






Wyandotte Energy Summit
NSP2 Building America Construction
 June 28, 2012

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Objectives for this workshop . . .

1. Introduce the Building America Research Program
2. Review NSP2 construction specification
3. Examine lessons learned

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Why build energy efficient homes?

For consumers:


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

For the nation:

- 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

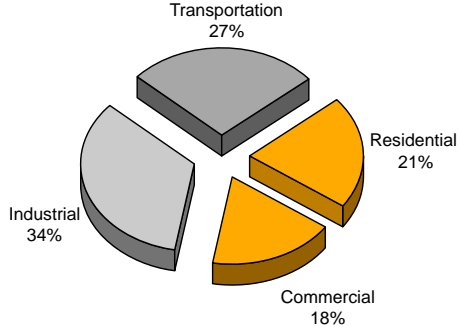
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Assessing the Impact of US Buildings

Total Energy Consumption by Sector, 2001

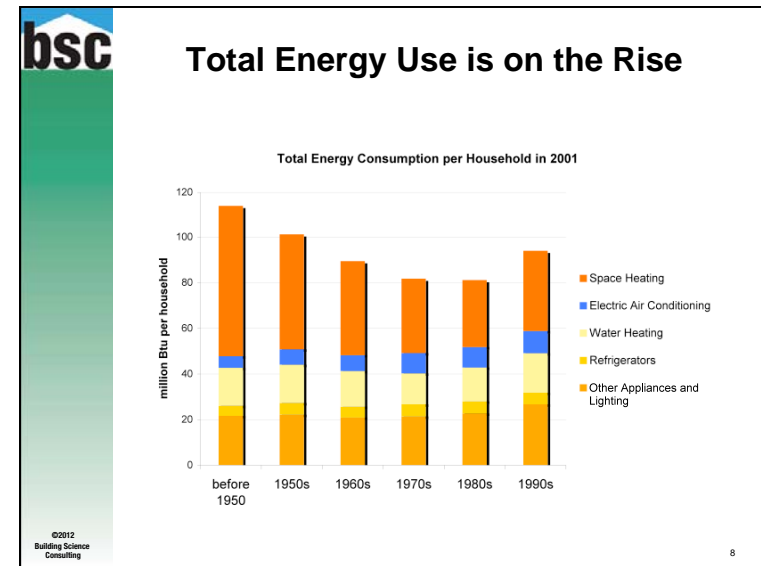
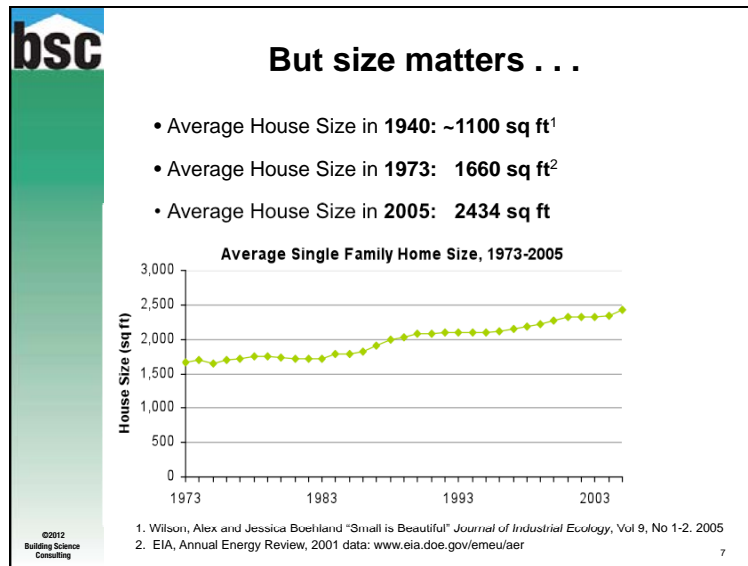
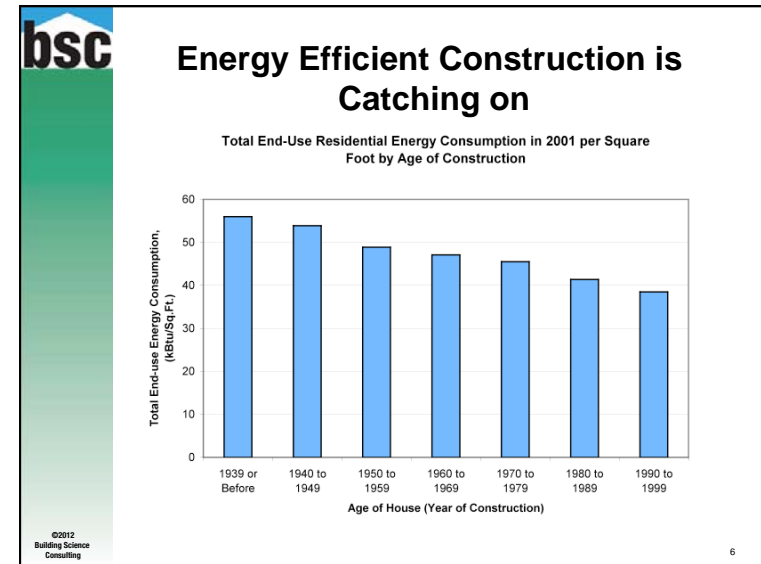
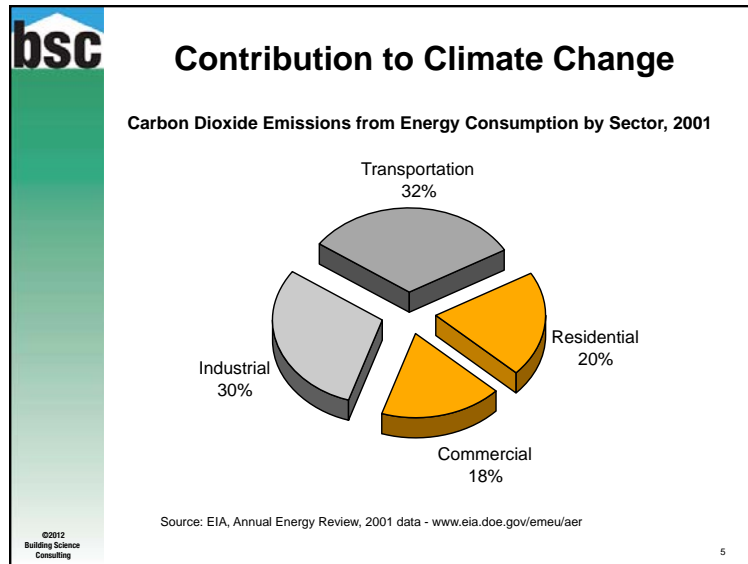



Sector	Percentage
Industrial	34%
Transportation	27%
Residential	21%
Commercial	18%

Source: EIA, Annual Energy Review, 2001 data - www.eia.doe.gov/emeu/aer

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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.




For more information, visit our website at:
www.buildingamerica.gov

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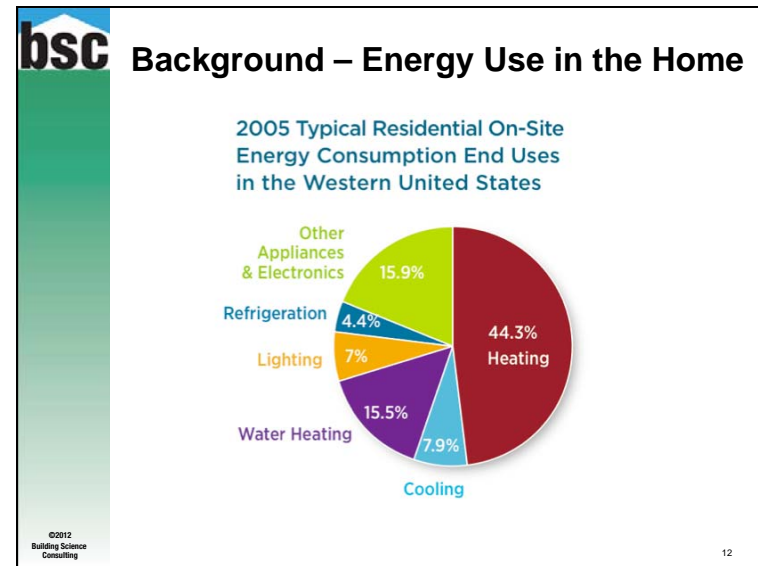
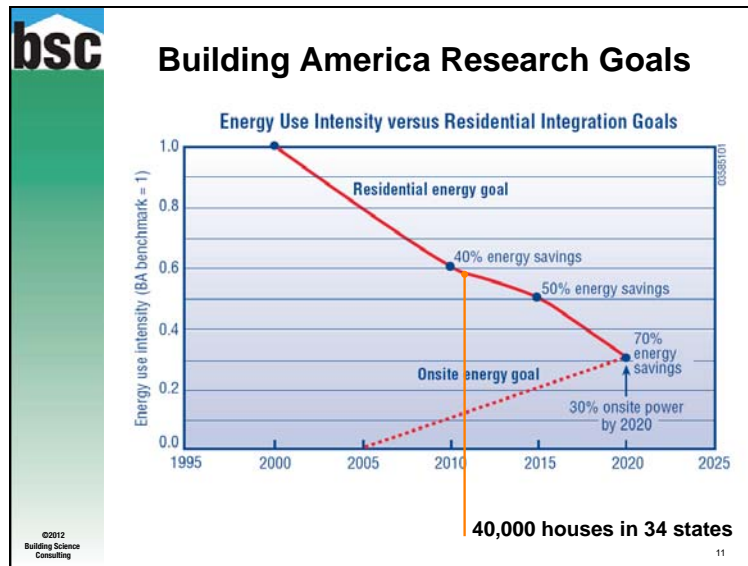


bsc Overview of the Design approach

Our approach follows 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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Systems Engineered for Zero Cost

Energy-Efficiency Feature	Added Cost, per Home, Over Builder's Conventional Practice
Double-wall construction	\$2,500
R-50 attic insulation	\$300
R-40 floor insulation	\$540
Triple-pane windows	\$3,000
Solar water heating system	\$9,750
Heating system	(\$5,000)
Ventilation system	\$450
100% CFL	\$114
ENERGY STAR appliances	\$190
Total	\$11,844
Annual cost (when incorporated into a 30-year loan at 7% interest)	\$1,050
Annual utility bill savings	\$2,192
Net Annual Cash Flow to Homeowner	\$1,142

Conclusion: These energy-efficiency improvements are actually money makers for the owner of this home.

