


Building for Energy Efficiency – Part 1


How to Design the Enclosure for a Home that Uses Less Energy
at Little or No Additional Cost

Alex Lukachko
Building Science Consulting LLC
www.buildingscience.com

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The U.S. Department of Energy's Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies – innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program uses a systems engineering approach to reduce energy use, utility bills, construction time, and construction waste.

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Objectives for this morning . . .

1. Help make decisions
2. Explain energy efficiency approach
3. Demonstrate business opportunities

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Why build energy efficient homes?

Consumers:

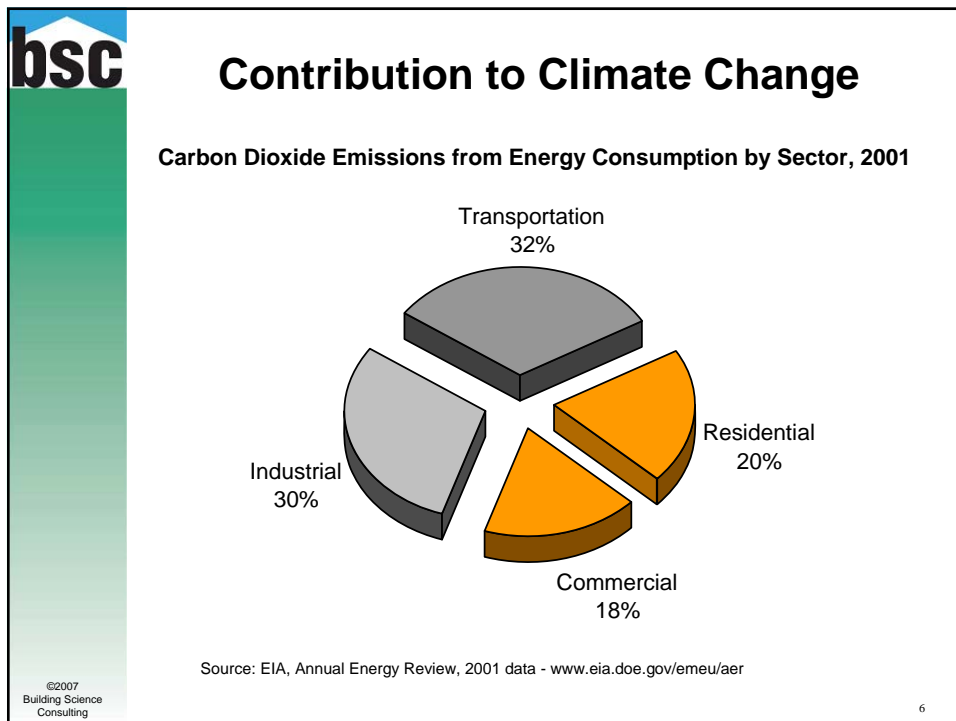
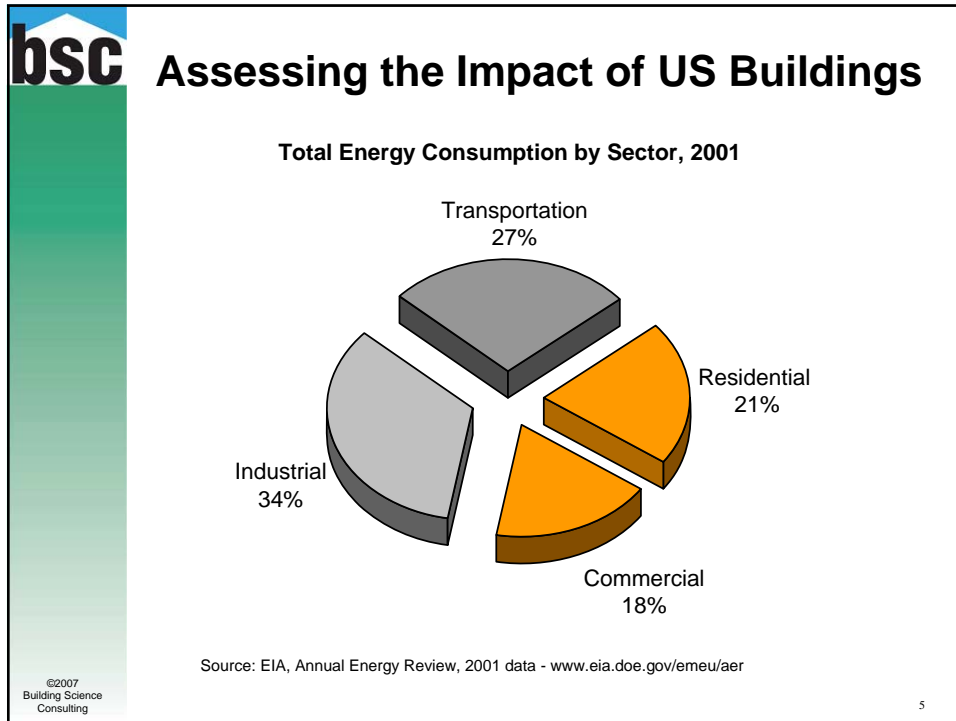
- Lower energy bills and maintenance costs
- More money for things other than energy
- Healthier, more comfortable, more durable homes

