Lessons from the Field for Scaling Up Deep Energy Retrofits

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ABSTRACT

The ability to reduce the energy use of a building by 50% or more has been documented through a number of deep energy retrofit projects, suggesting that the technology and techniques necessary to significantly reduce energy use in a home are available. Yet, there are still significant barriers, including up-front cost and workforce expertise that make widespread adoption of deep energy retrofits challenging. In this paper, we focus on lessons from the field from a number of home performance contractors that are each involved in multiple, sequential deep energy retrofit projects as part of a pilot program. We evaluate opportunities for work-flow enhancements and refinement of installation techniques for exterior wall insulation and air sealing that can be developed through a home performance contractor's experience in the field with multiple retrofit projects, and how that can translate into increased demand as well as increased willingness of contractors to offer the work on a more regular basis. In addition, we discuss how programs can enable contractors to develop methods for documentation of successful techniques, in an effort to enable high-quality retrofit work that is not as time intensive and costly as it currently is today. Lastly, we make recommendations for providing additional support to contractors to facilitate scaling up the workforce for deep energy retrofits.

Introduction

Residential buildings accounted for 22% of the energy consumed in the United States as of 2009 (EIA 2009). The majority of this energy is used in the 78.5 million existing single-family homes, most of which are ripe for improvements in their building shell and mechanical systems to reduce energy demand. While many programs address energy efficiency in existing homes, very few of them succeed in reducing home energy use by 50% or more. Nonetheless, a growing number of cities and states are setting energy-savings targets to help meet greenhouse gas emissions goals, and these targets will require large reductions in the energy use of existing homes.

For example, California is calling for a 40% reduction in existing homes' energy use by 2020, an ambitious goal considering that the highest performing residential retrofit energy efficiency programs result in savings of between 10% and 20% (Brook et al. 2012). Yet while the goal is ambitious, it is feasible. An increasing number of documented projects show how energy use in an existing home can be cut by 50% or more (Cluett and Amann 2014). A deep energy retrofit (DER), practiced and implemented to its full extent, represents a step-function advance to the business-as-usual incremental approach to home performance work that is typical in current practice. DER improves existing building stock to rival the insulation, air tightness, and air-quality characteristics of the highest-performance new-construction buildings today. Although DER can achieve all of these benefits, there is a long way to go toward achieving this at scale. Some of the primary barriers that prevent DER activity from being performed on a widespread basis are upfront cost, workforce ability, and consumer awareness. The New York State Energy Research and Development Authority (NYSERDA) Advanced Buildings Program has undertaken a series of projects in existing homes in upstate New York to demonstrate and develop high-performance retrofit strategies that explore and utilize installation techniques that are not regular practice in the building renovation or home performance industry today, thereby directly addressing two barriers to DER activity: workforce ability and up-front cost. NYSERDA developed a demonstration project to facilitate development of the local workforce, spurring local contractors to undertake DER projects by sponsoring multiple projects. Evaluation of insulation and air-sealing applications from these projects works toward addressing barriers to scaling up DER.

Project Description

The NYSERDA program involves two phases. Phase I, completed in 2011, aimed to demonstrate significant energy savings in four home retrofits. Funded by NYSERDA, these retrofits tested emerging insulating practices and construction techniques that could be applied on a larger scale to result in energy savings of about 50% or more. Projects cost an average of $94,000, $77,000 of which was for energy-related work, with an additional $17,000 spent on "unforeseen conditions" that were a direct result of deferred maintenance (NYSERDA 2013). In this cold-climate region, where heating loads are high (average of 55% of total energy use compared to the national average of 41%), the focus was placed on air sealing and insulating the building shell. Insulation and air sealing were applied to all "six sides" of the homes—including the roof, exterior walls, basement walls, and basement floors—and mechanical equipment was often upgraded. Measured pre- and post-retrofit energy use from the first four NYSERDA homes demonstrated heating load reductions of 75%. Phase I experience confirmed the labor intensity of exterior wall insulation applications. In the four projects, the exterior rigid foam strategy was used to insulate the above-grade walls. This is an increasingly preferred solution for significant energy reduction in homes because of its ability to serve as a robust air barrier, in addition to providing high insulating capability. Due to the cost and time intensity of its application, as observed in Phase I, the strategy was recognized as a significant barrier to scaling up this work. Phase II was designed to encourage contractors to improve strategies for insulating and air sealing above-grade walls as a part of an overall DER strategy. At this time, for the cold-climate zone, improving the exterior wall building shell is viewed as necessary to improve the building shell enough to reduce site energy use by 50% or more.

