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."

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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

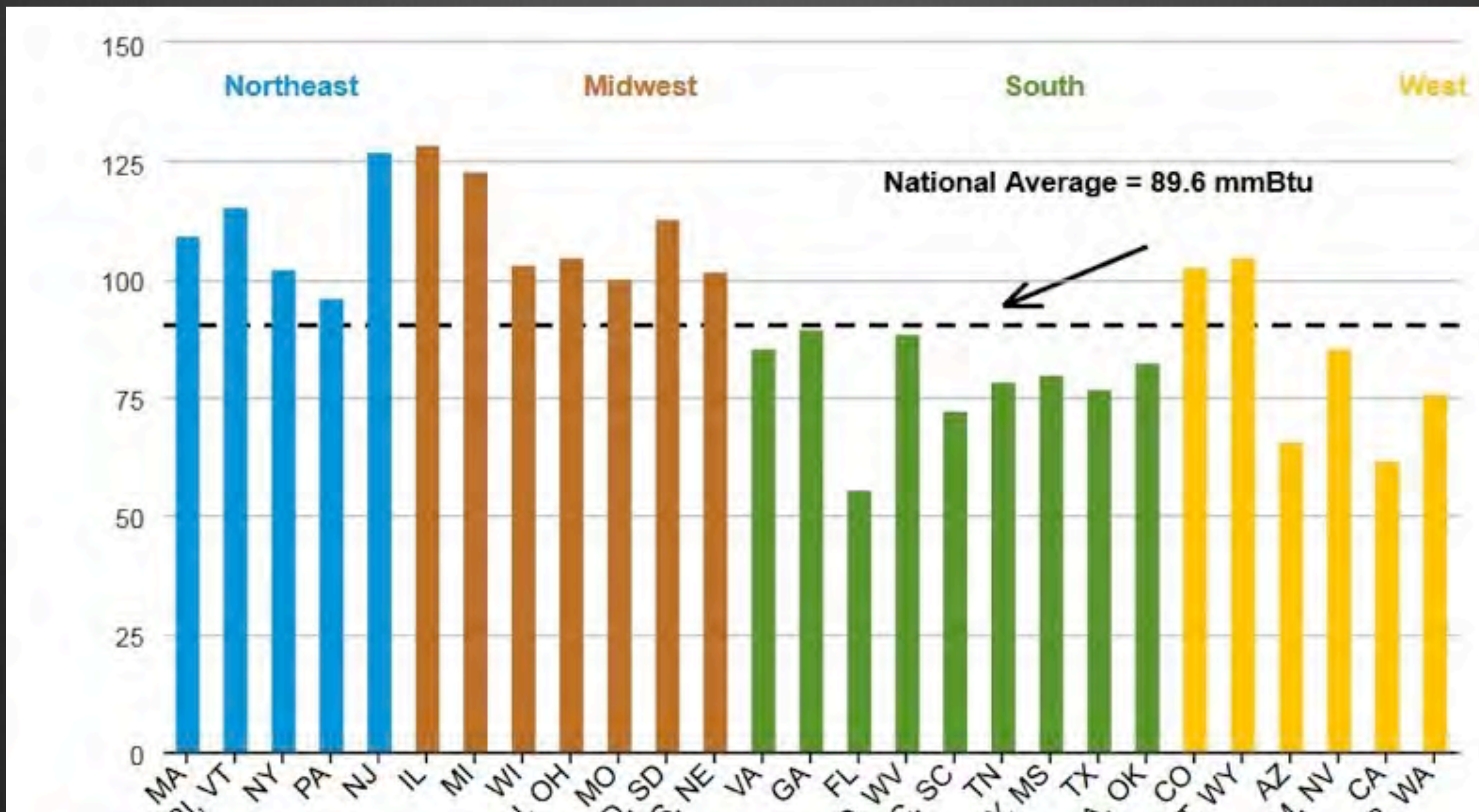
8. **The Roof**
   What it should always do and can do
   Details for attics and for vaulted ceilings

