FLORIDA SOLAR ENERGY CENTER
Creating Energy Independence

CASE STUDY
COLLABORATIVE RESEARCH WITH PACIFIC NORTHWEST NATIONAL LABORATORY
2012

Habitat for Humanity of Brevard County, Florida: Existing Home Retrofit 1

Figures 1-2. Pre-retrofit (left) and post-retrofit (right).

This unoccupied, foreclosed, single-family detached home in Melbourne, Florida (Figures 1-2) was completed in 2011 by Habitat for Humanity of Brevard County, Inc. (http://brevardhabitat.com), a non-profit, affordable housing organization. Table 1 summarizes the projected annual energy use and cost savings for this deep energy retrofit project.

Table 1. Annual Energy Use and Cost Simulation

Home Components	As Found	Minimal Improvement	Actual Retrofit
HERS Index	136	121	85
Annual Simulation kWh (BABM08)	17,386	15,870	11,628
Annual MBtu Usage (BABM08)	59.3	54.2	39.7
Annual Energy Cost (BABM08)	$2,260	$2,063	$1,511
Project Status: Completed 7/30/11			
"Minimal Improvement" reflects improvement for replacing the mechanical system with a SEER 13 air conditioner with electric resistance heating, the minimum efficiency system available.			

Notes: HERS, Home Energy Rating System; kWh, kilowatt hour; BABM, Building America Benchmark; Mbtu, million British thermal units; SEER, seasonal energy efficiency ratio

Built in 1964, this four bedroom, two bath home has 1,608 square feet of conditioned space. Renovations to this home were underway by the time a partnership was in place with this Habitat affiliate. The test-in audit was conducted to document as much as possible of the pre-retrofit character of the home as possible. Additional information was gathered from project staff. Pre-retrofit, the home was conditioned by a central, forced air heating and cooling system with a SEER 10 air conditioner and electric resistance heating. The foundation is slab-on-grade with concrete block walls. The thermal envelope included a 276 ft^2 enclosed porch with a shallow pitch, restricting potential ceiling insulation levels and cramping supply duct work. The remaining ceiling insulation was also very poor, and an R-9 average was estimated for the entire ceiling. Worn out single-pane, clear, metal frame windows were slated for replacement. At the time a partnership was formed with this Habitat affiliate, renovations were already underway, including installation of a new, forced air, central air conditioner (SEER 13) with electric resistance heating. Since the mechanical closet had already been rebuilt, there was no discussion of incorporating outside air. The partner was willing, however, to incorporate recommendations including installing double-pane, low-E, vinyl frame windows, insulating the attic to R-38, and selecting higher efficiency appliances and lighting. The package of improvements (Table 2) is estimated to produce $749 in annual energy savings. Based on the partner-provided renovation costs of $7,923, these savings outweigh the added mortgage cost by an average of $9 per month.

Table 2. Key Energy Efficiency Measures

Component	Pre- and Post-Retrofit Characteristics
Ceiling Insulation	From R-11 to R-38 in 1,320ft^2 of accessible section (single assembly ceiling over enclosed porch inaccessible)
Exterior Walls	From light colored exterior to light colored exterior
Windows	From single pane, metal frame, clear windows (U = 1.20; SHGC = 0.80) to Double-pane, low-E, vinyl frame (U = 0.30; SHGC = 0.29)
Doors	From wood to insulated (2 doors)
Floors	From 70% Carpet, 20% Tile, 10% Vinyl to 80% Vinyl, 20% Tile
Whole House Infiltration	From ACH50=11(est.) to ACH50 = 7.22
Heating and Cooling System	From SEER 10 with integral electric resistance heat to SEER 13 with integral electric resistance heat
Air Distribution System	From R-4.2 (est.) flex ducts; Qn,out = 0.13 (est.) to R-6 flex ducts; Qn,out = 0.57 and duct board return air plenum
Water Heating System	From 40 gal, electric, EF = 0.88 (est.) to 40 gal, electric; EF = 0.92
Refrigerator	From default to Energy Guide label of 383 kWh/yr
Lighting	From 0 CFLs to 80% CFLs
Ceiling Fans	From no fans to Non-ENERGY STAR® fans

Notes: U, a value denoting thermal conductance; SHGC, solar heat gain coefficient; EF, energy factor

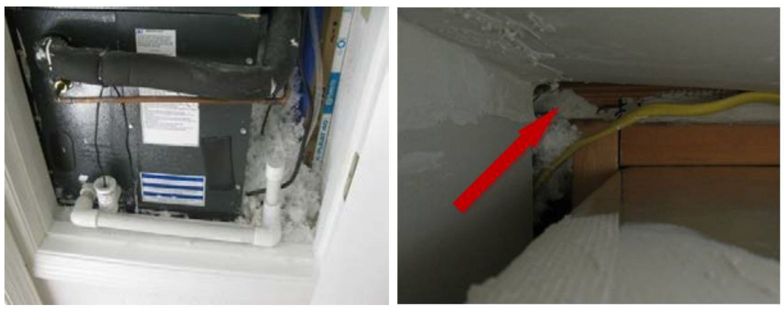
In further analysis, researchers assumed some minimum efficiency upgrades along with the incremental costs for higher efficiency options. Allowing for the fact that the mechanical system could not have been replaced with a less efficient unit, the projected energy cost savings over the minimal replacement is reduced to $552. This in consideration with incremental first costs only, the monthly cash flow is increased to $29 with a 5 year simple payback. The estimated annual energy savings, added mortgage costs, and anticipated positive cash flow associated with the whole package of improvements are presented in Table 3.

