R1959 Single-Family Renovation and Addition Potential Analysis

FINAL REPORT

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This study, conducted on behalf of the Connecticut Evaluation Administrator Team, estimated the market size, project scope, and potential savings associated with the single-family renovations and additions market in Connecticut. The study also included a limited process evaluation of the Connecticut Additions, Renovations, and Retrofit Initiative operating in Connecticut as a pilot under the umbrella of the Residential New Construction program.

Main Findings

Market Size

About 7% of single-family homes undergo renovations and/or additions each year. Homeowners completed approximately 63,000 permitted renovation and addition projects annually in Connecticut from 2016 to 2018. Based on the contractor survey results, homeowners completed almost 5,000 more without permits. In total, this is 27 times higher than the number of single-family homes built each year in the state (2,466 homes).

	Renovation Only (R)	Addition Only (A)	R&A	**Total**
Single-family R&A	40,983	15,342	6,405	**62,730**
Percent	65%	25%	10%	**100%**

Project Scope

Two Program Participation Paths

Minor projects: small and/or have limited scope; similar to HES
Major projects: large and/or include major changes; HERS rater path

Program Eligibility by Path

Minor path: 49% of projects
Major path: 51% of projects

Common Project Sizes

Renovations: 36% 100 - 500 sq. ft.
Additions: 58% 100 - 500 sq. ft.

Most Common Project Types

Renovations: kitchens & bathrooms
Additions: new section of the house & finishing a basement or porch/sunroom

Measures Commonly Affected by R&A Projects

Heating and cooling equipment, water heating equipment, insulation, and windows

Barriers to Participation

Costs associated with efficient building and a lack of program awareness; homeowner and contractor awareness of and interest in efficiency

Gross Technical Potential (GTP) Savings

Based on prototype energy models, average estimated annual savings per home are 15.6 MMBtu for projects 500 ft2 or less, 36.9 MMBtu for larger projects, and 26.2 MMBtu overall.

Recommendations

- Expand the program out of its pilot phase.
- As a part of the launch, apply lessons learned from the comparable program launched in MA in 2019, mimic successes from the RNC program, and target both small and large projects.
- Use the RNC program's new homes baseline as the baseline for major addition projects, rather than a baseline based on code compliance.
- Adopt a hybrid baseline for renovations: ISP for the portion of the home initially included in the project scope and pre-existing conditions for measures added to the scope due to the program.
- Streamline program eligibility criteria, in particular the distinction between major and minor project paths.
- Consideration: To the extent allowed in CT, claim savings generated from fuel-switching projects.

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Acronyms

Acronym	Meaning
AC	Air Conditioning
ACH50	Air Changes per Hour with a 50-pascal pressure gradient
AFUE	Annual Fuel Utilization Efficiency
ASHP	Central, ducted air-source heat pump
BTU	British Thermal Unit
CAC	Central Air Conditioner
CFA	Conditioned Floor Area
CFM25	Cubic Feet per Minute with a 25-pascal pressure gradient
Companies	The Connecticut investor-owned utilities (Eversource and the Avangrid companies, including United Illuminating Company [UI], Connecticut Natural Gas Company [CNG], and Southern Connecticut Gas Company [SCG])
COP	Coefficient of Performance
DHW	Domestic Hot Water
EA Team	Evaluation Administrator Team
EER	Energy Efficiency Ratio
EF	Energy Factor
Ekotrope™	A cloud based residential energy modeling software
ERV	Energy Recovery Ventilation
GSHP	Ground Source Heat Pump
GTP	Gross Technical Potential Savings, an estimate of savings that exist in the market. This is not an estimate of economic or achievable savings and should not be interpreted as savings a program would achieve.
HERS	Home Energy Rating System
HES	Home Energy Solutions, the Companies' residential retrofit program. "Core Services" include measures such as air sealing, duct sealing, and high-efficiency light bulbs and low-flow faucet aerators. Add-on measures such as discounted HVAC, water heating, and insulation measures are also available.
HES-IE	The income-eligible version of the Home Energy Solutions program, serving lower-income residents
HPWH	Heat Pump Water Heater
HRV	Heat Recovery Ventilation
HSPF	Heating Season Performance Factor
HVAC	Heating Ventilation and Air Conditioning
ISP	Industry Standard Practice, an estimate of typical practices among market actors
kWh	Kilowatt Hour
LED	Light-Emitting Diode
MSHP	Mini or Multi-Split Heat Pump (commonly referred to as a ductless mini-split)
MWh	Megawatt Hour
NMR	NMR Group, Inc.
REM/Rate™	Residential Energy Modeling and Rating software by NORESCO
RNC	Residential New Construction
R-value	A measure of material's resistance to the flow of heat, commonly used for insulation ratings
SEER	Seasonal Energy Efficiency Ratio
U-Factor	The mathematical inverse of R-value; commonly used to describe windows' thermal performance
UDRH	User-Defined Reference Home
UEF	Uniform Energy Factor

Abstract

The R1959 Single-Family Renovations and Additions Potential Analysis study examines the renovation and addition (R&A) market in Connecticut to inform the design and work of the Energize Connecticut (EnergizeCT) Additions, Renovations, and Retrofit Initiative (the program). The program provides financial incentives to builders, remodelers, and homeowners to offset some of the cost of incorporating energy-efficiency upgrades into R&A projects. At the time of the study, the program was in a pilot phase and had only completed three projects.

The study estimated the market size, project scope, and gross technical potential (GTP) savings associated with the single-family R&A market. The study also included a limited process evaluation of the participation for the first three pilot projects. To estimate the market size, the study used regression-based equations developed for Massachusetts using Connecticut-specific inputs. To describe typical R&A projects and decision-making, the study included a web survey of 73 contractors, a web survey of 104 homeowners, and in-depth interviews with ten market actors. The study calculated GTP savings using results from the web surveys and 48 prototype energy models; the GTP calculations do not predict real-world outcomes.

EnergizeCT offerings do not currently target the large R&A market. Typical R&A projects are not eligible for the Residential New Construction offering, which targets new homes and gut rehabs. Home Energy Solutions (HES) vendors improve existing homes, but not R&A projects specifically. Contractors in the R&A market are often different people from those primarily serving the new home and HES markets. Along with costs, awareness of and interest in energy-efficiency from homeowners and market actors limit the uptake of energy-efficient practices in R&A projects.

While GTP savings represent an upper bound of savings, higher than economic or achievable savings, GTP savings from the R&A market are substantial. The study estimated that 7% of single-family homes undergo renovations and/or additions each year; this is 27 times the number of new homes built annually. R&A projects are split relatively evenly between minor projects (500 ft^2 or less) and major projects (greater than 500 ft^2). The average modeled GTP savings per project (26.2 MMBtu) are comparable to claimed savings for the RNC program (28.9 MMBtu) and higher than that of HES Core Services (6.2 MMBtu). This compares *GTP savings* for the R&A program with *claimed savings* for the RNC and HES programs; achievable savings for the R&A program would be lower than these GTP values. These GTP values also include fuel-switching savings (homes shifting from oil heat to electric heat pumps), which the Companies may not be able to claim under the current PSD. Per early participants, key participation barriers are costs associated with energy-efficiency measures, adding HERS raters to the project team, and low program awareness, a result of the program being in pilot phase.

Recommendations & Considerations
Expand the program out of the pilot phase.
Apply lessons from the MA R&A program launch, mimic RNC program successes, and target small and large projects.
Adopt hybrid baseline for renovations that uses ISP for the portion of the home initially included in the project scope and pre-existing conditions for measures added due to program.
Adopt RNC program's new homes baseline for addition projects, rather than a code-based baseline.
Streamline program eligibility criteria, in particular the distinction between major and minor project paths.
To the extent allowed in Connecticut, claim savings generated from fuel-switching projects.

Executive Summary

This study, conducted on behalf of the Connecticut Evaluation Administrator (EA) Team, estimated the market size, project scope, and potential savings associated with the single-family renovation and addition (R&A) market in Connecticut. The study also included a limited process evaluation of the Connecticut Additions, Renovations, and Retrofit Initiative (the program) operating in Connecticut as a pilot under the umbrella of the Residential New Construction (RNC) program.

For the purposes of this study, renovations and additions are defined as follows:

- **Renovations** include major home remodeling or improvements that do not add to the conditioned square footage of a house. They do not include routine work, such as painting, decorating, fixing broken water pipes, landscaping, or projects limited to HVAC replacements.
- **Additions** expand the conditioned square footage of a home. Examples include adding separate rooms to previously unconditioned space, expanding a room by taking down an exterior wall, finishing and conditioning a previously unfinished basement or bonus room, or adding a new story to a home.

The study had several primary objectives, all focused on the single-family renovations and additions market:

- **Market size:** characterize the size and scope of the single-family renovations and additions market in Connecticut.
- **Potential savings:** estimate the market's gross technical savings potential. This represents the total savings that exist in the market if every eligible project participated in the program and achieved the estimated per project savings described in the study. These estimates should not be interpreted as cost-effective or market achievable savings, or a prediction of expected program savings; those values would be lower than GTP savings.
- **Process evaluation:** conduct a limited process evaluation of the program in Connecticut, including a document review with a limited comparison between Eversource, UI, and similar programs in neighboring states.
- **Program planning recommendations:** Make recommendations for program planning or updates to the Connecticut Program Savings Document (as appropriate), including identifying key participation barriers.

To address these goals, the study applied algorithms developed in a recent NMR study to estimate the market size in Connecticut, based on a regression that predicts permit activity based on Census estimates of a town's single-family home count, median household income, and population density. Additionally, the study conducted three other primary data collection activities, and developed energy models to estimate technical savings potential, as shown in Table 1.

Table 1: Research Activities Overview

Method Details	Permit Estimates	General Contractors	Homeowners with R&A Projects	Case Study Market Actors	Energy Models
Activity	Market size estimate	Web survey	Web survey	In-depth Interviews	Prototype homes
Sample size	169 municipalities	73	104	10	48

Market Size

The R&A market is substantial: 7% of homes are renovated or expanded each year.

Number of projects. Homeowners completed an estimated **63,000 permitted R&A projects annually** in Connecticut from 2016 to 2018. Based on the contractor survey results, homeowners completed **almost 5,000 more without permits**. In total, this is 27 times higher than the number of single-family homes built each year in Connecticut (2,466 homes).

Project frequency. About 7% of single-family homes undergo renovations and/or additions annually, with differing scopes and savings potential. Six of the seven percent get permits and the remainder do not (but likely should, based on descriptions provided by surveyed contractors).

Project type. Nearly two-thirds of annual projects were renovation-only (65%), 25% were addition-only, and 10% included a renovation and an addition.

Project Scope and Decision-Making

Small and large projects are common throughout Connecticut, but typical practices do not place significant emphasize on energy efficiency.

Two program participation paths: minor and major projects. The program provides incentives for incorporating energy-efficiency upgrades into R&A projects. The program is still new and operating in pilot phase. As described in program materials, it has two compliance paths, one for minor and one for major projects. The minor project path operates much like HES, encouraging whole home improvements as a part of a renovation or addition. The major projects path requires a HERS rater to model whole home performance, using a savings baseline of pre-existing conditions for the renovated portion of the home and prescriptive code for additions.

Projects eligible for minor project path. The minor projects path was not yet active during the study period. As designed, it would target projects affecting less than 500 square feet of floor area, or larger projects that fall short of qualifying for the major project path (described below). It would use a modified HES/HES-IE structure to encourage whole-home improvements alongside other renovation or addition work and would not require a HERS rater. Based on study findings, approximately 49% of annual projects (around 20,000 renovations, 10,600 additions, and 2,180 combined renovation and additions) are likely eligible for this path, given their size and scope (this number would vary depending on how the program implements the minor project path).

Projects eligible for major project path. The major projects path targets projects that are greater than 500 square feet of conditioned floor area and affect more than 50% of the existing building envelope. It requires a HERS rater and follows a performance-based incentive approach relying on energy modeling. Based on the square footage factor alone, approximately 51% of annual projects (around 24,500 renovations, 5,700 additions, and 4,600 combined renovation and addition projects) affect enough square footage that they may be targets for the major project pathway, depending on specific program eligibility rules.

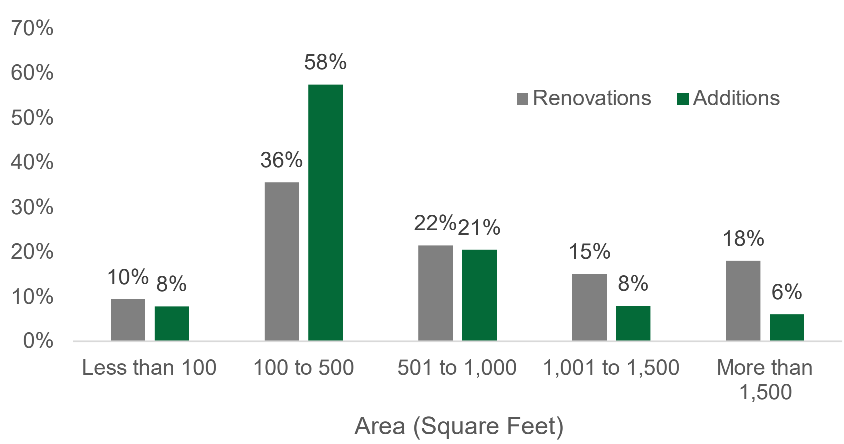
Types of rooms. Renovations commonly include kitchens and bathrooms. Common additions are building a new section of the house, finishing a basement, or finishing a porch or sunroom.

Affected measures. Key energy-related measures most commonly changed in R&A projects are heating and cooling equipment, water heating equipment, insulation, and windows.

Barriers to participation. Participants in early pilot projects said that the biggest barriers to participating in the program are the additional costs associated with efficient building and a lack of program awareness – to be expected given that the program has operated in pilot mode, without a full launch. Additional feedback from early participants can be found in Appendix C.

Project size. General contractors indicated that they work on many small and large renovation projects (Figure 1). Approximately 91% of renovations are larger than 100 square feet and thus could offer some potential for energy savings. For additions, 93% are larger than 100 square feet. Based on contractor estimates, there is substantial opportunity for the minor path of the program, which targets projects that are 500 square feet or less: 36% of renovations are between 100 and 500 square feet, and 58% of additions are between 100 and 500 square feet.

Figure 1: Size of Projects Across all Contractor Survey Respondents



Decision makers. Decision-making is driven by the motivations and knowledge base of the homeowner and the team hired by the homeowner. Key decision makers are the homeowner, general contractor, and architect (when present). Homeowners rarely make specific equipment and building component requests. This gives project teams flexibility in their recommendations, subject to budget constraints. While subcontractors, such as HVAC contractors, may not be considered key decision makers, their standard practices and preferences are often built into projects by default, making them even more important to final outcomes.

Limited focus on efficiency. Blower door tests are rare and HERS raters are seldomly involved in renovations or additions projects. In addition, these projects often have limited design phases, which limits the opportunity to incorporate efficiency beyond contractors' typical practices.

Recommending energy-efficiency upgrades. Sixty percent of homeowners with renovation or addition projects said they got at least one recommendation for an energy-efficiency upgrade from someone on their project team. They reported that they accepted 53% of these recommendations. Contractors reported that their customers accepted recommendations at particularly high rates for mechanical systems: 90% for HVAC systems and 77% for water heaters. These high uptake rates highlight the importance of market actors *making the recommendations in the first place*, given that customers are likely to accept them. More than one-third of homeowners (38%) said they did not implement energy-efficiency upgrades due to additional costs. A similar share (39%) said they faced no barriers implementing energy-efficiency upgrades.

Homeowners not engaged with the permitting process. Seventy-five percent of surveyed homeowners were unsure if their projects had obtained permits; only 18% recalled getting one, indicating the importance of a contractor's decision to advocate for or against getting a permit.

Homeowners doing work themselves. Do-It-Yourself (DIY) work is common. Among surveyed homeowners who underwent R&A projects, 56% said they had done some amount of the work themselves, with painting and design work being the most common DIY tasks. About 40% of DIY projects included more substantial work, such as demolition (44%), flooring or tile work (42%), or carpentry or insulation work (34%), some of which could represent a missed program opportunity.

Gross Technical Potential (GTP) Savings

Per-project GTP savings from R&A projects rival savings from RNC program homes.

Savings Potential Methodology. The study estimated gross technical potential savings by creating a set of energy models to simulate possible renovation and addition scenarios and then scaling the resulting model-level savings up to the state level. There is far more variation in project sizes and scopes in the market than can be estimated by models. These numbers should be treated as an estimate of the large opportunity that exists should every project participate in the program and achieve savings similar to that estimated by this study's modeling. GTP savings represent an upper bound of savings, higher than what would be economic or achievable.

Accordingly, GTP results are not a prediction of what the program will achieve.[1] For context, a previous Connecticut potential study estimated that market achievable potential savings were 6% of GTP fossil fuel savings and 29% of electric GTP. Additionally, modeling identified substantial GTP savings from switching from oil heat to electric heat pumps. This is an increasingly common practice in R&A projects, but the PSD does not currently allow the Companies to claim fuel-switching savings. The report focused on all savings estimated by modeling (including fuel switching), but also presents results excluding those savings and savings from lighting improvements, as lighting savings may not be claimable in the future.

Estimated per home savings. Based on modeling, average estimated annual savings per home are 26.2 MMBtu overall. Excluding savings from fuel switching (oil-heated homes switching to heat pump as a part of a major renovation) and lighting improvement reduces this to 21.2 (Table 2).

Table 2: Mean Per Project GTP Savings by Project Size (MMBtu)

Fuel	Minor Projects	Major Projects	Overall
Average savings per home	15.6	36.9	26.2
Average savings per home, *excluding fuel switching and lighting savings*	13.8	28.4	21.2

Estimated GTP statewide savings. Based on scaling up prototype model savings, statewide GTP could be as high as about two million MMBtu (Table 3). Excluding savings from fuel switching (not claimable currently) and lighting (which may not be claimable in the future) GTP decreases to about 825,000 MMBtu (Table 4).

Table 3: Statewide GTP Savings by Fuel and Project Size (MMBtu)

Fuel	Minor Projects	Major Projects	Total
Electric	111,199	181,254	292,453
Natural gas	104,236	237,478	341,714
Oil	110,966	1,233,260	1,344,226[a]
Propane	11,269	25,673	36,942
Total	**337,670**	**1,677,665**	**2,015,335**

[a] Oil heated homes underwent fuel switching in models where HVAC changes were included. They were converted to heat pumps. This increased oil savings and decreased electric savings.

[1] GTP values may also overlap with that from other programs. For example, homes could achieve some of these savings by participating in HES, without the benefit of deeper savings from an efficiency-minded renovation. https://energizect.com/sites/default/files/R15%20CT%20Single-Family%20Potential%20Study_Final_8.18.16.pdf

Table 4: Statewide GTP Savings by Fuel and Project Size, Excluding Fuel Switching and Lighting Savings (MMBtu)

Fuel	Minor Projects	Major Projects	Total
Electric (adjusted)	**47,669**	**287,804**	**335,473**
Natural gas	104,236	237,478	341,714
Oil (adjusted)	**110,967**	**0**	**110,967**
Propane	11,269	25,673	36,942
Total (adjusted)	**274,140**	**550,955**	**825,096**

GTP savings values estimated for R&A projects (a high estimate of savings) through modeling compare favorably to actual savings values seen in HES and RNC program homes. The 26.2 MMBtu average GTP savings per home is **close to the average achieved per home savings for RNC program participants** in 2020 according to the C&LM plan (28.9 MMBtu) and much higher than average achieved savings from HES Core Services (6.2 MMBtu).[2] The actual savings an R&A program might achieve would be lower than the GTP values shown here; this comparison with claimed savings for HES and RNC program participants is shown for illustrative purposes only.

Conclusions, Recommendations, & Considerations

The R&A market represents a sizeable opportunity for program savings, from both smaller and larger projects.

***Conclusion.* The renovations and additions market represents a huge potential for savings, though the PSD may impose limits on how much of this the Companies can claim.** Based on modeling, the average renovations or additions **program participant could generate 26.2 MMBtu of annual savings (GTP).** This is nearly as much as the average RNC participant (28.9 MMBtu, actual savings). Moreover, the renovations and additions market is **27 times larger than the RNC market**. As lighting savings diminish and new home energy code improves, renovations and additions represent a huge market potential for the Companies, though fuel switching (from oil to electric heat pumps, for example), represents a sizeable portion of these potential savings.

***Conclusion.* The renovations and additions pathway is not yet targeting the significant potential available.** At the time this study was commissioned, the renovations and additions program operated in pilot mode, with limited staff capacity and no online presence on the EnergizeCT.com site. The program has been highly selective about projects (e.g., choosing less-common whole-house gut rehab projects conducted by people with an interest in energy efficiency). Until the pathway is launched more fully, it cannot effect change in the broader market.

[2] Average HES Core Services values from the Connecticut Statewide Energy Efficiency Dashboard for 2020.

1 ***Recommendation. As soon as feasible, expand the program out of its pilot phase.***

Rationale. At the time of this study, this program was in its early pilot phases. Only a handful of projects had participated, all of which were deep-energy-retrofits. Once the program launches in earnest, the Companies will have a significant opportunity to drive savings in a new market area, including in small and large projects. Incentives may also entice DIY-minded homeowners to participate, likely yielding better energy-efficiency outcomes than if they did the work themselves.

2 ***Recommendation. As a part of the program's expansion, the Companies should (1) apply relevant lessons learned from the comparable program launched in Massachusetts in 2019,[3] (2) look to lessons from the Companies' work in the RNC market, and (3) work to target both small and large projects.***

Rationale. This launch should include making decisions about the focus of the program and what it can cost-effectively achieve, such as how it should target small and large projects, and the extent to which it should encourage homeowners to expand the scope of their projects, or how it could target homeowners who might otherwise pursue a DIY project. Below, we discuss some of the factors that the Companies should consider.

The Massachusetts energy-efficiency Program Administrators (including Eversource and Berkshire Gas, an Avangrid company along with United Illuminating) oversee a similar program that launched in 2019 and saw close to 1,000 participants in 2019 and 2020. For a comparison between state programs, see Appendix F. The Companies should develop a program for Connecticut that learns from the early experience in Massachusetts, facilitating a smooth program expansion. *However, this does not require that Connecticut copy the Massachusetts program design.* For example, recent research in Massachusetts[4] indicates that early participants rarely included whole-home envelope improvements in projects, focusing largely on the specific areas being renovated. Also, program funding levels differ between Massachusetts and Connecticut programs – another reason that it would be appropriate for the Companies to develop a program offering specific to Connecticut, without necessarily replicating the Massachusetts approach.