Thus, Phase II was designed to demonstrate strategies for exterior wall shell improvements that will have market appeal for homeowners and existing-building contractors (remodelers, siding professionals, roofers), so that solutions are desirable for pairing with other home improvement projects. Part of this is determining how to eliminate redundancies that add to the cost of the improvement, but are not critical to long-term durability. Phase II relies on the expertise of building science teams in New York State to undertake DER at market rate, with incentives from NYSERDA and manufacturer-donated materials. While exterior wall treatments are the focus, homes also receive treatments to the whole building shell, including the attic and basement/crawl space. Twenty-one homes are at various stages of the retrofit process, and five performance contractor teams are involved. Fewer preexisting home maintenance issues needed to be addressed in Phase II retrofits than in Phase I. Through this analysis of the Phase II projects, we aim to show improvements in work process and work flow realized by a team undertaking multiple projects by focusing on findings in the field from three building science teams (IBACOS®, Taitem, and Verdae). To the extent that it is available, we show the cost of exterior wall improvements in relation to the cost of siding replacement (when the two occurred in tandem). Lastly, we show what kind of additional support could be beneficial to the work force based on the NYSERDA experience, to facilitate scaling up activity for DERs.

Program Overview

NYSERDA recruited teams for this project through a solicitation process that called for teams comprised of building product/material manufacturers, building science professionals, and building contractors that could perform an emerging product solution and installation technique that was ready to field-test and implement in an existing building. The program requested application by building science–specific teams who then selected the building contractor based on previous working relationships. Teams were required to commit to at least three projects to demonstrate the emerging product strategy. Emerging product strategies met the following requirements:

- Durability, focusing on proper solutions for addressing moisture in the building assembly
- Attachment to exterior sheathing surfaces: fastening must be reliable, robust, and simplified
- Compliance with local and state building codes
- Ability to provide measurable benefits for air leakage, insulation, and cost reduction
- Allow for build-out/detailing around rough openings of windows and exterior doors
- Air barrier and sealants able to provide a very airtight building shell (total envelope air leakage level < 0.25 CFM50/ssf [shell square footage])
- Provide whole-wall assembly (excluding windows) insulation value of R > 25
- Field implementation (material and labor) cost less than $10/ssf

Although teams were anchored by a building science professional working at market rate, no one on the team was required to possess specific qualifications or certifications. While teams had experience with home performance energy improvements, none of the teams commonly marketed or employed deep energy improvements that altered the exterior building shell in their normal business routine before this project; however, they did have an interest in pursuing more in-depth energy-saving work. The program had reporting requirements for pre- and post-energy use to facilitate assessment of the efficacy of the techniques employed by the building science teams (to date, most of the available energy data are from modeling software outputs rather than measured data).

Findings from the Field

In this section we profile the deep energy wall retrofit strategies and lessons learned from three building science teams (Taitem, Verdae, and IBACOS). Through case studies submitted to NYSERDA as a part of project requirements, each contractor tracked project details, challenges in the field, and strategies used to improve work flow and process. The lessons that can be applied more broadly are captured here. We elaborate on the following elements: primary retrofit strategy focused on by the contractor team, process improvements realized, methods for capturing process improvements, and if the process improvements translated to lower implementation costs, faster installations, and/or greater likelihood of teams marketing and

selling the work outside of this pilot. We aim to uncover lesser-known variables and uncertainties in exterior wall retrofit work that have made efforts more volatile in timeline and price.

Taitem Engineering and Snug Planet Retrofit Experience

Taitem Engineering is an Ithaca, NY–based consulting firm that specializes in mechanical, electrical, and structural design, energy studies, and energy research. They partnered with a local home performance contractor, Snug Planet, a contractor with strong analytical skills, to perform four DERs. They employed a strategy using one layer of 2.5-inch-thick rigid foam board to insulate the exterior above-grade walls. In each example, a single level of foam that was carefully detailed with attention to air and moisture sealing resulted in low levels of air leakage in each home, as well as significantly less time spent by the crew for exterior foam board installation.

