To help ensure that the selected case studies represent reasonable proxies for New Hampshire's programs and can provide the most relevant and applicable results, DNV reviewed New Hampshire program planning documents, and program savings and spending data. This included reviewing the NH Utilities' 2021 Benefit/Cost (B/C) models to identify the programs and measures responsible for the largest shares of overall savings. In addition, DNV reviewed 2021 program spending on primary mechanisms/interventions for overcoming barriers (such as on-bill financing and awareness/marketing campaigns) from the NH Utilities' filings.[26] DNV also reviewed program websites and materials with information on program offerings and interventions related to selected case study topics.

3.1.2 Review of future savings opportunities

DNV reviewed the 2021–2023 New Hampshire Potential Study to identify the customer segments and measure types that present the greatest remaining savings opportunities for the programs. The team also obtained EM&V WG input on other strategic priorities for the programs beyond savings magnitude, as well as suggestions for selected case study topics that would provide forward-looking insights of value for the programs in achieving their savings goals and other objectives.

3.1.3 Determination of case study topics

Following these steps, DNV identified potential case study topics for EM&V WG feedback, which DNV considered when finalizing the selected case studies. Table 3-1 shows the final selected case study topics and the basis for their selection. There are several markets covered by the NHSaves programs that are not included in our case studies, in general the types of program interventions and the nature of the barriers has broad applicability beyond the selected case study topics.

[25] DNV staff have led or been part of numerous studies nationwide that have covered all selected case study topics. The evaluation team leveraged that body of expertise to identify key studies and highlight the most salient trends and findings on barriers to and adoption of efficient technologies.

[26] See Docket No. IR 22-042, 2021 Program Year Compliance Filing Order No. 26, 261 Report 9.v. Market Barriers, Aug. 31, 2022.

Table 3-1. Selected case study topics

Case study	Share of NH statewide savings (2021 actuals)	Future savings opportunities	Other factors for selection
Residential retail lighting	Large share of electric savings: • 51% of residential MWh (annual) • 20% of residential MWh (lifetime)	Steep decline in savings potential due to the lighting market's continued transformation (*2021-2023 NH Potential Study*)	Prime example of recent energy efficiency market transformation due to program investments Large body of existing research
Residential weatherization	Large share of fossil fuel savings: • 73% of residential MMBtu (annual) • 73% of residential MMBtu (lifetime) Moderate share of electric savings: • 14% of residential MWh (annual) • 28% of residential MWh (lifetime)	Reductions in space heating requirements from envelope measures are a key source of potential natural gas savings (*2021-2023 NH Potential Study*)	Persistent market barriers, but resource acquisition successes State priority to allocate at least 20% of funds for low-income programs (largely weatherization) Recognized customer-centric barriers and non-energy benefits
Residential new construction	Moderate share of electric and gas lifetime savings: • 17% of residential MWh (lifetime) • 17% of residential MMBtu (lifetime)	Growing opportunity due to gradually increasing new housing starts forecasted, and positive net migration into New Hampshire in recent years (*Census Bureau data*)	Body of existing research on market effects and code compliance Well-recognized and successful New Hampshire programs
C&I advanced lighting controls	Small share of current electric savings: • 3% of C&I MWh (annual) • 2% of C&I MWh (lifetime)	Growing opportunity, among the top measures for non-residential electric savings potential (*2021-2023 NH Potential Study*)	Well-researched technical barriers (e.g., limited cross-compatibility among different manufacturers) and customer awareness barriers
Industrial process measures	Moderate share of gas savings: • 18% of C&I MMBtu (annual) • 14% of C&I MMBtu (lifetime) Small share of electric savings: • 3% of C&I MWh (annual) • 4% of C&I MWh (lifetime)	The manufacturing and industrial segment is the second highest saving segment overall, with savings opportunities focused on process measures (and is also far less dependent on lighting savings than other segments) (*2021-2023 NH Potential Study*)	Large energy consumers with strategic program importance Diverse technology- and subsector-specific barriers

3.2 Literature review

Following case study selection, DNV's primary research activity was a literature review, which fell into two primary categories: (1) a review of foundational literature to identify and distill key concepts and research findings into a conceptual framework for market and customer barriers; and (2) program- or technology-specific literature for each of the selected case study topics, with a focus on evaluations from New Hampshire and other Northeast states. A list of all reviewed publications is provided in APPENDIX B.

3.2.1 Foundational literature

The review of foundational literature provided a basis for defining barriers and enumerating those identified in literature spanning from the early years of regulated energy efficiency programs in the United States. This literature review also identified the standard types of program interventions and the metrics programs have used to measure their success in overcoming barriers.

Our review included literature from the 1990s through current day, from sources including the U.S. DOE National Laboratories, industry and academic journals, and policy-focused organizations such as ACEEE. The literature was identified via web searches and queries of online journals, and mining the references cited in each source for additional key sources.

3.2.2 Review of relevant program research and evaluations

To provide a basis for the case studies, we reviewed program evaluations and other research related to the case study topics, primarily focusing on evaluations conducted on behalf of energy efficiency program administrators, regulators, and oversight bodies. We first reviewed any related research conducted on New Hampshire's programs, and then expanded the review to cover publicly available evaluations from other Northeast states, due to the similarity of programs, common program administrators and implementation vendors, overlapping market actors (e.g., distributors, retailers) and base of customers, and shared energy markets (e.g., wholesale electric and gas). We also consulted with internal experts involved in evaluations of case study topics to identify additional studies from beyond the Northeast region, and to ensure our review addressed the most salient findings and cross-cutting trends from the national body of research.

From this literature, the team gathered and synthesized quantitative and qualitative findings on (1) market and customer barriers, (2) program interventions, and (3) trends such as market share and net-to-gross (NTG) results for the measure and program types relevant to each case study. Where New Hampshire research was available, the case studies highlight these findings, and where there has not been New Hampshire research to date, the case studies identify the key research gaps that, if filled, would allow for improved estimates of barriers currently faced in New Hampshire and how programs can target interventions to overcome them.

Finally, the literature review included an in-depth review and re-analysis of data from the 2021–2023 New Hampshire Potential Study to quantify the achievable savings potential for the measures covered in each case study under the different barrier scenarios modeled in the study.

3.3 Scope limitations and opportunities for additional research

Due to the scope of the Commission's requests and the required deadline, the case study approach could not comprehensively address all Commission requests on market barriers—particularly those such as quantifying end-user costs of addressing barriers or directly quantifying the extent to which New Hampshire programs have removed them. As part of this review, throughout the report we have noted gaps where primary New Hampshire-based research such as customer surveys, market actor interviews, sales data analysis, or other methods would allow for a fuller assessment of the Commission's questions.

4 MARKET BARRIERS OVERVIEW

New Hampshire statute establishes several principles for the state's energy efficiency programs, including that "*utility sponsored energy efficiency programs should target cost-effective opportunities that may otherwise be lost due to market barriers*."[27] The statute does not establish a specific definition of market barriers, or related terms such as cost-effectiveness. However, in the 2022–2023 NHSaves Plan, the NH Utilities provided a list of the key barriers the programs are designed to overcome. The foundational literature we reviewed identifies many of these same barriers, as well as others not listed in the NHSaves plan. The following section provides general definitions of market barriers, an overview of types of barriers identified in the literature and the program interventions commonly used to address then, and different metrics for measuring success in addressing barriers.

4.1 Barriers definitions

There is a substantial body of literature on barriers to energy efficiency spanning back to the 1990's and earlier. The literature includes several variations of definitions for market barriers, but consistently finds a basis in evidence for the existence and importance of such barriers, and for justification for program interventions to address them. A foundational paper on the topic found that "significant opportunities exist to reduce energy utilization by implementing technologies that are cost-effective under prevailing economic conditions but that are not fully implemented by existing market institutions… problems of imperfect information and transaction costs may bias rational consumers to purchase devices that use more energy than those that would be selected by a well-informed social planner guided by the criterion of economic efficiency."[28] Numerous publications from as recently as 2020 have arrived at similar conclusions. (See APPENDIX A for a summary and classification of barriers identified in foundational literature.)

A distillation of the literature suggests the following simplified definition of barriers: *factors that inhibit adoption of otherwise cost-effective energy efficient technologies and behaviors, resulting in a sub-optimal level of investment in energy efficient technology.*[29]

There are several important factors to consider in applying this definition and assessing market barriers.

1. **The market is complex and heterogenous, and so are barriers**. The market for energy efficiency includes a multitude of technologies, customers, contractors, distributors, manufacturers, and other market actors. Market barriers represent a "complex web of micro-level considerations and constraints that differ greatly by customer group and end use,"[30] and must be "addressed in a highly disaggregate fashion, considering the workings of individual markets."[31] Within a given market, suppliers from upstream manufacturers to midstream distributors to downstream installation contractors each face a unique set of financial and operational circumstances, and each confronts a different mix of barriers. Among end use customers, heterogeneity in the population means that technologies that are cost-effective on average may not be cost-effective for certain groups of customers. For instance, capital intensive energy saving equipment must be more fully utilized to achieve the operational savings required for cost-effectiveness, so it may not be cost-effective for customers with intermittent operating schedules (e.g., schools, religious buildings, seasonal properties).[32,33] Furthermore, there are often lower barriers to adopting energy efficiency measures in industries where energy costs represent a larger share of operating costs, such as heavy manufacturing, where energy costs create a natural incentive to pursue efficiency. In contrast, barriers are often more significant among businesses where energy

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[27] RSA 374-F:3, X. https://www.gencourt.state.nh.us/rsa/html/XXXIV/374-F/374-F-3.htm.
[28] Howarth R, Andersson B. 1993. Market barriers to energy efficiency. Energy Econ. 15:262–72.
[29] In investigatory Docket No. IR 22-042, the NH Utilities provided several similar definitions for market barriers, including "the factors behind the so-called "efficiency gap" – the differential between the level of energy efficiency actually achieved the level judged to be cost-effective at prevailing prices" (LBNL 1992); and "a real or perceived impediment to the adoption of energy efficient technologies or energy efficiency behavior by consumers" (Iowa Administrative Code).
[30] LBNL and National Association of Regulatory Commissioners 1988.
[31] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, 1996.
[32] Howarth R, Andersson B. 1993. Market barriers to energy efficiency. Energy Econ. 15:262–72.
[33] Sorrell, S., O'Malley, E., Schleich, J., and Scott, S. (2004). The economics of energy efficiency - Barriers to cost-effective investment.

costs are a smaller share of total operating costs, such as those in the public or service sectors, because even when cost-effective energy efficiency opportunities exist, their financial benefit is less apparent or is outweighed by other factors such as high transaction costs.

2. **The market is ever-changing, and so are barriers**. All markets are dynamic, and the market for energy efficiency is especially so given the broad range of variables—from energy prices to equipment supply chains to public policies—that impact market actors and customers. As stated in seminal research on barriers, "technological and institutional change is an enduring feature of energy service markets. Public policies must be constantly scrutinized for their continuing appropriateness in view of technological advances and the emergence of new market institutions."[34] Chief among these factors is energy prices, which are generally more volatile than other commodities, due in part to customers' limited ability to substitute other fuels when the price of one fuel increases.[35] New Hampshire and the rest of New England have seen particularly sharp increases in electric rates in recent months. These increases impact the level of barriers experienced by customers and other market actors (e.g., reducing financial barriers by increasing the value of energy savings), and the effectiveness of program interventions such as rebates and financing.
3. **Cost-effectiveness is integral to evaluating market barriers**. Market barriers are defined relative to a threshold for cost-effectiveness, above which rational market actors not facing barriers would implement energy efficiency. Any assessment of the extent and magnitude of market barriers must be anchored to a defined threshold for cost-effectiveness. There are multiple perspectives from which to consider the cost-effectiveness of energy efficiency investments, including (1) the perspective of a customer faced with a decision of whether to adopt energy efficiency measure(s), (2) the perspective of society as a whole, in weighing whether the total societal benefits of incremental energy efficiency investments outweigh the total societal costs, and (3) the perspective of regulators within a jurisdiction, who must consider costs and benefits according to the applicable policy goals established in that jurisdiction.[1] This report primarily refers to cost-effectiveness in terms of the customer perspective. The exception to this is the team's quantification of New Hampshire-specific barriers (e.g., analysis of the 2021–2023 Potential Study results in Section 4.5), which assumes the use of the Granite State Test (GST). The GST reflects the regulatory perspective as described in the National Standard Practice Manual (NSPM), and accounts for long-term utility system avoided costs, other fuel and water resource savings, and certain non-energy benefits, as well as the costs of the programs.[36] The GST was developed through a stakeholder process that culminated in a consensus recommendation to adopt the test.[37] The Commission approved the use of the test, and the legislature subsequently established it as the primary cost-effective test for New Hampshire's energy efficiency programs.[38, 39]

Market barriers as described here are not necessarily market failures as defined in classical economics. These barriers are, however, factors that affect consumers' economic decision making, based on their perceived value of energy efficiency investments and their perceived costs of those investments. Program interventions targeting market barriers are designed to improve consumers' value proposition by providing direct rebates (lowering the cost), by mitigating other costs such as transaction or information search costs, or by increasing the perceived benefit such as by providing implicit or explicit endorsement of energy efficiency technologies. In contrast, without such interventions, markets may experience market

[34] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, 1996
[35] U.S. Energy Information Administration, *Volatility*. https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2003/10_23/Volatility%2010-22-03.htm.
[36] The NSPM outlines a process for developing cost-effectiveness tests that "encompasses the perspective of a jurisdiction's applicable policy objectives and includes and assigns value to all relevant impacts (costs and benefits) related to those objectives. The NSPM refers to this as the 'regulatory' perspective, which is intended to reflect the important responsibilities of institutions, agents, or other decision-makers authorized to determine utility resource cost-effectiveness and funding priorities." See NESP, *National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources,* Spring 2017, available at https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf
[37] NH PUC, *Re: DE 17-136, Electric and Gas Utilities 2018-20 New Hampshire Statewide Energy Efficiency Plan B/C Working Group Recommendations Regarding New Hampshire Cost-Effectiveness Review and Energy Optimization through Fuel Switching Study*, 2019. https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/LETTERS-MEMOS-TARIFFS/17-136_2019-10-31_STAFF_FILING_WORKING_GROUP_REC.PDF.
[38] NH PUC, *Order No. 26,322*, 2019. https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/ORDERS/17-136_2019-12-30_ORDER_26322.PDF
[39] Bill_Status (state.nh.us) https://gencourt.state.nh.us/bill_status/legacy/bs2016/bill_status.aspx?lsr=717&sy=2022&sortoption=&txtsessionyear=2022&txtbillnumber=HB549

failures as traditionally defined—that is, situations in which the allocation of resources is economically inefficient, resulting in a net loss of economic value.[40]

4.2 Types of barriers

Literature on market barriers consistently identifies a set of specific types of barriers to the adoption of energy efficiency. As with the overall definition of barriers, there are variations in the framing and organization of barrier types throughout the literature, due to inherent subjectivity and overlap in categories. However, the literature we reviewed includes a sufficiently consistent set of barriers to support a general classification into the following categories:

- Financial – barriers associated with end users' financial costs of adopting energy efficiency, including limited access to financing, internal competition for capital resources, and transaction costs such as time and labor for project installation
- Informational – barriers associated with obtaining information or lacking sufficient information, such as limited awareness of savings potential or limited access to information to assess and verify vendor claims of performance
- Organizational – barriers associated with the structure or practices of end-user organizations, including split incentives whereby owners or landlords decide whether to install efficient equipment, rather than occupants who pay energy bills
- Supply and provision – barriers associated with energy efficiency suppliers' resources and practices, including workforce capacity and training limitations, and limited product availability
- Behavioral – barriers associated with the behavioral patterns of end users, which can include factors such as end user habits, skepticism or lack of trust in the benefits of energy efficiency, or social group dynamics limiting adoption
- Public policy – barriers associated with public policies (or lack thereof) causing distortion in market prices or behaviors, including externalities or costs that are associated with transactions, but are not reflected in the transaction price (e.g., the potentially harmful consequences of economic activities on the environment)

There is some disagreement in the literature about the nature of one of the most commonly cited barriers to energy efficiency—upfront costs (also referred to as high first cost, and described in the NHSaves 2022-2023 plan as the incremental price difference between standard and high efficiency goods and services). In particular, some foundational literature states that upfront costs do not, in and of themselves, constitute a market barrier—rather, what studies and programs identify as upfront cost barriers are actually the result of a number of underlying market barriers.[41] Specifically, customers may lack access to financing to cover the higher upfront costs of energy efficient equipment, or they may lack information about equipment performance to properly assess its long-term payback. On the supply side, higher upfront costs for newer energy efficient technologies may be driven by suppliers facing poorer economies of scale for low-volume products and services that have not yet been widely adopted. Regardless of how high upfront cost fits into the market barriers framework, programs have long recognized it as a key barrier and designed and successfully deployed interventions—e.g., financial incentives and financing offerings—to help customers cover the upfront costs of energy efficiency measures that they were otherwise unwilling to pay for.

The NHSaves 2022–2023 Plan cites several barriers that align with these categories, most notably financial barriers, informational barriers, and supplier barriers. As noted in the literature, financial and informational barriers have been the most commonly cited barriers, and are the primary focus of core program interventions such as financial incentives and marketing and awareness campaigns.[42] The third category, supplier barriers, has been well understood since the early days of energy efficiency programs, but has received increased attention in recent years due to a growing shortage of contractor and other workforce, as well as an increase in midstream and upstream program designs targeting distributors and retailers.

[40] See Eto and Golove, 1996; Eto, Prahl, and Schlegel, 1996; New South Wales Government (2017). "A guide to categorising market failures for government policy development and evaluation." New South Wales Department of Industry.
[41] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency* 1996; Eto, Prahl, and Schlegel, *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*, 1996.
[42] Ibid.

The literature also identifies multiple underlying barriers within each category. This deeper understanding of barriers allows for fine-tuning program interventions. For instance, informational barriers in general might be addressed through increased marketing, but if the key underlying barrier for a technology is performance uncertainties (e.g., for emerging technologies with a relatively shorter record of operational performance), an intervention that focused on equipment performance, such as warranties or demonstrations, would be more effective.

A summarized list of the types of barriers identified in the foundational literature is presented in Table 4-1, alongside the barriers cited in the NHSaves 2022–2023 plan. A full list of categorized barriers from the foundational literature review is provided in APPENDIX A.

Table 4-1. Energy efficiency barriers identified in foundational literature and the NHSaves plan

Barrier Category	NHSaves 2022–2023 Plan	Summary of Foundational Literature
Financial	Incremental price difference between standard and high efficiency goods and services	• Limited access to financing and capital constraints • Hidden costs not captured by the price of efficiency investments, such as technical risks or O&M costs • Hassle or transaction costs, such as the time, materials and labor involved in obtaining or contracting for energy-efficient products or services
Informational	Lack of customer awareness related to: • benefits of energy efficiency • existence of high-efficiency alternatives. • where to purchase high-efficiency equipment/quality installation. how and when to reduce demand during system peaks.	• Lack of awareness of savings potential • Lack of confidence that advice received on pursuing energy efficiency is trustworthy and credible • High information or transaction costs for research on the availability of efficient technologies, to assess and verify vendor claims, find qualified contractors, and judge equipment uncertainties.
Organizational	N/A	• Split incentives, where building occupants who pay energy bills are not responsible for purchasing energy efficient equipment; rather owners, landlords or developers are • Organizational behavior or systems of practice that discourage or inhibit cost-effective energy efficiency decisions, for example, corporate or government procurement rules • Culture and values held by key individuals in a company that influence that company's decisions
Supply and provision	• Insufficient retailer stocking: Midstream (retailers/ distributors) fail to stock high-efficiency products • Building trades lack sufficient cadre of trained personnel, awareness, experience, or commitment to high-efficiency practices, both for existing building renovations and new construction	• Training and skills of professionals • Product or service unavailability: a failure of manufacturers, distributors, or vendors to make a product or service available in a given area or market • Innovation externalities: a firm that develops or implements a new technology typically creates benefits for others, and hence has an inadequate incentive to increase those benefits by investing in technology
Behavioral	N/A	• Non-economic consumer rationality: energy users influenced by factors such as appearance, public or peer opinions, and personal obligation or habit. • Bounded Rationality: The behavior of an individual during the decision-making process that either seems or actually is inconsistent with the individual's goals • Lack of interest and undervaluing energy efficiency benefits due to social group interactions, customs, and habits
Public policy	N/A	• Externalities: costs that are associated with transactions, but that are not reflected in the price paid in the transaction (e.g., the potentially harmful consequences of economic activities on the environment) • Prices faced by consumers in electricity markets may not reflect marginal social costs due to the common use of average-cost pricing under utility regulation. Average-cost pricing could lead to under- or overuse of electricity relative to the economic optimum.

4.3 Program interventions

To overcome barriers, programs use a range of interventions that are as varied and targeted as the barriers they are intended to address. The most common types of program interventions are financial—e.g., rebates and financing—and informational—e.g., marketing and educational campaigns.[43] However, successful programs tend to use multi-pronged approaches that include several forms of interventions targeting the same set of customers or technologies. Such approaches acknowledge that customers and suppliers often face multiple barriers, and overcoming or reducing one barrier will not always be sufficient to induce participation. For instance, a customer who is unaware of a program (informational barrier) may be informed via advertising, but the advertisement will not be sufficient to induce participation if they cannot access financing or otherwise afford to install energy saving equipment. Even if informational and financial interventions are effective, customers will be unable to install energy saving equipment if there are no contractors available to perform the work.

Well-designed program interventions are based on careful analysis and insights from customers and suppliers about the barriers they face, ideally drawn from first-hand relationships or primary research. Successful interventions "must be based on a sound understanding of the market problems they seek to correct and a realistic assessment of their likely efficacy. This understanding can only emerge from detailed investigations of the current operation of individual markets."[44] The information needed to design effective program interventions can be gathered over time through direct experience working with customers and trade allies, and when needed, through focused research involving surveys, focus groups, market data analysis and other methods.

Table 4-2 provides general categories of program interventions, and the information needed to design them.

Table 4-2. Types of program intervention and information supporting effective design

Intervention Type	Description	Information Supporting Effective Design
Financial incentives	Rebates, discounts, or other incentives (including financing) paid to customers, contractors, distributors, or manufacturers	Data on equipment and project costs, research on customer price sensitivity, access to and preferences for financing
Information and promotion	Marketing and educational materials or campaigns targeting customers, manufacturers, distributors, and retailers	Market research, program and technology awareness studies, media and audience research
Technical assistance	Engineering, design, and other technical support services, typically provided to assist customers with large, complex projects	Research on technological barriers, customers' technical capabilities and limitations, technical assistance vendor capabilities and limitations
Training and Trade Ally support	Educational and informational resources, training and technical support, joint promotion and advertising support provided to contractors or other trade allies	Technological and engineering expertise, workforce capacity research, market research

The NHSaves 2022–2023 plan identified several interventions that generally align with the categories above, and Figure 4-1 shows the program spending on those interventions in 2021.[45] Although rebates and associated services comprise the bulk of program spending, it is important to note that this spending covers a range of more specific intervention types beyond

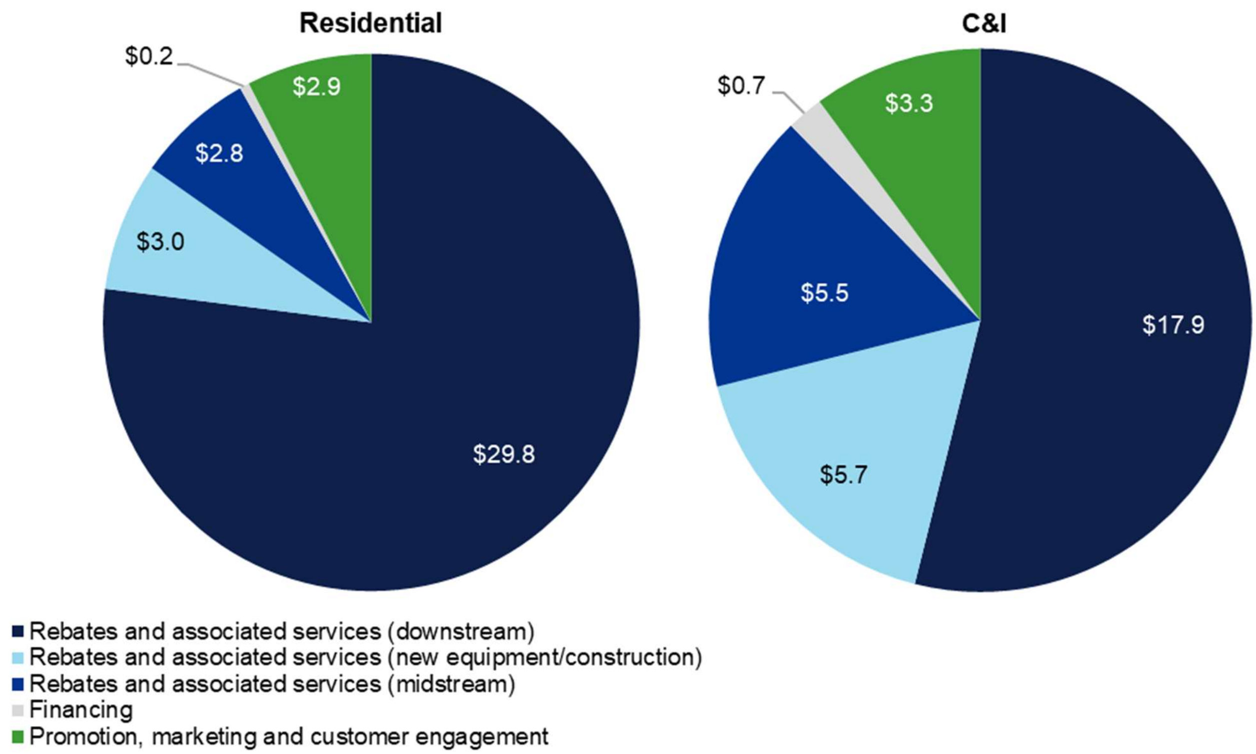
[43] Eto, Prahl, and Schlegel, *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*, 1996. The study notes that "if a market barrier is lowered, market adoption of energy-efficient products, services, or practices will increase. We recognize, however, that reducing any one market barrier may not lead to increases in adoption because other barriers may remain or be reinforced, or new barriers may be introduced."

[44] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* 1996

[45] See https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/LETTERS-MEMOS-TARIFFS/20-092_2022-03-01_NH_UTILITIES_NHSAVES-PLAN.PDF, pages 23 and 45.

direct customer rebates, including technical assistance services, incentives for distributors and retailers to stock and sell efficient equipment, and installation contractor services and incentives. In addition, the dollar amount of spending on interventions should not be considered a measure of their importance or effectiveness in overcoming barriers or inducing participation. For instance, a marketing campaign that reaches hundreds of thousands of customers may be a fraction of the cost of an incentive payment for one large C&I project. However the New Hampshire spending values below provide a general scale of the costs of circumventing different barriers, whether financial (rebates) or informational (promotion and marketing).

Figure 4-1. NHSaves 2021 spending on program interventions, by sector (millions)



The costs programs must incur for energy efficiency—in particular, the cost for customer rebates—is directly related to the level of savings being pursued. All else equal, the first savings achieved will be those with the lowest customer and market barriers, which also tend to require the lowest levels of incentives. Deeper savings levels, in general, require more generous incentives and more effort by program administrators to achieve. This dynamic can be seen in the increasing cost of savings faced by programs as they shift away from highly cost-effective measures such as lighting, where markets have been more transformed, toward measures such as controls, which are generally less cost-effective and less widely adopted due a range of market barriers, as discussed in section 5.4.

4.3.1 Market transformation and resource acquisition

Energy efficiency programs generally fall into two broad categories, based on their objectives and design: [46]

- **Resource acquisition programs** are designed to target specific sets of customers and market actors, and specific purchasing decisions. The general objective of these programs is to engage participants by circumventing individual customer barriers to achieve discrete project-level savings typically measured against short-term (e.g., annual) goals.

[46] A more detailed explanation of these categories of programs was submitted by the NH Utilities in IR 22-042 Investigation of Energy Efficiency Planning, Programming, and Evaluation, Joint Responses to Commission inquiries by NH Utilities, Nov. 30, 2022.

- **Market transformation programs** are designed to create long-term changes in the structure and function of markets. The general objective of these programs is to eliminate market-level barriers to the supply of energy efficiency, creating widespread changes in markets that persist after program interventions have been removed.

In designing interventions and measuring their effectiveness, it is important to consider the objectives and limitations of state energy efficiency programs. Barriers can be driven by factors that are beyond the reach of many program interventions. For instance, national and regional labor and workforce trends, disruptions in global supply chains and international energy markets, and shifting public policies can all influence the level of barriers customers and market actors face. For states such as New Hampshire, where program budgets and local markets are small relative to the regional or national markets in which they operate, it is important to consider the tradeoffs between resource acquisition and market transformation approaches. In general, the NHSaves programs are designed to be resource acquisition programs, not market transformation programs. As such, they generally aim to circumvent specific customer or market actor barriers through individual transactions, rather than aiming to eliminate barriers to a particular technology market-wide by achieving systematic changes to the market. Table 4-3 provides an overview of the tradeoffs, in terms of strengths and limitations, between these two general categories of program designs.

Table 4-3. Resource acquisition and market transformation strengths and limitations

Program Design	Strength	Limitation
Resource acquisition	Ability to identify, predict, and quantify savings impacts, due to the specificity of time, place, equipment, and participants involved in the purchase and installation of energy efficiency measures.	Limited ability to address market barriers that are driven by factors beyond those at play in specific purchasing and installation decisions. Examples of such barriers include organizational barriers (e.g., split incentives), or supply barriers (e.g., equipment stocking, workforce capacity).
Market transformation	Ability to create enduring changes in the structure and function of markets, achieving larger-scale, longer-lasting energy savings and addressing barriers beyond the reach of specific customer purchasing decisions.	Savings impacts are harder to predict and measure, since they occur as an indirect result of program influence via multiple causal relationships between market actors (e.g., manufacturers, distributors, and customers), rather than via direct impacts on customer decisions. In addition, the potential effectiveness of market transformation interventions is limited by the size and reach of a program relative to the broader market it seeks to transform.

