Renovation Nation: Granite Counters, Stainless Appliances, and … Thick Insulation

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ABSTRACT

Energy-efficiency program sponsors have long achieved savings by incentivizing efficient Residential New Construction (RNC) projects and by weatherizing existing homes. However, sponsors have not historically targeted home renovation and addition projects. Accordingly, many people renovating their homes or building additions move forward without incorporating easily achievable energy saving practices into their projects. This represents a clear opportunity for sponsors looking for new sources of savings.

Program sponsors in Connecticut and Massachusetts, two states with well-established RNC programs, have developed new program pathways that incentivize efficient renovation and addition projects based on modeled energy savings relative to a baseline scenario. This paper presents the results of evaluations performed in 2019 in Massachusetts and 2020 in Connecticut to inform the design of what are now the current R&A offerings. These studies highlight the unique approaches used to identify the size of the markets, the scope of projects, the savings potential, and key market barriers. Interestingly, these two states have since chosen different program approaches to the R&A market: one focuses on deep retrofits and the other on modest improvements over a wider market. This paper describes the issues each is confronting in trying to overcome market barriers and includes recommendations for other programs based on the difficulties each is encountering and the progress each is making.

Introduction and Background

Energy-efficiency program sponsors in both Connecticut and Massachusetts have long operated programs that incentivize high-performance residential new construction (RNC) and weatherization upgrades. Until recently, neither state operated programs targeted specifically at homes undergoing renovation or addition (R&A) work. Program sponsors saw an opportunity to achieve savings in this market sector by encouraging homeowners and contractors to incorporate better energy efficiency practices into these projects than they otherwise would. In 2020, the authors of this study completed a study for the Massachusetts program sponsors (NMR 2020) to help them better understand the Massachusetts R&A market. The authors completed a separate but complementary study in Connecticut in 2021 (NMR 2021a). The two studies included detailed assessments of the size, scope, and gross technical potential savings of the R&A markets in each state to inform the R&A offerings. The studies focused on using permit data and market actor feedback to learn about the number of permitted and unpermitted projects occurring each year and to describe the scope of typical R&A projects (e.g., how large projects were, what measures were changed, etc.).

The studies also gathered feedback from market actors and homeowners about barriers to participating in the programs and incorporating higher-efficiency practices into R&A projects more

generally. The Massachusetts study was conducted prior to the Connecticut study, which leveraged some of the results of the Massachusetts study (NMR 2021b, 2021c).[1]

For these studies, renovations were defined as major home remodeling or improvements that do not add to the conditioned square footage of a house. They do not include routine or limited work such as painting, decorating, fixing broken water pipes, landscaping, or projects limited to just HVAC replacements. Additions were defined as expanding the conditioned square footage of a home. This would include adding new, finished and conditioned rooms to previously unfinished space, building a new attached section of the home, finishing and conditioning a previously unfinished basement or bonus room, or adding a new story to a home. Simply changing the function of a room (e.g., turning a closet into a bathroom) would be considered a renovation because it does not make the home larger.

Below we present a high-level summary of the Massachusetts and Connecticut R&A programs at the time these studies launched.

Massachusetts R&A Program

As of 2021, the R&A program in Massachusetts operated within the Residential New Home and Renovations initiative. To participate in the program, participants were required to obtain a building permit for a project that alters or affects at least 500 square feet of building shell or conditioned floor area. The targeted projects were for one-to-four family residential and low-rise (three stories or less) multifamily homes. Participants had to enroll prior to enclosing wall cavities, as the path required an inspection for the quality of installation of insulation in the building cavities. The Massachusetts program used a pay-for-savings model, with projects examined using a whole-house approach. The program required a verification inspection by a HERS rater or similar energy auditor. These third-party verifiers are responsible for modeling the impacts of participating projects using Ekotrope, an energy modeling software tool. The modeling software calculates whole-home savings by comparing the as-built home (after the renovation and/or addition) to a baseline version of the home. Ekotrope uses a hybrid baseline; with this approach, renovated portions of the home are compared to pre-existing conditions[2] while additions are compared to a hypothetical addition built to typical efficiency levels seen in the Massachusetts market. The typically efficiency levels were based on the most recent Massachusetts RNC baseline study (NMR 2018a). The program used a new-home level of performance for additions since they are subject to the same energy efficiency requirements as new homes; renovations are not subject to the same levels of performance under the Massachusetts energy code.

