High Performance, Low Energy
DETAILS IN THE FIELD

Duluth Energy Design Conference 24 February 2015

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In accordance with the Department of Labor and Industry’s statute 326.0981, Subd. 11,

“This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward Building Officials and Residential Contractors continuing education requirements.”

For additional continuing education approvals, please see your credit tracking card.
Learning Objectives – Part 1

1. Introduction: Defining high performance/low energy
   An integrated approach

2. One Size Does Not Fit All: The Use of Design
   Determining how much, when, and where
   How building design impacts performance and energy use

3. Water Management
   The key to durability - everywhere

4. Air Sealing
   Managing heat, air and moisture - everywhere

5. A Good Foundation
   Basement/foundation walls
   Insulated Slab on grade
Learning Objectives – Part 2

6. Framed Walls
   Double stud
   Single stud with foam sheathing

7. Windows
   Product and performance
   Installation details

8. The Roof
   What it should always do and can do
   Details for attics and for vaulted ceilings

9. Systems (Mechanical, Electrical, Plumbing):
   Guidelines for low energy, high performance
   Matching performance to intent

10. Results of an Integrated Approach
Defining High Performance, Low Energy
“Average” energy use, 2009

Source: U.S. EIA
“Average” energy use, 2009

Newer U.S. homes are 30% larger but consume about as much energy as older homes.

Average household site energy consumption by end use, 2009

<table>
<thead>
<tr>
<th>Category</th>
<th>Homes built before 2000</th>
<th>Homes built 2000-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>+2%</td>
<td></td>
</tr>
<tr>
<td>Space Heating*</td>
<td>-21%</td>
<td></td>
</tr>
<tr>
<td>Water Heating</td>
<td>+3%</td>
<td></td>
</tr>
<tr>
<td>Air Conditioning*</td>
<td>+56%</td>
<td></td>
</tr>
<tr>
<td>Appliances, Electronics, Lighting</td>
<td>+18%</td>
<td></td>
</tr>
</tbody>
</table>


Note: Averages for space heating and air conditioning reflect only those households that heated or cooled their homes in 2009.
Region plays a role.

In 2009, the average Wisconsin household uses 103 million Btu of energy per home, 15% more than the U.S. average.  

Source EIA
Region plays a role.

**Pie Charts**
- **US**
  - Air conditioning: 6%
  - Water heating: 18%
  - Appliances, electronics, lighting: 35%
  - Space heating: 41%

- **ENC**
  - Air conditioning: 2%
  - Water heating: 16%
  - Appliances, electronics, lighting: 52%
  - Space heating: 28%

- **WI**
  - Air conditioning: 1%
  - Water heating: 15%
  - Appliances, electronics, lighting: 56%
  - Space heating: 23%

**Average Square Footage**
- **US**: 1,971
- **ENC**: 2,251
- **WI**: 2,605
Defining Low Energy

We’ll start with the goal of 50% less energy.

Let’s look at Wisconsin, and assume MN is similar.

Total energy 103 MMBtu: 50% Goal = 51.5 MMBtu

Heating Energy 57.68 MMBtu: 50% Goal = 28.84 MMBtu

How about energy per ft2?

Goals per square foot:

19.8 kBTu/ft² total energy

11 kBTu/ft² heating energy
High Performance is About More than Energy

- **FUNCTIONALITY** – make it understandable, easy to use
- **DURABILITY** – make it last and easy to maintain
- **ADAPTABILITY** – be able to change it
- **COMFORT** – make it feel good
- **HEALTH** – minimize the risks to occupants
- **RESILIENCY** – make it work under a variety of conditions
The Priorities

1. Healthy for Occupants.
2. Durable.
3. Uses less than half the energy than the “average” house of the same age.
Designing a High Performance, Low Energy Home

1. Healthy for Occupants.

2. Durable.

3. Uses less than half the energy than the “average” house of the same age.
One Size Does Not Fit All

- Big house or small house?
- Simple building form or complex form?
- Construction costs vs operating costs
- Orientation and solar opportunity
- Site constraints and topography

All will affect choices made to achieve high performance and low energy.
Prioritizing how much, where, and when

- GOALS
- BIGGER BUILDING, MORE INSULATION
- MORE WINDOWS, BETTER WINDOWS
- SITE CHARACTERISTICS
- SOLAR OPPORTUNITY
- ENERGY MODELING LEADS TO ENERGY BALANCE
- BUDGET
- BUILDING PROGRAM
Designing to Targets (the <50% goal): We use a baseline of code and compare versions of the same house