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

10. **Results of an Integrated Approach**

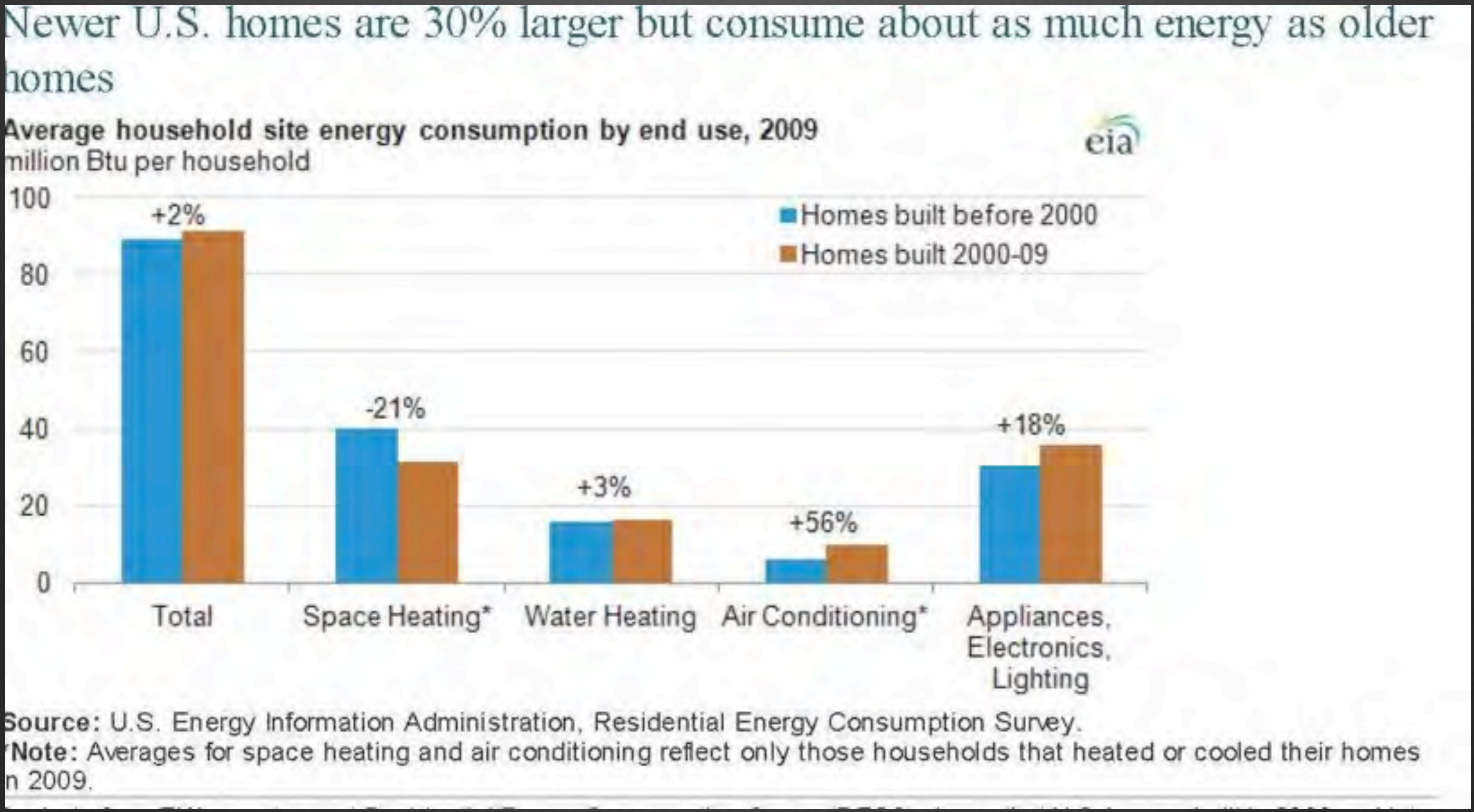
Defining High Performance, Low Energy

“Average” energy use, 2009



Source: U.S. EIA

"Average" energy use, 2009



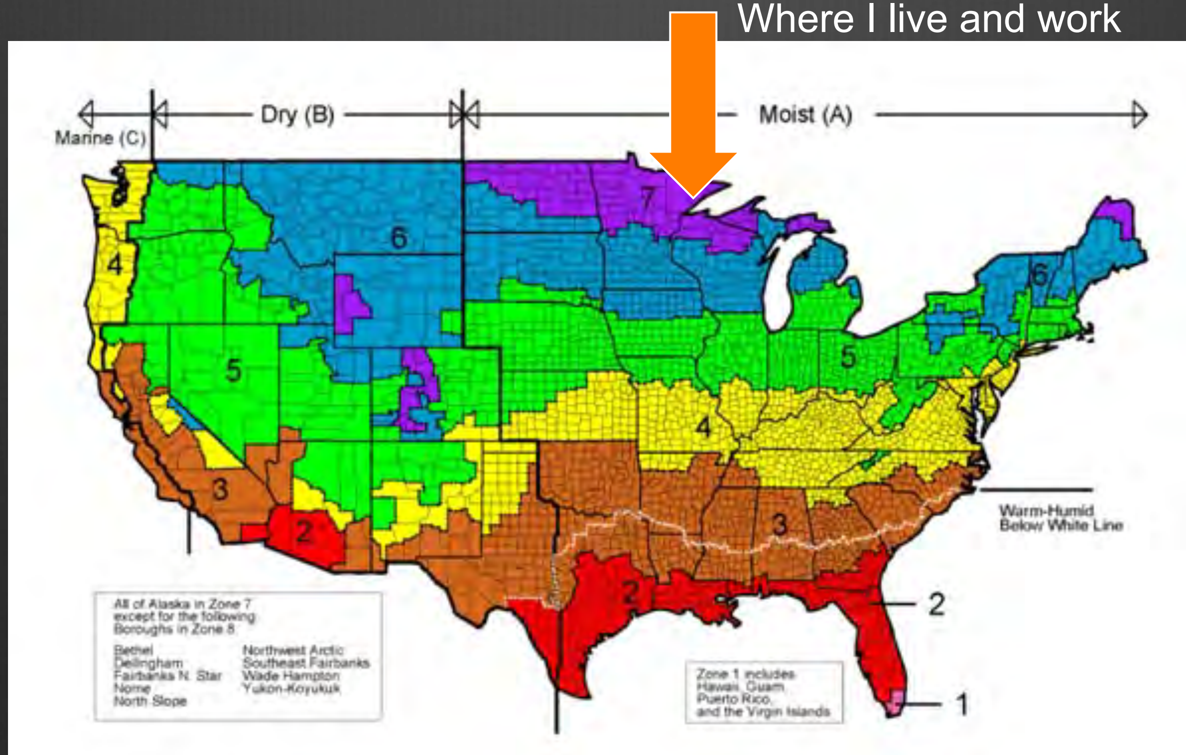
EIA

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

Where I live and work



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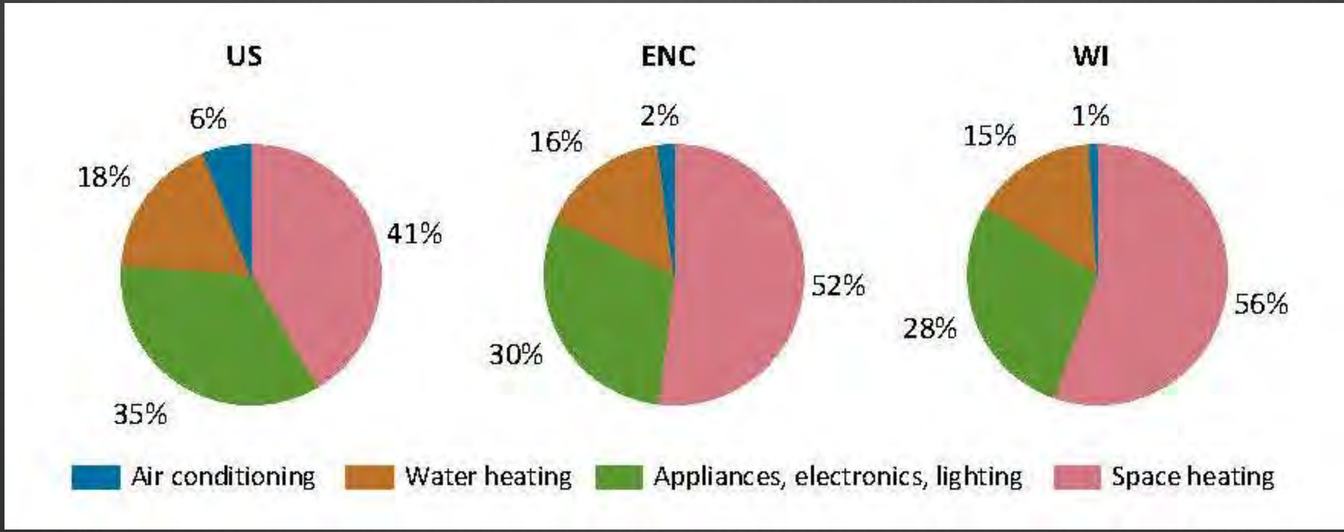


AVERAGE SQUARE FOOTAGE

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

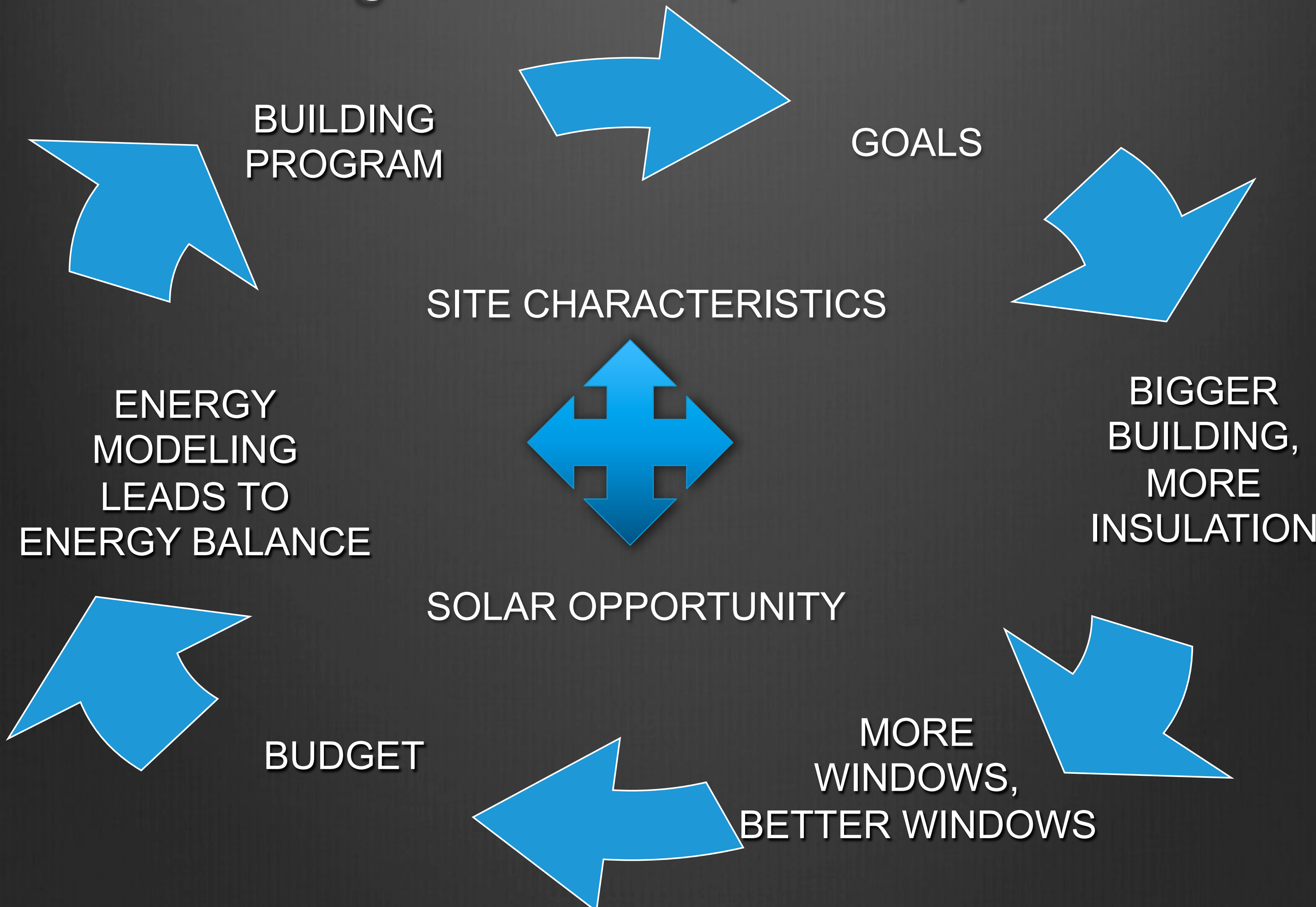
1. Healthy for Occupants.
2. Durable.
3. Uses less than half the energy than the "average" house of the same age.