Use of one layer of foam board was a change in typical exterior wall rigid foam board application. In many applications of exterior rigid foam board to date, two layers of foam board are preferred, so seams can be staggered to combat shrinkage by foam board as it ages. Research by Building Science Corporation demonstrates methods of addressing this issue without the need for redundancy of multiple rigid foam layers. Foam type should be chosen carefully—for the expanded polystyrene foam board compound, shrinkage is much more of a concern than it is for extruded polystyrene and polyisocyanurate. In addition, the way that seams are sealed between foam board pieces is important to performance; in the early Building Science Corporation experiment, seams sealed with mastic and mesh dried out and cracked over a 16-year time period, resulting in considerable air leakage, while peel-and-stick tape used on another portion of the house held strong (Lstiburek 2012). The Taitem example aims to reduce redundancies in insulating and air sealing above-grade walls.

Process Improvement Strategy

Taitem Engineering employed a series of tests called time and motion studies, a practice that traditionally comes from manufacturing, where a task is broken into small steps to determine wasteful or redundant motion. The team looked at the process of preparing and installing 2.5-inch rigid foam board to insulate an exterior wall as the primary time and motion technique. The main strategy used for improving the building shell was one layer of rigid foam insulation on the exterior of the wall, with wall cavities dense-packed with cellulose. Since exterior wall insulation was not a common practice for the home performance contractor, multiple aspects associated with using 2.5-inch rigid foam board were tested before field use. This included cutting, fastening, and taping materials and strategies that were observed and then reassessed when used in the field. The strategies for exterior wall insulation developed for use in the Ithaca area retrofits are in Table 1.

Table 1. Optimized strategies for installing rigid foam board as an exterior wall treatment

Process	**Optimized method**
Overall	Using one layer of 2.5-inch Thermax™ sheathing rigid foam board to reach optimal insulation value but reduce time needed for installing multiple layers
Cutting	Team used Accucutter® for full-length cuts, using two passes for 2.5-inch board to produce the cleanest cuts Crosscuts performed using a PVC saw or a woodworker's saw L-cuts performed by making to pieces with Accucutter for best precision Keyhole saw was preferred for hole cuts
Fastening	4-inch ci-Lock™ screws used to attach 2.5-inch Thermax sheathing to wood sheathing on building exterior Number of screws reduced from the manufacturer's recommendation of 28–30 for a full sheet to 12 per sheet ¾-inch furring strips attached over Thermax sheathing with 5-inch HeadLok® screws directly fastened to wall studs (provided very secure attachment for Thermax, and provided an air space for siding)
Taping Seams and Corners	Weathermate™ construction tape applied using a roller 9-inch straight flashing used to tape corners

Unforeseen Circumstances in Wall Insulation

In three retrofit case studies (West Hill, Hawthorne, and Ellis Hollow), building science teams came across unforeseen circumstances related to exterior wall treatment while using the same strategy for insulating each home:

- *Using creative strategies to avoid moving window and door openings* for houses with tricky geometric shapes. In a case where an existing door opening wouldn't have accommodated 2.5 inches of exterior insulation, closed-cell foam was used to insulate a small portion of the wall cavity rather than cellulose, which was being used in the rest of the house (Ellis Hollow and West Hill).
- *Altering insulation depths in certain areas to avoid costly roof overhang extensions*. On a gable end of a home where there was not enough room to include 2.5 inches of rigid foam without extending the roof overhang, 1 inch of rigid foam was used for the area, and a solution was devised to accommodate the change in plane between the two materials between the gable end and the above-grade wall. Due to the small area in question, this was not thought to significantly affect energy performance enough to warrant extension of the roofline (West Hill).
- *Keeping existing windows.* Windows that were double-paned, low-emissivity, vinyl insulated frames and in good condition could be kept in place and reinstalled to be more effective with air sealing, flashing, and trim (West Hill and Hawthorne).

Field application of the "lab" optimized method helped contractors become more confident with the installation methods and to develop methods for addressing more complex geometry and existing housing conditions.

