Advancing Residential Energy Retrofits

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for

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Context

• Residential Energy Efficiency is Important
• A Large Energy Efficiency Gap Exists
• But...
Project Goals

1. Can we retrofit existing homes to achieve energy savings of more than 30%
2. Can we **cost effectively** retrofit existing homes to achieve energy savings of more than 30%
3. Will homeowners pay for retrofits that achieve energy savings of more than 30%
4. Will reality (i.e. utility bills) match the projected energy savings

• In the event any of the answers to questions 1-4 is NO, what are obstacles to YES
Advancing Residential Energy Retrofits
HERS Indices for each home

- Yellow Jacket
- Michigan
- Two Cities
- Lakeview
- Eagle
- Virginia
- North Carolina
- New York
- South Carolina

HERS Index

- HERS before retrofit
Expected HERS Reduction After Retrofit

- Yellow Jacket
- Michigan
- Two Cities
- Lakeview
- Eagle
- Virginia
- North Carolina
- New York
- South Carolina

HERS before retrofit: Blue bars
HERS after retrofit: Red bars

HERS Index

0 50 100 150 200 250
Modeled Annual Source Energy Savings

- Yellow Jacket: 18%
- Michigan: 27%
- Two Cities: 30%
- Lakeview: 31%
- Eagle: 32%
- Virginia: 34%
- North Carolina: 37%
- New York: 42%
- South Carolina: 45%

HERS Index and Percent Source Energy Savings Graph with HERS before retrofit, HERS after retrofit, and Predicted Source Energy Savings markers.
## Overview of Retrofit Measures

<table>
<thead>
<tr>
<th>House</th>
<th>Sealed Attic</th>
<th>Attic Floor Sealing</th>
<th>Wall Insulation</th>
<th>Window Upgrade</th>
<th>HVAC Upgrade</th>
<th>Subfloor Sealing</th>
<th>Sealed Crawlspace</th>
<th>DHW</th>
<th>Predicted Source Energy Reduction (%)</th>
<th>Retrofit Cost ($K)</th>
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</thead>
<tbody>
<tr>
<td>Yellow Jackets</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
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<td>18</td>
<td>28</td>
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<tr>
<td>Michigan</td>
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<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>27</td>
<td>28</td>
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<tr>
<td>Two Cities</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>30</td>
<td>11</td>
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<td>Lakeview</td>
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<td>South Carolina</td>
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<td></td>
<td>x</td>
<td></td>
<td></td>
<td>45</td>
<td>38</td>
</tr>
</tbody>
</table>
Heating Season Source Energy Savings
Actual Savings are Similar to Modeled Savings

HERS Index

HERS before retrofit  HERS after retrofit  Predicted Source Energy Savings

Yellow Jacket  Michigan  Two Cities  Lakeview  Eagle  Virginia  North Carolina  New York  South Carolina

0%  5%  10%  15%  20%  25%  30%  35%  40%  45%  50%
0  50  100  150  200  250

Percent Source Energy Savings

18%  27%  30%  31%  32%  34%  37%  42%  45%
In Particular,

**Home Type:** Existing Single-Family  
**Location:** Atlanta, GA  
**Size:** 3,703 sq. ft.  
**Date Built:** 1920’s  
**IECC Climate Zone:** 3  
**HERS:** 169

**Air infiltration:** 12,691 cfm50 (i.e. 20.6 ACH)  
**Duct blaster test:** 22% (attic), ?? (crawlspace)  
**Cooling equipment:** 3.5 ton, 9.3 SEER (crawlspace); 2.5 ton, 9.5 SEER (attic)  
**Heating equipment:** 0.91 AFUE (x2)  
**Water heating equipment:** 0.59 energy factor
Tenant has Significantly High Utility Bills ($6,380/year*)