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.

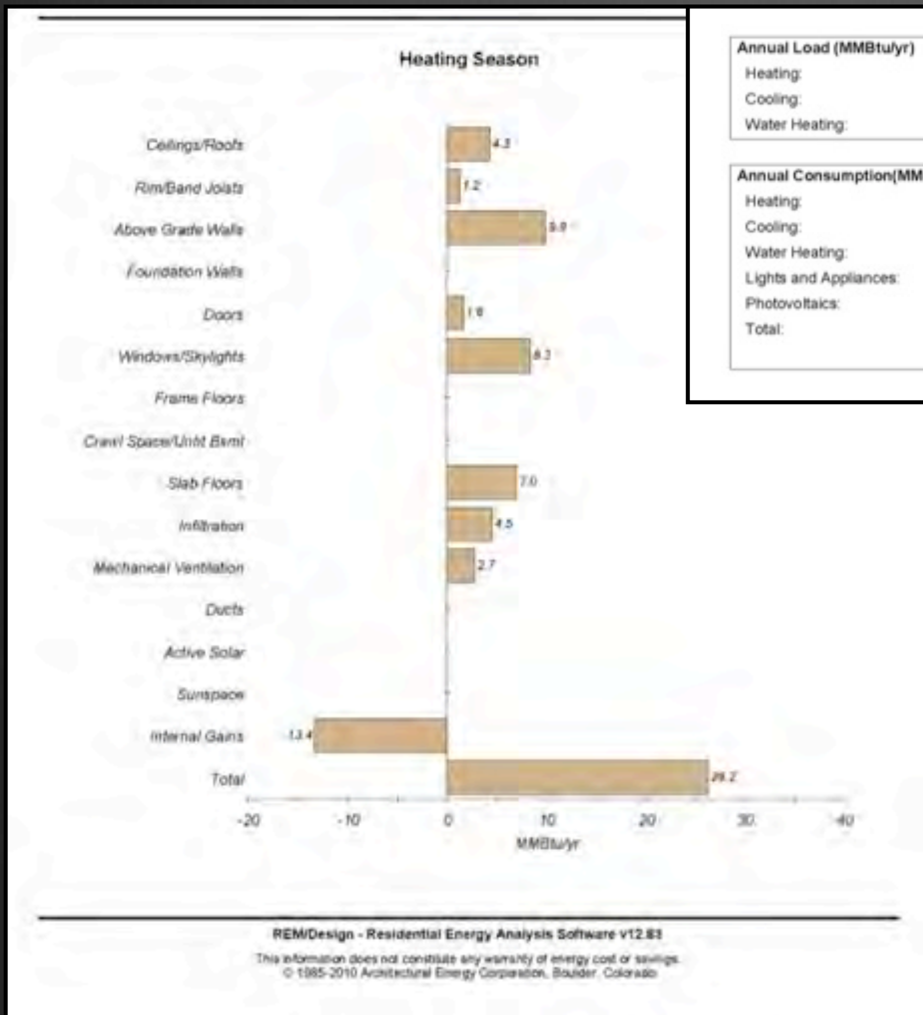
Prioritizing how much, where, and when



Designing to Targets (the <50% goal): We use a baseline of code and compare versions of the same house

Modeled Energy Data - "House X"		Code	Design
Peak Heating Load			
	Btu/hr	43,200 Btu/hr	19,900 Btu/hr
	Btu/hr/ft2	22.3 Btu/hr/ft2	10.3 Btu/hr/ft2
Annual Heating Demand		Code	Design
	MMBtu/year	93.8 MMBtu/yr	32.1MMBtu/yr
	kBtu/ft2 annual	48.55 kBtu/ft2/yr	16.61 kBtu/ft2/yr

Energy Modeling



Annual Load (MMBtu/yr)	
Heating:	26.2
Cooling:	0.0
Water Heating:	13.9

Design Load (kBtu/hr)	
Heating:	17.2
Cooling:	0.0

Annual Consumption(MMBtu/yr)	
Heating:	27.8
Cooling:	0.0
Water Heating:	14.6
Lights and Appliances:	22.1
Photovoltaics:	-0.0
Total:	64.4

Annual Energy Cost ($/yr)	
Heating:	815
Cooling:	0
Water Heating:	325
Lights and Appliances:	512
Photovoltaics:	-0
Service Charges:	80
Total:	1732

AN INDISPENSABLE TOOL

Can compare and evaluate

- design elements
- envelope components
- building and window orientation
- mechanical systems
- insulation levels

Can compare performance relative to

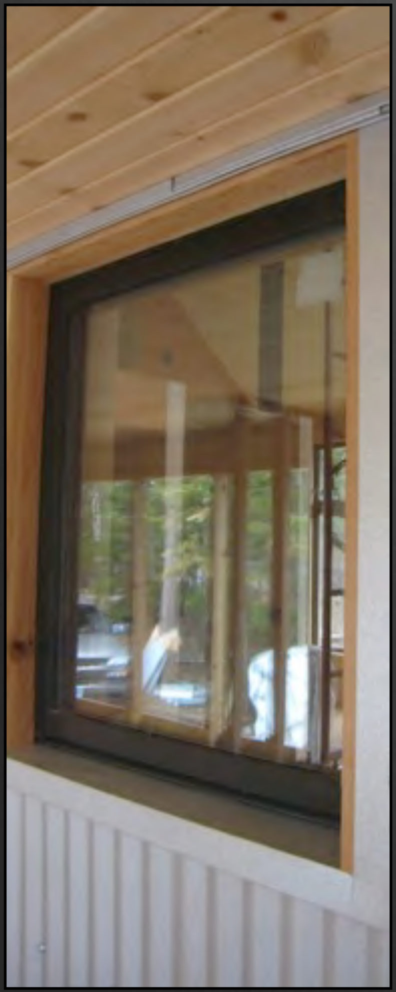
Code, Energy Star, Passivhaus, …

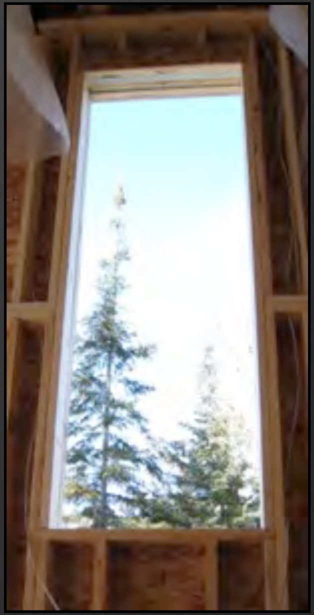
Performance priorities in design

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

Photo courtesy Dan Kolbert

Water has an easy path down the drainage plane.