Thus far, air infiltration measurements indicate that the wall treatment strategies have contributed to the three retrofits' surpassing the air leakage project goal of 0.25 CFM50/ssf.[1]

Table 2. Air infiltration measurements for three retrofits

House	CFM50/ssf	% reduction
Taitem 1: West Hill	0.14	64
Taitem 2: Hawthorne	0.23	76
Taitem 3: Ellis Hollow	0.19	73

Costs of Exterior Wall Improvements

One of the existing challenges with DERs is lack of experience scoping and applying exterior wall insulation methods. With increased experience with the application of these methods, the installation methods, timelines, and costs can become easier to predict. Table 3 depicts the difference in cost of the exterior rigid foam board wall treatments in the three retrofits. Figure 1 presents the percentage of total wall improvement cost for specific work tasks relating to the complete wall treatment, showing the variety of elements that contribute to costs. With more cost information on exterior wall retrofits, we can better predict how an exterior insulation treatment can be more cost-effective for some retrofits than others. The existing building condition as well as the structural features that increase the complexity of the exterior rigid foam application (overhangs, clearances around windows and doors for building out frames) are a good indicator of how much the work will cost. For homes with simple geometry and with roof overhangs that can accommodate the extra siding thickness, the addition of exterior rigid foam board during the time of siding replacement is less costly than for a complex house.

Table 3. Total cost of exterior wall improvement

House	**Total cost of wall improvement**	**Cost/ssf**	**% cost for siding**
Taitem 1: West Hill	$29,569	$21.74	26
Taitem 2: Hawthorne	$19,681	$12.85	50
Taitem 3: Ellis Hollow	$43,202	$16.88	36

[1]Surface square feet (ssf) is calculated by adding together the square footage of the exterior walls, floors, and roof.

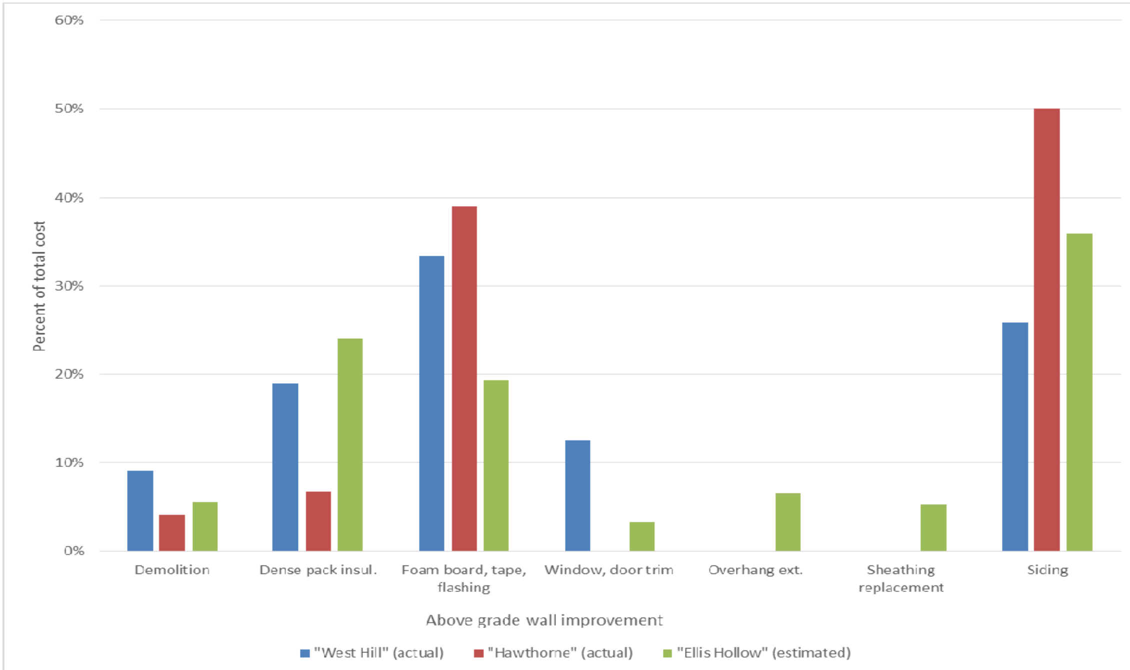

Figure 1. Cost of specific wall retrofit tasks as a percent of total wall treatment cost.

Notes: Some insulation was already present in wall cavities at Hawthorne; therefore, dense-pack efforts went toward filling remaining gaps. Window and door trim cost is not reported for Hawthorne.