Source: Adapted from Eto, Prahl, and Schlegel, 1996.

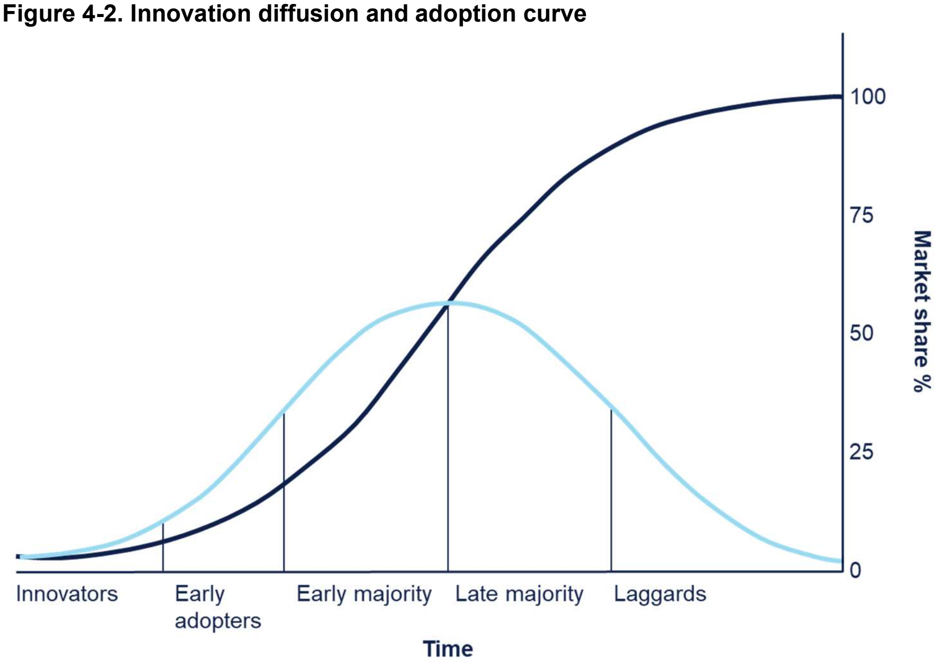
4.4 Measuring success

As barriers are overcome, there are two general frameworks for measuring the resulting increases in energy efficiency, based on the literature we reviewed: (1) technology adoption and (2) technology advancement, as described below. There are also different metrics for measuring program success within these frameworks. Most commonly, program attribution research—also known as net-to-gross (NTG) research—is used to measure the extent to which increases in adoption of energy efficiency are due to program interventions circumventing individual customer or market actor barriers or eliminating them market-wide.

4.4.1 Technology adoption

There are well-established methods for conceptualizing and modeling the adoption of new technologies over time, building on research dating back to the 1960's.[47] These modeling techniques have seen widespread application in industry settings, academic research, DOE National Laboratory research, and federal rulemaking processes.[48] They assume a process for technology adoption and diffusion, by which new, economically superior technologies are adopted gradually at first, and then with increasing speed until reaching a market saturation point at which adoption slows.[49] The models reflect heterogeneity among consumers in their likelihood to adopt, due to differences in financial circumstances, lifespan of existing equipment, and levels of awareness of new technologies, among others. This heterogeneity results in different groups of consumers adopting at different points in time, starting with innovators and ending with laggards, as shown in the light blue curve in Figure 4-2. As successive groups of consumers adopt a given technology, its cumulative market share increases, as shown in the dark blue adoption curve.

Figure 4-2. Innovation diffusion and adoption curve



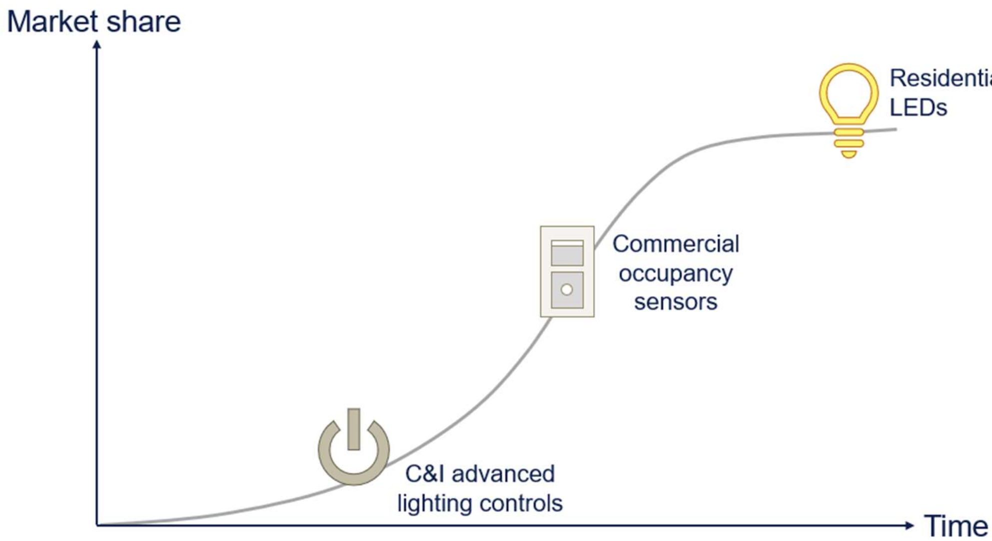
Source: Adopted from E. Rogers. *Diffusion of innovations*. 1962.

Technology adoption tends to follow this S-shaped pattern over time, with initially slow uptake followed by more rapid increase in adoption rates, and finally a levelling off as the market nears its full adoption potential. The adoption of different lighting technologies provides a useful illustration of this dynamic. Figure 4-3 shows a generalized representation of adoption for multiple lighting technologies, based on our literature review (see sections 5.1 and 5.4 for further details). Residential LEDs have generally reached a point of market saturation whereby barriers are mostly overcome, the pace of adoption has slowed as most consumers have already adopted LEDs, and there is little remaining savings to be had. In contrast, advanced C&I lighting controls are in the earlier stages of adoption and are seeing an increased pace of adoption as barriers are overcome for many consumers. Commercial occupancy sensors are at a mid-point in the adoption curve, where a

[47] Bass, F. M. (1969). *A New Product Growth Model for Consumer Durables. Management Science*, Vol. 15 page 224.
[48] Robert Van Buskirk, ***Estimating Energy Efficiency Technology Adoption Curve Elasticity with Respect to Government and Utility Deployment Program Indicators***, 2013, https://www.osti.gov/biblio/1164376; Everett Rogers, ***Diffusion of Innovations, 5th Edition,*** 2003, *https://books.google.com/books?id=9U1K5LjUOwEC*. Simon and Schuster, ISBN 978-0-7432-5823-4; Federal Register, DEPARTMENT OF ENERGY 10 CFR Part 430, *Energy Conservation Program: Energy Conservation Standards for General Service Lamps, A Proposed Rule by the Energy Department*, 2023 https://www.govinfo.gov/content/pkg/FR-2023-01-11/pdf/2022-28072.pdf.
[49] Adam B. Jaffe, *Economics of Energy Efficiency*, Brandeis University and National Bureau of Economic Research; Richard G. Newell, Resources for the Future*;* Robert N. Stavins, Harvard University, 2004.

majority of commercial businesses have adopted the technology, the pace of adoption is slowing, and barriers remain for a minority of consumers.

Figure 4-3. Adoption of selected energy efficient lighting technologies



Adoption curves are widely used to model the relationship between program interventions and the adoption rate of energy efficient products. This use includes U.S. DOE research to create tools for prioritizing investments in building sector energy efficiency measures, using adoption-based energy savings estimates as a metric to evaluate the potential impact of investments in different technologies in an energy efficiency portfolio. These energy savings estimates reflect the difference in energy usage between a baseline scenario and a program intervention scenario, each of which has different rates of technology adoption. The scenarios can be modeled using sales data and other information on the market share of efficient products in different states with different levels of program activity, to estimate correlations between technology adoption and program interventions. Such techniques have found statistically significant correlations between utility program spending and adoption of efficient appliances, lighting, and other technologies.[50] They have also found that increased adoption of efficiency measures such as building insulation and industrial motors is correlated with other factors, such as higher energy prices and lower costs of adoption.[51]

Adoption curves can also be used to model how different levels of program intervention—e.g., incentive levels, marketing and training initiatives—can impact levels of adoption for different technologies at different points on the adoption curve. For measures on the higher, flatter end of the adoption curve, there will be little proportional adoption for a given increase in program incentives, whereas for measures on the steeper part of the slope, increased program spending will result in greater increases in adoption. Ideally, programs will shift incentives away from those measures further along the adoption curve, and toward other measures where incentives can result in proportionally larger increases in adoption.

In New Hampshire, the 2021–2023 Potential Study used technology adoption curves to estimate the savings potential of different energy efficiency investments.[52] Specifically, the study modeled potential savings by calculating market adoption as a function of customer payback and a technology's underlying market barrier level. The study modeled multiple savings

[50] Robert Van Buskirk, *Estimating Energy Efficiency Technology Adoption Curve Elasticity with Respect to Government and Utility Deployment Program Indicators*, 2013. https://www.osti.gov/biblio/1164376

[51] Adam B. Jaffe, *Economics of Energy Efficiency*, Brandeis University and National Bureau of Economic Research; Richard G. Newell, Resources for the Future*;* Robert N. Stavins, Harvard University, 2004.

[52] Dunsky. *New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023*, 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf

scenarios with varying levels of program incentives and other "enabling strategies" for reducing barriers. Specifically, the study estimated statewide savings opportunities for the 2021–2023 NHSaves programs at each of the following levels of savings potential:[53]

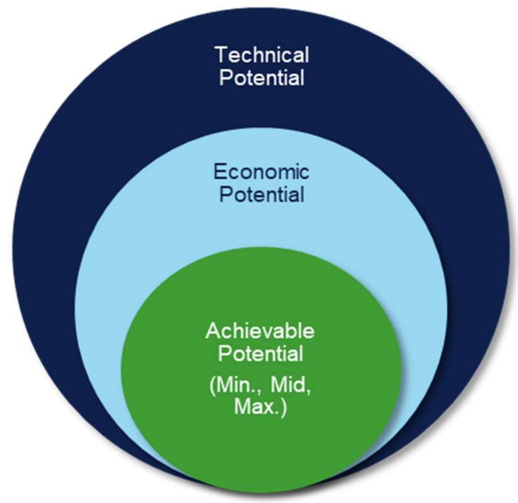
- **Technical potential** reflecting savings from installing all available efficiency measures, without consideration of cost or willingness of users to adopt the measures.
- **Economic potential** is subset of technical potential, reflecting savings from installing all measures that pass cost-effectiveness screening.
- **Achievable potential** is subset of economic potential, reflecting savings that can be realistically achieved given real-world constraints (e.g., the natural turnover rate of equipment) and market barriers. Three achievable scenarios are modeled, using different assumptions for (1) incentive levels, and (2) program "enabling" strategies for reducing barriers—such as contractor training, targeted marketing, and financing offerings. The scenarios are:
  - Low: Incentives and enabling strategies at the levels of the 2018-2020 NHSaves Plan
  - Mid: Incentives raised to a minimum of 75% of incremental cost, and increased enabling strategies
  - Max: Incentives raised to 100% of incremental cost, and same enabling strategies as mid scenario

The sidebar provides an introduction to potential studies, and Section 4.5 includes details on the results of the 2021–2023 Potential Study.

Introduction to potential studies

Potential studies help inform energy efficiency program planning by establishing guideposts for the amount of savings programs might achieve, as well as more detailed information on savings opportunities for specific customer segments and measure types.

Potential studies quantify energy savings opportunities in a jurisdiction by first obtaining data on the existing energy using equipment and building stock in that jurisdiction, referred to as baseline data. The baseline data is entered into a model with data on energy efficient equipment and associated savings, costs, customer and market barriers, and other inputs. Potential studies typically define three scenarios, reflecting different levels of theoretical savings: technical potential, economic potential, and achievable potential. Achievable potential can be further classified into a range of low to high savings scenarios.



4.4.2 Technology advancement

Adoption of a new technology is one stage in a larger process of technology advancement, which generally follows cyclical patterns from development and deployment of new technologies, to broad market adoption and standard practice baselines, followed by development of new codes and standards. The literature defines this process and its stages as follows:[54]

Technological change: the process of invention, innovation, and diffusion whereby greater and/or higher quality outputs can be produced using fewer inputs.

- **Invention**: the development and creation of a prototype new idea, process, or piece of equipment.
- **Innovation:** the initial market introduction or commercialization of new process or product inventions.
- **Diffusion**: the gradual adoption of new process or product innovations by firms and individuals.

[53] Dunsky. *New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023*, 2020.
[54] Adam B. Jaffe, *Economics of Energy Efficiency*, Brandeis University and National Bureau of Economic Research; Richard G. Newell, Resources for the Future; Robert N. Stavins, Harvard University, 2004.

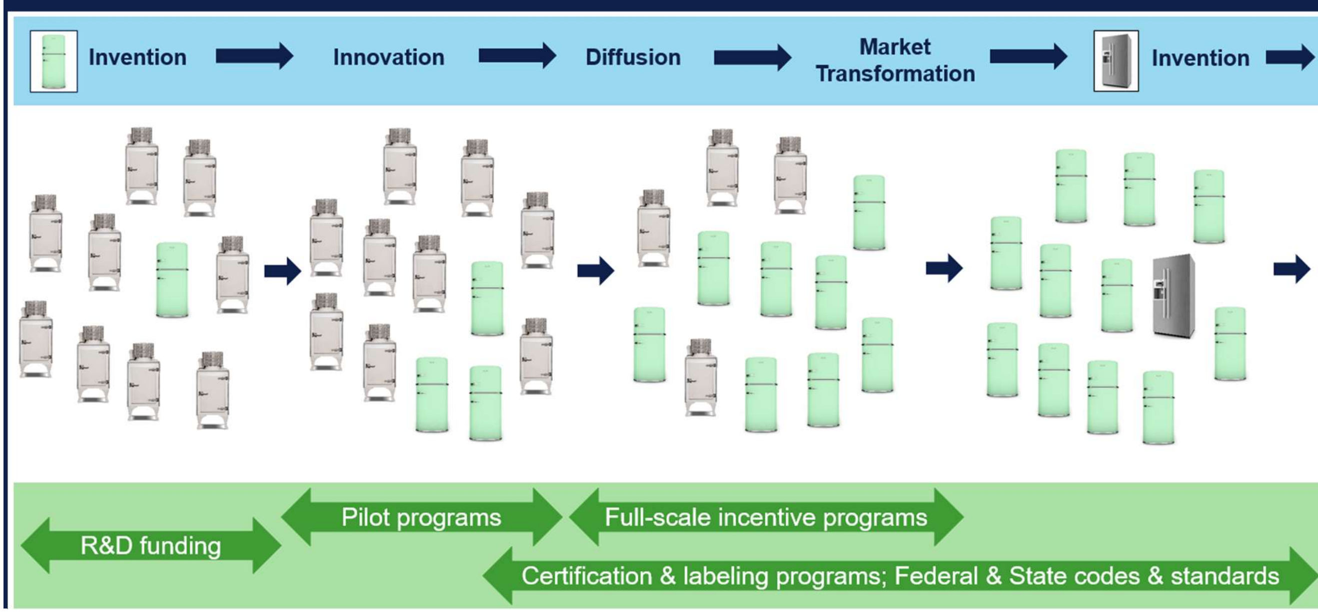
Market transformation: Following widespread adoption, technologies previously considered high efficiency become standard, baseline technologies, and the cycle begins again.

This cycle of technology advancement is influenced by many factors, including program interventions, which often act to accelerate the pace of advancement across the stages. Market transformation programs (see Section 0) are designed to create long-term changes in the structure and function of markets, and in doing so, can spur invention, innovation, and diffusion of efficient technologies. Federal or state codes and standards act in concert with program interventions to assure uniform, minimum levels of efficiency, encouraging innovation and allowing for economies of scale in manufacturing. In addition, energy labeling programs such as ENERGY STAR® help inform consumer decision making and have been found to stimulate private investment in innovations to increase energy efficiency.[55] This framework of policy and program supports has helped spur advancements in efficient lighting and appliances, as shown below for refrigerators.

Market transformation—residential refrigerators

Modern refrigerators use about 70% less energy than the average household refrigerator of the 1970s, while over the same time span refrigerators have grown larger.[56] This advancement was primarily driven by DOE-funded research and innovation in compressor technology,[57] which was followed by more stringent federal energy efficiency standards for refrigerators and adoption of the new compressor technology by manufacturers. Federal standards for refrigerators have been updated multiple times since the 1980s, and each time manufacturers have met the standards with innovations such as improved insulation, compressor efficiency, and fan motor efficiency. Further driving efficiency levels forward during this period, the EPA developed certification and labeling for high-efficiency products under the ENERGY STAR® program, while state energy efficiency programs such as those offered by NHSaves provided incentives and marketing for ENERGY STAR® appliances.[58] Figure 4-4 illustrates this cycle of technological advancement and program interventions.

Figure 4-4. Technological advancements and program interventions, residential refrigerators



[55] Richard Newell, Adam Jaffe, and Robert Stavins, *The Induced Innovation Hypothesis and Energy-Saving Technological Change*, The Quarterly Journal of Economics, vol. 114, no. 3, 1999. Pages 941–975.
[56] Andrew deLaski and Joanna Mauer, *Energy-Saving States of America: How Every State Benefits from National Appliance Standards,* An ASAP and ACEEE White Paper, 2017.
[57] National Research Council, *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*, National Academies Press, 2001.
[58] David Austin, Congressional Budget Office, *Addressing Market Barriers to Energy Efficiency in Buildings*, 2012.

Beyond program and policy interventions, energy prices are a key factor that has been found to influence the pace of advancement of energy efficient technologies. For example, researchers have found significant positive correlations between the price of energy and the number of patent applications for energy conservation technologies such as waste heat devices, heat pumps, and fuel cells. Other research has found that increases in energy prices have been followed by increased innovations in the energy efficiency of commercialized technologies such appliances, automobiles, and aircraft.[59] The effect of energy prices on technology advancement can be enhanced by requirements for energy efficiency product labeling (e.g., ENERGY STAR®), according to literature we reviewed.[60] Researchers hypothesized that labeling increased consumers' responsiveness to energy prices, and thereby increased suppliers' incentive to offer more energy efficient models as energy prices increased.

4.4.3 Net program impacts

Understanding the extent to which increases in technology adoption are due to program interventions requires research on program attribution—also known as net-to-gross (NTG) research. This area of research helps measure the impact of programs on customer decisions to purchase energy efficient equipment, and on other market actors' decisions to stock, promote, and sell energy efficient equipment. Savings from energy efficiency programs can be measured in terms of their gross impacts, and their net impacts, as follows:

- **Gross savings** reflects the difference in energy consumption with the energy-efficiency measures promoted by the program in place versus what consumption would have been without those measures in place
- **Net savings** reflects the difference in energy consumption with the program in place versus what consumption would have been without the program in place. Net savings account for the impact of:
  - **free-ridership**—savings from participants who would have implemented a measure or practice in the absence of the program, and
  - **spillover**—energy savings that are due to the program but occur outside of participants' program-rebated projects.[61]

Using these savings values, a NTG ratio can be calculated as the ratio of net savings to gross savings. Simply, it reflects the amount of gross program savings that can be attributed to the program.

As markets transform, NTG generally decreases, since fewer customers face barriers and program technologies start to become standard practice—that is, an increasing share of customers would purchase the technologies without program intervention. In general, higher NTG values reflect markets and technologies where program intervention is needed to circumvent barriers, and lower NTG values indicate markets and technologies where barriers have increasingly been circumvented or eliminated without the need for program intervention.

4.5 Quantifying barriers in New Hampshire

There have been several evaluations in New Hampshire that included some research on barriers, although primary New Hampshire-based research quantifying barriers has been limited. Recent evaluations of the ENERGY STAR® Homes, Home Energy Assistance (HEA), and Home Performance with ENERGY STAR® (HPwES) programs identified some specific barriers to energy efficient weatherization and residential new construction based on qualitative surveys and interviews (see sections 5.2 and 5.3), but the evaluations did not quantify the impact of these barriers or the costs to overcome them.

[59] Adam B. Jaffe, *Economics of Energy Efficiency*, Brandeis University and National Bureau of Economic Research; Richard G. Newell, Resources for the Future; Robert N. Stavins, Harvard University, 2004.
[60] Richard Newell, Adam Jaffe, and Robert Stavins, *The Induced Innovation Hypothesis and Energy-Saving Technological Change,* The Quarterly Journal of Economics, vol. 114, no. 3, 1999. Pages 941–975.
[61] DOE, National Renewable Energy Laboratory, *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 21: Estimating Net Savings – Common Practices,* https://www.nrel.gov/docs/fy17osti/68578.pdf.

However, as noted in Section 4.4.1, the 2021–2023 New Hampshire Potential Study did estimate the impact of barriers on savings opportunities for the NHSaves portfolio using quantitative modeling techniques. Specifically, the study modeled several achievable savings scenarios that assumed different levels of barriers and included different levels of program incentives and enabling strategies for reducing barriers—such as contractor training and support, targeted marketing, and financing offerings. The scenarios used to model achievable savings for the 2021–2023 period were:[62]

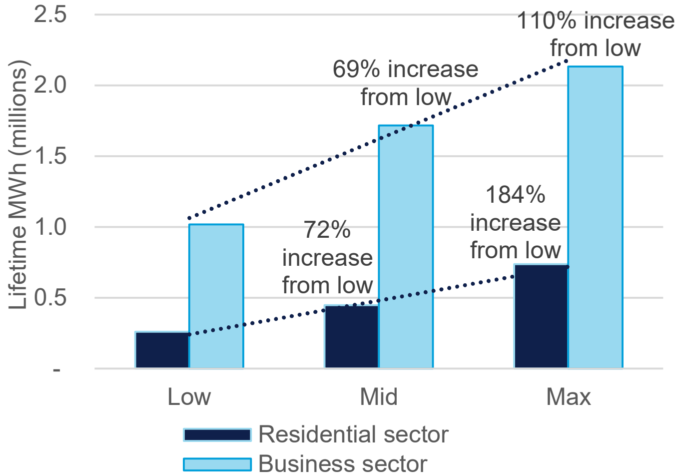
- **Low achievable:** incentives and enabling strategies at the levels of the 2018–2020 NHSaves Plan
- **Mid achievable:** incentives raised to a minimum of 75% of incremental cost, and increased enabling strategies
- **Maximum achievable:** incentives raised to 100% of incremental cost, and the same enabling strategies as mid scenario[63]

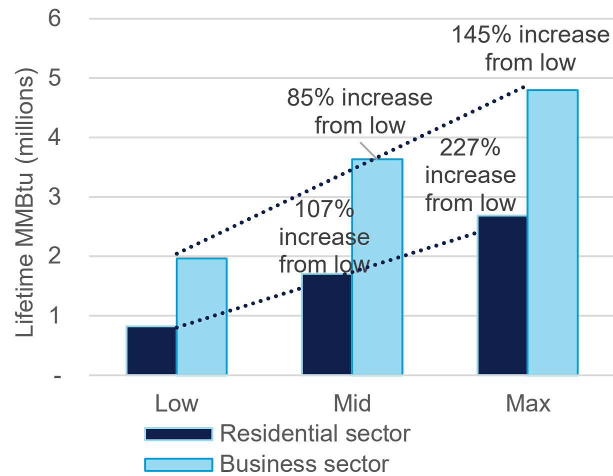
It is important to note that the study did *not* include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

The team re-analyzed this data to estimate the scale of savings that barriers are preventing and identify what savings programs may be able to achieve by overcoming them. In general, the NHSaves programs are designed to be resource acquisition programs, not market transformation programs. As such the Potential Study model represents achievable saving from circumventing specific customer or market actor barriers as part of individual transactions, rather than achievable savings from market-wide elimination of barriers. Using the Potential Study's achievable savings scenarios, the impact of market barriers on adoption of energy efficiency can be estimated based on the growth in savings when moving from the low, to mid, to maximum achievable scenarios. Specifically, larger increases in savings between the scenarios reflect a greater impact from increased incentives and enabling activities to circumvent barriers. In other words, greater increases reflect programs or measures where there is more potential savings to be unlocked by circumventing barriers. Figure 4-5 shows residential and business sector lifetime electric and gas savings for the 2023 program year, for each of the three achievable scenarios modeled in the study. As shown in the figure, there is a significant increase in potential savings moving from the low to mid to maximum achievable scenarios, with the residential sector showing a larger percentage increase, particularly for gas savings, and the business sector showing a larger absolute increase in savings due to increased program incentives and enabling activities to circumvent barriers.

[62] In addition to achievable savings, the study modeled economic savings potential, which reflects savings from the installation of all measures that pass cost-effectiveness screening, regardless of barriers.
[63] Incremental costs are foundational to energy efficiency program planning and cost-effectiveness testing. They represent the difference in cost between baseline, standard efficiency technologies and the energy efficient measures the programs offer.

Figure 4-5. Achievable savings scenarios, 2023 electric (MWh) and gas (MMBtu) lifetime savings

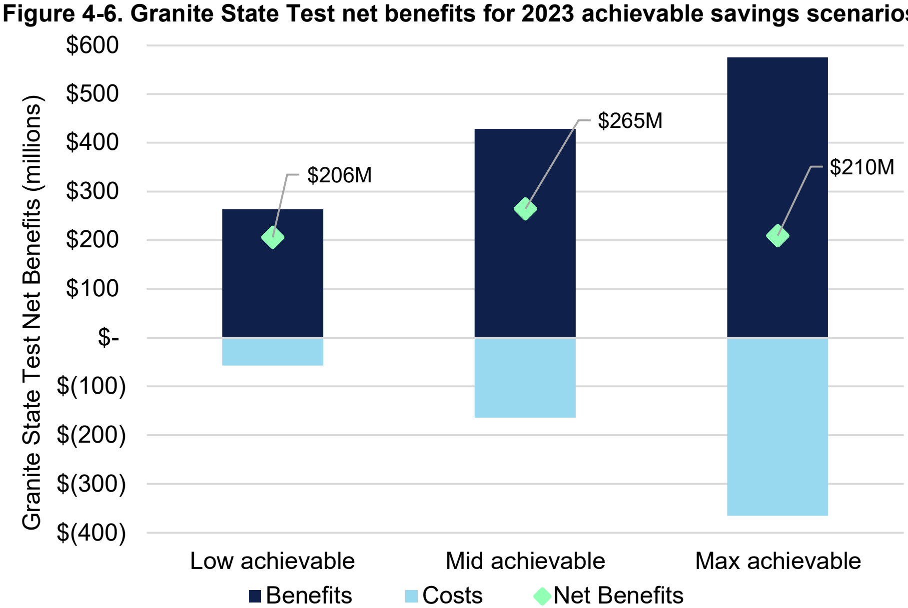




Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

These increased savings levels require increased levels of program spending on incentives and enabling strategies. To account for both the savings and the costs, the NHSaves Potential Study also modeled portfolio-wide benefits and costs for each scenario, using the GST.[64] As shown in Figure 4-6, the scenarios all have positive net benefits, with the mid-level achievable scenario seeing the greatest net benefits under the GST. As noted in the Potential Study, there are diminishing returns to increasing incentive levels to 100% of incremental costs, as in the maximum achievable scenario. That is, the increase in adoption of energy efficient technologies is smaller, in terms of benefits, than the increase in program costs needed to cover the full incremental costs of those technologies.

Figure 4-6. Granite State Test net benefits for 2023 achievable savings scenarios



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

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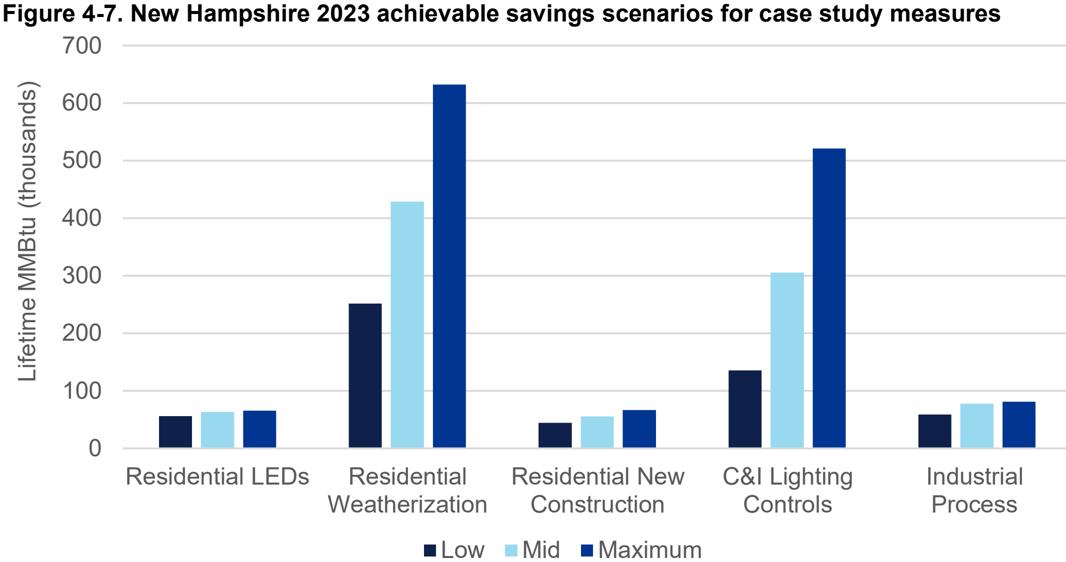
[64] As noted above, this report as well as the 2021-2023 Potential Study assumes the Granite State Test (GST) to assess program cost-effectiveness. The GST was developed through a stakeholder process that culminated in a consensus recommendation to adopt the test, followed by Commission approval and subsequent legislation establishing the GST as the primary cost-effective test for New Hampshire's energy efficiency programs. See https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-136/ORDERS/17-136_2019-12-30_ORDER_26322.PDF and https://gencourt.state.nh.us/bill_status/legacy/bs2016/bill_status.aspx?lsr=717&sy=2022&sortoption=&txtsessionyear=2022&txtbillnumber=HB549.