Connecticut R&A Program

At the time of the study, the R&A program in Connecticut was in a pilot phase and had not fully launched to the broader market. As in Massachusetts, the program was designed to incentivize energy efficiency upgrades as a part of renovation or addition projects. Also as in Massachusetts, program projects in Connecticut required a building permit, needed to meet code, and the customer had to apply for the program before enclosing wall cavities to ensure that efficiency upgrades such as insulation and air sealing could be inspected and verified.

[1] Follow-up studies in Massachusetts also assessed the incremental costs for early program participants and estimated a net-to-gross ratio for the early program.

[2] The program has since shifted its approach so that renovated home portions are no longer compared to pre-existing conditions but to industry standard practice (ISP) . ISP is a series of assumptions about what contractors normally do on renovation practices in the market, informed in part by the results of the R&A market study and program tracking data.

The Massachusetts program offered a single participation path, with incentives based on modeled savings. In contrast, the Connecticut pilot offered two paths: minor additions and renovations (less than 500 square feet of conditioned floor area or less than half of the home's building envelope impacted), and major additions or renovations, which targeted larger projects that affected at least 50% of the existing building envelope. The minor project path encouraged improvements in the whole home alongside other R&A work and would not require a HERS rater's involvement. It also used a delivery mechanism similar to the state's popular Home Energy Solutions (HES) program, in which a vendor provides whole-home efficiency upgrades to existing homes. The major project path is similar to that of the Massachusetts program, in that it requires a HERS rater and follows a performance-based incentive approach relying on energy modeling. While the modeling process also used a hybrid baseline, with renovated portions of the home compared to pre-existing conditions as-built additions were compared to expected performance under the code requirements of new construction rather than to typical new home performance.

Research Approach

Each study used a mixed-methods approach to characterize the R&A markets. Ideally, the Massachusetts program and Connecticut pilot would generate market-wide changes to contractor and homeowner practices. Accordingly, the studies laid the groundwork for developing indicators with which to track potential market effects. Table 1 below summarizes the key research activities conducted for both studies.

Table 1. Key research activities

Research Activity	Sample Sizes	
	Massachusetts	Connecticut
Develop program theory and logic model	✓	--
Online permit database review	56 (databases reviewed)	Applied MA formulas to CT's 169 municipalities
General contractor web survey	77	73
HVAC contractor phone interviews	10	--
Program participant phone interviews	--	10
In-person focus groups with general contractors	24 participants (5 focus groups)	--
Web survey of homeowners with recent R&A projects	207	104
Energy model prototypes	72 prototypes (multiple baseline scenarios)	48 prototypes

The Massachusetts study included an in-depth and iterative review of online permits from a sample of municipalities to identify the number of permitted projects in the state. From this permit review, the evaluation team created an algorithm created to estimate the total market size using several geographic and demographic variables. Combined, the studies included surveys, interviews and focus groups with market actors and stakeholders to describe common measure-level practices, which rooms are targeted, what building shell practices are used, and how mechanical systems are changed as a part of these projects.

The results from the market sizing and scope of projects efforts were used to develop hundreds of energy models to estimate potential savings against multiple baseline scenarios, leading to the recommendation of new baseline approaches for the programs.

Estimating the Size of the Massachusetts R&A Market

The evaluation team originally planned to gather information to estimate the number of permitted single-family renovation and addition projects in Massachusetts via in-person visits to building departments. However, the team found that so many municipalities offered online databases with permit data that it was worth examining the possibility of basing the estimate just on the data available online. . Accordingly, the team reviewed building department websites for all 351 municipalities in Massachusetts and found that 56 (16%) offered online databases that included permit records with project descriptions.[3] The team also confirmed that the demographic characteristics of cities and towns with online permit databases were not significantly different from those without them. With this assurance that the results of permit database reviews would be reasonably generalizable across the state, the evaluation team estimated the number of permitted single-family renovation and addition projects in Massachusetts using only the data available online.

The study used an iterative keyword analysis of the individual permits included in the 56 databases to identify relevant R&A projects and exclude projects that did not include a renovation or addition. Figure 1 shows common keywords found in permit records for R&A projects. Figure 2 includes keywords that typically indicated that a permit was for something other than a true R&A project, such as replacing a roof or adding a pool.