IBACOS and Green Homes America DER Experience

IBACOS, a consulting company that has a long-standing history of partnering with builders, manufacturers, governments, and industry to improve home quality and performance, partnered with GreenHomes® America (GHA), a home performance contractor in the Syracuse region. The IBACOS and GHA team tested three insulation strategies in nine deep retrofits. Each strategy was designed to be market friendly, affordable, and repeatable. Four homes were treated with exterior wall rigid foam insulation, four homes (three out of four have been completed) with exterior spray-foam insulation, and one home was treated with dense-pack cellulose in the walls. This last home was performed as more of a Home Performance with ENERGY STAR® (HPwES) strategy and was not intended to result in exterior walls that were as highly insulated as the first two strategies.

Exterior Wall Rigid Foam Board Strategy Lessons

The team's strategy involved two layers of rigid foam board insulation fixed to the exterior wall after the siding was removed. Vertical strapping was installed over the first layer of foam board, and the second layer of foam was inset. Seams were taped in accordance with Dow product recommendations. Material availability was a recurring issue for this team. Additional materials, particularly those not regularly used for home improvements (such as weather barrier seam tape), had to be ordered from a supplier because they were not available locally as in-store options. This slowed the work flow.

While the team noted that foam board installation was fairly straightforward, particularly on the geometrically simpler homes that it was applied to, window and door flashing applications were unfamiliar to the team and resulted in longer timelines. Contractors followed Dow WEATHERMATE™ Straight Flashing specifications for housewrapped homes to tape rigid foam board and create the weather-resistant barrier. However, there were instances where more challenging applications had to be addressed by the contractors without the help of the Dow specifications, and innovative solutions were devised. Resources for addressing taping solutions for DER exterior foam applications would be useful.

Exterior Wall Spray-Foam Strategy Lessons

The exterior wall spray-foam strategy involved building a frame on exterior walls, which was then filled with spray foam insulation. In the first application of this strategy, old siding was left on the house to minimize time and the costs of deconstruction. This resulted in a challenging frame-building scenario, causing more upfront layout work than expected before insulating because of the variations in siding thickness. Contractors struggled to get ledger boards (at the tops and bottoms of the walls, the basis for the frame) even against existing siding, creating challenging scenarios for installation of windows, doors, and new siding later in the project.

In later applications of exterior spray foam, the original siding was removed due to its irregularity, which would have caused irregular ledger boards and framing (House #7), as it had done in the first exterior spray-foam application (House #1). In addition, the siding removal allowed for access to sheathing, which is beneficial for homes needing repair as a result of past moisture or water damage.

Unforeseen Circumstances for Spray-Foam Treatment of Exterior Walls

The team addressed the following circumstances related to the application of spray foam to exterior walls:

- Due to the space required by the build-out of the frame on the wall exterior, there were some areas where the solution was not suitable, such as on a section of the wall with a bay window (House #1). The challenges caused by geometry in the first home with this application, in addition to evaluation of the types of homes that were chosen for the second and third exterior spray-foam retrofits, strongly suggests that this method can best serve only homes with simple geometry.
- In some areas where roof overhangs were not long enough to cover the additional wall thickness (which is greater than the addition of rigid foam board), siding was stripped to make room.
- An additional challenge with this method was making sure the framing was stable enough to have the spray foam applied and then stay in place. This was addressed by adding additional brackets in the middle of the framing pieces. This strategy was only employed on one-story homes, suggesting that the strategy may not be ideal for a two-story home.

Additional Lessons from the Field

The IBACOS and GHA experience with deep retrofits also indicate the importance of continued coordination with subcontractors. There were instances where subcontractor work had to be fixed or amended to resolve energy issues that also could have led to decreased durability. Mechanisms are needed to test or observe work during the construction process to ensure that it's the most efficient and durable product possible. In one case (House #4), issues were not detected until the homeowners noticed icicle formation caused by air leakage in some corners of the house.

In the first retrofit performed by the IBACOS team, where spray foam was applied to the exterior walls, the permitting process was slower than expected due to a lack of familiarity with the method of insulation. Anticipation of permit timing hurdles by contractor teams and clear explanations of project details are key when working in areas where code officials are not familiar with emerging DER techniques.

