Energy Myths and Energy Efficiency of Various Wall Systems

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40% of Exterior Residential Walls VS 60%+ of Exterior Residential Walls
U.S. Energy Consumption by Sector, 2009

INDUSTRIAL 30%
Top Industrial Sources:
- Petroleum
- Natural Gas
- Electricity

TRANSPORTATION 29%
Top Transportation Sources:
- Petroleum
- Biomass
- Natural Gas

COMMERCIAL 19%
Top Commercial Sources:
- Electricity*
- Natural Gas
- Petroleum

RESIDENTIAL 22%
Top Residential Sources:
- Natural Gas
- Electricity*
- Petroleum

*Electricity is an energy carrier, not a primary energy source
Note: Figures are rounded.
Data: Energy Information Administration

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LEED V 3.0; EA Category; Points Available

Prereq 2: Minimum Energy Performance
Credit 1: Optimize Energy Performance

Points for incremental improvement in energy performance above
ASHRAE Standard 90.1-2007 minimums
Historic Problem

“R” Value
vs
“U” Value
vs
Thermal Mass
vs
Actual Energy Performance
Another Historic Problem

Continuous VS Integral Insulation

Masonry Walls: Continuous Insulation
Masonry Walls: NOT Continuous

Yet Another Historic Problem

Prescriptive VS Performance
Prescriptive

- The simple way to figure out what to do
- Required values are spelled out in black and white
- Conservative because it covers a broad range of cases
- Valuable in marketing because it is simple, visual and general

Performance

- More complicated to use but more accurate
- The results are specific as opposed to general. This makes the results harder to use in describing general traits.
- Relies on sophisticated computer programs and requires more input up front.

Mandatory Requirements in the Commercial 2014 FBC Energy

Mandatory Section Requirements
C402.4 – Air Leakage
C403.2 – Provisions Applicable to All Mech Sys
C404 – Service Water Heating
C405 – Elect Power and Lighting Sys
Conversion of R to U

(U=1/R)
(R=1/U)

Layers

$R_{\text{TOTAL}} = R_1 + R_2 + R_3 + \ldots$

Whole Wall

Includes Air Films

\[ U = \frac{1}{R_{\text{TOTAL}}} \]

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### TABLE C402.2

OPAQUE THERMAL ENVELOPE REQUIREMENTS\(^a\) (By Added Continuous Insulation R Value)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>1 All Other</th>
<th>Group R</th>
<th>2 All Other</th>
<th>Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass(^c)</td>
<td>R-5.7ci(^c)</td>
<td>R-5.7ci(^c)</td>
<td>R-5.7ci(^c)</td>
<td>R-7.6ci</td>
</tr>
<tr>
<td>Metal building</td>
<td>R-13 + R-6.5ci</td>
<td>R-13 + R-6.5ci</td>
<td>R-13 + R-6.5ci</td>
<td>R-13 + R-13ci</td>
</tr>
<tr>
<td>Metal framed</td>
<td>R-13 + R-5ci</td>
<td>R-13 + R-5ci</td>
<td>R-13 + R-5ci</td>
<td>R-13 + R-7.5ci</td>
</tr>
<tr>
<td>Wood framed and other</td>
<td>R-13 + R-3.8ci or R-20</td>
<td>R-13 + R-3.8ci or R-20</td>
<td>R-13 + R-3.8ci or R-20</td>
<td>R-13 + R-3.8ci or R-20</td>
</tr>
</tbody>
</table>

\(^a\) By Added Continuous Insulation R Value

\(^c\) Mass
### TABLE C402.1.2

**OPAQUE THERMAL ENVELOPE REQUIREMENTS** *(By Through Wall U Value)*

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Other</td>
<td>Group R</td>
<td>All Other</td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.142</td>
<td>U-0.142</td>
<td>U-0.142</td>
</tr>
<tr>
<td>Metal building</td>
<td>U-0.079</td>
<td>U-0.079</td>
<td>U-0.079</td>
</tr>
<tr>
<td>Metal framed</td>
<td>U-0.077</td>
<td>U-0.077</td>
<td>U-0.077</td>
</tr>
<tr>
<td>Wood framed and other</td>
<td>U-0.064</td>
<td>U-0.064</td>
<td>U-0.064</td>
</tr>
</tbody>
</table>

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**Per 5th Ed. FBC Energy**

- Exterior Air Film: R=.25
- 8” CMU: R=1.3
- 1 ½ ” Reflective Air Space: R=5.6
- Int Gypboard: R=.45
- Interior Air Film: R=.68
- Tot R Value: R=8.28
C402.1.2 *U*-factor alternative. An assembly with a *U*-factor, *C*-factor, or *F*-factor equal or less than that specified in Table C402.1.2 shall be permitted as an alternative to the *R*-value in Table C402.2.