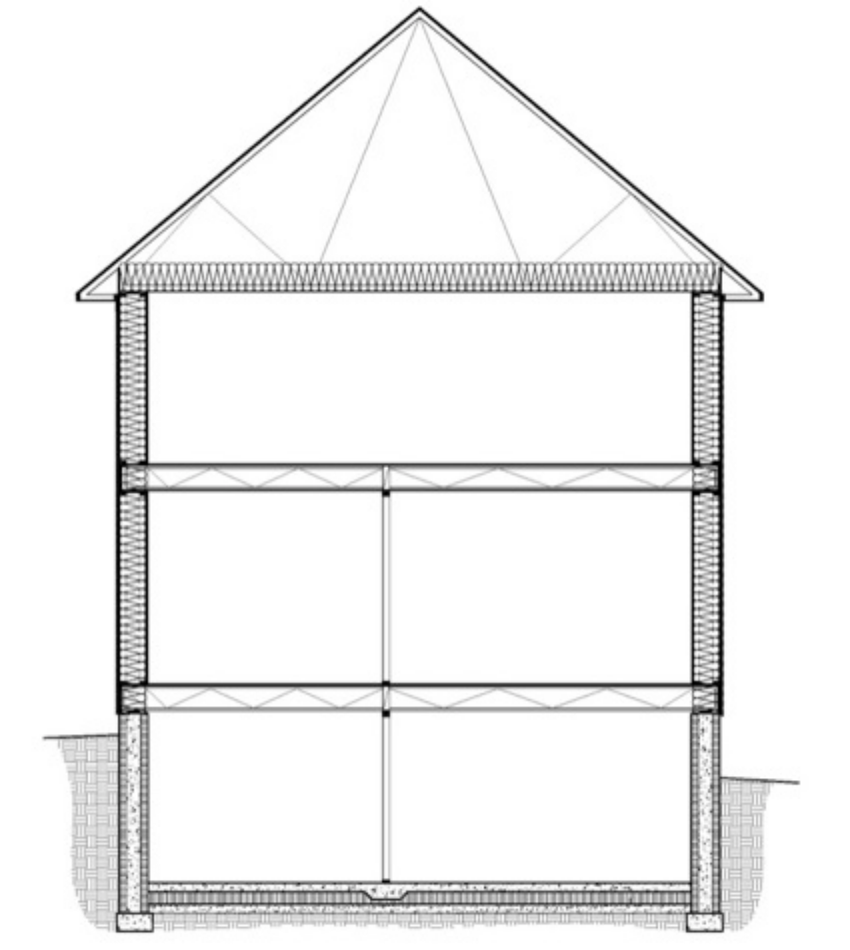
Cladding and/or sheathing have the ability to dry outward.

Siding and siding finish last longer.

