Cost-Effective, Energy Efficient Residential Retrofit Measures for the Hot Humid Climate

Florida Housing Coalition
Our Energy Economy – What Makes Cents?
September 27, 2011

Karen Sutherland, Research Analyst
Building America Partnership for Improved Residential Construction
Florida Solar Energy Center
• U.S. Department of Energy
  – Building America Program (www.buildingamerica.gov)
  • DOE National Renewable Energy Lab
    – Dr. Ren Anderson and Stacey Rothgeb
  • 15 Teams of researchers and housing industry stakeholders
    – FSEC led BA Team: Partnership for Improved Residential Construction (BA-PIRC) www.ba-pirc.org
• Pacific Northwest National Lab
  – Dr. Subrato Chandra
Building America

- 30+ Years High Performance Residential Construction
- Research Partners
  - Developers, Builders, Suppliers, Designers, State & National Laboratories, Municipalities, Utilities
- Flexible Residential Test Facility
  - Evaluate systems and envelop changes
A Special Thanks To…

• Collaborators and Partners
  – Florida Local Government Housing Entities
    • Sarasota County and the City of Sarasota, Volusia County, Brevard County, City of Palm Bay, City of Lakeland, Orange County
  – Non-profit Housing providers
    • Florida: Sarasota Housing Trust, Newtown Housing Trust, and Habitat for Humanity Affiliates in Brevard, Lake Sumter, Leesburg, Palm Beach & Sarasota Counties
    • Alabama: Mobile & Birmingham
  – Individual Home Owners planning deep energy retrofits
    • Brevard, Duval, Orange, Osceola, Polk & Seminole Counties
Research Objectives

• Identify Pathways for Achieving High Performance Renovations
  • Energy savings of 30%+ cost effectively
  • Off the shelf technology with existing labor pool
  • Improve indoor air quality, durability, and comfort

• Gather Typical Cost Data for Common Improvements in Florida

• Identify Gaps and Barriers to Broad Market Adoption
  • Availability of important materials, components & systems
  • Trade knowledge and skill sets
  • Code issues
Retrofit Study Procedure

• Primarily Unoccupied, Foreclosed Homes
  • Recently added occupied homes

• Test-In (Pre-Retrofit) Energy Audit & Annual Energy Cost
  • Measurements, observations, infiltration & duct leakage tests

• Technical Assistance

• Test-Out (Post-Retrofit): Repeat Audit & Analysis

• Final Analysis with Cost Data
  • Energy costs savings vs. incremental costs
Study Homes Description

- 100 Homes Initially Analyzed
  - 73 Retrofits completed, 14 Retrofits in progress, 13 Lost
- Average Size: 1365 sf Living Space
- Age Distribution:
  - 1950s: 7
  - 1960s: 21
  - 1970s: 19
  - 1980s: 25
  - 1990s: 15
  - 2000+: 13
- Typically: Single Family, Ranch, Slab-on-Grade
Typical Existing Homes HERS Indices

1960’s ~150

1970’s ~135

1980’s ~125

1990’s ~115

2000’s ~110

HOME ENERGY RATING CERTIFICATE

HERS® Index

1352 Hartsdale Street
New Port, FL 34287

Annual Estimates*:
Pre Post
Electricity (kWh): 11,700 7,477
CO₂ Emissions (Tons): 6.91 4.0
Savings 36%

Date of Rating: 04/29/2010
Rater: Florida Solar Energy Center

*Based on standard operating conditions

EnergyGauge
1679 Clearlake Road
Cocoa, FL 32922-5703
321-638-1492
energygauge.com

This Home has been inspected and performance tested in accordance with Chapter 3 of the RESNET Standards.
Concrete block, slab-on-grade
Built in 1967, 1190 sf, 2 bedroom, 2 bath
## Modeled Annual Energy Cost Profile

Energy Gauge USA Simulation Results:

<table>
<thead>
<tr>
<th>End Use</th>
<th>Test-In</th>
<th>Test-Out</th>
<th>Savings ($)</th>
<th>Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>$872</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>$86</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hot Water</td>
<td>$277</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling Fans</td>
<td>$71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>$183</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc. Loads</td>
<td>$203</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appliances</td>
<td>$293</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Annual Energy Cost</strong></td>
<td><strong>$1,985</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HERS Index</td>
<td>165</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Annual Energy Cost from HERS Index Rating Guide
New HVAC System

Pre-retrofit

SEER 8.7, HSPF 6.75 Heat Pump (qn, out = 0.05 ~5% leakage to outside of the home)

Post-retrofit

SEER 15, HSPF 8.8 Heat Pump (qn, out = 0.02 ~2% leakage to outside of the home)
AHU Closet Sealing, Return Plenum Sealing, Drywall Repair, New Windows

**Pre-retrofit**
- LR side of AHU closet
- Sparse ceiling in AHU closet, connected to attic & LR

**Post-retrofit**
- Closet gutted, drywalled; new return plenum & platform constructed
AHU Closet Sealing, Return Plenum Sealing, Drywall Repair, New Windows

**Pre-retrofit**
- LR side of AHU closet
- Mysterious return plenum

**Post-retrofit**
- Central return plenum constructed with duct board & sealed with mastic at edges, seams, & joints.
Infiltration Reduction

AHU Closet Sealing, Return Plenum Sealing, **Drywall Repair**, New Windows

Plumbing access panel & miscellaneous drywall penetrations were repaired
Infiltration Reduction