Where the Confusion Comes In

C402.2.3 Thermal resistance of above-grade walls. The minimum thermal resistance (*R*-value) of the insulating materials installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table C402.2, based on framing type and construction materials used in the wall assembly.

The *R*-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table C402.2.
**FBC 5th Ed. – Chapter 4**

**COMMERCIAL ENERGY EFFICIENCY**

**C402.1.2 U-factor alternative.** An assembly with a $U$-factor, $C$-factor, or $F$-factor equal or less than that specified in Table C402.1.2 shall be permitted as an alternative to the $R$-value in Table C402.2.

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**Historic Problem**

“$R$” Value vs “$U$” Value vs Thermal Mass vs Actual Energy Performance
THERMAL MASS: Materials with mass heat capacity and surface area are capable of affecting building loads by storing and releasing heat as the interior and/or exterior temperature and radiant conditions fluctuate.

Thermal mass tends to decrease both heating and cooling loads in a given building.
TABLE C402.1.2
OPAQUE THERMAL ENVELOPE REQUIREMENTS

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>1 All Other</th>
<th>Group R</th>
<th>All Other</th>
<th>Group R</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>U-0.142</td>
<td>U-0.142</td>
<td>U-0.142</td>
<td>U-0.123</td>
<td>R-8.13</td>
</tr>
<tr>
<td>Metal building</td>
<td>U-0.079</td>
<td>U-0.079</td>
<td>U-0.079</td>
<td>U-0.079</td>
<td>R-12.66</td>
</tr>
<tr>
<td>Metal framed</td>
<td>U-0.077</td>
<td>U-0.077</td>
<td>U-0.077</td>
<td>U-0.064</td>
<td>R-15.62</td>
</tr>
<tr>
<td>Wood framed and other</td>
<td>U-0.064</td>
<td>U-0.064</td>
<td>U-0.064</td>
<td>U-0.064</td>
<td>R-15.62</td>
</tr>
</tbody>
</table>

All of these walls are considered by the code to be equivalent in their energy efficiency. The difference is MASS.
Options for Reducing ‘U’ Values of Concrete Masonry Walls

Due to its mass factor, walls constructed of concrete masonry can meet the requirements of the Florida Energy Code without having to install a Continuous Insulation system to the exterior.

<table>
<thead>
<tr>
<th>Opaque Thermal Envelop Assembly Requirements (Values from Energy Conservation, Table C402.1)</th>
<th>U Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through Wall ‘U’ Value Prescriptive Requirements (All of FL other than Dade, does not include Residential)</td>
<td>0.142</td>
</tr>
<tr>
<td>Plain Concrete Block Wall</td>
<td>0.770</td>
</tr>
<tr>
<td>Foamed Cells with Exposed Interior</td>
<td>0.206</td>
</tr>
<tr>
<td>Interior ¾” Reflective Insulation</td>
<td>0.174</td>
</tr>
<tr>
<td>Interior 1½” Reflective Insulation</td>
<td>0.121</td>
</tr>
<tr>
<td>Interior ¾” Polyisocyanurate Board + ¾” Reflective Air Space</td>
<td>0.101</td>
</tr>
</tbody>
</table>

This advantage enables the stucco to be applied directly to the block, thus avoiding the additional expense and maintenance of a metal plaster base to the outside of the building.

Historic Problem

“R” Value vs “U” Value vs Thermal Mass vs Actual Energy Performance
COMMERCIAL HEATING AND COOLING LOADS COMPONENT ANALYSIS

Building Technologies Department
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory
University of California
Berkeley, CA 94720
Thermal Performance of Concrete Masonry Wall Systems

School in Bowling Green, KY

Diminishing Returns
School in Bowling Green Kentucky

Figure C.9 Specific Component Loads (kBtu/ft²) for Large Retail Stores in Houston

Estimate of Building Envelope Energy Use, Btu/ft²

School in Bowling Green, KY

Wall R-Value, hr-ft²·°F/Btu
Doubling insulation R-value from R7 to R14 drops building envelope energy use by 2.5%.

After R12 do not recover additional cost of insulation through energy savings during the lifetime of the building.
Average Utility Cost Per Sq. Ft.

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Block Home</td>
<td>.10¢ to .13¢ per month</td>
</tr>
<tr>
<td>Wood Frame Home*</td>
<td>.08¢ to .12¢ per month</td>
</tr>
<tr>
<td><strong>BuildBlock ICF Home</strong></td>
<td><strong>.03¢ to .04¢ per month</strong></td>
</tr>
</tbody>
</table>

Claims from $1440 to $2400
Saving / yr over
CMU construction

July 16th, 2014

Residential Wall Type Energy Impact Analysis
(Phase I)

Masonry Association of Florida
NCMA Foundation
Pacific NW National Laboratories
Project Goals

• Determine the difference in energy usage due **exclusively** to the exterior wall properties in residential structures.
• Evaluate both CMU and competing systems in one and two story structures across all US climate zones.