This analysis of portfolio-wide savings scenarios and net benefits provides some insight on the impact of barriers on program savings, but it obscures important differences between programs, measure types, and customer segments. For instance, within the residential sector, there are minimal increases in achievable savings for lighting measures between the low, mid, and maximum scenarios (see Section 5.1) due to the greater extent of market transformation for lighting, while there are much larger increases in achievable savings for weatherization measures between the scenarios (see Section 0). The actual portfolio savings and net benefits achieved in coming years will depend in large part on the mix of measures the programs incentivize. As markets transform and barriers are overcome for highly cost-effective lighting measures, programs will see an increasing share of savings and costs for less cost-effective non-lighting measures, decreasing overall portfolio net benefits. These differences are key to planning future programs, and Section 5 includes qualitative and quantitative information on the different impact of barriers for the measures included in each case study topic.

Figure 4-7 shows how modeled savings increases moving from low to maximum achievable potential scenarios for the measures in each case study topic. As with Figure 4-5, larger increases in savings between the scenarios reflect a greater impact from increased incentives and enabling activities to overcome barriers. In other words, greater increases reflect programs or measures where barriers are preventing larger amounts of potential savings from being achieved. In contrast, small increases in savings imply there are few barriers that programs can mitigate. Among case study measures, residential weatherization sees the greatest savings increase—in both percentage and absolute terms—from increased incentives and enabling activities to overcome barriers. LEDs, in contrast, show a relatively minor increase in savings moving from the low to maximum achievable potential scenarios. These low barriers are consistent with an assumption of a largely transformed market for retail lighting.

Figure 4-7. New Hampshire 2023 achievable savings scenarios for case study measures



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

On their own, the modelled results from the New Hampshire Potential Study are not definitive evidence of the state of market transformation or elimination of market barriers for the case study measures. However, when considered alongside other indicators, the achievable savings results help identify program areas where market barriers have been largely eliminated, and a market exit strategy should be considered for the programs. Among case studies in our review, retail lighting had the most consistent evidence of market transformation—including studies showing minimal price differences between LEDs and baseline lighting products, and LEDs capturing an overwhelming share of the retail lighting market, even in states without retail lighting programs. In other cases, the Potential Study shows relatively small increases in achievable savings from increased incentives and enabling strategies, but other indicators and research show that customers and market actors continue to face barriers. For instance, our case study of residential new construction found that, despite small increases in achievable savings in the Potential Study, residential new construction programs can continue to achieve savings by increasing program efficiency requirements to ensure participating homes stay ahead of the broader new construction market.

5 MARKET BARRIERS CASE STUDIES

New Hampshire-specific market research on most of the following case study topics exists but is fairly limited in its coverage of market barriers. More broadly in New England and the Northeast, the research is more robust, so publicly available research from peer states is incorporated below where necessary to portray the broader market and the relevant barriers. Any figures reproduced from non-DNV research are shown in gray borders with sources for the original reports. The case studies identify gaps where primary New Hampshire-based research such as customer surveys, market actor interviews, sales data analysis, or other methods would allow for a fuller assessment of the Commission's lines of inquiry, particularly on quantifying end-user barriers and the extent to which New Hampshire programs have circumvented or eliminated them.

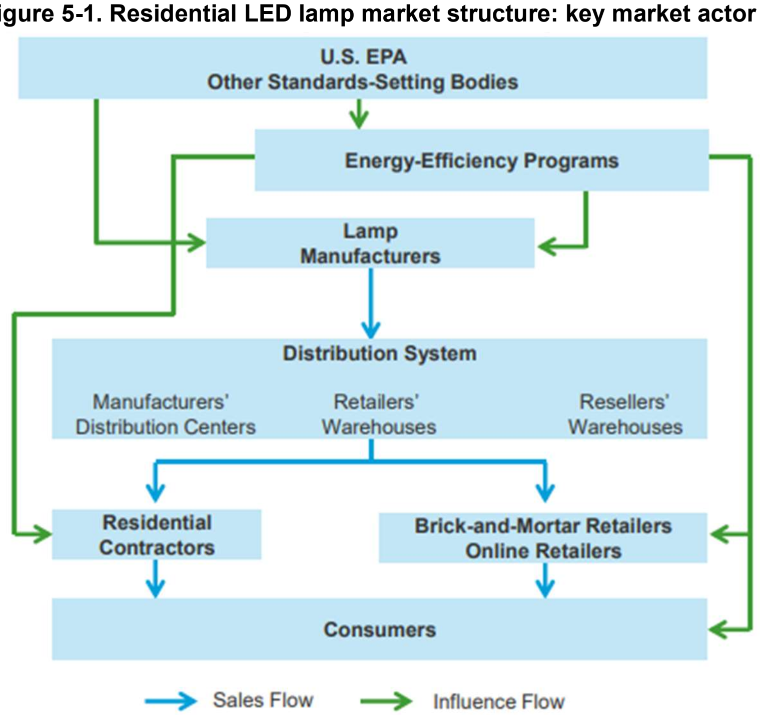
5.1 Residential retail lighting

5.1.1 New Hampshire program overview

Retail lighting has been an energy efficiency offering for over two decades in New Hampshire. Retail lighting offerings have changed forms over time and have been included in each NHSaves plan since the Energy Efficiency Resource Standard (EERS) was established, as part of the ENERGY STAR® Lighting program. The program incentivizes high-efficiency lighting in retail channels to increase ease of adoption and reduce barriers associated with the technology, and in recent years, the program has focused incentives on light-emitting diode (LED) Bulbs (general service lamps, linear, other specialty, and reflector) and LED fixtures. Program bulbs can replace any number of bulb technologies, such as incandescent or CFL, in an existing fixture. The program's upstream delivery model seeks to reduce barriers around retailer stocking practices, customer awareness, and upfront cost by incentivizing the stocking and sale of high efficiency products. This delivery model also reduces customer and supplier burden by avoiding the need for rebate forms or project paperwork.

NHSaves and other state energy efficiency programs have worked in concert with federal and industry bodies to set standards and encourage the manufacture, stocking, and sales of high efficiency lighting, as illustrated in Figure 5-1.

Figure 5-1. Residential LED lamp market structure: key market actor groups



Source: DNV, 2015. Final Report of Massachusetts LED Market Effects: Baseline Characterization. Prepared for the Massachusetts Energy Efficiency Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC).

5.1.1.1 Energy Independence and Security Act

Passed by Congress in 2007, the Energy Independence and Security Act (EISA) included critical policy interventions in the lighting market that underlie the discussion of barriers and interventions in the following section. Specifically, EISA requires certain general service lamps (GSL)[65] to meet specified standards for lumens[66] per watt. Although EISA did not explicitly ban incandescent lamps, the standards it established could not be met by traditional incandescent lamps. As such, EISA began to push some traditional incandescent lamps out of the market and force a shift to high-efficiency technologies.

EISA included a second, more stringent phase of regulations, originally set to begin in 2020, requiring at least 45 lumens per watt for all GSLs, and effectively eliminating most of the remaining incandescent and halogen screw-in lamps from the market. However, the impact of this phase was delayed due to the federal regulatory process and changes in the administration. Specifically, during the Obama administration, revised guidelines on the efficiency of GSLs were instated, and then rolled back during the Trump administration. In August 2021, the Department of Energy proposed reinstating these standards, including expanding the definition of GSLs to include other lamp types such as reflectors and candelabras that were previously exempt. As part of this reinstatement, a 45 lumens per watt standard applied to a majority of bulb types, rendering a majority of incandescent and halogen lamps not up to standard. This standard allowed for the production of non-compliant lamps through December 2022, and the sale of non-compliant lamps through July 2023.[67] DOE has stated that it will enforce penalties on non-compliant retailers beginning in July 2023.

5.1.2 Barriers

5.1.2.1 Financial barriers

Price—more specifically, the upfront incremental cost difference between a high efficiency product and its baseline technology counterpart—is a well-established barrier to adoption of energy efficiency, and lighting is not unique. The energy savings from LEDs is substantial—the LED equivalent to a 60-watt incandescent bulb uses roughly 6-8 watts, or 85%–90% less energy than its predecessors[68]—but customers must pay higher upfront costs in order to benefit from these savings. Retail pricing research has previously found that nearly all LED lighting technology types are higher priced than their first tier EISA compliant baseline counterparts.[69] However, this price differential has steadily decreased since LEDs were first introduced in retail outlets. In 2015, research on pricing and customer barriers found that initial upfront cost was still the primary barrier to increased LED adoption, but that research and development efforts by manufacturers and program interventions were driving down customer costs.[70] As recently as 2019, market research found that programs should continue to play a role in supporting LEDs, as they were not yet cost-competitive with baseline technologies, which were still widely available in stores and expected to remain so for several years.[71] However, continued declines in LED prices since then is further evidence of the rapid transformation of the retail LED market and the gradual elimination of upfront cost barriers on a market-wide level.

These price trends can be seen in Figure 5-2 for New Hampshire and other New England states, taken from recent lighting sales data research in the Northeast. [72] The trends were also found in states without upstream lighting programs, which saw decreasing prices as the nationwide market transformed due in part to programs' upstream influence on manufacturers.

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[65] EISA defines a general service lamp as a standard incandescent or halogen lamp that: 1) is intended for general service applications, 2) has a medium screw base, 3) falls within a range of 310 to 2,600 lumens, and 4) is capable of being operated at a voltage at least partially within the range of 110 and 130 volts.

[66] Lumens are a measure of the total quantity of visible light emitted.

[67] Dan Eisenberg, Aaron Goldber, and Jack Zietman, *U.S. Department of Energy Finalizes Rules to Impose Stringent Efficiency Standard on Most Lamps,* 2022. https://www.bdlaw.com/publications/u-s-department-of-energy-finalizes-rules-to-impose-stringent-efficiency-standard-on-most-lamps/.

[68] Superior Lighting, *Guide to Buying Equivalent Wattage LED Lights,* 2016. https://www.superiorlighting.com/blog/guide-to-buying-equivalent-wattage-led-lights-1c400f/.

[69] Energize CT, *Connecticut R1963b Short term residential lighting report,* 2020 https://energizect.com/sites/default/files/documents/R1963b_STLighting_FINAL%20Report_102920_0.pdf.

[70] DNV, Massachusetts LED Market Effects: Baseline Characterization, 2015. https://ma-eeac.org/wp-content/uploads/LED-Market-Effects-Baseline-Characterization-Final-Draft.pdf.

[71] Ibid.

[72] NMR Group Inc., *2019 Regional Lighting Sales Data Analysis (MA20R22-E) FINAL*, 2020 https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14263212.

Figure 5-2. Market-level LED price trends, 2016–2019[73]

Source: NMR, *Connecticut R1963A, Short term residential lighting report*, 2020.

According to this research, the low shelf prices of LEDs in Connecticut, Massachusetts, and Rhode Island were due in part to those states having relatively high per-bulb program incentives (i.e., program spending of more than $5 per household).[74] New Hampshire was classified as a "moderate program state" (i.e., program spending of between $0 and $5 per household), which in part explains the higher shelf price of LEDs in 2019 in New Hampshire relative to states with more aggressive programs. The researchers also concluded that the low average LED price in non-program areas reflects several factors, including that (1) retailers discounted LED prices in non-program states because those states had lower costs of living across the board than program states, and (2) the average prices include both ENERGY STAR® and non-ENERGY STAR® LEDs, the latter of which are less expensive but often lower quality. Regardless of these factors, the results provide additional evidence that the market for retail lighting had been nearly transformed by the end of the 2010s.

5.1.2.2 Informational barriers

Consumer awareness of and confidence in efficient lighting technologies have been historic barriers to adoption of LEDs and their predecessors, compact fluorescent lights (CFLs). Interventions including state efficiency program marketing and education as well as federal standard setting, certification and labeling initiatives have evolved over time to address these barriers. Energy efficiency programs nationwide began promoting CFLs in the 1990's, but despite many years of program support, consumer awareness of CFLs increased very slowly, and those who were aware were often dissatisfied with the technology due to performance issues such as lighting quality, lamp size and shape, and environmental concerns. To address informational barriers, regional groups including the Northeast Energy Efficiency Partnership (NEEP) worked with retailers to provide training and marketing resources and with manufacturers and program administrators to adjust program requirements. The U.S. DOE introduced the first ENERGY STAR® specification for CFLs in 1999, establishing national standards for product quality to guide manufacturers and provide customers with product assurance.[75]

[73] SCS Analytics, *Connecticut R1963b Short term residential lighting report,* 2020. https://energizect.com/sites/default/files/documents/R1963b_STLighting_FINAL%20Report_102920_0.pdf.
[74] NMR Group Inc., *2019 Regional Lighting Sales Data Analysis (MA20R22-E) FINAL*, 2020 https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14263212.
[75] Kelly K, Rosenberg M. *Some Light Reading: Understanding Trends Residential CFL and LED Adoption*. ACEEE Summer Study on Energy Efficiency in Buildings, 2016. https://www.aceee.org/files/proceedings/2016/data/papers/7_703.pdf.

Following the introduction of retail LEDs as an alternative to CFLs in the 2000's, customer awareness showed little improvement initially, and many customers remained skeptical of claims of performance after disappointing experiences with CFLs—despite LEDs' better performance and lighting quality, and significantly longer useful life.[76] Through the early 2010's, research found that customers and market actors cited performance concerns as well as a general lack of familiarity with LED products as barriers to their adoption. In part in response to these concerns, programs like the U.S. DOE's Solid State Lighting program and the DesignLights Consortium set standards for product quality, and in 2010 EPA added an ENERGY STAR® specification for LEDs, which it continued to update as the market progressed.[77] Manufacturers also partnered with these efforts to establish LED performance criteria and testing protocols to help address quality concerns.[78]

Building on this foundation, manufacturers, as well as retailers and energy efficiency program administrators, launched widespread marketing and education campaigns to spur sales of new LED products. Recognizing consumer familiarity with the ENERGY STAR® label, these information efforts often leveraged ENERGY STAR® branding—including in the program names themselves, as was the case with New Hampshire's ENERGY STAR® Lighting program. By the mid-2010's, customer awareness had improved significantly from when LEDs were first introduced in retail channels. For instance, 2015 research found that 84% of retail customers in Massachusetts and 80% in non-program comparison states had heard of LEDs, and this trend of increased awareness has continued since then.[79]

5.1.2.3 Supply and provision barriers

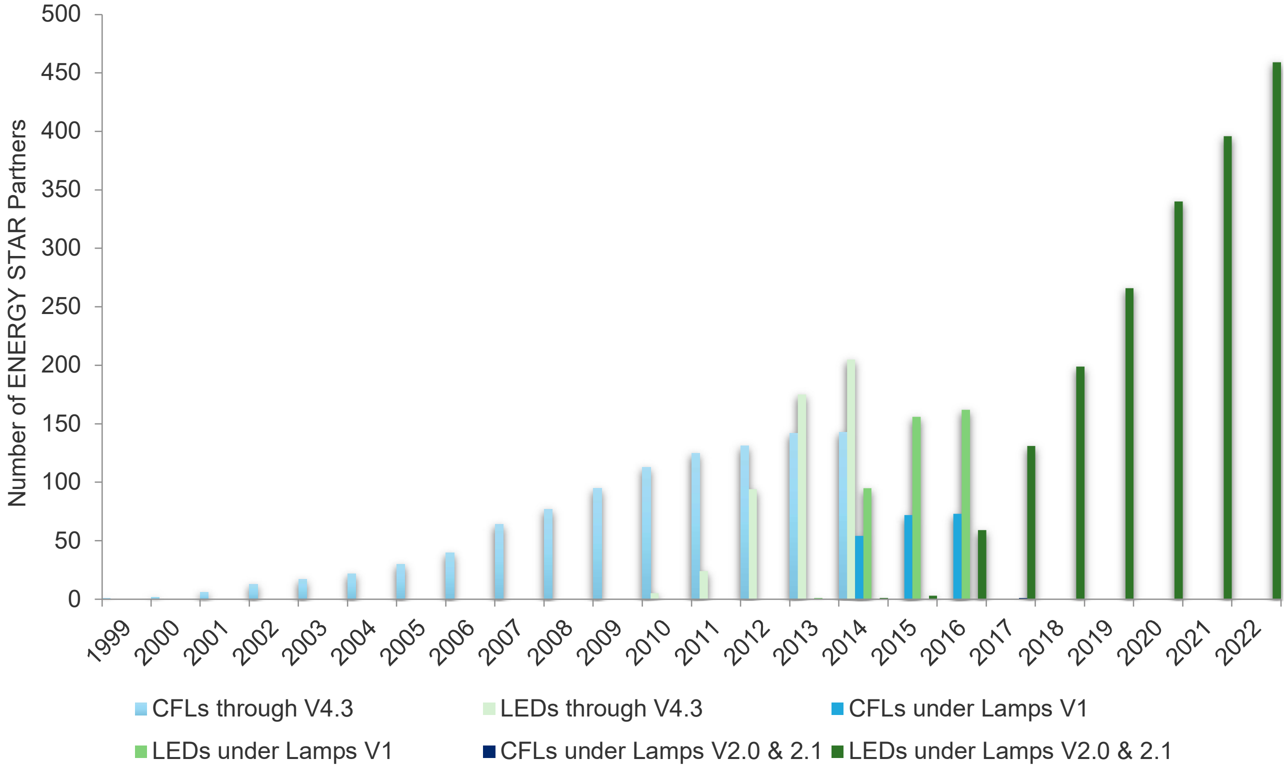
Retail stocking and manufacturer practices have posed historic barriers to adoption of efficient lighting products including LEDs and CFLs, but state energy efficiency program interventions and federal and other organizational support has helped to overcome them. In the early 2000's, consumers often purchased replacement lamps at grocery stores instead of the big box stores like Wal-Mart and Home Depot that are the predominant source of lighting today. Historically, the grocery retail channel did not heavily stock CFLs and this lack of availability became an early barrier to their adoption.[80]

Starting around 2010, the stocking of CFLs was on a steadily increasing trajectory in states with large energy efficiency programs. In Massachusetts, retail shelf stocking research found that the share of shelf space devoted to CFLs among stores that participated in the state's ENERGY STAR® lighting program had grown from 33% of all bulb shelf space in 2010 to 68% in 2012 and 62% in 2013.[81] Similarly in California in 2011, shelf stocking research found that advanced CFLs were present in 87% of retail stores, including 100% of hardware and home improvement stores—though only 56% of discount and 67% of grocery stores.[82]

In the mid-2010s, the stocking of CFLs began to decline as LEDs gained a stronger foothold and began appearing on retail shelves in greater numbers, particularly in states with upstream lighting programs. By 2015, Massachusetts research found that 44% of retailers in Massachusetts and 32% in non-program comparison areas stocked LED products. This trend of increased retail stocking of CFLs, and then LEDs, was mirrored further up the supply chain, in the share of ENERGY STAR® partners—e.g., manufacturers—with ENERGY STAR®-qualified lighting products, as shown in Figure 5-3. In more recent years, the trend of increasing partners has continued for each new iteration of ENERGY STAR® specifications.[83]

[76] Ibid.
[77] Ibid.
[78] DNV, *Massachusetts LED Market Effects: Baseline Characterization*, 2015. https://ma-eeac.org/wp-content/uploads/LED-Market-Effects-Baseline-Characterization-Final-Draft.pdf.
[79] Ibid.
[80] Pacific Northwest National Laboratory, *Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market*, 2006.
[81] Cadmus & NMR, *Massachusetts Residential Lighting Shelf Survey and Pricing Analysis FINAL REPORT,* 2014.
[82] DNV KEMA Energy & Sustainability, 2012. *Fall 2011 California Lighting Retail Store Shelf Survey Report*. Prepared for the California Public Utilities Commission Energy Division. https://www.calmac.org/publications/2011_CALIFORNIA_LIGHTING_RETAIL_STORE_SHELF_SURVEY_FINAL_REPORT_CALMAC.pdf.
[83] The EPA maintains a list of the ENERGY STAR qualified lamps which can be used as an indicator of lamp manufacturing organizations interest in producing lamps that meet certain quality standards by analyzing the number of ENERGY STAR® partners with qualifying lamps over time. EPA has issued multiple versions of these product specifications, with the first LED specification, version 1.0, going into effect on August 31, 2010.

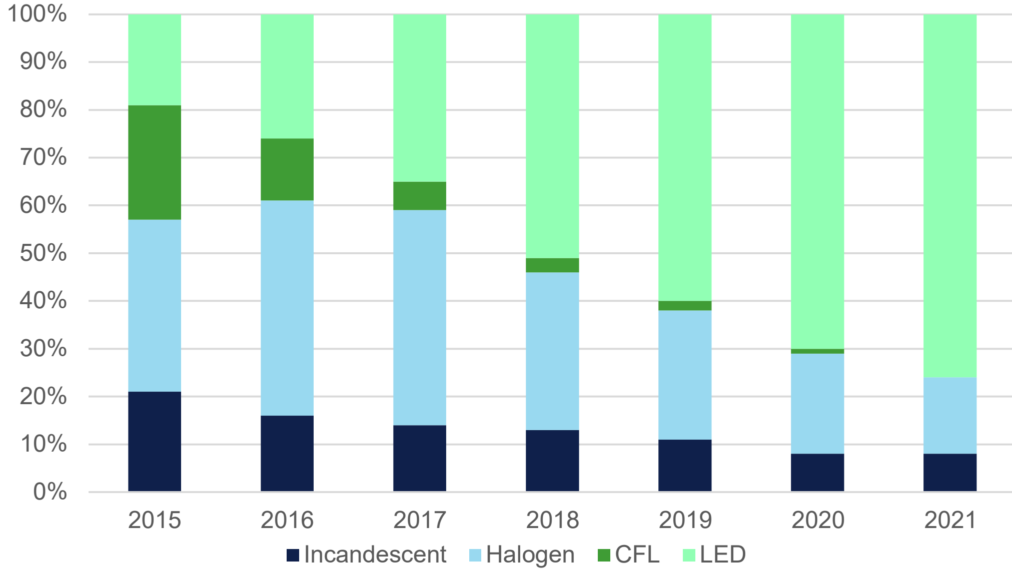
Figure 5-3. Number of ENERGY STAR® Partners with qualifying lighting products, by year and technology



Source: DNV analysis of US EPA. Archived CFLs Qualified Product List, 2014; Archived Integral LED Lamps Qualified Product List, 2014; ENERGY STAR® Qualified Lamps Product List, 2016; ENERGY STAR® certified light bulbs list, 2023.

Data on nationwide sales provide a broader view of the rapid evolution of the retail lighting market, first away from CFLs and toward LEDs in the mid-2010s. In the late 2010s, the growth of LEDs continued, and they began increasingly displacing baseline halogens and incandescent lamps, as shown in Figure 5-4. As of 2021, CFLs had all but disappeared from retail shelves, and their market share reflected this, and halogen and incandescent lamps represented less than 25% of sales.

Figure 5-4. U.S. retail lighting market share by technology, 2015 to 2021



Source: DNV analysis of LightTracker data. https://www.creedlighttracker.com.

In the Northeast, where most states have had high levels of upstream lighting program activity, stocking practices were generally ahead of the national trend, resulting in a small and shrinking presence of baseline lamps on store shelves by 2020. For example, 2020 research in Connecticut found that baseline halogen and incandescent bulbs were still available in the retail market in certain channels—e.g., grocery and hardware stores—but that other channels such as club stores did not carry any baseline lighting products. The study recommended the programs discontinue promotions and incentives at such stores where the "product choice landscape already favors efficient LED products."[84] Meanwhile, a 2020 study in New Hampshire found, based on interviews with 19 manufacturers and retail buyers (collectively termed suppliers), that following many years of program activity, most suppliers reported limited variation in stocking practices between program areas and non-program areas (although three did report some remaining differences in the share of LEDs stocked between program and non-program areas).[85] These stocking results add to the evidence of market transformation across the region.

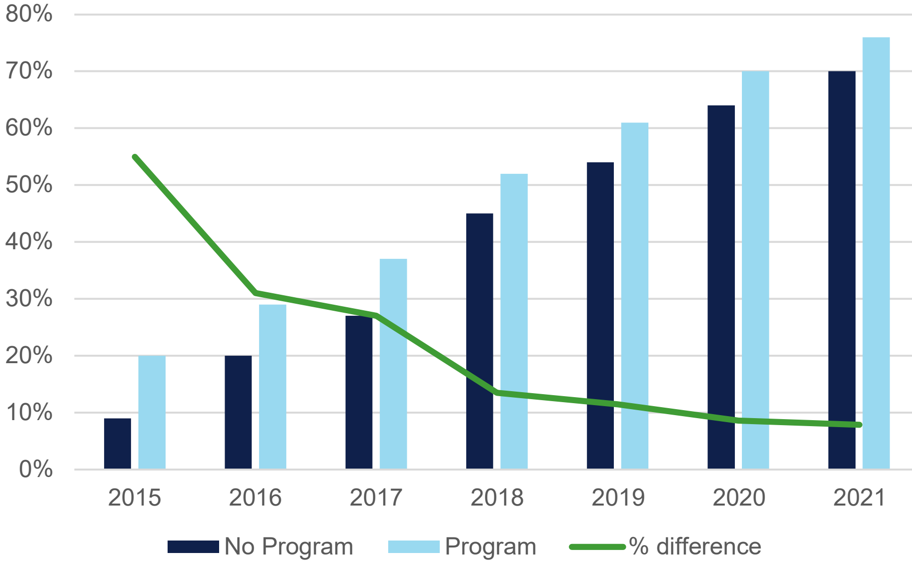
5.1.3 Market trends

As shown in Figure 5-4 and discussed in the above sections, retail LEDs have seen widespread adoption in New Hampshire, in New England, and nationally. The influence of state energy efficiency programs on this trend can be seen in Figure 5-5 below, which shows the difference in LED market share between states with and without upstream lighting programs. Program states have consistently seen higher LED market share than non-program states, but this gap has shrunk as the broader market has transformed. Specifically, in 2015, LED market share in program states was 55% higher than in non-program states, but by 2021, program states' market share was only 8% higher than non-program states.

[84] SCS Analytics, *R1963B: SHORT TERM RESIDENTIAL LIGHTING REPORT*, 2020. https://energizect.com/sites/default/files/documents/R1963b_STLighting_FINAL%20Report_102920_0.pdf

[85] NMR, *New Hampshire Lighting Supplier Insights report,* 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200814-NH-Lighting-Supplier-Insights.pdf.

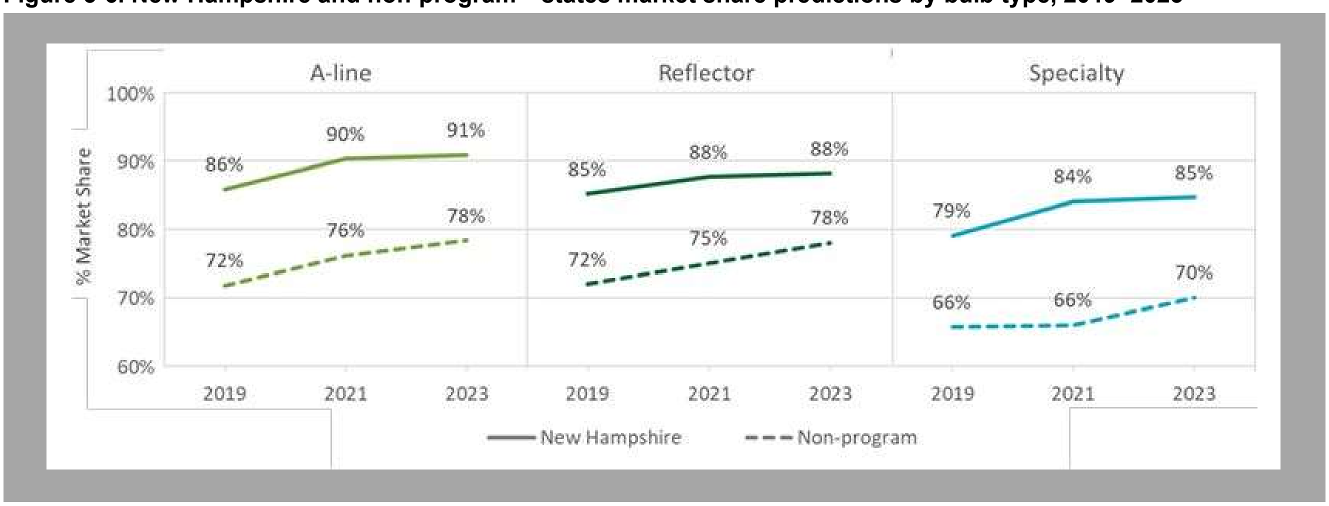
Figure 5-5. LED Market Share in Program and Non-Program States, 2015-2021



Source: DNV analysis of LightTracker data. https://www.creedlighttracker.com.

Similarly, in New Hampshire, market share has been found to outpace non-program states, but by a decreasing amount. Figure 5-6, from the 2020 New Hampshire Lighting Supplier Insights report, shows the growth in market share (i.e., percent of retail lighting sales) and projected increases from 2019 to 2023 for New Hampshire and non-program states, by lamp type, based on interviews with lighting suppliers.[86]

Figure 5-6. New Hampshire and non-program[87] states market share predictions by bulb type, 2019–2023



Source: 2020 New Hampshire Lighting Supplier Insights report, page 4. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200814-NH-Lighting-Supplier-Insights.pdf.

