RECOMMENDATIONS FOR 15% ABOVE-CODE ENERGY EFFICIENCY MEASURES FOR SINGLE FAMILY RESIDENCES

Mini Malhotra
Graduate Research Assistant

Jaya Mukhopadhyay
Research Associate

Betty Liu, Ph.D.
Research Associate

Jeff Levenhagen, Ph.D., P.E.
Associate Director

Charles Culp, Ph.D., P.E.
Associate Director

Bahman Yazdani, P.E.
Associate Director

Energy Systems Laboratory
Texas Engineering Experiment Station
Texas A&M University System

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Faculty/Staff:
Tom Fitzpatrick, Don Gilman, Mushtaq Ahmed, Betty Liu, Juan-Carlos Baltazar, Sherrie Hughes, Angie Schafer, Larry Degelman, David Claridge, Dan Turner, Stephen O'Neal.

Students:
Mini Malhotra, Piljae Im, Seongchan Kim, Soolyeon Cho, Ben Burkhert, Indira Mohandross, Kyle Marshall, Matt Moss, Megan Bednarz, Robert Stackhouse.

TCEQ: Steve Anderson, Akin Olubiyi.

USEPA: Art Diem, Julie Rosenberg.

OUTLINE

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Base-Case Building
Energy Efficiency Measures
Results
Conclusion

INTRODUCTION

THE 79TH LEGISLATURE TO ENHANCE EFFECTIVENESS OF SENATE BILL 5

Requires the Laboratory
To develop 3 methods for achieving at least 15% potential energy savings in residential, commercial, and industrial construction.

The Process
Worked on residential and commercial measures
Held stakeholder meetings
Refined measures

BASE-CASE
As per IECC 2001 for Residential Buildings

Two system types:
Electric cooling Natural gas heating (Electric / Gas)

Building Envelope
- Detached single story (2325 ft²) in Houston, TX
- Light weight wood frame construction
- Ceiling R-value: R-30
- Wall R-value: R-11.76
- Un-insulated slab-on-grade

Fenestration
- 18% window to floor area ratio
- U-value: 0.47 Btu/hr ºF ft²
- SHGC: 0.40

Air Infiltration
- Conditioned space: 0.47 ACH
- Max: 15 ACH

BASE-CASE
As per IECC 2001 for Residential Buildings

Two system types:
Electric cooling Natural gas heating (Electric / Gas)

HVAC System Characteristics
- Room air conditioner with SEER 13
- Gas fired forced air furnace - AFUE = 0.78
- Heat Pump HSPF = 7.7

Air Distribution System Characteristics
- Ducts in attic
- 10% duct leakage
- Supply duct R-value = R-8
- Return duct R-value = R-4

Energy Systems Laboratory @2007
**BASE-CASE**

As per IECC 2001 for Residential Buildings

Two system types:
- Electric cooling Natural gas heating (Electric / Gas)
- Electric cooling Electric heating (All - Electric)

**DHW System Characteristics**
- Daily hot water use 70 gallons/day
- 40 gallon storage
- Energy Factor – 0.54
- Pilot light
- For All-Electric
- 50 gallon storage
- Energy Factor – 0.86

**ENERGY EFFICIENCY MEASURES**

12 INDIVIDUAL MEASURES

**DHW System Measures**

1. Tankless Domestic Water Heater (Electric/Gas & All-Electric)
   - For Electric / Gas
   - No Pilot light
   - Energy Factor raised from 0.54 to 0.85
   - For All-Electric
   - Energy Factor raised from 0.86 to 0.95

2. Solar Domestic Water Heater (Electric/Gas & All-Electric)

3. Removal of Standing Pilot Light from Gas DHW (Electric/Gas)

**Air Distribution System Measures**

4. Ducts in Conditioned Space
   - Moving ductwork and HVAC system within the thermal envelope

5. Improved Duct Sealing
   - Changing from 10% to 5%

**Envelope & Fenestration Measures**

6. Increased Air-Tightness
   - Changing from 0.47 to 0.35

7. Addition of Window Shading
   - Roof overhangs of 4 ft.

8. Window Shading and Redistribution
   - From 18% WFAR distributed 25% WWAR on each orientation to windows distributed 45% on the south, 25% on the north, 15% each on east and west orientations
   - 4 ft. roof overhang was also included on all four sides

9. Improved Window Performance
   - U-Value = 0.42 Btu/h-sq. ft.-°F
   - SHGC = 0.33

10. Improved Air Conditioning Efficiency
    - From SEER 13 to SEER 15

11. Improved Furnace Efficiency
    - From 0.78 AFUE to 0.93 AFUE

12. Improved Efficiency of the Heat Pump
    - From 7.7 HSPF to 8.5 HSPF

**COMBINED SET OF MEASURES**

Combination 1
- Tankless Water Heater (Tankless, Stand-up, Pilot Light)
- Relocate HVAC Unit Including Supply and Return Ducts in Conditioned Space

Combination 2
- Solar Domestic Hot Water System
- Improved Duct Sealing (5% Duct Leakage)
- Improved Air Conditioner (SEER 15)

