Commercial Wall Designs using Continuous Insulation (CI) under Cladding

BCBEC Vancouver and Victoria

May 25th & 26th, 2011

BCBEC

Dow Building Solutions

JRS ENGINEERING
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Presenters: Les Yard and Scott Croasdale

Global Sustainability Concerns

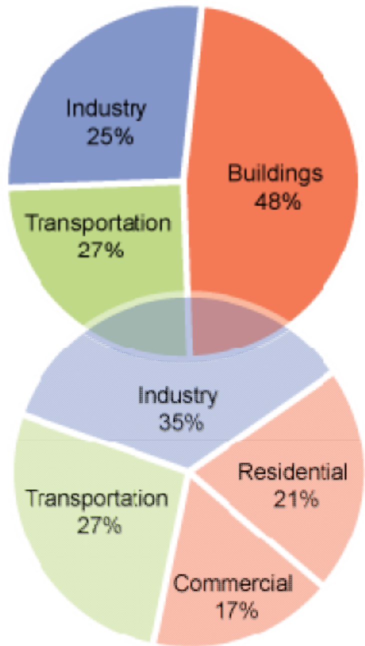
- Rising utility costs
- Climate change
- Natural resource depletion
- Landfill issues

The Greatest Impact

The building sector accounts for about 50% of all energy consumption and greenhouse gas emissions in the U.S. annually (in Canada about 40%).

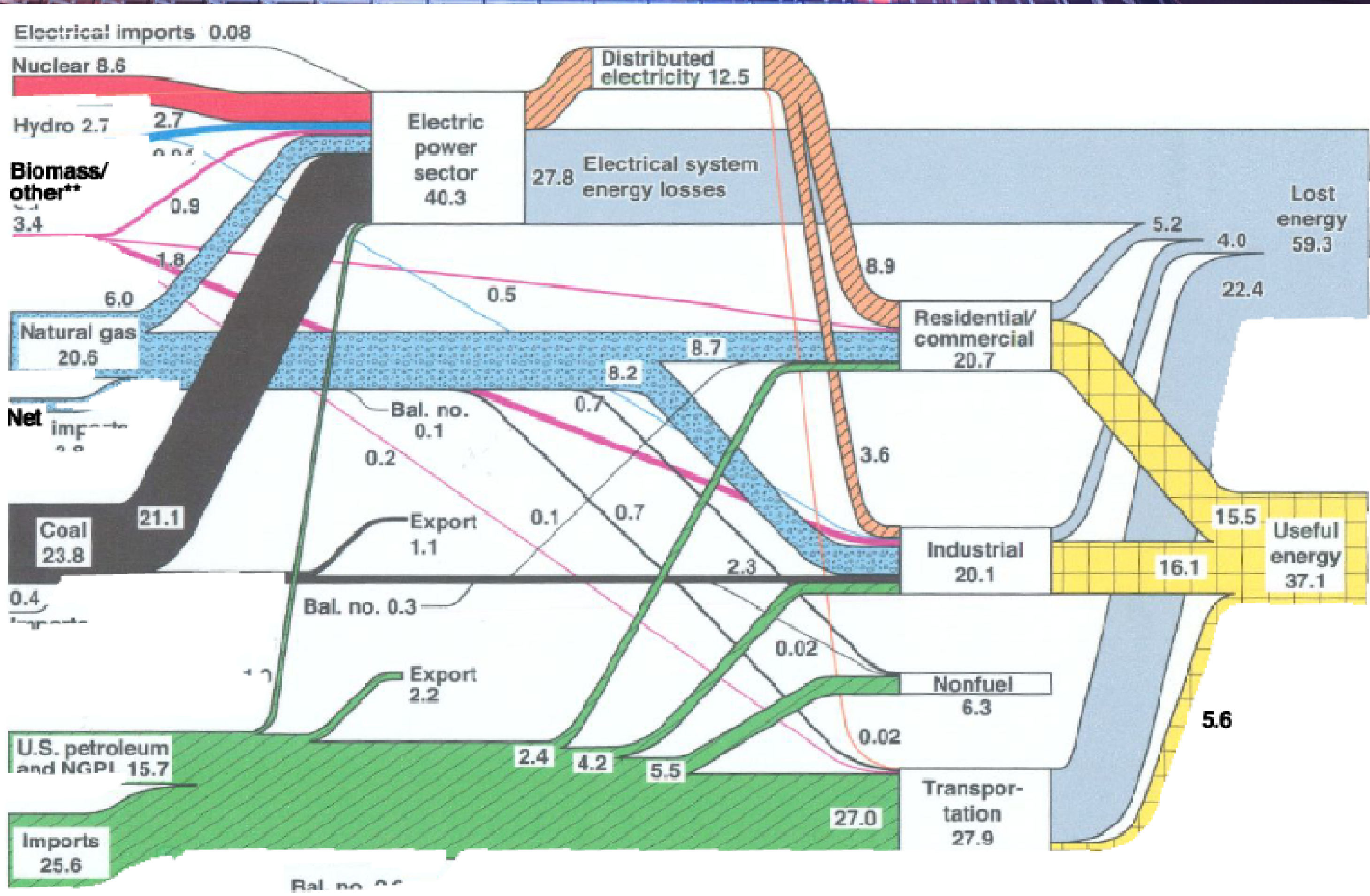
76% of all power-plant-generated electricity is used just to operate buildings.