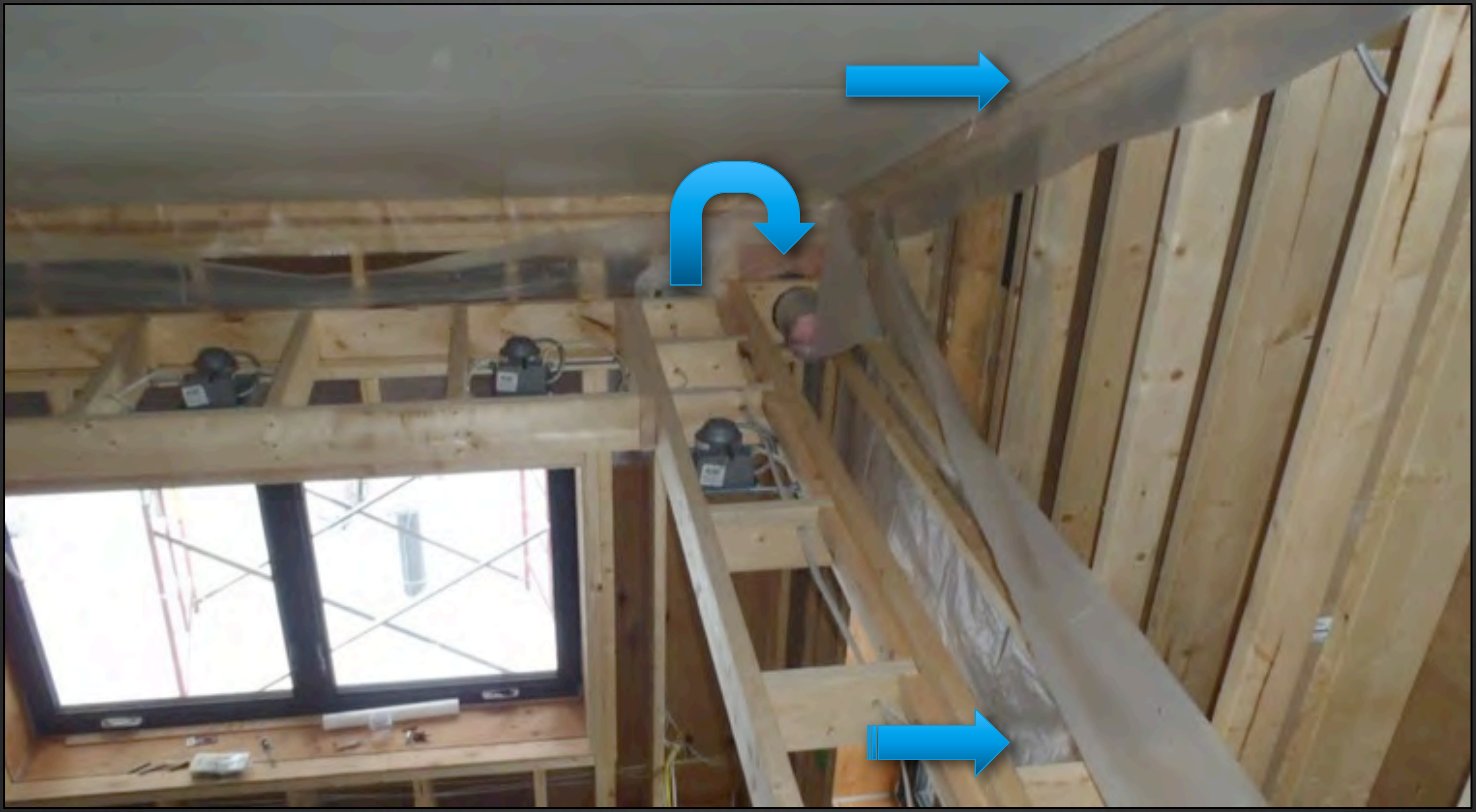
Managing Air

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

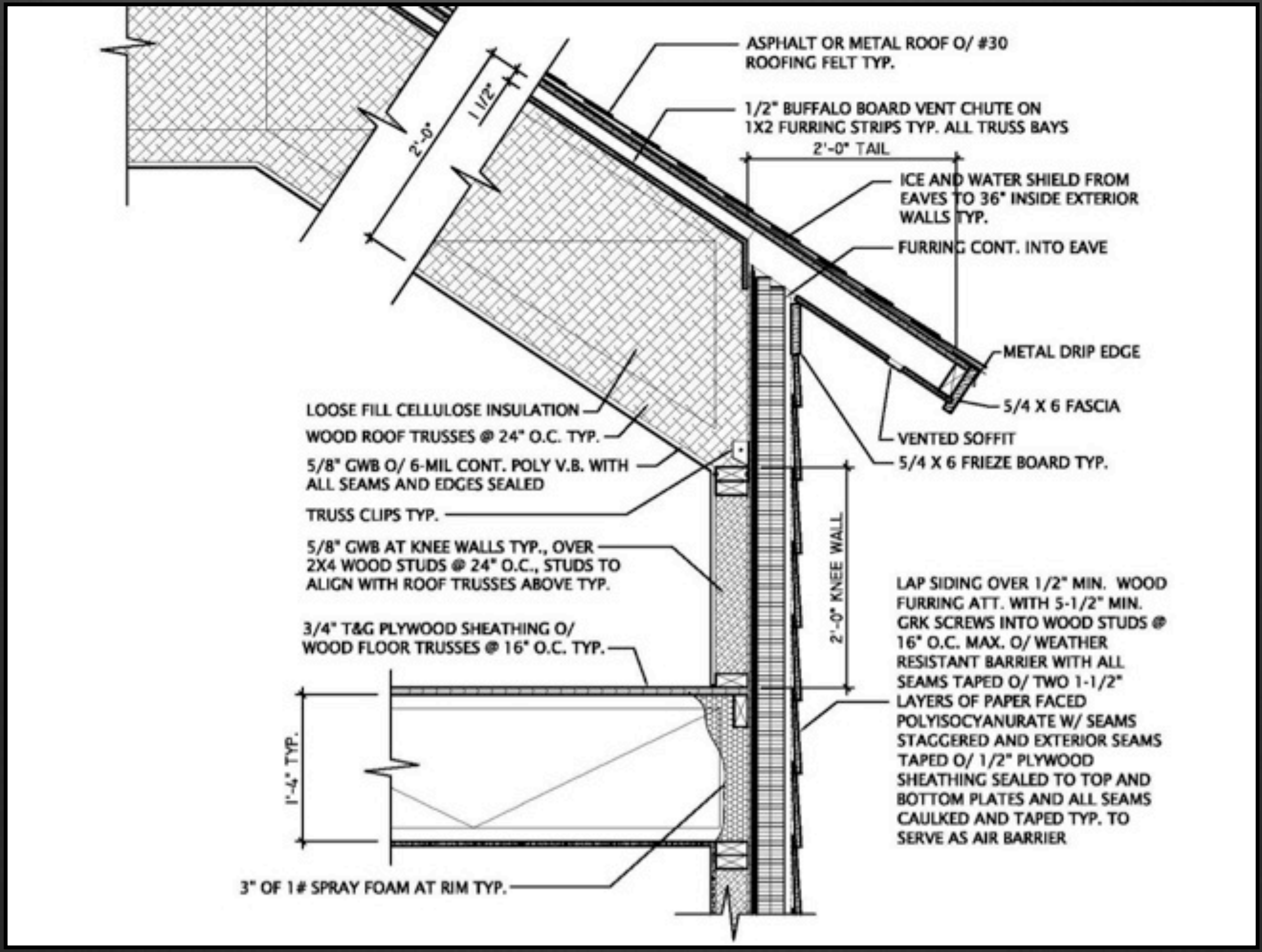


Bad air sealing can make a good envelope perform poorly.