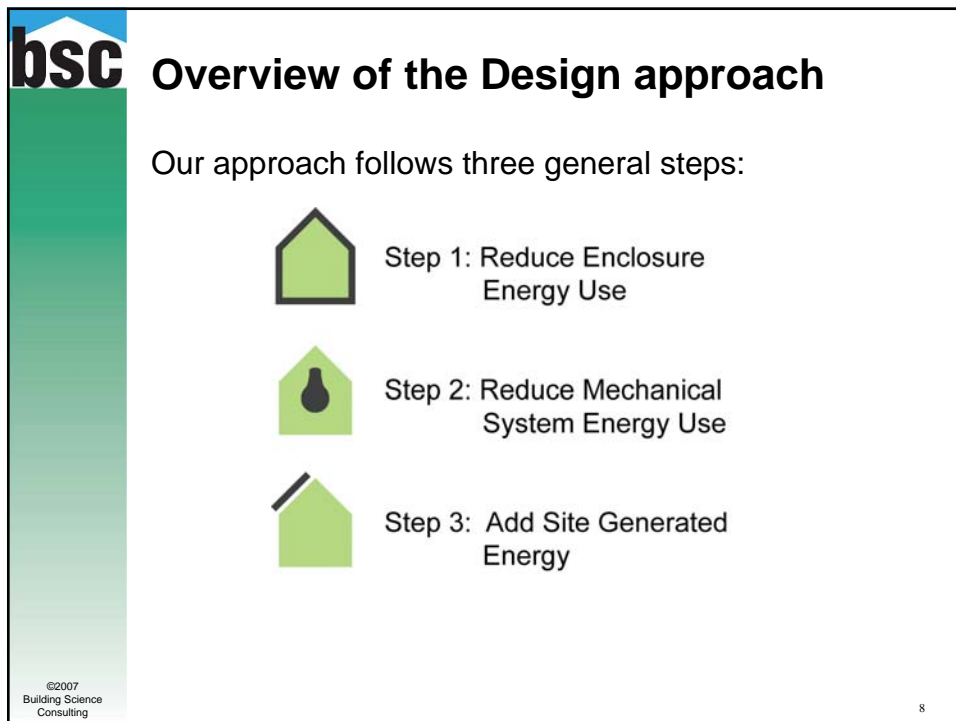
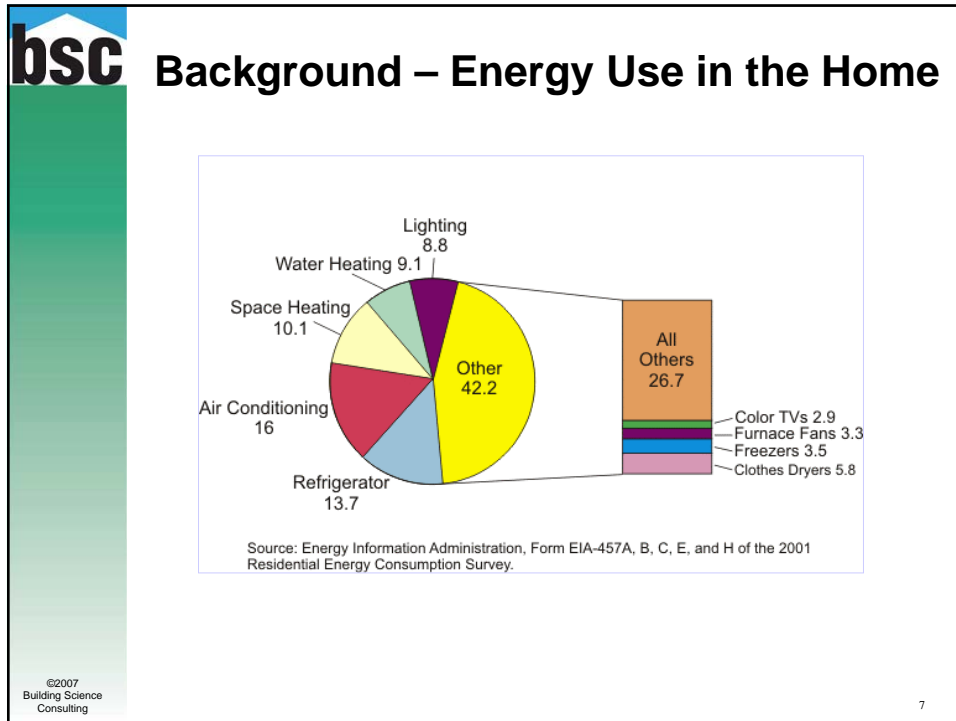
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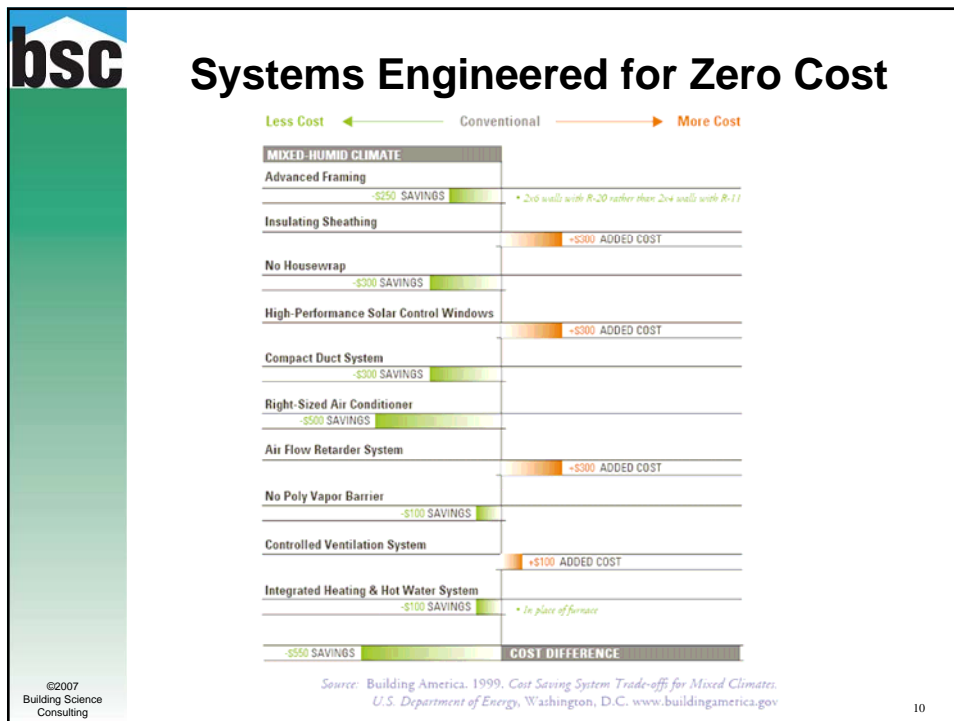
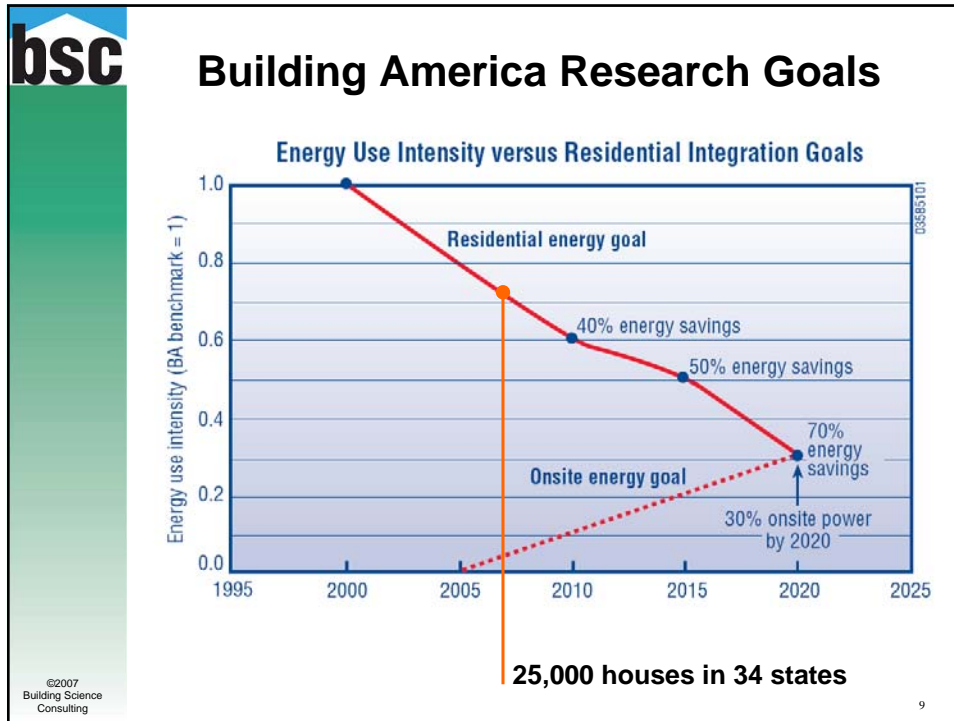
- Wise use of resources through energy savings
- Greater energy security through the use of domestic resources
- A healthier environment through reduced emissions
- Increased use of onsite power and renewable energy systems


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Looking long-term . . .

MIXED-HUMID CLIMATE CASE STUDY HOUSE
 Richmond, VA

STEP	DESCRIPTION OF STEP	Estimated Individual Cost of Change	Estimated Cumulative Cost of Change	TOTAL SOURCE ENERGY SAVINGS (heating, cooling, dhw, lighting, appliances, plug loads)				
				over BA Benchmark	Incremental	Annual Energy Cost	Simple Payback (yr)	Incremental Payback (yr)
0	Benchmark	n/a	n/a	n/a	n/a	\$1,288	n/a	n/a
1	Benchmark + Enclosure Upgrades	\$400	\$400	6.0%	6.0%	\$1,210	5	5
2	Above + Mechanical Upgrades	\$1,000	\$1,400	21.9%	16.0%	\$1,000	5	5
3	Above + Lights & Appliances	\$350	\$1,750	27.4%	5.4%	\$929	5	5
4a	3 + 17 EER, 4 COP GSHP	\$6,000	\$7,750	33.3%	6.0%	\$851	18	77
4b	3 + 40 sq ft SHW	\$3,700	\$5,450	38.5%	11.1%	\$765	10	23
4c	3 + 2kW PV	\$10,000	\$11,750	41.7%	14.3%	\$758	22	58
5	All Strategies	\$19,700	\$21,450	58.8%	31.4%	\$516	28	48

- Balance initial investment with long-term savings
- Add technology in a cost-effective manner

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Overview of the Design approach

Top ten elements in the design of high performance homes:

1. Design for comfort with as little added energy as possible
2. Built tight
3. Ventilate
4. Use more insulation
5. Provide for durability by controlling moisture
6. Design a roof that is sloped to the south
7. Use the most efficient equipment the project can afford
8. Use efficient lighting, appliances and match to occupant needs
9. Reduce energy use 40-70% before adding onsite energy generation
10. Commission mechanical and onsite energy systems

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1. Design for comfort with as little added energy as possible

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Start with the building itself

- 1. Siting** (choice of building site or position on it)
 - exposure to wind and rain
 - micro-climate: trees for shading, wind-blocks
- 2. Orientation**
 - windows south, "service" rooms north
 - positioning and size of windows and doors
- 3. Building form**
 - external features: overhangs, breezeways, porches
 - building size and shape


- **At each step there are opportunities to reduce the energy that the building will use**
- **These changes decisions can't be made later**

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Breezeways and Porches




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Overhangs

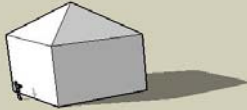


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House size and form – Unvented Roof