[Source: Architecture 2030]



Why is Energy Loss with Buildings Important?

Saving one unit of energy at a building level actually saves 2.6 units of energy???



Source: Production and end-use data from Energy Information Administration, *Annual Energy Review 2002.*
*Net fossil-fuel electrical imports.
**Biomass/other includes wood, waste, alcohol, geothermal, solar, and wind.

June 2004
Lawrence Livermore National Laboratory
http://eed.llnl.gov/flow

Architecture 2030 Challenge

A global initiative to make all new buildings and major renovations reduce their fossil-fuel GHG-emitting consumption by 50% by 2010 and to be carbon neutral by 2030.

LEED 2009 – Priorities have been adjusted

Platinum
(80+ pts)

Gold
(60-79pts)

Silver
(50-59pts)

Certified
(40-49pts)

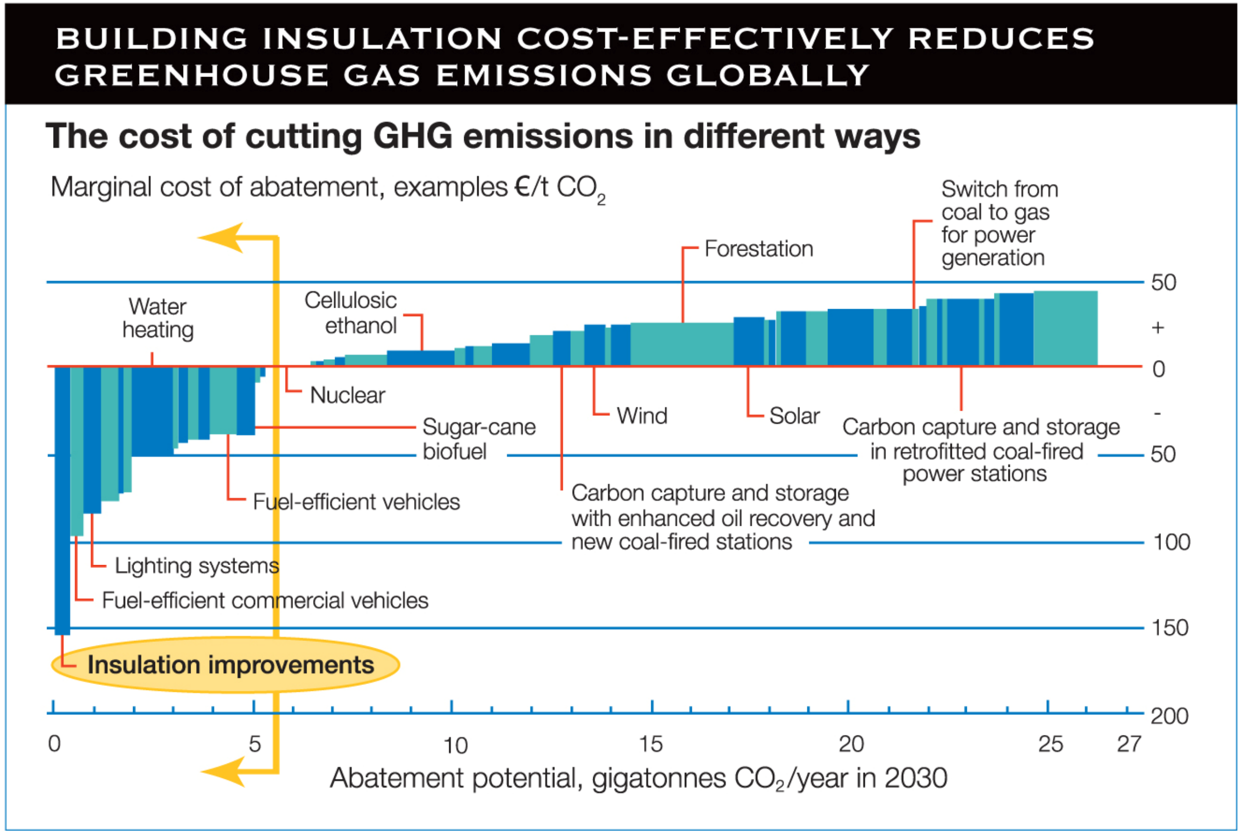
- 35% of base points from Energy and Atmosphere in LEED 2009 (versus 25% with orgininal LEED in 2000)
- Minimum Energy Performance (no points) is 10% higher that ASHRAE 90.1 – 2007 for new buildings

What is Sustainable Design?

- Constructing smarter more energy efficient buildings
- Making better and more efficient use of building materials
- What happens at the end of a buildings life (cradle to cradle…)
- Look closer and harder at building performance
  * Building monitoring – are buildings performing as well as we think?
  * Integrated design and a system approach to the building envelope
  * Holistic approach to making decisions on how to build

But what can have the greatest impact?