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



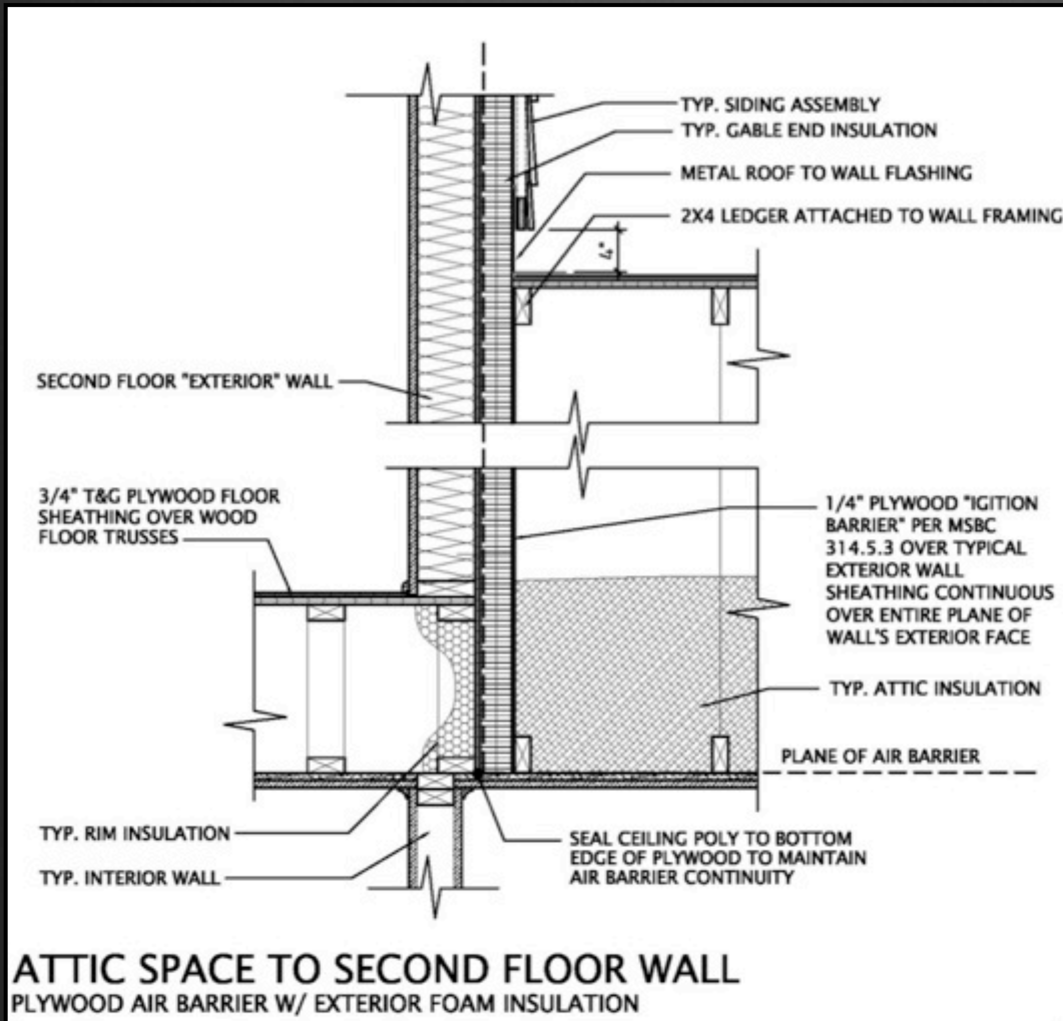
Integrated Air Barrier in Progress

Door frame sealed to door jamb

Poly sealed to door frame

Flanged boxes

Continuity can get complicated



Results: Air Tightness in the Field

0.7 ACH50

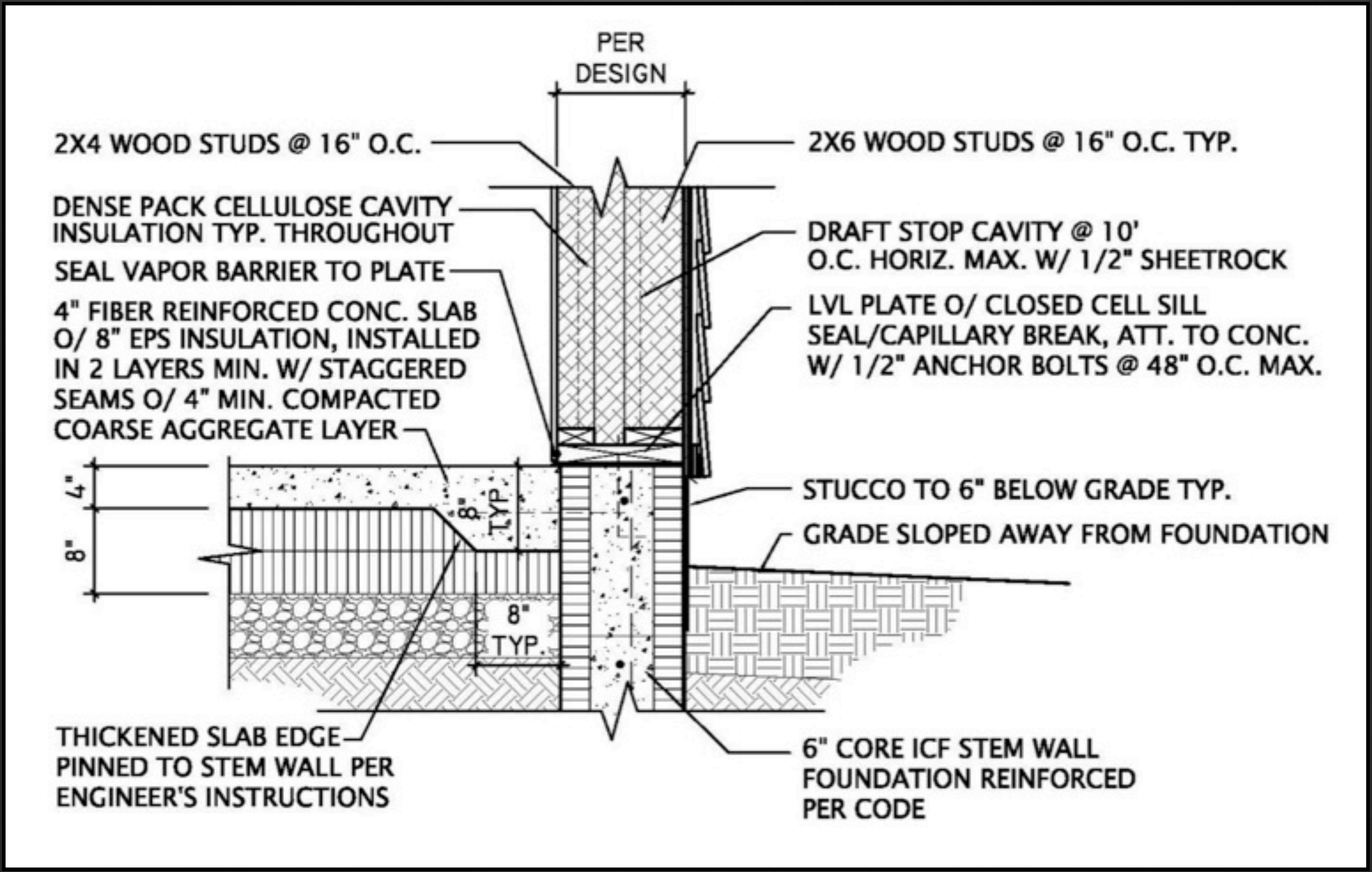
0.4 ACH50

0.5 ACH50

0.26 ACH50

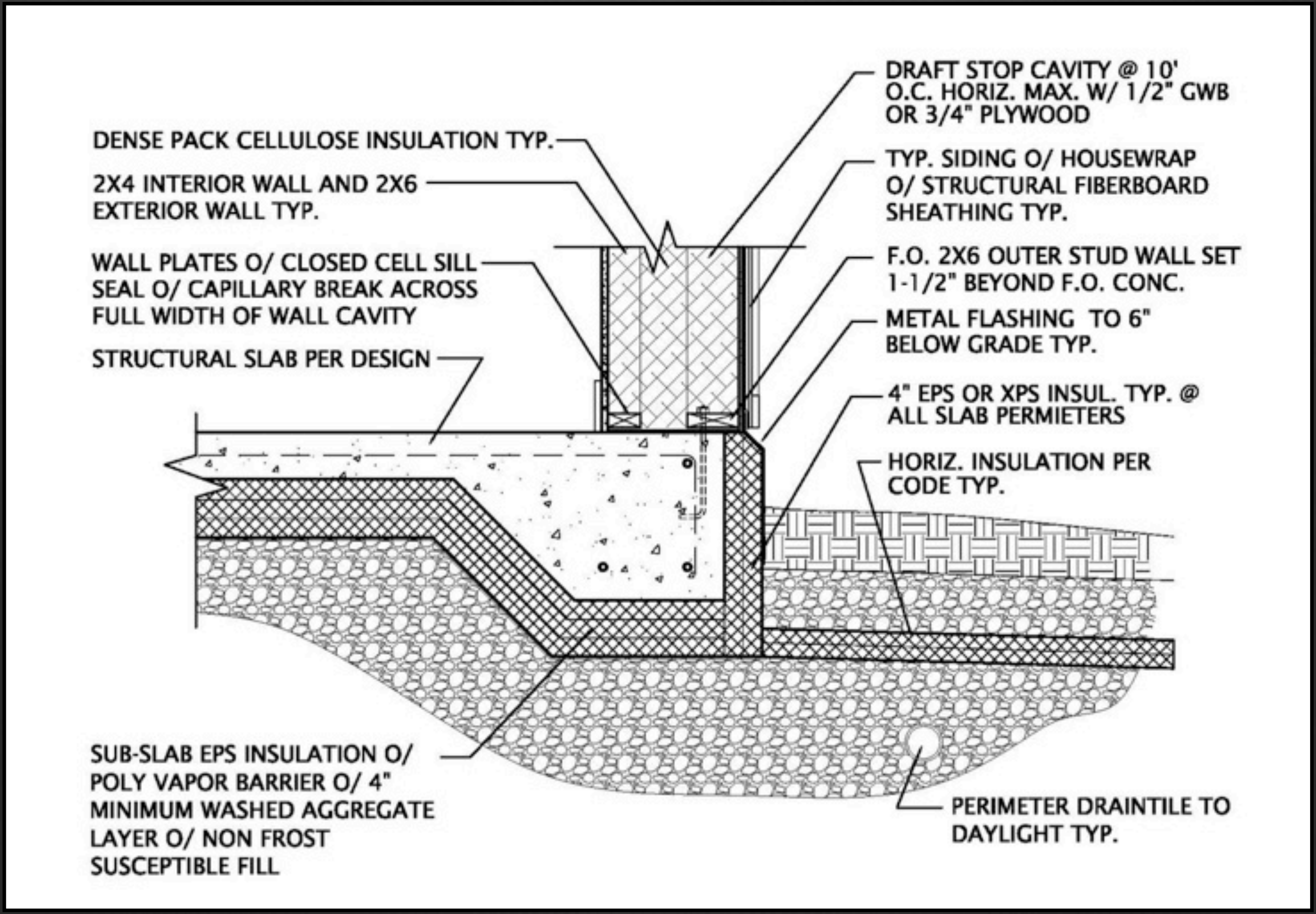