5.1.3.1 Net-to-gross (NTG) ratios

As noted in Section 4.4.3, NTG ratios reflect the extent to which adoption of energy efficiency measures can be attributed to the programs that offer them. Specifically, higher NTG ratios indicate a higher level of program influence and lower levels of

[86] The report notes some methodological limitations that may have caused these market share estimates to be higher than broader trends in program state market share would suggest. These include the fact that the team interviewed only program partners and used question wording that forced LED-focused suppliers to report a 100% LED market share.
[87] Non-Program state defined as state without retail lighting program such as Kansas, Alabama, etc.

free-ridership among participants. Lower NTG scores reflect a larger share of participants who would have adopted the efficient measure with or without the program. Generally, more transformed markets will see lower NTG values.

NTG ratios have not been directly evaluated for retail lighting in New Hampshire, but they have been studied throughout the Northeast and nationwide. According to the New Hampshire Technical Reference Manual, New Hampshire applied Connecticut's 2020 NTG values to the NHSaves programs in 2021, one year behind, to account for the relatively slower pace of market transformation, due in part to fewer program LED bulbs per home in New Hampshire (2.5 bulbs per home in 2019) compared to Connecticut (4 bulbs per home in 2019).

Regardless of state, the trend for retail lighting is evident below in Table 5-1, which shows a steadily decreasing level of savings that can be attributed to programs as LEDs have become the dominant technology in the retail lighting market. This trend mirrors the other trends above showing increasing market share, decreasing upfront prices, and increasing supplier manufacture and stocking of LEDs.

Table 5-1. Retail lighting net-to-gross values in the Northeast

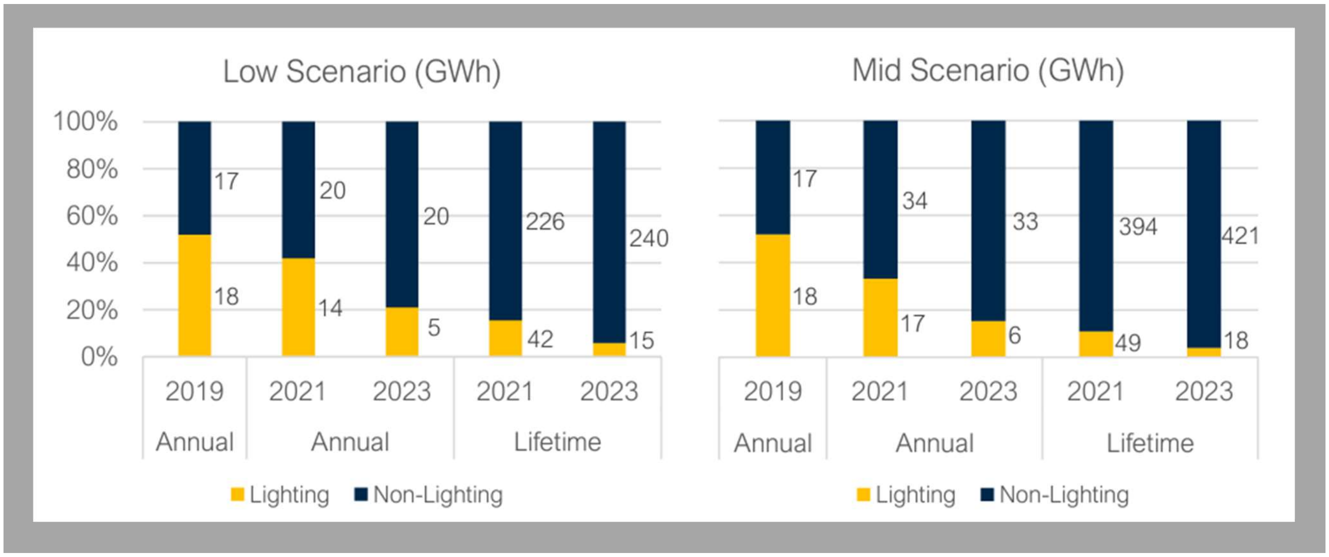
Measure	CT 2016[1]	CT 2017[1]	CT 2018[1]	MA & RI 2018[2]	CT 2019[1]	NY 2019[3]	NY 2020[3]	CT 2020, NH 2021[4]	CT 2021[1]
Residential LEDs (all except hard-to-reach)	57%	47%	40%	25% (A-line) 35% (specialty, reflector)	36%	35%	31%	33%	30%
Residential LEDs (hard-to-reach channels)	77%	67%	60%		56%			53%	50%

[1]NMR, CT R1615 LED Net-to-Gross Evaluation, 2017.
[2]NMR Group, Inc., *MA NTG Consensus Panel Report,* 2018 and NMR Group, Inc., *RLPNC 17-11 LED NTG Consensus Process Products,* 2018.
[3]DNV*, Free-ridership and Spillover Evaluation, Residential and Commercial Portfolio Report,* 2022.
[4]NH Technical Reference Manual & CT-NMR LED NTG Evaluation 2017, "The 2020 Connecticut net-to-gross values are applied to New Hampshire for 2021 to account for the relatively slower pace of market transformation, due in part to fewer program bulbs per home in New Hampshire (2.5 bulbs per home in 2019) compared to Connecticut (4 bulbs per home in 2019)."

5.1.4 Future opportunities

As noted in Table 3-1, retail lighting previously accounted for a large share of NHSaves savings—51% of residential annual MWh and 20% of residential lifetime MWh in 2021. According to the NH Potential Study, the incremental additions in savings associated with retail lighting are diminishing, as shown in Figure 5-7. NH Utilities acknowledged this result in the 2022-23 Plan, which included a "planned reduction in investment in high-efficiency lighting measures in the electric programs. Focus will shift to lighting retrofits and customer segments that still have market barriers."

Figure 5-7. Lighting as a share of overall residential savings for low and mid scenario, New Hampshire



Source: Dunsky. New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023, Oct. 2020

The historical trends and recent research, along with the full implementation of EISA starting this year, provide compelling evidence that the retail lighting market has been fully transformed, in significant part due to the long-term engagement of state energy efficiency programs. Removing any remaining doubt about the completeness of this transformation, the U.S. EPA released a letter on March 13, 2023 to all ENERGY STAR® Lighting brand owners and interested parties, which stated the following:[88]

"With this letter, the U.S. Environmental Protection Agency (EPA) is finalizing the sunset of the ENERGY STAR® specifications for lamps and luminaires effective December 31, 2024. Recessed downlights, discussed more below, will be covered by a new specification moving forward. Lighting requirements will be removed from the ENERGY STAR® ceiling fan and ventilation fan specifications effective August 1, 2023. Fans with lighting will still be eligible. … Multiple commenters suggested that the marketplace still needs part or all the ENERGY STAR® lighting program to avoid losing the significant efficiency gains associated with lamps and luminaires. To the contrary, historical efficiency gains for lamps and luminaires will be secured by way of the sales prohibition of inefficient light sources in the United States that will be enforced starting this summer."

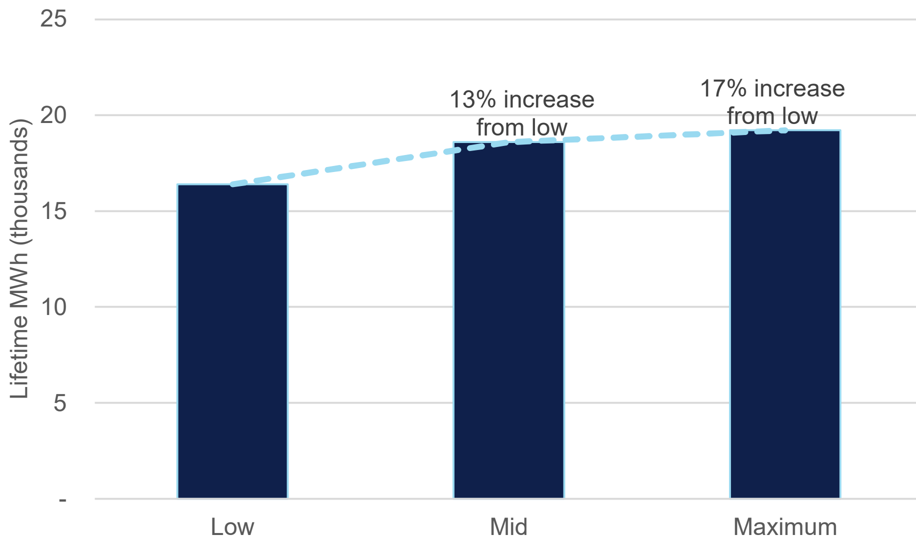
5.1.4.1 New Hampshire Potential Study achievable savings

To estimate the scale of retail lighting savings that the NHSaves programs may be able to achieve by overcoming barriers, the evaluation team analyzed savings opportunities for retail lighting as originally modeled for the 2021–2023 New Hampshire Potential Study. As shown in Figure 5-8, residential LEDs see relatively small increases in achievable savings resulting from increased incentives and enabling activities to overcome barriers, which is consistent with an assumption of a largely transformed residential lighting market and few remaining barriers.[89] These results—which do not account for more recent developments such as full implementation of EISA—suggest that at the time of the study, there were little remaining residential LED lighting savings opportunities for the NHSaves programs. In the period since the study, any savings opportunities have effectively disappeared.

[88] U.S. EPA, *ENERGY STAR® Lighting Sunset Memorandum*, 2023. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Lighting%20Sunset%20Memo.pdf

[89] It is important to note that the study did not include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

Figure 5-8. New Hampshire achievable savings scenarios for residential LEDs, 2023



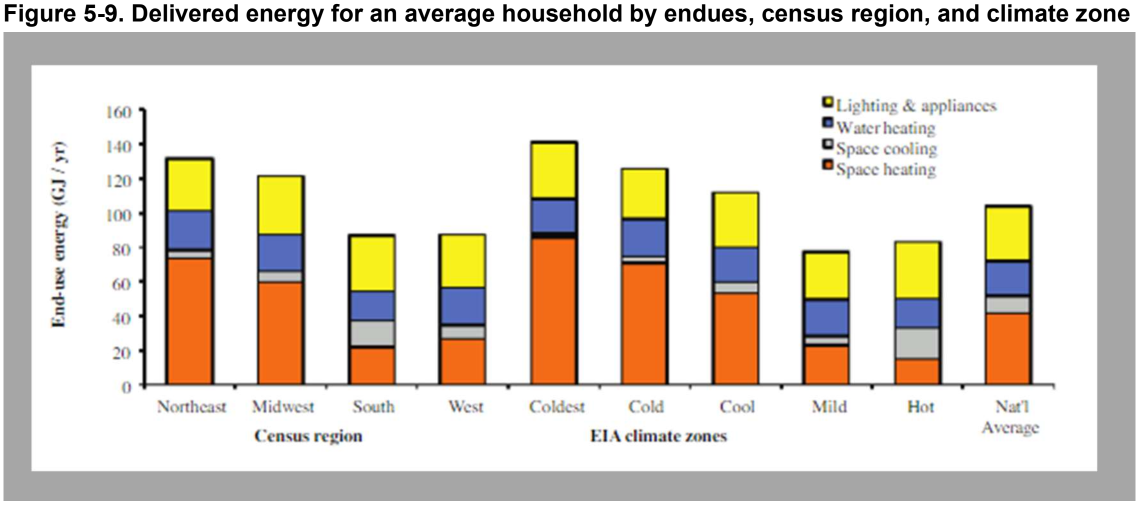
Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

5.2 Residential weatherization

Measures such as air sealing and building shell insulation are primary components of most weatherization programs. Wi-Fi-enabled thermostats and heating equipment, duct repairs and sealing, window and door repairs and replacement, and pipe and tank insulation can also be included in residential weatherization programs.[90]

Household energy use for space heating comprises a significant portion of overall energy use, particularly in the Northeast. As shown in Figure 5-9, due to differences in climate and housing stock, energy costs in the Northeast and cold climates are higher than in other regions, demonstrating the potential for savings from weatherization in these regions.[91]

Figure 5-9. Delivered energy for an average household by endues, census region, and climate zone



Source: Bradshaw et. al., *Comparing the effectiveness of weatherization treatments for low-income American urban housing stocks in different climates,* Energy and Buildings, 2014.

[90] U.S. Department of Energy, *Weatherization Assistance Program*, 2021. https://www.energy.gov/sites/default/files/2021/01/f82/WAP-fact-sheet_2021_0.pdf
[91] Bradshaw, Jonathan, Elie Bou-Zied, and Robert Harris, *Comparing the effectiveness of weatherization treatments for low-income American urban housing stocks in different climates*, Energy and Buildings, 2014. https://www.academia.edu/23454980/Comparing_the_effectiveness_of_weatherization_treatments_for_low_income_American_urban_housing_stocks_in_different_climates.

5.2.1 New Hampshire program overview

The NH Utilities have administered weatherization programs for over 20 years, originally focused on electric savings in low-income households and expanding to cover fossil fuel savings and market rate households in the past decade. Weatherization programs in New Hampshire are broadly similar to those in nearby states such as Vermont,[92] Maine,[93] Connecticut,[94] and Massachusetts.[95] Weatherization measures are currently offered through the market-rate Home Performance with ENERGY STAR® (HPwES) program and the low-income Home Energy Assistance (HEA) program. These measures include blower door guided air sealing and insulation, coupled with home energy audits. Home energy audits and blower door tests are prerequisites for participation in the HPwES and HEA programs, with exceptions for cases with health and safety barriers like asbestos and mold, which present health concerns if a blower door test is performed.

The market-rate HPwES program contractors take a “whole-house” approach. The program prioritizes treatment of homes that exceed a threshold of energy use intensity, regardless of their primary heating fuel type. HPwES currently offers financing at 2% annual percentage rate (APR) for Home Energy Efficiency Improvement Loans and a revolving on-bill financing option at 0% interest.[96] Previously, the incentive cap per project was $4,000. In the 2021–2023 program cycle, the Utilities increased the cap to $8,000. If a gas project reaches this cap, the customer’s electric utility may incent the customer with an additional $8,000.[97] To qualify, homes must meet a threshold Home Heating Index (HHI) score, which is calculated using location, conditioned square footage, and annual heating fuel usage. The NH Utilities also offer a Visual Audit pathway for those customers who do not meet the HHI threshold and are exploring opportunities for virtual assessments.

The low-income HEA Program offers incentives covering up to the full project cost for this customer segment, with rebates previously capped at $8,000. In the 2021 to 2023 term, the NH Utilities raised the incentive cap to $20,000, including heating systems. NHSaves coordinates delivery of the HEA program with Community Action Agencies (CAAs), which implement the program alongside the federal Weatherization Assistance Program (WAP).[98] The New Hampshire CAAs operate and deliver WAP services, through which they offer funds for health and safety improvements for weatherization (discussed further in Section 5.2.2.1). As described in a recent program evaluation, *“to facilitate the use of collaborative funding, the eligibility criteria for the HEA Program mirrors the eligibility guidelines of other assistance programs. New Hampshire residents are eligible to receive HEA benefits if they qualify for the state fuel assistance program (currently household income is equal to or less than 60% of the state’s median income), the electric assistance program (currently household income is equal to or less than 200% of the federal poverty guideline) or live in subsidized housing”.*[99]

5.2.2 Barriers

Market barriers to weatherization in New Hampshire span multiple categories, including financial, technical and physical, organizational, informational, and supply and provision.

5.2.2.1 Financial barriers

Residential weatherization measures can produce significant lifetime energy and cost savings and non-energy benefits,[100] but upfront costs, access to financing, and perceived risk present barriers to acquiring this longer-term savings. A recent DNV study found that almost half of responses from weatherization contractors in a Northeast state say that residential customers cited high upfront costs as a barrier to installing weatherization improvements.[101] Additionally, older housing

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[92] Efficiency Vermont, *Weatherization*, 2023. https://www.efficiencyvermont.com/services/renovation-construction/weatherization.
[93] Efficiency Maine, *Weatherization*, 2023. https://www.efficiencymaine.com/at-home/weatherization/.
[94] CT DEEP, *Weatherization*, 2023. https://portal.ct.gov/DEEP/Energy/Weatherization/Weatherization-in-Connecticut.
[95] Mass Save, *Building Insulation and Weatherization*, 2023. https://www.masssave.com/business/rebates-and-incentives/building-insulation-and-weatherization
[96] NHSaves, *Energy Audits & Weatherization*, 2023. https://nhsaves.com/learn/rebate/weatherization/.
[97] NHSaves, 2021-2023 New Hampshire Statewide Energy Efficiency Plan https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/INITIAL%20FILING%20-%20PETITION/20-092_2020-09-01_NHUTILITIES_EE_PLAN.PDF
[98] Opinion Dynamics, *New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL,* 2020. Page 6.
[99] Ibid.
[100] U.S. DOE, *WAP Fact Sheet*, 2018. https://www.energy.gov/sites/prod/files/2018/03/f49/WAP-fact-sheet_final.pdf.
[101] DNV, CONFIDENTIAL CLIENT STUDY, 2022.

stock, like that found in New Hampshire, can add time and complexity to weatherization projects, although older homes generally present greater opportunities for savings.[102] According to the American Community Survey, 12.2% of U.S. homes were built in 1939 or earlier, while in New Hampshire, that number is 19.6%.[103]

Costs for weatherization projects can vary widely across the country, depending on the age of the home, presence of health and safety hazards, and other factors. According to the New Hampshire Department of Energy, the average cost of weatherization for low-income households is $6,500 per home.[104] According to the U.S. Department of Energy, the average per home cost of weatherization through the federal WAP program was $4,695 in 2021.[105] Costs also depend on the types of measures being installed. For instance, costs associated with measures like thermal windows can range from $315 to $800 per window, which may be prohibitive for many customers.[106]

Financial barriers differ by customer class, and as such the NHSaves weatherization programs offer financial interventions for two targeted customer classes: low-income and market-rate customers. However, heterogeneity in New Hampshire's customer base means that technologies that are cost-effective for low-income or market-rate customers on average may not be cost-effective for certain customers within those classes. "Thrifty" or moderate-income customers were identified as a hard-to-reach customer class in a 2020 report on HPwES. These are *"customers who keep their thermostats set at low temperatures because they cannot afford to heat their homes to a comfortable level. These may be moderate-income customers who do not qualify for income-based assistance programs, but still struggle financially."*[107]

> *"Several representatives from CAAs noted that there are a large number of participants that do not meet the income qualifications for the HEA Program, have a need to weatherize their homes, but cannot afford the Home Performance with ENERGY STAR® Program co-pay."*
>
> *- New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL, 2020. Page 46*

Some NHSaves program offerings address financial barriers for moderate-income customers, such as the zero-percent moderate income financing offering established during the 2019 program year. As described in the 2021–2023 plan, *"The NH Utility buys down the lender interest rate to zero percent and the lender additionally extends the maximum loan term to 10 years. These actions combine to result in a lower monthly loan payment for moderate-income customers compared to the payment for the typical Residential Energy Efficiency Loan. The lending partner determines whether the customer is within a moderate-income bracket and eligible for a loan based on income review and lending criteria."*[108]

The NHSaves programs offer rebates and loans to overcome financial barriers to weatherization, spending approximately $10,583,646 on these interventions for market-rate customers and $13,076,492 for low-income customers in 2021.[109]

5.2.2.2 Technical and physical barriers

Technical and physical barriers to weatherization impede measure installation. For instance, accessing wall and ceiling interiors is often more technically challenging than installing light bulbs, water conservation devices, or thermostats. In some

[102] National Trust for Historic Preservation, Energy Advice for Owners: Historic and Older Homes. https://archive.epa.gov/region5/sustainable/web/pdf/energy-advice-for-owners-of-older-homes.pdf.
[103] U.S. Census Bureau, *Why we ask questions about…Year built and year moved in,* https://www.census.gov/acs/www/about/why-we-ask-each-question/year-built/.
[104] New Hampshire Department of Energy, *Weatherization Assistance FAQ*, 2023. https://www.energy.nh.gov/consumers/help-energy-and-utility-bills/weatherization-assistance-program/faq.
[105] U.S. Department of Energy, *Weatherization Assistance Program*, https://www.energy.gov/sites/default/files/2021/01/f82/WAP-fact-sheet_2021_0.pdf, 2021.
[106] https://modernize.com/windows/energy-efficient/thermal-windows.
[107] New Hampshire Utilities, *Home Performance with ENERGY STAR® Program Evaluation Report 2016-2017 – FINAL*,2020. Page 38.
[108] NHSaves, *2021-2023 New Hampshire Statewide Energy Efficiency Plan* https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/INITIAL%20FILING%20-%20PETITION/20-092_2020-09-01_NHUTILITIES_EE_PLAN.PDF.
[109] NH Utilities 2021 reported program spending

cases, limited spaces between walls do not allow for insulation at all. Such barriers are exacerbated in multifamily buildings because of the logistics and permissions needed to insulate or otherwise weatherize units with shared walls.

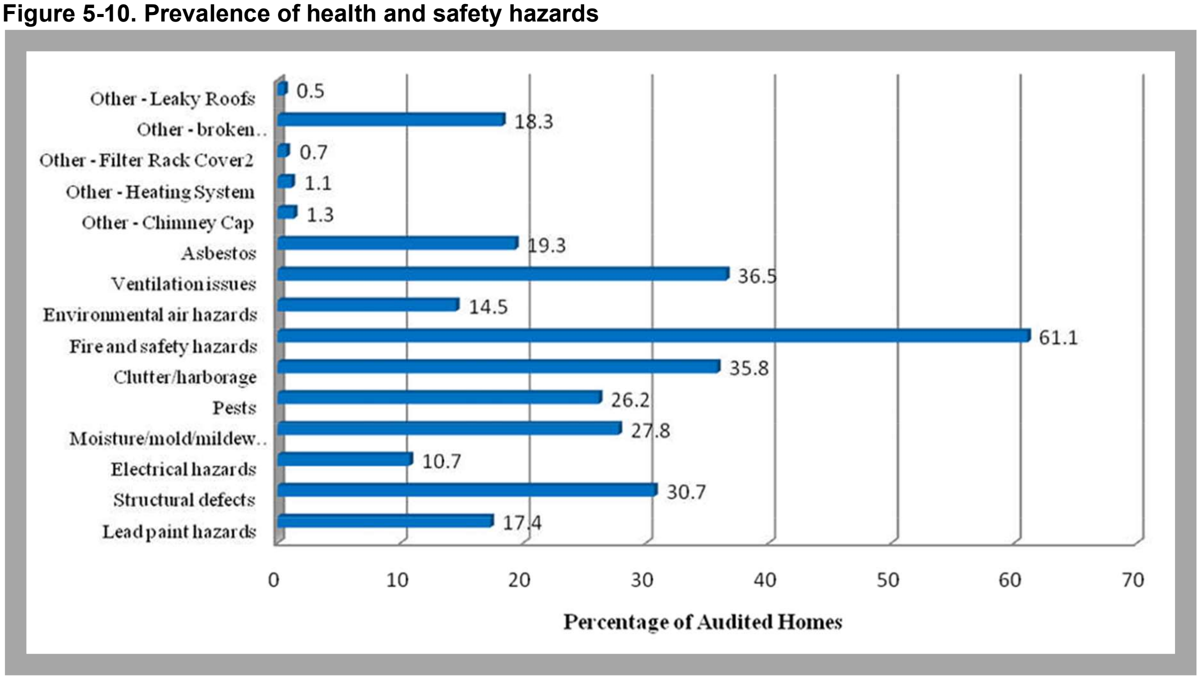
Manufactured housing is prevalent in New Hampshire and poses a particular set of technical and physical barriers. These homes are often underserved by weatherization programs due to such barriers.[110] As detailed in the recent evaluation of the HEA program: *"[HEA] Program staff also indicated that manufactured homes… are a difficult segment to serve through the HEA Program due to limited opportunities to install additional insulation. Specifically, walls cavities in manufactured homes tend to be thin and therefore lack space to add supplemental insulation… contractors sometimes have difficulty accessing certain areas due to low ceiling clearance… Along with a moderate income offering, including measures aimed at this type of housing stock…may help HEA Program teams to serve more participants with manufactured homes."*[111]

Health and safety barriers

Health and safety issues in a home often preclude residents from implementing weatherization measures. As described by the New Hampshire DOE, *"major plumbing, electrical or structural deficiencies, major moisture problems—roof leaks and very wet basements all could slow down progress."*[112] Research from the Green and Healthy Homes Initiative (GHHI) found that nearly 13% of homes audited by GHHI in cities across the United States were ineligible for participation in weatherization programs due to health and safety barriers.[113] Health and safety barriers to weatherization identified in this study included, but were not limited to, the presence of asbestos, ventilation issues, fire and safety hazards, excessive clutter, pests, the presence of moisture, mold, and mildew, electrical hazards, structural defects, and lead paint hazards.[114] See

Figure 5-10 for the prevalence of these barriers as studied by GHHI.

Figure 5-10. Prevalence of health and safety hazards



Source: Ruth Ann Norton, Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization (Green & Healthy Homes Initiative, 2010),

[110] Emmeline Luck, Northeast Energy Efficiency Partnerships, *Recognizing Energy Inequities for Building Decarbonization* and *Near-Term Solutions for Centering Energy Equity*, https://neep.org/solutions-low-carbon-states-and-communities/equitable-home-and-building-decarbonization, 2021.

[111] Opinion Dynamics, *New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL, June 11, 2020.* Page 46.

[112] New Hampshire Department of Energy, Weatherization Assistance FAQ, 2023. https://www.energy.nh.gov/consumers/help-energy-and-utility-bills/weatherization-assistance-program/faq

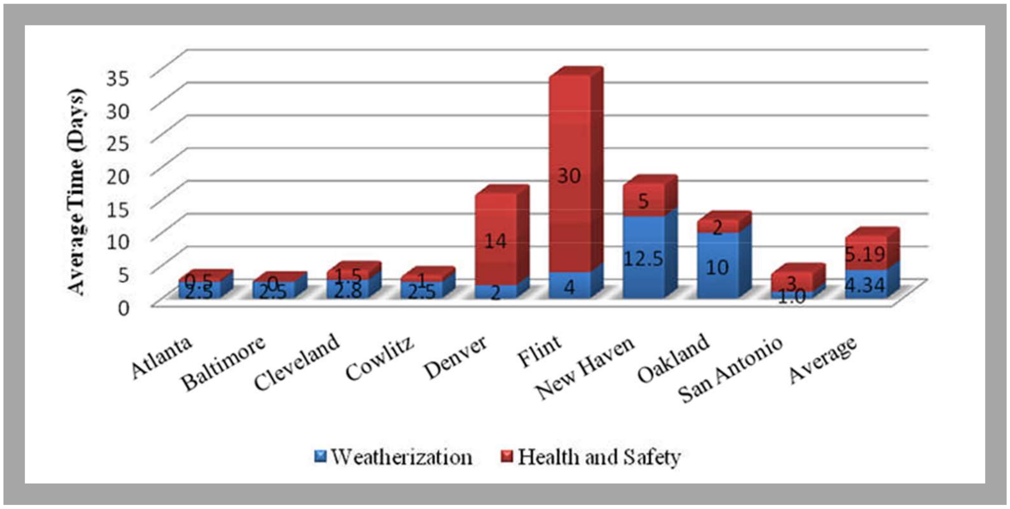
[113] Ruth Ann Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization*,Green & Healthy Homes Initiative, 2010/ Page 6.

[114] Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization*, Page 8.

Page 8.

The time needed to remediate these health and safety barriers can sometimes be greater than the time required for the weatherization projects themselves. As shown in Figure 5-11, based on sites studied by GHHI, the average time spent on necessary remediation of health and safety barriers for weatherization (5.19 days) outweighs the average time spent installing the weatherization measures (4.34 days). Due to its older housing stock, weatherization times in the Northeast may be longer than in other places.[115]

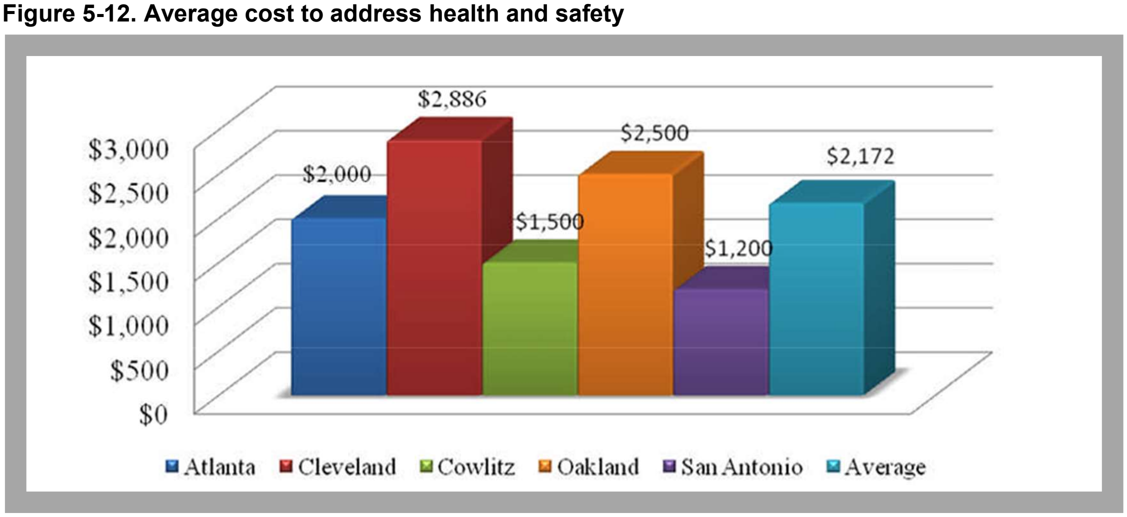
Figure 5-11. Time duration for weatherization and health and safety



Source: Ruth Ann Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization* (Green & Healthy Homes Initiative, 2010), Page 7.