Cost estimates were provided by the builder. A 10% markup is assumed; incentives and rebates are not considered. . AFUE = annual fuel utilization efficiency, CFL = compact fluorescent lamp, EF=energy factor

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Looking long-term . . .

End Use	Annual Electric Energy (Site)			Annual Gas Energy (Site)			Annual Utility Bill Reduction vs Benchmark (\$/yr)	Local Marginal Electricity Price (\$/kWh)	Local Marginal Gas Price (\$/therm)
	Benchmark	Builder Standard Practice (Optional)	Prototype House	Benchmark	Builder Standard Practice (Optional)	Prototype House			
Space Heating	1647.5	594	2142.5			778	\$2,533	\$0.19	\$1.71
Space Cooling	2763		1389				\$261		
DHW	0		0	291		152	\$238		
Lighting	3463		1626				\$349		
Appliances and MFLs	6642		6292	0		0	\$67		
Ventilation	13.5		15				(\$0)		
Total Usage	14529	0	9916	2433.5	0	930	\$3,447		
Site Generation							\$0		
Net Energy Use	14529	0	9916	2433.5	0	930	\$3,447		
Added Annual Mortgage Cost w/o Site Gen.							\$2,055		
Net Cash Flow to Consumer w/o Site Gen.							\$1,392		
Added Annual Mortgage Cost with Site Gen.							\$2,055		
Net Cash Flow to Consumer with Site Gen.							\$1,392		

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

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WYANDOTTE NSP2 NEW CONSTRUCTION SPECIFICATION

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NSP2 Enclosure Specifications

High R-value Wall

- 2x6 Advanced Framing
- 2" R-10 Insulating Sheathing, Exterior Drainage Plane
- Hybrid wall insulation, 2" R-12 closed-cell spray foam insulation + R-12 fiberglass batt insulation
- Airtight construction

ENERGY STAR windows – U 0.28!

Full Height basement R-10 insulation

Compact High R-value Roof

- 3" – 4" R-18 to R-24 closed-cell spray foam insulation
- R-28 fiberglass batt insulation

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NSP2 Enclosure Specifications

ENCLOSURE	SPECIFICATIONS
Roof	
Description -	Dark color asphalt shingles on rafter roof – unvented cathedralized attic
Insulation -	3" (R-18) ccSPF on underside of roof, R-28 fiberglass batt below
Walls	
Description -	Hybrid wall with insulating sheathing and spray foam
Insulation -	2" (R-10) XPS sheathing, 2" (R-12) ccSPF in cavity, 3.5" (R-12) fiberglass
Foundation	
Description -	Conditioned Basement / Crawlpace
Insulation -	2" XPS (R-10) on walls or 2" (R-12) ccSPF
Windows	
Description -	Double pane vinyl framed with LoE3 spectrally selective glazing
Manufacturer -	Anderson U-value = 0.28 (R-3.6), SHGC = 0.29
Infiltration	
Specification -	2.5 sq in leakage area per 100 sf enclosure @ 50 Pa
Performance test -	Initial test result = 2.0 sq in leakage area per 100 sf enclosure @ 50 Pa

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History

The Year – 1854
The Book – The American Cottage Builder

Plate 5.

Fig. 1.

Fig. 2.

Fig. 3.

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History

1970s

U.S. Department of Housing and Urban Development

NAHB Research Foundation

Operation Break-through delivered “optimum value engineering framing”

Today this is “Advanced Framing”

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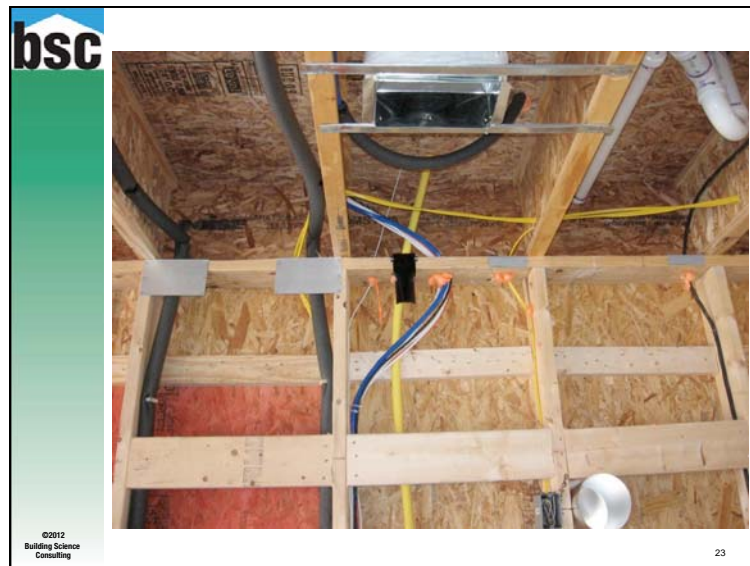
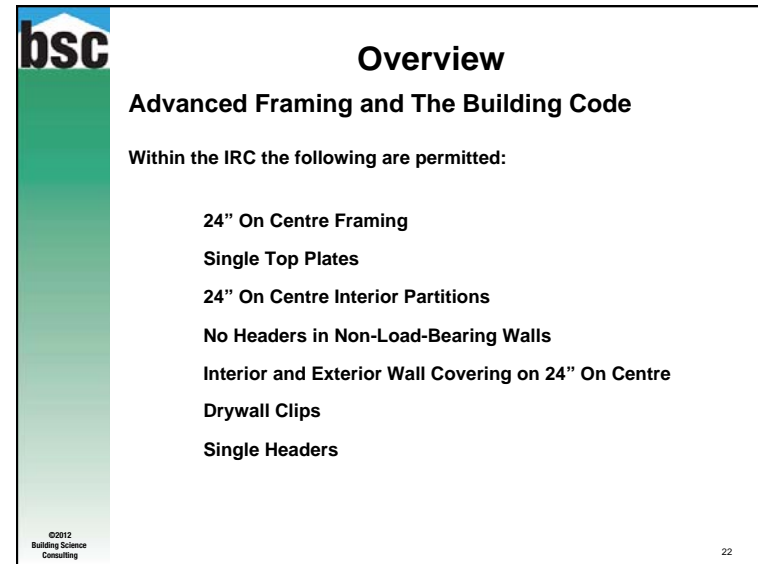
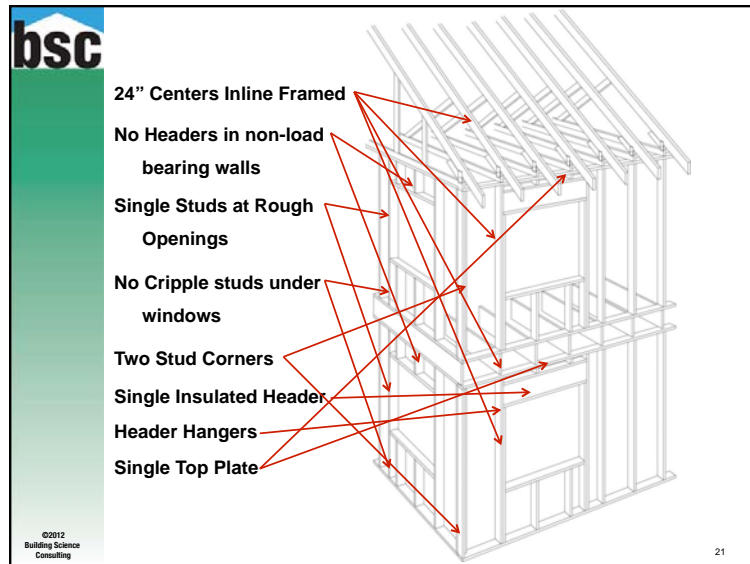
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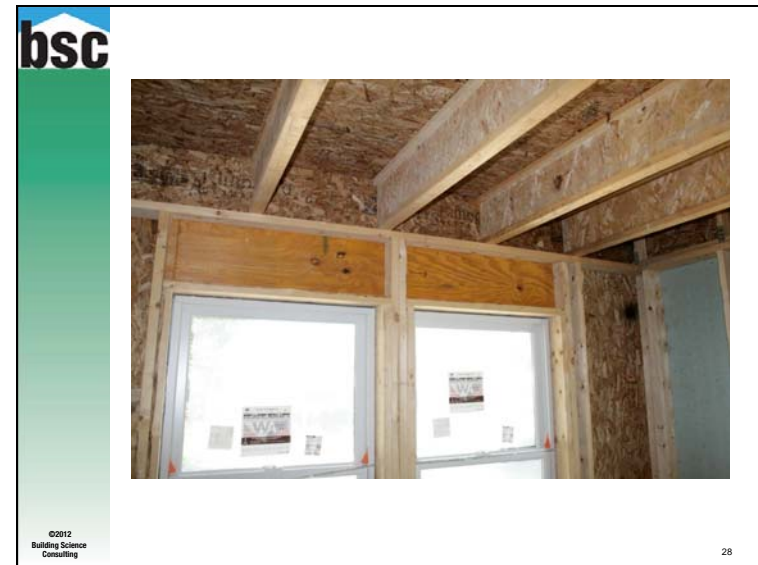
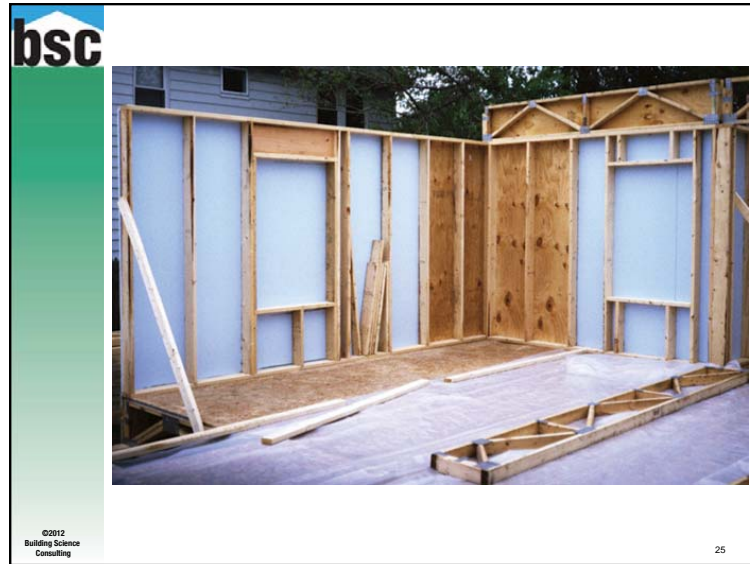
Overview