AHU Closet Sealing, Return Plenum Sealing, Drywall Repair, **New Windows**

**Pre-retrofit**

Note angle of window in ‘closed’ position

**Post-retrofit**

Major infiltration reduction: $\text{ACH}(50) = 8$

- Replaced Windows: $U$-Value = 0.47, $\text{SHGC} = 0.37$

Exceptionally leaky: $\text{ACH}(50) = 42$
Ceiling Insulation

Insulated to R - 30

Pre-retrofit

Post-retrofit

Note: Image from alternate house
EnergyStar® Appliances & CFLs

Pre-retrofit

Post-retrofit
Light Exterior

Pre-retrofit

Post-retrofit
# End Use Predicted Savings

## Case Study - Sarasota, FL Simulated Annual Energy Use (Energy Gauge USA)

<table>
<thead>
<tr>
<th>End Use</th>
<th>Test-In</th>
<th>Test-Out</th>
<th>Savings ($)</th>
<th>Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>$872</td>
<td>$228</td>
<td>$644</td>
<td>74%</td>
</tr>
<tr>
<td>Heating</td>
<td>$86</td>
<td>$34</td>
<td>$52</td>
<td>60%</td>
</tr>
<tr>
<td>Hot Water</td>
<td>$277</td>
<td>$256</td>
<td>$21</td>
<td>8%</td>
</tr>
<tr>
<td>Ceiling Fans</td>
<td>$71</td>
<td>$71</td>
<td>$0</td>
<td>0%</td>
</tr>
<tr>
<td>Lighting</td>
<td>$183</td>
<td>$76</td>
<td>$107</td>
<td>58%</td>
</tr>
<tr>
<td>Misc. Loads</td>
<td>$203</td>
<td>$203</td>
<td>$0</td>
<td>0%</td>
</tr>
<tr>
<td>Appliances</td>
<td>$293</td>
<td>$244</td>
<td>$49</td>
<td>17%</td>
</tr>
<tr>
<td><strong>Total Annual Energy Cost</strong></td>
<td><strong>$1,985</strong></td>
<td><strong>$1,112</strong></td>
<td><strong>$873</strong></td>
<td><strong>44%</strong></td>
</tr>
<tr>
<td>HERS Index</td>
<td>165</td>
<td>73</td>
<td>92</td>
<td>56%</td>
</tr>
</tbody>
</table>

### Annual Energy Cost from HERS Index Rating Guide

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Total Incremental Cost (Based on cost reported by partner)</td>
<td>$4,441</td>
</tr>
<tr>
<td>Monthly Cost (7%, 30 yr mortgage)</td>
<td>$30</td>
</tr>
<tr>
<td>Estimated Monthly Energy Savings</td>
<td>$58</td>
</tr>
<tr>
<td>Net Monthly Cash Flow</td>
<td>$28</td>
</tr>
<tr>
<td><strong>Net Annual Cash Flow</strong></td>
<td><strong>$336</strong></td>
</tr>
</tbody>
</table>
Post-Retrofit Issues

Mechanical Equipment Installation

• Small, Poorly Sealed Air Handler Closets & Leaky Air Handlers (AHU)
  • Pressure issues
  • Dirt build-up
  • Longer operation times

• Over Sized Equipment
  • Pressure issues
  • Shorter operation times
    • Humidity & moisture issues

• Leakier Ducts

Hole from AHU closet to attic
Unsealed plenum area
**Post-Retrofit Issues**

**Pressure Differences**

- High Pressures Differences Between Rooms
  - Combustion safety issues
  - Moisture issues (Mold)
  - Durability issues
Pre- & Post-Retrofit Comparisons

**Duct Leakage**
Pre- vs. Post-Retrofit

- Test In Qn,out Mean = 0.13; n = 72
- Test Out Qn,out Mean = 0.07; n = 72

**Whole House Air Tightness**
Pre- vs. Post-Retrofit

- Test In ACH50, Mean = 10.6; n = 72
- Test Out ACH50, Mean = 6.9; n = 72

**HERS Indices**
Pre- vs. Post-Retrofit

- Test In HERS Index, Mean = 132; n = 73
- Test Out HERS Index, Mean = 84; n = 73
• Predicted Savings in 73 Completed Homes
  • A combination of retrofit measures:
    • “Tune up" tasks
    • Low cost, low hanging fruit
    • Higher efficiency choices upon replacement
  • Partner’s use of standards
    • Achieve a bulk of the improvement
    • 3rd Party role in ensuring quality
• Cost Data Collected for 50 Homes
  • Providing costs to US Dept. of Energy national database

### Cost Data Collected for 50 Homes

<table>
<thead>
<tr>
<th>% Improvement (HERS)</th>
<th># of Homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15%</td>
<td>6</td>
</tr>
<tr>
<td>15&lt;30%</td>
<td>25</td>
</tr>
<tr>
<td>30&lt;40%</td>
<td>19</td>
</tr>
<tr>
<td>40&lt;50%</td>
<td>21</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>2</td>
</tr>
</tbody>
</table>

Average Energy Cost Savings: 33%
• Identified Gaps and Barriers
  • Physical limitations of mechanical closets
  • Typical areas contractors need help meeting specifications
    • System sizing & Pressure differences
  • Identification of critical QA tasks
    • Mechanical contractors to identify and seal all joints and seams to reduce duct leakage
    • Testing to ensure leakage levels below threshold
    • Testing to ensure pressure differences below threshold
    • Inconsistent code perspectives
    • Gap in contracting paradigm
• Community Scale “Best Practices” Retrofit Study
  • Apply Lessons Learned in 100+ houses
  • Standard set of specifications for replacement and maintenance
    • Design, implementation, and verification
  • Apply across a whole community
  • Document problematic aspects of specifications
  • Develop and test solutions

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Building America Partnership for Improved Residential Construction
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http://www.ba-pirc.org/