*Utility bills are from 2/2010-1/2011
Many Problems Exist

Uninsulated knee walls

Leaky Ducts

Significant attic infiltration
# The Solution,

<table>
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<tr>
<th>Attic/ Knee walls</th>
<th>R-38 blown fiberglass and other air sealing measures / R-15 open-cell foam</th>
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<tr>
<td>Foundation Walls</td>
<td>R-13 (close-cell foam on walls), R-11 (open-cell foam on band), New vapor barrier</td>
</tr>
<tr>
<td>Cooling</td>
<td>4-ton, 16 SEER (first floor)</td>
</tr>
<tr>
<td></td>
<td>2.5-ton, 16 SEER (second floor)</td>
</tr>
<tr>
<td>DHW</td>
<td>50 gal. Heat Pump Water Heater</td>
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Total Cost: $35,750, Projected Source Energy Savings: 38%
Energy Savings

June 28-July 3

Pre-Retrofit (Average Daily Electricity Use = 166 kWh)
Energy Savings

June 28-July 3

Pre-Retrofit (Average Daily Electricity Use = 166 kWh)

August 19 - August 24

Pre-Retrofit (Average Daily Electricity Use = 92 kWh)
Energy Savings

- Pre-Retrofit (Average Daily Electricity Use = 166 kWh)
- August 19 - August 24
- Pre-Retrofit (Average Daily Electricity Use = 92 kWh)

~43% Reduction in Energy
A Closer Look at HVAC Performance

First Floor Outdoor Unit
1st Floor Runtime 14.7 hours/day
Second Floor Outdoor Unit
2nd Floor Runtime 19.2 hours/day

July 2, 2011 (pre-retrofit, 84 °F)
**Retrofit Results: Shorter runtimes, lower power consumption**

- **1st Floor**
  - **Runtime**: 14.7 hours/day
- **2nd Floor**
  - **Runtime**: 19.2 hours/day

### Power Consumption Comparison

**July 2, 2011 (pre-retrofit, 84 °F)**

- **First Floor Outdoor Unit**
- **Second Floor Outdoor Unit**

**August 20, 2011 (post-retrofit, 83 °F)**

- **First Floor Outdoor Unit**
- **Second Floor Outdoor Unit**
So.... We did it!!!  We saved energy.
We saved money.
But it’s about more than energy and $$$

But what about Comfort
So Much More than Energy….
Comfort Matters

This 2-story home functions as a 1-story uncomfortable home
Post Retrofit Comfort

First Floor Temperature

Second Floor Temperature

Average Temperature, °F

70.00

83.00
Post Retrofit Comfort (comparison)
Post Retrofit Comfort

First Floor Humidity

Hour of the Day
- 10 PM
- 8 PM
- 6 PM
- 4 PM
- 2 PM
- 12 PM
- 10 AM
- 8 AM
- 6 AM
- 4 AM
- 2 AM

Aug 14  Aug 19  Aug 24  Aug 29
Date [2011]

Second Floor Humidity

Hour of Day
- 10 PM
- 8 PM
- 6 PM
- 4 PM
- 2 PM
- 12 PM
- 10 AM
- 8 AM
- 6 AM
- 4 AM
- 2 AM

Aug 14  Aug 19  Aug 24  Aug 29
Date [2011]

RH, %
- 50.00
- 75.00
Post Retrofit Comfort (comparison)
Let’s Recap

A $36k retrofit has yielded:
• Projected savings of ~$2400

• 1300 sq. ft of comfortable living area to the homeowner
Retrofit Lessons Learned:

1. Can we retrofit existing homes to achieve energy savings of more than 30% --- Yes
2. Can we *cost effectively* retrofit existing homes to achieve energy savings of more than 30% --- Not today (more research is needed)
3. Will homeowners pay for retrofits that achieve energy savings of more than 30% --- Maybe
4. Will reality (i.e. utility bills) match the projected energy savings --- For the most part

Non-energy benefits can be the largest motivators for retrofits
Thank You

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