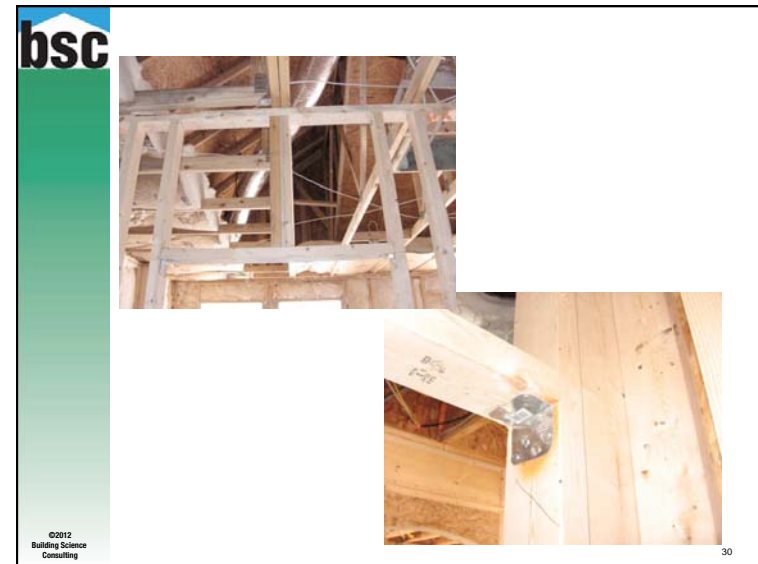
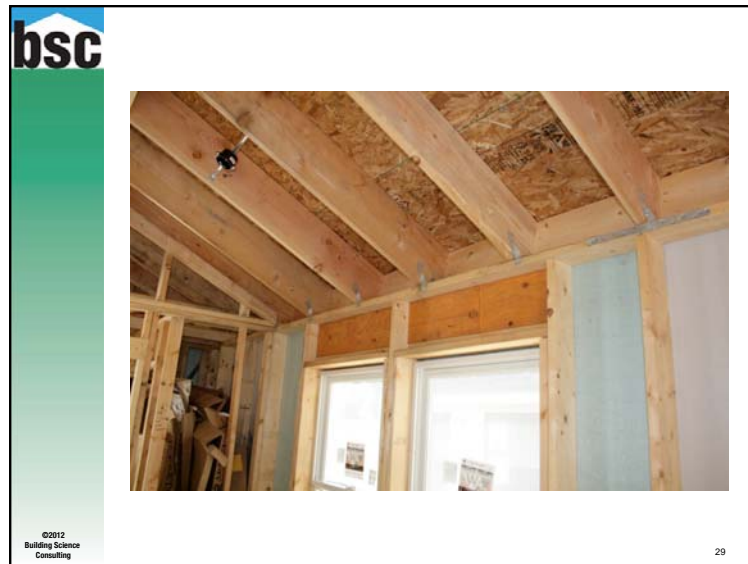
What is Advanced Framing?

Framing system on 2' centers
Reduce Framing Material Use
Increases Insulation Volume
Improves Energy Performance
Reduces Labor Costs (eventually)

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Benefits

- Reduced Framing Material Use
 - Lower Construction Costs
- Reduced Number of Framing Members
 - Reduces Labor Costs and Increases Speed
- Increased R-Value
 - Lower Operating Costs
- Improved Energy Performance
 - Reduces Emissions from Space Conditioning

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Benefits

Case Study – Residential House – Material

	8' Studs	Board Feet
Standard Framing	Exterior Wall	467
	Exterior Plate	95
	Interior Wall	715
	Interior Plate	126
	Header	273
Total	1403	5186

	8' Studs	Board Feet
Advanced Framing	Exterior Wall	238
	Exterior Plate	63
	Interior Wall	279
	Interior Plate	85
	Header	148
Total	665	3082

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Benefits

Speed of Construction

- Usually Takes 5 Houses to Gain Familiarity
- Fewer Pieces of Lumber to Handle
- Fewer Holes to Drill
- Less Framing to Work Around
- Larger Areas to Work

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Benefits

- Fewer Holes to Drill
- Less Framing to Work Around
- Larger Areas to Work

HVAC Installer !
Electrician !
Plumber !
Drywaller !

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Benefits

The Truth about R-VALUE

Wood is More Conductive than Insulation

Less Framing Means Higher Overall R-Value!

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Wall 1 (2x6 24"o.c.)	
Plate	36'-0" 2
Stud	8'-0" 20
Jack	7'-9 1/2" 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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Benefits

Case Study – Residential House 1 – Energy

- 2,800 ft²
- Slab on grade
- 2-story, detached single family house
- R-13 Walls (2x4 Construction)
- R-38 Ceiling
- 90% AFUE Furnace
- 14 SEER Air Conditioner
- BSC Building America target enclosure airtightness (0.25 CFM/ft²)

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Benefits

Case Study – Residential House 1

	Annual Energy Savings (%)	One Time Construction Material Costs
Exterior 2x4 Framing at 16" OC	0.0%	\$0
Exterior 2x6 Framing at 16" OC	9.2%	\$1,177
Exterior 2x6 Framing at 24" OC w/2 Stud Corner	1.7%	\$143
Exterior Single Top Plate	0.9%	\$54
Exterior Opening Framing (Sills, Kings, Jacks)	0.2%	\$89
Exterior Single Headers with Insulation	0.9%	-\$27
Interior Stud Spacing at 16" OC	0.0%	\$0
Interior Stud Spacing at 24" OC	0.0%	-\$238
Interior Single Top Plate	0.0%	-\$83
Interior Opening Framing	0.0%	-\$31
Floor Joist Spacing at 16" OC	0.0%	\$0
Floor Joist Spacing at 24" OC	0.2%	\$0
Roof Rafter Spacing at 16" OC	0.0%	\$0
Roof Rafter Spacing at 24" OC	0.0%	\$0
Total Energy Savings	13.0%	
Total Cost		-\$92

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bsc **Reduce Unnecessary Thermal Bridging**



Where 4 is Good

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bsc **Reduce Unnecessary Thermal Bridging**



Where 5 is Better

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bsc Reduce Unnecessary Thermal Bridging



10 Has to Be Just GREAT!

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bsc Spray Foam in Wyandotte




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bsc Spray Foam in Wyandotte



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bsc Closed Cell Spray Foam in Wyandotte



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bsc NSP2 Mechanical Specifications

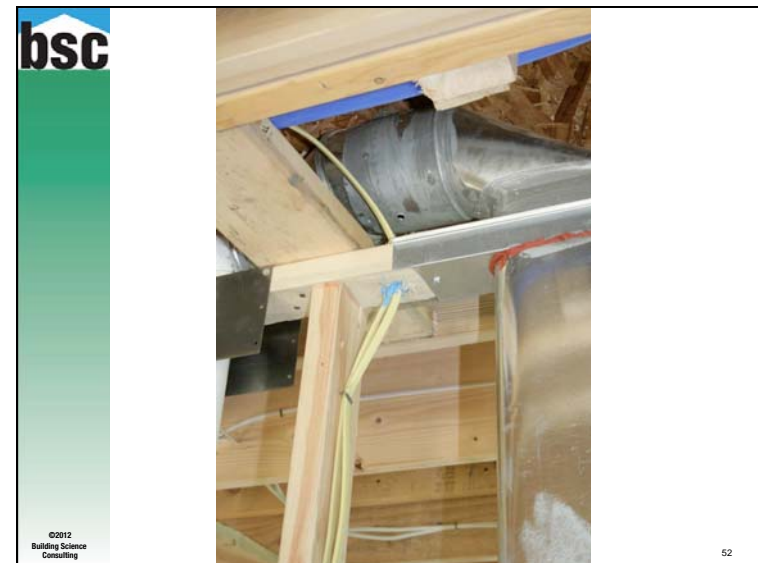
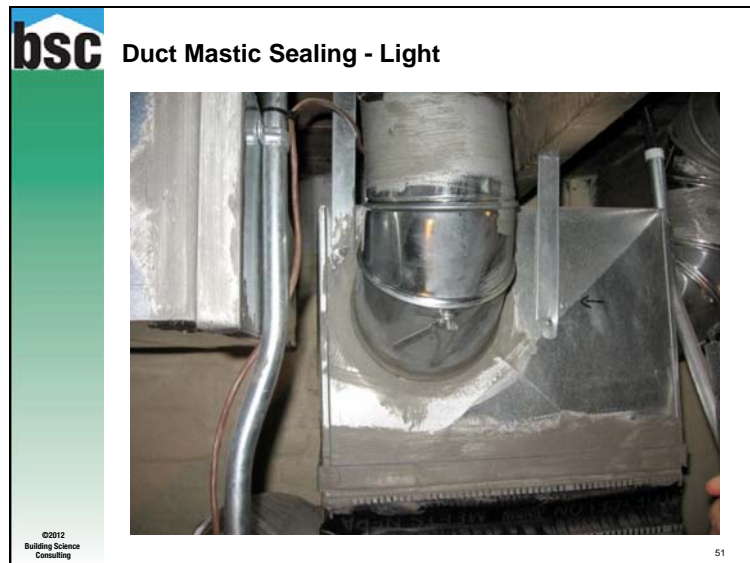
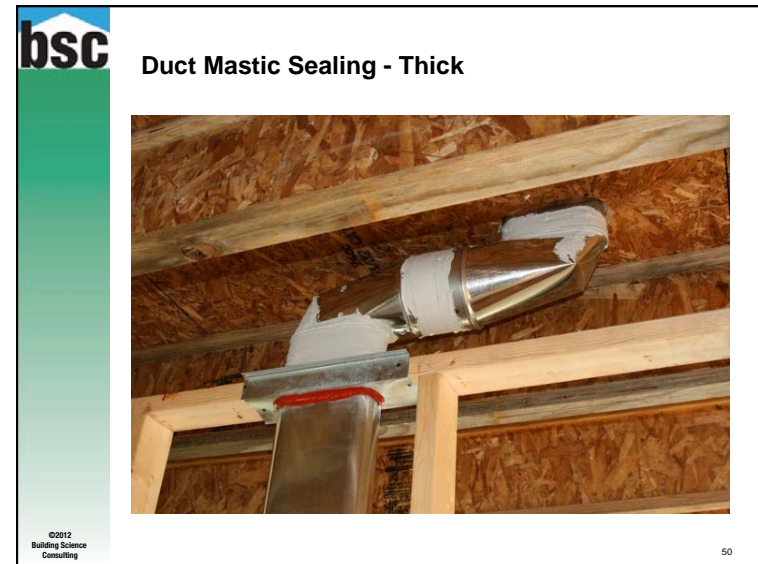
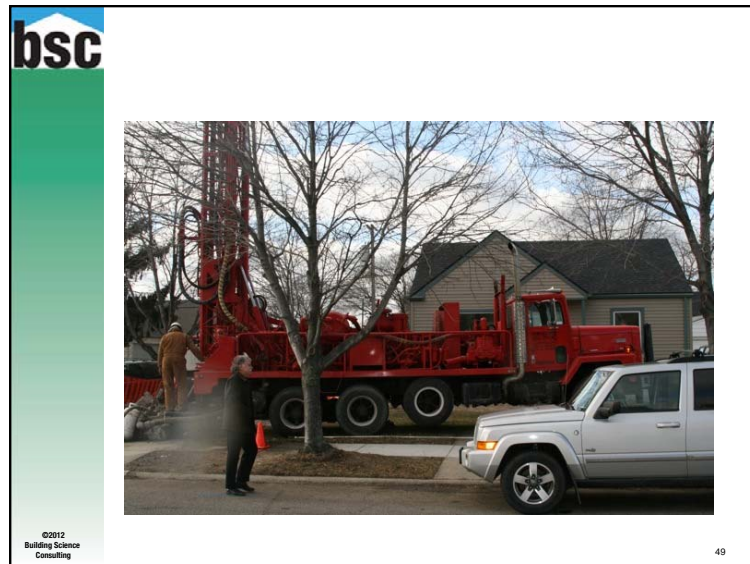
- Heating and cooling by Ground Source Heat Pump (GSHP)
- Efficient electric hot water tank boosted by GSHP
- Ductwork sealed with mastic
- Central fan integrated ventilation system
- ENERGY STAR appliances
- CFL lighting package

