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 2

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

This unoccupied, foreclosed, single-family detached home in Melbourne, Florida (Figures 1-2) was initiated 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	Actual Retrofit
HERS* Index	117	76
Annual Simulation kWh (*BABM08)	16,077	10,450
Annual MBtu Usage (BABM08)	54.9	35.7
Annual Energy Cost (BABM08)	$2,091	$1,360
Project Status: Completed 8/13/11		

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 1962, this three bedroom, two bath home has 1,583 square feet of conditioned space. This slab-on-grade, concrete block home had a light colored exterior and light asphalt single roof. The thermal envelope included a $285ft^2$ enclosed porch with a shallow pitch, which restricted the level of ceiling insulation. Ceiling insulation consisted of a mixture of batt and blown-in fiberglass and was estimated to be an average of R-11 for the entire ceiling. The existing windows, a mixture of awning style and single hung, were all single-pane, clear, with metal frame, and all were planned for replacement. The mechanical system was a forced air, SEER 12, central air conditioner with a heat pump. Appliances and lighting in place included an older 40-gallon electric hot water heater, no refrigerator, and 100% incandescent lighting.

The home was exceptionally leaky (air changes per hour at 50 pascal's (Pa) of pressure (ACH50) = 16.3). The predominant causes of infiltration included several wall penetrations, an abandoned mechanical system return drop creating an open pathway to the attic, and a previously retrofitted bathroom lighting fixture. The air handler closet design consisted of a stand, no platform return, and was installed behind airflow-restricting louvered doors. The resulting dust build-up in the closet prevented researchers from performing duct leakage tests. A Qn,out[1] of 0.13 was used as a default, the average pre-retrofit duct leakage found in prior research.

The retrofit was completed on August 13, 2011. Measures with the most significant contribution to projected energy cost savings were the almost exclusive use of compact fluorescent lighting bulbs (CFLs), the installation of low-E windows, the reduction in house and duct leakage, and the installation of R-38 ceiling insulation, respectively. The entire package of improvements, listed in Table 2, is estimated to produce $731 in annual energy cost savings. The partner has reported the costs for all of these measures to be $7,867. Based on these costs, projected savings outweigh the added mortgage cost by an average of $8 per month for an 11-year simple payback. Researchers also analyzed the incremental first costs for the higher efficiency options. Considering only incremental costs, monthly cash flow is increased to $38, and simple payback is reduced to 5 years.

Table 2. Key Energy Efficiency Measures

Component	Pre- and Post-Retrofit Characteristics
Roof	Light asphalt shingles, same as pre-retrofit
Ceiling Insulation	From R-11 to R-38 in accessible section (1298sf)
Exterior Walls	New paint, light color, same as pre-retrofit
Windows	From single pane, clear, metal frame (U = 1.20; SHGC = 0.80) to double-pane, low-E, vinyl frame (U = 0.30; SHGC = 0.29)
Doors	From wood to insulated (1 door)
Whole House Infiltration	From ACH 50 – 16.3 to ACH50 = 6.23
Heating and Cooling System	From SEER 12 with heat pump; HSPF 6.8 (est.) to SEER 14 with integral electric resistance heat
Air Distribution System	From Qn,out = 0.13 (est.) to Qn,out 0.033
Water Heating System	From 40 gal, electric, EF = 0.92 to 40 gal, electric, EF = 0.92
Refrigerator	From default to Energy Guide label of 383 kWh/yr
Lighting	From 0 CFLs to 12 of 14 fixtures with CFLs

Notes: U, value denoting thermal conductance; SHGC, solar heat gain coefficient; HSPF, heating seasonal performance factor; EF, energy factor

The estimated annual energy cost savings, added mortgage costs, and anticipated positive cash flow associated with the whole package of improvements are presented in Table 3.

[1] Duct air tightness is expressed in terms of airflow required to achieve a standard test pressure (25 Pa) in the duct system, measured in cubic feet per minute or CFM25. The test procedure measures leakage involving air outside the conditioned space (CFM25,out). For comparison among different size house, CFM25,out results are normalized by condition floor area of the house, yielding Qn,out.

Table 3. Annual Energy Savings Analysis

Parameter	Full Cost & Savings (As Found vs. Actual)	Incremental Cost & Savings (Minimal vs. Actual)
HERS Index Improvement (%)	35%	35%
Annual Energy Cost Savings ($)	$731	$731
Annual Energy Cost Savings (%)	35%	35%
Improvement Costs	$7,867	$3,459
Monthly Mortgage	$53	$23
Monthly Energy Cost Savings	$61	$61
Monthly Cash Flow	$8	$38
Simple Payback (years)	11	5

The partner's election to install an air conditioner with integral electric resistance heat rather than with a heat pump was a missed energy-savings opportunity. The projected annual energy cost savings of the resistance heat system installed was only $15, whereas the heat pump had a projected annual energy cost savings of $174, a difference of $159 annually.

As previously mentioned, the existing mechanical closet was poorly designed with an open return in a closet with airflow-restricting louvered doors. Such a design allowed for uncontrolled airflow and resulted in dust build-up. The mechanical system retrofit included constructing a ducted return and bringing filter access to the wall plane (Figures 3-4). Outside air ventilation via a runtime vent was not incorporated into this mechanical system retrofit. Although the deep retrofit package proposed to the partner recommended outside air, researchers prioritized efficiency measures at this early stage in the partnership. Post-retrofit duct leakage tests confirmed that the contractor performed a good job with respect to sealing the supply plenum and return plenum. If post-retrofit whole house air tightness testing had revealed an extremely tight envelope, researchers would have re-visited the issue with the partner.

Figures 3-4. Air Handler Closet: Pre-retrofit without return plenum and installed behind airflow-restricting louvered doors (left), Post-retrofit platform return plenum with filter access on same plane as wall (right).

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 to -2.5 pa. Bedrooms were moderately pressurized. Table 4 shows a summary of the post-retrofit pressure mapping results.

Table 4. Post-Retrofit Pressure Mapping

Location	Pressure (Pa)
House WRT Out	-2.5
Master WRT House	2.7
Bedroom 2 WRT House	3.2
Bedroom 3 WRT House	3.3

Note: WRT, with respect to

During the test-out audit, researchers observed no change in the attic insulation, which was previously estimated to be an average of R-11 (Figures 5-6). Our partner understood the insulation contractor had completed this work before scheduling our post-retrofit audit. Ultimately, fiberglass was blown-in to achieve R-38. However, this measure would have potentially been skipped had it not been for our involvement in this retrofit.

Figures 5-6. Ceiling insulation: Pre-retrofit estimated average of R-11 (left), post-retrofit no additional insulation (right).

In summary, a combination of low-cost and high-cost measures helped this project exceed its deep energy retrofit goal, for a projected energy cost savings of 35%. Savings were achieved primarily through the installation of efficient lighting, low-E windows, R-38 ceiling insulation, and a drastic reduction in whole house leakage, and tight duct work. There were two shortcomings of this project, however:

The mechanical system chosen for this retrofit was suboptimal. An air conditioner with a heat pump rather than an integral resistance heat is the preferred system for this location.

The partner failed to confirm the completion of all subcontractor work. This lapse in communication and lack of central oversight indicate a gap in the contracting paradigm.

Despite the issues noted above, the project cost-effectively achieved its deep retrofit goal. With total costs of $7,867 for the energy-related retrofit measures and projected annual energy cost savings of $731, the projected monthly cash flow is $8 for an 11-year simple payback. Monthly cash flow is increased to $38 for a 5-year simple payback when only the incremental first costs are considered.

***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.**