A Good Foundation

Slab on Grade w/ICF Stem Wall

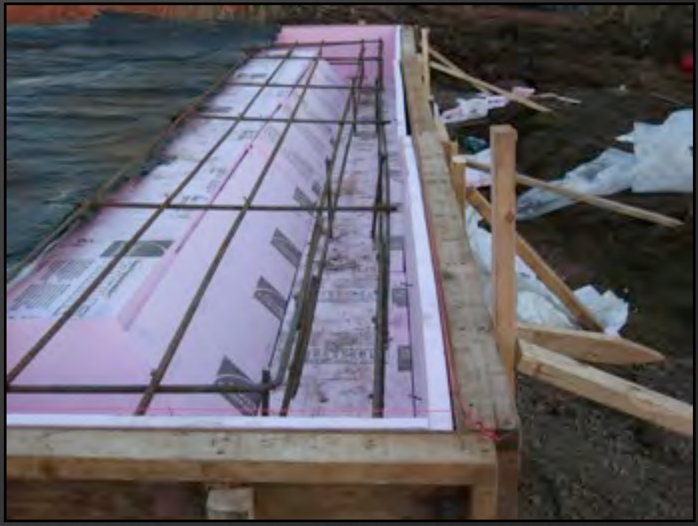


Frost Protected Slab w/ICF Stem Wall

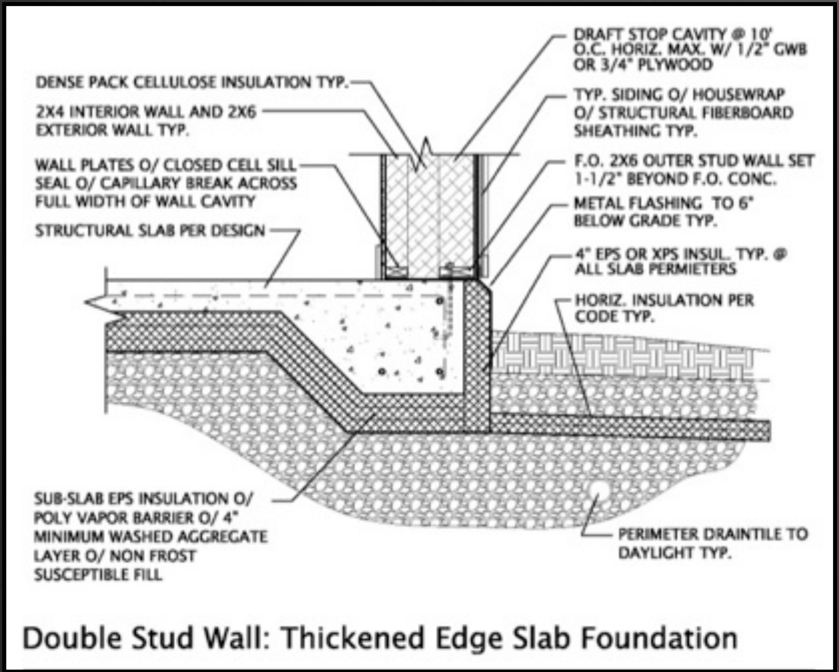
Frost Protected Monolithic Slab with Double Stud Wall



Frost-protected Monolithic Slab



Edge details matter



Double Stud Wall: Thickened Edge Slab Foundation

Can framing overhang the foam?

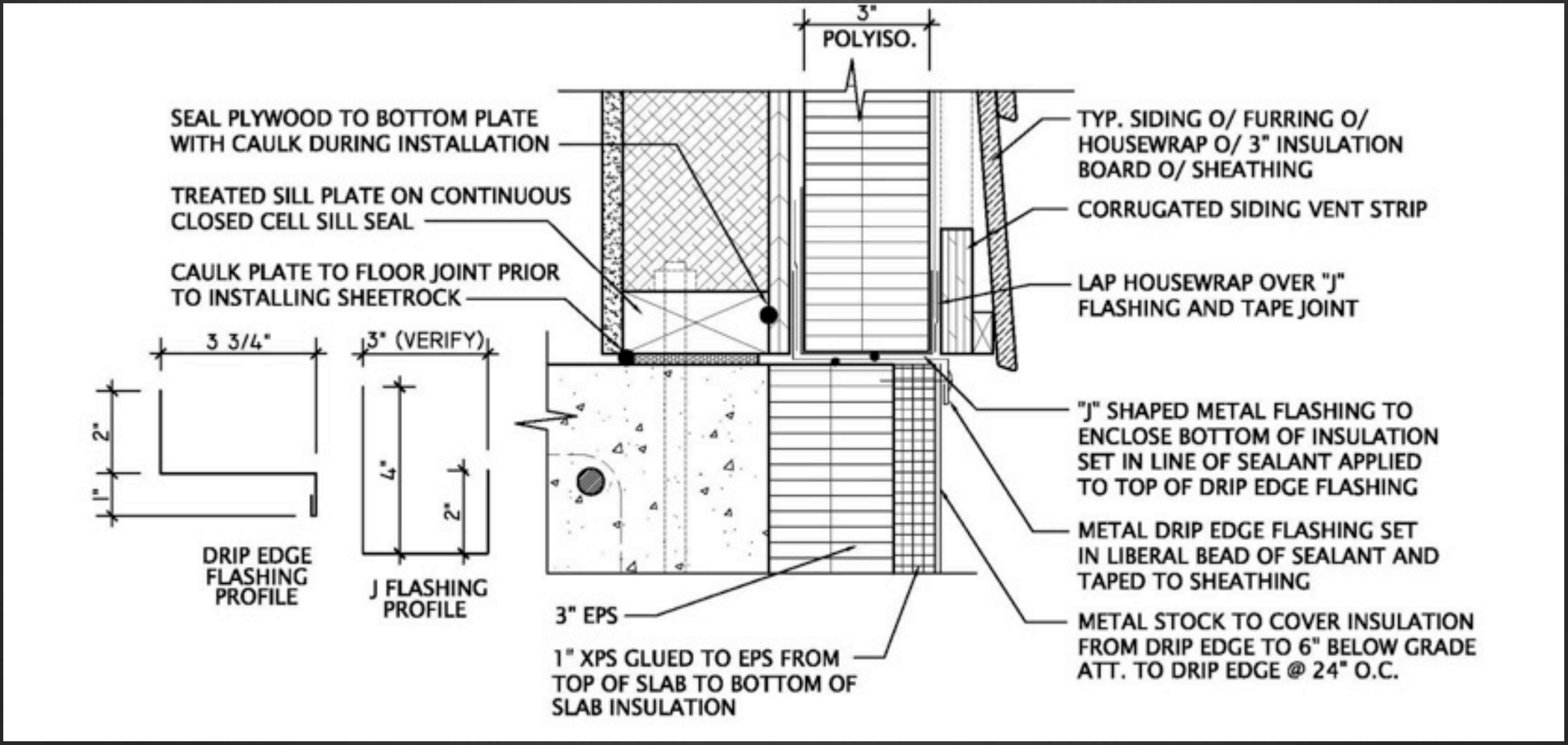
It depends:

Where you are

How much it overhangs

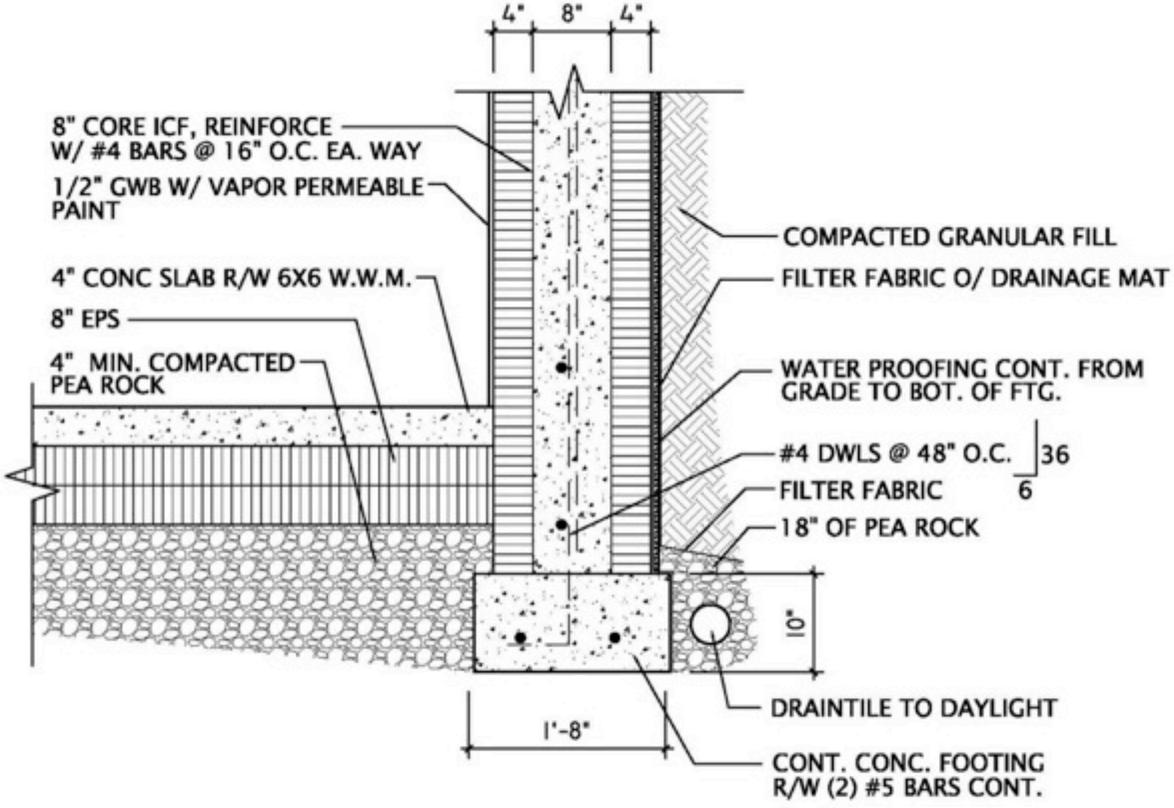
Whether an engineer signed off on it

Details to manage air and water



A Low-energy Basement

ICF walls + super-insulated slab



ESKO FARMHOUSE SLAB AND FOUNDATION DETAIL

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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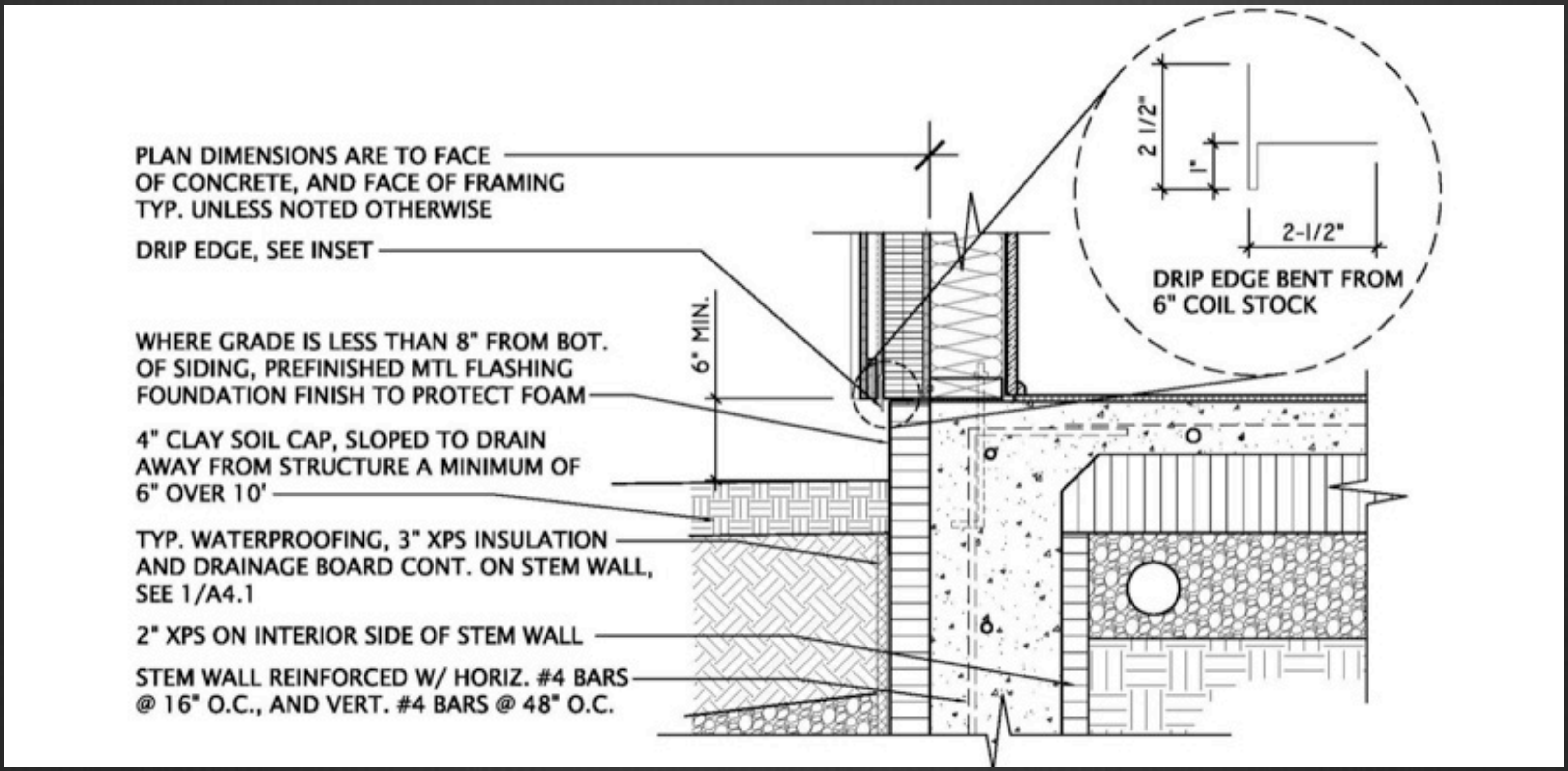

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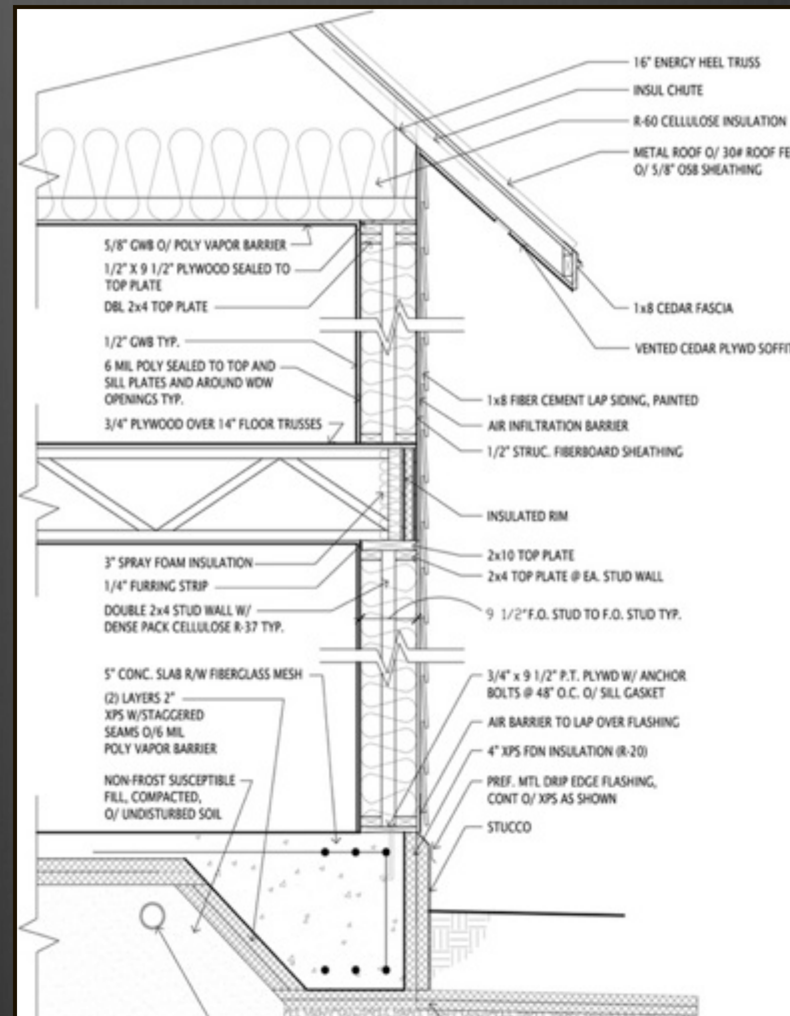
Framed Walls for Durability and Energy Efficiency

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.