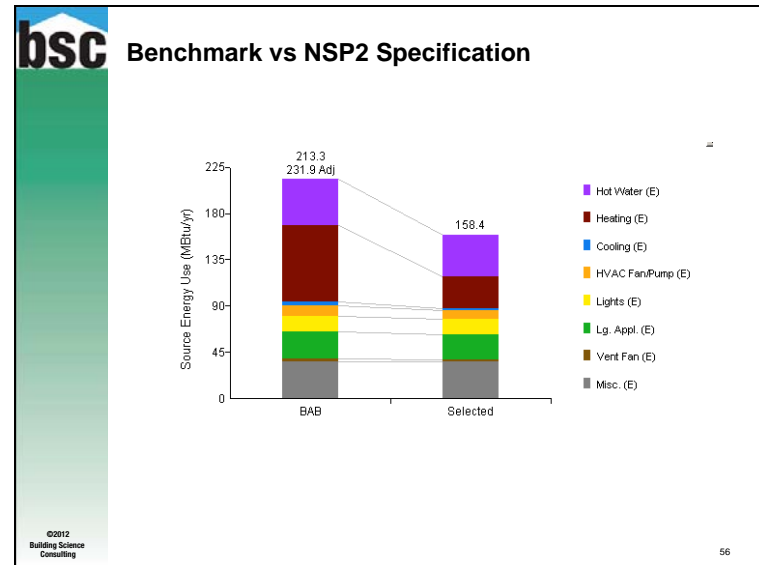
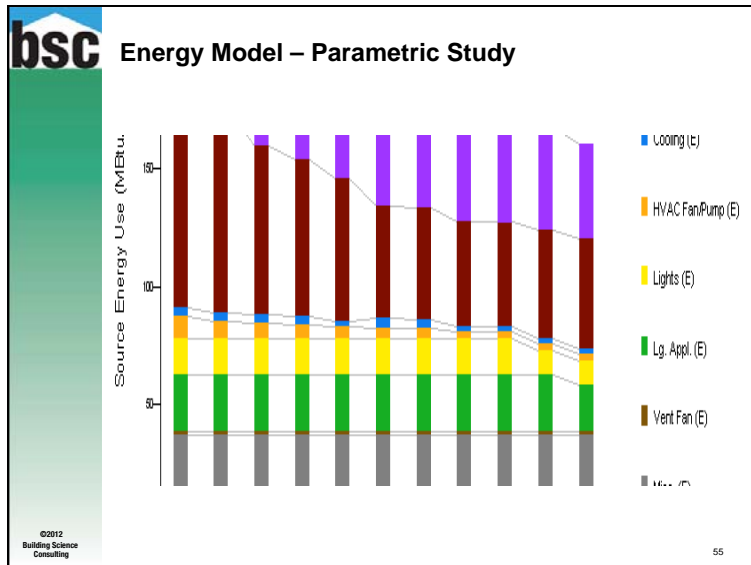
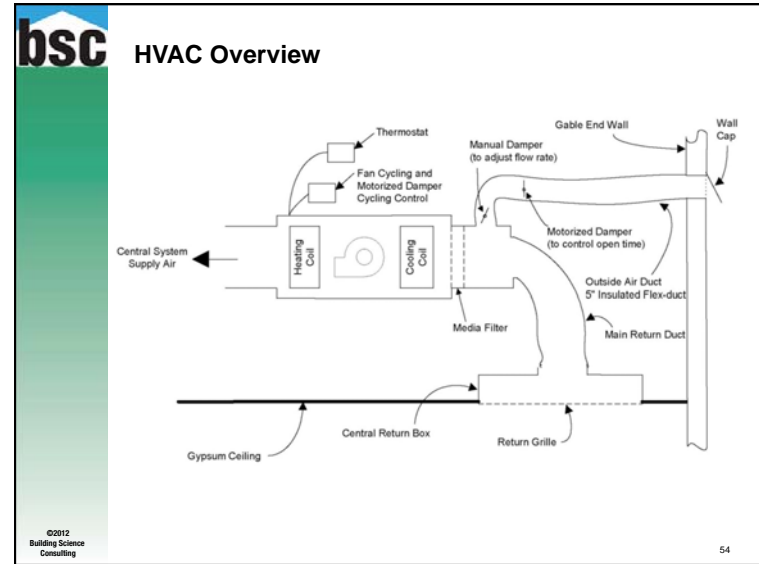
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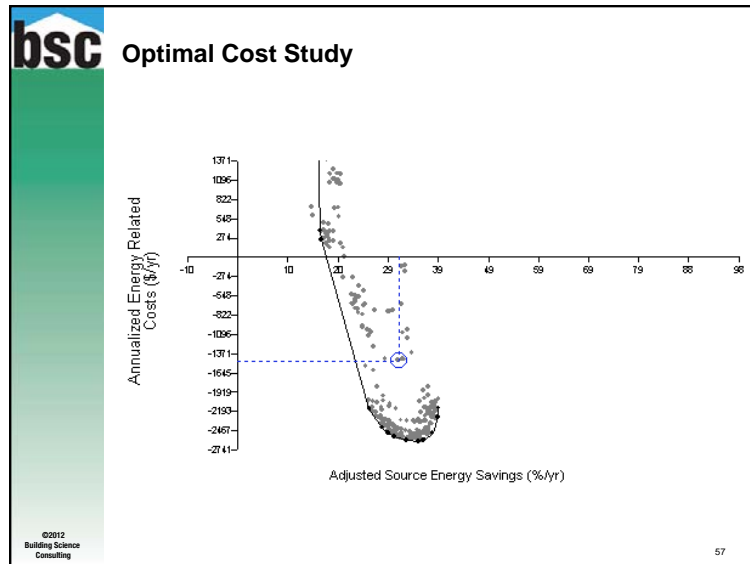
bsc NSP2 Mechanical Specifications

MECHANICAL SYSTEMS	SPECIFICATIONS
Heating and Cooling	
Description -	9.2 HSPF ground source heat pump
Manufacturer & Model -	WaterFurnace
Domestic Hot Water	
Description -	Tank electric hot water heater (EF=0.98),
desuperheater	
Manufacturer & Model -	Rheem
Distribution	
Description -	R-6 flex ducts in conditioned unvented cathedralized
attic	
Leakage -	maximum 5% duct leakage to outside
Ventilation	
Description -	Supply-only system with Aprilaire™ 8126 VCS, 33%
Duty Cycle:	10 minutes on; 20 minutes off, 50 CFM average flow
Manufacturer & Model -	Aprilaire™ 8126 VCS fan cyclor
Return Pathways	
Description -	Central return on first floor, jump ducts in bedrooms

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**WYANDOTTE NSP2
LESSONS LEARNED**