As designed, the Connecticut program, unlike the Massachusetts program, offers two project paths. The minor project path may better serve small projects, bundling HES services into limited-scope projects that would never have included whole-home improvements and avoiding the complexity of including a HERS rater on the project (a requirement in Massachusetts). Such a path would not yield market transformation benefits, but could allow HES-style services to reach more homes when they are already being improved.

A major project path could engage design and construction teams that would work with a HERS rater to improve a project's performance. This path has the potential to achieve greater savings from larger projects and potentially yield market transformation results, using a program theory comparable to that of the Companies' RNC program. The RNC program, for example, has yielded significant spillover savings by improving outcomes outside of the program through a mix of incentives, outreach, trainings, and requiring the use of HERS raters who can help guide

[3] https://www.masssave.com/saving/residential-rebates/renovations-and-additions
[4] https://ma-eeac.org/wp-content/uploads/MA20R27_RAIncCost_Final_Report_20210628.pdf

efficiency practices on projects.[5] The R&A path could follow a similar trajectory, helping to increase the awareness of and demand for energy-efficient practices and improve the skills of contractors. A path designed to transform the market could also build the HERS rater market like the RNC program has done, according to previous evaluations.[6]

> Market actors are "**ready and willing** to accept this type of program. They just need the knowledge of the techniques and the program offerings."
> ***-Contractor***

After the added costs of incorporating efficient practices into projects, the second largest barrier to participation identified by interviewees was a lack of program awareness. Study respondents identified helpful messaging for potential participants as the program considers its recruitment messaging. For example, contractors may be drawn to messaging that describes the program as a way to learn new techniques that can provide a competitive advantage, particularly if the cost of learning those techniques can be subsidized by the program. Once market actors are comfortable with efficient practices, they can ideally leverage that ability in their own marketing to stand out from competitors. Two interviewees mentioned some non-energy benefits in their market, especially increased comfort and *sustainability*.

In outreach to homeowners, the program could emphasize that they should not miss out on a rare opportunity to fully upgrade their home, an opportunity that is easier to take advantage of while the home is already being changed. The program should include architects in outreach, as they may be likely to serve as efficiency champions on project teams, particularly for larger projects.

The Companies should also consider how to target homeowners considering DIY projects to encourage them to participate and avoid lost opportunities. Many homeowners may not understand energy-efficient practices or have the expertise to execute them in a DIY project. Program incentives could entice DIY-minded homeowners to consider professional help on their projects, leading to more energy-efficient outcomes. If the R&A program incentivizes DIY projects, quality control inspections could ensure that DIY work meets program standards. Future evaluation research could investigate additional opportunities and barriers associated with shifting the sizeable number of non-participant DIY-minded homeowners to the program, helping the program better capture some portion of the DIY market.

Interviewees also highlighted the value that a HERS rater provides on major R&A addition projects. Should the Companies launch a program path that requires a HERS rater's participation, the Companies will likely want to heavily promote the value of the HERS rater on the project and consider continuing to offer the HERS rater subsidy that was available to early program participants. Because using HERS raters on renovation projects is not common, many projects lack an efficiency *champion*, who can help ensure that efficiency is built into a project. HERS raters add energy performance expertise to design teams and, with modeling software, can help provide contractors and builders with third-party verification of efficiency benefits, which

[5] https://energizect.com/sites/default/files/R1707%20NTG%20Study%20for%20CT%20RNC_Final%20Report_10.5.18.pdf

[6] https://energizect.com/sites/default/files/R1602_Residential%20New%20Construction_Process%20Evaluation_Final%20Report_8.4.17.pdf

contractors can market to future clients. Additional lessons and feedback from early program participants can be found in Appendix C.

***Conclusion.* A pre-existing conditions baseline for major renovations would likely overstate savings from renovations.** As designed, the program would calculate modeled savings for major renovation projects against a pre-existing conditions baseline, which attributes all savings to the program. For some measures, this approach may be appropriate. For example, this study, and similar studies in Massachusetts, have found that typical renovation projects generally do not include whole-home air sealing, making pre-existing conditions an appropriate baseline for air infiltration improvements. When wall and ceiling cavities are opened, code requires them to be filled with insulation, and research indicates that filling cavities would be a typical practice, making pre-existing conditions an artificially low baseline for this measure.[7]

3 ***Recommendation.* Adopt a hybrid baseline for renovations: ISP for the portion of the home initially included in the project scope and pre-existing conditions for measures added to the scope due to the program (e.g., wall cavities that would not have been opened otherwise).**

Rationale. The study recommends developing a hybrid baseline for renovation projects. An **ISP baseline** is most appropriate for the portion of a project that was part of the initial scope. Here, the program would claim savings for improvements over typical practices. An ISP approach – recently adopted in Massachusetts – better reflects what contractors may do, creating a reasonable baseline for savings. An ISP baseline will never perfectly reflect what a contractor would do in any particular home. Just like the UDRH for the RNC program, it is an estimate based on assumptions. **A pre-existing conditions baseline**, however, may be appropriate for improvements that were not part of the original project scope. Examples could include insulating the ceiling of an entire home, not just over the kitchen being renovated, or reinsulating wall cavities not in the initial scope. This approach would allow the program to achieve savings if homeowners expand the scope of projects due to program participation. This hybrid baseline would require the program to identify the scope of projects pre-participation and due to participation.

This process would best be informed with the guidance of an expert working group, who can think through measure-level values and develop a reasonable set of baseline assumptions for Connecticut. The values in the modeling portion of this potential study are a first attempt at estimating ISP based on a combination of data sources (e.g., HES program values, survey respondents), but also include evaluator assumptions that could be reasonably adjusted with additional research and stakeholder feedback.

It is also worth noting that surveyed non-participant homeowners reported they accepted about half of the efficiency recommendations presented to them for their projects. Surveyed contractors noted that their customers rarely make specific efficiency-related requests. This indicates the significant opportunity available to the program to encourage contractors to (1) simply make efficiency recommendations because they are likely to be accepted, and (2) build efficiency into their typical practices because customers do not have the technical experience to request specific measures or practices on their own. By doing these things, participants can more easily achieve

[7] The study used ISP as a baseline when calculating potential savings.

savings well beyond that of the ISP of typical contractors, thereby increasing their incentives through the program. To the extent that HERS raters are involved in participant projects, the recommendation rate and adoption may be higher, given their expertise.

***Conclusion.* For additions, the use of a code-compliant addition as the modeled baseline is inconsistent with the RNC program's baseline as a savings baseline for newly constructed homes.** As designed, the program calculates savings for major addition projects against an addition built to code levels of efficiency. However, for new homes, the RNC program calculates savings against its UDRH, which approximates typical new construction practices in Connecticut, rather than code-compliant practices.

4 ***Recommendation.* Use the RNC program's new homes baseline as the baseline for major addition projects, rather than a baseline based on code compliance.**

Rationale. New homes and additions do not always perfectly meet energy code requirements. On some measures, they might under- or over-perform against a minimally code-compliant project. Accordingly, the RNC program calculates savings for participant homes against a UDRH based on typical new construction practices, informed by onsite studies. Additions, being new (albeit attached structures) should be treated similarly, as with the Massachusetts R&A program. A UDRH informed by a new homes baseline study will likely better approximate real-world practices than code minimums. *An expert working group gathered to develop an ISP baseline for renovations may also consider if there are caveats to this general principle for addition projects.*

***Conclusion.* The distinction between minor and major project eligibility paths may be unclear.** Program materials define minor project path eligibility based on the affected floor area, while major projects have additional requirements, such as the portion of the building shell that must be re-insulated. Potential participants may need assistance determining the appropriate participation path for their projects, since it is not solely based on project size.

5 ***Recommendation.* Streamline program eligibility criteria, in particular the distinction between major and minor project paths (should the program follow a two-path approach).**

Rationale. As designed, the project paths operate differently. The minor project path aligns with the HES program, where a participant uses the HES process to upgrade their home as a part of a smaller renovation or addition project. The major path requires a HERS rater and energy modeling and focuses on larger projects with greater savings opportunities. The program would likely benefit from a simplification of the eligibility requirements of the two paths, so that participants can more easily determine which best suits their needs. For example, a project that is larger than 500 square feet sounds like it would only qualify for the major path, but if it does not re-insulate enough of the home, it is still considered a minor project. Clear eligibility criteria may also help participants decide which path is appropriate to their project early in the project cycle, helping to incorporate energy-efficiency decisions as early as possible.

***Conclusion.* The study indicates that there are significant savings available from R&A projects that include fuel-switching, i.e., switching from lower efficiency fossil fuel systems to higher efficiency electric systems.**

6 ***Consideration. To the extent allowed under Connecticut law and regulations, the Companies should claim savings from R&A program projects achieved via fuel switching.***

Rationale. The study shows that the R&A program could yield substantial energy savings in projects that switch from fossil fuel systems to high-efficiency electric systems. If these fuel-switching savings are generated, ideally the Companies would claim them. If Connecticut law and regulations permit, this study supports the Companies pursuing those savings. As a part of Recommendation 3, the study suggests assembling an expert working group to develop an ISP baseline. That group could also assess appropriate baseline assumptions for fuel-switching scenarios and determine what information program participants might need to record in order to determine the most appropriate baseline for their project.

Section 1 Introduction and Methodology Overview

This study, on behalf of the Connecticut Evaluation Administrator (EA) Team, included a detailed assessment of the size and scope of the renovations and additions market in Connecticut for single-family attached and detached homes. The study utilized an algorithm to estimate market size using Census data, along with contractor and homeowner surveys to characterize the scope of renovations and additions projects. The study used these estimates to inform energy simulation models to estimate the potential savings associated with different renovations and additions scenarios. The study scaled these savings results up to estimate the gross technical potential savings associated with this market for the state. In addition to estimating potential savings, the data collection activities gathered baseline information on market effects indicators so that market effects can be measured and tracked in future evaluations. Finally, the study included a limited process evaluation of the pilot phase of the renovations and additions program operating in Connecticut under the umbrella of the Residential New Construction (RNC) program.

1.1 Current Program Design

The Connecticut Additions, Renovations, and Retrofit Initiative provides financial incentives to builders, remodelers, and homeowners to offset some of the cost of incorporating energy-efficiency upgrades into a renovation or addition project. It was developed in recognition of an identified gap in program services, specifically between new construction or gut rehab projects and the Home Energy Solutions (HES) program that addresses high-impact measures in existing buildings.

As designed, the program offers two participation paths: **minor additions or renovations,** which affect less than 500 square feet of conditioned floor area, and **major additions or renovations,** which affect more than 50% of the existing building envelope. All projects must obtain a permit, meet code, and apply for the program before work has been completed. The program also requires that LEDs be installed in new, high-use sockets and that new appliances be ENERGY STAR®-qualified. Both paths follow the same performance-based incentive structure, based on the percentage reduction in energy use intensity (EUI) relative to the baseline home.

However, at the time this study was commissioned, the program was in its early pilot phase – *no minor projects and only three major projects had been completed*. Accordingly, the following description of the minor project path is based purely on the program design literature.

Minor projects path. As designed, the minor project path uses a modified HES program structure that incentivizes improvements to both the affected area (i.e., the space being renovated or added) and the remainder of the home. In the affected area, a licensed home improvement contractor (HIC) would install measures such as insulation, windows, or HVAC equipment, and the customer would be eligible for any measure-level rebates through the EnergizeCT offerings. For the existing portion of the home, an HES vendor (or an approved HIC contractor) would provide HES Core Services such as LED lighting, water conservation measures, and air sealing as part of a separate visit. The HIC would receive a flat fee for participation, and the HES vendor would be paid according to a set fee-schedule (similar to the HES process). No HERS rater is required for this program path.

Major projects path. The major addition or renovation path takes a more performance-based approach and requires the use of a HERS Rater. The incentives for this path are based on a percentage of energy savings over the baseline scenario in MMBtu consumption. This requires the HERS Rater to create two energy models in the REM/Rate tool, one an *As-Is* model created from an inspection of the home before work is completed, and the other an *As-Built* model of the home after work is complete. Table 5 shows how these models would differ between given renovation or addition scenarios. The HERS Rater then generates various reports from the software for the two models, including fuel summaries, load summaries, and performance summaries, which are used to assess savings.

Table 5: Addition or Renovation Energy Modeling

Energy Model	Project Type		
	Renovation Only	Addition Only	Renovation and Addition
Baseline	As-Is Home	As-Is Home + Code Addition	As-Is Home + Code Addition
As Built	As-Built Home	As-Is Home + As-Built Addition	As-Built Home + As-Built Addition

1.2 Study Objectives and Research Activities

This study builds on Connecticut's past baseline studies and leverages comparable research in Massachusetts to help the EEB and Companies better understand how the renovation and additions market operates in Connecticut and the potential savings that could be achieved with a program offering targeting this market.

The objectives of this study are as follows:

- Characterize the size and scope of the single-family renovations and additions market in Connecticut.
- Estimate the savings potential associated with this market.
- Conduct a limited process evaluation of the program in Connecticut, including a document review with a limited comparison between Eversource, UI, and similar programs in neighboring states.
- Make recommendations for program planning, as appropriate, including identifying key participation barriers.

The key research tasks are summarized in Table 6.

Table 6: Task Summary

Task	Sample Size	Incentive
Staff/Technical Consultant Interviews	2 interviews	-
Market Size Estimate	-	-
Process Evaluation	10 interviews	$50
Contractor Web Survey	73	$50-$100
Homeowner Web Survey	104	$50
Potential Savings Assessment	48 prototype energy models x 2 (pre and post participation)	

1.3 Methodology Overview

This section summarizes the methodologies used for this study. Additional methodological details can be found in Appendix A.

1.3.1 Staff and Technical Consultant Interviews

Evaluators conducted initial interviews with program staff from the Companies and their technical consultants. NMR also received written responses to questions provided to the Companies. The information clarified the current program structure and shed light on the implementation of program and participation to date.

1.3.2 Market Size

The study estimated the number of renovation and addition projects conducted annually in Connecticut, taking into account the number of permitted and non-permitted projects.

1.3.2.1 Number of Permitted Projects

To estimate the number of permitted single-family renovation and addition projects in Connecticut, this study adapted formulas created in Massachusetts by NMR.[8] This study applied those formulas to each Connecticut city and town to develop a bottom-up estimate of the market size. This process assumes that the Massachusetts and Connecticut markets share significant similarities in terms of the drivers of renovation and addition activity.

The Massachusetts study included regression modeling based on thousands of permit records to develop formulas estimating the number of permitted projects in a given city or town based on that municipality's single-family home count, median household income, and population density.[9,10] NMR used publicly available Census data for Connecticut from 2010 to 2018 to adapt the Massachusetts formulas to Connecticut. The formulas can be found below.

[8] See Appendix A in the following report for detail on the methodology used in that study. https://ma-eeac.org/wp-content/uploads/MARLPNC_1812_RenoAddMarketPotential_Report_Final_2020.03.30_Clean_v2.pdf

[9] "2013-2017 ACS 5-Year Estimates" https://www.census.gov/programs-surveys/acs

[10] The Massachusetts regression identified these as key variables significantly correlated with R&A permit activity in a given municipality.

$$\textbf{Renovation Permit Estimate} = \frac{(SFHomes \times 0.033510) + (MedIncome \times 0.004594) + (PopDensity \times 0.131258)}{3}$$

$$\textbf{Addition Permit Estimate} = \frac{(SFHomes \times 0.013345) + (MedIncome \times 0.001490) + (PopDensity \times 0.065888)}{3}$$

$$\textbf{Renovation and Addition Estimate} = \frac{(SFHomes \times 0.004896) + (MedIncome \times 0.000707) + (PopDensity \times 0.023645)}{3}$$

1.3.2.2 Number of Non-Permitted Projects

While assuring confidentiality, the contractor web survey asked contractors to report the percentage of their renovation and addition projects that did not obtain a permit. The study used the resulting averages to estimate the number of renovation and addition projects performed in the state without a permit.

Specifically, the study used the following equation for each type of project (i.e., *renovation only*, *addition only*, and *renovation and additions*):

$$\textbf{NonPermit Estimate} = \left(\frac{Permitted\ Projects}{\%\ Permitted} - Permitted\ Projects\right) * \%\ NonPermitted\ Projects\ Requiring\ Permits$$

Where:

- *Permitted projects* is the number of permitted projects for the given project type estimated from Census data.
- *% Permitted* is the percent of the given project type that contractors reported obtaining permits for.
- *% Nonpermitted Projects Requiring Permits* is the percent of non-permitted projects for the given project type that required permits based on the responses from the contractor survey. This adjustment excludes projects that were limited to minor aesthetic changes and thus would not require a permit or present opportunities for significant energy savings.

The resulting estimate describes the full market, including projects that were permitted and those that were not permitted but likely should have sought permits.

1.3.2.3 Mini-Process Evaluation

The study included a *mini*-process evaluation based on in-depth interviews with the program's earliest participants. There had only been three full participants at the time the study was commissioned, and these three projects were treated as case studies. The study interviewed as many market actors associated with these projects as possible. Of the ten interviews conducted, seven respondents were involved in the case study projects, two were with Company staff responsible for overseeing the early program, and one was with a high-performance non-participant (contractor) for an outside perspective. The study offered each of the eight non-Company respondents $50 to participate in a 30-minute phone interview. Table 7 identifies the case study project with which each respondent was associated, and the type of market actor they represented. On two projects, the homeowner was also the contractor or architect.

Table 7: Non-Utility-Staff Interview Participants

	Architect	Homeowner	General Contractor	HERS Rater	Insulation Contractor
Case Study One	■			■	
Case Study Two	■		■	■	
Case Study Three		■			■
Non-participant			■		

1.3.3 Contractor Web Survey

The study included a survey with 73 general contractors across Connecticut between August and September of 2020. All respondents had completed renovation or addition projects in Connecticut in 2019. The study identified contractors using web scraping of online directories and by purchasing market actor contact information from InfoUSA. Contractors received $50 Amazon gift cards for completing the survey. Eventually, the study doubled the incentive to $100 to increase the response rate.[11] The study recruited contractors through mailed postcards, emails, reminder postcards, and reminder emails. The final sample had a standard error of ±9.6% at the 90% confidence level.

Table 8 shows the average share of respondents' work in each county, compared to the study's estimates of county-level activity, based on the three-year average share of estimated renovation and addition permits from 2016 to 2018.[12] It also shows the count of contractors who said they had work in each county in 2019. The sample is mostly aligned with the county-level project distribution, with only a slight over-representation of Fairfield County, so responses are left unweighted.

[11] The final response rate was 3%.

[12] See the Market Sizing methods in Appendix A.

Table 8: Where Surveyed Contractors Work

(Source: contractor survey, "Please estimate the percentage of those projects in 2019 that were in each county.)

(contractors = 73)

County	Percent of Statewide R&A Projects	Surveyed Contractors	
		Average Percent of Projects	# with Projects in County
New Haven	19%	19%	24
Hartford	21%	23%	25
Fairfield	21%	32%	28
Litchfield	11%	6%	8
Tolland	6%	4%	5
Middlesex	7%	6%	8
New London	10%	8%	9
Windham	5%	3%	5

1.3.4 Homeowner Web Survey

The study included a web survey with 104 single-family Connecticut homeowners in June of 2020. Homeowners were recruited through a Qualtrics panel, with county-level quotas based on relative population. Homeowners received a $50 Amazon gift card for completing the 30-minute survey. All the homeowners had completed a renovation or addition project on their home in the last three years (72%) or had such a project underway (28%). Eighty-nine percent of the respondents owned detached homes and 11% owned attached homes (i.e., townhomes).

Table 9 compares where respondents live with the county-level estimates of annual renovation and addition permits.[13] The final sample has a standard error of ±10% or less at a 90% confidence level and tracks closely with the county-level permit distribution, and analysis results were unweighted as a result.

[13] See the Market Sizing methods in Appendix A.

Table 9: Where Surveyed Homeowners Live

County	Percent of Statewide R&A Projects	Surveyed Homeowners	
		% of Sample	n
New Haven	19%	24%	25
Hartford	21%	24%	25
Fairfield	21%	23%	24
Litchfield	11%	8%	8
Tolland	6%	7%	7
Middlesex	7%	7%	7
New London	10%	6%	6
Windham	5%	2%	2
Total	**100%**	**100%**	**104**

1.3.5 Potential Savings Assessment

The study estimated the savings potential of the renovation and addition market in Connecticut by first creating energy models to simulate savings for different renovation or addition scenarios. The study developed 48 prototype models in RESNET-approved residential energy modeling software to represent differences in project type, scope, heating fuel, and location across the state. The study calculated savings by creating both baseline model scenarios (pre-renovation or addition) and upgrade model scenarios (post-renovation or addition) and taking the difference in energy consumption between the two.

Baseline assumptions. The baseline model scenarios for this study utilized a more efficient baseline for renovation projects than the current program, which uses pre-existing conditions. The baseline used for these models attempts to better approximate standard or typical renovation practices, based on the results of this study's data collection and evaluator judgment, including recent evaluations in Massachusetts for a comparable program. The baseline generally assumes that, in a renovation, contractors would upgrade wall and ceiling components immediately affected by a renovation to modest levels, such as filling an exposed cavity with fiberglass batt insulation. For addition portions of the projects, the study used the RNC program's user-defined reference home (UDRH) values, which reflect typical new construction practices in Connecticut.

Upgrade assumptions. For the upgrade scenarios, the study developed estimates of what typical upgrades might be for participating projects, given the low levels of participation to date. For renovations, the upgrade scenario assumed that installed measures would mirror the average measure-level performance of homes that participated in the Home Energy Services (HES) program. The upgrade scenario also assumed that all participant renovation projects would include whole-home upgrades beyond what would be typical industry standard practice (ISP) for contractors, such as the following:

- Insulating the entire attic
- Insulating the entire frame floor over a basement
- Air sealing the entire home

For addition projects participating in the program, the upgrade models assumed that installed measures would be similar to the performance of typical of RNC program participants.

Scaling results to population. After calculating savings for each of the prototype models, the study scaled the results up to each Company territory and to the entire state. The study scaled results up based on the findings from the permit count analysis, including adjustments to account for non-permitted projects. The study then weighted per home savings results by the statewide prevalence of project sizes, project types, climates, and heating fuels. Note that due to the higher prevalence of oil heating in Connecticut than in Massachusetts, the savings assumptions relating to oil-heated homes result in higher overall results for Connecticut than Massachusetts when scaling savings up to the state level. See Appendix F.2 for more detail.