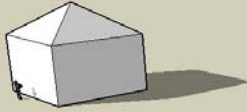


Plan 'A'
30' x 30'
2 Stories
8:12 roof

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bsc House size and form – Unvented Roof



Plan 'A'
30' x 30'
2 Stories
8:12 roof

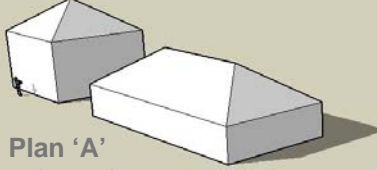
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Floor Area	1800 sq ft
Surface Area	4142 sq ft

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bsc House size and form – Unvented Roof



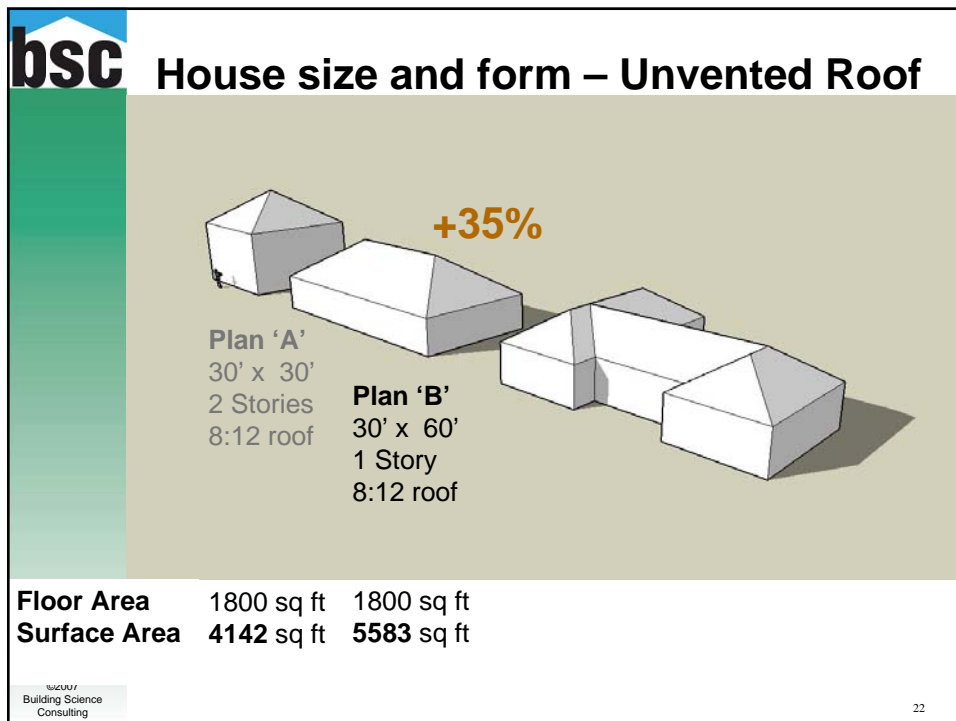
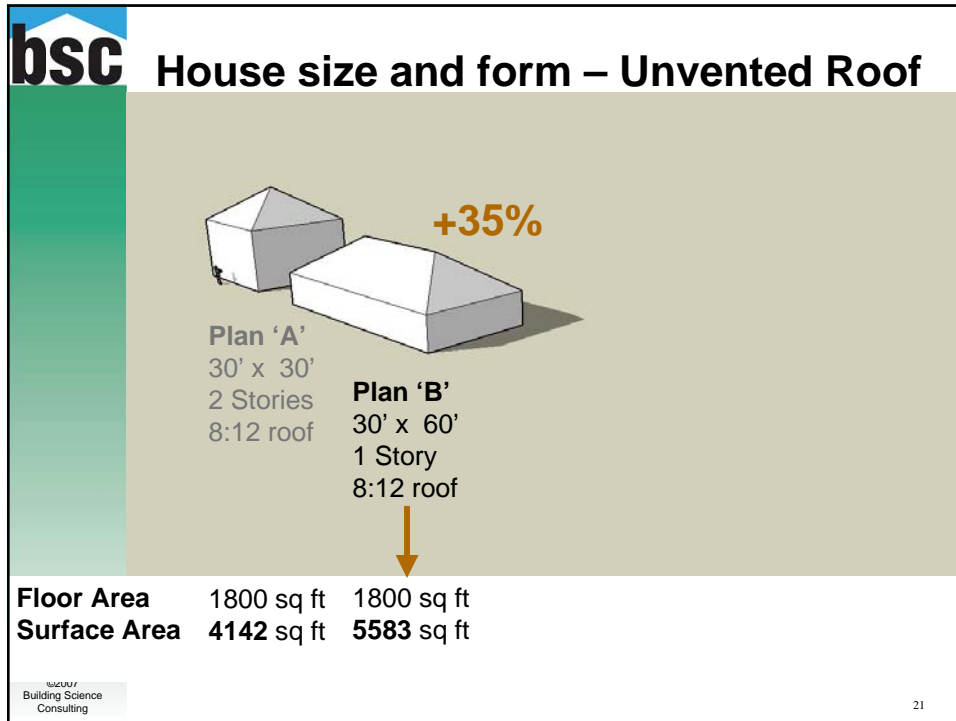
Plan 'A'
30' x 30'
2 Stories
8:12 roof

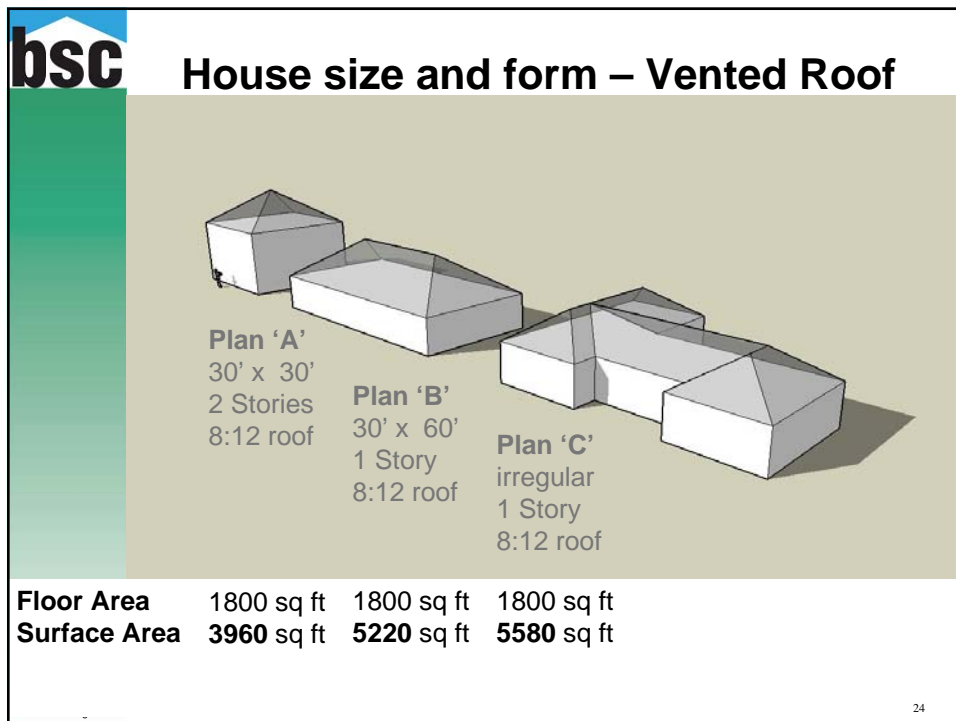
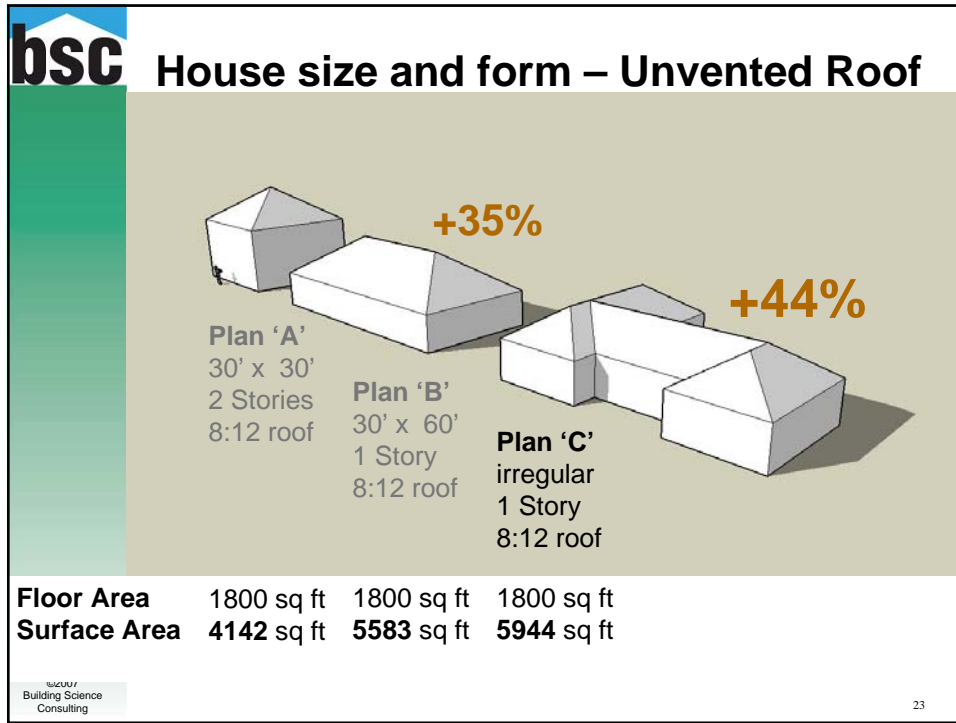
Plan 'B'
30' x 60'
1 Story
8:12 roof