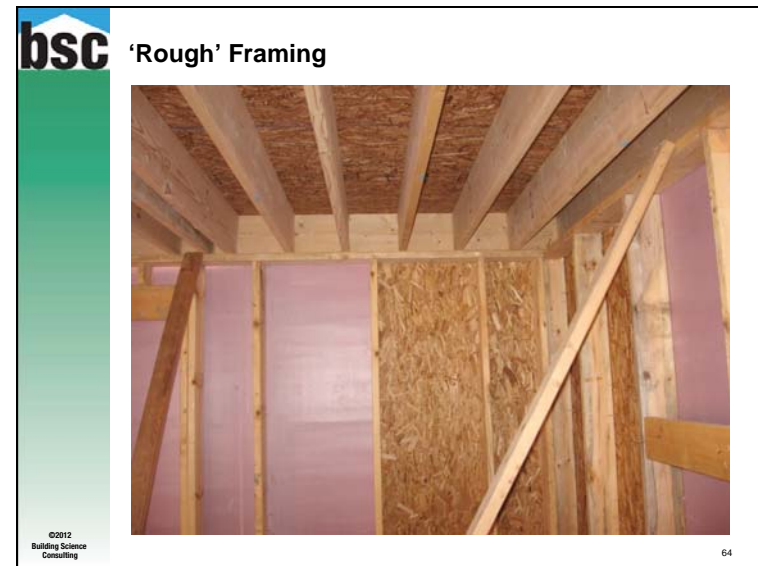
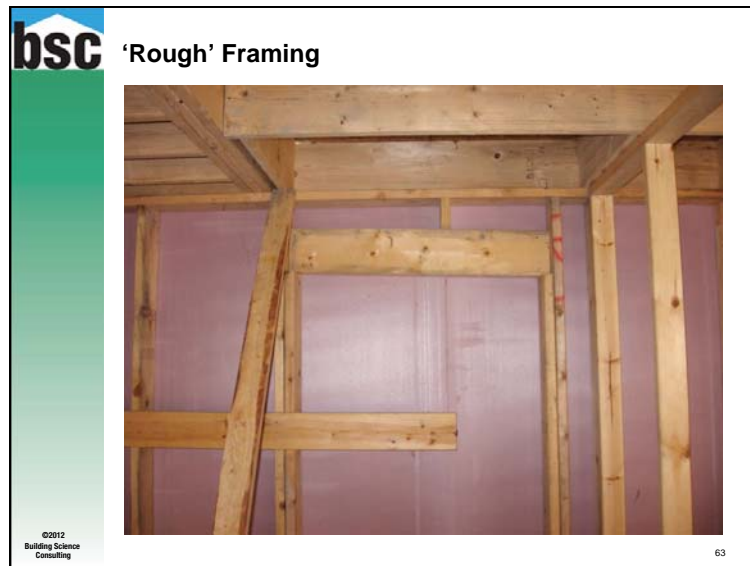
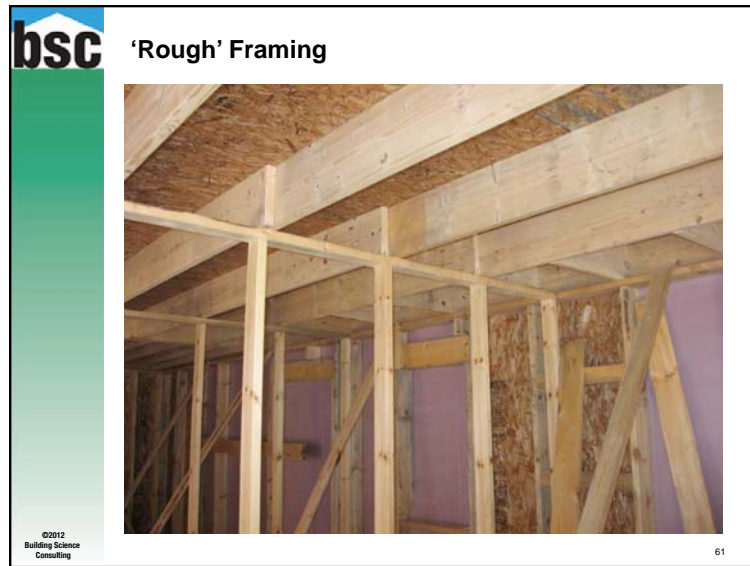
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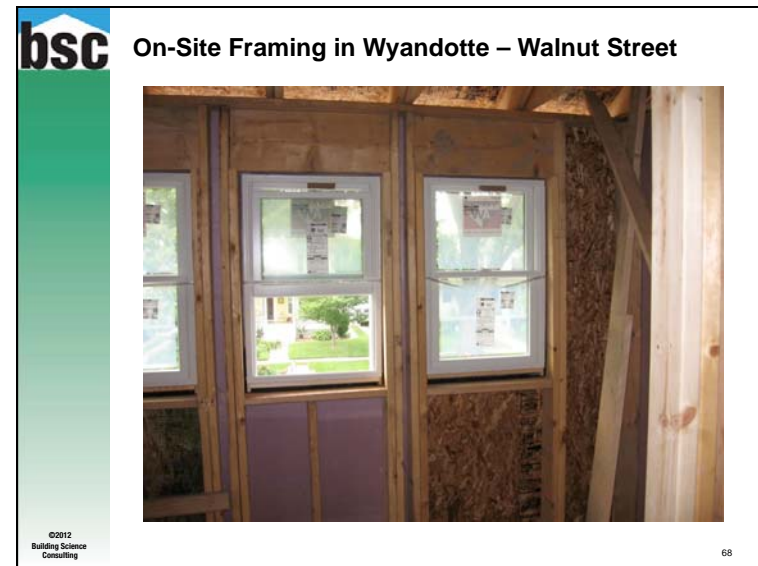
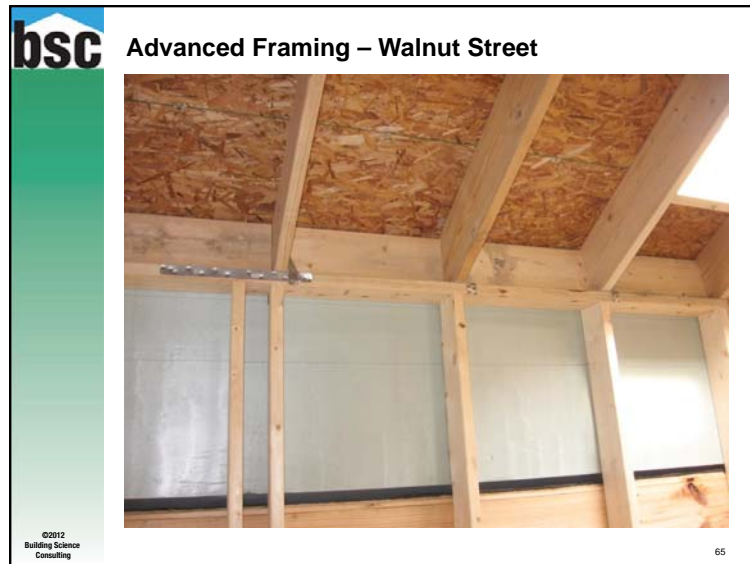
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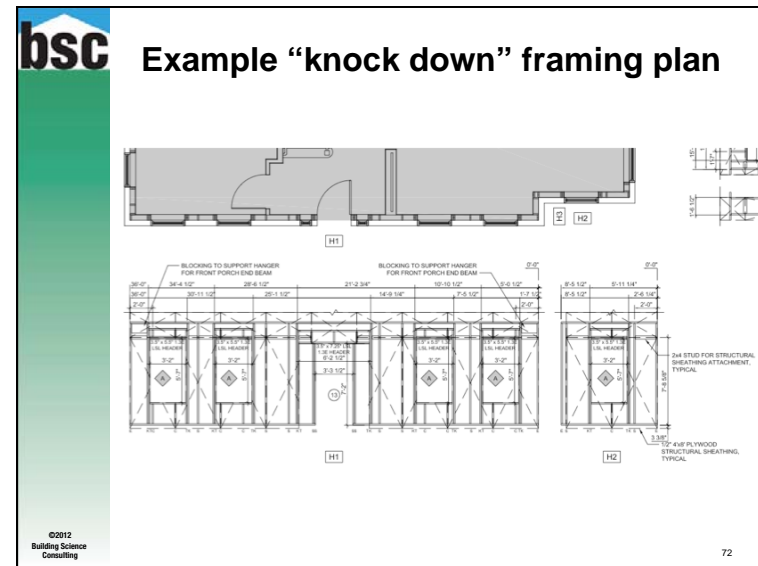
**COMMUNICATION WITH
DRAWINGS**

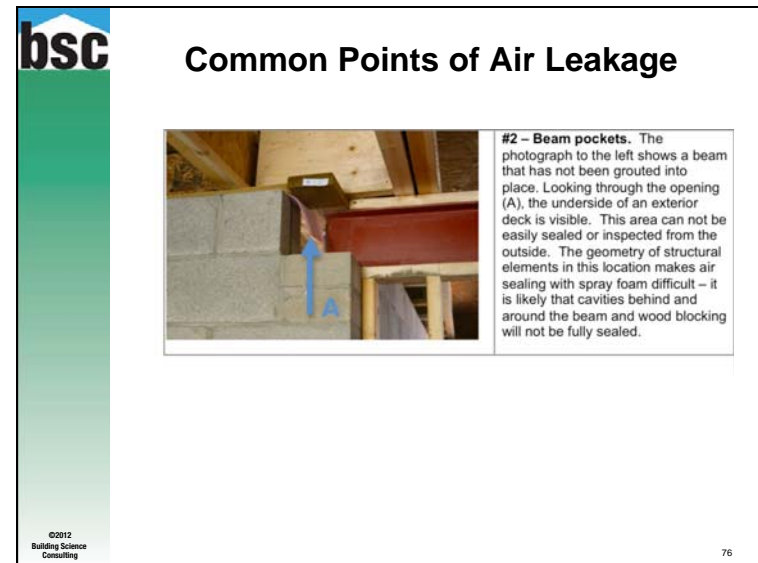
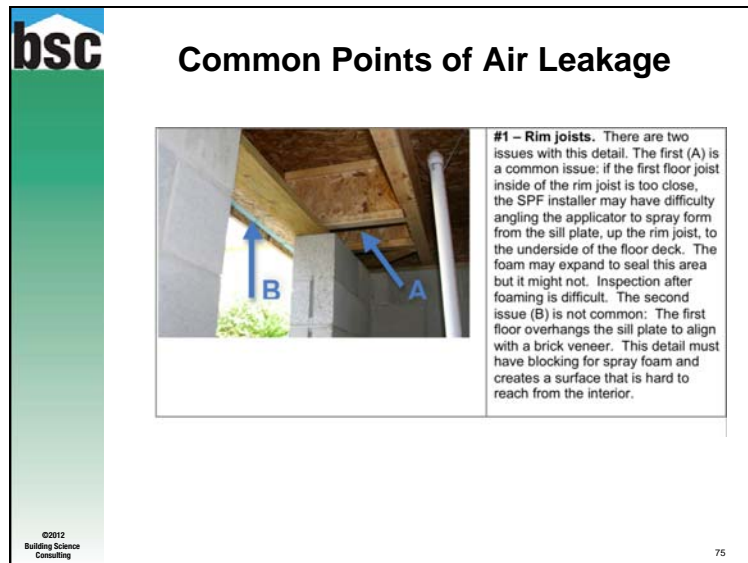
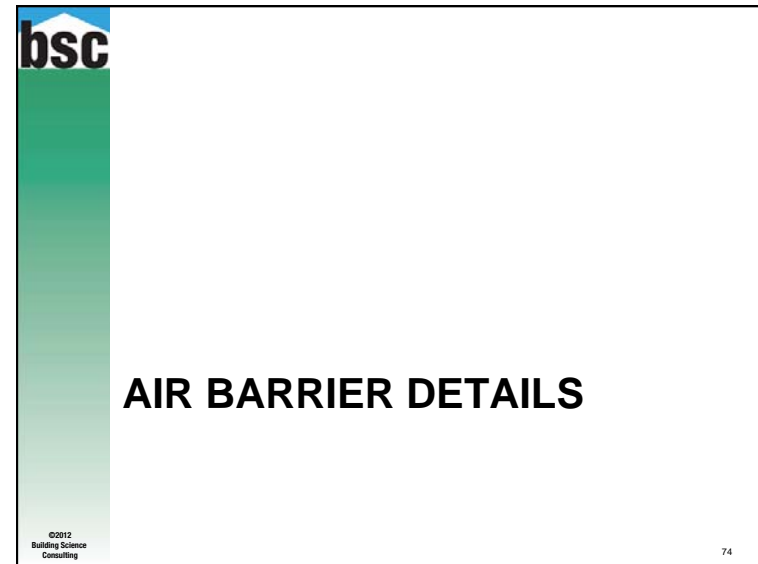
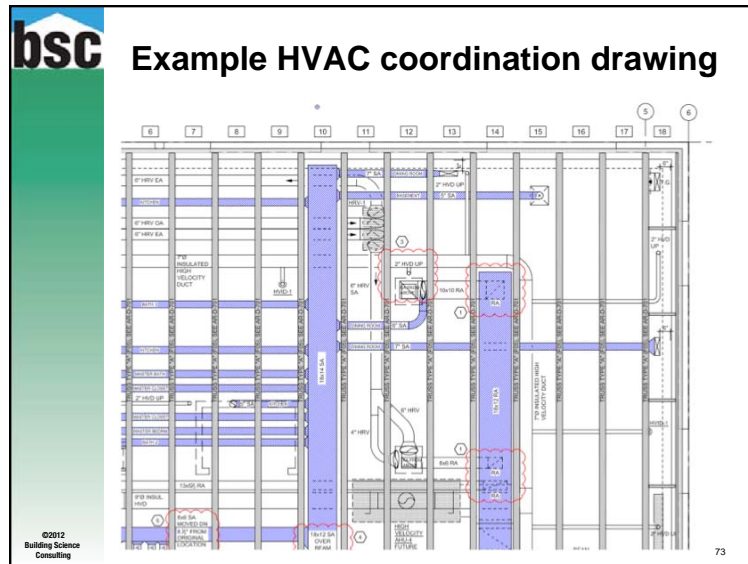
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Common Points of Air Leakage