General Concept
For PNNL Research

One and Two Story Homes Based on Standard Reference Design Criteria of Both the IECC and the FBC
Wall Combinations

Walls Designed from:

- CMU;
- Wood and;
- ICF

Building Parameters - National

- Building Types
  - 1 Story, 2000 square feet, slab on grade
  - 2 Story, 2200 square feet, crawl space
- Rectangular buildings
- Fenestration – 15% of floor area, equally distributed among cardinal directions
- Natural Gas Furnace, split system cooling with DC coil, natural gas water heat
- DOE Parameters for IECC analysis with 2012 IECC parameters
Building Parameters - Florida

- **Building Types**
  - 1 Story, 2000 square feet, slab on grade
  - 2 Story, 2200 square feet, slab on grade
- **Rectangular buildings**
- **Fenestration** – 15% of floor area, equally distributed among cardinal directions
- **Electric heat pump** for heating/cooling and electric water heater
- **FSEC prototypes** for 2010 Florida Energy Code (2009 IECC basis)

CMU Wall Variables

- **Types of CMU** - Standard Web or Reduced Web (ASTM C90-11b)
- **Unit Weights** - 85, 115 and 135
- **Grout Spacing** - Solid, 24, 48, 96 and no grout
- **Filled Cell Insulation** - Foam Fill or Empty
- **Insulation Location** - Interior or Exterior
- **Insulation Levels** – Zero to R24
Wood Wall Variables

• **Stud Spacing** - Standard at 16” oc
• **Wall Stud Thickness** - 3 ½” or 5 ½”
• **Bat Insulation** - R13 (3 ½” Stud) or R19 (5 ½” Stud)
• **Board Insulation** – Zero to R7
• **Total Insulation Range** – R13 to R26
• **Exterior Finish** – Stucco on Lath

ICF Wall Variables

• **Core Width** – 4” or 6”
• **Concrete Density** – 120 pcf or 140 pcf
• **Insulation (Split)** – R16 to R24
<table>
<thead>
<tr>
<th>Location</th>
<th>State</th>
<th>Climate Zone</th>
<th>Moisture Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miami</td>
<td>FL</td>
<td>1A</td>
<td>Moist</td>
</tr>
<tr>
<td>Phoenix</td>
<td>AZ</td>
<td>2B</td>
<td>Dry</td>
</tr>
<tr>
<td>Houston</td>
<td>TX</td>
<td>2A</td>
<td>Moist</td>
</tr>
<tr>
<td>El Paso</td>
<td>TX</td>
<td>3B</td>
<td>Dry</td>
</tr>
<tr>
<td>San Francisco</td>
<td>CA</td>
<td>3C</td>
<td>Marine</td>
</tr>
<tr>
<td>Memphis</td>
<td>TN</td>
<td>3A</td>
<td>Moist</td>
</tr>
<tr>
<td>Albuquerque</td>
<td>NM</td>
<td>4B</td>
<td>Dry</td>
</tr>
<tr>
<td>Salem</td>
<td>OR</td>
<td>4C</td>
<td>Marine</td>
</tr>
<tr>
<td>Baltimore</td>
<td>MD</td>
<td>4A</td>
<td>Moist</td>
</tr>
<tr>
<td>Boise</td>
<td>ID</td>
<td>5B</td>
<td>Dry</td>
</tr>
<tr>
<td>Chicago</td>
<td>IL</td>
<td>5A</td>
<td>Moist</td>
</tr>
<tr>
<td>Helena</td>
<td>MT</td>
<td>6B</td>
<td>Dry</td>
</tr>
<tr>
<td>Burlington</td>
<td>VT</td>
<td>6A</td>
<td>Moist</td>
</tr>
<tr>
<td>Duluth</td>
<td>MN</td>
<td>7</td>
<td>---</td>
</tr>
<tr>
<td>Fairbanks</td>
<td>AK</td>
<td>8</td>
<td>---</td>
</tr>
</tbody>
</table>

**Florida Climate Regions – Miami, Orlando, Jacksonville**

![USA Climate Zones Map](image)
Total Project Scope

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Wall Combos</th>
<th>One or Two Sty</th>
<th>X 18 Climate Zones</th>
<th>Number of Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Web CMU</td>
<td>314</td>
<td>X 2</td>
<td>X 18</td>
<td>11,304</td>
</tr>
<tr>
<td>2 Web CMU</td>
<td>273</td>
<td>X 2</td>
<td>X 18</td>
<td>9828</td>
</tr>
<tr>
<td>ICF</td>
<td>12</td>
<td>X 2</td>
<td>X 18</td>
<td>432</td>
</tr>
<tr>
<td>Wood Frame</td>
<td>8</td>
<td>X 2</td>
<td>X 18</td>
<td>288</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>607</strong></td>
<td><strong>X 2</strong></td>
<td><strong>X 18</strong></td>
<td><strong>21,852</strong></td>
</tr>
</tbody>
</table>