Figure 1. Keywords found in R&A Permits

Figure 2. Keywords found in Non-R&A Permits

The Massachusetts study used regression modeling to analyze the thousands of permit records included in the online permit databases and develop estimates of permit counts for cities and towns without accessible databases. The team developed simple formulas derived from the modeling to estimate the number of permitted projects in a given city or town based on three key variables from Census data: the municipality's single-family home count, median household income, and population density.[4] While the team tested a variety of variables that could potentially be used in a regression analysis to predict permit activity, these three variables were the most significant predictors, together

[3] In addition to the 56 municipalities, four more offered online databases but did not provide any aggregated or summary information of online records, meaning the reviewer had to open each permit record individually to ascertain what the permit covered. These databases were not included in the analyses.

[4] "2013-2017 ACS 5-Year Estimates" https://www.census.gov/programs-surveys/acs. The study used 2010 to 2018 data to develop the regression models.

explaining approximately 75% of the variation in municipal permit counts.[5] The formulas to calculate the estimated number of permits can be found below.

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

$$\boldsymbol{Addition\ Permit\ Estimate} = \frac{(SF\ Home\ Count \times 0.013345) + (Median\ Income \times 0.001490) + (Population\ Density \times 0.065888)}{3}$$

$$\boldsymbol{Renovation\ and\ Addition\ Estimate} = \frac{(SF\ Home\ Count \times 0.004896) + (Median\ Income \times 0.000707) + (Population\ Density \times 0.023645)}{3}$$

To reflect the total market size, the study also developed estimates of the number of R&A projects completed without permits, using results from a contractor web survey that asked respondents to report the percentage of their R&A projects that did not obtain a permit.

Estimating the Size of the Connecticut R&A Market

The Connecticut study applied the regression model from the Massachusetts study to estimate the number of R&A projects for a given municipality in Connecticut based on the city or town's single-family home counts, median income, and population density. As in Massachusetts, the Connecticut contractor web survey was used to estimate the number of projects completed without permits. This process was based on the premise that the Massachusetts and Connecticut markets shared significant similarities in terms of the drivers of renovation and addition activity.

Characterizing the Scope of R&A Projects

The studies used primary data collection activities to characterize the scope of these projects, as described in Table 1. Surveys, interviews, and focus groups gathered information about typical project scopes, including project size, which rooms are changed or added, and which measures are commonly affected by R&A projects. The studies also gathered information about the energy-efficiency practices that contractors typically use in their projects, the types of recommendations different market actors make to their customers, and the extent to which customers request high-efficiency upgrades.

Estimating Gross Technical Savings Potential

The studies estimated the gross technical savings (GTP) potential of the R&A markets in each state by creating a set of prototypical energy models for different R&A scenarios and then scaling the resulting savings up to the state level. The GTP estimates assume that all R&A projects both resemble the prototypical models and that all projects would participate in the program. Accordingly, the resulting values are upper bounds of savings, and do not represent economic or achievable savings, which would be substantially lower. The savings were calculated by creating models of prototype homes before (baseline) and after (upgrade scenario) a renovation or addition had taken place and taking the difference in energy consumption between the two. At the start of the studies, both the Massachusetts and

[5] Regression modeling investigated the significance of other independent town-level variables, such as total population, median length of occupancy, median room count, median home age, and median property value. However, these variables were either not meaningful predictors or, in the case of population, were too closely correlated with home counts.

Connecticut programs anticipated using a savings baseline for renovation projects as the pre-existing conditions. Based on the study results, the team modeled a more efficient baseline for renovation projects than pre-existing conditions, to better approximate industry standard practices (ISP) for renovation projects.

At a high level, the modeling assumed that for a renovation, contractors would upgrade wall and ceiling components immediately affected by a renovation to modest levels, filling cavities with fiberglass batts with moderate gaps and compression. For additions, each study modeled the program's RNC baseline, which reflects typical RNC practices. For the upgrade scenarios, the study developed estimates of what typical upgrades might be for participating projects, given the low levels of participation in each program to that point. For renovations, the upgrade scenario assumed that installed measures would mirror the average measure-level performance of homes that participated in Connecticut's Home Energy Services (HES) program or Massachusetts' residential Mass Save weatherization program. The upgrade scenario also assumed that all participant renovation projects would include whole-home upgrades beyond what would be typical ISP for contractors, such as insulating the entire attic, insulating the frame floor over a basement, and 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.