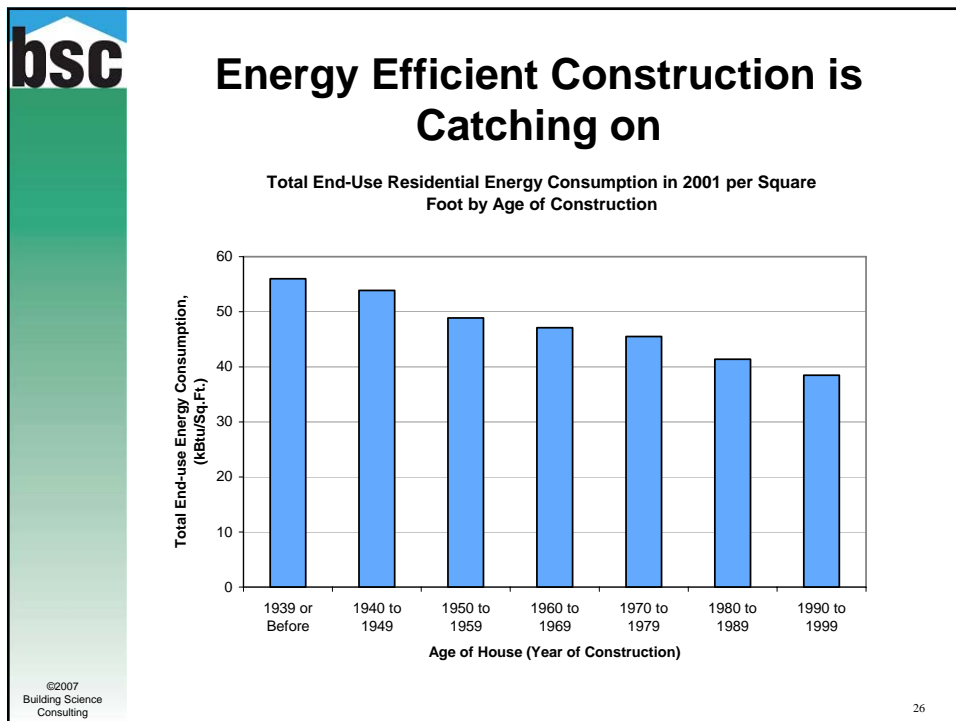
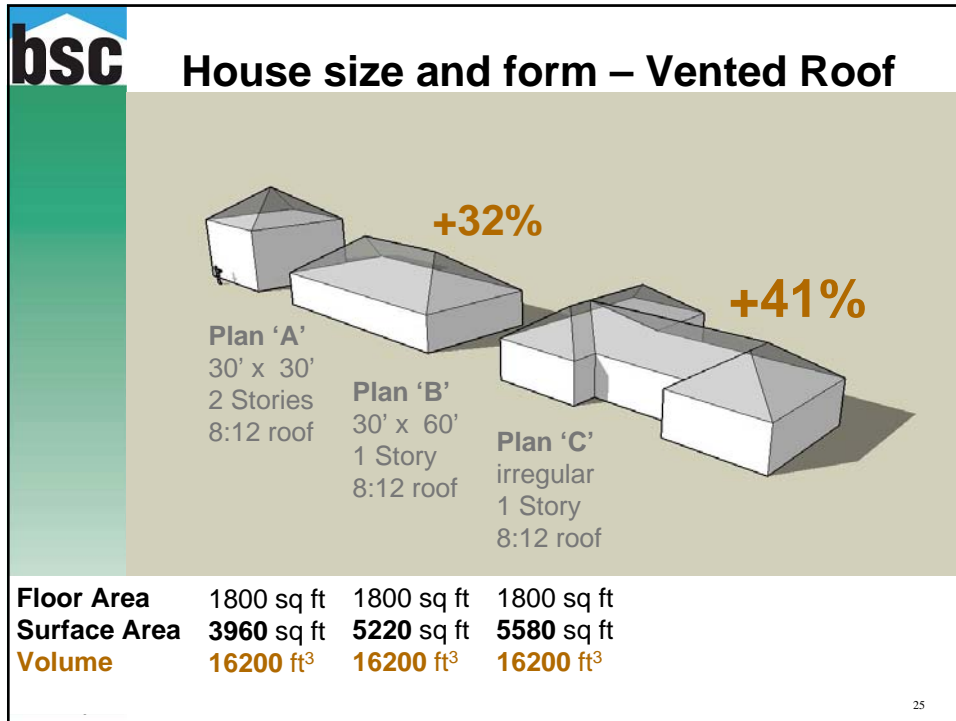
Floor Area	1800 sq ft
Surface Area	4142 sq ft