Cost and Performance of Exterior Wall Improvements

Energy improvements were, on average, 57% of the total cost of the exterior wall improvements, further suggesting that timing the improvements with a new siding job is important to reducing the payback of this improvement (Figure 2). The IBACOS project that received only dense-pack insulation for exterior wall treatment performed considerably differently than the projects where an exterior foam treatment was used (Table 4). The project intended to use a standard home-performance strategy for insulating walls. While the heating/cooling load modeled estimates include all the measures in each DER project (attic insulation, basement insulation, heating/cooling system replacement), the most pronounced difference in the improvement package was the above-grade wall treatment, suggesting that significant reductions in heating/cooling load are a result of the extensive air sealing and above-grade wall insulation that the strategies employed provide. A majority of projects came close to surpassing or did surpass the air infiltration project goal of 0.25 CFM50/ssf set by NYSERDA. Projects that were unable to meet the goal included House #5, the home-performance strategy house, and House #6, where contractors ran into significant existing maintenance issues, as well as three existing chimneys that contributed to air-sealing challenges.

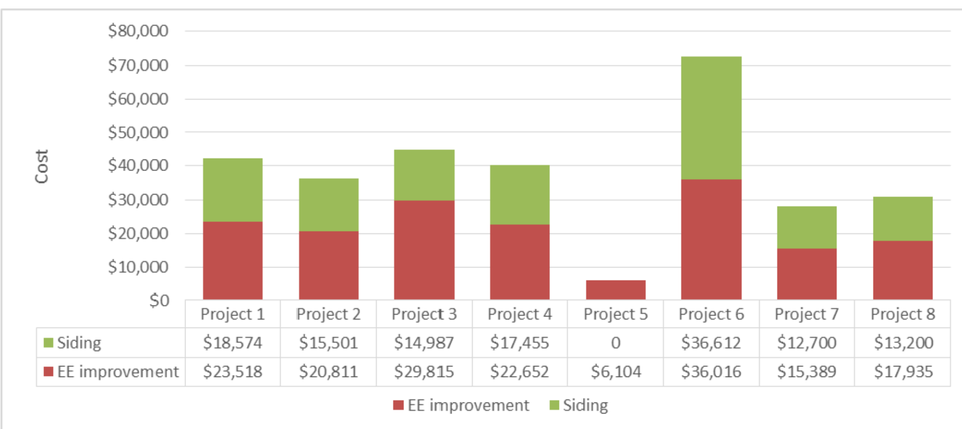

Figure 2. Total cost of exterior wall improvement.
Notes: Project 5 employed a HPwES strategy. Walls were treated with dense-pack blown insulation only.

Table 4. IBACOS project wall costs and modeled heating load reduction estimates

Project	Wall insulation strategy	Total cost/sq. ft.	Heating/cooling load reduction	CFM50/ssf
1	Spray foam	$19.26	64%	0.24
2	Rigid foam	$19.22	33%	0.23
3	Rigid foam	$20.82	63%	0.32
4	Rigid foam	$18.64	79%	0.27
5	Dense-pack wall	$3.50	4%	0.37
6	Rigid foam	$25.57	49%	0.42
7	Spray foam	$21.66	58%	0.16
8	Spray foam	$19.65	65%	0.16

Note: Heating/cooling load reduction is an estimate based on pre-retrofit TREAT modeling that includes savings that result from all improvements, not solely the wall insulation.

Verdae Deep Retrofit Experience

The Verdae team was composed of an individual building scientist and project manager (who had experience as the project manager for other DERs), in partnership with a contractor (Mulder Construction Group) and an energy auditor/modeler. They committed to three retrofits through the NYSERDA program, and have profiled one via case study.

The team in this project used two layers of exterior rigid foam board (Dow Tuff-R™) installed on the exterior walls, with seams offset by at least one foot and then taped with Dow Weathermate straight flashing and then sealed with Dow Weathermate construction tape to prevent peeling. Furring strips were installed over the foam insulation to secure it and to provide a base for the siding install (held in place with 5/4-by-3-inch furring strips screwed into the wall studs). The bottom of the foam was enclosed by aluminum coil stock bent into U-shaped flashing that was caulked and nailed to the sill, and flashed to the face of the outside layer of foam. The basement walls received 4 inches of closed-cell foam sprayed directly on the wall from the floor to the sill. The attic/roof interface was specific to each house.

Exterior Wall Rigid Foam Board Strategy

Many homes do not have eaves that are sufficiently long to accommodate exterior wall insulation. In the Cottekill retrofit, the eaves were extended using a method coined a “chainsaw retrofit” to cut back the existing roof to the edge of the wall. After the exterior of the roof and walls were insulated, eaves were rebuilt to allow enough room for insulation. The team encountered challenges sealing the transition between the roof and the wall, and chose to seal the seam where the wall and roof insulation abutted with a layer of spray-foam insulation. This team also noted the significant amount of time it took (especially in winter) to form the weather-resistant barrier for the rigid foam board exterior via taping.