Readers should note that the savings values presented here are purely estimates of gross technical potential – they are based on a finite set of modeled scenarios that do not reflect the full universe of projects. Additionally, to date, the program has only focused on larger, deep-energy-retrofit projects. The savings values presented in the study include savings from both major and minor projects. This study does not assess the economic potential or cost-effectiveness of an expanded program that would focus more heavily on a broader range of project types. For reference, according to a previous Connecticut potential study, fossil fuel market achievable potential savings were estimated at 6% of gross technical potential, and electric achievable savings were 29% of technical potential.[14]

[14] https://energizect.com/sites/default/files/R15%20CT%20Single-Family%20Potential%20Study_Final_8.18.16.pdf

Section 2 Market Size Findings

This section details the market size estimates. Additional findings can be found in Appendix B.

Based on the methodology described in Appendix A, this study developed the following estimates about the size of the single-family renovation and additions market in Connecticut:[15]

- On average, about 62,730 permitted renovation and addition projects were completed annually across the entire state from 2016 to 2018, including municipal electric territories.
- An additional 4,983 unpermitted substantial renovation and/or addition projects were completed in 2019, based on contractor survey responses.
- Nearly two-thirds (65%) of permitted projects were renovation-only, almost one-quarter (24%) were addition-only, and 10% included both a renovation and an addition.
- Annually, about 7% of single-family homes undergo a renovation and/or additions. Six of the seven percent are permitted, and one of the 7% are not permitted, but are likely substantial enough to have merited a permit.
- Homeowners were not well informed on the permitting process: 75% of surveyed homeowners were unsure if their renovation or addition projects had obtained permits.

[15] MA RLPNC 18-12: Renovations and Additions Market Characterization and Potential Savings Study. March 30, 2020.
http://ma-eeac.org/wordpress/wp-content/uploads/MARLPNC_1812_RenoAddMarketPotential_Report_Final_2020.03.30_Clean_v2.pdf

2.1 Permitted Project Estimates by County and Utility

Table 10 shows the estimated average annual renovation and addition permit counts by county from 2016 to 2018. It also includes the population of single-family homes in each county from the Census,[16] and the portion of homes in each county that are renovated or added onto each year. Fairfield and Hartford have the largest share of single-family homes and the largest share of projects annually (21% each).

Table 10: 2016-2018 Average Annual Permitted Project Estimates by County

County	Renovation Only	Addition Only	Renovation and Addition	Share of Projects	Total SF Homes	% with R&A Projects
Fairfield	8,723	3,322	1,365	21%	237,662	6%
Hartford	8,344	3,238	1,314	21%	231,616	6%
Litchfield	4,375	1,519	674	11%	68,013	10%
Middlesex	3,008	1,079	466	7%	56,557	8%
New Haven	7,790	3,050	1,231	19%	213,464	6%
New London	4,044	1,478	629	10%	84,559	7%
Tolland	2,475	879	383	6%	43,380	9%
Windham	2,223	777	343	5%	34,809	10%
Total	**40,983**	**15,342**	**6,405**	**100%**	**970,060**	**6%**

Table 11 shows the estimated average annual renovation and addition permits within each electric utility's service territory from 2016 to 2018. Most projects (88%) occurred in the Companies' electric territories (Eversource: 82% and UI: 6%).

Table 11: 2016-2018 Average Annual Permitted Project Estimates by Electric Utility

Count	Renovation Only	Addition Only	Renovation and Addition	Total Projects	Share of Projects	SF Homes	% with R&A Projects
Eversource	33,604	12,373	5,231	51,208	82%	752,727	7%
Municipal	4,977	1996	792	7,764	12%	146,441	5%
UI	2,402	973	383	3,758	6%	70,892	5%
Total	**40,983**	**15,342**	**6,406**	**62,731**	**100%**	**970,060**	**6%**
Eversource and UI	**36,006**	**13,346**	**5,614**	**54,966**	**88%**	**823,619**	**7%**

[16] https://www.census.gov/programs-surveys/acs/technical-documentation/table-and-geography-changes/2017/5-year.html

Table 12 shows the distribution of estimated three-year average annual permit counts in the gas utility service territories in Connecticut from 2016 to 2018. Eversource (45%) and UI (including CNG and SCG; 39%) had the largest share of projects (84%).

Table 12: Average Annual Permitted Project Estimates by Gas Utility (2016-2018)

Count	Renovation Only	Addition Only	Renovation and Addition	Total Projects	Share of Projects	SF Homes	% with R&A Projects
CNG	7,589	2903	1,192	11,685	19%	195,230	6%
Eversource	18,397	6923	2,872	28,192	45%	477,550	6%
None	6,594	2247	1,015	9,855	16%	75,193	13%
Norwich Public Utilities	314	121	49	484	1%	9,933	5%
SCG	8,089	3148	1,278	12,515	20%	212,155	6%
Total	**40,983**	**15342**	**6,406**	**62,731**	**100%**	**970,060**	**6%**
CNG, SCG, & Eversource	**34,075**	**12,974**	**5,342**	**52,392**	**84%**	**884,935**	**6%**

2.2 Detailed Non-Permitted Projects Estimates

Homeowners are not well informed on permitting. When asked if permits had been obtained for their projects, 18% of surveyed homeowners said "yes," 7% said "no," and 75% were unsure. Of the seven people who did not think they obtained a permit, four said they did not think they needed one, two said it would cost too much, and one said it would have taken too much time.

Surveyed contractors reported that 79% their renovation projects and 94% of their addition projects obtained permits.[17] Contractors said the most frequent reason for not obtaining permits was that they did not think one was required (67%), or that the homeowner did not want to get a permit (41%) – an opinion that contractors are in a position to influence (Table 13).

Table 13: Contractor Reported Reasons for Not Pulling Permits

(Source: contractor survey, "On projects where you did not obtain a permit, why was that the case?")

(contractors = 27)

Project Type	Percent of Respondents
Did not think one was required	67%
Homeowner did not want to	41%
Too much time/effort	11%
Subcontractor did not want to	4%
Other	4%

[17] These percentages reflect the share of all projects across all survey respondents for which respondents reported obtaining permits.

Overall, the study estimates that there are approximately 4,983 non-permitted annual renovation projects in Connecticut (Row F of Table 14), representing 7% of the 67,712 substantial renovation and addition projects annually.[18] Row A provides the average annual estimated permit counts, while Row B shows the percent of projects that obtain permits, based on the contractor survey. Row C combines those to show the number of permitted and unpermitted projects, including minor projects that may not have required permits and would offer little potential for energy savings. As shown previously in Table 13, 67% of contractors said that some of their projects did not obtain permits because they did not think one was needed. Therefore, the study assumes that the remaining 33% of non-permitted renovations had a scope that merited a permit.[19]

Table 14: Estimate of Non-Permitted Projects

		Renovations Only	Additions Only	Renovations and Additions	Total
A	Annual permitted projects (2016-2018 average, from Census data)	40,983	15,342	6,405	62,730
B	% of projects permitted (contractor survey)[20]	79%	94%	94%	84%
C	Total projects (A/B)	51,877	16,321	6,814	75,012
D	Total non-permit projects (C–A)	10,894	979	409	12,282
E	% of non-permitted projects that should have gotten permits (contractor survey)	33%	100%	100%	41%
F	**Non-permit projects that should have been permitted (D*E)**	**3,595**	**979**	**409**	**4,983**

[18] 67,712 is the estimated count of permitted and non-permitted projects that are substantial enough to require permits. The 75,012 total projects in Table 14 include 7,300 projects that would not trigger a permit requirement.
[19] This represents the share of contractors who did not obtain permits, excluding who did not believe they were required.
[20] This value reflects the percentages from the contractor survey rather than the homeowner survey because most homeowners did not know whether their projects included permits.

Section 3 Market Characterization

This section summarizes findings about the nature of the renovations and additions market in Connecticut, based on in-depth interviews with market actors in the mini-process evaluation, along with results from the homeowner and contractor survey. Additional findings are in Appendix C.

- Decision-making is driven by the motivations and knowledge base of the homeowner, as well as the team hired by the homeowner and its knowledge base.
- Key decision makers are the homeowner, general contractor, and architect, when present. Homeowner desires and budgets set the parameters of the project; although, homeowners rarely make highly specific requests for equipment types and building components, leaving that to the project team. Subcontractors (e.g., HVAC or insulation contractors) are not typically considered decision-makers, but their standard practices and preferences can still impact project efficiency.
- HERS raters are rarely involved in non-program renovation or addition projects and the design phase on such projects is typically minimal, limiting the opportunity for efficiency to be a focus of the design process.
- Sixty percent of non-participant homeowners reported receiving at least one recommendation for an energy-efficient upgrade; they accepted 53% of these energy-efficiency recommendations.

3.1 Barriers

The Companies have only implemented the renovation and addition program for a handful of pilot projects. Interviews with pilot project participants and surveys with contractors and homeowners identified the following barriers that could inhibit future projects from participating in the renovation and addition program.

- **Cost:** Homeowners, architects, and contractors identified costs as one of the most important factors in determining the scope of a project. These higher costs come from more expensive materials and additional labor.
- **Lack of energy-efficiency advocates during design:** renovation and addition projects are often designed largely by general contractors. Occasionally, renovation and addition projects include architects. The general contractors and architects in the renovation and addition market are often different from the builders in the RNC market, and thus may not have had as much outreach and training from the Companies regarding the EnergizeCT new homes program that encourages energy-efficient construction practices. Additionally, renovation and addition projects almost never include a HERS rater. The RNC program relies on HERS raters for recruitment and to shepherd projects through the program. Without an advocate for energy efficiency and program participation during the design

phase, projects are less likely to participate in the program and/or incorporate energy-efficient practices.

- **Lack of importance given to energy efficiency:** Related to the lack of an energy-efficiency advocate, is a lack of importance given to energy efficiency. Since most project teams do not focus on energy efficiency, the push for energy efficiency is steered largely by homeowner preferences. Less than half of homeowners considered energy efficiency a primary concern, a function both of priorities and general awareness.
- **Awareness of efficiency and the program:** The Companies have conducted little outreach for the renovation and addition program to date. Interviewees expressed that contractors would be interested in participating in the program if they knew about it.
- **Lack of energy-efficient recommendations:** Two out of five homeowners reported not receiving any recommendations for energy-efficiency upgrades from their project teams, at least in part due to a lack of awareness and interest in efficiency. When project teams made such recommendations, homeowners reported accepting 53% of them.
- **Contractor ability:** Seven percent of homeowners reported that they did not do energy-efficient upgrades due to a perceived lack of contractor ability to execute such work.

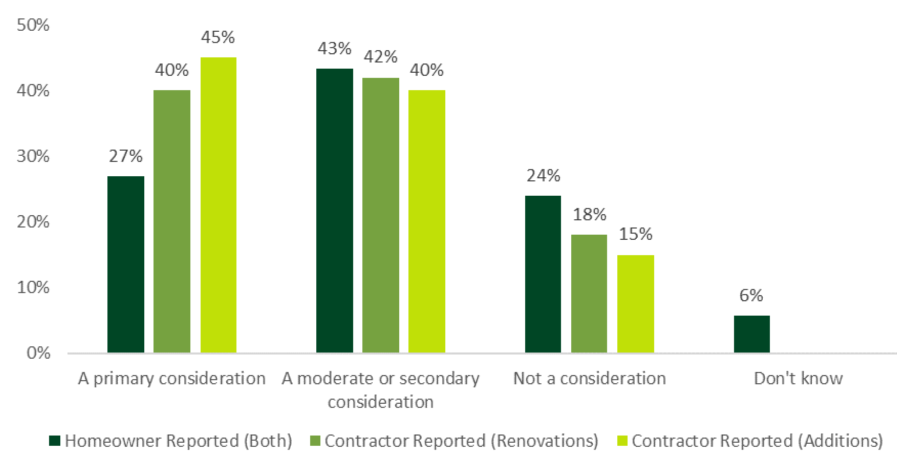
3.2 Decision Making in the Remodeling Market

Based on interviews in the mini-process evaluation, the decision-making processes in the remodeling market typically depend on the following:

The motivations of the homeowner. Homeowners, of course, have varying goals for their remodeling projects, such as "increasing floor area at the lowest cost to support a growing family" or "increasing the energy efficiency of the home to reduce greenhouse gas emissions." The homeowner's motivations and budget shape therefore dictate project scope.

Surveyed homeowners and contractors both reported that energy efficiency was a secondary consideration for about 2 out of 5 homeowners (Figure 2). Interestingly, 27% of surveyed homeowners said that energy efficiency was a primary consideration for their specific projects, while contractors estimated that, based on their experience, it was a primary consideration for homeowners at least 40% of the time. This indicated that there is significant

Figure 2: Importance of Energy Efficiency to Homeowners



opportunity in the market to meet the needs of energy-conscious homeowners. Other important considerations for homeowners are costs, aesthetics, and project duration.

The knowledge base of the homeowner. As described by pilot participant interviewees, homeowners who have experience as contractors, architects, builders, or other trades rely less on recommendations from hired project team members and may make more specific requests – such homeowners were included in the renovations and additions program's early pilot projects. Homeowners without this background rely on the project team to identify the practices and materials for the project based on the homeowner's motivations. Additionally, homeowners who are aware of building practices and concepts engage more thoroughly in the design process and might request practices or technologies not typically implemented by contractors.

The composition of the team. The key decision makers on a remodeling project are often those first contacted by the homeowner. If a homeowner reaches out to a general contractor for a quote on a project, the contractor will often prepare a design and will have a larger impact on decisions. If the homeowner reaches out to a design professional, such as an architect, the design professional may make more recommendations about the team composition and project details. Projects with architects often have larger teams and a more thorough design phase than projects without an architect, aligning with higher budget projects.

The knowledge base of the project team. Contractors and design professionals make recommendations based on practices, materials, and technologies with which they are comfortable. Given that surveyed homeowners reported accepting about half of the energy-efficiency related recommendations made on their projects, team members have a huge opportunity to influence projects by either making recommendations to their clients based on better-performing practices, or by simply building those into their standard practices, reducing the decision-making process for the homeowner.

3.3 Key Decisions Makers

Key market actors. Market actor interviewees reported that, in the typical remodeling project, the key decision makers regarding the scope and energy performance are the homeowner(s) and either the architect or the general contractor. If the project includes an architect, the architect may help select the general contractor and makes many key decisions. If the project does not include an architect, the general contractor serves as the project's decision maker in terms of specific construction practices. Architects and general contractors make specific recommendations for project measures (e.g., insulation levels) based on the homeowners' priorities and the homeowners make the ultimate approvals on project budgets.

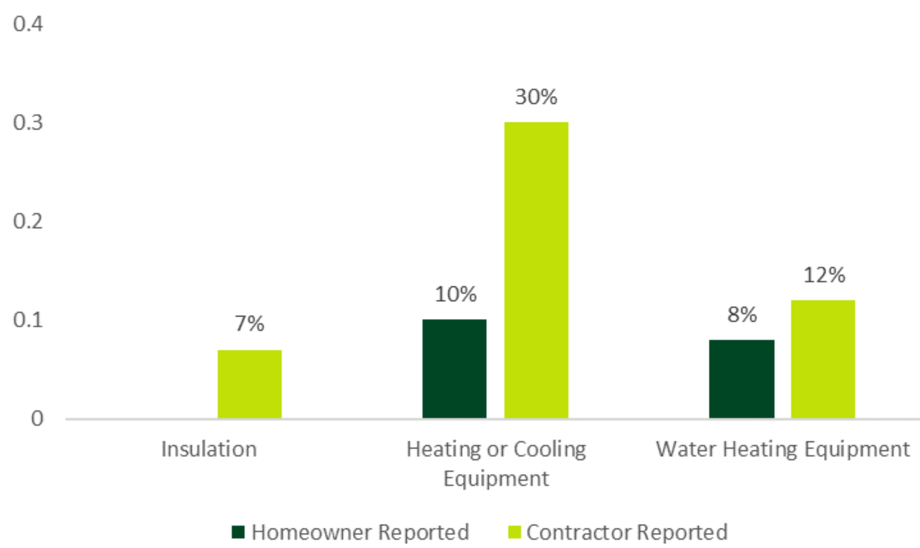
Key Decision Makers

- Homeowners
- Architects (when present)
- General contractors

Homeowners made limited construction-related requests. Homeowners rarely get involved in the specific construction methods of a project. Contractors reported that only about one-third of homeowners on projects involving heating or cooling equipment requested a specific type.[21] For insulation and water heating, survey respondents indicated that only about 1 in 10 homeowners made specific requests. Figure 3 shows the share of homeowners who made specific requests for insulation, heating, cooling, or water heating equipment, as reported by homeowners and contactors.[22]

Figure 3: Share of Homeowners Who Made Specific Requests by Measure

(source: homeowner survey, n=104; contractor survey, n=73)[a]



[a] The study did not ask homeowners about insulation.

Homeowner knowledge levels can steer the project. The extent to which homeowners defer to architect or contractor recommendations vary based on the homeowner's personal knowledge base. For example, according to the market actor interviewees, homeowners with no design or construction experience typically defer completely to the architects, engineers, or other team members. In these situations, the project team may present options to the homeowner based on the homeowner's motivations, preferences, and budget. Homeowners with a background in design or construction, or who have done their own substantial research, are more likely to request specific technologies and practices – these homeowners represented the participants for early renovation and addition pilot program participants.

[21] This better represents the average project in Connecticut. The homeowner responses are based on their specific projects, not the broader population of projects. Only 10% of surveyed homeowners who had heating or cooling projects reported requesting a particular system type.

[22] The homeowner survey reflects homeowners reporting on their own projects, while the contractor survey reflects contractor estimates for all their homeowner clients.

The standard practices of "non-decision makers" still influence projects. Subcontractors, such as carpenters, plumbers, electricians, HVAC contractors, and insulation contractors, are not typically involved in decision making regarding the project scope or energy-efficient practices. One insulation contractor said, "*insulators are usually in and out. It's an isolated part of the project*." However, subcontractors can determine the type of mechanical equipment installed. Surveyed contractors reported that they defer to plumber preferences for heating and cooling equipment 25% of the time and water heaters 31% of the time, giving these contractors significant influence, even if they are not traditionally considered decision makers. Surveyed contractors choose systems based on their own preferences 23% of the time for heating and cooling equipment and 25% of the time for water heating (Table 15).

Table 15: How Contractors Typically Determined What HVAC Systems to Install

(Source: contractor survey)

	Heating and Cooling	Water Heating
n	*40*	*32*
My customers requested a particular type	30%	12%
My plumber prefers to install a particular type	25%	31%
I prefer to install a particular type	23%	25%
We installed something similar to what was there before	18%	25%
Other	5%	6%

HERS raters are beneficial but are rarely involved with renovations and additions. Interviewees reported that HERS raters are not typically involved in the remodeling market. A participating HERS rater mentioned that when they were a remodeler, they did not know what a HERS rater was and said, "using a HERS rater is not very typical [for remodels] in Connecticut." A contractor said, "I don't think I've ever been involved with HERS raters in the scoping in the beginning." Nearly half (46%) of surveyed contractors had never heard the term "HERS rater" and another 40% said they had heard of HERS raters, but never worked with them.[23]

A participant architect reported that the addition of the HERS rater to the project team was a substantial benefit of the program:

> *"The special addition [the program offers] is the third-party certifier who is doing the blower door who, is going to look at the plans upstream and say, 'yes we can predict the home will use this much energy'."*

In fact, 45% of respondents in the contractor survey said they would be interested in program participation even if it required including a HERS rater on the project, while 32% said they would be uninterested.[24] One respondent said, "*I would welcome the opportunity to work with people familiar with energy efficiencies and incentives for the homeowner*."

[23] See E.1 in Appendix E.
[24] See E.1 in Appendix E.

In the three case study participant projects, the role of HERS raters varied widely in terms of their influence on the project. In one case, they served simply as an independent evaluator/diagnostic tester with no input on the project scope, in another, they made recommendations for the project lead to consider, and in the third, they served as an integral team member, driving the efficiency of the project (having been brought on to the team by the homeowner for that purpose).

3.4 Determining Project Scope and Energy Efficiency

Limited design in renovations and additions. The project scope, including the project's emphasis on energy efficiency, is determined in the early planning and design phase. Interviewees reported that the design phase in remodeling projects is often minimal. This limits the opportunity to incorporate energy-efficient practices if not specifically requested by the homeowner. Accordingly, the importance of the architect or general contractor and their standard practices can greatly influence the energy efficiency of the project. One participating architect noted,

> *"The design side bears a lot of the responsibility [for efficiency]. In remodeling there is not much of a design team. It may just be the general contractor who got the contract. Whoever has the responsibility to plan the project will decide the energy performance of the home."*

The interviewed Connecticut program staff recognized the importance of the design phase and mentioned that they tried to participate in the design phase of pilot projects. Specifically, the staff mentioned shaping projects to avoid "value engineering" that removes energy-efficient practices later in the project in the face of cost overruns. One program representative said,

> *"You almost have to do the value engineering up front with them. They come to you with the idea of closed cell spray foam, [but] maybe your best option is flash batts so you can use the $15,000 in extra savings on more solar. You have to do some of that value engineering up front."*

Once the plans are finalized and the design phase ends, the scope of the project rarely changes. An architect explained, "*People are just going to do what's on the plans. If the designer hasn't thought about designing for energy reduction it won't be in the plans and it won't be in the project.*" A participating contractor concurred by saying, "*We go into it with a scope of work and a budget. If you and people plan on the budget being the budget – unless they're extremely well off – most of the time, once you start, usually you don't go past what you've already agreed on*."

Recommendation rates and uptake. Sixty percent of surveyed homeowners reported receiving at least one recommendation for energy-efficient upgrades from either an architect, general contractor, or HVAC contractor on their project. Surveyed homeowners reported accepting 53% of recommendations for energy-efficient upgrades. The most frequently recommended energy-efficient upgrades were, "more/better insulation than required," a "high-efficiency water heater," and "high-efficiency heating or cooling systems."[25]

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[25] See E.2 in Appendix E.

Homeowners were most likely to accept recommendations for better insulation (75%) or high-efficiency heating or cooling systems (64%; Table 16). Surveyed contractors reported that more homeowners accept their recommendations than indicated in the surveyed homeowner sample. Surveyed contractors said that homeowners accepted their recommendations for heating or cooling equipment 90% of the time and for water heating equipment 77% of the time (Table 100 in Appendix E). These high recommendation acceptance rates highlight the importance of market actors *making the recommendations in the first place.*

Table 16: Homeowners' Acceptance of Recommendations

(Source: homeowner survey, "Which recommendations did you include in your project?")