In addition to time, addressing health and safety concerns adds significant costs to weatherization projects. Based on GHHI research, the average cost to address health and safety issues was $2,172 per residential property in 2010 ($2,998.78 in 2023 dollars using a CPI inflation calculator[116]), as shown in Figure 5-12. Homes in Northeast communities with older housing stock may require more investment of time and resources to remediate health and safety issues for weatherization improvements.[117]

Figure 5-12. Average cost to address health and safety



Source: Ruth Ann Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization* (Green & Healthy Homes Initiative, 2010), Page 7.

115 Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization*, Page 7.
116 CPI Inflation Calculator, https://data.bls.gov/cgi-bin/cpicalc.pl?cost1=2172&year1=201001&year2=202301
117 Norton, *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization*, Page 7.

NHSaves programs partially address health and safety hazards remediation for weatherization for the low-income customer class, and federal WAP funding provides additional support. However, according to the New Hampshire Department of Energy, *"there are limits on repairs and various programs to address some additional problems."*[118] WAP may cover some health and safety costs for weatherization, as may the HEA program. However, additional programs require additional paperwork, meaning increased time and inconvenience costs for customers and administrators. Furthermore, larger structural repair needs may not be covered by the allocated rebate funds.

> *"Program teams indicated that a substantial portion of HEA participants require health and safety upgrades prior to completing insulation or air sealing works (65% of participating households received health and safety measures). The WAP currently funds many of these upgrades, and representatives from CAAs suggested adjusting program requirements and funding to allow more health and safety upgrades through the HEA Program may help program teams serve more participants"*
> *- New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL, 2020. Page 46.*

The NH Utilities are actively working on attaining funds to improve financial and technical and physical barriers. As stated in the 2021-2023 plan, "d*uring the 2021-2023 term, the NH Utilities will continue to work with stakeholders, local non-profits, and foundations in order to procure funds to be used to enhance offerings or overcome barriers beyond what is typically funded by the NHSaves Programs. This could include pre-weatherization barriers for HEA customers, expansion costs for Community Action Agencies ("CAAs"), funding the copay of moderate-income customers, coordination with efforts that provide interactive benefits with energy efficiency, such as public health, or other identified opportunities."*[119]

> *"The HEA Program provides health and safety measures to participants, such as carbon monoxide detectors, smoke detectors, and bath fans. Larger health and safety barriers are also covered if they can be accommodated within the $8,000 rebate cap and the package is still cost effective."*
>
> *- New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL, 2020. Page 1.*

5.2.2.3 Organizational barriers

Tenants of leased properties face barriers to weatherization, due to the "split incentive" barrier. This barrier results from the property being owned and largely managed by a landlord—who is responsible for deciding whether to weatherize—while the tenant is responsible for paying energy bills and therefore would be the primary beneficiary of weatherization improvements. Foundational literature on energy efficiency market barriers from a national perspective identifies the landlord/tenant split incentive issue as a significant barrier.[120] In New Hampshire, trends show an increase in multi-family housing permits, correlated with higher rental rates. Data from the New Hampshire Department of Business and Economic Affairs shows that 52.7% of permits issued in 2021 were for single-family homes, decreasing from 59.2% in 2020. This reflects a decrease of 28 single family permits. Meanwhile, the number of multi-family permits issued increased by 569 from 2020 to 2021.[121] This trend suggests that split incentive barriers may become more prevalent in coming years.

Despite these barriers, the NHSaves programs have made significant inroads in the multifamily market and are often involved in new construction of multifamily properties, particularly when they involve other public funding or public housing agencies. About 31% of HEA program participants resided in multi-family buildings in 2017. Additionally, the NH Utilities

[118] New Hampshire Department of Energy, *Weatherization Assistance FAQ,* 2023. https://www.energy.nh.gov/consumers/help-energy-and-utility-bills/weatherization-assistance-program/faq
[119] NHSaves, *2021-2023 New Hampshire Statewide Energy Efficiency Plan*, https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-092/INITIAL%20FILING%20-%20PETITION/20-092_2020-09-01_NHUTILITIES_EE_PLAN.PDF, Page 95.
[120] Steve Sorrell, Eoin O'Malley, Joachim Schleich, and Sue Scott, *The Economic of Energy Efficiency: Barriers to Cost-Effective Investment*, 2004.
[121] New Hampshire Department of Business and Economic Affairs, *Current Estimates and Trends in New Hampshire's Housing Supply*, 2022. https://www.nh.gov/osi/data-center/documents/housing-estimates-trends.pdf.

partner with public housing authorities across the state to complete projects in multi-family buildings, a practice also seen in neighboring states such as Maine.[122, 123] Public housing authorities operate in a different financial environment than private landlords and may not face split incentive barriers to the same degree. For instance, authorities often receive funding from public grant and tax credit sources that include requirements for energy efficiency. Partnering with these authorities provides an opportunity for the NHSaves programs to serve multifamily residents where the split incentive barrier is less acute.

5.2.2.4 Informational barriers

Customer awareness of weatherization was identified as a key barrier in a 2020 New Hampshire report. According to the report, only 6% of eligible non-participants were aware of HPwES. Participating contractors also indicated that awareness among their general customer base was a barrier to weatherization projects.[124]

Programs provide information and marketing to increase awareness of weatherization. For instance, program marketing—either direct or through co-marketing with contractors or other partners—helps to address informational barriers by educating residents on opportunities for savings. Marketing under a statewide brand such as NHSaves, or with utility company branding, can bolster these efforts by providing assurance and credibility to customers; however, programs generally need to balance marketing—which drives demand—with the availability of resources to meet that demand. NH Utilities have invested $149,204 in marketing interventions for their weatherization programs in 2021.[125]

Home energy labeling is another informational intervention growing in prevalence around the U.S., including in states and communities in the Northeast region. This practice helps raise awareness of home energy needs that may lead to weatherization upgrades, and can create a pipeline of eligible customers in need of energy improvements. Communities in New Hampshire have expressed interest in home energy labeling policies and programs.[126]

5.2.2.5 Supply and provision barriers

While financial and informational barriers prevent some customers from pursuing weatherization, workforce constraints present an overarching barrier that impacts customers and trade allies economy-wide. Overcoming other barriers such as lack of awareness will not result in more weatherization if there is an insufficient workforce to serve customers. CAAs reported in 2020 that the capacity of implementation teams is the largest barrier to completing projects through the HEA program. For instance, a CAA staff member cited in the HEA program evaluation stated: *"I can't see spending dollars trying to get more people into the program, because there's already more people in the program than we can get to. And advertising that this program's available isn't going to help, because we still can't get to all the people."*[127] The evaluation also noted that the contractors for HEA largely overlap with those for HPwES, further constraining the available labor pool.[128] In addition to installing weatherization measures, the report cites program enrollment, scheduling, and service delivery coordination activities as accounting for a considerable amount of staff time and capacity. As such, addressing workforce capacity constraints may require assessing administrative and technical staff capacity, in addition to installation contractors.[129]

Lack of training compounds the workforce capacity barrier. CAAs and the NH Utilities reported a skills gap in workers able to complete home energy assessments and measure installations. Additionally, contractors involved in the HPwES program noted high turnover rates and difficulty finding experienced staff members, increasing the need for new employee training and staff development resources.[130] New Hampshire contractors have indicated that utility-sponsored training programs on

[122] Opinion Dynamics, *New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL,* 2020. Pages 17, 47.
[123] https://www.mainehousing.org/programs-services/HomeImprovement/homeimprovementdetail/weatherization
[124] New Hampshire Utilities, *Home Performance with ENERGY STAR® Program Evaluation Report 2016-2017 – FINAL June 11, 2020*. Page 28.
[125] NH Utilities 2021 reported program spending
[126] Northeast Energy Efficiency Partnerships, CONFIDENTIAL WORK WITH NH COMMUNITIES, 2020-2022.
[127] Opinion Dynamics, *New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL,* 2020. Page 41.
[128] Ibid.
[129] Ibid.
[130] New Hampshire Utilities, Home Performance with ENERGY STAR® Program Evaluation Report 2016-2017 – FINAL June 11, 2020. Page 39.

topics such as best practices for weatherization measure installation might be beneficial to new staff members.[131] Recognizing this challenge, utilities and program administrators across the Northeast region are seeking to increase investments in workforce training.[132] Partnerships with local community colleges and trade allies seeking interns or entry-level staff have also found some success in New Hampshire and elsewhere in building and training the pipeline of new entrants to the workforce.

Despite these efforts, workforce barriers have repeatedly been emphasized in numerous studies across the region and over time, indicating that they are pervasive. Given the scope of labor market dynamics and workforce constraints, the NH Utilities are limited in their ability to mitigate these barriers.[133]

5.2.3 Market trends

5.2.3.1 Market share trends

The market for weatherization services has been growing steadily over recent years, a trend that is expected to continue. Recent market research has found that the global weatherization services market is expected to grow at over 8% annually through the end of the decade.[134] A weatherization study in New York found that around 300,000 homes, or about 30% of existing residences, are likely to pursue weatherization upgrades in the next several years.[135] In Connecticut, the state legislature has established a goal to weatherize 80% of residences by 2030—a goal the state's energy efficiency programs are working to achieve but that faces significant barriers as discussed above, notably health and safety barriers.[136]

5.2.3.2 Net-to-gross trends

New Hampshire programs have not undergone NTG evaluations, but there have been several in other Northeast states that provide context for how programs have influenced the market in their states. Weatherization measures and programs have been consistently found to have NTG values in the 80% to 100% range, as shown in Table 5-2. Weatherization measures generally have low levels of free-ridership, particularly among low-income participants, indicating that relatively few people would pursue weatherization absent program intervention. This trend underscores the importance of programs in overcoming the range of barriers described above.

Table 5-2. Comparison weatherization program NTG evaluation results

	CT, 2016[1]	RI, 2020[2]	MA, 2021[3]	CT 2022[4]
Free-ridership	0.22 (market rate) 0.08 (low-income)	0.14	0.19	0.11 to 0.28 for envelope measures
Participant spillover	0.02 (market rate) 0.03 (low-income)	0.01	0.12	0.07
NTG	0.80 (market rate) 0.95 (low-income)	0.87	0.97[5]	0.79 to 0.96 for envelope measures

[1] NMR (2016), HES/HES-IE Process Evaluation and Real Time Research, Apr. 13, 2016
[2] Cadeo/Illume (2020). 2017-2018 Impact Evaluation of EnergyWise Single Family Program http://rieermc.ri.gov/wp-content/uploads/2020/10/ng-ri-ewsf-impact-and-process-comprehensive-report_final_04sept2020.pdf
[3] Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures:
[4] NMR (2022), R1983 NTG FINAL TOPIC MEMORANDUM. Energize Connecticut, https://energizect.com/sites/default/files/documents/R1983_HES%26IE_NTG_FinalTopicMemo_FINAL_20220912_sent_0.docx
[5]Also includes 0.04 in contractor spillover.

[131] Ibid.
[132] DNV, CONFIDENTIAL CLIENT STUDY, 2022.
[133] DNV, CONFIDENTIAL CLIENT STUDIES, 2021, 2022.
[134] Straits Research, *Weatherization Services Market,* 2022. https://straitsresearch.com/report/weatherization-services-market
[135] DNV, CONFIDENTIAL CLIENT STUDY, 2022.
[136] Acadia Center. https://acadiacenter.org/work/connecticut/.

5.2.4 Future opportunities

Research in other states has identified a range of opportunities programs have for achieving additional weatherization savings and overcoming the types of barriers to weatherization described above. Many of these opportunities are available to the NHSaves programs to pursue, although primary research or New Hampshire-specific data would enable the programs to refine and target interventions on the specific barriers New Hampshire customers face.

Funding opportunities

The recently enacted Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA) provide significant opportunities for residential weatherization. IIJA included a $3.5 billion investment in the federal WAP, similar to the American Recovery and Reinvestment Act (ARRA)-era WAP appropriation.[137] IRA supports tax credits, rebates, and related programs with the potential to further the benefits of energy efficiency to low- and moderate-income households.[138]

Community partnerships

Partnerships with community-based organizations, including but not limited to CAAs and public housing authorities, provide a meaningful opportunity to engage stakeholders while prioritizing equity and inclusivity. Feedback from utility weatherization program administrators and contractors in another Northeast state highlights the importance of community partnerships for the implementation of weatherization measures.[139] Research from Northeast Energy Efficiency Partnerships describes the need for equitable and inclusive stakeholder engagement and provides examples of implementation methods.[140] New Hampshire utilities have established working relationships with CAAs and housing authorities to implement weatherization, which may be built upon to continuing addressing persistent barriers in the low-income community.

Efficiency measures

- **Efficient windows.** The 2021-2023 Potential Study found that efficient windows present a significant opportunity for weatherization savings in New Hampshire.[141] This may include complete replacement of windows with more efficient versions as well as existing window repairs. DNV research for a confidential Northeast client in 2022 also found that window upgrades present significant opportunity for future energy savings.[142]
- **HVAC and electrification**. Overcoming weatherization barriers provides a path for efficient HVAC upgrades, including heating electrification (i.e., heat pumps). Successful weatherization projects can unlock additional savings opportunities by reducing other barriers. For instance, weatherized homes have lower heating and cooling loads, meaning that HVAC measures can be right-sized and therefore less costly—reducing financial barriers to efficient electrification or other HVAC upgrades. Also, weatherization contractors are often able to provide financing options and information on additional opportunities for more comprehensive home retrofits, reducing financial and informational barriers. While New Hampshire has focused its program goals on reducing electric consumption, electrification is a growing trend throughout the Northeast region, which will impact customer adoption and market supply in New Hampshire as well.[143]

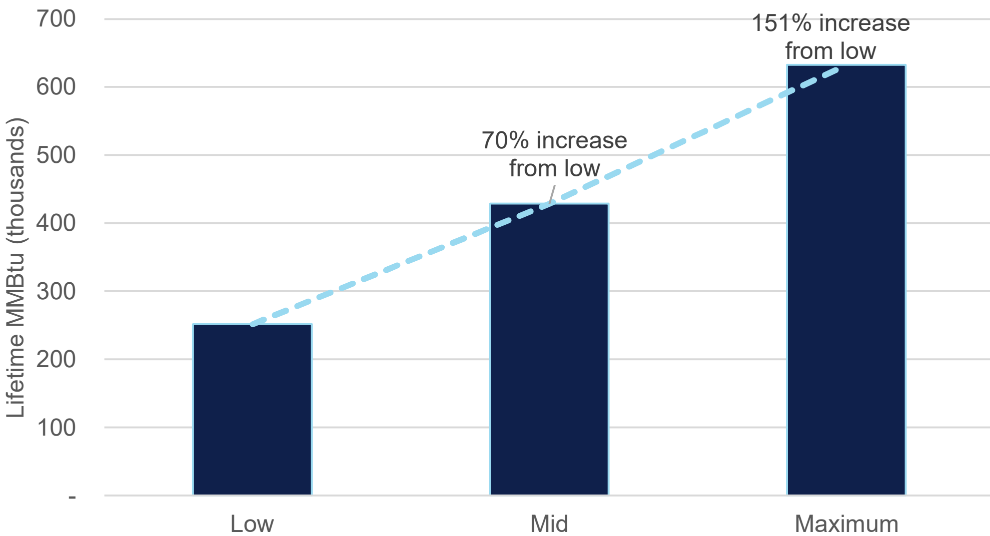
5.2.4.2 New Hampshire Potential Study achievable savings

To estimate the scale of residential weatherization savings that the HPwES and HEA programs may be able to achieve by overcoming barriers, the evaluation team analyzed savings opportunities for weatherization as originally modeled for the

[137] Carols Martin, Joint Center for Housing Studies of Harvard University, *Harnessing the IIJA's Weatherization Assistance Program to Leave No Household in the Cold*, 2023. https://www.jchs.harvard.edu/blog/harnessing-iijas-weatherization-assistance-program-leave-no-household-cold.
[138] Carols Martin et al, Joint Center for Housing Studies of Harvard University, *Targeting Weatherization: Supporting Low-Income Renters in Multifamily Properties Through the Infrastructure Investment and Jobs Act's Funding of the Weatherization Assistance Program and Beyond*, 2023. https://www.jchs.harvard.edu/research-areas/working-papers/targeting-weatherization-supporting-low-income-renters-multifamily.
[139] DNV, CONFIDENTIAL CLIENT STUDY, 2022.
[140] Emmeline Luck, Northeast Energy Efficiency Partnerships, *Recognizing Energy Inequities for Building Decarbonization* and *Near-Term Solutions for Centering Energy Equity*, https://neep.org/solutions-low-carbon-states-and-communities/equitable-home-and-building-decarbonization, 2021.
[141] Dunsky Energy Consulting, *New Hampshire Potential Study: Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023*, Volume I, https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf, 2020. Pages 59-60.
[142] DNV, CONFIDENTIAL CLIENT STUDY, 2022.
[143] Northeast Energy Efficiency Partnerships, *Strategic Electrification,* https://neep.org/equitable-home-and-building-decarbonization-leadership-network/strategic-electrification.

2021–2023 New Hampshire Potential Study.[144] As shown in Figure 5-13, residential weatherization sees significant and steady increases in achievable savings resulting from increased incentives and enabling activities to overcome barriers.[145] This points to relatively low participant cost-effectiveness and high market barriers, both of which are mitigated via the increased program incentives and enabling strategies modeled in the mid and maximum scenarios. These model results also imply that absent all program interventions; barriers would effectively prevent any modeled savings from occurring.

Figure 5-13. New Hampshire achievable savings scenarios for residential weatherization, 2023



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

5.3 Residential New Construction

5.3.1 New Hampshire program overview

The New Hampshire ENERGY STAR® Homes Program provides three offerings to support efficient design and advance the efficiency of New Hampshire's residential construction market: Drive to ENERGY STAR® Code Plus Initiative, ENERGY STAR® 3.1, and the Net Zero Challenge.[146] All three offerings require program participants to exceed current building code requirements, with progressively higher efficiency requirements moving from Drive to ENERGY STAR®, to ENERGY STAR® 3.1, to the Net Zero Challenge.

The ENERGY STAR® Homes program underwent an impact and process evaluation in 2017, reviewing program years 2014–2015.[147] The evaluation concluded that the program is conducted well from an administrative standpoint, and surveyed participants and other stakeholders valued the offering. At the time of the evaluation, the program had yearly been awarded ENERGY STAR® Partner of the Year awards, beginning in 2013, and the state's largest builders were supporters and active participants in the program. The evaluation summarized the benefits delivered, benefits received, and costs incurred by program stakeholders, depicted in Table 5-3. The program interventions summarized below, including incentives, training, home certification, and outreach and education, target the full range of barriers faced in energy efficient new home construction. As detailed below, these include financial, organizational, and supply and provision barriers.

[144] Dunsky. *New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023*, 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf

[145] It is important to note that the study did not include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

[146] NHSaves, Program Highlights, 2021. https://nhsaves.com/wp-content/uploads/2021/11/NHSaves-Program-Highlights.pdf.

[147] ERS, *New Hampshire ENERGY STAR® Homes Program Impact Evaluation (2014–2015).* 2017. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf.

Table 5-3. Benefit cost matrix[148]

Party	Benefits delivered by the party	Benefits received by the party	Costs incurred by the party
Utility	• Incentives • Trainings • Contracted Home Energy Rating System (HERS) rater	• Energy savings towards program and utility goals • Customer relationship with the utility • National recognition by EPA • Helping to move the housing market towards efficient design	• Incentive costs • Additional training costs • Program staff time
HERS rater	• Outreach and education • Home rating services • Recommendations on building systems • Final home certification	• Payment for 3 steps of process • HERS rating work • Lead generation (through outreach) • Trust of builders, HVAC contractors, and other industry partners	• HERS Rater Certification: $1,200-$2,500 • Annual HERS fee: $250-$995/year • REM/Rate per project fee • Cost of annual continuing education units (CEUs) • Time spent with builders who do not complete participation • Additional time spent with contractors for education or tracking down reports
Builder	• Home that meets ES standards • Any necessary reporting	• Program incentive up to $4,000 per home • HERS rater services for free (value of $1,300) • Certification as a distinguishing characteristic, proof to customers of home quality • Additional selling point to customers • Education on best practices	• Additional cost of more efficient materials • Extra time spent to ensure that homes meet requirements • Additional cost of certified HVAC system • Additional cost to find a certified HVAC contractor (if needed)
HVAC contractor	• HVAC system that meets Program standards • All necessary reporting	• Ability to work on certified homes with builders • Certification as a distinguishing characteristic, proof to customers of home quality • Pass-through of incentive/ability to charge more for a system	• ES certification costs: $600-$900 • AE/ACCA annual fees: $600-$800 • Extra cost of HVAC system • Extra time for sealing to ES requirement • Extra administrative time for reporting
Homeowner	• Demanding a certified home that the utilities can claim savings on • Moving the market by purchasing a certified home	• Home that meets Program standards • Energy bill savings • Peace of mind on quality, savings, comfort, durability, value	• Incremental cost of home

In 2021, over 1,300 homes in New Hampshire participated in the ENERGY STAR® Homes Program.[149] According to the NH Utilities, program homes accounted for approximately 25%–30% of all new homes in New Hampshire in recent years. Each participating builder was eligible for up to $4,000 in incentives in addition to professional consultation and certification services. The list below provides details on the financial incentives and technical assistance offerings provided to meet ENERGY STAR® v3.1 standards, as of program year 2023.

- Coverage of all technical guidance and support costs paid directly to the ENERGY STAR®-certified contractor responsible for the construction of the home
- Performance-based incentives up to $4,000 per single-family home/townhouse based on modeled Home Energy Rating System (HERS) performance
- Performance-based incentives up to $1,000 per unit in multifamily buildings based on modeled HERS performance
- Rebates for ENERGY STAR®-qualified lighting and appliances

[148] Table taken from: ERS, *New Hampshire ENERGY STAR® Homes Program Impact Evaluation (2014–2015)*. 2017. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf
[149] NHSaves, New Home Construction, https://nhsaves.com/learn/rebate/new-construction-and-retrofit/.

5.3.2 Barriers

Three common types of barriers were uncovered during the literature review of New Hampshire and peer jurisdiction residential new construction programs: financial (upfront cost and time), organizational (split incentives), and supply and provision (workforce capacity, awareness, and expertise). Each of these barriers, as well as the program interventions used to overcome them by the NHSaves program and peer programs, are addressed in this section.

5.3.2.1 Financial barriers

The upfront incremental costs associated with energy efficient residential new construction may deter its adoption. This is driven, in part, by developers being focused on limiting construction costs and foregoing capital-intensive energy efficiency offerings.[150] Additionally, financial barriers may take root due to time constraints during construction. For builders who are not already experienced with energy efficiency measures and practices, their use can require increased review time. As one study noted, “time pressures seem to be a key factor affecting investment in energy efficiency.”[151] These delays result in uncertainty around ever-changing interest rates, which can be a steep hurdle to maintaining funding commitments, as well as delays resulting in project permits expiring. Further, one study focused on residential new construction in Rhode Island, states “a lengthy approvals process and mandated phasing harm profits. Planners can use these factors as leverage to encourage developers to…build products preferred by planners.”[152] Given such cost pressures, the added time required to incorporate energy efficient measures can deter developers from building their homes to higher levels of efficiency.

According to research in the Northeast, trade allies involved in residential new construction estimate that incremental construction costs for building to program efficiency levels are generally around 6%–8% of total project costs, but may be lower for those who are more experienced with energy efficient techniques.[153] These incremental costs were attributable to “purchasing new materials, increased labor (such as for air sealing), HVAC equipment, and hiring HERS raters, who perform home energy audits and assign ratings.”[154] Programs use a range of incentives to overcome the upfront cost barrier for uptake of energy efficient measures. Studies have characterized incentive offerings as being important or key to the adoption of energy efficient measures in residential new construction projects.[155,156] These incentives allow builders to overcome upfront cost barriers and increase market adoption of new construction efficiency measures.[157]

5.3.2.2 Organizational barriers

The literature review repeatedly identified split incentives as a market barrier for residential new construction. This barrier is a result of two separate parties being responsible for purchasing the energy efficient measure(s) and utilizing the measure(s). For example, developers may be more invested in the cost of construction and have little to no interest in the efficiency of the installed measures since they will not be responsible for the resulting energy bill,[158] whereas a building owner may be more concerned about costs of operation following construction.[159] The literature review did not identify interventions from peer programs specifically targeting the split incentive barrier, although financial interventions and informational interventions can indirectly mitigate or circumvent split incentive barriers. For instance, incentives help lower

[150] Golove, William, and Eto, Joseph. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* LBNL. 1996. https://www.osti.gov/servlets/purl/270751.

[151] Ibid.

[152] Mohamed, Rayman.. *Are profits from subdivision development higher in areas with more regulations? A case study of South Kingstown, Rhode Island and some implications for land use planning,* Housing Policy Debate, Taylor & Francis Journals, vol. 20(3), pages 429-456, 2010. https://ideas.repec.org/a/taf/houspd/v20y2010i3p429-456.html

[153] NMR Group, Inc.. R1602 Residential New Construction Program – Process Evaluation. 2017. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf

[154] Ibid. .

[155] NMR Group, Inc.. *R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction.* 2018. https://energizect.com/sites/default/files/documents/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf.

[156] NMR Group, Inc.. R1602 Residential New Construction Program – Process Evaluation. 2017. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf

[157] NMR Group, Inc.. *R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction.* 2018. https://energizect.com/sites/default/files/R1702-R1710_CodesStandards_Final%20Report_6.29.18_0.pdf.

[158] Eto, Joseph, Prahl, Ralph, and Schlegel, Jeff. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*. LBNL. 1996. https://eta-publications.lbl.gov/sites/default/files/lbnl-39058.pdf.

[159] Golove, William, and Eto, Joseph. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,* LBNL. 1996. https://www.osti.gov/servlets/purl/270751.

the cost of energy efficient construction for developers, and promotional materials or home energy labeling can provide information that buyers incorporate into the price they are willing to pay for a new home. Together, these interventions can help align the different incentives of developers and buyers in favor of energy efficiency. A previous study further elaborated on the various policy responses to the split incentive barrier and detailed the benefits and concerns, which can be seen in Table 5-4. NHSaves does not have authority over interventions such as building codes or taxpayer-funded grant programs, but can play a convening role or design programs to coordinate or leverage external interventions.[160]

Table 5-4. Policy responses to the split incentive barrier[161]

	Description	Benefits	Concerns
Contracts			
Green or energy efficiency lease	Landlord and tenant agreement to conserve energy, where landlord retrofit investments are trickled down to tenant.	• Higher rents offset by lower utility costs. • Mutual commitment to conservation.	• Requires cooperation from landlord and tenant. • Continual capital improvements and maintenance necessary. • Currently geared toward commercial leases.
Energy efficiency mortgages (PACE financing)	Externally funded loan attached to the property.	Capital improvements can be done at one time and paid in installments.	• Benefits remain with the property and lien complicates property resale. • Liability for property owner.
On-bill financing	Capital improvements are tied directly to utility company payments.	Capital improvements can be done at one time and paid in installments with no lien issues.	Usually focused on live-in homeowners, not tenants.
Regulation			
Green building codes	Application of higher energy standards for new construction.	Potential to benefit all new housing developments, including buildings for low-income tenants.	• Only applies to new construction. • Higher rent prospects along with higher construction and maintenance cost can create bias against low-income tenants.
Low-income rental mandates	Mandate of higher energy standards for low income housing.	Potential for high scale implementation in low-income rental housing.	Creates serious disincentive to provide low-income housing.
All-in Services			
Weatherization assistance program	• National weatherization program, usually implemented as grants. • Differs from state to state.	• Has highest reach; especially under the U.S. Stimulus Program. • Variety of policy programs and state differentiation/experimentation.	• Cannot be implemented at scale because of cost; inefficient. • No follow-up for maintenance. • Hardly used for low-income rental housing.
Concierge Services	Small niche programs designed to provide comprehensive efficiency assistance with education.	Highest success rate for efficiency gains and behavioral improvements; addresses poverty concerns effectively.	• Cannot be implemented at scale because of cost. • Highest expense.

Source: Bird and Hernandez.

5.3.2.3 Supply and provision barriers

Lack of workforce and/or workforce awareness and expertise can be a barrier for multiple market actors, including but not limited to builders, developers, contractors, and designers.[162] This barrier is driven by not having enough workers to meet market demand overall, and among available workers, not having sufficient training or education regarding energy efficient technologies and building practices. This barrier is exacerbated by challenges retaining workers who have gained knowledge and expertise, who may be drawn to work out of state or to follow different career paths.

In addition, while workforce supply is constrained, market demand for efficient homes has grown. One study from a peer jurisdiction found that new home buyer interviews indicated growing awareness of and interest in energy efficient

[160] Bird, Stephen and Hernández, Diana. "Policy options for the split incentive: Increasing energy efficiency for low-income renters." *Energy Policy*, Volume 48, 2012, Pages 506-514, ISSN 0301-4215. https://doi.org/10.1016/j.enpol.2012.05.053.

[161] Table taken from: Bird, Stephen and Hernández, Diana. "Policy options for the split incentive: Increasing energy efficiency for low-income renters." Energy Policy, Volume 48, 2012, Pages 506-514, ISSN 0301-4215. https://doi.org/10.1016/j.enpol.2012.05.053.

[162] A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs.

measures[163] and a second study found that home buyers placed high importance on energy efficiency.[164] Given recent program and customer focus on all-electric new home construction in New Hampshire and across the region, there will be increased demand for workers who are skilled in this area, and the gap between supply of and demand for trained workforce may increase. More targeted market and customer research may aid in developing interventions to identify and overcome specific workforce barriers.