Results Summary

- **EUI** – Energy Use Intensity (Btu per square foot per year)
- **ECI** – Energy Cost Index ($ per square foot per year)
National – R13 Wood vs. R7.8 CMU

Masonry performers better in 7 of 8 climate zones and approximately equals R13 wood in CZ:8 (Fairbanks)

FLORIDA ENERGY RESEARCH REPORT
Initial Florida Report on Results of PNNL Residential Energy Study
**MYTH #1**  
Putting heavy insulation in your walls can save you hundreds of dollars PER MONTH - FALSE!

**MYTH #2**  
More insulation is always better - FALSE!

**MYTH #3**  
R13 wood walls are much more energy efficient than R4 CMU - FALSE!

**MYTH #4**  
Insulation is only effective on the outside of CMU - FALSE!
Claims from $1440 to $2400 Saving / yr over CMU construction

July 16th, 2014

Table 1: Comparison of Energy Savings of the Least and Most Insulated Walls in Florida

<table>
<thead>
<tr>
<th>Wall#</th>
<th>Wall Disc</th>
<th>Overall R Value</th>
<th>$ Savings in Miami</th>
<th>$ Savings in Orlando</th>
<th>$ Savings in Jax</th>
<th>Cost of Energy Upgrade</th>
<th>Payback Period for Mia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CMU R4</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>CMU R7</td>
<td>8.3</td>
<td>$38</td>
<td>$30</td>
<td>$36</td>
<td>$437$</td>
<td>11.5 yrs</td>
</tr>
<tr>
<td>3</td>
<td>ICF R20</td>
<td>21.7</td>
<td>$101</td>
<td>$79</td>
<td>$96</td>
<td>$4,207$</td>
<td>41.5 yrs</td>
</tr>
</tbody>
</table>
Table 1: Comparison of Energy Savings of the Least and Most Insulated Walls in Florida

<table>
<thead>
<tr>
<th>Wall#</th>
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<th>Overall R Value</th>
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<th>$ Savings in Jax</th>
<th>Cost of Energy Upgrade</th>
<th>Payback Period for Mia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CMU R4</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>CMU R7</td>
<td>8.3</td>
<td>$38</td>
<td>$30</td>
<td>$36</td>
<td>$437$</td>
<td>11.5 yrs</td>
</tr>
<tr>
<td>3</td>
<td>ICF R20</td>
<td>21.7</td>
<td>$101</td>
<td>$79</td>
<td>$96</td>
<td>$4,207$</td>
<td>41.5 yrs</td>
</tr>
</tbody>
</table>
Figure 1 – Diminishing Returns of Added Insulation to Mass CMU Walls

**MYTH #2**
More insulation is always better - FALSE!

**MYTH #3**
R13 wood walls are much more energy efficient than...
### Table 2 - Energy Differences Between R4 CMU and R13 Wood Walls

<table>
<thead>
<tr>
<th>Wall#</th>
<th>Wall Disc</th>
<th>Overall R Value</th>
<th>Miami</th>
<th>Orlando</th>
<th>Jax</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>CMU R4</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Wood R13</td>
<td>10.9</td>
<td>$46</td>
<td>$15</td>
<td>$18</td>
</tr>
</tbody>
</table>
Table 3 - Comparison of Energy Savings of Interior vs. Exterior Insulation (FL CMU Walls)

<table>
<thead>
<tr>
<th>Wall #</th>
<th>Wall Disc</th>
<th>Overall R Value</th>
<th>Mia</th>
<th>Orl</th>
<th>Jax</th>
<th>Cost of Exterior Insulation</th>
<th>Payback Period(^6) for Jax</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>CMU Int Insul</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>CMU Ext Insul</td>
<td>10</td>
<td>$14</td>
<td>$17</td>
<td>$22</td>
<td>$3366</td>
<td>153 yrs</td>
</tr>
</tbody>
</table>
Phase II
(Currently Contracted)
• Include Steel Frame
• Enhanced Documentation
• Cost Effectiveness Spreadsheet
• Heating System Selection
• Enhanced Spreadsheet Including:
  – Interpolation Between Analyzed Results
  – Analysis Increased from 5 to 10 walls

PNNL and Florida Report
Available at www.floridamasonry.com
QUESTIONS?