The studies developed 120 prototypic models (72 in Massachusetts, 48 in Connecticut) using RESNET-approved residential energy modeling software to represent differences in project type, scope, heating fuel, and location across both states. Once the savings for each prototype were calculated, the results were scaled up to each utility territory and to the entire state 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 savings estimates for Connecticut than Massachusetts when scaling savings up to the state level.

Summary of Findings

Market Sizing Findings – How Many R&A Projects Happen in a Given Year?

Table 2 presents estimates of the annual numbers of renovation and addition projects completed in Massachusetts and Connecticut in a given year, based on recent permit data, current Census data, and data collected from the studies.

Table 2. Estimates of Annual R&A Projects (Massachusetts: 2019; Connecticut 2020)

	Massachusetts	Connecticut
Renovation only	89,424	40,983
Addition only	30,364	15,342
Renovation and addition	12,828	6,405
Total projects	132,616	62,731
% of single-family homes in the state	7.5%	6.5%
% of renovations permitted	88%	79%
% of additions permitted	97%	94%

Massachusetts. Based on the data collected in the Massachusetts study, the report estimated that the single-family renovations and additions market in Massachusetts comprises approximately 130,000 projects in Massachusetts each year, including permitted and non-permitted projects (Table 2). This represents about 7.5% of all single-family homes in the state, a market nearly 18 times larger than

the annual single-family new construction market (about 7,200 homes)–a tremendous market opportunity. Based on the permit analysis, the team estimated that two-thirds of the annual projects are renovation-only (66%), 24% are addition-only, and 10% include both a renovation and an addition, with a variety of project sizes and scopes included within each of these categories.

Connecticut. Relying on the algorithms created for Massachusetts, the Connecticut study estimated that about 63,000 permitted R&A projects have been completed each year in recent years (Table 2). Based on the contractor survey results, the study estimated that homeowners completed almost 5,000 more projects without permits. In total, this is 27 times higher than the number of single-family homes built each year in Connecticut (2,466 homes). An estimated 7% of single-family homes undergo renovations and/or additions annually in Connecticut, with differing scopes and savings potential. Applying the regression model from the Massachusetts study to Connecticut provided similar results for the estimated percentage penetration.

Permitted vs. non-permitted projects. Each study developed estimates of how many R&A projects were completed without the benefit of permits, a challenging premise given that this essentially requires contractors to acknowledge behavior that does not comply with code. As Table 2 shows, in Massachusetts, surveyed contractors reported that 88% of their renovation and 97% of their addition projects included permits. In Connecticut those figures were 79% and 94%, respectively. The high rate of permitting among addition projects appears reasonable, given that code requires these projects to be permitted and it is harder to hide an addition than a renovation project from neighbors or local code officials. Additions that fall within the footprint of the home, such as finishing a basement or attic space, may also be easy to hide. One would expect these to be permitted less often than other more visible additions, such as expanding the actual footprint of the home.

Surveyed contractors who reported not obtaining permits on R&A projects explained their reasoning (Table 3). Contractors in Massachusetts were more likely to report that they skipped permits because they did not think one was required (86% in Massachusetts versus 67% in Connecticut). They may have been correct in this assessment, or they may have been operating out of ignorance of code requirements. In Connecticut, more contractors reported that they skipped permits at the request of the homeowner (41% in Connecticut versus only 9% in Massachusetts). Not getting a permit due to homeowner request is a problematic response, given that contractors are in a position to influence this preference and that getting a permit protects the homeowner by helping ensure that the work will meet energy and safety standards (even if the permit may increase project costs).

Table 32. Contractor-Reported Reasons for Not Pulling Permits (Multiple Response)

Reason for Not Getting Permits	Massachusetts (n=22)	Connecticut (n=27)
Did not think one was required	86%	67%
Homeowner did not want to	9%	41%
Too much time/effort	5%	11%
Subcontractor did not want to	--	4%
Other	5%	4%

Additionally, the studies concluded that homeowners were generally not engaged with the permitting process at all. In Connecticut, 75% of surveyed homeowners who had completed recent R&A projects were unsure if their project had gotten one; only 18% recalled getting one, indicating the importance of a contractor's decision to advocate for or against getting a permit.