(homeowners = 104)

Recommendations	Received Recommendation (n)	Accepted Recommendation	
		n	%
More/better insulation than required	36	27	75%
High-efficiency heating or cooling system	28	18	64%
High-efficiency lighting	24	14	58%
High-efficiency windows	26	13	50%
Air sealing / blower door test	18	9	50%
High-efficiency water heater	28	13	46%
High-efficiency ventilation system	14	6	43%
Solar panels (PV)	7	3	43%
High-efficiency appliances	16	6	38%
Duct sealing / duct leakage test	28	10	36%
Total	**225**	**119**	**53%**

Most case study interviewees reported that persuading homeowners to increase the energy efficiency of their projects in general is difficult, with one participating contractor saying that "it's rare." Interviewees highlighted costs and extended timelines as the main barriers to convincing typical homeowners to incorporate more energy-efficient practices into their projects. Appendix C.4 describes the barriers faced by the program in more detail.[26]

Thirty-nine percent of surveyed homeowners said that nothing got in the way of making all the efficiency upgrades they cared to; a similar amount (38%) mentioned costs as a limiting factor (Table 17).

[26] A non-participant interviewee provided an alternative suggestion for increasing uptake, which is to simply include the better practices into the cost of the project quote, and fully describe the benefits of the resulting project, rather than framing it as an additional or upgrade cost, thereby allowing the contractor to differentiate themselves from lower performers.

Table 17: Homeowner Reasons for Not Making Energy-Efficient Upgrades

(Source: homeowner survey, "What if anything, prevented you from making energy-efficiency upgrades as part of your project?")

(homeowners = 104)

Response	Percent of Homeowners
Nothing prevented me – I did everything I wanted to	39%
Cost	38%
I was not aware of any other efficiency options	8%
Contractor interest or ability	7%
Appearance / aesthetic concerns	6%
Time	3%
Not relevant	2%

While interview respondents indicated that increasing the scope of projects to improve the energy performance of the home is difficult, many saw typical renovations and additions as great opportunities to upgrade the energy performance of buildings. Specifically, interviewed respondents highlighted the ability to take advantage of the exposed building envelope during many renovation projects. Additionally, if homeowners do not incorporate energy-efficient practices during a renovation, they are less likely to upgrade that measure later because they do not want to work on a section of their home that they just completed. One architect said,

> *"If the exterior of the house needs to have a roof replaced or siding replaced, those are the ideal opportunities [for adding exterior insulation] because that's a sunk cost. You have to spend money on the siding anyway so while the siding is being removed and being put on there's an opportunity that is only going to happen then and there to add insulation on the outside of the house."*

3.5 HES Vendors

Respondents agreed that the market actors in the remodeling market are different than the professionals who serve as HES vendors. A Company representative theorized that the business model of HES vendors is not suited for the remodeling market. "*[HES vendors] have a goal of weatherizing so many homes a year; there's no way they have the time to do the work; this goes beyond building science and into the realm of design and redevelopment."* An architect affirmed and elaborated on this perception:

> *"They have a whole business model based on doing energy audits, coming in, fulfilling the program, getting paid according to that system and then upselling from there additional energy savings such as insulation or mechanical system replacement. They work directly for homeowners not for contractors. And their pace is different, they do the audit, they do the work, they schedule the work. It's a very specialized business. It's not designed to be integrated with remodeling projects."*

Still, some respondents saw potential for incorporating HES vendors into the remodeling market. One said, "*I would love to have had one of those providers be part of the team. They are equipped to be a part, but their business model doesn't make them a natural fit. They are two different animals*."

It may be unlikely that renovation contractors could readily incorporate HES vendors onto their project teams, but program renovation and addition projects could follow the minor project pathway, essentially requiring HES improvements in the whole home as a condition of participation.

Section 4 Characteristics of R&A Projects

The findings in this section are based entirely on the contractor and homeowner surveys. For additional findings, see Appendix D and Appendix E.

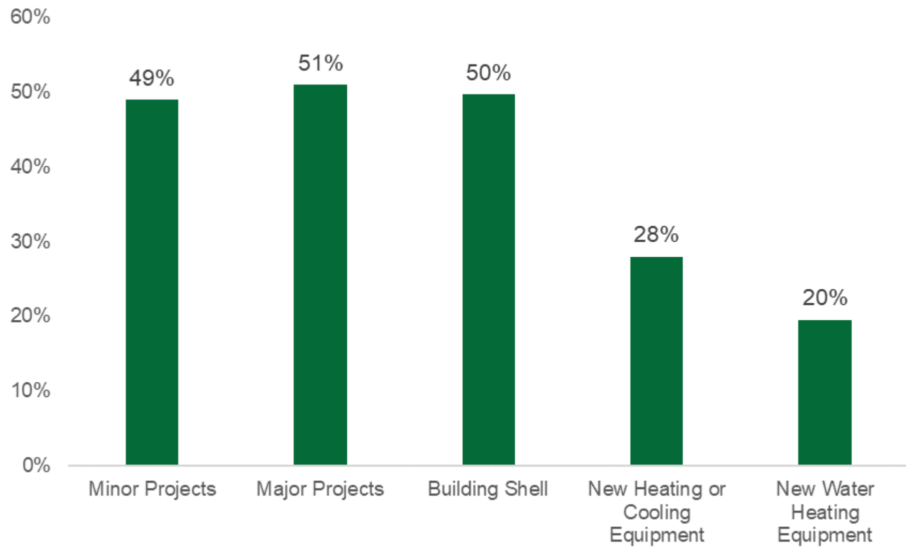
- About 49% of renovation and addition projects that would require permits are minor renovations of 500 square feet or less. This includes 20,060 renovation projects, 10,609 addition projects, and 2,180 projects that were both renovation and additions annually. On average, these projects were about 300 square feet.
- About 51% of renovation and addition projects that would require permits are major renovation greater than 500 square feet. This includes 24,518 renovation projects, 5,712 addition projects, and 4,633 projects that have both renovations and additions annually. On average, these projects were about 1,000 square feet.
- The most common renovation types are kitchen and bathroom renovations. The most common addition types are building a new section of the house, finishing a basement, or finishing a porch or sunroom.
- Key measures in renovation and addition projects are heating and cooling equipment, water heating equipment, insulation, and windows.
- Seventy percent of heating and cooling system replacements and 75% of water heater replacements are like-for-like replacements.

Figure 4 summarizes project scopes across all surveyed contractors' renovation and addition projects.

- The market is split relatively evenly between minor and major projects in terms of square footage affected.
- At least half of all projects involve work on the building shell, providing an opportunity for shell-related savings. This includes all addition projects and 41% of renovations.
- More than one fourth of all projects (28%) involve installing new heating or cooling equipment either to replace old equipment or to serve new spaces. Customers reported installing new mechanical equipment to increase system size, get a more efficient model, or to replace a broken system.
- One fifth of projects (20%) include installing new water heaters. The main motivations for installing new water heaters are replacing a broken system, customers wanting unlimited hot water, or needing bigger water heaters.
- Three-fourths of mechanical equipment replacements are "like-for-like" replacements.

Figure 4: Summary of Project Scopes

(source: contractor survey, n=783)



4.1 Project Types

All 73 contractors who responded to the web-survey had worked on renovation projects in 2019 in Connecticut. Thirty-six of the 73 contractors had also worked on projects that were either only additions or both renovation and additions. Table 18 shows the count of projects across all surveyed contractors that were each type. Overall, contractor respondents had worked on 783 projects in 2019 in Connecticut, 94% of which included renovations and 15% of which included additions.

Table 18: Surveyed Contractors' Projects in 2019

(Source: contractor survey, "How many of the following projects did you work on in Connecticut in 2019 in single-family homes?")

(contractors = 73)

Project Type	Count of Projects	Percent of Projects	Respondents
Renovation only	668	85%	96%
Addition only	46	6%	26%
Renovation and addition	69	9%	44%
Total	**783**	**100%**	**100%**

Table 19 shows the most recent projects undertaken by surveyed homeowners. Ninety-three percent of homeowners had projects that included renovations and 54% had projects that included additions.

Table 19: Surveyed Homeowners' Projects in 2019

(source: homeowner survey, homeowners = 104)

Project Type	Count of Projects	Percent of Projects
Renovation only	48	46%
Addition only	7	7%
Renovation and addition	49	47%
Total	**104**	**100%**

The most frequent type of renovations according to both the homeowner and contractor survey responses are kitchen and bathroom renovations (Table 20). "Other" types of renovations included, "repairs," "doors and windows," "roofing," or "adding walls."

Table 20: Contractor and Homeowner Reported Types of Renovation Projects

(Source: contractor survey, "Of your renovation projects, what percentage included the following?" homeowner survey, "Which of the following did your renovation or addition project include?")

(contractors = 73, homeowners = 97)

Renovation Type	Percent of Contractors	Percent of Contractors' Renovation Projects	Percent of Homeowners' Renovation Projects
n	*73*	*738*	*97*
Kitchen	84%	31%	54%
Bathroom	88%	26%	54%
Bedroom	41%	6%	22%
Living/dining room	44%	6%	28%
Combining rooms by removing interior walls	42%	9%	14%
Other (please specify)	36%	29%	9%

The most frequent addition type for surveyed contractors was "building a new section of the house," followed by "finishing a basement." For surveyed homeowners, the most frequent addition type was "finishing a basement," followed by "finishing a porch or sunroom" (Table 21).

Table 21: Contractor and Homeowner Reported Types of Addition Projects

(Source: homeowner and contractor survey, "Of your addition projects, what percentage included the following?")

Addition Type	Percent of Contractors' Addition Projects	Percent of Homeowners' Addition Projects
n	*115*	*56*
Finishing a basement	17%	59%
Building a new section of the house	33%	13%
Finishing a porch or sunroom	10%	27%
Finishing an attic space or bonus room over a garage	13%	20%
Adding a story to the home	9%	14%
Other (please specify)	2%	5%

4.2 Project Size

Small renovations (no more than 500 ft^2 of conditioned floor area), which would use the minor project path of the program, accounted for 45% of all renovation projects across all surveyed contractors, while 55% of renovations were larger than 500 ft^2 (Table 22). Fifty-eight percent of contractors' renovation projects were between 100 and 1,000 ft^2. The average size of renovations reported by surveyed homeowners was 590 ft^2 (Table 23).

Small additions (500 ft^2 or less) account for 65% of all addition projects across all surveyed contractors, while large additions (greater than 500 ft^2) comprised 35% (Table 24). Seventy-eight percent of contractors' addition projects were between 100 and 1,000 ft^2. The average size of addition projects reported by surveyed homeowners was 369 ft^2 (Table 23).

Table 22: Contractor Reported Renovation Project Size

(Source: contractor survey, "What percentage of your renovation projects fell into each of the following size categories?)"

(contractors = 73)

	Percent of All Renovations	Count of Contractors	Average Percent per Contractor
n	*738*	*73*	*73*
Less than 100 ft^2	9%	24	10%
100 to 500 ft^2	36%	46	36%
501 to 1,000 ft^2	22%	33	23%
1,001 to 1,500 ft^2	15%	20	13%
More than 1,500 ft^2	18%	24	19%

Table 23: Size of Homes and Projects (Square Feet)

(Source: homeowner and contractor survey, "What size is the home you renovated or expanded--including the addition?)"

	Size of Renovation (Reported by Homeowner)	Size of Addition (Reported by Homeowner)	Size of Home (Reported by Homeowner)	Average Home Size (Reported by Contractors)
n	*74*	*33*	*82*	*73*
Minimum	50	50	500	100[a]
Maximum	2,400	2,000	6,000	8,000
Mean	590	369	1,955	2,550
Median	500	300	1,800	2,400
Sd.	485	359	877	1,271

[a] The survey asked contractors and homeowners to confirm any response that was less than or equal to 100 ft^2.

Table 24: Contractor Reported Addition Project Size

(Source: contractor survey, "What percentage of your addition projects fell into each of the following size categories?)"

(contractors with addition projects = 36)

	Percent of All Additions	Average Percent Per Contractor
n	115	36
Less than 100 ft^2	8%	12%
100 to 500 ft^2	57%	39%
501 to 1,000 ft^2	21%	29%
1,001 to 1,500 ft^2	8%	9%
More than 1,500 ft^2	6%	11%

Nearly two-thirds of renovation projects have large enough scopes to accommodate energy-efficiency upgrades. Contractors reported that 59% of their renovation projects were “complete guts” or “substantial renovations.” Similarly, 68% of homeowners characterized their renovation projects as “complete guts” or “substantial renovations” (Table 25).

Table 25: Renovation Scope

(Source: contractor survey, “What percentage of your renovation projects fell into each of the following categories?”; homeowner survey, “Which of the following best describes the work done in the room(s) you renovated?)”

	Percent of All Contractor Renovations Projects	Percent of Homeowners’ Projects
n	*738*	*97*
Complete gut	41%	26%
Substantial renovation	18%	42%
Limited renovation	10%	18%
Minor/aesthetic changes	12%	10%
Other	19%	4%

According to surveyed homeowners, 59% of renovation projects cost between $2,000 and $10,000, with another 28% between $10,001 and $50,000. One-half of the additions cost between $20,000 and $50,000. Projects involving both renovations and additions have a larger variation in costs, with 59% costing between $5,001 and $50,0000 (Table 26).

Table 26: Homeowner Reported Project Cost

(Source: homeowner survey, “Including labor and materials how much did this project cost?)”

(homeowners excluding outliers and invalidated responses = 104)

	Renovation Only	Addition Only	Renovation and Addition
n	46	6	49
Less than $2,000	9%	33%	4%
$2,000 to $5,000	33%	0%	12%
$5,001 to $10,000	26%	17%	14%
$10,001 to $20,000	13%	0%	27%
$20,001 to $50,000	15%	50%	18%
$50,001 to $100,000	2%	0%	10%
$100,001 to $200,000	2%	0%	10%
More than $200,000	0%	0%	4%

A little less than half (44%) of homeowners hired professionals to conduct all the project work, while 14% did their entire project themselves (Table 27). The most frequent types of work done by homeowners were painting (80% of homeowners who did some work themselves), designing (66%), and installing fixtures (56%). About 40% of Do-It-Yourself (DIY) projects included more substantial work, such as demolition (44%), flooring or tile installation (42%), or carpentry or insulation work (34%) (Table 28). For homeowners who are not industry professionals, some of this DIY R&A work likely includes lost opportunities as homeowners may not understand energy-efficient practices or have the technical expertise to execute them.

Table 27: DIY Portions of Projects

(Source: homeowner survey, "what percent of the work was done by hired help (such as contractors)?")

(homeowners = 104)

Portion of Project that was DIY	Percent of Homeowners
None (all work conducted by hired help)	44%
1% to 25%	12%
26% to 50%	8%
51% to 75%	4%
76% to 99%	18%
All (completely DIY)	14%

Table 28: Types of Work Done DIY By Homeowners

(Source: homeowner survey, "what kind of work did you do yourself?")

(homeowners who did work themselves = 59)

Types of Work	Percent of Homeowners
Painting	80%
Design (choosing layout, materials, etc.)	66%
Installing fixture (lighting, mirrors, showerheads, etc.)	56%
Demolition	44%
Flooring or tile installation	42%
Carpentry or insulation work	34%
Plumbing (installing water heater or toilets, running water lines, etc.)	22%
Major electrical work	12%
Heating/cooling system repair or installation	8%
Other (please specify)	2%

Most surveyed contractors noted that blower door tests are never conducted in their renovation (69%) or addition projects (53%; Table 29). Fewer respondents (11% for renovations and 22% for additions) noted that blower door tests occur "less than half the time."

Table 29: Contractor Reported Blower Door Tests

(Source: contractor survey, "How often were blower door tests done on the projects you worked on in the last year?")

(contractors = 73)

	Renovation	Additions
n	*73*	*36*
Always	5%	6%
More than half the time	4%	6%
About half the time	1%	3%
Less than half the time	11%	22%
Never	69%	53%
Don't know	10%	11%

4.3 Mechanical Systems

Surveyed homeowners and contractors indicated that between 40% and 45% of renovation and addition projects included work on heating or cooling equipment. About 20% to 28% of projects included installing a new system (either to replace an old system or add an additional capacity). A fourth of homeowners' projects (25%) included alterations or repairs to existing systems, while contractors noted that such alterations comprise only 13% of their projects (Table 30).

Table 30: Homeowner and Contractor Reported Heating and Cooling Equipment Scope

(Source: homeowner survey, "What did you do to your heating or cooling equipment as part of this project?)"; contractor survey, "Of your projects, what percentage included each of the following?")

(homeowners = 104, contractors = 73)

	Percent of Homeowners Projects	Average Percent of Contractor Projects
Left it as-is / not part of the project	55%	60%
Replaced it	13%	17%
Repaired or serviced it	14%	4%
Altered it so the existing system could serve the addition	11%	9%
Added an additional system	7%	11%
Don't know	1%	0%
Other (please specify)	1%	0%

Surveyed homeowners most frequently said the motivation for including heating or cooling equipment in their project was because they wanted a more efficient model (32%), followed by their system "needing repair/going to fail soon" (26%) and "needing a bigger or additional system to serve an addition" (26%) (Table 31).

Surveyed contractors highlighted the same three reasons when asked why a new heating or cooling system was installed. They said the most frequent reason was because a "bigger or additional system was needed to serve an addition," followed by the "customer wanting a more efficient model" and an old "system failing or needing repair" (Figure 5).

Table 31: Homeowner Reported Reasons for Heating or Cooling Improvements

(Source: homeowner survey, "Why was heating or cooling equipment part of your renovation or addition project?)"

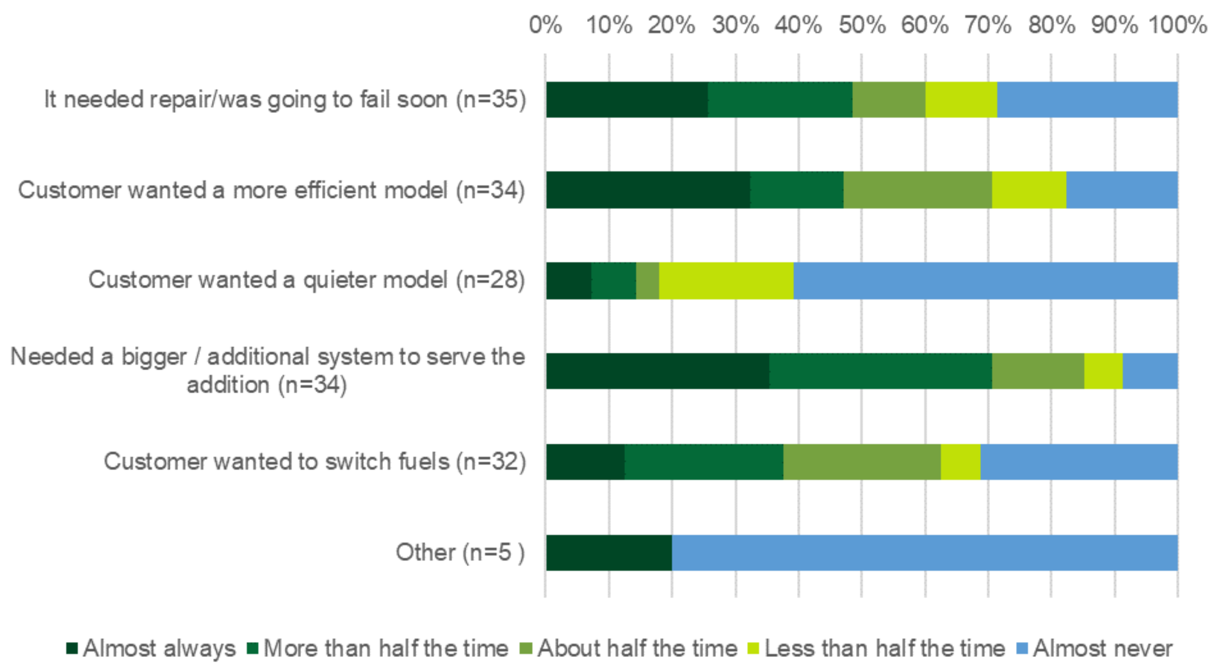
(homeowners with heating and or cooling projects = 47)

	Count	Percent
Wanted a more efficient model	15	32%
It needed repair / was going to fail soon	12	26%
Needed a bigger / additional system to serve the addition	12	26%
Wanted a quieter model	8	17%
Wanted to switch fuels	5	11%
Other (please specify)	1	2%

Figure 5: Contractor Reported Reasons for Heating or Cooling Improvements

(Source: contractor survey, "When a new HVAC system was installed, how often was it due to each of the following reasons?)"

(contractors with heating or cooling projects = 35)



Like-for-like replacements remains common, MSHPs gain traction. Of the 20 systems homeowners reported installing as replacements in Table 32, 14 were like-for-like replacements, two replaced conventional fossil fuel systems with heat pumps, two replaced heat pumps with conventional systems, and two replaced a conventional system with a different system type of similar efficiency (e.g., a furnace with a boiler). Of the six systems homeowners reported adding as additional capacity, two were furnaces, two were electric baseboards, one was a central air-conditioner, and one was a ground-source heat pump.

When asked about heating and cooling equipment that they removed and installed, contractors indicated that most renovation projects included like-for-like replacements (Table 33). For example, 32% of removed equipment in renovations were furnaces and 29% of installed equipment were furnaces. The systems with the largest gaps between removals and installations, indicating an increase in saturation, were ductless minisplits (MSHP) (1% of removals and 14% of installations) and central air-conditioners (11% of removals and 20% of installations).

The low amount of MSHP removals is due to the technology being relatively new and not having many systems in existing homes. The increase in central air-conditioners could reflect homes installing central air conditioning for the first time. There was also a big gap in electric baseboards (14% of removals and only 4% of installations) which points to homeowners removing electric baseboards overall. In projects that included additions, most replacements appear to be like-for-like, with mostly equal percentages reported by contractors for removals and installations. This could represent situations where systems are replaced with systems of greater capacities to serve the addition without changing the distribution system for the home. Still, contractors indicated that more MSHPs are installed than replaced in addition projects (5% replaced to 14% installed). This could reflect homes where supplemental MSHPs are installed in additions (Table 33 and Table 34).

Table 32: Homeowner Reported Equipment Replacements and Installations

(Source: homeowner survey, "What kind of heating or cooling equipment did you remove?" and "What kind of heating or cooling equipment did you install?")

(installed equipment = 26)

Replaced equipment	Installed Equipment						
	Furnace	Boiler	ASHP	Elec. Baseboard	CAC	MSHP	GSHP
Furnace	4		1			1	
Boiler	1	2					
Electric baseboard				2			
MSHP						1	
Central ASHP			2	1	1		
GSHP							
Central AC					3		
Window AC					1		
None (new install)	2			2	1		1

Table 33: Contractor Reported Equipment Removals and Installations (Renovations)

(Source: contractor survey, "What percentage of the HVAC systems your removed/installed were each of the following types?)"