Additional Lessons from the Field

The process of permitting and compliance with the energy conservation building code in New York State provides an additional lesson. In anticipation of local code inspector unfamiliarity with DER work, the team decided to meet with the local code inspector ahead of time to determine how to indicate code compliance for work that didn't fit clearly into documentation for compliance with the existing building energy code.

Cost and Performance Metrics

Efforts to reduce energy consumption in this house were successful. Although measured energy-use data are not currently available, energy modeling indicated an 83% reduction in heating design load (to 16 kBtu/h), and blower door testing indicated an air-leakage reduction of 85%, well below the 0.25 CFM50/ssf NYSERDA project goal at 0.17 CFM50/ssf. The cost of energy work for this project, including windows and doors, was calculated at $58,000, with contractors estimating an extra cost of $33,800 to add the energy-specific work to an already planned window/siding replacement.

Discussion

DER work evokes thoughts of very high quality, durable homes that are much more resilient and less prone to issues associated with uncontrolled air and moisture movement, including rot, mold, mildew, ice damming, and standing water. Many of the techniques that are inherent to the success of a DER are not common practice in the building industry today, including proper implementation of water management details around window, door, and mechanical ventilation openings (Neuhauser 2012). For more-insulated and air-tight homes, it is critically important to make sure that retrofit measures are installed with great attention to detail so that homes do not face durability issues in the future.

Existing Barriers

NYSERDA convened teams involved in the project to discuss existing barriers and provide input on the feasibility of the work after the program is complete.

Engaging Homeowners at the Right Time

Teams indicated that the best time to perform DERs is to intercept siding and roofing projects. One project performed by Taitem Engineering and Snug Planet was timed with a significant rehab. This home was owned by a local affordable-housing nonprofit at the time of the retrofit, and it required roof, siding, window, and door replacement for resale (Hawthorne house). In this scenario, many costs that would normally be attributed to the DER can be "shared" with other renovations, including demolition, replacement of sheathing, and repair of other unforeseen issues. Experience with close monitoring of costs in the NYSERDA projects has allowed contractors to get more experience in estimating costs and articulating timelines in a way that could fit with other planned work.

While deep energy upgrades are least costly when timed with other home improvements, a project on a home that hasn't been well maintained will likely require unanticipated repairs that can contribute to higher unplanned costs. Deep retrofits make most sense when the home is already being torn apart for renovation, but going into a project not anticipating existing issues that are a result of poor or limited maintenance is detrimental to the cost and timeline of the project. Phase II was characterized by homes with more consistent maintenance and upkeep, where costs were more predictable and efforts focused primarily on improving the energy performance of the house. Wall cost information detailed earlier indicates that adding exterior rigid foam insulation during the time of siding and/or window replacement is roughly equivalent to the cost of siding. Recognizing that this cost is but one piece of the overall DER cost, efforts in this project are focused on wall cost, as other retrofit measures are more common and more established pricing structures are set for them, including attic, basement/crawl wall air sealing and insulation.

Marketing DERs

It continues to be challenging for contractors to market the quality and effectiveness of DER work. The retrofit solutions are still quite new to homeowners, and appear complicated and time intensive. To gain market acceptance, it would help to develop a package of solutions that have been tested and proven to save energy in a variety of applications so that they can gain recognition in the market. Homeowners need a clear picture of what can save them energy, how much improvements cost, and what other benefits the work provides. They need more information on what improvements are most effective for energy-use reduction, and which ones are best addressed at the time of other renovations. There is also a need to better quantify the non-energy benefits of DERs, including increased home durability, greater comfort, and better indoor air quality, in order to articulate these benefits to homeowners, who are usually motivated by more than energy savings.

All three home performance contractors—GHA, Snug Planet, and Verdae—are now trying to sell DER projects in their respective areas. With only a handful of examples to point to, however, it has been difficult. Contractors continue to incorporate DER techniques into their projects by pointing to the results from their efforts and the efforts of others. The pool of DER homes, which will number 25 when all are complete, can be a resource for contractors in the region to refer to. Having more examples of success in completing DER projects is an important tool.