Project Scope Findings

Table 4 shows the average size and most common types of projects in both Massachusetts and Connecticut according to the contractors surveyed.

Table 43. Project Scope Findings, According to Surveyed Contractors

	Massachusetts	Connecticut
Renovation size	Mean: 887 ft^2 Range: 50 – 2,400 ft^2	Mean: 590 ft^2 Range: 50 – 2,400 ft^2
Addition size	Mean: 808 ft^2 Range: 100 – 2,500 ft^2	Mean: 369 ft^2 Range: 50 – 2,000 ft^2
Most common renovation types	Bathroom (44%), Kitchen (41%)	Kitchen (31%), Bathroom (26%)
Most common addition types	Finishing and conditioning basement, building new section of the house, finishing and conditioning an attic space or bonus room over garage	Finishing and conditioning basement, building new section of the house, finishing and conditioning porch or sunroom
Most common affected measures	Heating and cooling equipment, insulation, lighting, windows	Heating and cooling equipment, water heating equipment, insulation, windows

Massachusetts. The average size of Massachusetts projects reported by market actors was 887 square feet for renovations and 808 square feet for additions. Half of the renovation projects were between 100 and 1000 square feet, while half of addition projects were between 100 and 500 square feet, indicating a substantial part of the market is relatively small and may have limited energy savings opportunities without also improving other parts of the home. Both the homeowner survey and the online permit analysis suggest that renovations most commonly included a bathroom or kitchen upgrade while additions commonly included adding square footage to the home by finishing a basement, adding a story, or expanding the footprint of the existing home. Common measure types for Massachusetts and Connecticut included HVAC, insulation, and windows.

HVAC measures in Massachusetts were observed to involve replacements more often than repairs. The most common HVAC systems used as replacements were air source heat pumps (ASHP). Over 40% of homeowners with renovation projects and new HVAC equipment indicated they installed an ASHP. That number rose to over 50% for homeowners undertaking an addition project that included new equipment. The remainder of homeowners installed other new systems, such as ground source heat pumps (GSHP), or more traditional equipment such as boilers, furnaces, and central air conditioners. Water heaters were generally the measure least often included in R&A projects.

Contractors who participated in focus groups in Massachusetts suggested that wall insulation was frequently included in renovation projects. Opening walls allows for the installation or repair of electrical wires or plumbing lines -- but also triggers the code's insulation requirements, forcing insulation to be part of the project. Some participants preferred to open the walls in renovation projects, gutting the space to better address hidden issues. Contractors that participated in a focus group said that wall insulation (except for spray-foam) is inexpensive relative to other renovation components, making it an easy decision to replace pre-existing insulation. Leaving existing wall insulation untouched might occur in projects with extremely limited scopes or in non-permitted projects without a code official's inspection.

Connecticut. Across all surveyed contractors, small projects (500 square feet or less) comprised the majority of additions (65%) while projects larger than 500 square feet comprised the majority of renovation projects (65%). Like Massachusetts, the most common renovation types for Connecticut were kitchen and bathroom renovations, while the most common addition types were building a new section

of the house, finishing a basement, or finishing a porch or sunroom. Key measures in Connecticut renovation and addition projects included HVAC, water heating equipment, insulation, and windows.

In the Connecticut study, homeowners who had recently completed R&A projects reported a surprisingly high percentage (56%) with a do-it-yourself (DIY) component. This DYI work primarily consisted of activities not associated with energy efficiency, such as painting or design work. About 40% of projects with a DIY component included more substantial DIY work such as demolition (44%), flooring or tile work (42%), or carpentry or insulation work (34%). As we would expect relatively few homeowners to have expertise in energy efficiency, this could have resulted in missed opportunities for the program.

Savings Potential Findings

Table 5 shows the gross program savings that could potentially be obtained from renovation and addition projects in Massachusetts and Connecticut.