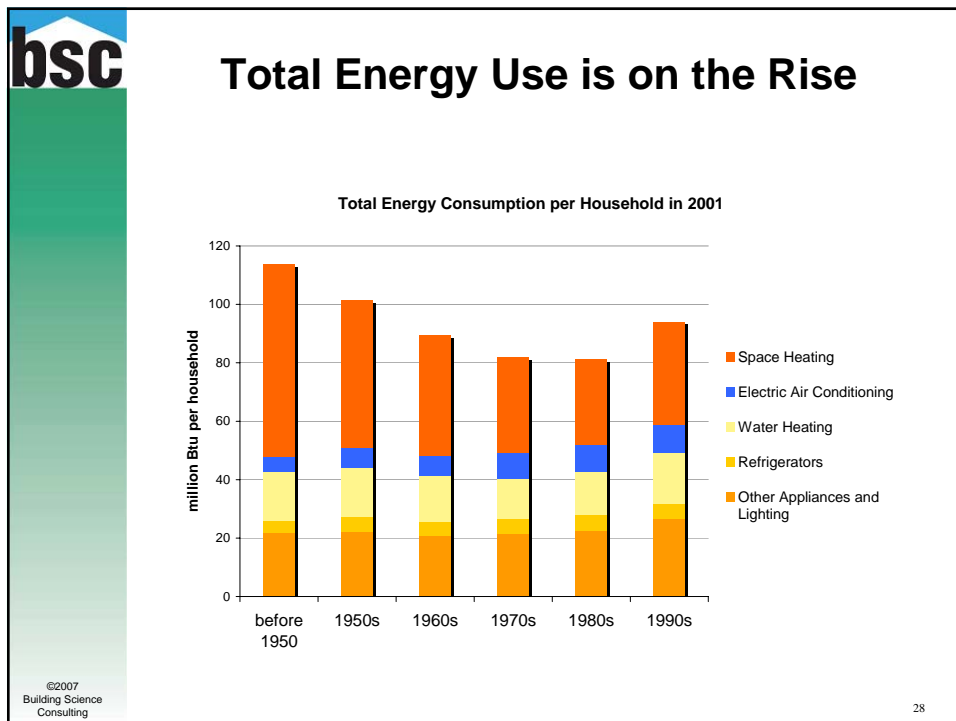
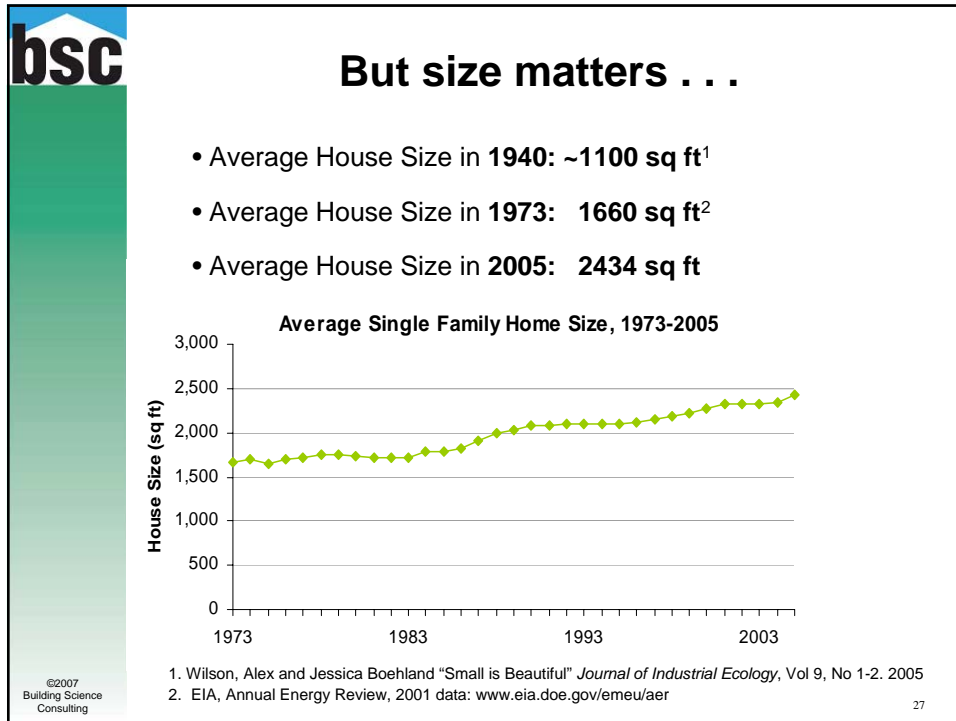
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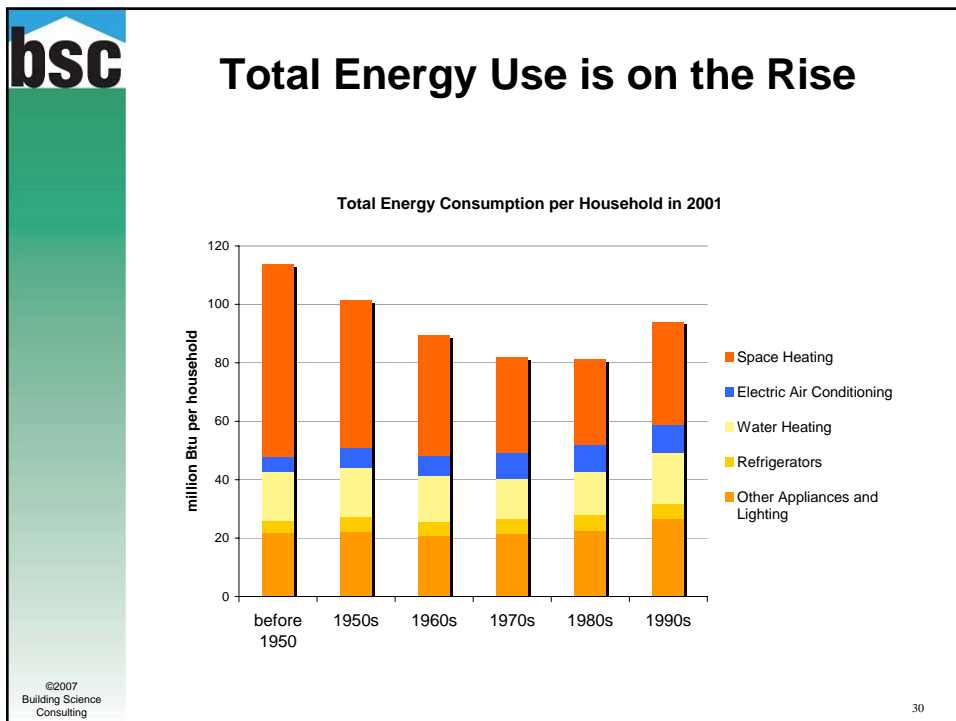


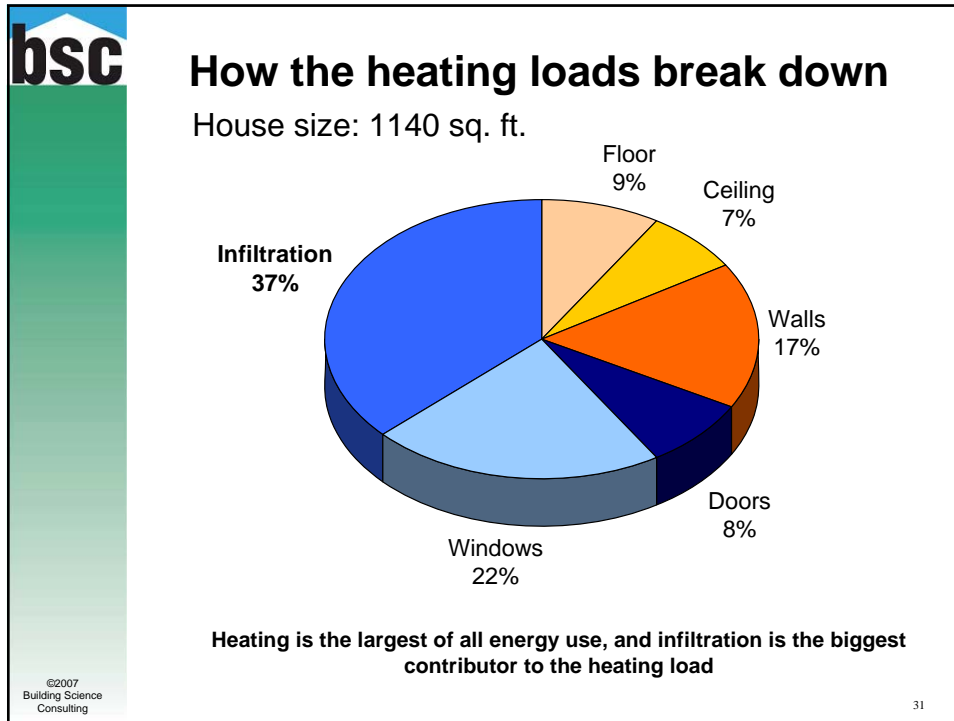


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2. Build tight

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Why airtight buildings?