(contractors = 73)

	Removals		Installations	
	Contractors	Avg % of Projects	Contractors	Avg % of Projects
Furnaces	13	32%	20	29%
Central AC	8	11%	19	20%
Boiler	15	33%	15	22%
MSHP	2	1%	12	14%
ASHP	1	0%	4	4%
Electric baseboard	6	14%	3	4%
GSHP	0	0%	3	4%
Window or portable RAC	5	6%	2	1%
Other	1	3%	1	2%

Table 34: Contractor Reported Equipment Removals and Installations (Additions)

(Source: contractor survey, "What percentage of the HVAC systems your removed/installed were each of the following types?)"

(contractors = 73)

	Removals		Installations	
	Contractors	Avg % of Projects	Contractors	Avg % of Projects
Furnaces	12	42%	17	38%
Central AC	8	19%	10	19%
Boiler	8	13%	6	8%
MSHP	2	5%	9	14%
ASHP	1	1%	4	6%
Electric baseboard	4	4%	3	6%
GSHP	1	1%	2	5%
Window or portable RAC	4	5%	2	2%
Other	2	11%	1	3%

Contractors reported that Heat Recovery Ventilation systems (HRVs) and Energy Recovery Ventilation systems (ERVs) are only included in 11% of renovation projects and 20% of addition projects (Table 35).

Table 35: Contractor Reported HRV or ERV Penetration

(Source: contractor survey, "On what percentage of your projects did you install a Heat Recovery Ventilation system (HRV) or Energy Recovery Ventilation system (ERV) unit?")

(contractors = 73)

	Renovations	Additions
n	*70*	*35*
Minimum	0%	0%
Maximum	100%	100%
Mean	11%	20%
Median	0%	0%
Sd.	27%	32%

Water heaters were part of 36% of surveyed homeowners' projects, 21% of contractors' renovation projects, and 26% of addition projects. When water heaters were involved in projects, it typically involved replacing an old water heater. Twelve percent of homeowners also reported having water heaters repaired or serviced (Table 36).

Table 36: Homeowner and Contractor Reported Water Heating Equipment Scope

(Source: homeowner survey, "What did you do to your water heater as part of this project?"; contractor survey, "What percentage of your projects included each of the following?")

(homeowners = 104, contractors n=73)

	Homeowner Percent	Average Percent of Contractor Projects (Renovations)	Average Percent of Contractor Projects (Additions)
Left it as-is / not part of the project	64%	72%	60%
Replaced it	23%	17%	20%
Repaired or serviced it	12%	2%	2%
Altered it so the existing system could serve the addition	0%	0%	0%
Added an additional system	0%	2%	4%
Don't know	0%	7%	14%
Other (please specify)	1%	0%	0%

Surveyed homeowners most frequently said that expecting a water heater to fail soon or a water heater needing repair was the most common reason for involving water heaters in a renovation project (44%). The next most frequently cited reasons were "wanting unlimited hot water" (40%) and needing a bigger/additional system to serve an addition (24%; Table 37). Contractors also most frequently highlighted a water heater needing repair and customers wanting unlimited hot water as the top two reason water heaters were installed (Figure 6).

Table 37: Homeowner Reported Reasons for Water Heater Improvement

(Source: homeowner survey, "Why was your water heater included in your renovation or addition project?)"

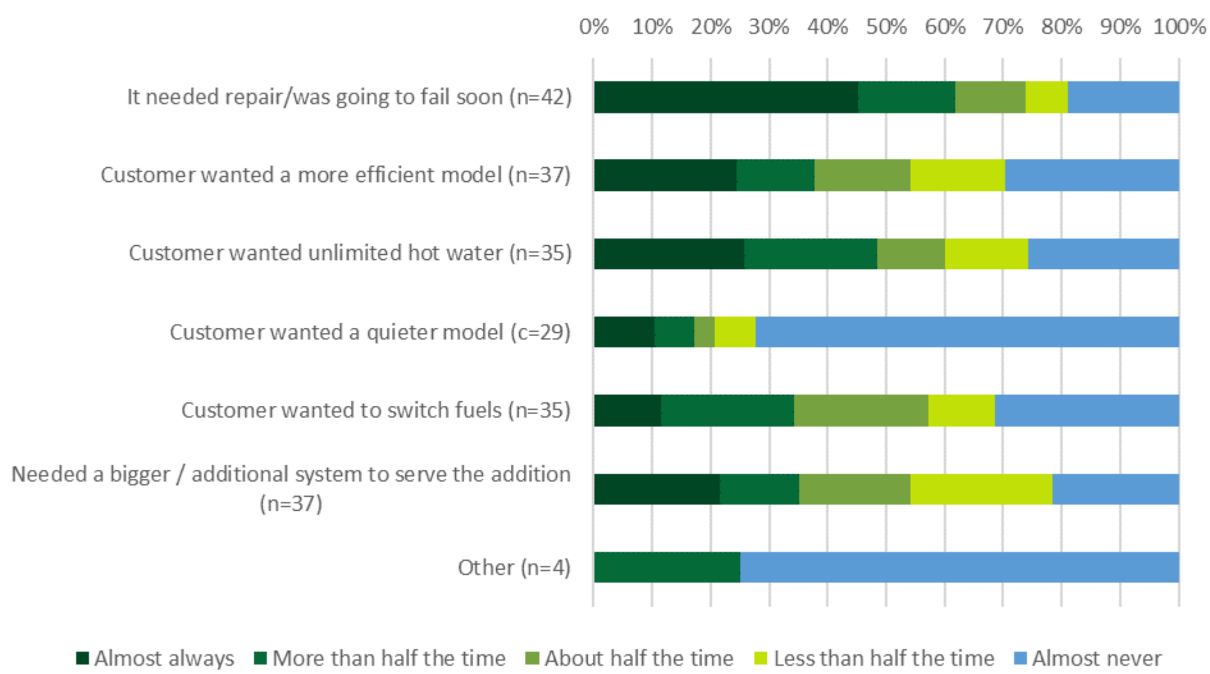
(multiple response; homeowners who installed water heater(s) = 25)

	Count	Percent
Needed repair/ was going to fail soon	11	44%
Wanted unlimited hot water	10	40%
Needed a bigger/additional water heater to serve the addition	6	24%
Wanted a more efficient model	5	20%
Wanted a quieter model	3	12%
"Needed upgrade"	2	8%

Figure 6: Contractor Reported Reasons for Water Heating Improvements

(Source: contractor survey, "When a new water heater was installed in your projects, how often was it due to each of the following reasons?")

(contractors = 73)



Of the 20 water heaters homeowners reported replacing, 15 were like-for-like replacements, three replaced indirect systems with stand-alone systems, two were upgrades from conventional electric to heat pump water heaters, and one was a fuel switch from an electric tank to a gas tank. One homeowner reported adding a solar hot water heater (Table 38).

Surveyed contractors' estimates of the share of water heaters removed and installed indicate that most system replacements are like-for-like systems (Table 39 and Table 40). Still, tankless systems stood out as having far less removals than installations (3% compared to 16%) for renovations, pointing to their increasing share of the market.

Table 38: Homeowner Reported Water Heating Equipment Scope

(Source: homeowner survey, "What did you do to your water heater as part of this project?)"

(homeowners who installed water heater(s) = 23[a])

Replaced System	Gas or Propane Storage	Electric Storage	Gas Tankless	HPWH	Indirect attached to boiler	Solar
Gas or propane storage tank	3					
Electric storage tank (conventional)	1	8		2		
Gas tankless			3			
HPWH				1		
Indirect attached to boiler	1				1	
Indirect attached GSHP		1	1			
None (new install)						1

[a] Two homeowners did not know what type of system was replaced and installed.

Table 39: Contractor Reported Water Heater Removals and Installations (Renovations)

(Source: contractor survey, "What percentage of the water heaters you removed/installed were each of the following types?)"

(contractors = 73)

	Removals		Installations	
	Contractors	Avg % of Projects	Contractors	Avg % of Projects
Gas/propane storage	20	49%	19	43%
Gas/propane tankless	4	3%	9	16%
Electric storage	13	21%	10	15%
HPWH	3	3%	2	2%
Solar thermal	1	1%	0	0%
Indirect	6	12%	7	14%
Tankless coil	1	3%	1	3%
Other	6	10%	6	11%

Table 40: Contractor Reported Water Heater Removals and Installations (Additions)

(Source: contractor survey, "What percentage of the water heaters you removed/installed were each of the following types?)"

(contractors = 73)

	Removals		Installations	
	Contractors	Avg % of Projects	Contractors	Avg % of Projects
Gas/propane storage	9	42%	10	33%
Gas/propane tankless	3	6%	7	20%
Electric storage	9	24%	7	12%
HPWH	1	2%	3	8%
Solar thermal	1	1%	1	6%
Indirect	4	23%	4	11%
Tankless coil	0	0%	0	0%
Other	2	2%	4	15%

4.4 Building Shell

When building shell components are involved during renovations, contractors reported installing average R-values that met prescriptive code for foundation walls, frame floors and ducts (Table 41 through Table 44). The average reported R-values for flat (R-33) and vaulted ceilings (R-32) are below prescriptive code (R-49), while the average R-value for walls (R-18) is only slightly less (R-20). For additions, contractors reported average R-values that met prescriptive code for walls, foundation walls, frame floors, and ducts. Average R-values for ceilings over additions were still below code, though higher than average R-values for renovations.

Table 41: Renovation Wall and Ceiling Insulation R-Values

(Source: contractor survey, “Please describe the R-value of the insulation you typically installed in each of the following places, when they were part of your projects.”)

(contractors = 73)

	Walls	Foundation Walls	Flat Ceiling	Vaulted Ceilings	Roof Rafter
n	*55*	*41*	*45*	*33*	*32*
Minimum	13	5	1[a]	13	13
Maximum	45	38	50	60	60
Mean	18	16	33	32	34
Median	19	15	38	30	34
Sd.	6	6	11	10	10

[a] Potentially indicated they do not insulate.

Table 42: Renovation Floor and Duct Insulation R-Values

(Source: contractor survey, “Please describe the R-value of the insulation you typically installed in each of the following places, when they were part of your projects.”)

(contractors = 73)

	Floor over Basement	Floor Over Garage	Floor Over Ambient	Supply Duct Basement	Supply Duct Attic
n	*43*	*37*	*36*	*23*	*14*
Minimum	11	13	13	5	5
Maximum	38	48	50	25	19
Mean	22	29	30	12	11
Median	21	30	30	8	8
Sd.	7	8	8	6	5

Table 43: Addition Wall and Ceiling Insulation R-Values

(Source: contractor survey, "Please describe the R-value of the insulation you typically installed in each of the following places, when they were part of your projects.")

(contractors = 73)

	Walls	Foundation Walls	Flat Ceiling	Vaulted Ceilings	Roof Rafter
n	*28*	*23*	*26*	*22*	*20*
Minimum	15	10	1	15	15
Maximum	38	30	49	49	49
Mean	21	17	35	35	36
Median	21	15	38	38	38
Sd.	5	6	11	9	9

Table 44: Addition Floor and Duct Insulation R-Values

(Source: contractor survey, "Please describe the R-value of the insulation you typically installed in each of the following places, when they were part of your projects.")

(contractors = 73)

	Floor over Basement	Floor Over Garage	Floor Over Ambient	Supply Duct Basement	Supply Duct Attic
n	*23*	*23*	*24*	*13*	*13*
Minimum	11	15	12	5	5
Maximum	30	48	50	19	19
Mean	23	29	32	11	11
Median	21	30	30	8	8
Sd.	7	9	8	6	5

Surveyed contractors reported that they use fiberglass batts as insulation in at least 6 out of 10 projects for walls and ceilings in both renovations and additions (Table 45).

Table 45: Wall and Ceiling Insulation Types

(Source: contractor survey, "Please describe the insulation material you typically installed in each of the following places, when they were part of your projects.")

(contractors = 73)

	Renovation		Addition	
	Wall	Ceiling	Wall	Ceiling
n	*71*	*70*	*35*	*35*
Fiberglass batts	62%	69%	63%	71%
Spray-applied foam	18%	11%	20%	17%
Blown-in or spray-applied cellulose	8%	1%	6%	3%
Mineral wool/rock wool batts	7%	7%	6%	3%
Rigid foam board	1%	4%	6%	3%
Blown-in fiberglass	0%	4%	0%	3%
Other	3%	3%	0%	0%

Contractors reported that ceiling insulation work usually only occurs in the ceiling above the project area (59% for renovations and 63% for additions) rather than throughout the whole home (33% for renovations and 37% for additions) (Table 46).

Table 46: Contractor Reported Ceiling Insulation Levels

(Source: contractor survey, "Which of these best describes your typical attic insulation practice on renovation/addition projects?

(contractors = 73)

	Renovation	Additions
n	*69*	*35*
Insulated only the attic space above renovated room or addition	59%	63%
Insulated the attic space above the whole home	33%	37%
Other	7%	0%

Contractors reported that new double-pane windows were installed in 55% of their renovation projects and 86% of their addition projects. Thirty-two percent of renovation projects do not involve windows, while only 3% of addition projects do not involve windows. Triple-pane windows were rarely installed (Table 47).

Table 47: Types of Installed Windows

(Source: contractor survey, "What percentage of your projects included the following?)"

(contractors = 73)

	Renovations		Additions	
	Contractors	Avg % of Projects	Contractors	Avg % of Projects
New double-pane windows or sliding doors	62	55%	34	86%
New storm windows	10	4%	3	3%
New triple-pane windows or sliding doors	9	3%	4	3%
No new windows	39	32%	5	3%
Other	5	5%	2	6%

Table 48: Installed Insulation During Renovations

(Source: contractor survey, "When you exposed the framing of an exterior wall during a renovation, how much insulation did you typically install in that wall, if any?)"

(contractors = 73)

	Percent
Enough to meet a specific R-value	64%
Enough to fill the existing wall cavity	23%
None; code does not require insulation in exterior walls being renovated	1%
Don't know	1%
Other	10%

5

Section 5 Gross Technical Potential Findings

A primary goal of the study was to estimate the energy savings potential for the renovations and additions market in Connecticut (i.e., the amount of savings that could be achieved if all renovation and addition projects in the state in a given year participated in the program and achieved the levels of energy efficiency common to program projects, based on the study's modeling). The study used prototype energy models with energy modeling software to simulate different renovation and addition scenarios and their associated savings. The values below are estimates; the prototype energy models cannot describe all possible renovation and addition scenarios. Assumptions included in the models are described in Appendix A.2.

- Average estimated GTP savings per home are 15.6 MMBtu for projects 500 ft^2 or less, 36.9 MMBtu for projects greater than 500 ft^2, and 26.2 MMBtu overall.
- The 26.2 MMBtu average GTP savings per home is close to the average achieved 2020 savings per home for RNC program participants from the C&LM plan (28.9 MMBtu) and much higher than the average achieved per-home savings HES core services (6.2 MMBtu).
- Heating is the main driver of overall savings for renovations and additions, representing 81% of potential savings.
- Projects with the largest scopes achieve the highest average savings, but they are more expensive projects and represent a smaller portion of the market.

For each prototype model, a baseline and upgrade scenario were created, and savings were calculated by taking the difference in energy consumption between the two scenarios. A total of 96 energy models were created and the resulting model-level savings were scaled up to the Companies' territory and to the state level using a weighted scheme representing the relevant distributions of project type, project scope, heating fuel, and climate for those areas.

Detailed energy consumption values for each of the baseline and upgrade scenario energy models included in the study are provided in spreadsheet form as Appendix H.

5.1 Savings by Project

The study included energy models to simulate the baseline (pre-renovation/addition) and upgrade (post-renovation/addition) scenarios for each model type. Table 49 shows the mean savings per project by heating fuel type and project size. Oil savings may be overstated due to the assumption that homes undergoing a major renovation or addition in which the HVAC system was being upgraded would switch to a ductless mini-split heat pump rather than a more efficient oil system. Models with fuel switching resulted in large oil savings, as well as negative electric savings due to the added electric heating and cooling consumption. Projects going through the major pathway (greater than 500 ft^2) represent significantly larger potential savings per project than the minor pathway. It should be noted the current PSD does not support fuel switching scenarios, and therefore the oil savings shown below may not currently represent a claimable opportunity for the

Companies. Excluding the oil savings resulting from fuel switching, the average per project savings decreases slightly to 13.8 MMBtu for minor projects, 28.4 MMBtu for major projects, and 21.2 MMBtu overall.

Table 49: Mean Per Project Gross Technical Potential Savings by Heating Fuel and Project Size (MMBtu)

Fuel	Minor	Major
Electric	14.0	49.2
Natural Gas	13.9	18.0
Oil	13.4	63.8[a]
Propane	13.9	18.0
Total	**15.6**	**36.9**

[a] Oil heated prototype homes underwent fuel switching in models where HVAC changes were included. They were converted to heat pumps. This increased oil savings and decreased electric savings.

Table 50 presents mean savings for prototype models by end use. Reducing heating consumption represents the largest opportunity for savings by a wide margin. Domestic hot water savings are far lower than heating on average. Cooling savings are minimal in all scenarios due to low cooling loads, and because some pre-renovation prototype homes were designed without cooling, and some included additional cooling demand from added heat pumps. Lighting savings assume that the program upgrades lighting throughout the home, regardless of project scope. This analysis also assumes no savings from appliance upgrades.

Table 50: Mean Per Project Gross Technical Potential Savings by Fuel and End Use (MMBtu)

End Use	Savings
Heat	
Electric	24.4
Natural Gas	13.9
Oil	38.6
Propane	13.9
Heat Total	**20.5**
Domestic Hot Water	
Electric	4.7
Natural Gas	2.1
Propane	2.1
DHW Total	**3.4**
Other Electric	
Cooling	0.2
Lighting	2.2
Total	**26.2**

Measure Level Contribution to Savings. Heating is the main driver of overall savings for renovations and additions, based on modeling. Table 51 shows the relative contribution of various measures on heating savings. Air sealing improvements are the largest contributors to savings, followed by floor insulation. Wall insulation represents the lowest contribution to savings due to the ISP baseline being very close to what the program would be able to achieve in wall cavities.

Table 51: Measure-Level Contribution to Potential Savings

Measure	Savings Contribution
Air sealing	46%
Floor insulation	30%
Ceiling Insulation	14%
Windows	6%
Wall insulation	4%

Table 52 presents the average savings by project type for the modeled projects. Addition-only projects achieve the lowest savings since they are compared to the relatively efficient UDRH baseline. Logically, projects with the largest scopes – that include a renovation and addition – achieve the highest average savings, but they are more expensive projects and represent a smaller portion of the market.

Table 52: Per Project Gross Technical Potential Savings by Fuel and Project Type (MMBtu)

Fuel	Savings
Renovation Only	
Electric	37.8
Natural Gas	13.7
Oil	55.5
Propane	13.7
Total	**28.5**
Addition Only	
Electric	12.0
Natural Gas	10.8
Oil	3.9
Propane	10.8
Total	**13.0**
Renovation and Addition	
Electric	45.0
Natural Gas	23.4
Oil	56.4
Propane	23.4
Total	**37.3**

5.2 STATEWIDE SAVINGS

After calculating savings for each individual prototype model, the study scaled the resulting savings up to represent the potential savings associated with projects across the state, assuming that all projects participated and achieved savings similar to those described in the study's limited energy modeling. Using estimates of project counts adjusted to include non-permitted projects, the project level savings were scaled up to the entire state using a weighting scheme based on the penetration of project types (renovation, addition, or renovation and addition), project scope (minor or major), heating fuel, and climate zone (two across the state). Additionally, the homeowner survey estimated that 14% of homeowners undergoing R&A projects did all of the work themselves (See Section 4.2 for additional information); the GTP savings values assume all projects went through the program, DIY or not, and thus is a higher estimate than the potential that is economic or achievable.

Table 53 shows the statewide potential savings estimates for the Connecticut renovation and addition market, broken out by fuel type and project scope, based on the assumptions and energy models previously described.

Oil-heated homes represent the highest estimated potential savings, which is expected due to the prevalence of oil in the state, as well as the assumption that oil heated homes would undergo fuel switching during the renovation and install heat pumps. This assumption also added electric heating load to many homes, and so total electric savings represent a net value after taking these negative electric heating savings into account. Projects going through the major project pathway represent larger potential savings than the minor pathway for all fuel types.

Table 53: Statewide Gross Technical Potential Savings by Fuel and Project Size (MMBtu)

Fuel	Minor Projects	Major Projects	Total
Electric	111,199	181,254	292,453
NG	104,236	237,478	341,714
Oil	110,966	1,233,260	1,344,226[a]
Propane	11,269	25,673	36,942
Total	**337,670**	**1,677,665**	**2,015,335**

[a] Oil heated homes underwent fuel switching in models where HVAC changes were included. They were converted to heat pumps. This increased oil savings and decreased electric savings.

Table 54 shows lower savings values, excluding modeled savings associated with fuel-switching and lighting. The study provides these additional values because the current PSD generally does not allow the Companies to claim savings from fuel switching, and because in the near future, they also will not be able to claim savings from lighting improvements.

Table 54: Statewide Gross Technical Potential Savings Excluding Fuel Switching and Lighting (MMBtu)

Fuel	Minor Projects	Major Projects	Total
Adjusted electric savings	**47,669**	**287,804**	**335,473**
Natural gas savings	104,236	237,478	341,714
Adjusted oil savings	**110,967**	**0**	**110,967**
Propane savings	11,269	25,673	36,942
Total adjusted savings	**274,140**	**550,955**	**825,096**

Table 55 shows the full statewide potential savings estimates by end use. Reducing heating consumption represents the vast majority of potential savings (81% of total savings). Due to the fuel switching noted above, there are negative statewide electric savings from heating consumption. Potential savings from domestic hot water savings are limited in comparison to space heating but are still significant (12% of total savings). Cooling savings are negligible due to the overall low use of cooling and low cooling loads, as well as the fact that some models were designed without cooling. Lighting savings represent a fair opportunity (7% of total savings) and are based on the program replacing all lights in a home, not just the renovated portion.