Table 54. Massachusetts and Connecticut Gross Technical Potential Savings Comparison

	Massachusetts	Connecticut
Average Per Home Savings from Modeled Prototypes	19.0 MMBtus	21.2 MMBtus
Statewide Savings	1,055,955 MMBtus	825,096 MMBtus

Massachusetts. Table 5 shows that based on modeling, the average renovation or addition project could generate approximately 19 MMBtus of annual savings in Massachusetts. Statewide these estimates equate to about 1.1 million MMBtus. The estimated GTP savings for renovations and additions in single-family homes alone is several times higher than claimed savings (net savings) for the RNC program's traditional single- and multifamily projects, representing a huge program opportunity.

Connecticut. Based on modeling, the average renovation or addition project could generate 21.2 MMBtus of annual savings in Connecticut, yielding about 825,000 MMBtus statewide (Table 5). These values exclude savings associated with fuel switching, as Connecticut's savings calculation methods generally do not include all the savings associated with switching from a delivered fuel to an electric heating system.[6]

Conclusion and Recommendations

Huge market potential in both states. Both studies found that the R&A market represents a huge potential for savings. Based on the findings of these two studies, not only are there many R&A projects occurring in Massachusetts and Connecticut in a given year, significant energy savings could be achieved in these projects. Furthermore, energy efficiency opportunities taken will generate savings that will last for many years, while opportunities not taken are likely permanently lost. If new R&A programs can win more participants, program sponsors should have a significant opportunity to drive savings in a new market area. This is a key opportunity in light of diminishing savings from traditional RNC programs. These studies suggest that R&A programs should work to target all different sizes of projects so as to avoid

[6] The study also included a higher set of savings values for Connecticut (26.2 MMBtu per home and 2 million MMBtu total), that included savings from fuel switching projects (i.e., homes heated by oil that switched to electric heat pumps as a part of the R&A project). The lower (but still substantial) values represent savings that appear to be claimable within the state's current policy framework, which does not allow for fully claiming savings from fuel-switching projects (i.e., the energy saved by switching from an oil system to an electric heat pump). As of this writing, the Connecticut Program Savings Document uses a less efficient electric heat pump as the baseline measure for projects installing heat pumps, rather than an oil system.

substantial missed opportunities. The Connecticut study in particular found high rates of DIY work in that market, which can lead to sub-optimal energy efficiency outcomes. Incentives from an R&A program may also entice DIY-minded homeowners to participate, likely yielding better energy efficiency outcomes than if they did the work themselves.

The studies suggest that both programs also have not only a large savings potential, they have a significant opportunity to shift the overall market toward higher-efficiency practices by helping build contractor skills and incorporating energy efficiency into typical practices. The RNC programs in Connecticut and Massachusetts have long followed a market transformation-style approach (NMR 2018a, 2018b), achieving market effects by helping build the market for HERS raters in each state and teaching contractors how to build to higher efficiency practices and incorporate them into their typical projects.

Non-permitted projects represent a minority of renovation projects in each state. Contractors in our surveys reported that 12% of their projects in MA and 21% in CT were not permitted. Because these projects are not inspected and, as our customer survey, often involve DYI work, the levels of energy efficiency achieved in projects that are not permitted may be lower than in permitted projects. For good reason, both the MA and CT programs currently require participating projects to be permitted and are likely to continue to do so. If programs are to reach the segment of customers that does not obtain a permit for their R&A projects, they will need to provide education and sufficient incentives to homeowners to encourage them to seek permits in order to compensate for the extra cost and hassle of going through the permitting process.

Learning from early experiences. Program sponsors in other states have opportunities to learn lessons from the early experiences in Massachusetts and Connecticut and build on their successes and challenges. For example, recent research in Massachusetts (NMR 2021b) indicated that early participants rarely included whole-home envelope improvements in projects, focusing largely on the specific areas being renovated. This highlights opportunities for program implementers to provide additional guidance to participating contractors. The Massachusetts program also discovered that it needed to change its renovations baseline from pre-existing conditions to an ISP baseline, representing a challenge for implementers who had to retool their savings calculation approach. The Connecticut study was conducted during the program's pilot phase, giving program designers an opportunity to carefully consider challenging factors such as appropriate baselines or how to best market the program. As program funding levels and rates of obtaining permits, etc., differ across jurisdictions, it is most appropriate for program sponsors to develop offerings specific to their territory rather than simply replicating the Massachusetts and Connecticut approaches.