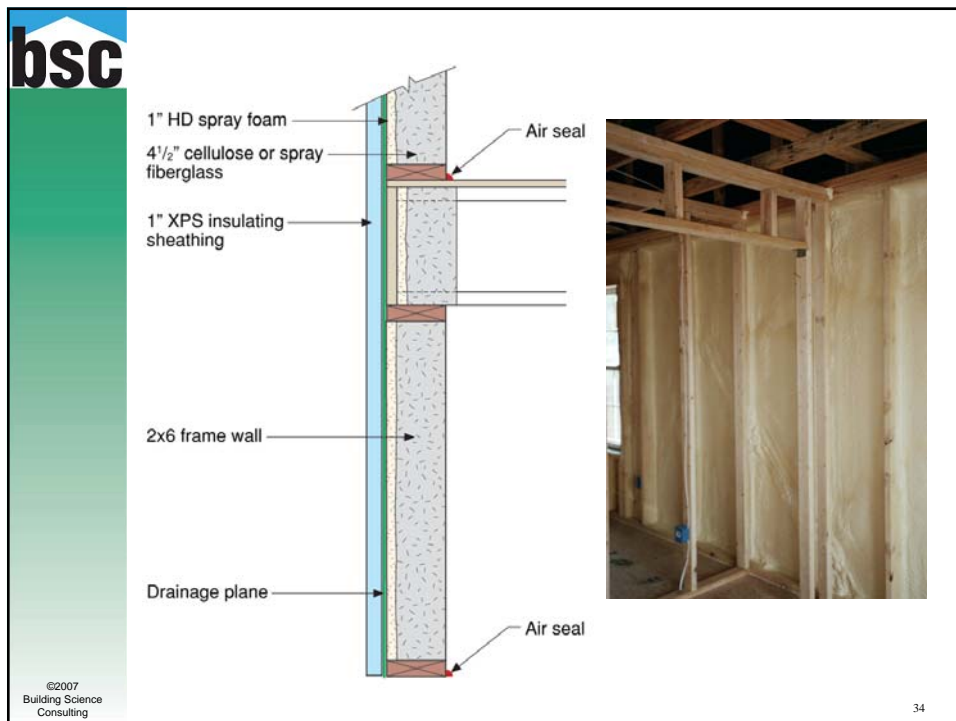
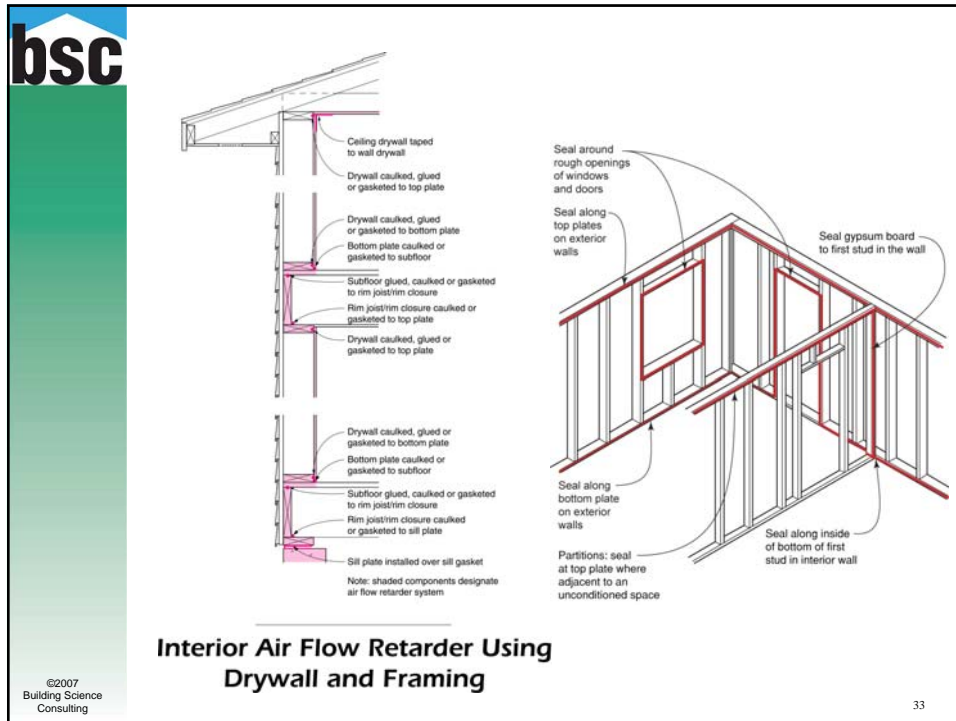
Reasons to control airflow:

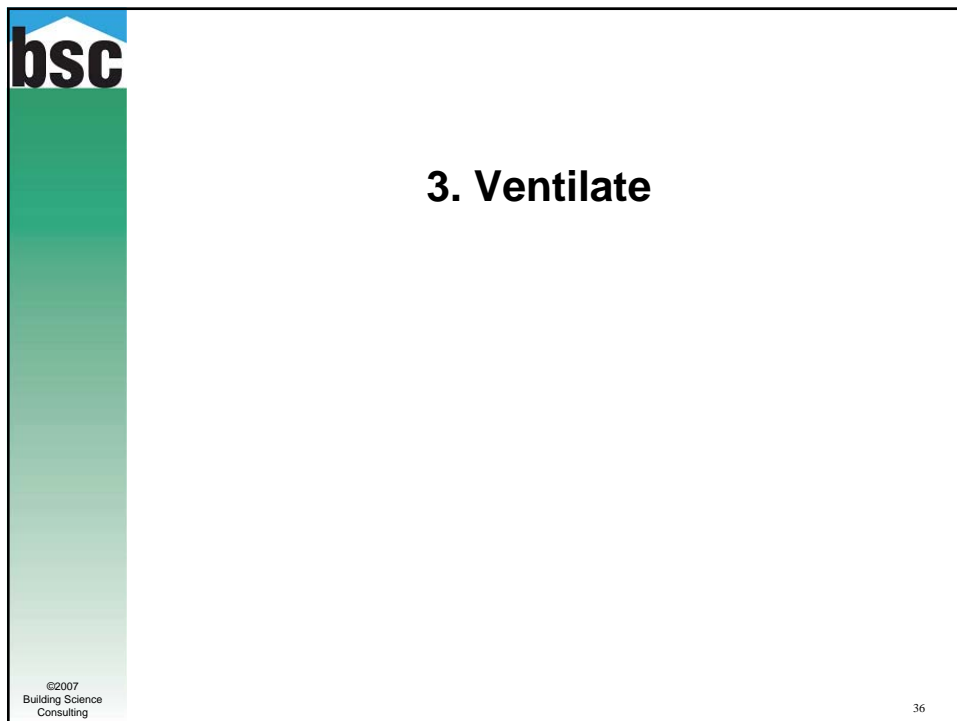
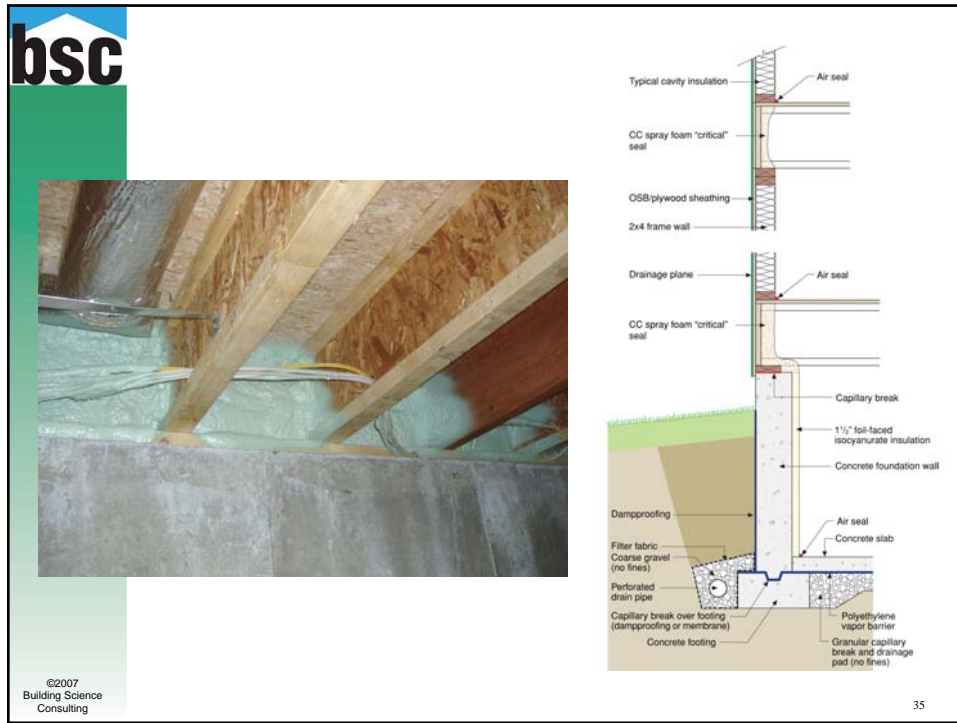
- Energy - Heat loss/gain
- Durability - Air leakage condensation
- Occupant health - Pollution and odors
- Occupant comfort - Drafts, noise