<table>
<thead>
<tr>
<th>Modeled Energy Data - “House X”</th>
<th>Code</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Heating Load</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Btu/hr</td>
<td>43,200 Btu/hr</td>
<td>19,900 Btu/hr</td>
</tr>
<tr>
<td>Btu/hr/ft2</td>
<td>22.3 Btu/hr/ft2</td>
<td>10.3 Btu/hr/ft2</td>
</tr>
<tr>
<td><strong>Annual Heating Demand</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMBtu/year</td>
<td>93.8 MMBtu/yr</td>
<td>32.1 MMBtu/yr</td>
</tr>
<tr>
<td>kBtu/ft2 annual</td>
<td>48.55 kBtu/ft2/yr</td>
<td>16.61 kBtu/ft2/yr</td>
</tr>
</tbody>
</table>
Energy Modeling

AN INDISPENSABLE TOOL
Can compare and evaluate
design elements
envelope components
building and window orientation
mechanical systems
insulation levels
Can compare performance relative to
Code, Energy Star, Passivhaus, …
Performance priorities in design

1. Understand how form, assemblies, and materials affect energy and durability.
2. Create a building form that helps manage water, heat, and air flow.
3. Maximize use of the sun.
4. Include systems of Energy Flexibility.
5. Minimize vulnerability to the occupants.

(indoor environmental quality and resiliency)
From design to build: Real Details in the Field
Seeing the Forest for the Trees

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."

- John Muir (1838-1914), engineer, naturalist
Water Management

Good water management begins with the SITE.
Water management

Areas needing the most attention:

- Roofs
- Windows and Doors
- Penetrations to the enclosure
- Joints and seams
- The building perimeter
Roofs should shed water off the building and preferably out of the path of pedestrian travel. Flashing details must keep water out of the structure.
Water management protects the structure

Manage penetrations
Why I like rain screens

Water has an easy path down the drainage plane.

Cladding and/or sheathing have the ability to dry outward.

Siding and siding finish last longer.
Managing Air

The air barrier is a continuous assembly of components connected to the entire thermal envelope.

To maintain continuity of the air barrier, the separate components of the assembly must be continuously connected to one another.
Air Sealing: doing it right takes time and attention

Bad air sealing can make a good envelope perform poorly.
Uncontrolled air leakage poses risks beyond lost energy.

It can create paths and trapped areas for pollutants, moisture, critters and more, causing building damage and unhealthy environments.
Integrating air barrier language in drawings and specs
Integrated Air Barrier in Progress

- Flanged boxes
- Poly sealed to door frame
- Door frame sealed to door jamb
Continuity can get complicated
Results: Air Tightness in the Field

0.7 ACH50

0.4 ACH50

0.5 ACH50

0.26 ACH50
A Good Foundation
Slab on Grade w/ICF Stem Wall

2X4 WOOD STUDS @ 16” O.C.

DENSE PACK CELLULOSE CAVITY INSULATION TYP. THROUGHOUT
SEAL VAPOR BARRIER TO PLATE
4” FIBER REINFORCED CONC. SLAB O/ 8” EPS INSULATION, INSTALLED IN 2 LAYERS MIN. W/ STAGGERED SEAMS O/ 4” MIN. COMPACTED COARSE AGGREGATE LAYER

2X6 WOOD STUDS @ 16” O.C. TYP.

DRAFT STOP CAVITY @ 10’ O.C. HORIZ. MAX. W/ 1/2” SHEETROCK
LVL PLATE O/ CLOSED CELL SILL SEAL/CAPILLARY BREAK, ATT. TO CONC.
W/ 1/2” ANCHOR BOLTS @ 48” O.C. MAX.

STUCCO TO 6” BELOW GRADE TYP.
GRADE SLOPED AWAY FROM FOUNDATION

THICKENED SLAB EDGE PINNED TO STEM WALL PER ENGINEER’S INSTRUCTIONS

6” CORE ICF STEM WALL FOUNDATION REINFORCED PER CODE
Frost Protected Slab w/ICF Stem Wall
Frost Protected Monolithic Slab with Double Stud Wall
Frost-protected Monolithic Slab
Edge details matter

Can framing overhang the foam?

It depends:

Where you are

How much it overhangs

Whether an engineer signed off on it
Details to manage air and water
A Low-energy Basement
ICF walls + super-insulated slab

Underslab insulation: 6”-8” EPS for R 24 – R-32

2012 IECC requires R-10
ICF = easy super-insulation

ICF wall can be built with standard-order forms for R-22 – R-40
Heat, Air and Moisture at the Slab

Seal Penetrations
Insulate Under Bearing Walls/Posts
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End of Part 1

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Part 2

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10. **Results of an Integrated Approach**
Framed Walls for Durability and Energy Efficiency
Double Stud Wall Construction
Double Stud Walls

With one approach to details, you can vary the thickness and achieve an overall R-value that “fits.”

In a cold climate, 10” - 16” thick makes sense for low energy construction.