Building America
U.S. Department of Energy

Case Study

High Performance Residential Retrofits

Florida and Alabama

Project Profile

Project Team:
Building America Industrialized Housing Project, BAIHP

Location:
Florida and Alabama

Description:
Single family; detached and two half-duplex units, concrete masonry unit or frame construction, mostly slab-on-grade, primarily single story, built between 1954 and 2004, living area between 780 sq. ft. to 2,408 sq. ft.

Completion Date:
As of June 2010, 10 renovations completed, 31 in progress

Estimated Annual Energy Savings:
15% to 50% savings per year

Overview

In 2009, a Department of Energy Building America team led by the Florida Solar Energy Center began working with eight local government and non-profit partners to find cost-effective paths for improving the energy performance of existing homes in the hot humid climate. Our research was designed to determine if and under what circumstances deep energy retrofits (HERS Index of 70 or 30-50% improvement) could be cost-effectively achieved.

Commitments were received from partners to attempt cost-effective renovations in 10 or more homes targeting a HERS Index of 70 or below as part of the overall scope of work. In all partnerships, the scope of renovation work encompassed general repair and renovation needed to bring homes up to market standards which often included components, equipment, and appliances that impact energy efficiency.

A test-in energy audit and energy use modeling of the partner's proposed renovation package was performed for 41 affordable and middle income foreclosed homes in Florida and Alabama. HERS Indices ranged from 92 to 184 with modeled energy savings ranging from 3% to 50% (average of 26%). Of these homes, 10 renovations have been completed. Analyses and recommendations were discussed with partners to encourage more efficient retrofits, highlight health and safety issues, and gather feedback on incremental cost of higher performance measures. A summary of cost-effective improvements most commonly incorporated into our recommended deep retrofits is illustrated in this study.

Mold and debris in air handler closet

Assumptions & limitations

Acquiring improved cost data is a major need in the area of evaluating cost-effectiveness of deep energy retrofits. Obtaining reliable cost data has been among the most challenging aspects of our study. Determining labor costs is particularly difficult due to a lack of contractor response to quote requests. Some of the partners provide us with their estimated costs, but these often include an allowance for unforeseen difficulties and do not break out specific elements of general work categories. Other partners have been unwilling to provide us with their cost estimates due to the sensitive nature of the bid process.

Another stumbling block of the study is that partners are often slow to acquire properties as they are not able to contract to purchase as quickly as their competition. There have also been long delays in starting renovations as they work to get their programs in place. Many of the properties have been severely neglected and some vandalized. Because of these conditions, certain assumptions have been made about the as-found characteristics of the homes. Some have a potentially significant impact on the calculations of test-in whole house efficiency. For example, when a home has significant mold issues (see photo above), tests cannot be performed. Therefore, infiltration and duct leakage levels have to be estimated.

Change in appliance fuel type is an additional limitation of the study because of the differences in fuel costs and minimum efficiencies. A scope of work requiring the replacement of a propane water heater with an electric water heater can have a significant impact on the pre-retrofit and post-retrofit annual energy cost comparison.

Pre-Retrofit Findings

Typical envelope related findings include single pane casement windows with poor closure, low levels of attic insulation, and missing plumbing access covers and other drywall holes causing high levels of air infiltration. The homes typically have old or missing appliances and little, if any, fluorescent lighting, including compact fluorescent light bulbs (CFLs). Split-system forced air mechanical systems are the norm. Heat pump and electric resistance configurations are both common in the central Florida homes with gas heating dominating in north Florida and Alabama. All homes had a single central return, rather than a set of return ducts from each room. The test-in audits produced HERS Indices ranging from 92 to 184, with a mean of 130. A summary of the test-in HERS Indices broken down by decade is provided in Table 1.

Table 1. Test-in HERS Index by decade

Decade Built	Mean HERS Index	n
1950’s	158	1
1960’s	157	6
1970’s	137	10
1980’s	129	12
1990’s	116	8
2000’s	101	4

Parters’ Proposed Scopes of Work & Baihp Recommendations

Annual energy savings in 36 homes for which we received a partner's scope of work ranged from 3% to 50% of predicted annual energy use with a mean savings of 27%. Regardless of the age of the home, most of the partners’ scopes of work produced a HERS Index well below 100. In several homes, the partner’s proposed scope of work produces a HERS Index not far from the goal of 70. Among these motivated partners, many have been eager to incorporate

Partners

- Sarasota County and the City of Sarasota, FL (including the Florida House Foundation, Community Housing Trust of Sarasota, and Newtown Community Development)
- Volusia County, FL
- Brevard County, FL
- City of Palm Bay, FL
- Orange County, FL
- Habitat for Humanity affiliates in Leesburg, FL, Sarasota, FL, and Mobile and Birmingham, AL

Typical attic insulation before (top) and after (bottom)

These simulation results, coupled with our partners' projected cost (when able to collect these data), provide insight into which items are most cost-effective. A deep retrofit model was then created integrating high performance, cost-effective, energy efficient measures based on BAIHP research on new home construction in the hot-humid climate. Incremental analyses were again run comparing the partner's proposed package to each of the high performance measures. In this analysis to develop recommendations, the partner's proposed scope of work was taken as a given based on need to bring the house up to market standards.