Overcoming High Costs

It is difficult to complete a DER that saves more than 50% of the energy used in a home without significant financial investment. Costs are high for these projects relative to other home improvements and renovations, and limited experience with the work makes it more challenging to predict costs and therefore riskier to contractors and less palatable to homeowners. Efforts to continue to understand what conditions make the cost of exterior wall insulation more significant in some projects than in others can help determine which homes are better suited to easier, more cost-effective DER work. As discussed, engaging homeowners at the time of other renovations can be a critical trigger point for performing DER in a more cost-effective way. In the NYSERDA projects observed, roughly 40% of the wall treatment costs were attributed to siding. While there is no getting around having to address the siding when installing exterior wall insulation, lining up an energy efficiency improvement with a siding replacement provides a significant opportunity for offering improvements at a more reasonable cost.

Recommendations for Additional Support

Based on the program and the contractor perspective, the types of additional support that would be beneficial to the workforce to facilitate scaling up activity are discussed below.

Measurement and verification of actual energy use. Pre- and post-retrofit can be used to evaluate and validate early retrofit efforts and provide customers with clear examples from contractors on the types of improvements that can realize real savings.

Capturing process improvements. Sharing successful methods for implementing deep retrofit measures can contribute to more cost-effective applications. Open forum discussions have been successful in educating and generating interest. Presentations at conferences including the Affordable Comfort, Inc. National Home Performance Conference and the Northeast Sustainable Energy Association BuildingEnergy13 Conference have served as a means to present data, results, and explanations from this project. Disseminating results and sharing improved techniques and practices so that a much broader audience can share best practices is key to scaling up DER, and additional efforts to do so are important to increasing incorporation of DER into already planned upgrades.

Encouraging better valuation in the real estate market is important to building momentum for this work. Homeowners commonly take on home renovations to increase the sale price of their home. If realtors and appraisers highlight the value of efficient homes, they can encourage homeowners to invest in efficiency improvements as a way to add value. Realtors and appraisers are already developing tools and strategies to highlight the value of energy efficiency. For example, the Appraisal Institute has developed the Residential Green and Energy Efficient Addendum to supplement the widely used form for mortgage lending appraisals and provide a framework for evaluating energy-efficient homes. In addition, realtors have been active in the Green MLS movement, which is supported by the National Association of Realtors. This program highlights the features and performance of energy-efficient homes by including verifiable metrics in home listings.[2]

Getting capital and investment behind the work (financing options). There are some financing opportunities already offered by states and energy efficiency programs to help participants complete retrofits without significant up-front costs. Both rebates and financing are available in some Home Performance with ENERGY STAR programs. Once understanding of the solutions that DERs can provide are better understood and valued, financing can be a critical bridge to making the work feasible for a broader group of homeowners, particularly at times when other renovations are undertaken.

[2] *Unlocking the Value of an Energy Efficient Home* provides a blueprint for program sponsors and energy efficiency organizations who wish to integrate information about retrofitted homes into real estate transactions. It is available through Elevate Energy: http://www.elevateenergy.org/wp-content/uploads/2014/01/Unlocking_the_Value_an_Energy_Efficient_Home.pdf.

Conclusion

DERs are not an easy task. All involved parties, including the homeowner, builder, building science contractor, and financial institutions involved, have to be well educated and informed about the strategies being used and ready to commit resources, time, and energy toward achieving the objectives. There are few efforts underway to encourage DER work, but interest in and uptake of DERs is increasing as an option for utility-scale energy efficiency programs. DER utility programs such as that from National Grid hold promise for encouraging the scaling up of deep retrofit work so that it is accessible for more homeowners.

DERs can improve a home's longevity and resiliency to the changes in climate, along with supporting the local regional economy through the work's intensive labor needs, which is unique to this work. Those who undertake DERs will improve the comfort level, life span, and resale value of the home once this work is implemented and completed. The work also enables the downsizing of mechanical equipment found in homes with large heating/cooling loads. Demonstration projects such as NYSERDA's are an important way to identify best practices, develop improved techniques, build capacity, and reduce costs for this type of work. Learning from these early efforts to employ deep retrofit is key to scaling up work that can have a critical role in meeting goals for residential sector energy-use reduction that are already set in many localities, and it can be of significant value to homeowners in ways that far outweigh energy savings: having healthier, longer-lasting, and more comfortable places to call home.

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