The New Hampshire ENERGY STAR® Homes Program evaluation specifically addressed workforce barriers. In both New Hampshire[165] and a peer jurisdiction,[166] studies have found rapid turnover for subcontractors (HVAC, plumbing, etc.) who had been involved in new construction programs. In New Hampshire specifically, the evaluation found that HVAC contractors perceived a high burden for meeting the design and administrative requirements necessary to receive ENERGY STAR® certification. Since the time of the evaluation, the program has added a participation pathway which offers a reduced rebate for projects involving HVAC contractors who build to the same program efficiency standards but who are not ENERGY STAR®-certified, helping to circumvent this barrier.

The literature review found a common approach for overcoming workforce awareness and expertise barriers among peer jurisdictions is providing training on energy efficient designs. Developers are inclined to prefer familiar, replicable designs,[167] so providing training to increase knowledge and transforming unfamiliar concepts into familiar concepts may help encourage the adoption of energy efficient designs. One study found that program trainings on code compliance and trainings about building practices were key activities driving savings in non-program homes, providing a key mechanism to impact the overall market.[168] Another study found that a lack of information regarding energy efficient designs contributed to suboptimal home designs,[169] and could be remedied with additional education and training. In a peer jurisdiction, trainings offered by program staff or third-party trade organizations left HERS raters very satisfied with program offerings, while builders cited a desire to receive technical guidance in more practical terms.[170] In the same study, HERS raters stated a need for more extensive air sealing technique trainings for builders, which expanded upon the finding that builders are aware of the necessity of receiving more practical guidance.[171] To overcome workforce awareness barriers, program training offerings should consider the specific needs of the relevant workforce.

5.3.3 Market trends

The review of literature on New Hampshire and peer jurisdiction residential new construction programs provided insights on the market trends detailed below.

5.3.3.1 Market share

The New Hampshire ENERGY STAR® Homes Program evaluation found that the program reached 5% of homes built in 2014–2015.[172] NH Utilities staff estimated that the program has increased its coverage of the market in recent years to around 25% to 30% of new homes in New Hampshire. Increased program participation also increases overall levels of code

[163] Eto, Joseph, Prahl, Ralph, and Schlegel, Jeff. 1996. "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs." LBNL. Accessed January 15, 2023. https://eta-publications.lbl.gov/sites/default/files/lbnl-39058.pdf.
[164] NMR Group, Inc. 2017. "R1602 Residential New Construction Program – Process Evaluation." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf.
[165] ERS. 2017. "New Hampshire ENERGY STAR® Homes Program Impact Evaluation (2014–2015)." Accessed January 15, 2023. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf.
[166] Eto, Joseph, Prahl, Ralph, and Schlegel, Jeff. 1996. "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs." LBNL. Accessed January 15, 2023. https://eta-publications.lbl.gov/sites/default/files/lbnl-39058.pdf.
[167] Golove, William, and Eto, Joseph. 1996. "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency." LBNL. Accessed January 15, 2023. https://www.osti.gov/servlets/purl/270751.
[168] NMR Group, Inc. 2018. "R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf.
[169] Golove, William, and Eto, Joseph. 1996. "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency." LBNL. Accessed January 15, 2023. https://www.osti.gov/servlets/purl/270751.
[170] NMR Group, Inc. 2017. "R1602 Residential New Construction Program – Process Evaluation." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf
[171] NMR Group, Inc. 2017. "R1602 Residential New Construction Program – Process Evaluation." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf.
[172] ERS. 2017. "New Hampshire ENERGY STAR® Homes Program Impact Evaluation (2014–2015)." Accessed January 15, 2023. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf.

compliance, which paves the way for new practices and technologies to be later mandated by code updates.[173] Code revisions are made through an extensive process involving stakeholder input and analysis of current building practices and tradeoffs of increased requirements, including cost to builders and buyers of more efficient construction. As efficient construction practices advance and penetrate the market, first among participating and then among non-participating builders and contractors, the tradeoffs around code updates lean more toward increased efficiency requirements.

Increased program participation can also provide workforce benefits that enable further growth in the market share of efficient homes. For instance, in a separate residential new construction process evaluation, evaluators found that the program helped grow the HERS rater business in the state.[174] HERS raters are critical to ensuring homes are built efficiently, and so this dynamic can create a positive feedback loop between programs and the workforce needed to implement them.

5.3.3.2 Net-to-gross

Net-to-gross (NTG) ratios have not been directly evaluated for residential new construction in New Hampshire. However, the ENERGY STAR® Homes evaluation noted signs of spillover found in the process evaluation, based on comments made by builders and HVAC contractors stating that their program experience raised performance levels in all homes they are involved with.[175] For instance, several participating builders and HVAC contractors stated that they build their homes to ENERGY STAR® standards, regardless of whether the home is built through the program.

A 2018 Connecticut study of NTG for residential new construction found an overall NTG ratio of 1.56, with high free-ridership (0.69) and higher non-participant spillover (1.25).[176,177] In other words, for every MMBtu of energy saved by program participants, the program resulted in another 1.25 MMBtu of savings among non-participating homes. The high level of spillover was attributed to training and program requirements for key measures such as air infiltration, duct leakage, and insulation installation quality, which impacted construction practices across the market.[178] Similarly, an earlier study of the Massachusetts Residential New Construction Program found significant non-participant spillover (1.39), driven by the same dynamics.[179]

More recent studies have found decreasing NTG estimates, as shown in Table 5-5, which are indicative of reduced program impacts due to broader efficiency advancements in new construction markets. Such results suggest that barriers to efficiency in other states—as defined by program efficiency requirements in those states—are being overcome, increasingly without program intervention. These results may not be indicative of the ENERGY STAR® Homes program and of New Hampshire's new construction market. However, New Hampshire may consider assessing NTG for the program, considering the trend found in peer jurisdictions and the signs of spillover and increasing non-program efficiency levels previously found in New Hampshire.

[173] Eto, Joseph, Prahl, Ralph, and Schlegel, Jeff. 1996. "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs." LBNL. Accessed January 15, 2023. https://eta-publications.lbl.gov/sites/default/files/lbnl-39058.pdf.
[174] NMR Group, Inc. 2017. "R1602 Residential New Construction Program – Process Evaluation." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf.
[175] ERS. 2017. "New Hampshire ENERGY STAR® Homes Program Impact Evaluation (2014–2015)." Accessed January 15, 2023. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf.
[176] NMR Group, Inc. 2018. "R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf.
[177] The study noted that gross savings may decrease as non-program baselines improve, and lighting savings diminish. However, without the program, the study authors surmise that non-program homes would have been somewhat less efficient than actuality, and program homes would have been much less efficient than actuality.
[178] NMR Group, Inc. 2017. "R1602 Residential New Construction Program – Process Evaluation." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf.
[179] NMR Group, Inc., 2014. "Massachusetts Residential New Construction Net Impacts Report." Accessed Mar. 9 2023. https://ma-eeac.org/wp-content/uploads/Residential-New-Construction-Net-Impacts-Report-1-27-14.pdf

Table 5-5. Comparison Residential New Construction program NTG evaluation results

	MA, 2011[1]	CT, 2015[2]	MA, 2015[3]	MA, 2017-2019[4]	MA, 2022[4]	MA, 2023[4]	MA, 2024[4]
Free-ridership	0.53	0.69	0.67	0.80	-	-	-
Non-participant spillover	1.39	1.25	0.55	0.75	-	-	-
NTG	1.87	1.56	0.88	0.95	0.49	0.43	0.38

Note: Year reflects the year of construction for program homes covered in the study.
[1] NMR Group, Inc., 2014. "Massachusetts Residential New Construction Net Impacts Report." Accessed Mar. 9 2023. https://ma-eeac.org/wp-content/uploads/Residential-New-Construction-Net-Impacts-Report-1-27-14.pdf
[2] NMR Group, Inc. 2018. "R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf
[3] NMR Group, Inc. 2018. "Residential New Construction and CCSI Attribution Assessment (TXC48)." Accessed Mar. 9 2023. https://ma-eeac.org/wp-content/uploads/TXC_48_RNCAttribution_24AUG2018_Final.pdf
[4] NMR Group, Inc. 2021. "Low-Rise Residential New Construction NTG Study (MA20X05- B-RNCNTG)." Accessed March 8, 2023. https://ma-eeac.org/wp-content/uploads/MA20X05-B-RNCNTG_Low-rise-RNC-NTG_FinalDraft-07272021.pdf.

5.3.4 Future opportunities

The ENERGY STAR® Homes Program has achieved high levels of participation and has been nationally recognized year over year for its success. However, there is additional room for growth and further market transformation. Although program participants must exceed current building code requirements, code levels and efficient building practices are continually advancing. As such, there will continue to be opportunities for the program to push the market forward, ahead of code and toward the most efficient practices. As found in the 2017 evaluation:

> *"While the Program has done a commendable job promoting, facilitating, and validating the construction of ENERGY STAR v3.0 homes, the larger issue facing the Program is the apparent widespread adoption of efficient construction practices across the market. …[The evaluation results] present convincing evidence that the playing field shifted beneath the Program and nonparticipant homes have improved beyond the baseline assumptions embedded in the Program savings estimates."*

Since the time of the study, the NH Utilities have responded by increasing program efficiency levels (to ENERGY STAR® v3.1), but this dynamic of advancing efficiency levels will likely continue for new home construction, as it has across sectors and technologies, as described in Section 4.4.2. As similarly found in a recent peer program evaluation, "as non-program homes continue to gain in efficiency, the study recommends the program push for higher levels of performance to stay ahead of non-program homes that continue to rapidly increase in efficiency."[180] In addition, as discussed above, the literature review uncovered multiple persistent residential new construction market barriers that programs can still address to achieve further savings, including upfront cost, split incentives, and workforce barriers.

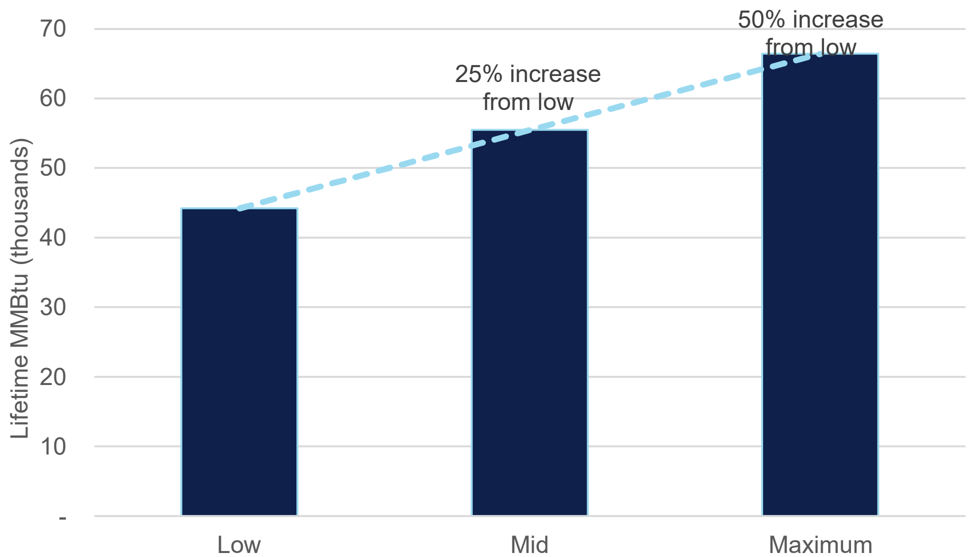
Continued support of the ENERGY STAR® Homes Program will provide a path for incentives and trainings to inject direct support into the residential new construction market, principally for program participants, but likely inducing spillover effects for non-participant homes following trends identified in secondary research. To ensure continued progress in advancing efficiency levels, it is important that the program maintain high standards for efficiency levels of participating homes to ensure they stay ahead of the broader market. Beyond incentives and trainings, interventions such as home energy labeling[181] can help the program overcome barriers related to customer awareness. Along these same lines, the ENERGY STAR® Homes *Drive to Net Zero* pathway—a design and build competition for single and multi-family homes—provides an avenue for promoting and highlighting high efficiency, net zero homes, which can address informational and other barriers.

[180] NMR Group, Inc. 2018. "R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction." Accessed January 15, 2023. https://energizect.com/sites/default/files/documents/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf
[181] https://empress.naseo.org/energy-labeling#:~:text=Residential%20home%20energy%20labeling%20refers%20to%20programs%20or,labels%20for%20appliances%2C%20and%20nutrition%20facts%20for%20food.

5.3.4.1 New Hampshire Potential Study achievable savings

To estimate the scale of residential new construction savings that the ENERGY STAR® Homes program may be able to achieve by overcoming barriers, the evaluation team analyzed savings opportunities for residential new construction as originally modeled for the 2021–2023 New Hampshire Potential Study.[182] As shown in Figure 5-14, residential new construction sees moderate, steady increases in achievable savings resulting from increased incentives and enabling activities to overcome barriers.[183] Further, these model results imply that absent all program interventions, barriers would effectively prevent any modelled savings from occurring.

Figure 5-14. New Hampshire achievable savings scenarios for residential new construction, 2023



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

5.4 C&I lighting controls

Lighting controls in C&I facilities are intended to save energy by reducing the total hours of use of a lamp by reducing how often the lamp is "on" through switches and sensors, and/or reducing the lumen output based on the lighting requirements in a space and available lighting from other sources. The types of lighting controls available in the market range from manual switches, occupancy sensors, and timers to advanced lighting controls (ALC), including networked lighting controls (NLC) and luminaire level lighting controls (LLLC). This case study uses the definitions shown below in Table 5-6, derived from recent studies in Massachusetts.[184] More details on controls technologies can be found in those studies.

Table 5-6. Lighting control categories and associated controls

Control type	Basic controls	Standalone Sensor Controls	Room-Based Controls	Luminaire Level Lighting Controls (LLLC)	Network Lighting Controls (NLC)
Features	Manual switch, manual dimmer, time clock	Occupancy sensor, daylight sensor	Code-compliant "kits" with occupancy and daylight sensors; may have	Wireless networked fixture-level integrated occupancy and daylight sensors;	Wired or wireless networked occupancy and daylight sensors;

[182] Dunsky. New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023, Oct. 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf

[183] It is important to note that the study did not include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

[184] DNV. Massachusetts C&I Lighting Controls Market Study, 2021.

			high-end trim; networking within zone only; fixtures operate as a group	high-end trim; fixtures can be controlled independently or as a zone	high-end trim; fixtures can be controlled independently or as a zone

Source: MA 2020 C&I Lighting Controls Market Study, page 26. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf;

In addition, there is not a large body of recent lighting controls research, and none in New Hampshire. As such, the team relied primarily on several studies from Northeast states with larger energy efficiency program budgets, and different markets than New Hampshire. The section below cites several Massachusetts studies, but it should be noted that the Massachusetts C&I lighting market has been found to be about 2 years ahead of New Hampshire in terms of LED adoption, a trend which is likely relevant for C&I lighting controls as well.[185]

5.4.1 New Hampshire program overview

C&I lighting controls comprised a small share of NHSaves program savings in 2021, accounting for just 3% of annual C&I MWh savings and 2% of lifetime C&I MWh savings. C&I lighting controls have a great deal of remaining energy savings potential, ranking in the top five non-residential measures in the 2021-2023 New Hampshire Potential Study, but programs must overcome several hurdles to for this potential to be realized.

A suite of lighting control options is offered to C&I customers through the NHSaves programs. This includes networked lighting controls, dimming sensors, and occupancy sensors, offered through Small Business Energy Solutions (SBES) and Large Business Energy Solutions (LBES) programs as part of the commercial new construction or major renovation pathways. LED lighting with controls, such as LED troffers with controls, troffer retrofit kits with controls, and high and low bay lighting with controls are also offered through the C&I Midstream Lighting Initiative, which discounts the price of equipment by providing the distributor an incentive for sales of program-eligible measures. Of these, networked lighting controls are a relatively novel technology, while occupancy sensors and dimmers have been in the market for many years.

5.4.2 Barriers

The sections below discuss how adoption of controls is impeded by different types of barriers, but it is important to note that these barriers vary by lighting control type, customer type, and individual customer needs and motivations. Individual customer operating characteristics, such as how facilities are designed, what different spaces are used for, and what their operating hours are, will impact the cost-effectiveness and appropriateness of different control types. Similarly, customer adoption varies by their level of willingness to invest in controls with longer payback periods compared to standard lighting upgrades, and their willingness to engage with control systems.

5.4.2.1 Financial barriers

The upfront incremental cost of lighting controls pose a barrier to their adoption, but this barrier has been found to be less prominent than other types of barriers discussed below. Research into decreases in lighting control savings in Massachusetts in 2014 found that the market was likely saturated with basic occupancy sensors, and that upfront incremental cost was a primary barrier to the installation of more advanced controls[186]. Research conducted in Massachusetts in 2021 again found that upfront incremental cost of advanced controls was a barrier for some customers—though not as significant as other barriers (e.g., informational and technical).

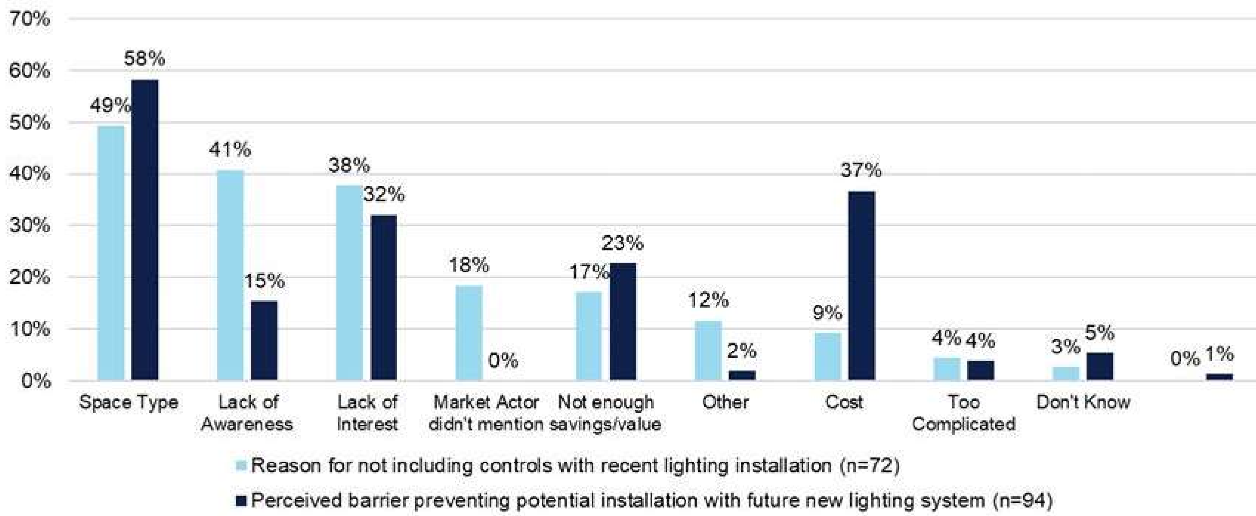
However, as seen in Figure 5-15, only 9% of customers that had recently completed a lighting upgrade that did not include controls indicated that the upfront cost associated with advanced control systems influenced their decision not to include

[185] ERS & Dunsky. New Hampshire Potential Study, 2021-2023 Volume IV: Non-Residential Market Baseline Study, 2020 https://www.puc.nh.gov/Electric/Monitoring and Evaluation Reports/20201016-NHSaves-Potential Study-Final Report-Volume IV.pdf

[186] DNV, Massachusetts Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT, 2014. https://ma-eeac.org/wp-content/uploads/Lighting-Retrofit-Control-Measures-Final-Report.pdf

lighting controls in their recent project. On the other hand, 37% of customers who had not recently installed a new LED lighting system indicated that upfront cost may impact their decision to include lighting controls in a future lighting project. This suggests that customers' perception of the potential upfront cost is a more prominent barrier than the actual cost of controls.

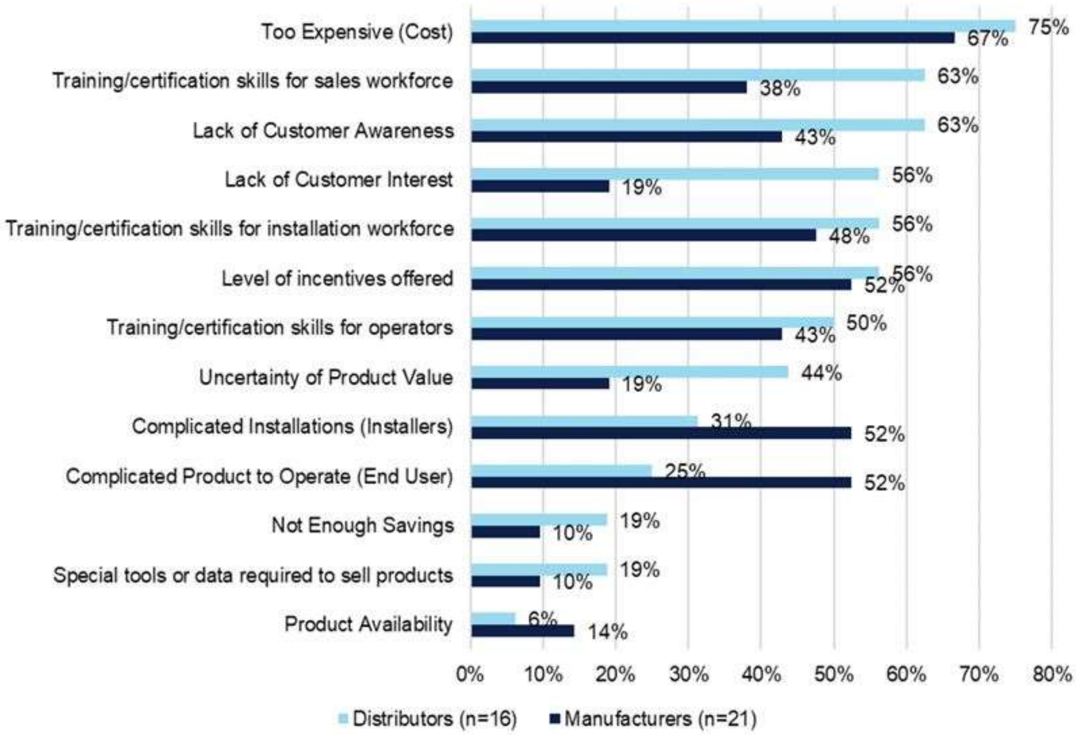
Figure 5-15. Customer reasons for not including advanced controls



Source: DNV, 2020 Massachusetts C&I Lighting Controls Market Study, page 17. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

Other market actors view upfront cost as a significant barrier to increased adoption of advanced lighting controls. In Massachusetts, as seen in Figure 5-16, cost was the most cited barrier by both lighting distributors and manufacturers and roughly half of each group also indicated the current incentive level as another barrier. Customers' uncertainty of the value provided by advanced controls was also cited by almost half of the interviewed distributors as well.

Figure 5-16. Distributor and manufacturer identified barriers to further sales and adoption of advanced lighting controls



Source: DNV. 2020 Massachusetts C&I Lighting Controls Market Study, page 26. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

Similar research on the market for LLLC in the Pacific Northwest also found the real and perceived cost of these controls was a barrier. One manufacturer noted the following about including controls alongside LED replacements: "*the biggest [challenge] is staying ahead of the cost curve…The cost adder for the control—let's say the fixture was X dollars plus 25% to get the control in there. As the cost of lighting has dropped over the years, the cost of controls has not kept pace at the same rate, so controls cost has become a larger cost adder.*"[187] Market actors interviewed for the study also noted they have observed customers declining to include lighting controls in retrofit lighting projects as the energy savings and associated financial benefits resulting from new LEDs meets their needs without adding controls.

Beyond upfront project costs, controls technologies can also face financial barriers due to hidden costs not captured in the price of efficiency investments—specifically, technical appropriateness and performance risks. For instance, when customers perceive that advanced controls are not appropriate for their specific needs in a space (they may need lighting at all times due to safety concerns or security, the space may be low occupancy, or they need to trust the lights will be available when needed), it becomes more difficult to convince these customers that the additional benefits provided by controls outweighs the cost. Control owners in the Pacific Northwest indicated they have had "to remove some automatic control functionality due to safety concerns in a dentist office, delays in lights turning on after a control input, and issues with system components failing shortly after installation."[188]. Challenges like these are hidden costs associated with controls that do not meet the needs of the space. On-going operations and maintenance costs, including tune-ups and reprogramming, and software support are on-going costs customers may incur over the lifetime of the controls system. An ESCO in the Pacific Northwest noted there is a perceived risk that software support of functionality may erode over time and add

[187] NMR and Energy Futures Group. 2019-2020 Luminaire Level Lighting Controls Market Assessment, November 2020. https://neea.org/img/documents/2019-2020-Luminaire-Level-Lighting-Controls-Market-Assessment.pdf
[188] https://neea.org/img/documents/Luminaire-Level-Lighting-Controls-Market-Progress-Evaluation-Report-1.pdf

additional, potentially unforeseen expenses. [189]. A control owner in this area also "reported significant challenges with system commissioning, with no real resolution after several years and multiple calls to the manufacturer"[190].

Finally, controls projects can face financial barriers due to transaction costs associated with project installations. The optimal time to install lighting controls is often in coordination with an LED retrofit as it is the more convenient and cost-effective to fully update the lighting system in a single project rather than through two separate projects. As C&I lighting programs have successfully influenced customers to replace their previous lighting systems with LEDs, it may be many years before current lighting systems need to be updated or replaced. As a result, to install advanced lighting control systems, many customers would have to retrofit their existing lighting systems, increasing not only the total cost of lighting savings (through having to pay for two separate installation projects) but also increasing the transaction costs by potentially interrupting the customers' operations as their lighting system is being modified. In Massachusetts, when customers who recently completed a lighting project without controls were asked if they would consider retrofitting their current LED system to include advanced lighting controls, only 24% were interested.

5.4.2.2 Informational barriers

Manufacturers and distributors report having high levels of awareness of advanced controls but report low levels of awareness among their customers. All manufacturers and distributors interviewed for the Massachusetts lighting control study noted they had familiarity with standalone controls, room-based controls, and LLLCs and all but one manufacturer and two distributors were familiar with NLCs. However, almost two thirds of distributors (63%) and 43% of manufacturers indicated that customer awareness of advanced lighting controls was a barrier to adoption.[191] Manufacturer representatives interviewed in the Pacific Northwest also cited market actors' and customers' lack of familiarity with LLLC and the inadequate communication of the benefits of these systems by market actors as major barriers.[192]

As shown in Figure 5-15 above, 41% of customers who had recently completed a lighting project without controls in Massachusetts indicated they were not aware of advanced controls at the time of their project, though among customers considering a future lighting project, only 15% were unaware of advanced lighting controls. This suggests that more information had become available in the market since prior participants had completed their lighting projects. Overall across both groups, roughly two thirds of customers were aware of advanced lighting controls in 2020, up from 23% in 2018[193]. In addition, only 18% of customers indicated that the market actors they worked with did not mention advanced controls.

The lack of awareness of advanced lighting controls is compounded by their complexity and challenges in communicating these complexities to customers. With the introduction of more advanced controls, such as LLLCs and NLCs, the opportunities for savings increase but the complexity does as well. A manufacturer recently interviewed for research in the Pacific Northwest noted that "some customers and installers are drawn to non-LLLC controls just because it is easier to understand."[194] In Massachusetts, 27% of customers expressed a desire for better guidance and support on determining types of controls appropriate for their space.[195]

Customer skepticism of the usability and function of advanced lighting controls also serves as another barrier to adoption, which is also driven in part by their increasing complexity as well as disappointing experiences with prior controls projects. Similar to residential customers' skepticism of LEDs after negative experiences with CFLs, some C&I customers hesitate to adopt advanced controls because of prior experience with poorly functioning occupancy sensors. Lighting vendors

[189] NMR and Energy Futures Group. 2019-2020 Luminaire Level Lighting Controls Market Assessment, November 2020. https://neea.org/img/documents/2019-2020-Luminaire-Level-Lighting-Controls-Market-Assessment.pdf
[190] NEEA, Luminaire Level Lighting Controls Market Progress Evaluation Report, 2021. https://neea.org/img/documents/Luminaire-Level-Lighting-Controls-Market-Progress-Evaluation-Report-1.pdf.
[191] DNV. 2020 Massachusetts C&I Lighting Controls Market Study. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf.
[192] NMR and Energy Futures Group. 2019-2020 Luminaire Level Lighting Controls Market Assessment, November 2020. https://neea.org/img/documents/Luminaire-Level-Lighting-Controls-Market-Progress-Evaluation-Report-1.pdf.
[193] DNV. 2020 Massachusetts C&I Lighting Controls Market Study. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf
[194] Ibid.
[195] Ibid.

interviewed in 2014 also found customers to be skeptical of new lighting control technologies due to "a bad reputation hangover from the first generation of sensors."[196] Other market actors interviewed in the Pacific Northwest noted that customers value simplicity and remain skeptical of automated controls after negative experiences with occupancy sensors, finding them difficult to operate as they can turn off at inappropriate times or otherwise not work as expected [197]. Recent research in Connecticut found many customers reported that information on advanced technologies provided by contractors, distributors, and retailers was often misleading. The study identified a need for programs to ensure appropriate commissioning and networking for NLCs to improve product performance and help address skepticism barriers.[198]

Finally, as noted above and shown in Figure 5-15, customers' perception of the potential upfront cost of lighting controls is a more prominent barrier than the actual cost of controls for those who have completed projects. This result may reflect an underlying lack of awareness of the true costs of lighting controls and suggests an opportunity for improved communication and education to customers about project costs.

5.4.2.3 Organizational barriers

As discussed in the industrial process case study in section 5.5.2.2 below, C&I customers commonly operate on strict planning and budgeting cycles with prescribed processes for developing business cases and evaluating and approving equipment upgrades. These customers do not always consider or prioritize energy costs as part of this process, so cost-effective energy savings projects may not be identified or planned for as part of the standard planning and budgeting cycle.