Combination 3
- Removal of Pilot Light from DHW System
- Relocate HVAC Unit including Supply and Return Air Ducts in Conditioned Space
- Window Shading and Redistribution
Energy Savings

- HVAC Unit & Duct in Conditioned Space: 8.5%
- Improved Duct Sealing: 4.3%

Payback Period

- HVAC Unit & Duct in Conditioned Space: 100 years
- Improved Duct Sealing: 31.7 years

Envelope & Fenestration Measures for Electric/Gas Building

<table>
<thead>
<tr>
<th>Item</th>
<th>Energy Use Savings</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Window Performance</td>
<td>8%</td>
<td>11 years</td>
</tr>
<tr>
<td>Shading + Window Redistribution</td>
<td>2.6%</td>
<td>3.6 years</td>
</tr>
<tr>
<td>Shading</td>
<td>2.1%</td>
<td>2.1 years</td>
</tr>
</tbody>
</table>

Energy Savings

- Air Tightness: 1.1%
- Shading: 2.1%
- Shading + Window Redistribution: 3.6%
- Window Performance: 4.0%

Payback Period

- Air Tightness: 10 - 43 years
- Shading + Window Redistribution: 25 - 33 years
- Window Performance: 6 - 11 years
## RESULTS

### Energy Use Savings from Individual Measures for All-Electric Building

<table>
<thead>
<tr>
<th>Measure</th>
<th>Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>3.2</td>
</tr>
<tr>
<td>Equipment</td>
<td>3.2</td>
</tr>
<tr>
<td>Heating</td>
<td>6.3</td>
</tr>
<tr>
<td>Cooling</td>
<td>5.9</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.2</td>
</tr>
<tr>
<td>Fans</td>
<td>2.4</td>
</tr>
<tr>
<td>Domestic Water Heating</td>
<td>2.6</td>
</tr>
</tbody>
</table>

**Total Savings %**: 63.7

### Payback Periods

<table>
<thead>
<tr>
<th>Measure</th>
<th>Payback Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>15.1</td>
</tr>
<tr>
<td>Equipment</td>
<td>15.4</td>
</tr>
<tr>
<td>Heating</td>
<td>9.3 – 27.6</td>
</tr>
<tr>
<td>Cooling</td>
<td>15.1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>14.5 – 22.4</td>
</tr>
</tbody>
</table>

### Most Effective Individual Measures

<table>
<thead>
<tr>
<th>Combination</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### For Electric / Gas Building

### Increased First Costs and Energy Savings

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost ($1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tankless DHW Heater</td>
<td>1,500</td>
</tr>
<tr>
<td>Tankless Gas Water Heater</td>
<td>4,000</td>
</tr>
<tr>
<td>Solar DHW System</td>
<td>7,500</td>
</tr>
</tbody>
</table>

**Average Energy Savings**: 33.0

**Maximum Energy Savings**: 7.1

**Minimum Energy Savings**: 4.1

### Natural Gas Heating (Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Payback Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>17.4</td>
</tr>
<tr>
<td>Combination 2</td>
<td>15.8</td>
</tr>
<tr>
<td>Combination 3</td>
<td>11.2</td>
</tr>
</tbody>
</table>

### Electric Heating (Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>17.8%</td>
<td>6.8 – 25.7</td>
</tr>
<tr>
<td>Combination 2</td>
<td>15.8%</td>
<td>11.2 – 20</td>
</tr>
<tr>
<td>Combination 3</td>
<td>16.8%</td>
<td>10 Years</td>
</tr>
</tbody>
</table>

### FOR ELECTRIC / GAS BUILDING IN HOUSTON:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Removal of Pilot Light</td>
<td>17.8%</td>
<td>9 Years</td>
</tr>
<tr>
<td>2. Improving Duct Sealing</td>
<td>21.8%</td>
<td>5 Years</td>
</tr>
<tr>
<td>3. Improved Window Performance</td>
<td>16.8%</td>
<td>10 Years</td>
</tr>
</tbody>
</table>

**Most Effective Individual Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>17.8%</td>
<td>6.8 – 25.7</td>
</tr>
<tr>
<td>Tankless DHW Heater</td>
<td>17.8%</td>
<td>6.8 – 25.7</td>
</tr>
<tr>
<td>Radiant HVAC unit including supply and return air ducts in conditioned space</td>
<td>17.8%</td>
<td>6.8 – 25.7</td>
</tr>
</tbody>
</table>
# Conclusions

For all-electric building in Houston:

<table>
<thead>
<tr>
<th>Most Effective Individual Measures</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Duct Sealing</td>
<td>17.8%</td>
<td>4 Years</td>
</tr>
<tr>
<td>Improved Window Performance</td>
<td>3.3%</td>
<td>10 Years</td>
</tr>
<tr>
<td>Solar Hot Water System</td>
<td>10.9%</td>
<td>13 Years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Most Effective Individual Measures</th>
<th>Energy Savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>15.7%</td>
<td>7.6 – 13.5 Years</td>
</tr>
<tr>
<td>Solar Hot Water System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved Duct Sealing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ESL Contact Information**

minimalhotra@tees.tamus.edu
jayamukhopadhyay@tees.tamus.edu

http://eslsb5.tamu.edu