Table 55: Statewide Potential Savings by End Use (MMBTU)

End Use	Savings
Heat	
Electric	-32,020
Natural gas	288,943
Oil	1,344,226
Propane	31,237
Heat Total	**1,632,386**
Domestic Hot Water	
Electric	180,970
Natural gas	52,771
Propane	5,705
DHW Total	**239,446**
Other Electric	
Cooling	11,509
Lighting	132,815
Total	**2,015,335**

Table 56 presents estimated statewide potential savings by project type. Renovation-only projects represent the largest statewide savings as they are the most prevalent project type. The study estimated 44,578 renovation-only projects statewide and modeled both minor (500 sq. ft.) and major (1,500 sq. ft.) projects. The study estimated 16,321 qualifying addition-only projects and modeled both minor (500 sq. ft.) and major (1,000 sq. ft.) projects. Addition-only projects represent the smallest potential savings at the project and state levels. Potential savings are limited for addition-only projects because they were compared to the RNC UDRH, a relatively efficient baseline. Despite showing the largest potential savings at the project level, renovation and addition projects have lower potential savings when scaled to the state level as they are the least prevalent project type, based on market analysis. The study estimated 6,405 renovation and addition projects, and modeled both small (500 sq. ft. renovation, 500 sq. ft. addition) and large (875 sq. ft. renovation, 875 sq. ft. addition) projects.[27]

Table 56: Statewide Potential Savings by Project Type (MMBTU)

Type	Savings
Renovation Only	
Electric	146,383
Natural Gas	234,284
Oil	1,127,664
Propane	25,328
Total	**1,533,660**
Addition Only	
Electric	94,203
Natural Gas	53,165
Oil	26,373
Propane	5,748
Total	**179,488**
Renovation and Addition	
Electric	51,867
Natural Gas	54,265
Oil	190,189
Propane	5,866
Total	**302,187**

Savings values by Company territory can be found in Appendix G.

[27] The 875 sq. ft. value for large projects is consistent with the Massachusetts renovation and addition market characterizations from which this study borrows methodology.

5.3 Deep Energy Retrofit Comparison

Given that the pilot version of the program has focused more on deep energy retrofit projects rather than minor renovations so far, the study included two additional model scenarios to represent deep retrofit projects that push to higher levels of efficiency. These models incorporated higher efficiency measures, as seen in some of the pilot projects, rather than the more modest upgrades represented in the larger modelling effort, which were based on levels achieved in the HES and RNC programs. They included higher R-value shell measures, lower U-value windows, significantly lower infiltration rates, and the addition of balanced mechanical ventilation.

The study implemented these changes on two large renovation model scenarios: one with electricity as the primary heating fuel and the other with natural gas. The deep energy retrofit scenario in the electrically heated home resulted in 16% higher savings than the typical upgrade scenario used in the larger modeling effort. In the home heated with natural gas, the deep energy retrofit savings were 44% higher than the typical upgrade. These additional savings are significant, but it should be noted that these projects are more expensive and often more intrusive and time consuming (Table 57).

Table 57: Deep Energy Retrofit Savings Comparison (MMBtu)

Upgrade Type	Energy Consumption	Energy Savings	% Savings
Electric Home			
Baseline	121.3	-	-
Typical upgrade	55.1	66.2	55%
Deep Retrofit	35.4	85.9	71%
Natural Gas Home			
Baseline	140.3	-	-
Typical Upgrade	123.1	17.1	12%
Deep Retrofit	61.8	78.4	56%

A

Appendix A Detailed Methodology

A.1 Market Sizing

The study leveraged research conducted in Massachusetts by NMR to estimate the single-family renovation and additions market size in Connecticut.[28] The Massachusetts study used regression modeling to develop equations that would estimate the number of renovation and addition projects for a given municipality, based on its single-family home counts, median income, and population density. The R1959 study applied those formulas to Connecticut-specific Census data. This process is founded on the assumption that there are similarities in terms of the drivers of single-family renovation and addition activity between Massachusetts and Connecticut.[29]

The study used the following formulas to estimate the number of renovation and addition permits in Connecticut for each Connecticut city and town.

$$\boldsymbol{Renovation\ Permit\ Estimate} = \frac{(SF\ Homes \times 0.033510) + (Median\ Income \times 0.004594) + (Population\ Density\ \times\ 0.131258)}{3}$$

$$\boldsymbol{Addition\ Permit\ Estimate} = \frac{(SF\ Homes \times 0.013345) + (Med.Income \times 0.001490) + (Pop.Density \times 0.065888)}{3}$$

$$\boldsymbol{Renovation\ and\ Addition\ Estimate} = \frac{(SF\ Homes \times 0.004896) + (Med.Income \times 0.000707) + (Pop.Density \times 0.023645)}{3}$$

[28] https://ma-eeac.org/wp-content/uploads/MARLPNC_1812_RenoAddMarketPotential_Report_Final_2020.03.30_Clean_v2.pdf

[29] The team investigated using the Remodeling Market Index (RMI) from the National Association of Home Builders (NAHB) to make longitudinal adjustments based on economic indicators. The RMI is based on a quarterly survey of NAHB remodeler members that provide information on the current market, as well as future indicators for the remodeling market. However, the study concluded that applying this qualitative index would result in false precision around an inherently broad estimate of the market size. NAHB RMI: https://www.nahb.org/News-and-Economics/Housing-Economics/Indices/Remodeling-Market-Index

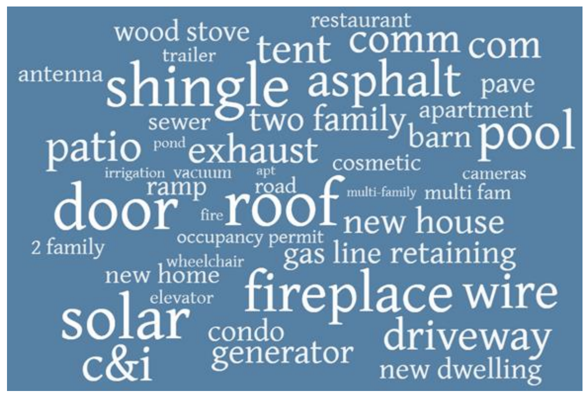
A.1.1 Massachusetts Online Permit Database Methodology

This section outlines the approach used to estimate the permit counts in the Massachusetts study.[30] This study leveraged those results to make estimates for the Connecticut market. The Connecticut study used the formulas developed in the Massachusetts study to estimate relevant permit counts in Connecticut; it did not include a separate analysis of Connecticut building department databases.

For the Massachusetts study, NMR reviewed online building permits in 56 Massachusetts municipalities. Fifty-six of the 351 cities and towns (16%) had online databases that included permit records with some summary description of the work permitted. NMR used an iterative keyword analysis to identify permit records from 2017 that corresponded to single-family renovations and additions. Figure 7 shows keywords used to flag relevant permits, while Figure 8 shows keywords used to flag potentially irrelevant permits. The keyword analysis was a highly iterative process; NMR continually reviewed permit records to ensure relevant projects were included.

Figure 7: Keywords for Relevant Projects

Figure 8: Keywords to Flag for Possible Exclusion



In Massachusetts, NMR also conducted a regression analysis of demographic variables for municipalities using Census data (independent variables) and the number of renovation and addition permits from 56 online databases (dependent variables). This allowed the findings of the permit database review to be extrapolated to cities and towns without those databases.[31] The key independent variables the model identified were single-family home count, population density, and median income.[32] The adjusted R-square values indicated that the regression model explained about 75% of the variation in the permit count estimates (the dependent variable). NMR

[30] Additional detail about study methodology available in Appendix A of the Massachusetts report. https://ma-eeac.org/wp-content/uploads/MARLPNC_1812_RenoAddMarketPotential_Report_Final_2020.03.30_Clean_v2.pdf

[31] The Massachusetts team confirmed that there were no systematic differences between the municipalities with and without permit databases.

[32] The study excluded population as a predictor of permit activity, due to multicollinearity between single-family home counts and population.

then used the regression modeling effort to derive the equations shown above, which were then used for the Connecticut market in this study.

A.2 Savings Potential

The study estimated the savings potential of the renovations and additions market in Connecticut by building energy models of prototype homes – before and after undergoing renovation and/or addition projects – and then scaled up the associated savings from each of those prototype scenarios to reflect the market of renovation and addition projects in Connecticut. The section below describes the following:

- Prototype home energy models developed to reflect typical renovation and addition projects
- Baseline and upgrade scenarios that could be used to estimate savings (including model inputs and assumptions)
- This study's methodology for scaling up savings from the model-level results to the broader Connecticut market

The energy models created for this effort, and the resulting savings values, are only estimates and do not reflect the myriad of possibilities for how a home might be renovated or added-on to in the real world.

A.2.1 Prototype Model Scenarios

The study developed prototype energy models using the Ekotrope energy simulation tool (approved by RESNET for HERS ratings, and comparable to REM/Rate). The prototypes included three core project types:

- Renovation-only projects
- Addition-only projects
- Projects with both a renovation and addition

For each of these three core project types, the study included prototype model variants to better represent the pool of homes being renovated and added to in Connecticut. The study included prototype mode variants adjusted to reflect differences in the following:

- Affected square footage
- Scope/depth of work
- Climate
- Heating fuel

The prototype models included different percentages of affected square footage to reflect the two program paths as defined in the ARR Program Guidelines document: minor additions or renovations and major additions or renovations. This approach yields estimated potential savings for a program design that targets both small and large projects, though the current program design focuses only on major projects, such as deep energy retrofits.

Each prototype model reflected different variable combinations, detailed in Table 58. The combination of these details resulted in 12 prototype models for each of the core project types, yielding 36 prototype models.

Table 58: Prototype Model Scenarios

Variable	Model Variants			Model Variations	Data Source
Home size (A)	Typical single-family existing home ($2,000\ ft^2$)			1	Evaluator judgment and Secondary Sources*
Renovation-only model: project size/scope (B1)	Minor project ($500\ ft^2$) w/no HVAC changes	Major project ($1,500\ ft^2$) w/ HVAC changes		2	Program requirements, evaluator judgement
Addition-only model: project size/scope (B2)	Minor project ($500\ ft^2$) w/no HVAC changes	Major project ($1,000\ ft^2$) w/new supplemental HVAC		2	Program requirements, evaluator judgement
Renovation and Addition Model: Project Size/Scope (B3)	Minor project ($500\ ft^2$) w/no HVAC changes	Major project ($1,750\ ft^2$) w/new whole-home HVAC		2	Program requirements, evaluator judgement
Climate location (C)	Hartford	New Haven		2	Evaluator judgement
Heating fuel (D)	Electric	Gas	Oil	3	n/a
Renovation only models (A*B1*C*D)				12	
Addition only models (A*B2*C*D)				12	
Renovation and addition models (A*B3*C*D)				12	

*Secondary sources included local RASS or weatherization studies.

A.2.2 Measure-Level Inputs for Baseline and Upgrade Energy Models

Baselines. The current program baseline for the renovated portions of the existing home (i.e., alterations that do not add new conditioned floor area) reflects how those areas were built and configured prior to the renovation. However, for some measures, it may not be appropriate to use the pre-existing conditions as the savings baseline because doing so ignores ISP, yielding an artificially inefficient baseline. Accordingly, this study developed energy models using an ISP baseline scenario to provide a more realistic estimate of potential savings.

Upgrades. For the upgrade scenarios, the study used energy models that reflect likely upgrades associated with participation in the program. For renovations, the models assumed that the installed measures would mirror the average measure-level performance of homes that participated in the HES program. For additions, the study assumed that installed measures would be similar to the performance of typical RNC program participants or would meet EnergizeCT incentive levels for that measure. The study also created one high performance model that performed well above typical HES measure-level performance to estimate the additional per project savings available if the program were to focus on these high-performance projects.

Table 59 outlines the data sources used to develop measure-level inputs for the baseline and upgrade scenarios.

Table 59: Data Sources for Baseline and Upgrade Inputs

Measure	Baseline		Upgrade
	Current	*ISP*	
Renovations			
Insulation	Pre-existing conditions	Evaluator assumption* - Attic: Contractor survey - Walls: Evaluator judgement - Frame floor: Evaluator judgement	HES Implementation Guide
Air sealing		Pre-existing conditions	HES Implementation Guide
Duct sealing		Pre-existing conditions	HES Implementation Guide
Windows		RNC UDRH	EnergizeCT Incentives
Heating		ROF from PSD	EnergizeCT Incentives
Cooling		ROF from PSD	EnergizeCT Incentives
Water heating		ROF from PSD	EnergizeCT Incentives
Appliances		RESNET Defaults	RESNET Defaults
Instant savings measures		CT PSD	EnergizeCT Incentives
Lighting		RASS 2018	100% LED
Additions			
All	RNC UDRH		RNC Program Data

*This was based on responses to other research activities in this and related studies that determined common practice is to insulate up to code (e.g., filling wall cavities).

Detailed Measure Inputs. Table 60 describes the measure-level inputs used in the baseline and upgrade scenarios for renovation projects. For most envelope measures, baseline conditions assume that a renovation would be focused on the immediate area being renovated, while the upgrade scenario assumes that the program would improve parts of the home outside of the direct scope of the renovation, such as upgrading the entire attic, even if the renovation was limited to a smaller portion of the home. The table below identifies the measure-level values that were applied in the unrenovated portion of the home, the renovated portion of the home, or the whole home, as appropriate.

Table 60: Baseline and Upgrade Model Inputs for Renovations

Measure	Unit	Baseline		Upgrade
		Current	*ISP*	
Envelope				
Foundation	R-value	0		0
Slab	R-value	0		0
Attic	R-value/Grade (G1=Good, G2=Fair, G3=Poor)	21.1/G3	Unrenovated: 21.1/G3 Renovated: 32*/G2	Whole home: 38.0/G1
Walls	R-value/Grade	9.5/G3	Unrenovated: 9.5/G3 Renovated: 13*/G2	Unrenovated: 9.5/G3 Renovated: 13.0/G1
Frame floor	R-value/Grade	4.4/G3		Whole home: 19.0/G1
Air sealing	ACH50	12.7		Whole home: 10.0
Duct sealing	CFM25	18.3		Whole home: 14.1
Windows	U-factor	0.30		Unrenovated: 0.30 Renovated: 0.27
Heating and Cooling				
Electric baseboard	COP	1.0		Mini-split heat pump (18 SEER/10 HSPF)**
Oil boiler	AFUE	Existing System	84.0	Mini-split heat pump (18 SEER/10 HSPF)**
Gas/LP boiler	AFUE	Existing System	85.0	Furnace (95 AFUE) and CAC (16 SEER)**
CAC	SEER	Existing System	13.0	16.0**
Thermostat set points	ºF	Heating: 69; Cooling: 73		Heating: 69; Cooling: 73
Water Heating				
Electric tank	EF	0.93		HPWH (3.03 EF)**
Gas tank	EF	Existing System	0.71	Tankless (0.94)**
Lighting, Appliances, and Instant Savings Measures				
Lighting		RASS 2018		100% LED
Appliances		RESNET Defaults		RESNET Defaults
Flow rates		Standard		Low Flow

*ISP values came from contractor survey responses where applicable, and otherwise from evaluator judgement.
**Upgrade only applied to select models, as described in Table 58.

Table 61 describes the measure-level inputs used in the baseline and upgrade scenario energy models for additions.

Table 61: Baseline and Upgrade Model Inputs for Additions

Measure	Units	Baseline Inputs (UDRH Values)	Upgrade Inputs
Envelope			
Foundation	R-value	0	0
Slab	R-value	0	0
Frame floor	R-value/Grade	25.7/G2	28.0/G1
Attic	R-value/Grade	36.9/G2	46.0G1
Walls	R-value/Grade	20.8/G2	22.3/G1
Air sealing	ACH50	4.9	3.0
Duct sealing	CFM25	6.2	1.9
Windows	U-factor	0.30	0.27
Heating and Cooling			
Gas/LP furnace	AFUE	93.8	95.0*
Heat pump	SEER/ HSPF	14.6/9.0	18.0/10.0*
CAC	SEER	14.6	16.0*
Thermostat set points	ºF	Heating: 69; Cooling: 73	Heating: 69; Cooling: 73
Water Heating			
Electric tank	EF	1.42	HPWH (3.03 EF)*
Gas/LP tank	EF	0.65	Tankless (0.94)*
Lighting, Appliances, and Instant Savings Measures			
Lighting		RNC Baseline 2017	100% LED
Appliances		RESNET Defaults	RESNET Defaults
Flow rates		Standard	Low Flow

*Upgrade only applied to select models, as described in Table 58.

A.2.3 Lighting

The study calculated lighting savings outside of the energy simulation models. In the energy models, the efficient lighting saturation was left constant in the baseline and upgrade energy models, such that the energy models did not incorporate savings associated with lighting improvements.

The study calculated savings assuming that all bulbs installed were LEDs, with an annual savings value of 24 kWh per bulb (consistent with the 2020 PSD for LEDs). It also assumed that in the upgrade scenario reflecting program participation, the program would upgrade all light bulbs in the home, even outside of the renovation or addition area. The lighting saturation value used for the existing portion of the home is from the 2018 CT RASS Study; this value has likely improved since then and therefore these savings values may be overstated.

Table 62: Data Sources for Lighting Saturation in Baseline Scenarios

Measure	Source	Value
Renovation Area		
% inefficient bulbs	2018 CT RASS Study	43%
Bulbs/sq. ft.	2018 CT RASS Study	0.023
Addition Area		
% inefficient bulbs	2017 CT RNC Baseline	46%
Bulbs/sq. ft.	2017 CT RNC Baseline	0.039

Table 63: Detailed Inputs for Lighting Savings

Renovation Type	Lighting Savings per Home	
	kWh	*MMBtu*
Small renovation	484	1.7
Large renovation	501	1.7
Small addition	695	2.4
Large addition	914	3.1
Small renovation and addition	703	2.4
Large renovation and addition	606	2.1

A.2.4 Scaling Results to Population

The study weighted the model simulation results by several different factors to determine both statewide potential and Company-specific potential for this market. This approach used the order of operations listed below to calculate market-wide savings potential.

- Energy models
  - Create all energy models, including baseline and upgrade scenarios (96 models total)
  - Complete model simulation runs
  - Develop per-home savings estimates by end use (heating, cooling, water heating, and lighting)
- Market size
  - Estimate the total permitted population of each core project type based on the results of the permit analysis (which included statewide and Company-specific estimates)
  - Adjust permit estimates based on the results of the homeowner and contractor survey to account for non-permitted projects
- Scaling results to state
  - Apply per-home savings estimates to the statewide market size for each core project type, weighting each model proportionally based on the statewide prevalence of the following factors:
    - Project size (source: homeowner survey)

    - Project type (renovation and/or addition)
    - Climate (source: GIS mapping)
    - Heating fuel (source: U.S. Census)
  - Develop statewide values that reflect all potential renovation and addition projects across the state, including municipal territories

Table 64, Table 65, and Table 66 show the statewide proportions used to scale up model level results by the above factors.

Table 64: Statewide Heating Fuel Prevalence

Heating Fuel	Statewide Prevalence
Electric	17%
Natural gas	37%
Oil	42%
Propane	4%

Table 65: Statewide Climate Location Prevalence

Climate Location	Statewide Prevalence
New Haven	58%
Hartford	42%

Table 66: Statewide Project Size Prevalence

Project Type	Small		Large	
	%	*n*	*%*	*n*
Renovation only	45%	20,060	55%	24,518
Addition only	65%	10,609	35%	5,712
Renovation and addition	32%	2,180	68%	4,633

- Disaggregating results to Company territories
  - Company-level results generally follow the statewide approach (scaling per-home results up to the market), but results were weighted based on these Company-specific factors:
    - Climate (source: GIS mapping)
    - Project Type (renovation and/or addition)
    - Heating fuel (source: U.S. Census data, mapped to Company-territories using GIS)
  - Company-level results are based on assumptions that each Company has the same mix of project sizes (large vs. small projects). While these may vary, the sample sizes from the contractor and homeowner survey were not sufficient to develop robust estimates at the Company-level for this factor.

Table 67 and Table 68 show Company specific proportions used to scale model results up to Company territories.

Table 67: Heating Fuel Prevalence by Company

Company	Electric	Natural Gas	Oil	Propane
United Illuminating Company	14%	53%	31%	2%
Eversource (Electric)	17%	35%	43%	5%
Eversource (Gas)	16%	35%	45%	4%
Connecticut Natural Gas Company	14%	47%	36%	3%
Southern Connecticut Gas Company	14%	49%	34%	3%

Table 68: Climate Location Prevalence by Company

Company	New Haven	Hartford
United Illuminating Company	100%	-
Eversource (Electric)	50%	50%
Eversource (Gas)	50%	50%
Connecticut Natural Gas Company	20%	80%
Southern Connecticut Gas Company	100%	-

Detailed energy consumption values for each of the baseline and upgrade scenario energy models included in the study are provided in spreadsheet form as Appendix H.

Appendix B Renovation and Addition Permit Estimates from 2010 to 2017

This section provides detailed estimates of the number of renovation and addition permits issued annually in Connecticut by electric and gas provider.