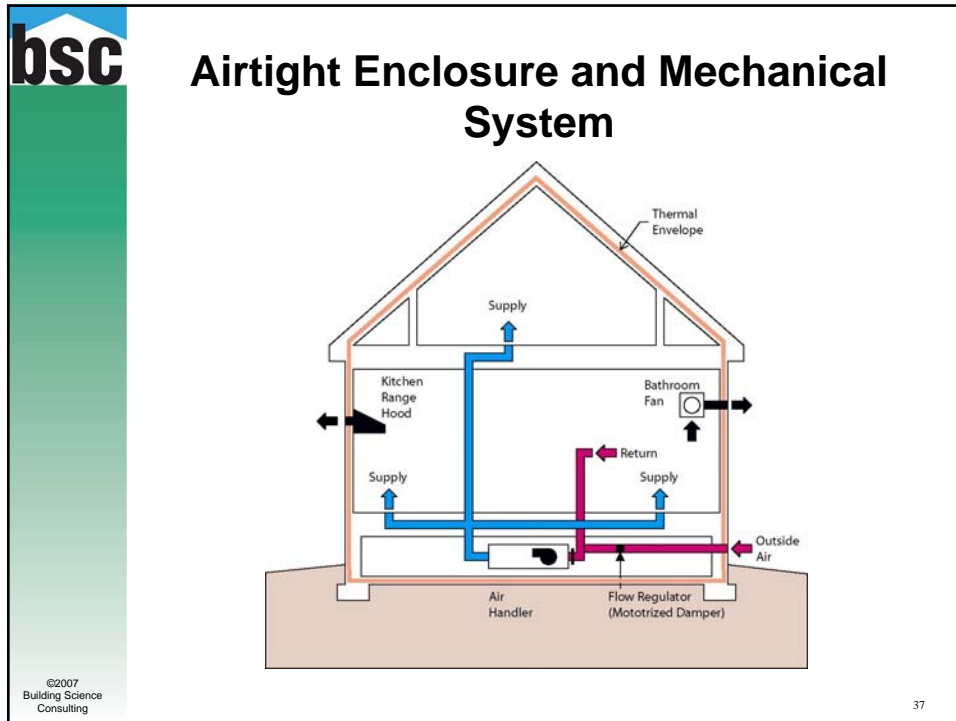
Do this using an “AIR BARRIER SYSTEM”

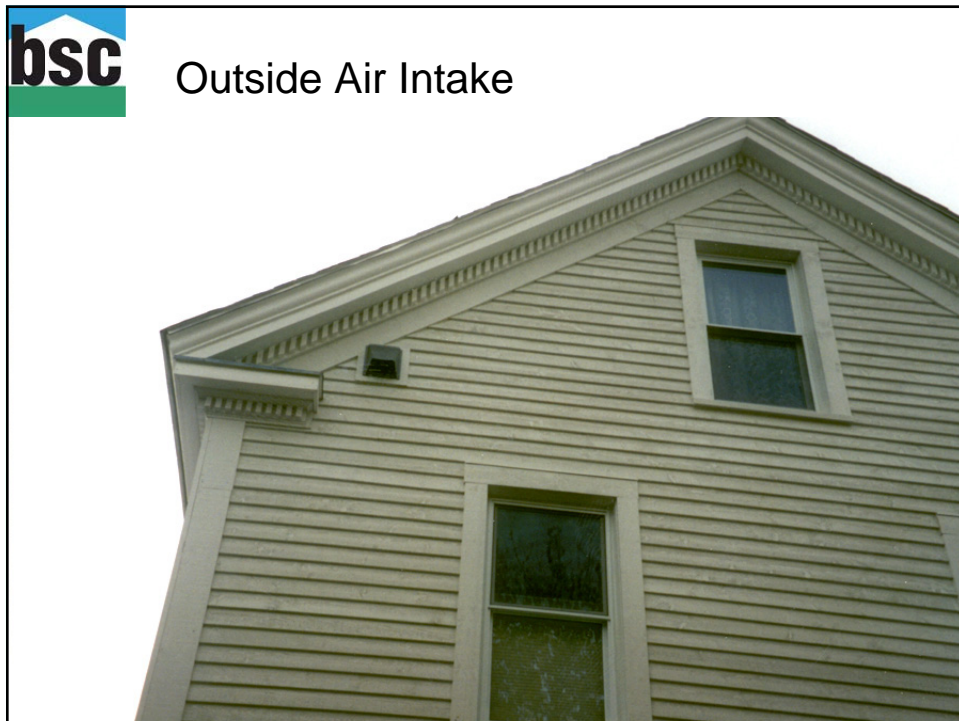
- Many materials are air impermeable, most systems are not

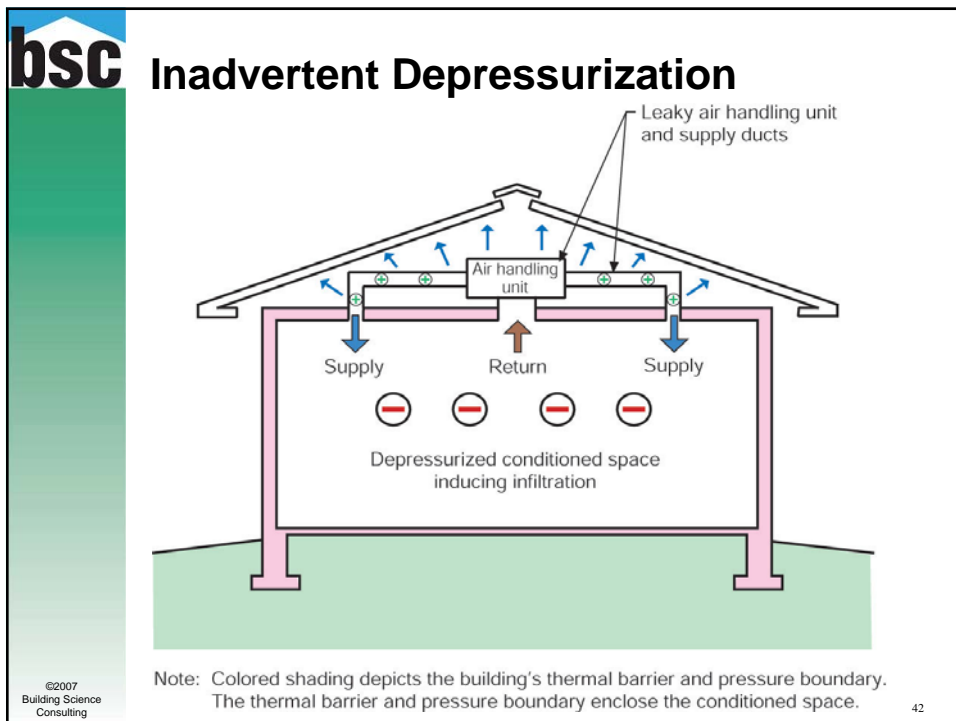
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4. Use more insulation

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bsc **It's not just how much you use . . .**

2x6 Framed Wall

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bsc **Surface temperature and condensation**

Thermal Bridging Causes Surface Condensation

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Eliminating thermal bridging

2x4 with Exterior Insulation

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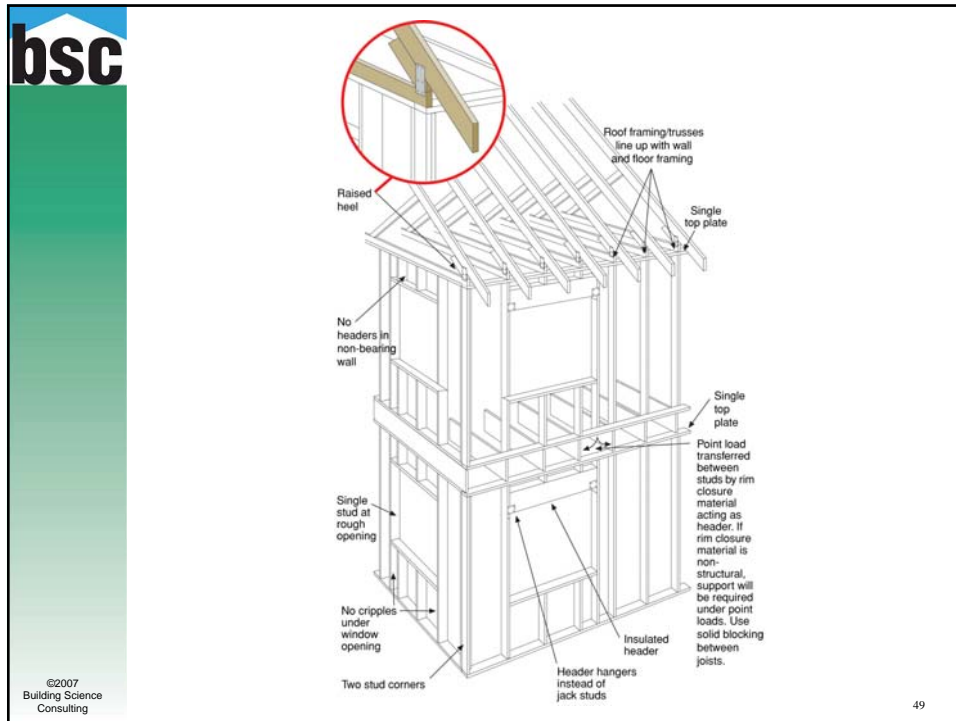
Advanced Wall Framing

Wall 1 (2x6 24" o.c.)	
Plate	36'-0" 2
Stud	8'-0" 20
Jack	7'-9 1/4" 6
Jack 2	6'-8 1/2" 2
Cripple 2	1'-2 1/4" 2
Cripple 3	2'-1" 3
Gross wall area	327 ft ²
Window area	74 ft ²
Opaque area	45.17 ft ²
Cavity area	207.83 ft ²

Wall 1 (2x6 16" o.c.)	
Plate	36'-0" 3
Stud	8'-8 1/2" 29
Jack	7'-8 1/2" 6
Jack 2	6'-8 1/2" 2
Cripple 1	0'-2 1/4" 6
Cripple 2	1'-2 1/4" 2
Cripple 3	2'-1" 8
Gross wall area	327 ft ²
Window area	74 ft ²
Opaque area	65.60 ft ²
Cavity area	181.40 ft ²

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5. Provide for durability by controlling moisture

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Why control moisture?