We compiled a summary of the measures most commonly incorporated into our recommended deep retrofits which, taken together, were part of a cost-effective package. Improvements that are cost effective, based on our current cost data include adding CFLs to any number of outlets, installing ENERGY STAR ceiling fans and refrigerators, bringing ceiling insulation levels up to R-30 or R-38, reducing envelope infiltration with air sealing measures, adding spectrally selective window tint to single pane windows, sealing ducts or replacing ducts when exceptionally leaky, replacing the HVAC with a 15 SEER or 16 SEER heat pump when the existing is a 10 SEER or less, installing a programmable thermostat, upgrading from a standard efficiency electric water heater to a heat pump water heater, and using white or light shades if repainting the exterior or replacing an asphalt shingle roof. There have been a limited number of homes in our study with gas heating and water heating. In these cases, we have recommended direct vent or tankless gas water heaters and high-efficiency gas furnaces.

Post-Retrofit Findings

Renovations for ten study homes have been completed, re-audited, and results analyzed. Modeled savings for actual post-retrofit configurations ranged from 9% to 48%, with an average of 31%. The results closely mirror projections, with one exception; a home projected to have a savings of 16% has post-retrofit modeled savings of 33%. Energy efficiency measures beyond the original scope were incorporated into this retrofit, the first of our study to score a HERS index of 70 or less. The post-retrofit HERS Index was 67.

Table 2 presents the pre-retrofit and post-retrofit HERS Indices, duct leakage, infiltration, and modeled savings for the post-retrofit homes. Data are ranked by modeled savings, highest to lowest. The largest reductions are realized where the test-in HERS Indices are the poorest. These are typically the older homes.

Poorly sealed return plenums, including building cavities used as ducts (platform returns), are commonly found in both pre-retrofit and post-retrofit energy audits. Unsealed or poorly sealed duct systems degrade mechanical system performance.

Table 2. Post-Retrofit Projected Energy Use and Savings Results for ten complete renovations

Year Built	Test-In HERS Index	Test-Out HERS Index	Test-Out ACH50	Test-Out qn,out	Annual Energy Use Savings
1987	156	78	5.39	0.04	48%
1967	165	73	8.12	0.02	44%
1981	151	79	5.38	0.11	43%
1963	177	81	7.24	0.04	41%
1978	143	92	16.8	0.08	34%
1995	99	67	5.51	0.4	33%
1993	109	79	3.82	0.02	22%
1981	112	87	7.65	0.09	22%
1983	116	86	4.37	0.02	17%
1995	98	86	6.07	0.03	9%

In May of 2010, based in part on the field experience under this partnership, one encouraging result of this study has been the refinement of one partner's standard specifications for the retrofit activity under the second round of their Neighborhood Stabilization Program funding (NSP2). The Sarasota Office of Housing and Community Development adopted energy conservation standards for their home rehabilitation projects under their NSP2 funding.

Among the replacement standards are a 16 SEER heat pump (as space allows), light or white colored roof and exterior, R-38 attic insulation, ENERGY STAR windows and appliances, 80% ENERGY STAR LED or CLFs or hard-wired fluorescent light bulbs, and programmable thermostats. Further, they are requiring duct leakage tests to be performed on all homes with a goal of 6 cfm or less leakage per 100 square feet of conditioned space at a test pressure of 25 pascals with respect to outside.

Health & Safety Issues

Health and safety issues are significant factors to consider when retrofitting homes. For example, while completing this case study, we learned that typical insulation contractors may not be sufficiently aware of the risks involved with recessed lighting fixtures coming in contact with insulation. Likewise, there seems to be little attention to disruption of attic ventilation at the eaves. One area of particular concern was evident in several homes that had atmospheric combustion gas furnaces which needed to be replaced. Contractors who replace these worn out units with new atmospheric combustion units as part of an overall renovation involving shell air sealing may be exposing themselves and occupants to combustion safety risks not present in the pre-retrofit house.

Solution: BAIHP researchers conducted combustion safety testing to ensure that the new furnaces would not be exposed to such risk; however, contractors do not typically retain professionals capable of conducting this testing. Researchers also made recommendations to install carbon monoxide detectors and to select units with safety mechanisms such as those that prevent electronic ignition when draft can not be established in the flue.

Energy Savings & Results

Partners have completed renovation of ten homes, including general repairs, with varying attention to energy efficiency. In six of the ten, partners achieved a post-retrofit HERS Index of 70 and/or 30-50% projected energy savings based on annual energy use simulation. Three of the four remaining homes saw improvements between 15% and 30%. The incremental cost is available for two of the homes at this time. One home (built in 1995) had predicted annual savings of $495 (33%), and the HERS Index was improved from 99 to 67 with an associated incremental cost of $3,327. The incremental cost included the full cost of a new heat pump water heater ($1,700) because it was installed strictly for energy efficiency improvement, not because the existing unit needed replacement.

The other home (built in 1967) had predicted annual savings of $873 (44%), and the HERS Index was improved from 165 to 73 with an associated incremental cost of $3,958. Both homes were fueled with electricity only, and the energy costs for pre-retrofit and post-retrofit simulations were calculated using a cost of $0.13/kWh. Researchers are continuing to gather cost data with partners to produce economic analysis for completed and in progress retrofits.

This case study has been prepared by the Building America Industrialized Housing Partnership for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

For more information about this or other case studies by the Building America Industrialized Housing Partnership go to:
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