Table 69: 2010 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	728,874	31,315	11,599	4,879	47,792
Municipal	48,723	1,449	561	226	2,236
United Illuminating Company	172,850	5,913	2,403	945	9,261
Total	**950,446**	**38,676**	**14,563**	**6,050**	**59,289**

Table 70: 2011 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	734,124	31,850	11,780	4,961	48,591
Municipal	49,005	1,466	567	229	2,262
United Illuminating Company	173,580	5,966	2,422	954	9,341
Total	**956,708**	**39,281**	**14,768**	**6,143**	**60,193**

Table 71: 2012 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	735,826	31,937	11,812	4,975	48,723
Municipal	49,089	1,485	573	232	2,290
United Illuminating Company	174,610	6,011	2,438	961	9,410
Total	**959,525**	**39,432**	**14,824**	**6,167**	**60,423**

Table 72: 2013 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	736,844	31,991	11,832	4,983	48,807
Municipal	49,735	1,465	568	229	2,262
United Illuminating Company	175,518	6,036	2,449	965	9,449
Total	**962,096**	**39,492**	**14,849**	**6,176**	**60,517**

Table 73: 2014 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	739,909	32,194	11,902	5,014	49,110
Municipal	48,988	1,464	567	229	2,260
United Illuminating Company	173,980	5,983	2,431	957	9,371
Total	**962,877**	**39,641**	**14,900**	**6,200**	**60,741**

Table 74: 2015 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	739,529	32,353	11,953	5,039	49,345
Municipal	49,078	1,471	569	230	2,271
United Illuminating Company	174,971	6,010	2,441	961	9,412
Total	**963,577**	**39,834**	**14,964**	**6,229**	**61,027**

Table 75: 2016 Permit Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	739,188	32,709	12,067	5,093	49,870
Municipal	48,942	1,497	577	234	2,308
United Illuminating Company	174,746	6,043	2,451	966	9,460
Total	**962,875**	**40,249**	**15,096**	**6,293**	**61,638**

Table 76: 2017 Permitted Project Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	749,194	33,382	12,294	5,196	50,872
Municipal	49,685	1,501	579	234	2,314
United Illuminating Company	175,136	6,115	2,476	977	9,569
Total	**974,014**	**40,998**	**15,350**	**6,407**	**62,755**

Table 77: 2018 Permitted Project Estimates by Electric Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	748,517	33,976	12,493	5,289	51,758
Municipal	49,472	1,524	586	238	2,348
United Illuminating Company	175,303	6,201	2,502	990	9,694
Total	**973,292**	**41,701**	**15,582**	**6,516**	**63,799**

Table 78: 2010 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	465,697	17,410	6,584	2,720	26,713
Southern Connecticut Gas Company	209,850	7,761	3,034	1,227	12,021
Connecticut Natural Gas Company	192,531	7,215	2,779	1,135	11,128
Norwich Public Utilities	9,764	313	121	49	483
None	72,605	5,978	2,045	920	8,943
Total	**950,446**	**38,676**	**14,563**	**6,050**	**59,289**

Table 79: 2011 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	469,108	17,659	6,669	2,758	27,086
Southern Connecticut Gas Company	210,847	7,806	3,051	1,234	12,090
Connecticut Natural Gas Company	193,507	7,332	2,818	1,153	11,304
Norwich Public Utilities	10,053	316	122	49	488
None	73,193	6,169	2,107	949	9,226
Total	**956,708**	**39,281**	**14,768**	**6,143**	**60,193**

Table 80: 2012 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	469,542	17,715	6,690	2,767	27,171
Southern Connecticut Gas Company	211,954	7,867	3,073	1,243	12,184
Connecticut Natural Gas Company	193,866	7,391	2,838	1,162	11,392
Norwich Public Utilities	10,297	318	123	50	490
None	73,866	6,141	2,099	945	9,185
Total	**959,525**	**39,432**	**14,824**	**6,167**	**60,423**

Table 81: 2013 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	471,241	17,720	6,694	2,768	27,182
Southern Connecticut Gas Company	212,648	7,882	3,080	1,246	12,208
Connecticut Natural Gas Company	193,557	7,398	2,841	1,163	11,402
Norwich Public Utilities	10,323	312	121	49	483
None	74,328	6,180	2,112	951	9,243
Total	**962,096**	**39,492**	**14,849**	**6,176**	**60,517**

Table 82: 2014 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	471,693	17,792	6,720	2,779	27,291
Southern Connecticut Gas Company	212,301	7,847	3,069	1,240	12,156
Connecticut Natural Gas Company	194,213	7,421	2,849	1,167	11,437
Norwich Public Utilities	10,017	305	119	48	472
None	74,654	6,276	2,143	966	9,385
Total	**962,877**	**39,641**	**14,900**	**6,200**	**60,741**

Table 83: 2015 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	471,954	17,844	6,737	2,787	27,368
Southern Connecticut Gas Company	213,242	7,905	3,089	1,249	12,244
Connecticut Natural Gas Company	193,731	7,447	2,857	1,171	11,475
Norwich Public Utilities	9,795	305	119	48	471
None	74,856	6,333	2,162	975	9,470
Total	**963,577**	**39,834**	**14,964**	**6,229**	**61,027**

Table 84: 2016 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	473,089	18,088	6,816	2,824	27,728
Southern Connecticut Gas Company	211,764	7,978	3,111	1,261	12,350
Connecticut Natural Gas Company	193,298	7,468	2,863	1,174	11,505
Norwich Public Utilities	9,845	308	119	48	475
None	74,880	6,408	2,186	986	9,580
Total	**962,875**	**40,249**	**15,096**	**6,293**	**61,638**

Table 85: 2017 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	478,995	18,366	6,912	2,867	28,145
Southern Connecticut Gas Company	212,266	8,094	3,150	1,279	12,523
Connecticut Natural Gas Company	197,371	7,610	2,913	1,195	11,719
Norwich Public Utilities	9,971	315	122	49	487
None	75,411	6,612	2,253	1,017	9,882
Total	**974,014**	**40,998**	**15,350**	**6,407**	**62,755**

Table 86: 2018 Permit Estimates by Gas Utility

	Total SF Homes	Renovation	Addition	Renovation and Addition	Total
Eversource	480,566	18,736	7,043	2,925	28,704
Southern Connecticut Gas Company	212,435	8,196	3,182	1,294	12,672
Connecticut Natural Gas Company	195,021	7,689	2,933	1,207	11,829
Norwich Public Utilities	9,983	319	123	50	492
None	75,287	6,761	2,301	1,040	10,102
Total	**973,292**	**41,701**	**15,582**	**6,516**	**63,799**

C

Appendix C Mini-Process Evaluation Detailed Findings

This section provides detailed findings from the mini-process evaluation. The process evaluation included ten in-depth interviews: two with program staff, seven with people involved with projects that participated in the program (multiple respondents per project, in some cases), and one with a non-participating high-performance contractor. The participant interviewees were associated with the program's first three projects (i.e., case studies) and included architects, homeowners, general contractors, HERS raters, and an insulation contractor.[33] The interviewers asked respondents to describe the decision-making process for these case study projects, along with their broader experience in the renovation and addition market.

Occasionally, related results from either the homeowner or contractor survey (additional study tasks not directly related to the mini-process evaluation) are mentioned. In those instances, the results are identified as being from either surveyed homeowners or surveyed contractors rather than process interview participants.

At the time of these interviews, only three projects had been completed under the renovations and additions program and a handful more were in progress. Program staff described the path as still in a pilot phase. The three projects were all deep energy retrofits completed by homeowners who were highly motivated to achieve high levels of energy efficiency. Six thousand dollars is the maximum incentive allowed under the program. These projects each received $6,000 in performance-based incentives and an additional bonus incentive (only available to early pilot participants) to subsidize the use of an Energy Specialist (i.e., HERS rater).

C.1 Detailed Findings

Participating homeowners were more motivated to participate due to their interest in energy efficiency and *being green* than by the available incentive. Company staff hand selected the three pilot projects to participate because the homeowners voiced an interest in building efficiently to their HERS rater or architect who then spoke to Company staff. During the interviews, both participating homeowners shared how they wanted to both increase the energy efficiency of their homes and use their projects as an example to help the remodeling market incorporate more energy-efficient practices. One homeowner described wanting to help the development of the program and wanting to gain the technical support of the energy specialist.

> *"My main reason was to support the development of the program and to have the technical support of the energy modeling and the blower door testing that shows that you actually accomplished something." - Homeowner*

[33] The study offered the eight non-Company staff interview respondents $50 each to participate in a 30-minute phone interview.

Participants highly valued the HERS rater subsidy provided by the program as it added expertise not typically found on remodeling project teams. During the interviews, homeowners, architects, HERS raters, and contractors reported that HERS raters are not typically involved in remodeling projects. Architects and homeowners expressed that they greatly appreciated the program adding the HERS rater to the team. Respondents indicated that HERS raters' verification services provided the team with confidence in the performance of the anticipated efficiency improvements, and they offered valuable energy-efficiency recommendations and assistance with shepherding the project through the program. However, the HERS rater subsidy is not a permanent program fixture and was only offered to pilot participants.

> *"The only special addition [to the standard renovation and addition process] is the third-party certifier who is doing the blower door and who is going to look at the plans upstream and say, "yes, we can predict the home will use this much energy." The HERS rater is the critical addition."* - Architect

Early pilot projects yielded signs of potential spillover: general contractors and subcontractors said they had used practices learned from their program project on non-participating projects. Architects said that they used heat pump systems for the first time through the pilot program and that they have since installed them in other projects. Additionally, subcontractors said they had suggested air sealing improvements on projects with different team leads after working on these participant pilot projects.

> *"I can carry a lot of [these program practices] into everything I do … It's all about keeping the outside [air] out and the inside [air] in … so we try to at least incorporate some sort of practice, whether we're doing just a simple remodeling job, or if we're going really deep into it."* - Contractor

Abatement of costs and existence of project champions are critical to achieving energy efficiency. While the highly motivated homeowners in the three pilot projects reported that they would have built the projects just as efficiently without the program, respondents cited increased costs and the typical lack of an energy-efficiency champion as the greatest challenges to achieving high energy efficiency in remodeling projects. Increased costs result from more expensive materials and extra labor. The lack of an energy-efficiency "champion" refers to the siloed nature of remodeling projects, where contractors design scopes for their pieces of the project without considering other aspects of the home. For example, an architect and a HERS rater reported that HVAC contractors size new systems without considering changes in insulation that could reduce heating load. They explained that an energy-efficiency champion, such as an architect, can create a holistic approach to energy performance in the design process and ensure that subtractors use energy-efficient practices (such as air sealing around plumbing and electrical holes) during construction. One interviewee described the dynamics behind and outcomes of an unintegrated process:

> *"One of the huge missing pieces is that in the remodeling industry [subcontractors are] compartmentalized. Someone does carpentry, someone does insulation, someone does plumbing, and someone does electrical. All of them are used to doing things in a business-as-usual way. None of them are charged with thinking of the energy performance of the building. There is no one who has a role who is thinking that they have responsibility to reduce energy let alone thinking in way in which all those components are integrated if you are going to think about energy." - Architect*

The pilot program is geared towards large projects. Based on program design literature, the program has two paths for renovation projects:

- **Minor Additions and/or Remodels/Renovations**: Targets projects that total less than 500 square feet and uses flat rate incentives for various measures.
- **Major Addition and/or Major Renovation:** Targets projects over 500 square feet and uses incentives based on energy performance demonstrated by energy modeling.

All three pilot projects went through the major path. Company staff reported that they target large projects to maximize cost-effectiveness, explaining that smaller projects are better served through Home Energy Solution measures and rebates. Company staff reported that good candidates for this program typically involve renovations to at least 50% of the conditioned floor area.

Decision making in the remodeling market is typically based on the homeowner's motivations and budget, but architects and general contractors have a limited opportunity to increase the energy efficiency of projects during the design phase. Homeowners control the scope of a project and often have an idea of what they want before they seek out quotes from contractors. Depending on their motivations and budget, certain homeowners are more amenable than others to recommendations that increase the energy efficiency of the project. However, respondents reported that it is often difficult to persuade budget-limited homeowners to agree to scope expansions, and any such scope changes must occur during the design phase.[34]

Respondents from the three pilot projects reported that remodeling projects typically lack a champion for energy efficiency during the design phase. The design phase of a remodeling project is often brief. Sometimes a general contractor does a simple design alone, other times the homeowner hires an architect. Whoever the designer, respondents indicated that projects are typically designed in accordance with the homeowner's requests and budget, and designers and contractors do not bring up energy efficiency beyond code unless asked for by the homeowner or unless the contractor has set practices that incorporate efficiency, such as using spray-applied foam insulation as a standard practice.

Additionally, while achieving a high level of energy efficiency requires looking at the home as a whole, contractors on remodeling projects are often siloed and not able to make whole-building level decisions. For example, proper air sealing can allow for an HVAC system to be replaced

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[34] A similar study conducted in Massachusetts found that contractors rarely change project scopes after reaching an original agreement with the homeowner. See section D.4 at http://ma-eeac.org/wordpress/wp-content/uploads/MARLPNC_1812_RenoAddMarketPotential_Report_Final_2020.03.30_Clean_v2.pdf

with a smaller system. However, HVAC contractors may not consider changes to the building shell when recommending a new system and therefore will be more likely to do a like-for-like replacement instead of downsizing to a smaller system.

Respondents indicated that incorporating energy-efficient practices was more of a conceptual and management challenge than a technical skill challenge. While respondents felt market actors were capable of using energy-efficient technologies and practices, they highlighted the need for someone to champion energy efficiency by providing guidance across the entire team. Such guidance could include instructing electricians and plumbers to seal any penetrations they might make holes in the envelope, having contractors consider the order of operations when finishing assemblies (e.g., making sure everything is properly sealed before closing a wall), and to make sure decisions are made in a holistic manner (at the whole-home level).

Respondents said the biggest barriers to program participation for other projects would likely be the additional costs associated with the energy-efficient practices and the HERS rating as well as a lack of program awareness. Participants felt there were few barriers for themselves to participate in the pilot program since the homeowners of these three particular projects were highly motivated. However, respondents discussed possible barriers for projects in general. Cost was the most frequently cited potential barrier. Additional costs result from more expensive materials and increased labor. The HERS rater requirement of the program was also a cost not typically incorporated into remodeling projects. Respondents reported that homeowners typically have strong budget constraints and thus additional costs would be a primary barrier to homeowners who do not have a particular interest in energy efficiency.

Awareness was the second most cited potential barrier. Respondents said outreach to market actors could drive participation as savvy contractors use the program to learn efficient practices on the job and increase their competitive advantage. According to respondents, additional outreach to homeowners could increase the likelihood that homeowners would request energy-efficient practices when they seek quotes.

C.2 Case Study Summary

Table 87 and Table 88 characterize the three case studies. A summary is provided below.

- All three include renovations to the majority of the home and consisted of both insulation and mechanical equipment improvements.
- All three had architects on the project team (in one instance the architect was the homeowner). Respondents reported that remodeling projects often do not include architects. A general contractor usually designs the project.
- Decision making fell to the homeowner, architect, or HERS rater.
- The level of the HERS rater's role varied from minimal (just verifying energy performance), to moderate (making suggestions about specific technologies to use), to maximum (driving energy-efficiency decisions).

- Homeowners were motivated to participate because they wanted to advance energy efficiency in their projects and the market and because they wanted HERS rater services.
- Projects entered the program through an architect or HERS rater who frequently communicates with Company staff. Architects and HERS raters referred the projects to the program because the homeowners highly value energy efficiency.
- According to interviewees, all three projects would have been built the same way without the program because the homeowners highly value energy efficiency.

Table 87: Case Study Summaries – Scope, Team, and Decision Making

Project Component	Case Study One	Case Study Two	Case Study Three
Scope of work	An architect wanted to remodel and increase the efficiency of their own home. The project included spray foam insulation in walls and ceilings, air sealing, replacing oil mechanical systems with heat pumps, and adding solar panels to offset electrical loads from the new heat pumps.	A homeowner had just purchased a house built in the 1960s and wanted to make it much more efficient. The homeowner hired a design-build firm known for efficient building. The project included cellulose wall insulation, attic insulation, and exterior wall insulation; windows; doors; rigid foam insulation on the basement floor; and new mechanical equipment.	A builder wanted to remodel and increase the efficiency of their own home. The builder had already hired a HERS rater prior to participation. The project included spray foam insulation to the entire envelope, new appliances and lighting, removing electric baseboards, increasing the distribution of a boiler, and replacing an old mini-split heat pump with a new one.
Team	Homeowner/architect, HERS rater, general contractor, HVAC contractor, insulation contractor, and other contractors	Architect, HERS rater, general contractor, HVAC contractor, and other contractors	Hom,466eowner/builder, architect, HERS rater, general contractor, insulation contractor, HVAC contractor, and other contractors
Decision making	The homeowner/architect guided the scope of the project and the level of energy efficiency. The HERS rater made suggestions for techniques and technologies.	The homeowner hired an architect and directed them to make the project energy efficient. The architect made the decision regarding techniques and materials and hired a HERS rater to serve only as a third-party verifier.	The homeowner/builder and HERS rater drove the energy-efficiency decisions.

Table 88: Case Study Summaries – Motivations, Entry Channel, and Signs of Free-ridership

	Case Study One	Case Study Two	Case Study Three
Motivation for participation in pilot program	The homeowner/architect was interested in using the project to promote deep retrofits and wanted to present the project to the CT Green Building Council. The homeowner/architect wanted the expertise of the HERS rater.	The homeowner and architect were passionate about energy efficiency and wanted to help the program by serving as early participants. The architect wanted to help the program develop because they see opportunity for energy efficiency in the remodeling market. They also wanted the HERS rater services.	The homeowner wanted to be *green*.
Entry channel	The HERS rater had previously talked with Eversource about identifying projects for the pilot and suggested participating.	The design-build firm's architects had previously talked with Eversource about identifying projects for the pilot and suggested this one given the motivated homeowner.	The homeowner/builder wanted energy efficiency and thus hired the HERS rater. The HERS rater suggested participating to the homeowner.
Free-ridership[a]	*"We would have done a lot of it but would not have been able to do all of it. The program covered the cost of the HERS rating, which was great. "* -Homeowner/architect	*"I told the homeowner about the program, but we would have done all the things we were going to do anyway."* -Architect	Homeowner said they would have built this way anyway since their goal was to be as efficient as possible, but the program allowed for minor small upgrades due to the incentive.

[a] These projects were not typical since the decision makers were particularly motivated to achieve high energy efficiency.

C.3 Building Practices

Respondents generally indicated that the case study projects would have been built similarly even without the program, given that the projects were being undertaken by homeowners who were particularly interested in high-efficiency building practices. The main efficiency improvements attributed to program participation were the HERS raters' verification services.

Though program participation may not have substantially changed these projects, respondents did highlight the differences between their projects and ISPs. They also pointed to the program's ability to move the industry toward the high-efficiency practices used in these pilot projects. The respondents pointed to the program's opportunity to not only encourage project teams to adopt advanced materials, technologies, and building practices, but also to change teams' conceptual approach to completing the work.

C.3.1 Improved Practices

Respondents reported that the materials and technologies used in the case studies went beyond those typically used in ISP. Practices found in the pilot projects included extremely high levels of insulation, insulation on portions of the envelope that are often ignored such as slabs, adding energy recovery ventilators (ERVs) and heat pumps, and using thorough air and duct sealing practices.

Additionally, respondents described how their projects involved conceptualizing energy efficiency differently than is typical in ISP: energy efficiency needs to be considered as a holistic goal for the project and factored in right at the outset. An architect reported that in a typical remodeling project, decision makers do not consider the opportunity to increase the energy performance of the building. The architect said, "There is nothing in standard practice that remotely thinks of that. They just go in and do the remodeling. They do a new kitchen. They might just change the siding and not consider any opportunity there for energy performance." The architect thought the program could encourage people to recognize this opportunity.

A contractor posited that teams need to think more thoroughly about the "order of operations" on high-efficiency projects than on typical projects. For example, the contractor described needing to make sure all envelope seams are properly sealed before closing a wall or attic. "If you're creating a spot where you're not going to be able to get to again, you definitely have to think about it…that's where it becomes complicated because you have to think about the assemblies and how they go together. And if you're not thinking about how it's going together, that's when something gets overlooked and you've left a hole that you can't get to." While building efficiently requires more thought, the contractor did not if feel it was difficult to do if there is proper guidance.

C.3.2 Spillover

Respondents indicated that they or members of their team learned new energy-efficient practices from the pilot projects. Moreover, architects and contractors reported using these practices on other projects (participant spillover).

The architect from case study one said that this project was their "first experience with variable refrigerant flow (VRF) heat pumps," and that they have now "used VRF heat pumps in several commercial projects," adding that they "would be less inclined to use these things without having participated in the program."

The architect from case study two said they "learn on every project" and specifically highlighted learning better ways to install ductless mini-splits that make the equipment quieter during use. When asked if their subcontractors had learned practices that they carried over to different projects, the architect said, "Yeah! Some of them have asked on other projects, 'are you doing anything about air sealing' when it wasn't brought up. There is gradual dissemination out into the industry through people working on these projects." A contractor from case study two confirmed this spillover: "I can carry a lot of that into everything I do … It's all about keeping the outside out and the inside in … so we try to at least incorporate some sort of practice, whether we're doing just a simple remodeling job, or we're going really deep into it."

C.4 Barriers to Program Participation

The two most frequently cited barriers to greater program participation by interviewees were the extra costs associated with incorporating high-efficiency practices and a lack of program awareness amongst market actors and homeowners. Respondents also cited challenges with incorporating energy-efficient practices, such as extra time and effort, workforce capabilities, and an aversion to change amongst contractors and other industry professions.

C.4.1 Costs

Seven of eight market actors cited increased costs as the main barrier to participating in the program. Costs were not a direct barrier for those participants, given that the pilot projects were undertaken by highly motivated homeowners, but they indicated that costs would be the main barrier for the broader market. Only the non-participant contractor thought that lack of program awareness was the main barrier and that any increased incremental costs could be built into quotes that leveraged energy efficiency as a competitive advantage.

Respondents described how incremental costs on their high-performance projects are driven by labor and materials costs, such as sealing holes made in the envelop by plumbers and electricians, and the use of higher cost materials such as spray foam insulation. Using a HERS rater also adds additional costs since they are not typically involved in remodeling projects. The program subsidized but did not fully covered the cost of the HERS in the three completed pilot projects.

- *"People want a lot of stuff they can see like a countertop. This is spending money on stuff that you don't see, and the reward is especially abstract."* – participating architect
- *"Getting the [spray foam] truck to the job is the most expensive part and it's not worth it to do 50 ft^2. So, if you can increase that scope, it makes more financial sense."* – participating insulation contractor
- *"One thing we've learned is that certification costs get high when you have to do two ratings on a building, so that's a challenge. The modeling is complex and so the HERS rater fees may be a challenge."* – participating HERS rater

- *"The biggest barrier would be the price of the HERS rater."* – program staff

C.4.2 Program Awareness

Six out of ten respondents, including the Company staff, cited a lack of program awareness amongst market actors and homeowners as a major barrier to program participation. The program has made some outreach efforts including presenting the program to the Remodelers' Council of the Connecticut Home Builders and Remodelers Association, but a Company representative hypothesized that additional outreach would not yield limited additional participants, given the seemingly small market for significant single-family renovations.

Still, respondents felt that a lack program awareness is a major barrier. As discussed in Appendix C.5, respondents felt the program should increase awareness amongst contractors and architects so that they can recommend the program to clients and that the program should target homeowners to increase demand for energy efficiency. The non-participant exhibited a lack of awareness of not only the program but of Energize Connecticut offerings: they thought of Energize Connecticut only as the Smart-E loans program.

- "The program needs to be advertised more. I hadn't heard of it before the HERS rater mentioned it." – participating architect
- "[The market] is ready and willing to accept this type of program. They just need the knowledge of the techniques and the program offerings." – participating insulation contractor
- "It would be great if there was more help in figuring out which programs/incentives you are qualified for. Need more clarity there. It gets confusing since there are a lot of different programs and certifications you can go for. The consultant is helpful with this, so maybe targeting those types of groups to make them aware of the different offerings would be good." – participating homeowner/builder
- "[There is a] lack of awareness, you need to get the word out to builders, architects and HERS raters so they can recommend it to homeowners." - participating architect

C.4.3 Challenges and Discomfort with Efficient Construction Practices

Respondents cited several challenges associated with achieving high-efficiency standards in renovation and addition projects, providing lessons for other teams. The challenges noted were generally process-oriented rather than technical. For example, respondents explained that to achieve a tight envelope, a project lead needs to communicate the importance of sealing to all subcontractors and needs to continually remind subcontractors of best practices and efficiency goals. An architect mentioned that the typical siloed management structure of a renovation project is not well suited for achieving high levels of energy efficiency using a whole-home approach. For example, an HVAC contractor might design a like-for-like replacement of an HVAC system without considering the potential for air sealing, which would allow the HVAC contractor to reduce the size of the new HVAC system. HVAC contractors may also have a financial disincentive to sell smaller systems that cost less than their larger counterparts. The extra effort required to overcome these process challenges might also increase project timelines.