#3 – Framing at dormers.
Blocking is missing between the rafters in the dormer pictured in the photograph to the left. The dormer side wall framing creates an air leakage path that is not sealed by the SPF installation.

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Common Points of Air Leakage



#4 – Rafter-to-floor-deck air seal.
The rafter bays pictured in the photograph to the left have blocking and are ready for SPF installation. Preliminary blower door testing indicated that significant leakage occurred in this area.

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Spray Foam Air Sealing

Spray foam is only an air barrier where the spray foam is applied!

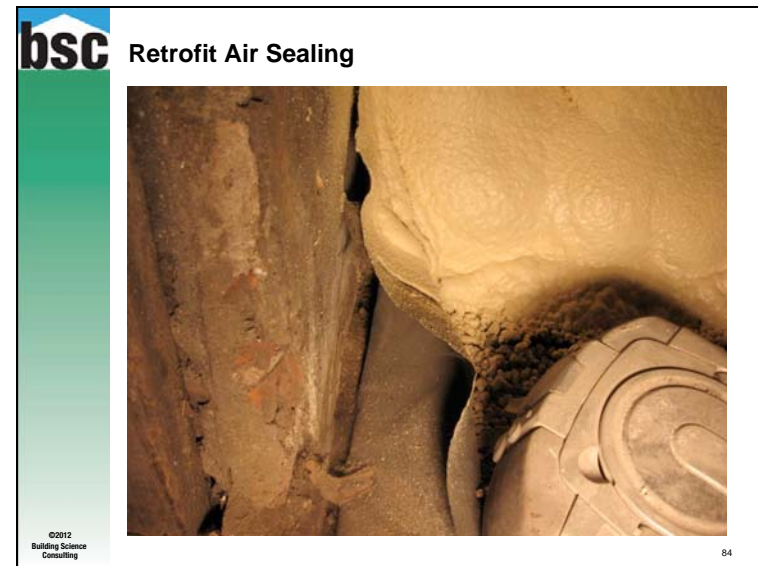
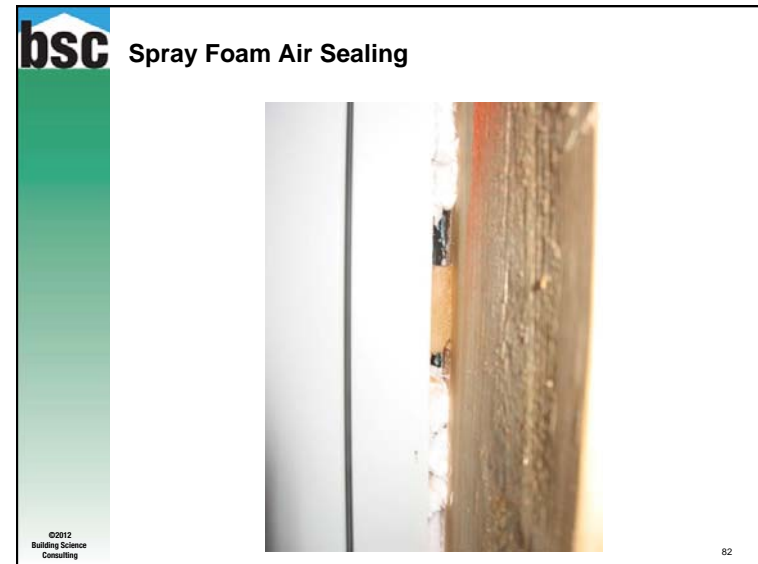
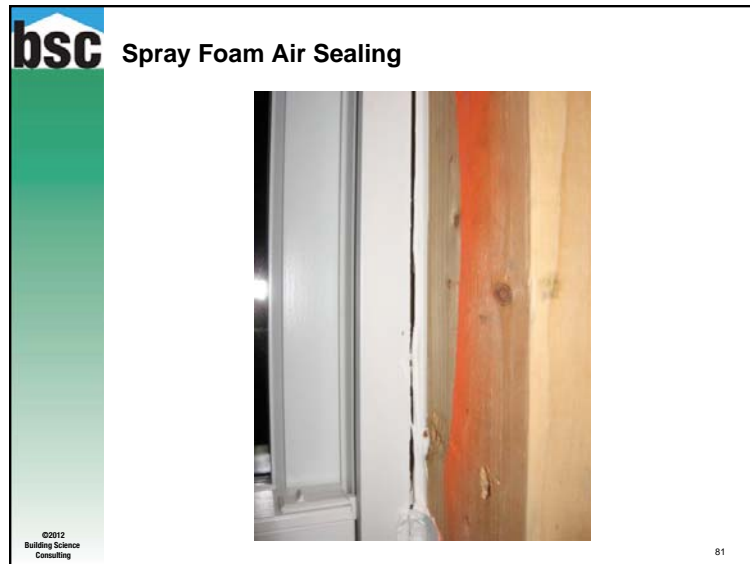
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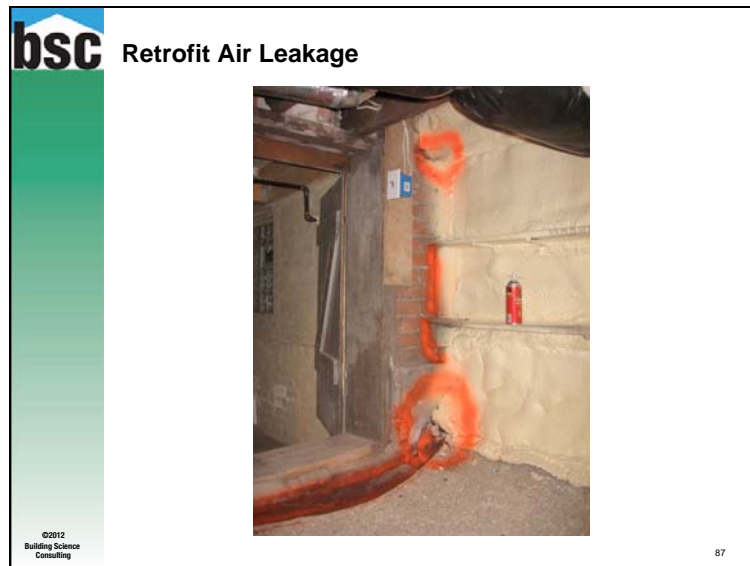
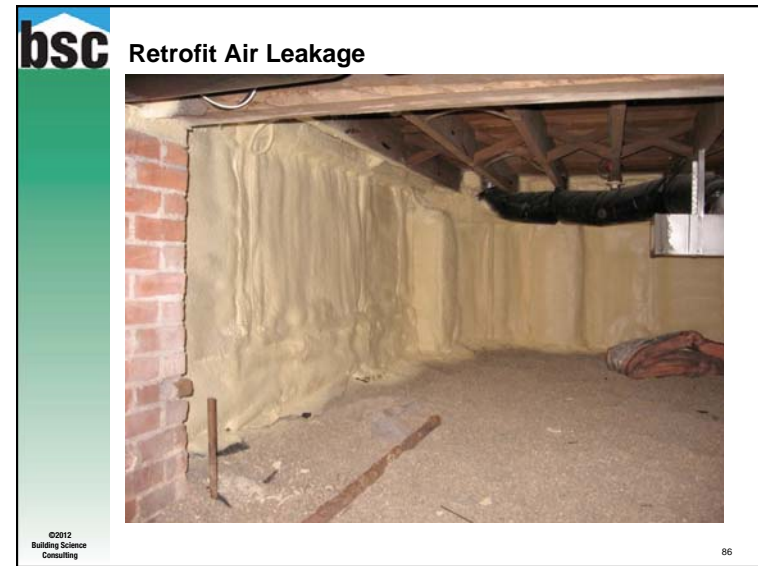
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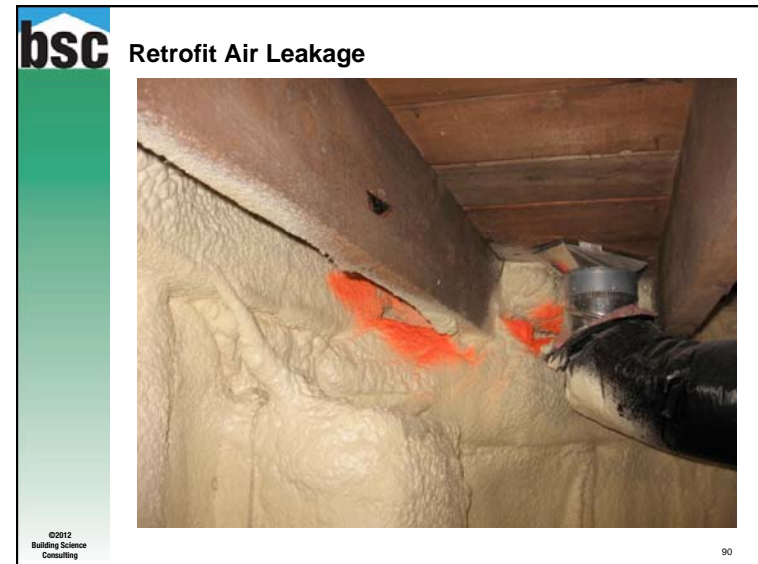
Spray Foam Air Sealing