Table 3. Annual Energy Savings Analysis

	Full Cost & Savings (As Found vs. Actual)	Incremental Cost & Savings (Minimal vs. Actual)
HERS Index Improvement (%)	38%	30%
Annual Energy Cost Savings ($)	$749	$552
Annual Energy Cost Savings (%)	33%	27%
Improvement Costs	$7,923	$2,567
Monthly Mortgage	$53	$17
Monthly Energy Cost Savings	$62	$46
Monthly Cash Flow	$9	$29
Simple Payback (years)	11	5

Most of the energy cost savings for this renovation, completed July 30, 2011, resulted from installing high efficiency windows, using efficient lighting almost exclusively, and increasing ceiling insulation to R-38. Replacement of the mechanical distribution system was also fairly significant in its contribution to energy cost savings.

Working with limited air-handler closet space proved to be a challenge for the mechanical contractor. Unsealed holes in the ceiling of the air handler closet resulted in ceiling insulation to being pulled into the air handler closet when the mechanical system was running (Figures 3-4). Leaving a large hole in the closet is a result of poor quality assurance. Although researchers offered to retest the home, the partner declined post-corrective testing. The subcontractor returned to correct this installation.



Figures 3-4. White attic insulation around air handler (left) fell through spaces in the closet ceiling (right, looking up at closet ceiling framing).

In contrast, the new return air plenum was notably well constructed by reversing the duct board (shiny side in) and sealing all seams well with mastic (Figure 5). This achieves an adequately sealed plenum; however, when researchers discussed this approach with engineering staff at one manufacturer and no known problems with this installation were in evidence; however, two concerns were raised. First, this approach is not consistent with manufacturer guidance on product use and therefore would likely not be supported in the case of a dispute involving the product in this configuration. Second, the foil side is a vapor flow retarder which should not be on the cold side of the assembly. This installation is inside the conditioned space so that the temperature and moisture conditions on both sides of the material are similar; however, if this were in an unconditioned space it would warrant a more thorough review.

Figure 5. New return air plenum constructed of foil faced duct board, shiny side facing in.

Testing of the new duct work found higher than expected leakage, especially considering the apparently well sealed return plenum. Researchers performed pressure pan diagnostics. The results of this test pointed to leakage at the small, cramped supply registers at the entrance into the enclosed porch. Inadequate work space prevented the contractor from addressing the problems near this register. Findings are presented in Table 4.

Table 4. Pre-Retrofit Pressure Pan Diagnostics

Register Location	Pressure (Pa)
Kitchen	0.2
Utility Room	1.5
Living Room 1	0.3
Living Room 2	0.4
Florida Room 1	0.8
Florida Room 2	0.4
Florida Room 3	3.5
Bedroom 1	0.4
Bedroom 2	0.4
Bedroom 3	0.4
Bedroom 4	0.3
Bathroom 1	0.8
Bathroom 2	0.0

Note: Pa, pascals

During the post-retrofit audit, pressure mapping was performed to assess whole house system pressure boundaries. Auditors induced a "worst case" scenario by running the air handler and exhaust fans and shutting all bedroom doors. Operating in "worst case" the home was depressurized only slightly, -0.5 Pa. All bedrooms were moderately pressurized. The home had no passive air transfer grilles or jump ducts from the bedrooms. Table 5 shows a summary of the post-retrofit pressure mapping results.

Table 5. Post-Retrofit Pressure Mapping

Location	Pressure (Pa)
House WRT Out	-0.5
Master WRT House	3.4
Bedroom 2 WRT House	3.8
Bedroom 3 WRT House	2.2
Bedroom 4 WRT House	5.1

Note: WRT, with respect to

Researchers informed the partner of the pressure pan and the pressure mapping results and recommended correction action. Citing inaccessibility to the problem registers and plans for immediate occupancy of the home, the partner was unable to address either issue.

In summary, this retrofit highlights two retrofit challenges:

Lack of quality assurance – The missing ceiling in the air handler closet points to a need for better quality assurance processes. Although the construction manager was aware of the need for this detail, it did not get integrated into the regular quality assurance procedures. Integrating new details into the existing framework of subcontractor communications remains a major challenge to achieving high performance in the retrofit arena.

Confined work spaces – Performing an adequate job requires sufficient work space. An air distribution system housed within the attic of a shallow pitched roof continues to be a challenge for existing home retrofits.

Despite the issues during the retrofit and considering that the mechanical equipment installed was of minimal efficiency, the project easily met its goal of a deep energy retrofit with 33% projected energy cost savings, projected energy costs of $1,511, and a projected annual cost savings of $749. Using costs provided by our partner to address the cost-effectiveness of this retrofit, we see a monthly cash flow of $9 and a simple payback of 11 years.

***This case study is an excerpt of the following master report and has been modified to stand alone:**

McIlvaine, J., Chasar, D., Beal, D., Sutherland, K., Parker, D., Abbott, K. (2012). *Partnership for High Performance Housing Draft Final Report*. FSEC-CR-1911-12. Florida Solar Energy Center: Cocoa, FL.