Speaking generally, respondents also cited market actor resistance to change as a factor that would limit program participation. Respondents described how contractors may be hesitant to adopt new practices which could lead to additional costs as they get through the learning curve. Additionally, market actors may be hesitant to implement a technique or technology that might lead to callbacks or dissatisfied clients. Respondents mentioned that the program could help bring contractors up the learning curve, including through training and real-world demonstrations of advanced techniques.

- *"The challenge is a design challenge not an execution challenge. All the trades can do this, they just need guidance to say, 'here's what we're going to do'."* – participating architect
- *"A lot of guys that have been doing it for 20 to 30 years … they have trouble grasping the concepts."* – participating contractor
- *"An HVAC contractor on their own can't make [home level recommendations] such as reducing equipment capacity because their scope of work does not address air sealing. The reverse is true for siding or roofing contractors. They'll include quotes of air sealing but not consider changes to HVAC systems."* – participating architect
- *"The HVAC industry is woefully uninterested in doing anything besides just replacing equipment and why would they?"* -participating architect

C.5 Program Marketing, Outreach, and Recruitment

The early pilot program has not been actively marketed. Company program staff reported a desire to keep program activity limited during this early phase, to allow them to focus on strong candidates for significant upgrades rather than being overloaded with requests for incentives for minor projects, many of which may not yield energy savings. Other respondents indicated that marketing and outreach from the program to homeowners and contractors would be necessary to increase program participation since a lack of awareness was the second most cited barrier. Marketing efforts should be strategically targeted and clearly designed to avoid an influx of request from inapplicable projects.

Marketing efforts could frame the program as adding design expertise to the homeowner's renovation and addition projects while also supporting energy-efficiency upgrades. Representatives from all three case studies highlighted that one major benefit of the program was the addition or subsidization of the HERS rater to the project team. The program could be framed to pay for independent verification of energy performance while also getting recommendations for energy-efficiency improvements. One homeowner/builder already viewed the program as providing the HERS rater: *"The incentive basically offsets the cost of the [HERS rater]."*

Adding this expertise to the project would allow the homeowner to take full advantage of the opportunity to improve their home. As mentioned above, replacing siding presents a great opportunity to upgrade insulation. An architect said, *"It's making a different kind of team than business as usual with a recognition of the opportunities that would otherwise be missed. The way to sell it is missed opportunities. Everyone I work with wants to make a smart choice…part* *of making a smart choice is you don't want to miss an opportunity: 'Ah! I wish I knew about that before I bought this!' That's what you want this to be. 'No missed opportunities.'"*

Outreach towards contractors could include trainings, case studies, and feasibility studies. The messaging could present the program as a way to help market actors learn new energy-efficient practices on the job that can be translated into a competitive advantage for their businesses. A goal of the outreach would be to increase the scope of the design process so that decisions are made holistically that improve overall energy performance. Marketing materials demonstrating the successes and costs of complete projects, similar to the net-zero energy challenge, would make more remodelers comfortable with attempting energy-efficient practices.

Respondents suggested trainings, participation in industry conferences and associations, handouts and literature at building departments that project decision makers see when applying for permits, and larger campaigns that encourage homeowners to ask for energy efficiency in their projects. One architect said, *"If you don't know you can have it you don't ask for it."*

C.5.1 Non-Energy Benefits

Interviewed respondents reported that they often mention non-energy benefits to homeowners when scoping a project; however, all respondents were familiar with efficient building and thus may not be representative of the larger market. Specifically, respondents highlighted mentioning noise control and better comfort associated with energy-efficient building. The non-participant contractor said that they try to mention everything to make sure they "hit" all of the customer's "hot buttons" to make a sale. An architect said that they highlight the increased comfort resulting from a tighter house by explaining that homeowners will no longer have to buy extra sweaters to keep warm inside and that homeowners will, *"not only save on energy, but on wardrobe too."*

Respondents said the amount of importance homeowners place on non-energy benefits is highly variable. Just like with energy efficiency, the importance given to non-energy benefits is based on homeowner's motivations for the project. As the non-participant contract said, *"Some people may be all about the aesthetics because they're trying to keep up with the Joneses. Other people really don't care what it looks like they want to utilize it and live in it."* Generally, homeowners do think of non-energy benefits regardless of it they value the benefits enough to justify additional costs.

C.6 Satisfaction with Program

C.6.1 Satisfaction with Incentives

All the respondents indicated that they were highly satisfied with the incentives although the incentive was not a major motivation for participating. The pilot program pays an incentive based on energy performance above a baseline EUI with a maximum of $6,000. In addition, the program paid for half the cost of the HERS raters' verification services for the projects participating in the pilot. In all cases, incentives were paid to the homeowners. All of the pilot projects received the maximum $6,000 incentive. One noted that the incentive covered such a small portion of the budget that they were not sure how much of a motivator it would be to people doing large projects.

When asked, interviewed respondents confirmed that the current incentive structure seemed appropriate – that it should be performance-based and paid to the homeowner. Most surveyed homeowners (61%) also thought the incentives should be given to the homeowner (Table 89). Some respondents additionally supported paying the builder so that they can pass along the incentive to the homeowner via a discount on the project price.

- *"Incentives for the builder or HERS rater would be better, since they are driving these decisions. They would then be more likely to push these types of projects since they can pass that discount down to the homeowner potentially."* – Homeowner/Builder
- *"Present it as part of the sales package or whatever to the homeowner. The homeowner could then look at these incentives as a reason to go ahead and do these improvements. I think the incentives should go to the homeowner."*
- *"The incentive is also like getting an award: 'Hey you've done something important. We're offering this money because we want more people to do it. You're a good person!'"*

Table 89: Contractor Incentive Recipient Recommendation

(Source: contractor survey, "To encourage the most participation and to maximize energy efficiency, to whom should the program give financial incentives for high-efficiency renovation and addition projects?)"

(homeowners = 72)

	Count	Percent
Homeowner	44	61%
General Contractor or Builder	26	36%
Other	2	8%

Unlike the interviewed market actors, most surveyed contractors (68%) said the incentive should be a fixed amount for meeting clearly defined practices rather than a variable amount that is performance based (Table 90). The surveyed contractor sample is likely less motivated on average to achieve high-energy performance as is the small sample of market actors who participated in the pilot program and responded to the interviews.

Table 90: Contractor Incentive Basis Recommendation

(Source: contractor survey, "What type of financial incentive would make you most likely to participate in a program that offers financial incentives for high-efficiency renovation and addition projects?")

(homeowners = 72)

	Count	Percent
An amount that *varies* depending on how much energy is saved	*23*	*32%*
A *fixed* amount for meeting clearly defined practices	49	68%

C.6.2 Satisfaction with HERS Raters

All interviewed participants reported high satisfaction with the HERS raters on their projects and the program requirement of using a HERS rater. Respondents described the requirement of a HERS rater on all program projects as a benefit rather than a hinderance to participation. Respondents noted that the independent verification provided by the rater added legitimacy to the claimed efficiency of a project. They also reported that the HERS raters had provided helpful recommendations for how to achieve a higher level of efficiency.

Representatives from two case studies credited the HERS rater with informing them about the program as well as facilitating all of the application and verification processes for the program. As such, participants did not find the program's application processes onerous.

- *"They were knowledgeable and had good recommendations on how to achieve the level of efficiency we were going for. I wish they had been a little more involved with recommending contractors and with the HVAC specifications."*
- *"[The] program was very easy, since the HERS rater took care of all of the program requirements, application, etc."*

C.6.3 Overall Satisfaction with the Program

Participating respondents were highly satisfied with the program. Respondents said that the program application process was easy and the incentive served as a "nice bonus." Additionally, interviewees – many of whom were proponents of energy-efficient practices – were particularly excited about the *concept* of the program and its potential to move the remodeling market to more energy-efficient practices. A participating architect summarized respondents' satisfaction with the potential of the program:

> *"We need to get good at doing this and by that, I mean the industry needs to get good at this. The industry needs to change practices. Planning projects for energy savings and having third parties that can verify the success of those projects are the missing pieces. The trades can do it, they just need a guide."*

Respondents provided two key suggestions for improving the program: (1) increasing publicity about the program and (2) fully subsidizing the HERS rater fee. Both suggestions echo topics previously discussed in this memo. As of this report, the program does not do active outreach since it is only looking for pilot projects, yet respondents anticipated wider participation if more contractors and homeowners knew about the program.

C.7 Suggestions for Improvements

Respondents – all of whom were associated with major-path pilot projects – provided suggestions for the program regarding increasing program participation and messaging. Common suggestions are characterized below:

Focus program on increasing the consideration of house-level energy performance during the design phase of renovation projects. Respondents reported that little emphasis is put on the design phase of remodeling projects. Often a general contractor does the design themselves and individual contractors do their own work without looking at the home as a system. Additionally, respondents reported that the design phase is the only opportunity to increase the energy efficiency of a project since subcontractors simply follow plans. Program administrators should encourage project decision makers to increase the rigor of the design process and to make energy-efficient decisions at a holistic level.

Frame the program as adding the expertise of a HERS rater to the project rather than requiring HERS rater verification. Pilot participants cited the HERS rater verification as a major benefit of the program. HERS rater verification may be a program requirement, but with sufficient incentive to subsidize the cost of a HERS rater, the program can frame this requirement a useful service rather than an extra hurdle. Renovation teams could seek out the program as a cost-effective means of gaining HERS rater expertise. The program should continue to structure incentives to substantially cover the HERS rater fees.

In outreach to contractors, frame the program as a way to learn new techniques that can provide a competitive advantage. Participants said that the market actors can implement efficient practices and technologies but need guidance to get over the learning curve and confidence that the practices and technologies will satisfy the homeowner. The program can encourage market actors to get hands on experience with new practices by subsidizing costs. Once market actors are comfortable with the efficient practices, they can separate themselves from competitors by highlighting their advanced capabilities.

In outreach to homeowners, frame the program as a way to ensure they do not miss out on a unique opportunity to fully upgrade their home. Renovation projects provide a significant opportunity to increase the energy efficiency of a home, but respondents said that most renovation teams do not take full advantage of this opportunity. Messaging to homeowners could highlight the opportunity to use their project to not only improve how their home looks and feels, but also how it performs, offering a subsidy to improve their home more fully with better materials and technologies.

Appendix D Impacts of COVID-19

The study surveyed contractors (n=73) and homeowners (n=104) about projects undertaken before the COVID-19 pandemic of 2020, to better represent the typical Connecticut market. The surveys also gathered information about how the pandemic might have affected the 2020 market. Accordingly, the survey asked respondents to imagine that they were about to start their projects when the pandemic began, and then reflect on how the pandemic might have changed the scope or timing.

Homeowner opinions about impacts on project scope. Half of surveyed homeowners (50%) said they would not have changed the scope of their projects if they had still been in the planning stages during the COVID-19 pandemic. One-fifth (22%) said they would have made the project less expensive and 17% said they would have canceled the project. One-tenth said they would have made the project larger.

Homeowner opinions about impacts on project timing. Of those respondents who would not have cancelled the project, 45% said they would not have delayed the project due to COVID-19. Another 37% estimated they would have had a one- to six-month delay, 10% said a seven- to twelve-month delay, and 8% said a delay of more than a year.

Table 91: Homeowner Reactions to COVID-19

(Source: homeowner survey, “Imagine that you had not yet started your project, and were still in the early planning phases. How do you think the current COVID-19 pandemic would affect what you did as part of your project?)”

(homeowners = 101)

Response	Percent of Homeowners
No significant changes from what I had planned	50%
I would make it a smaller or less expensive project	22%
I would have cancelled the project	17%
I would make it a larger or more expensive project	9%
Other	2%

Table 92: Homeowner Reactions to COVID-19

(Source: homeowner survey, “Imagine that you had not yet started your project, and were still in the early planning phases. How do you think the COVID-19 pandemic would affect when you would begin your project?)”

(homeowners = 78)

Response	Percent of Homeowners
No significant delays	45%
1-6 month delay	37%
7-12 month delay	10%
Over 1 year delay	8%

Contractor opinions about impacts on workload and recommendations. When asked to predict how many projects they would have in 2020 (during the pandemic) compared to 2019 (before the pandemic), 33% of surveyed contractors said they would have "about the same amount" and 27% thought they would have "a lot fewer" (Table 93). Additionally, when considering the impacts of COVID-19, most surveyed contractors (64%) said they would recommend high-efficiency measures at the same rate in 2020 as they did and 2019 and 27% said they would make such recommendations "more frequently" (Table 94).

Table 93: Contractor Reported Impacts of COVID-19

(Source: contractor survey, "Compared to 2019, how many projects do you think you will complete in the next 12 months??)"

(homeowners = 73)

	Count	Percent
Many more	*4*	*5%*
Slightly more	14	19%
About the same	24	33%
Slightly fewer	11	15%
A lot fewer	20	27%

Table 94: Contractor Reported Impacts of COVID-19

(Source: contractor survey, "In the next 12 months, do you think you will recommend high-efficiency measures for your renovation and addition projects more frequently, at about the same rate, or less frequently than as you did in 2019?)

(homeowners = 73)

	Count	Percent
More frequently	*20*	*27%*
About the same rate	47	64%
Less frequently	2	3%
Don't know	4	5%

Appendix E Detailed Survey Findings

This section provides additional results from the contractor and homeowner surveys.

E.1 Perceptions of HERS Raters and Ratings

Table 95: Contractor Experience with HERS Rater

(Source: contractor survey, "Which of the following best describes your familiarity with what HERS raters do?")

(contractors = 72)

	Count	Percent
I have not heard of this term	33	46%
I have heard of them but have not worked with them	29	40%
I occasionally work with them	5	7%
I regularly work with them	5	7%

Table 96: Contractor Interest in Program with HERS Rater Requirement

(Source: contractor survey, "HERS raters are trained energy auditors who measure the efficiency of homes. How would you feel about participating in the program if it required you to include a HERS rater on the project?")

(contractors = 66)

	Count	Percent
Interested	30	45%
Not interested	21	32%
Depends on cost/benefits / need more info	12	18%
Other	3	5%

Table 97: Contractor Reported Frequency of Pulling Permits

(Source: contractor survey, "On what percentage of your projects in Connecticut in 2019 did you obtain a permit?")

(contractors = 73)

Project Type	Renovations	Additions
n	72	35
Min	0	0
Max	100	100
Mean	79	94
Median	100	100
Sd.	34	23

E.2 Energy-Efficiency Recommendations

Table 98: Energy-Efficient Recommendations Made by Project Members

(Source: homeowner survey, "What did they recommend to improve the energy efficiency of your home?")

(recommendations from project members= 275)

Recommendations	Architects	General Contractor	HVAC Contractor	Energy Specialist	Percent of All Recommendations
n[a]	*16*	*45*	*36*	*23*	*314*
More/better insulation than required	10	24	15	8	18%
High-efficiency water heater	6	11	19	8	14%
High-efficiency heating or cooling system	6	15	12	9	13%
High-efficiency windows	9	13	8	8	12%
Duct sealing / duct leakage test	5	14	10	8	12%
High-efficiency lighting	5	12	7	8	10%
High-efficiency appliances	2	7	6	5	6%
Air sealing / blower door test	1	8	5	4	6%
High-efficiency ventilation system	4	4	4	4	5%
Solar panels (PV)	2	3	1	4	3%

[a] The "n" value represents the count of each type of project member that gave a recommendation for "architects," "general contractors," "HVAC contractors," and "energy specialists," and then the number of total recommendations for "percent of recommendations."

Table 99: Project Members Who Recommended Energy-Efficient Upgrades

(Source: homeowner survey, "Did any of the following people recommend ways to improve the energy efficiency of your home as a part of the project?")

(homeowners = 104)

Types of Work	Architects	General Contractor	HVAC Contractor	Energy Specialist
No	60%	44%	47%	54%
Yes	15%	43%	35%	22%
Don't know	3%	2%	3%	3%
Not Applicable	19%	10%	13%	19%
Unanswered	3%	1%	2%	2%

Table 100: Contractor Reported Homeowner Acceptance of Recommendations

(Source: contractor survey, "When you or your HVAC contractor recommended a particular type of HVAC system, what percentage of the time did the customer install what you suggest?")

(contractors = 73)

	Heating and Cooling	Water Heating
n	*40*	*71*
Minimum	0%	0%
Maximum	100%	100%
Mean	90%	77%
Median	100%	100%
Sd.	20%	38%

Table 101: Contractor Reported Frequency of Specific Homeowner Requests

(Source: contractor survey, "On what percentage of your projects did homeowners request a particular type or amount of insulation?")

(contractors = 73)

Minimum	0%
Maximum	75%
Mean	7%
Median	0%
Sd.	15%

Table 102: Contractor Reported High Performance Projects

(Source: contractor survey, "What percentage of your projects met or came close to a high performance energy-efficiency standard such as LEED, Energy Star for Homes, Passive House, Net Zero Energy?")

(contractors = 73)

Statistic	Percentage
Minimum	0%
Maximum	100%
Mean	36%
Median	10%
Sd.	40%

E.3 Decision Making

Table 103: Homeowner Decision Making for Picking Heating and Cooling Types

(Source: homeowner survey, “How did you determine what type of heating or cooling system was installed in your project?)”

(homeowners who installed heating or cooling systems = 20)

	Count	Percent
Contractor recommendation	18	90%
I requested a particular type of system.	2	10%

Table 104: Homeowner Decision Making for Picking Water Heating Types

(Source: homeowner survey, “How did you determine what type of heating or cooling system was installed in your project?)”

(homeowners who installed heating or cooling systems = 25)

	Count	Percent
My contractor selected or recommended the type of system	21	84%
I requested a particular type of system.	2	8%
Other	2	8%

Appendix F Benchmarking: Comparable Programs in the Region

F.1 Regional Program Comparison

This section describes comparable renovations and additions programs in surrounding states. The study looked at three nearby states for comparison: Massachusetts, Rhode Island, and Vermont. Renovation and addition program offerings are a relatively new development in the energy-efficiency program market in New England, and some programs are still in the pilot phase. Therefore, detailed information about the program requirements, incentive levels, and participation are not as readily available as they might be for more established program types, as they have not all been evaluated yet.

In both Rhode Island and Vermont, renovation initiatives listed on their respective program websites, but little detail is otherwise publicly available. As in Connecticut, these offerings fall under the umbrella of the RNC programs, but additional metrics have not been broken out specifically in planning or annual reporting documents. Similarly, there are not yet any readily available evaluations of these programs in either state. Accordingly, the Massachusetts renovations and additions program serves as the best point of comparison, as it is active and has been the subject of evaluations.

Table 105 shows a comparison of program structure and offerings only between Connecticut and Massachusetts, given the lack of available information regarding the other programs. For the Connecticut pilot program, performance incentives for major pathway participants are capped at $6,000, with an additional subsidy to pay HERS rater fees. There have been no minor pathway participants in the Connecticut pilot program.

Table 105: Comparison to Similar Programs in the Region

	Connecticut	Massachusetts
Total participants	3 (more in progress)	973
Eligibility	Minor: <500 ft^2 CFA Major: >500 ft^2 CFA (addition) or >50% building shell affected (renovation); HVAC upgrade	>500 ft^2 building shell affected
Compliance path	Minor: prescriptive Major: performance	Performance
HERS rater required?	Minor: no Major: yes	Yes
Incentive structure	Minor: Prescriptive Major: Tiered percent EUI savings	Electric savings*$0.50/kWh + Fuel savings*$50/MMBtu + Percent savings*$4,000
Savings baseline	Renovation: pre-existing conditions Addition: UDRH	Renovation: ISP Addition: UDRH

F.2 Savings Potential Comparison

The study also compared savings potential results in this study to a recent renovations and additions potential study in Massachusetts, which used similar energy modelling and scaling methodology. Table 106 shows the results of that comparison. Estimated gross technical potential savings are higher in Connecticut than in Massachusetts, both at the per-home level and statewide, due to the following reasons:

- **Program criteria**: The assumptions put into energy models for the major path of the Connecticut program resulted in larger scope projects than were modeled in the Massachusetts study, where there is only one program path and criteria.
- **Heating fuel prevalence**: Both studies assumed in energy models that homes previously heating with oil would switch to heat pumps if HVAC was being upgraded, which led to high oil savings in both studies. However, the prevalence of oil heating is higher in Connecticut, yielding higher overall results when scaling savings up to the state level.

Table 106: CT and MA Potential Savings Comparison (MMBtu)

	Connecticut	Massachusetts
Per Home Savings	26.2	19.0
Statewide Savings	2,015,335	1,055,955

It should also be noted the potential estimates are not guarantees or predictions of savings. Below, are limitations of the energy modelling approach as it relates to the validity of these estimates:

- **Number of prototype models**: The study created several dozen prototype energy models meant to simulate the different project sizes, scopes, locations, and heating fuels that might exist in the CT market. However, countless more models would need to be created to perfectly represent the diversity of homes and renovation projects that exist in the real world. That said, these models rely on reasonable assumptions, informed by primary and secondary data collection.

- **Model assumptions**: The study made judgements on what types of upgrades would happen in each simulated scenario, but contractors on their own (or as encouraged by the program) could choose others. Examples might be which walls would be opened and reinsulated, whether to put a separate HVAC system in an addition or to tie in to the existing one, or whether to condition a basement or insulate the framed floor above it. Actual renovation projects will differ from models, and it is impossible to represent all possibilities and the savings associated.

Appendix G Savings by Company Territory

The following tables show estimated potential savings by Company territory. The total savings values do not match statewide savings as they exclude municipal electric and gas territories and areas with no gas service. Oil and propane savings are each shown in two tables, first distributed across the Companies' electric territories and then across their gas territories.

Table 107: Gross Technical Potential Electric Savings by Company Territory (MMBtu)

Company	Electric Savings
Eversource	233,744
United Illuminating	17,333

Table 108: Gross Technical Potential Gas Savings by Company Territory (MMBtu)

Company	Gas Savings
Eversource	145,314
SCG	90,987
CNG	82,090

Table 109: Gross Technical Potential Oil Savings by Electric Company Territory (MMBtu)

Company	Oil Savings
Eversource	1,127,961
United Illuminating	57,769

Table 110: Gross Technical Potential Oil Savings by Gas Company Territory (MMBtu)

Company	Oil Savings
Eversource	647,789
SCG	218,219
CNG	218,418

Table 111: Gross Technical Potential Propane Savings by Electric Company Territory (MMBtu)

Company	Propane Savings
Eversource	37,828
United Illuminating	1,671

Table 112: Gross Technical Potential Propane Savings by Gas Company Territory (MMBtu)

Company	Propane Savings
Eversource	16,607
SCG	5,571
CNG	5,240

H

Appendix H Individual Energy Model Results

See the spreadsheet, which provides individual model-level consumption results for the energy models included in this study.