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bsc Airtightness Test Results

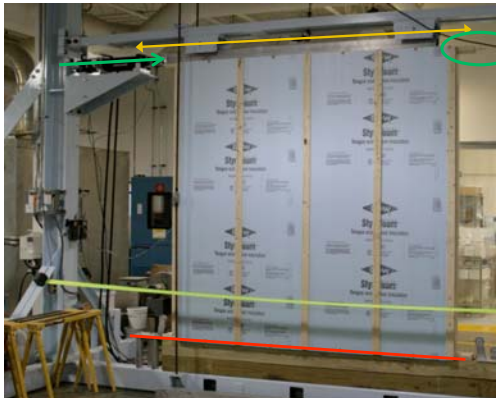
House Number	Airtightness Test results		
	CFM50	ACH50	CFM50/ft ²
Walnut 1	1030	2.7	0.20
Walnut 2	1007	2.6	0.19
Cora 5	678	3.6	0.49
Vinewood 2	539	2.7	0.36
Poplar 4	447	2.3	0.31
Cora 1	407	2.1	0.28
Poplar 3	202	0.92	0.14
Cora 2	197	1.0	0.14
Cora 6	148	0.8	0.11
Vinewood 1	n/a	n/a	n/a

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- bsc** ccSPF Other Benefits
Structural Analysis
- ASTM E72 Racking Testing**
- Deflection as a result of loadings**
- Ram locates wall and zeros its displacement measurement
 - Loadings applied 395 lbs/minute
 - Loading to 790lbs
 - Release loading
 - Loading to 1570 lbs
 - Release loading
 - Loading to 2360 lbs
 - Release loading
 - Load to failure (4" deflection or 30,000 lbs)
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ASTM E72 Racking Testing




A photograph of an ASTM E72 racking test setup. A large, light-colored OSB wall panel is mounted on a metal frame. A horizontal force is applied to the top edge of the panel, indicated by a yellow arrow pointing to the right. A green arrow points to the top edge of the panel, and a red arrow points to the bottom edge. A yellow line is stretched across the panel from the top to the bottom. A green circle highlights a specific point on the top edge of the panel.

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Base Case OSB Wall




A photograph of a base case OSB wall. The wall is made of light-colored OSB panels. A horizontal force is applied to the top edge of the wall, indicated by a yellow arrow pointing to the right. A green arrow points to the top edge of the wall, and a red arrow points to the bottom edge. A yellow line is stretched across the wall from the top to the bottom. A green circle highlights a specific point on the top edge of the wall.

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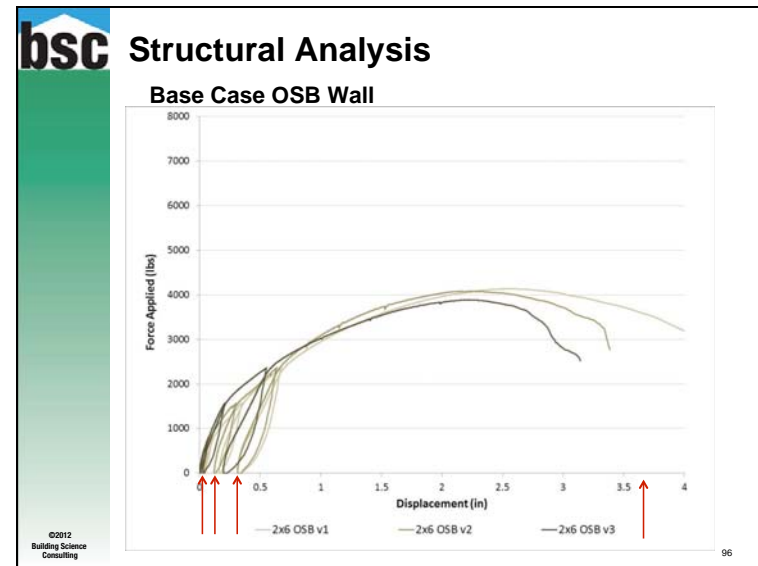
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Base Case OSB Wall




A close-up photograph of the joint between two OSB panels. A vertical metal fastener is visible, securing the panels together. A red circle highlights the joint area.

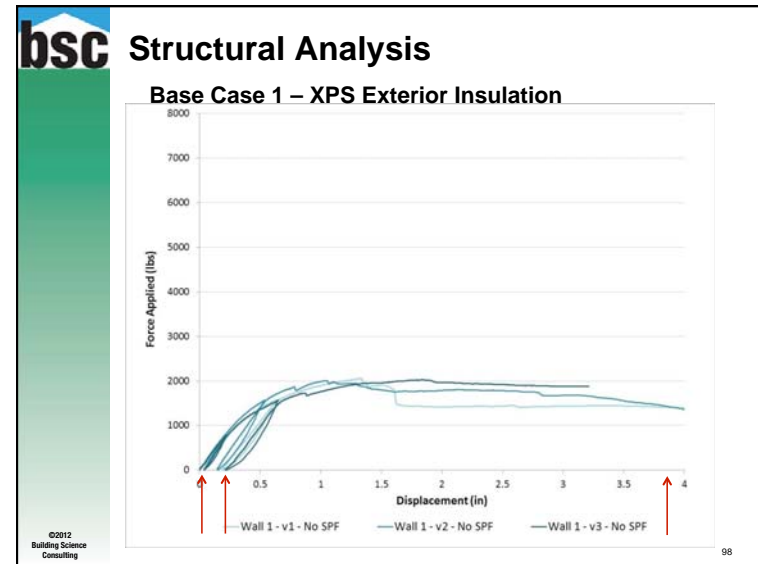
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Base Case 1 – XPS Exterior Insulation



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Hybrid Test 2 – XPS Exterior Insulation

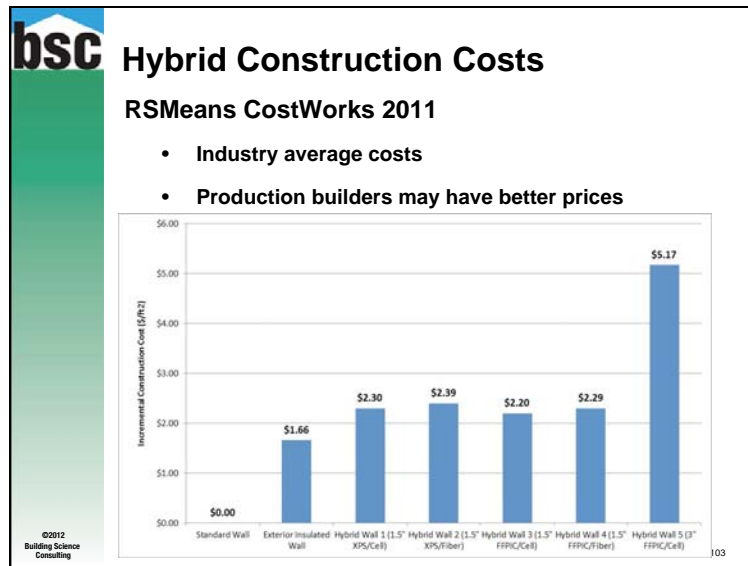
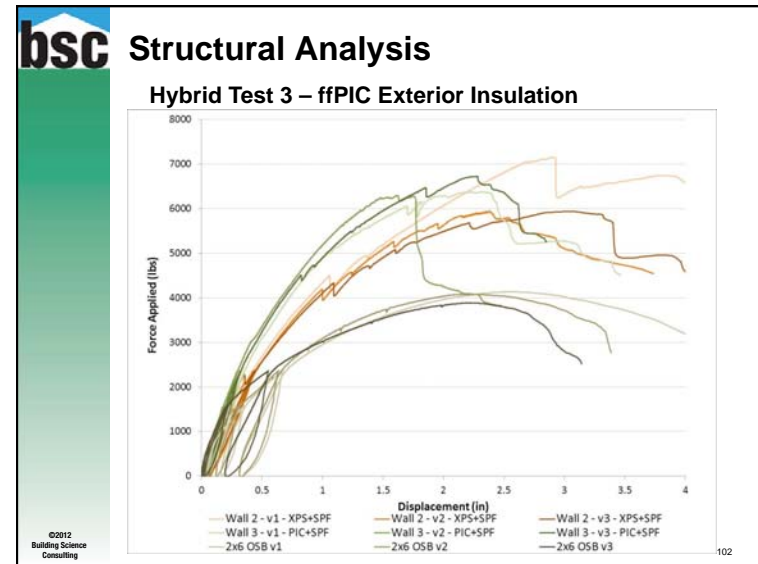
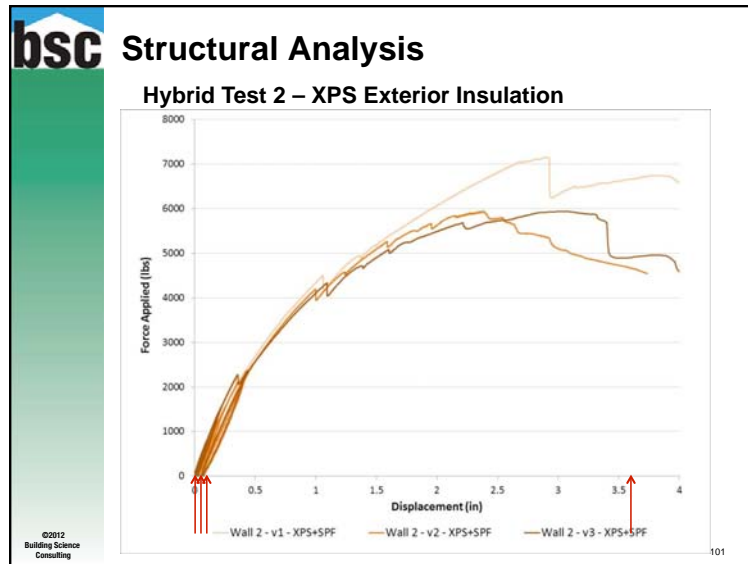


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Hybrid Test 2 – XPS Exterior Insulation



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DRAINAGE PLANE DETAILS

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#1 – Roof to Wall Flashing. In the photograph to the left, a roofing membrane has been run up the wall from the roof sheathing and step flashing is properly installed with the shingles. However, it is not clear that the roof membrane bridges to the roof deck and the top of the membrane strip is not properly integrated with the surface of the insulating sheathing. BSC recommends that sheathing tape be used to terminate the top of the membrane, or—better—the membrane be regletted into the insulating sheathing.