Internal organizational walls between facility managers, financial units, and IT departments can further complicate and impede adoption of advanced lighting controls. Advanced control owners in the Pacific Northwest emphasized the importance of engaging with their IT departments, or assigning ownership of the control system to the IT department, before control installation to ensure they are integrated correctly and able to operate effectively.[199] Engaging IT early in the selection and installation process can also help mitigate customer concerns around cyber security. If this engagement does not happen, it can lead to poor performance and limit future adoption. For instance, In Massachusetts, 60% of customers who installed advanced lighting controls needed to adjust, tune, or reprogram them to maintain performance or proper operation,[200] and 52% of manufacturers and 25% of distributors feel that advanced lighting controls are complicated to operate, and this can perpetuate difficulty of adoption.

Corporate financial requirements and processes are also common features of large C&I customers that create barriers to adoption of controls. These features are discussed in more detail in the industrial process case study in Sections 5.5.2.1 and 5.5.2.2 below. Market actors interviewed in the Pacific Northwest noted that adding LLLC to projects extends projects' payback period beyond what is often acceptable to commercial customers, making it almost impossible to include these controls in projects they offer. They also noted that customers pursuing lighting system retrofits are sensitive to budget increases due to internal requirements, further complicating the promotion of advanced controls in these projects.[201]

Finally, management resistance to controls projects has been found to be an organizational barrier to their adoption. When key individuals in an organization do not support projects, they will typically fail to obtain the necessary internal capital and approvals. Even if approved and installed, if key managers are dissatisfied with project performance, they may remove the measures and/or resist future opportunities to pursue efficiency measures. For example, interviewees in a recent

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[196] DNV, *2020 Massachusetts C&I Lighting Controls Market Study,* 2020. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf
[197] NEEA, *2019-2020 Luminaire Level Lighting Controls Market Assessment,* 2020. https://neea.org/img/documents/2019-2020-Luminaire-Level-Lighting-Controls-Market-Assessment.pdf.
[198] DNV, *Recommendations for ALC Measure Parameters*, 2022. https://energizect.com/sites/default/files/2022-07/CT%20X1931-4%20ALC%20PSD%20Phase%202%20Memo%20Final060822.pdf
[199] NEEA, Luminaire Level Lighting Controls Market Progress Evaluation Report, 2021. https://neea.org/img/documents/Luminaire-Level-Lighting-Controls-Market-Progress-Evaluation-Report-1.pdf.
[200] 2020 C&I Lighting Controls Market Study. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf
[201] NEEA, *2019-2020 Luminaire Level Lighting Controls Market Assessment,* 2020. https://neea.org/img/documents/2019-2020-Luminaire-Level-Lighting-Controls-Market-Assessment.pdf.

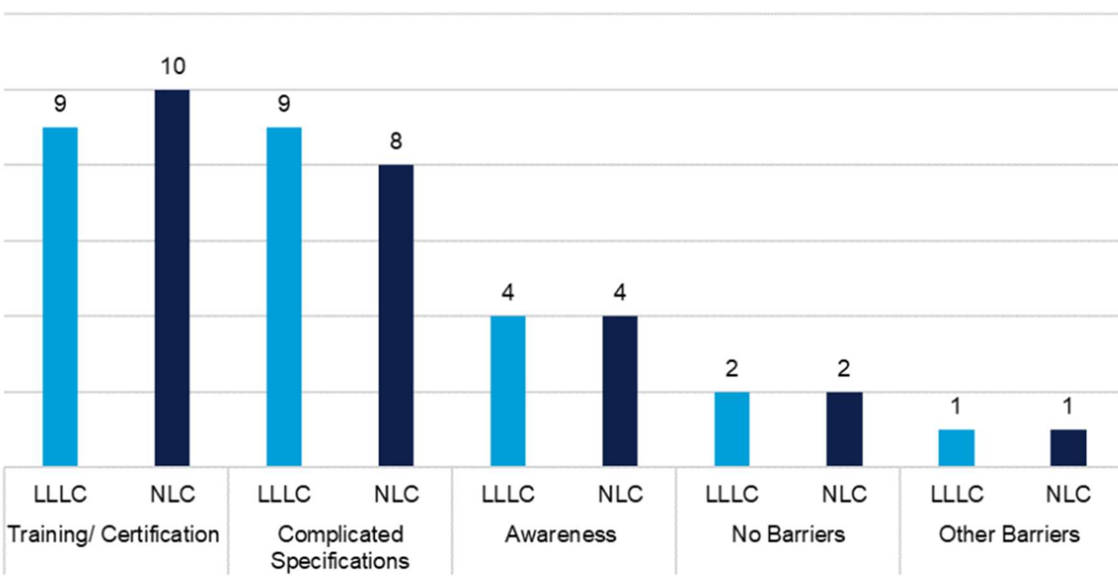
Connecticut study noted that proper setup and commissioning was often an issue for customers, and one respondent provided an example of a business CEO using the bathroom and having the sensors turn the lights off on him. After this event, the CEO had the controls mechanisms removed or disabled.[202]

5.4.2.4 Supply and provision barriers

Adoption of C&I lighting controls is impeded to some extent by the same type of workforce constraints facing the energy efficiency sector and the economy more broadly, as discussed throughout this report. New Hampshire faces this barrier to an equal or greater extent as other states in the region. For instance, DNV interviewed individuals from organizations with expertise and knowledge of the NHSaves programs as part of a parallel study to this market barriers review, covering topics including local workforce needs and opportunities.[203] These organizations included two vendors and three large, multi-project participants in the NHSaves programs. According to the interviewees, complex C&I projects such as controls projects, are one of two program areas (along with weatherization) that face the most significant workforce shortages in New Hampshire. They said that they frequently need to rely on out-of-state firms for projects requiring specialized expertise in complex custom projects and controls measures.

As shown above in Figure 5-16, distributors and manufacturers in Massachusetts cited (1) lack of training and certification skills among the installation workforce and (2) complicated installation requirements as barriers to installation of advanced controls. However, among distributors, 56% cited lack of training and certification, while only 31% cited complicated installations as a barrier. This suggests that training and certification opportunities are a more prohibitive factor than the complexity of the installations themselves. Figure 5-17 below provides additional detail on the contractor-reported training and workforce barriers to adoption of advanced lighting controls in Massachusetts.

Figure 5-17. Contractor (n=12) training and workforce development barriers to LLLC and NLC adoption



Source: 2020 C&I Lighting Controls Market Study, page 19. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

Various types of lighting control technologies also flow through different supply chains. Each link in each supply chain can represent a possible risk in getting a product from the supplier into the customer's facility.[204] As shown in Figure 5-18, the

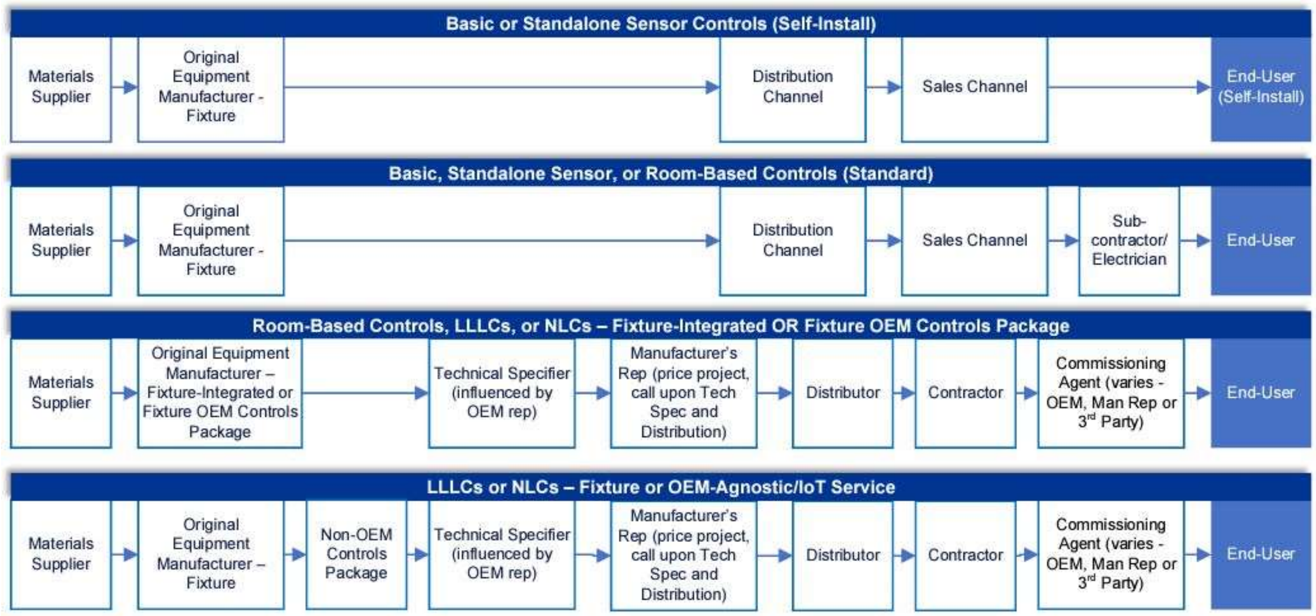
[202] Energize CT, *Recommendations for ALC Measure Parameters,* 2022. https://energizect.com/sites/default/files/2022-07/CT%20X1931-4%20ALC%20PSD%20Phase%202%20Memo%20Final060822.pdf.

[203] See DNV. Report on Economic Impacts of the NHSaves Programs, Mar. 2023 (to be filed).

[204] MA EEAC, *2020 C&I Lighting Controls Market Study.* https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

more advanced the control, the greater the quantity of links in the supply chain and the more opportunities for success or failure due to supply issues. Given the complexity of the supply chain for advanced controls, planning and coordinating the timing of project installations is important, particularly if the controls are to be installed as part of larger lighting retrofit projects.

Figure 5-18. Simplified supply chain mapping for control categories[205]



Source: 2020 C&I Lighting Controls Market Study, page 19. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

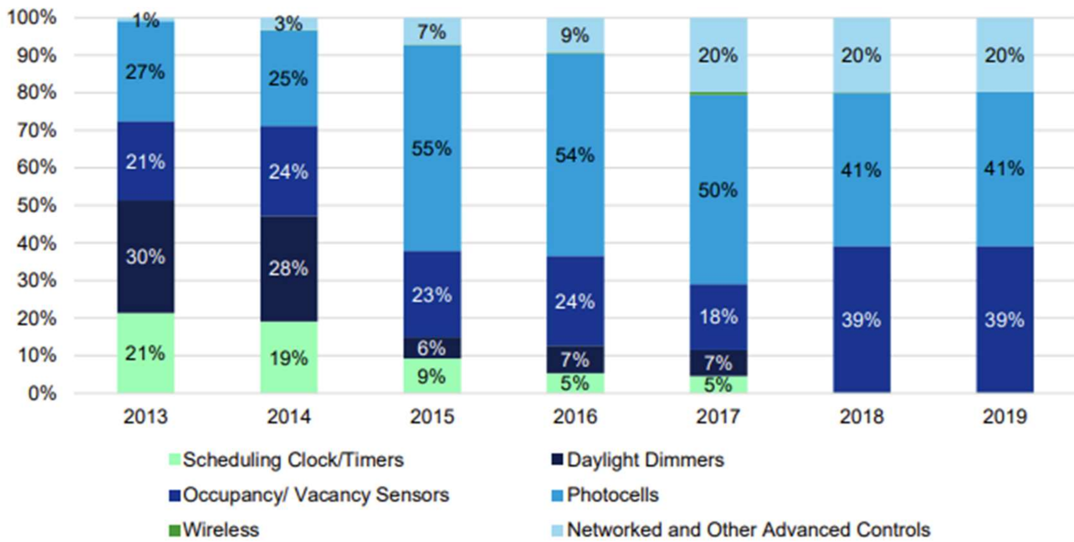
5.4.3 Market trends

Basic lighting controls such as occupancy sensors have been widely adopted in certain subsectors (e.g., offices), but more advanced lighting controls have seen relatively low market uptake in C&I facilities, despite the potential energy and cost savings. Massachusetts research from 2020 found that less than 1% of C&I customers had installed advanced lighting controls and roughly 22% had standalone controls, such as occupancy sensors. There is a pronounced difference between program participants and non-participants with 39% of lighting participants and 16% of non-participant C&I customers having standalone controls. Approximately 15% of lighting systems in Massachusetts were controlled with standalone controls[206]. As noted above, the New Hampshire 2021-2023 Potential Study found that the Massachusetts C&I lighting market was about 2 years ahead of New Hampshire in terms of LED adoption. As such, we can reasonably estimate current adoption of lighting controls in New Hampshire to be similar to what was observed in Massachusetts in late 2020.[207]

Figure 5-19 shows how the mix of lighting controls sold in the Pacific Northwest has shifted from simple controls such as timers and daylight dimmers towards more advanced controls. While advanced controls grew to 20% of reported sales in 2017 through 2019, occupancy sensors and photocells still dominate the market. It is also important to note that this figure only reflects controls projects and does not provide insight into the overall level of adoption of lighting controls over time.

[205] Ibid.
[206] Ibid.
[207] Dunsky. *New Hampshire Potential Study*

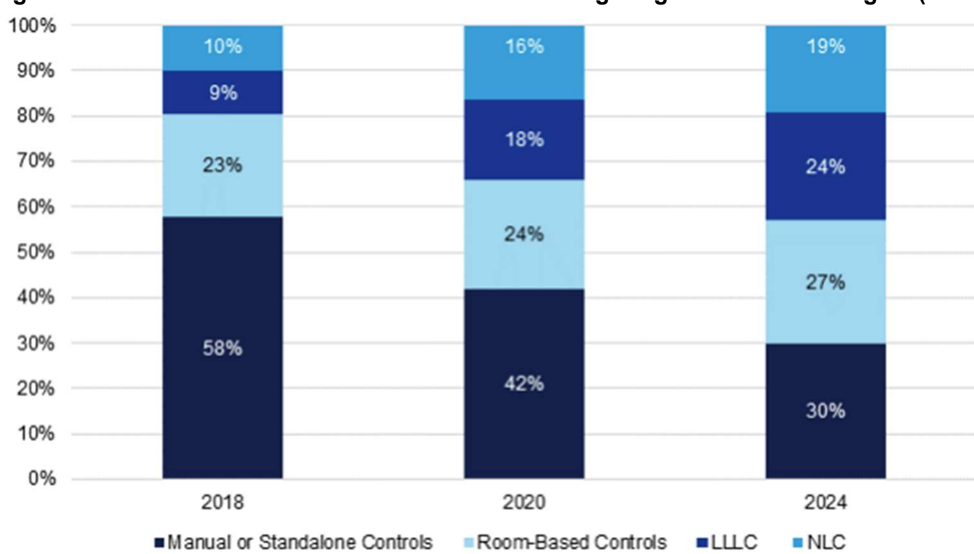
Figure 5-19 Pacific Northwest BPA controls sales data



Source: 2020 C&I Lighting Controls Market Study, page 24. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

Distributors in Massachusetts also provided researchers insights into the mix of lighting control technologies they sold in 2018, and what they anticipated market share would look like in 2020 and 2024. As shown in Figure 5-20, the market share for advanced controls (LLLC and NLC) in 2018 was similar to what waws observed in the Pacific Northwest during the same time. Massachusetts distributors anticipate that the market share of advanced lighting controls will increase by 79% between 2018 and 2021 and another 26% between 2021 and 2024. Most of the increase in advanced controls market share is expected to be offset by a decrease in manual or standalone controls, while market share for room-based controls is expected to remain around 25%.

Figure 5-20 Distributors estimated market share for lighting control technologies (2018 –2024)



Source: 2020 C&I Lighting Controls Market Study, page 23. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

5.4.4 Future opportunities

With such low prevalence across the C&I space, there should be many opportunities for increased adoption of lighting controls if the identified barriers to adoption can be mitigated. As stated in the NH Potential Study, *"Advanced lighting controls, including networked lighting, is a growing opportunity as new technologies and products integrate efficiency savings with increased functionality and non-energy benefits. These offer an emerging opportunity that also faces notable challenges including limited cross-compatibility among products from different manufacturers, limited customer awareness of the options and benefits, and timing re-lamping efforts with controls change-outs. Achieving the potential savings from advanced lighting controls will likely require investment to identify the most effective delivery strategies and tracking product development and roll-out."*[208]

Overall, controls are often most convenient and cost-effective to install during a broader lighting retrofit project. With LED lamps and fixtures having high saturation, this poses a large barrier as existing systems likely do not need to be replaced for many years and retrofitting LEDs with controls can be inconvenient, as it may lead to interruption in building operations for a second time, and costly, as labor and equipment needs to be brought in again.

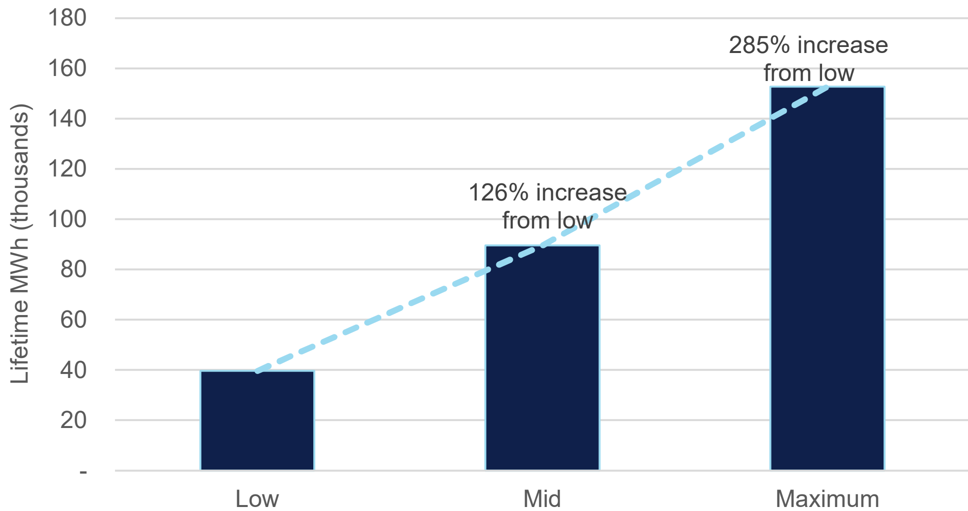
Increasing the adoption of lighting control technologies and their effective use will take investment and efforts from utility programs. Overcoming the barriers identified in this case study relies heavily upon increasing awareness amongst customers of the benefits and use of controls, providing market actors and customers with accurate information on the benefits, lifetime costs, and best type of control for their space and needs, and honing the supply process. The nuance and complexity inherent in complicated advanced control measures requires clear training, workforce development, and understanding throughout the supply chain so distributors, retailers, installers, and customers understand what they are purchasing, how it is used, and how it saves them energy. Appropriate installation can help avoid negative customer experiences that lead to disabling of control systems. Furthermore, utilizing utility programs as a pathway to finding customers at the point of lighting retrofit can ease the difficulty and incremental cost of installing controls as well.

5.4.4.1 New Hampshire Potential Study achievable savings

To estimate the scale of C&I lighting controls savings that the NHSaves programs may be able to achieve by overcoming barriers, the evaluation team analyzed savings opportunities for C&I lighting controls measures as originally modeled for the 2021–2023 New Hampshire Potential Study.[209] As shown in Figure 5-21, C&I lighting controls see significant increases in achievable savings resulting from increased incentives and enabling activities to overcome barriers.[210] This points to relatively high market barriers and low participant cost-effectiveness in the absence of incentives, both of which are mitigated via the increased program incentives and enabling strategies modeled in the mid and maximum scenarios. These model results also imply that absent all program interventions, barriers would effectively prevent any modeled savings.

[208] Dunsky. New Hampshire Potential Study
[209] Dunsky. New Hampshire Potential Study
[210] It is important to note that the study did not include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

Figure 5-21. New Hampshire achievable savings scenarios for C&I lighting controls, 2023



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

5.5 Industrial process measures

5.5.1 New Hampshire program overview

NHSaves has offered a Large Business Energy Solutions (LBES) Program to customers including those in the New Hampshire industrial sector since before 2000. In its current form, it targets customers with an average monthly demand of 200kW or larger, providing them with incentives and other support for the purchase and installation of energy efficient equipment. Energy efficient equipment must be part of a new construction or renovation project, process expansion, replacement of equipment that has reached its end of useful life or to replace less efficient existing equipment.[211] Program interventions include incentives, technical assistance, and free energy audits. Installations of energy efficient technology can be done by industrial customers' in-house staff or vendor/contractors.

The program provides custom incentives for complex or tailored measures, including process measures, that meet eligibility criteria. Eligibility is based on project cost and potential energy savings quantified and evaluated through a benefit/cost model. Technical assistance by an outside engineering firm may be offered through the program to quantify the energy savings potential of a proposed project. The program offers free audits to identify opportunities to improve industrial process energy efficiency. Following the audit, a report is delivered to the customer that provides a menu of potential savings opportunities.

5.5.2 Barriers

The industrial sector is highly heterogenous, with significant variation in types of process measures, usage patterns, and facility types. For example, the Manufacturing Energy Consumption Survey (MECS), a mandatory survey administered by the U.S. Census, covers 21 manufacturing subsectors and 79 industry groups and industries, all with highly specialized equipment.[212] The heterogenous nature of industrial facilities and process equipment complicates efforts to study energy consumption and implement energy efficiency offerings on a large scale. There has not been primary research specifically on energy efficiency adoption in New Hampshire's industrial sector and there are limited program evaluations on industrial

[211] Liberty Utilities, *Large Business Programs*, 2023. https://new-hampshire.libertyutilities.com/acworth/commercial/smart-energy-use/electric/large-business-programs.html,
[212] MECS is a national survey that collects information on the stock of U.S. manufacturing establishments, their energy-related building characteristics, and their energy consumption and expenditures. The MECs survey is required of any manufacturing establishment. See https://www.eia.gov/consumption/manufacturing/about.php

process offerings and equipment nationally. The team leveraged available research from DOE and several jurisdictions with industrial process offerings that have been studied.

The barriers to industrial customers adopting energy efficient process measures are described in this section.

5.5.2.1 Financial barriers

Process equipment upgrades are often a large budget item for industrial businesses, and the incremental upfront cost of high-efficiency technologies can be accordingly large. Industrial businesses face internal competition for capital, which must be allocated across multiple business needs and budget areas. As such, they often have limited capital available for end-use efficiency projects and frequently require very short payback periods for such investments. A 2021 study of equipment saturation in California's industrial and agricultural markets found that concerns of upfront cost were among the most common barriers to adopting energy efficient measures within these sectors.[213] More specifically, the study cited risk of industrial facilities investing in energy efficiency projects and the challenges in accessing capital to make said investments. Industrial customers' access to internal capital designated for energy efficiency projects is commonly limited and requires short payback periods (1–3 years). Specifically, end user interviews found that the median payback period required for internal management approval of energy efficiency projects was 3.5 years—56% of the companies with threshold payback periods had periods of 3.5 years or less.

Financial risks create another barrier to adoption of efficient industrial process measures. The volatility of energy prices and broadly increasing price trends can make accessing and allocating funds for energy efficiency projects difficult.[214] Specifically, volatile prices cause uncertainty in projecting cost savings from efficiency investments, creating an additional barrier to internal capital allocation decisions and approval for energy efficiency projects. The extent of this barrier differs by customer, as energy costs differ depending on several factors, including the energy intensity of production processes. As such, projected cost savings from energy efficiency measures impact business margins differently—for energy intensive businesses, potential cost savings are greater, but so are the impacts of energy price volatility. Complex corporate financing and tax structures, including depreciation periods and treatment of energy costs, can also act as a deterrent to adopting energy efficient measures because they create financial risk and complicate internal financing processes. These challenges may also result in industrial customers facing difficulty securing low-cost financing.[214]

Finally, transaction costs—specifically the costs of business disruption associated with installing an energy efficiency measure—pose a financial barrier to adoption. Studies of large business efficiency programs have found that disruption of production and the associated impact to revenue is generally an important consideration during internal decision making.[215] This is particularly the case for measures that are entirely intended for energy savings purposes, rather than those being implemented as part of planned replacements or upgrades that would have had to happen regardless of whether an efficient technology was involved.

Program interventions

Energy efficiency programs including NHSaves provide custom incentives to help overcome financial barriers. Due to heterogeneity in process measures, facility types, and operations and usage patterns, a one-size-fits-all, prescriptive, technology-specific incentive approach is not feasible. Rather than provide fixed incentives for specific pieces of equipment, programs typically provide incentives based on the amount of energy saved (e.g., cents per kWh or therm). Program staff and vendors also work with customers to address other barriers, such as by coordinating installations to minimize business

[213] DNV andGuidehouse, *Industrial/Agricultural Market Saturation Study: 2021 Potential and Goals Study,* https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/energy-efficiency-potential-and-goals-studies/2021-potential-and-goals-study.

[214] U.S. Department of Energy, *Barriers to Industrial Energy Efficiency,* https://www.energy.gov/eere/amo/articles/barriers-industrial-energy-efficiency-report-congress-june-2015.

[215] Opinion Dynamics, *Connecticut C1901 Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation*. 2021.

disruption, and communicating and coordinating incentive agreements to provide a predictable commitment of funding to help alleviate financial risks.

5.5.2.2 Organizational barriers

The organizational structure of industrial customers can result in the costs and benefits of energy efficient projects being split across various business units within a company. Cost is commonly the primary factor in business leaders' decision-making, and the non-energy or co-benefits of energy efficiency projects—which are typically experienced by the specific business unit managing the process line—are not always recognized when forming the business case for these upgrades.[216] This is a variation of the split incentive barrier prevalent in the residential sector between landlords and tenants, or between new home builders/developers and future owners.

Industrial facilities commonly operate on strict planning and budgeting cycles—typically annual—with prescribed processes for developing business cases and evaluating and approving equipment upgrades. Energy resource planning is not always required within industrial businesses, so cost-effective energy savings projects may not be identified or planned for as part of the standard planning and budgeting cycle. In addition, these internal planning cycles may not align with utility and state energy efficiency program cycles, hindering businesses' ability to benefit from offerings.[217] For instance, a large industrial customer with energy-intensive engineering and laboratory facilities in New Hampshire who was interviewed as part of a recent NHSaves evaluation described the complexities of their corporation's internal financial cycle. The interviewee said that their company's central financial department has one fixed bucket of funding each year for equipment upgrades, creating internal competition for funding and challenges in planning and prioritizing facility maintenance and improvements. NHSaves program funding must be identified and arranged at the right time in the planning cycle to use it as part of the business case to secure internal funding for efficiency projects. The interviewee said that predictable program funding was critical to this process.

Program interventions

As described by NH Utilities staff, to address these organizational barriers, utility account executives (i.e., staff who manage relationships with large customers) work closely with large industrial customers to help manage energy needs and costs, including by leveraging NHSaves offerings. This direct relationship approach allows the programs to circumvent organizational barriers by accessing key decision makers responsible for managing overall energy costs. Program staff can provide key information to support developing a business case for energy efficiency upgrades, and coordinate program incentives to align with businesses' internal planning cycles.

5.5.2.3 Informational barriers

The heterogenous nature of the industrial sector requires knowledge of highly specialized processes to identify and execute energy savings opportunities. For example, recent research in California found that lack of knowledge of efficient equipment and knowledge of benefits among facility managers was one of the most common barriers to installing industrial and agricultural energy efficiency measures.[213] Furthermore, businesses that do have general awareness of energy efficiency often lack in-house expertise or the resources to hire outside experts to identify specific opportunities and design energy efficiency projects. This lack of knowledge of technologies, implementation strategies, and financing mechanisms limits businesses' ability to consider energy efficiency in their capital planning cycles. As mentioned in Section 5.4.2.2, incorporating energy efficiency in businesses' planning cycles is critical to obtaining internal capital and gaining management approval for equipment upgrades.

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[216] U.S. Department of Energy, *Barriers to Industrial Energy Efficiency,* https://www.energy.gov/eere/amo/articles/barriers-industrial-energy-efficiency-report-congress-june-2015. 2015.

[217] Ibid.

Informational barriers can also impede policy makers and program planners from designing programs to support the industrial sector. Such efforts often rely on data on equipment stocks, manufacturing processes, and other information to understand trends in energy use and inform programs and policies to reduce energy consumption. The heterogeneous nature of industrial process measures can create challenges in gathering and analyzing such data (e.g., metering measures to collect energy consumption data), particularly at an aggregate level needed to develop broad policies and programs. The lack of broad industry data and expertise to evaluate such data can create barriers to identifying and evaluating opportunities to reduce energy consumption and can hinder the development of programs to support industrial facilities adopting energy efficient technologies.[214]

Program interventions

As noted in 5.5.2.2, the NHSaves program engages large industrial customers directly through account executives, and this direct relationship approach is the primary focus for marketing and promotion of industrial offerings. Through these relationships, program staff can provide information on the cost savings, energy savings, and non-energy benefits of efficiency upgrades, and provide technical assistance resources to identify energy savings opportunities. This can include a no-cost, high level scoping study that provides a set of potential energy savings opportunities for the customer, followed by more rigorous technical assistance studies, generally provided at a 50% cost share.

5.5.2.4 Supply and provision barriers

If businesses are able to overcome the financial, informational, and organizational barriers cited above, finding qualified vendors and contractors to install measures can pose yet another barrier to their adoption.[218] Process measures may be unique to an industry, requiring highly specialized knowledge for equipment maintenance and installation. For example, according to a recent interview with a large industrial customer with energy-intensive engineering and laboratory in New Hampshire, a lack of technical expertise for controls and retro-commissioning projects in New Hampshire has caused significant wait times in accessing technical support, resulting in further challenges with financial planning. As noted in other sections in this report, workforce constraints are widespread, including in the energy services sector. These constraints can be especially acute in trying to meet custom, specialized needs, as if often the case for industrial process projects.