1. Our efforts to save energy and reduce the flow of heat through building assemblies have **reduced drying potentials** and, therefore, increased the importance of controlling moisture flow through building assemblies.
2. Building **materials last longer** when their faces are exposed to similar or equal temperature and humidity.
3. Three things destroy materials in general and wood in particular: **water, heat, and ultraviolet radiation**. Of these three, water is the most important by an order of magnitude.

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How to control moisture?

In moisture control, the priority is **liquid water first**, particularly when it comes in the forms of rain and groundwater. In these forms it is referred to as “bulk” water.

Drain Building
Drain Roof
Drain Material
Drain Component
Drain Opening
Drain Wall
Drain Site
Drain Gound

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How to control moisture?

Following are **air-transported vapor** and then **diffusive vapor**, all other things being equal.

4x8 sheet of gypsum board
Interior at 70° F
and 40% RH

1/3 quart of water

AIR LEAKAGE

4x8 sheet of gypsum board
with a 1 in² hole
Interior at 70° F
and 40% RH

30 quarts of water

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Remember:

It's always a question of **quantities** and **rates**, of wetting and drying, and the tolerance of materials (individually and in combination) for each and all of the above.

- When the rate of wetting exceeds the rate of drying, **accumulation** occurs.
- When the quantity of accumulated moisture exceeds the storage capacity of the material or assembly, **problems** occur.
- The storage capacity of a material or assembly depends on **time**, **temperature**, and the **material** itself.

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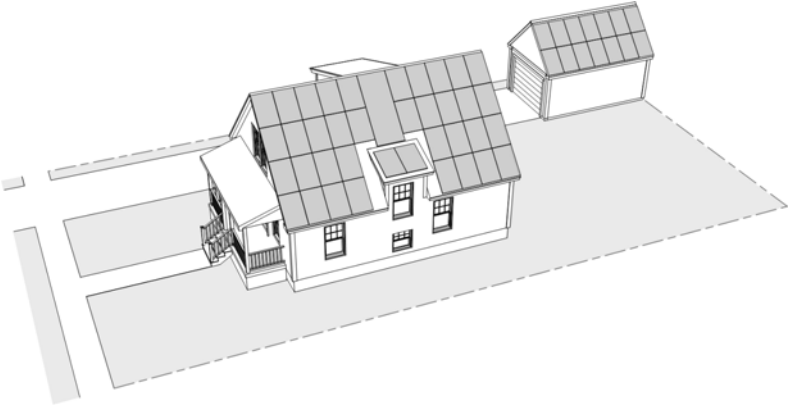
6. Design a roof that is sloped to the south

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Plan to use the available solar resource






These two roofs total about 900 sq.ft. of south sloping roof and can accommodate about a 9 kW PV system and 40 sq. ft. of SHW panels . . . but the roof needs to face the right direction!

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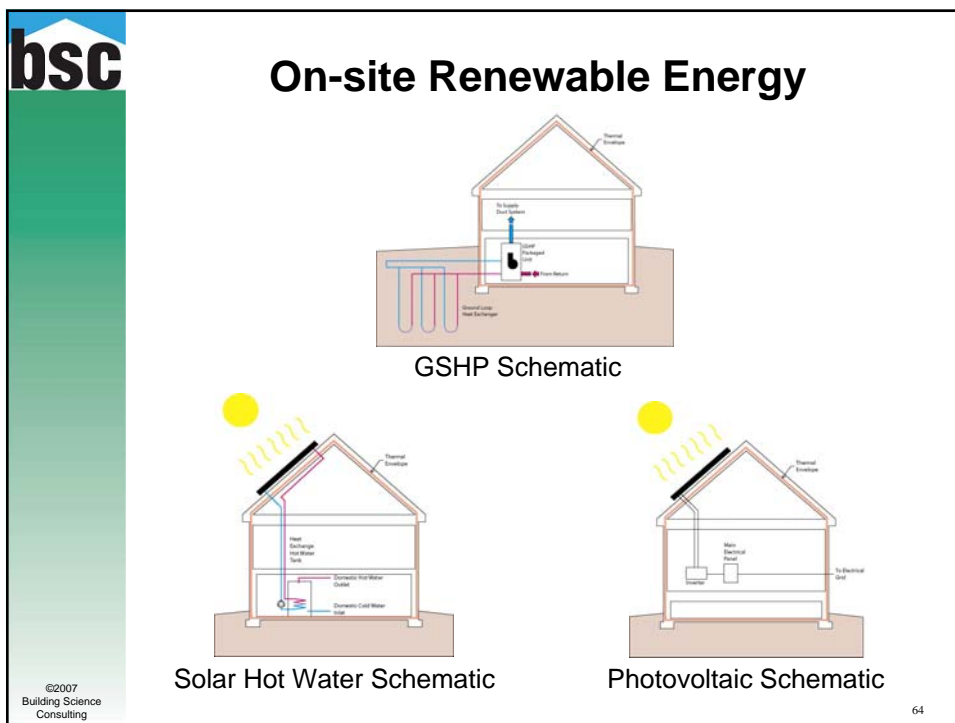
bsc **But the loads must be minimized first**


Recall the three general steps:

-  Step 1: Reduce Enclosure Energy Use
-  Step 2: Reduce Mechanical System Energy Use
-  Step 3: Add Site Generated Energy

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Summary of the Design approach

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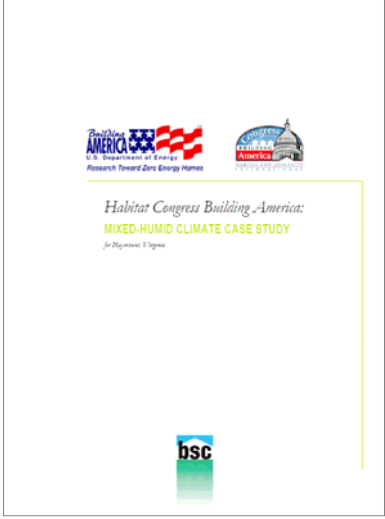
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Resources

Building Science Corporation
Designs that Work – Mixed-Humid Climate Case Study
find this at:
www.buildingscience.com/dtw



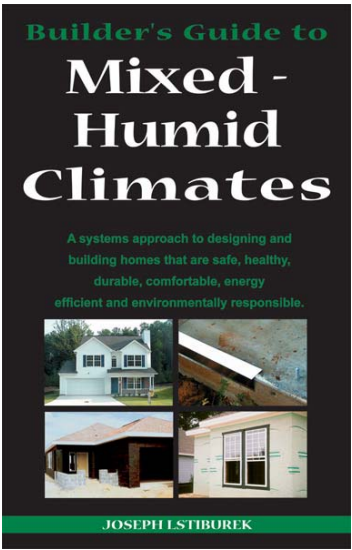
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Resources

Building Science Corporation
Builder's Guide to Mixed-Humid Climates
find this at:
www.buildingsciencepress.com




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Resources

Building America
Mixed-Humid Climate Best Practices Guide
find this at:
www.buildingamerica.gov
(look for "publications")




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Rebuilding Greensburg A Seminar Series on Affordable, Energy Efficient Construction Techniques



Part 1: House Design and Foundation Systems
Date: September 8, 2007

- An overview of energy efficient and affordable house design
- Foundations and rainwater management

Part 2: Framing

- Advanced framing techniques
- Choosing the right windows and doors

Part 3: Mechanical Systems and Airtightness

- Build tight, ventilate right
- Mechanical system design and selection

Part 4: Enclosure


- Insulation – theory and installation practices
- Exterior cladding systems

Part 5: Finishes, Testing and Commissioning

- Measuring building performance
- Whole house commissioning and homeowner training

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Questions?

Before you go . . .

- **Sign up sheet for builders**

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