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#2 – Similar Roof to Wall Detail. No transition membrane or step flashing has been installed.

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#3 – Similar Roof to Wall Detail. Here there is no membrane but step flashing has been installed. Note that in this case, the drainage plane is not carried over onto the roof surface but instead will allow water to drain behind the step flashing.

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#4 – Bottom flange of window. The bottom flange of this window has been sealed with flashing tape. This will not allow the window unit and window opening to be drained to the exterior as intended. This issue is typically resolved easily by removing the tape and discussing with the installer.


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#5 – Sheathing tape. In the photograph to the left, the sheathing tape has not been rolled after application and ‘bubbling’ of the tape has occurred. Even on a vertical joint, this increases the risk of water penetration and must be correct.


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This photograph shows the exterior of a house under construction. A dormer window is visible, with its sheathing and weatherstripping being installed. The roof is partially shingled, and the sky is blue with some clouds.

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This close-up photograph shows blue Weathermate construction tape being applied to a surface. The tape has the brand name 'Weathermate' and 'Dow' printed on it in white and blue. A red UL logo is visible in the upper left corner of the image.

bsc Making the sheathing water tight



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This close-up photograph shows blue Weathermate construction tape being applied to a surface. The tape has the brand name 'Weathermate' and 'Dow' printed on it in white and blue. A red UL logo is visible in the upper left corner of the image.

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This photograph shows the exterior of a house under construction. The walls are covered in blue Weathermate construction tape. The roof is partially shingled, and the sky is blue with some clouds.

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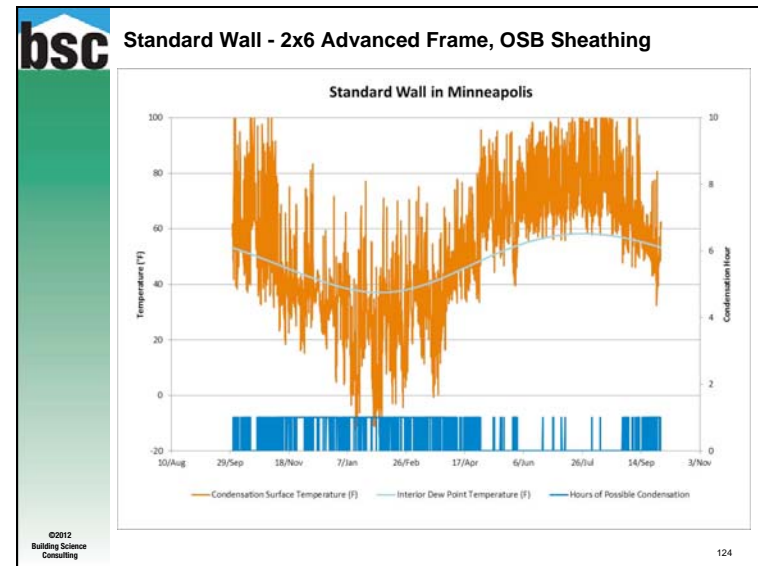


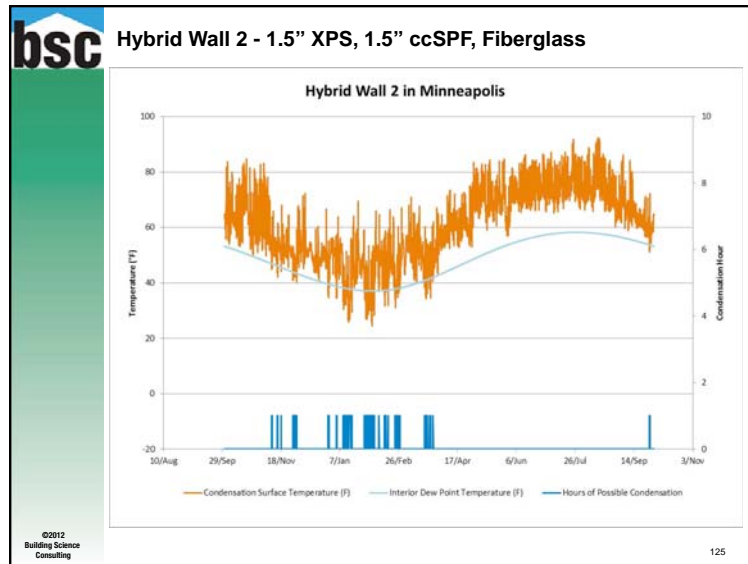
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FINISHING DETAILS

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Tricky finishing details

#1 – Deck ledgers. The ledgers for attached decks should be “stood off” the structural frame to allow for continuous insulation and a continuous drainage plane down to the foundation wall level. This detail is at lower risk of water-related damage because the attached decks in the Wyandotte house designs are well sheltered by a porch roof.

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Tricky finishing details

#2 – Corner and banding trim boards. Trim boards are typically being installed in direct contact with the sheathing. It is not clear that proper flashing details are being provided to direct water over and away from the back side of the trim. Adding furring behind these trim boards would greatly decrease the risk of water damage. Another trim-related issue is the provision of adequate blocking behind the insulating sheathing for trim attachment. This is being addressed by the framing crews.

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bsc Tricky finishing details

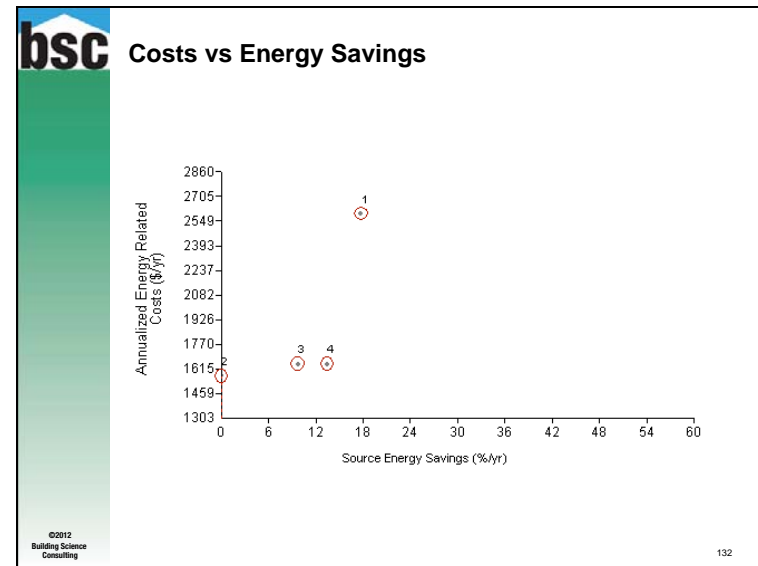
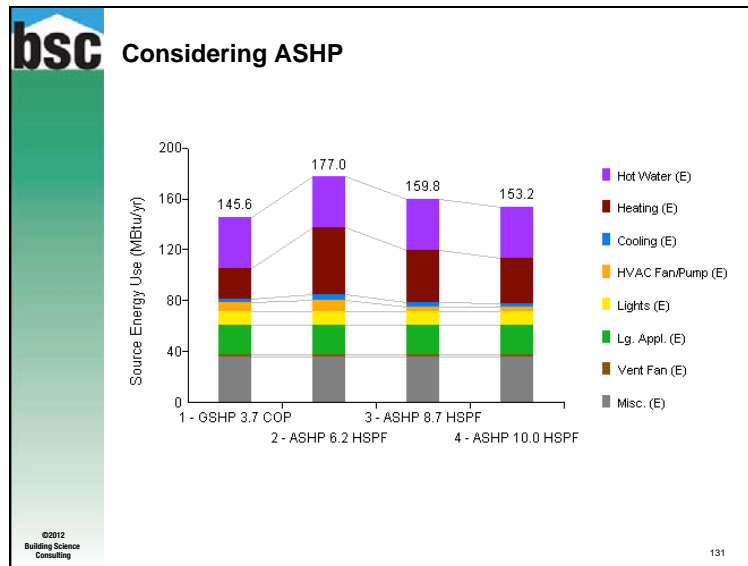
#3 – Water table. There are two issues pictured to the left. The first (1) is that mechanical penetrations through this trim board are not properly flashed. The second is that a regletted flashing must be installed over the trim board to direct water over and away from the small gap behind the trim board.

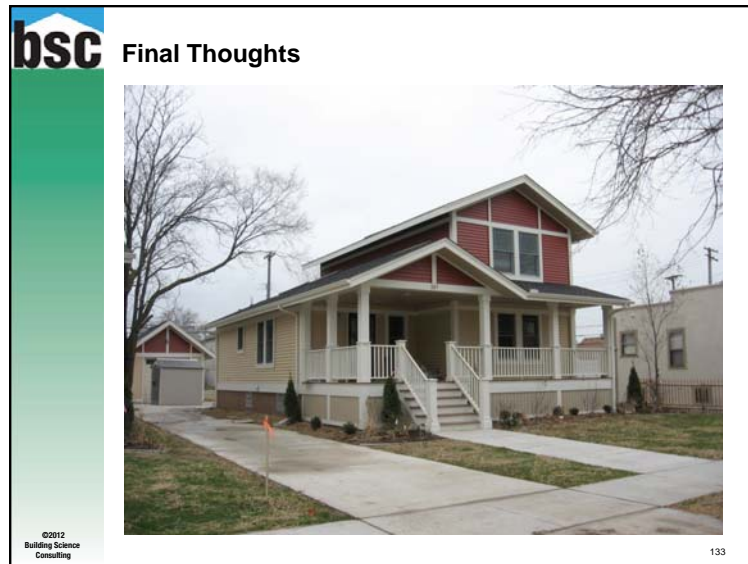
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AIR SOURCE HEAT PUMP AS OPTION

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Final Thoughts

- Achieving a coordinated approach between the architectural plans and the mechanical system design and installation.
- Supporting multiple builders as they adjust to new construction techniques and new materials.
- Implementing a quality control process based on performance testing and feedback for the builder, specifically in the areas of air sealing and cladding attachment.
- Adjustment of plans and specifications to incorporate solutions for issues observed on site, specifically involving framing and water management details.
- Developing a plan for marketing to buyers and educating homeowners.

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Resources

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

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Resources

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




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Resources

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



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Questions?

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