5.5.3 Market trends

Market share

Due to the heterogeneity of the industrial sector, it can be cost-prohibitive to gather comprehensive data on the market share of efficient equipment across the sector. New Hampshire has not conducted research in this area, but some studies elsewhere have collected and analyzed data on the prevalence of efficient technologies in targeted subsectors. For instance, recent research in California estimated the saturation of selected efficiency measures, as shown in Table 5-7.[219] While the sample size was small, the study estimated relatively low levels of saturation of energy efficient equipment. Specifically, average estimates provided by end users and vendors indicate that saturation of efficient measures for most industrial and agricultural equipment types was less than 50%, which suggests that there are significant remaining opportunities for energy savings.

[218] Opinion Dynamics, *Connecticut C1901 Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation*, 2021.
[219] DNV and Guidehouse, *Industrial/Agricultural Market Saturation Study: 2021 Potential and Goals Study,* 2021. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/energy-efficiency-potential-and-goals-studies/2021-potential-and-goals-study.

Table 5-7. Efficient measure saturation levels by selected subsector, California 2021

Subsector	Energy efficiency measure	End user estimates of measure saturation	Vendor estimates of measure saturation	Average measure saturation estimate
Electronics Manufacturing	Chiller plant optimization	6%	24%	15%
	RCx	44%	No estimates provided	44%
	Low pressure drop filters in cleanroom spaces	39%	36%	38%
Food Production	Refrigeration system optimization	62%	24%	43%
	Boilers and heat recovery	19%	11%	15%
	VFDs on pumps and motors	68%	No estimates provided	68%
Chemical Manufacturing	Heat recovery	30%	12%	21%
	Advanced automation and optimization	29%	33%	31%
	Mechanical drives/VSDs	40%	51%	46%
Dairies	Refrigeration system heat recovery	19%	29%	24%
	VFDs on pumps	31%	32%	32%
	EE fans and ventilation	62%	48%	55%
Water Pumping for Agriculture	Efficient pumps and motors	63%	42%	53%
	Sensors and controls	59%	44%	52%
Greenhouses	LED grow lights	38%	41%	40%
	EE HVAC	42%	46%	44%
	Energy curtains	42%	60%	51%

Source: DNV and Guidehouse, *California Industrial/Agricultural Market Saturation Study: 2021 Potential and Goals Study,* 2021.

Beyond California, the 2018 MECS survey of manufacturing facilities provided estimates of nationwide rates of businesses conducting energy audits to identify potential energy saving opportunities. The level of energy audit activity varied widely among the 79 industries surveyed, ranging from audit rates of over 60% of surveyed businesses in the mils and petroleum refinery subsectors to less than 10% in several subsectors including furniture products and fertilizer production subsectors. The average rate of audit activity across the surveyed industries was 17%.[220] As with the California study, the MECS data indicates that there is significant opportunity for energy savings in the industrial sector.

5.5.4 Future opportunities

Due to the heterogenous and specialized nature of most industrial process measures, program interventions must be tailored and customizable for individual customers. Interventions that are often successful in the residential or small business sectors, such as prescriptive, technology-specific incentives, mass-market outreach and promotion, and support for manufacturing and stocking of equipment by upstream and midstream market actors, would not be feasible or effective for the industrial sector.

The NHSaves programs provide tailored interventions to this sector, including custom incentives, direct customer outreach and engagement, and technical assistance. There are similar program models throughout the Northeast, as well as alternative or additional approaches that utility programs have used to engage industrial customers. For instance, Connecticut and New York both have initiatives focused on continuous engagement of industrial participants through regular

[220] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis, *Energy Management Activities and Energy Savings Tech, table 8.11*, 2018. https://www.eia.gov/consumption/manufacturing/data/2018/#r10.

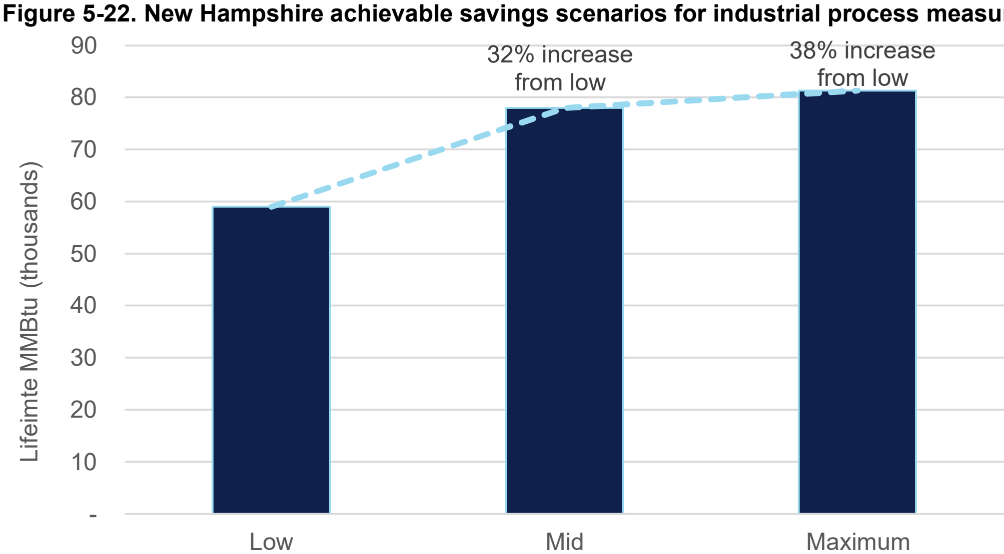
events and facility visits to increase education and awareness of energy saving technologies and identify and coordinate opportunities to use behavioral measures or capital improvements to reduce energy use and costs.[221][222]

Due to limited available market saturation research in New Hampshire, our review cannot reliably estimate the future savings opportunities in the state. More specific insights on these savings opportunities in New Hampshire, and the optimal targeting and design of program interventions, would require deeper analysis on equipment stocks in the state's industrial sector, along with other firmographic data on facility types, manufacturing and production processes, and energy use profiles. More broadly however, the available evidence shows that significant savings opportunities remain within this sector.

5.5.4.1 New Hampshire Potential Study achievable savings

To estimate the scale of industrial process savings that the NHSaves programs may be able to achieve by overcoming barriers, the evaluation team analyzed savings opportunities for process measures as originally modeled for the 2021–2023 New Hampshire Potential Study.[223] As shown in Figure 5-22, industrial process measures see moderate increases in achievable savings from increased incentives and enabling activities between the low and mid scenarios, and a smaller increase from maximizing incentives under the maximum scenario.[224] This suggests that these measures can be cost-effective for participants without large program incentives, but that moderate incentives and enabling activities are important for unlocking savings. These model results also imply that absent all program interventions, barriers would effectively prevent any modeled savings from occurring.

Figure 5-22. New Hampshire achievable savings scenarios for industrial process measures, 2023



Source: DNV analysis of 2021–2023 New Hampshire Potential Study results

[221] Opinion Dynamics, *Connecticut C1901 Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation.* 2021.
[222] NYSERDA, *Flexible Technical Assistance Program*, 2023, https://www.nyserda.ny.gov/All-Programs/FlexTech-Program.
[223] Dunsky. *New Hampshire Potential Study, Statewide Assessment of Energy Efficiency and Active Demand Opportunities*, *2021-2023.* 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20201016-NHSaves-Potential%20Study-Final%20Report-Volume%20I.pdf
[224] It is important to note that the study did not include primary research to enumerate and quantify market barriers in New Hampshire. Rather, the study used generalized assumptions of market barrier levels that define maximum adoption rates for each measure based on market research and professional experience. New Hampshire-specific primary research would be needed to ground-truth these model results.

6 CONCLUSIONS AND CONSIDERATIONS FOR NEW HAMPSHIRE

The primary objectives of this review were to (1) identify and enumerate the market barriers addressed by the NHSaves programs, (2) assess the extent to which selected energy efficiency programs such as those in New Hampshire have overcome such barriers, and (3) identify how New Hampshire's programs could continue to do so going forward. Key takeaways from this review are as follows.

Market barriers addressed by the NHSaves programs

Market barriers incorporate a broad and diverse set of obstacles to energy efficiency adoption that vary across customers, technologies, and other dimensions. As stated in the foundational literature, "there is no single market for energy services; instead, the "market" consists of hundreds of end uses, thousands of intermediaries, and millions of consumers. As a result, …these issues must be addressed in a highly disaggregate fashion, considering the workings of individual markets."[225] The NHSaves programs cover the full spectrum of technologies and customer types, and as such, the programs confront a broad range of barriers. By the same token, they face a wealth of potential savings opportunities from circumventing or eliminating those barriers.

Some barriers, such as physical health and safety barriers to weatherization projects, are unique to specific measures and markets covered in our case studies. Other barriers, such as financial barriers, appear in different forms across most markets, and programs consistently offer interventions—i.e., incentives—targeted to the specific customers and market actors involved. Predominant across nearly all markets are overarching barriers related to workforce. Workforce barriers are driven by economy-wide labor supply and demand dynamics, which reach beyond the purview of the NHSaves programs and beyond the geographic boundaries of New Hampshire.

Progress in overcoming barriers and transforming markets

In this diverse landscape of barriers, programs including those in New Hampshire have found ways to intervene and circumvent barriers, though there were few areas we reviewed where barriers had been fully eliminated. A key question facing program administrators, stakeholders, and regulators is as follows: in what areas have market barriers been eliminated, if not market-wide, then for a large enough share of customers and market actors whereby program intervention is no longer justified? To definitively answer this question, it is important to have multiple sources of evidence pointing toward the same conclusion.

Drawing on secondary research, we found that programs vary in the extent to which they have circumvented or eliminated barriers. For retail lighting, it is clear from a preponderance of evidence that programs have helped eliminate market barriers, and program interventions are no longer needed in most cases—and the NH Utilities are discontinuing their offerings in response to this market transformation. However, the other NHSaves programs and offerings covered in our case studies all still face a range of barriers and savings opportunities that justify continued program intervention, with weatherization and C&I lighting controls presenting the greatest opportunities in New Hampshire. In addition, given the ever-changing market for energy efficiency and the continual progress of technological advancement, newer, more efficient technologies are always arising which often face a new set of financial, informational, behavioral and other barriers. These advances present opportunities for program intervention even as other opportunities diminish due to market transformation.

Considerations for program interventions in evolving markets

There are clear and significant remaining opportunities for program savings across the markets covered in our case studies. The scope and depth of our analysis does not allow for definitive conclusions about targeting and design of NHSaves program interventions, nor how programs should prioritize resources across programs or among the different types of interventions (e.g., financial, informational, training, etc.). Ultimately barriers are best understood, circumvented, and

[225] Eto and Golove, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, 1996.

eliminated through direct interactions between programs, market actors, and the customers they serve. The first-hand knowledge of program implementers and trade allies is critical in this process. As a complement to this expertise, research can provide insights reflecting a broader view, through methods such as surveys, focus groups, or market data analysis.

6.2 Further research

Due to the scope and timeline of the Commission's requests, the team's case study approach could not comprehensively address all areas of inquiry on market barriers—particularly those such as quantifying end-user costs of addressing barriers and directly quantifying the extent to which New Hampshire programs have removed them. As part of this review, we identified gaps where primary New Hampshire-based research such as customer surveys, market actor interviews, sales data analysis, or other methods would allow for a fuller assessment of the Commission's questions, as shown in Table 6-1. New Hampshire may consider pursuing such research, while weighing the tradeoffs between its costs, rigor, and value to the NHSaves programs and customers in understanding and overcoming barriers.

Table 6-1. Information to support further assessment of barriers and refinement of program interventions

Case Study Topic	Information gaps
Residential retail lighting	Due to high levels of market share and limited remaining savings opportunity, additional research is not recommended for retail lighting
Residential weatherization	Primary research on: • upfront weatherization costs residents are willing to incur, by customer class and measure type, and single family vs. multifamily • workforce capacity, knowledge, and skills gaps • coordination of program offerings and other funding sources to address health and safety barriers
Residential new construction	Primary research on: • homebuyer awareness of and preferences for energy efficient homes, and developer perception of market demand for energy efficiency • incremental costs of energy efficient construction • ENERGY STAR® Homes attribution (NTG) and market penetration
C&I lighting controls	Primary research on: • workforce capacity, knowledge, and skills gaps regarding controls • contractor and customer research on barriers and opportunities for integration of controls into LED retrofit projects • customer research on awareness and perception of controls technologies and persistence of savings
Industrial process	Primary research on: • Industrial stock in New Hampshire • Customer research on internal and external financing processes and sources

APPENDIX A. MARKET BARRIERS CLASSIFICATION

Table 6-2 provides a categorized list of barriers as identified in the foundational literature, alongside the barriers cited in the NHSaves 2022–2023 plan.

Table 6-2. Market barriers as classified in foundational literature

Barrier Category	NHSaves 2022-2023 Plan	LBNL and National Association of Regulatory Commissioners (1988)	Eto, Prahl, and Schlegel (1996)	Sorrell, S., O'Malley, E., Schleich, J., and Scott, S. (2004)	Jaffe, Newell, and Stavins (2004)	Bagaini, Colelli, Croci, Molteni (2020)	Gillingham, Newell, and Palmer (2009)
Financial	Incremental price difference between standard and high efficiency goods and services	Limited access to financing and protection from financial risk: energy users face limited access to financing or are unwilling to sink scarce cash or credit into investments with multi-year payback. Irreducible but hidden indirect costs: hidden costs not sufficiently captured by the price of efficiency investments, such as technical risks.	Access to Financing: the difficulties associated with the lending industry's historic inability to account for the unique features of loans for energy savings products (i.e., that future reductions in utility bills increase the borrower's ability to repay a loan) in underwriting procedures. Hidden Costs: Unexpected costs associated with reliance on or operation of energy-efficient products or services - for example, extra operating and maintenance costs Hassle or Transaction Costs: The indirect costs of acquiring EE, including the time, materials and labor involved in obtaining or contracting for an energy-efficient product or service. (Distinct from search costs in that it refers to once a product has been located.)	Access to Capital: (1) an overall limitation on access to capital for the organization; or (2) restricted access to capital for energy efficiency within internal capital budgeting procedures Hidden Costs: The costs of production disruptions, hassle, and inconvenience; identifying opportunities, analysing cost-effectiveness, and tendering; staff replacement, retirement, and/or retraining; possible poor performance of equipment; difficulty and cost of obtaining information on the energy consumption of purchased equipment; and lack of time and the existence of other priorities.	Hidden costs: costs of adoption that are not included in simple cost-effectiveness calculations - for example, learning about reliable suppliers, qualitative attributes of new equipment seeming less desirable	Socio-economic status of building users; lack of funds, high capital costs and financial risk; limited payback expectations / investment horizons; building stock characteristics	Capital liquidity constraints that hinder access to financing for energy-efficient investments and cause some purchasers of equipment to choose the less energy-efficient product owing to lack of access to credit, resulting in underinvestment in energy efficiency
Informational	Lack of customer awareness related to: • benefits of energy efficiency. • existence of high-efficiency alternatives. • where to purchase high-efficiency equipment/quality installation. • how and when to reduce demand during system peaks.	High information or transaction costs: Costs of research to find out about the availability of efficient technologies, to assess and verify vendor claims, find qualified contractors, and judge equipment uncertainties.	Information or Search Costs: The costs of identifying energy-efficient products or services or of learning about energy-efficient practices, including the value of time spent finding out about or locating a product or service or hiring someone else to do so. Performance Uncertainties: The difficulties consumers face in evaluating claims about future benefits. Closely related to high search costs, in that acquiring the information needed to evaluate claims regarding future performance is rarely costless. Asymmetric Information and Opportunism: The tendency of sellers of energy-efficient products or services to have more and better information about their offerings than do consumers, which, combined with potential incentives to mislead, can lead to sub-optimal purchasing behavior.	Imperfect Information: Firms may not be aware of energy efficiency opportunities or may not know how to get information; knowledge of their energy use itself is limited. Credibility and Trust: lack of confidence that advice received on pursuing energy efficiency is trustworthy and credible	Incomplete or Inadequate Information: The lack of information or communication between a home builder or landlord and the buyer or tenant can lead to less energy-efficient equipment or improvements.	Lack of awareness of savings potential Lack of trusted information and experience	Lack of information and asymmetric information that cause consumers to systematically underinvest in energy efficiency because they lack sufficient information about the difference in future operating costs between more-efficient and less-efficient goods necessary to make proper investment decisions
Organizational		Split incentives: users of buildings or equipment are not responsible for purchasing energy efficiency measures; rather owners or landlords are.	Misplaced or Split incentives: Cases in which the incentives of an agent charged with purchasing EE are not aligned with those of the persons who would benefit from the purchase	Split Incentives: occurs when buildings or machinery are leased rather than owned, or when rapid job rotation impedes implementation because any incentive to save energy is diluted if the employee is not in a place to see the program through to the end.		Split incentive	Principal-agent or split-incentive problem describes a situation where one party (the agent), such as a builder or landlord, decides the level of energy efficiency in a building, while a second party (the principal),

DNV

Barrier Category	NHSaves 2022-2023 Plan	LBNL and National Association of Regulatory Commissioners (1988)	Eto, Prahl, and Schlegel (1996)	Sorrell, S., O'Malley, E., Schleich, J., and Scott, S. (2004)	Jaffe, Newell, and Stavins (2004)	Bagaini, Colelli, Croci, Molteni (2020)	Gillingham, Newell, and Palmer (2009)
			Organization Practices or Customs: Organizational behavior or systems of practice that discourage or inhibit cost-effective EE decisions, for example, procurement rules that make it difficult to act on EE decisions based on economic merit.	Principal-agent barriers: Monitoring and control in hierarchical organizations that cause the principal to specify strict investment criteria for the agent to follow, limiting energy efficiency investments. Values and organizational culture: The values held by key individuals in a company are likely to influence that company's performance.			such as the purchaser or tenant, pays the energy billss
Supply and provision	Insufficient retailer stocking: Midstream (retailers/ distributors) fail to stock high-efficiency products Building trades lack sufficient cadre of trained personnel, awareness, experience, or commitment to high-efficiency practices, both for existing building renovations and new construction		Product or Service Unavailability: The failure of manufacturers, distributors or vendors to make a product or service available in a given area or market. May result from collusion, bounded rationality, or supply constraints. Inseparability of Product Features: The difficulties in acquiring desirable EE features in products without also acquiring (and paying for) additional undesired features that increase the total cost of the product beyond what the consumer is willing to pay	Heterogeneity: Off-the-rack technology might not always be suitable. This operates as a barrier if energy efficiency measures that are generally suitable in most firms in a sector are not suitable in certain specific firms.	Adoption and Innovation Externalities: A firm that develops or implements a new technology typically creates benefits for others, and hence has an inadequate incentive to increase those benefits by investing in technology. A successful innovator will capture some rewards, but those rewards will always be only a fraction—and sometimes a very small fraction—of the overall benefits to society of the innovation.	Training and skills of professionals	R&D spillovers may lead to underinvestment in energy-efficient technology innovation owing to the public good nature of knowledge, whereby individual firms are unable to capture the full benefits from their innovation efforts, which instead accrue partly to other firms and consumers
Behavioral		Non-economic consumer rationality: energy users influenced by factors such as appearance, public or peer opinions, and personal obligation or habit.	Bounded Rationality: The behavior of an individual during the decision-making process that either seems or actually is inconsistent with the individual's goals Irreversibility: The difficulty of reversing a purchase decision in light of new information that may become available, which may deter the initial purchase, for example, if energy prices decline, one cannot resell insulation that has been blown into a wall.	Risk: perceived risks that make for more cautious behaviour and could delay or reduce investment in non-essential measures. This includes technical risk that the technology would be found wanting, and business risk or market uncertainty.		Lack of interest and undervaluing energy efficiency benefits, social group interactions Customs, habits, and behavioral aspects	Systematic biases in consumer decision making that may be relevant to decisions regarding investment in energy efficiency, including propsect theory; bounded rationality; and heuristic decision-making
Public Policy			Externalities: Costs that are associated with transactions, but which are not reflected in the price paid in the transaction. Non-externality Pricing: Factors other than externalities that move prices away from marginal cost. An example arises when utility commodity prices are set using ratemaking practices based on average (rather than marginal) costs.		Environmental Externalities: the potentially harmful consequences of economic activities on the environment constitute externalities, which if not fully addressed by policy, result in a level of energy efficiency that is likely too low. Average-Cost Pricing: The incremental costs of increasing electricity supplies are sometimes significantly greater than the average costs of existing electrical capacity, suggesting that consumers face inadequate incentives to conserve electricity, e.g., during peak demand periods.	Lack of specific legislation Complex/inadequate regulatory procedures	Energy Market: Prices faced by consumers in electricity markets may not reflect marginal social costs due to the common use of average-cost pricing under utility regulation. Average-cost pricing could lead to under- or overuse of electricity relative to the economic optimum.

APPENDIX B. LITERATURE REVIEW SOURCES

Foundational literature

The following sources were reviewed to provide a basis for defining barriers and enumerating those identified in literature. These sources also identified the standard types of program interventions and the metrics programs have used to measure their success in overcoming barriers.

- Austin, David, Congressional Budget Office. *Addressing Market Barriers to Energy Efficiency in Buildings*, August 2012.
- Bagaini, Annamaria, Francesco Colelli, Edoardo Croci, Tania Molteni. "Assessing the relevance of barriers to energy efficiency implementation in the building and transport sectors in eight European countries," *The Electricity Journal*, Volume 33, Issue 8, 2020, https://doi.org/10.1016/j.tej.2020.106820.
- Davis, Beth, Jan Harris, and Dan Violette. *REGULATORY SPOTLIGHT: Estimating Energy Savings From Resource Acquisition and Market Transformation Programs*, February 2019. https://guidehouse.com/-/media/www/site/downloads/energy/2019/market-transformation-summit-regulatory-spotlight.pdf.
- Eto, Joseph H., Ralph Prahl, Jeff Schlegel. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*, July 1996. https://eta.lbl.gov/publications/scoping-study-energy-efficiency.
- Fujita, K. Sydny, Lawrence Berkeley National Laboratory. *Market and behavioral barriers to energy efficiency: A preliminary evaluation of the case for tariff financing in California,* June 2011.
- Fuller, Merrian. *Enabling Investments in Energy Efficiency: A study of energy efficiency programs that reduce first-cost barriers in the residential sector.* 2009.
- Gillingham, Kenneth, Richard Newell, and Karen Palmer. "Energy Efficiency Economics and Policy." *Resources for the Future*. 2009.
- Golove, William H. and Joseph H. Eto. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency*, March 1996. https://www.osti.gov/biblio/270751.
- Howarth, Richard B. and Bo Andersson. "Market barriers to energy efficiency," *Energy Economics*, Volume 15, Issue 4, 1993, https://doi.org/10.1016/0140-9883(93)90016-K .
- International Energy Agency. *Promoting Energy Efficiency Investments: Case Studies in the Residential Sector*, OECD Publishing, Paris, 2008. https://doi.org/10.1787/9789264042155-en
- Jaffe, Adam B., Brandeis University and National Bureau of Economic Research; Richard G. Newell, Resources for the Future; Robert N. Stavins, Harvard University. *Economics of Energy Efficiency,* Encyclopedia of Energy, Volume 2. 2004.
- Lawrence Berkeley National Laboratory and National Association of Regulatory Commissioners. *Least-Cost Utility Planning Handbook for Public Utility Commissioners, Volume 2, the Demand Side: Conceptual and Methodological Issues*, December 1988.
- Sorrell, S., O'Malley, E., Schleich, J., and Scott, S. *The economics of energy efficiency - Barriers to cost-effective investment*, 2004.
- Ungar, Lowell, Rodney Sobin, Neal Humphrey, Tom Simchak, Nancy Gonzalez, and Francesca Wahl, Alliance to Save Energy. *Guiding the Invisible Hand: Policies to Address Market Barriers to Energy Efficiency*, ACEEE Summer Study 2012.

- Vaidyanathan, Shruti, Steven Nadel, Jennifer Amann, Casey J. Bell, Anna Chittum, Kate Farley, Sara Hayes, Michelle Vigen, and Rachel Young. *Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency*, March 2013. https://www.aceee.org/sites/default/files/publications/researchreports/e136.pdf.
- Van Buskirk, Robert. *Estimating Energy Efficiency Technology Adoption Curve Elasticity with Respect to Government and Utility Deployment Program Indicators*, December 2013. https://www.osti.gov/biblio/1164376.

Case study literature

The following sources were reviewed to synthesize quantitative and qualitative findings on (1) market and customer barriers, (2) program interventions, and (3) trends such as market share and net-to-gross (NTG) results for the measure and program types relevant to each case study.

Retail lighting

- DNV. Final Draft Report of *Massachusetts LED Market Effects: Baseline Characterization* Massachusetts Program Administrators and Energy Efficiency Advisory Council Report No.: Final Draft Date: March 1, 2015.
- DNV. *FREE-RIDERSHIP AND SPILLOVER EVALUATION Residential and Commercial Portfolio Report* SUBMITTED TO: National Grid New York. Date: December 20, 2022.
- Itron. *NEW HAMPSHIRE RESIDENTIAL BASELINE STUDY* Submitted to: New Hampshire Evaluation, Measurement and Verification Working Group Prepared by Itron, June 11, 2020.
- Kelly & Rosenberg, DNV. *Some Light Reading: Understanding Trends Residential CFL and LED Adoption*, 2016 ACEEE Summer Study on Energy Efficiency in Buildings.
- NMR Group, Inc. *New Hampshire Lighting Supplier Insights* FINAL August 14, 2020 SUBMITTED TO: New Hampshire Program Administrators.
- NMR. *R1615 Light Emitting Diode (LED) Net-to- Gross Evaluation* FINAL REPORT FOR CONNECTICUT EEB August 7, 2017.
- NMR. *R1963 Short-Term Residential Lighting Report* FINAL September 11, 2020 SUBMITTED TO: Connecticut Energy Efficiency Board.
- SCS ANALYTICS. *R1963b SHORT TERM RESIDENTIAL LIGHTING REPORT* FINAL Prepared for: The CT EEB Evaluation Administration Team, October 29, 2020.

Residential Weatherization

- Opinion Dynamics. *New Hampshire Utilities Home Performance with ENERGY STAR Program Evaluation Report 2016-2017 – FINAL,* June 11, 2020.
- Opinion Dynamics. *New Hampshire Utilities Home Energy Assistance Program Evaluation Report 2016-2017 – FINAL*, July 29, 2020.
- NYSERDA, *Comfort Home: Getting NY Homes Heat Pump Ready with Standardized Envelope Packages*, July 29, 2020.
- NMR. *R1983 NTG FINAL TOPIC MEMORANDUM Re: R1983 Savings-Weighted NTG Results – Final Results & Recommendations*. July 1, 2022.
- [Confidential Northeast client]. *Understanding the Opportunity for Residential Weatherization*, January 27, 2021.

- National Coalition to End Childhood Lead Poisoning. *Identified Barriers and Opportunities to Make Housing Green and Healthy Through Weatherization: A Report from Green and Healthy Homes Initiative Sites*, October 2010.

Residential New Construction

- ERS. 2017. *New Hampshire ENERGY STAR Homes Program Impact Evaluation (2014–2015)*.
- International Code Council. 2023. *ICC Code Development Process.*
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- NMR Group, Inc. 2017. *R1602 Residential New Construction Program Baseline Study.*
- NMR Group, Inc. 2017. *R1602 Residential New Construction Program – Process Evaluation.*
- NMR Group, Inc. 2018. *R1702/R1710 Codes and Standards Assessment.*
- NMR Group, Inc. 2018. *R1707 Net-to-Gross Study (NTG) of Connecticut Residential New Construction.*
- Port, Darren, Krim, Andrea, and Wu, Cornelia. 2023. *Code Adoption*. Northeast Energy Efficiency Partnerships.
- Stern, Ari, and Tyler, Zack. 2022. *Connecticut R1968 RNC Baseline & Code Compliance Study Design Presentation.* NMR Group, Inc.
- Eto, Joseph, Prahl, Ralph, and Schlegel, Jeff. 1996. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs*. LBNL.
- Golove, William, and Eto, Joseph. 1996. *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency.* LBNL.

C&I Lighting Controls

- DNV. *2020 C&I Lighting Controls Market Study.* Prepared for the Massachusetts Program Administrators and Energy Efficiency Advisory Council. June 30, 2021.
- Energy Solutions. *Energy Savings from Networked Lighting Control (NLC) Systems with and without LLLC.* Prepared for Northwest Energy Efficiency Alliance and DesignLights Consortium. September 24, 2020.
- Dunsky. *New Hampshire Potential Study: Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023.* Prepared for the New Hampshire Evaluation, Measurement and Verification Working Group. October 16, 2020.
- DNV. *CTX1931-4 ALC PSD Phase 1 Memo: Summary of Literature Review and Recommendations*. Prepared for the CT EEB Evaluation Administration Team. July 22, 2021.
- DNV. *CTX1931-4 ALC PSD Phase 2 Memo: Recommendations for ALC Measure Parameters.* Prepared for the CT EEB Evaluation Administration Team. June 6, 2022.

Industrial Process Measures

- U.S. Department of Energy. 2015. “Barriers to Industrial Energy Efficiency.” Barriers to Industrial Energy Efficiency - Report to Congress, June 2015 | Department of Energy
- Energize Connecticut. 2021. “C1901 Commercial and Industrial Energy Efficiency Programs (non-SBEA) Process Evaluation.”

- California Public Utilities Commission. 2021. “Industrial/Agricultural Maret Saturation Study 2021 Potential and Goals Study.” 2021 Potential and Goals Study (ca.gov)
- New York State Energy Research & Development. 2017. “NYSERDA Continuous Energy Improvement Evaluation.”
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