Appropriate baselines. These studies pointed to the challenge of developing appropriate savings baselines for R&A programs. When these two studies launched, the programs in Massachusetts and Connecticut used pre-existing conditions as the baseline for renovation projects. This approach is not unreasonable – if a participant home is renovated, its consumption decreases relative to the preexisting conditions of the home. However, the data these studies collected indicate that when it comes to renovations, certain practices generally happen as a part of ISP and may be appropriate to include in baselines to avoid overstating savings. For example, when contractors open wall cavities they generally install enough insulation to fill the cavity (though it may not be installed to program standards). In this case, ISP would be an appropriate baseline. The studies showed that conducting whole-home air sealing or insulating an entire attic (beyond the area included in the specific project itself) would not be a contractor's normal practice, so that pre-existing conditions would be an appropriate baseline. Such whole-home work represents a significant opportunity for R&A programs to achieve savings that might not happen otherwise.

Another baseline consideration that surfaced during these studies was the question of expanding the scope of projects (in a limited way) to maximize savings beyond the original project scope. Program staff in Massachusetts and Connecticut confirmed that their programs were designed to improve the

efficiency of participant projects by helping make the renovation or addition more efficient than it would have been without the program. The programs *were not actively encouraging more homeowners to leverage or expand the renovation to increase the energy efficiency of other parts of their homes*, such as through opening up additional walls or renovating more rooms than initially scoped with an eye to improving energy efficiency in the process. A more lenient, pre-existing conditions baseline 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 a program to achieve savings if homeowners expand the scope of projects due to program participation.

Given that the Connecticut program was in its early pilot phase while the study was being conducted, the study team suggested that the program sponsors consider actively encouraging project scope expansion. This effort would likely be undertaken largely by HERS raters, who could guide the R&A team on the merits of different efficiency options. Of course, this approach complicates program savings calculations, as it would require two different baselines for renovated portions of the home, depending on what work was initially part of the scope versus not. It also complicates program delivery, as it would require changing how the program is marketed, focusing on expanding projects rather than simply improving the efficiency of projects with fixed scopes. Many projects also would not be candidates for scope expansions, as many homeowners plan their projects with extremely fixed budgets in mind and do not consider energy efficiency a high priority.

For all these reasons, the Connecticut study team specifically recommended that prior to fully launching any R&A program, the program sponsors should consider convening a working group of stakeholders to determine the appropriate measure-level baseline values for the R&A program. By discussing and sorting out these complicated issues up front, sponsors can try to develop a baseline that they can implement cost-effectively and that adequately reflects their market condition.

NTG impacts. Developing baselines for these programs will inevitably lead to questions of NTG impacts. A follow-up Massachusetts study (NMR 2021c) assessed the NTG ratio for the Massachusetts program, settling on 85% (34% free-ridership, 2% participant spillover, and 17% non-participant spillover) for the period when the program used pre-existing conditions as the renovations baseline. However, the Massachusetts program has since shifted to a new, more efficient ISP baseline for renovation projects. Going forward, that NTG study suggested a higher 92% NTG ratio to avoid double-discounting program savings for any potential overlap between the higher ISP baseline and free-ridership. Double-discounting could occur when free-ridership is calculated for a program without adjusting for the higher baseline, while program savings would be calculated using the higher baseline, yielding an overestimate of free-ridership. The Massachusetts NTG evaluation process included an expert consensus group to determine how to handle free-ridership and ISP overlap. Programs considering changes along the lines proposed here should carefully consider what baselines they might want to use and the impact on program savings.

Outreach to customers. Program awareness and limited customer prioritization of energy efficiency were substantial barriers identified during the R&A studies. Market actors indicated interest in the R&A programs, but they were generally unfamiliar with the new programs. Study respondents identified helpful messaging for potential participants as the programs consider 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 the techniques can be subsidized by the program. Once market actors are comfortable with efficient practices, ideally they will leverage that ability in their own marketing to stand out from competitors. For 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 upgraded. Programs should probably also include architects in their outreach, as architects may be as strong efficiency champions on project teams, particularly for larger projects.

Overall, the R&A market represents a significant opportunity for savings, though one that may need market intervention on the same order as previously invested in new construction. In Massachusetts and Connecticut, potential R&A savings substantially exceed savings from the RNC market. As lighting savings diminish and new home energy code improves, renovations and additions represent a huge market potential.

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