Greatest Value: Insulation

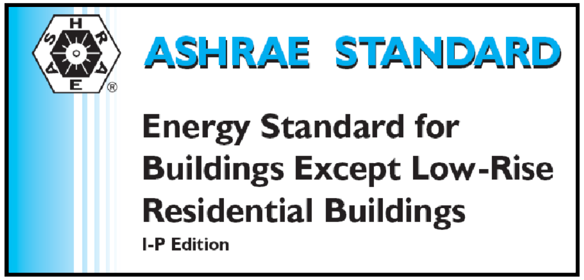


Source: Study conducted by McKinsey & Company, and Vattenfall

McKinsey & Company studied the costs of implementing various GHG abatement options. "Insulation improvements" is among the more economical measures at the left of the arrows that provide the fastest payback and should be implemented before doing any of the other measures. And as the graph shows, "insulation improvements" is by far the best measure in terms of a negative marginal cost. This graph represents only a few of the abatement options researched. For the graph in its entirety, visit www.mckinseyquarterly.com/A_cost_curve_for_greenhouse_gas_reduction_1911.


Not Just a "Nice to Do"

Increasing Regulation and Mandates



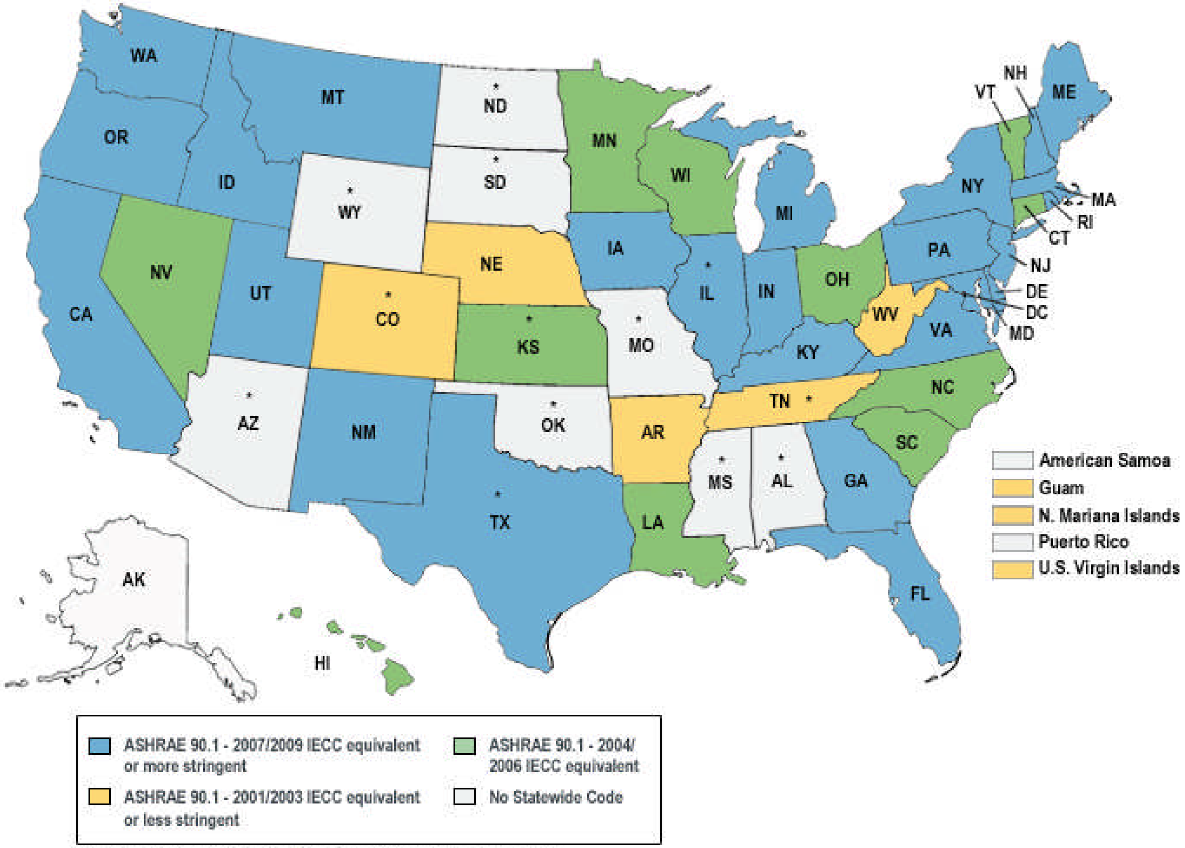
United States

- ASHRAE 90.1-2007 was incorporated into LEED 2009
- 19 US States Have Adopted ASHRAE 90.1 2007 Standards
- 35 States will have Adopted new codes by end of 2011, balance by 2012
- 66% of Major Design Firms are designing to 90.1 2007 standards or higher

Status of Code Adoption: Commercial

Overview of the currently adopted commercial energy code in each state

as of March 31, 2011



* Adoption by county/jurisdiction above state mandated minimum

Increasing Regulation and Mandates

Canada

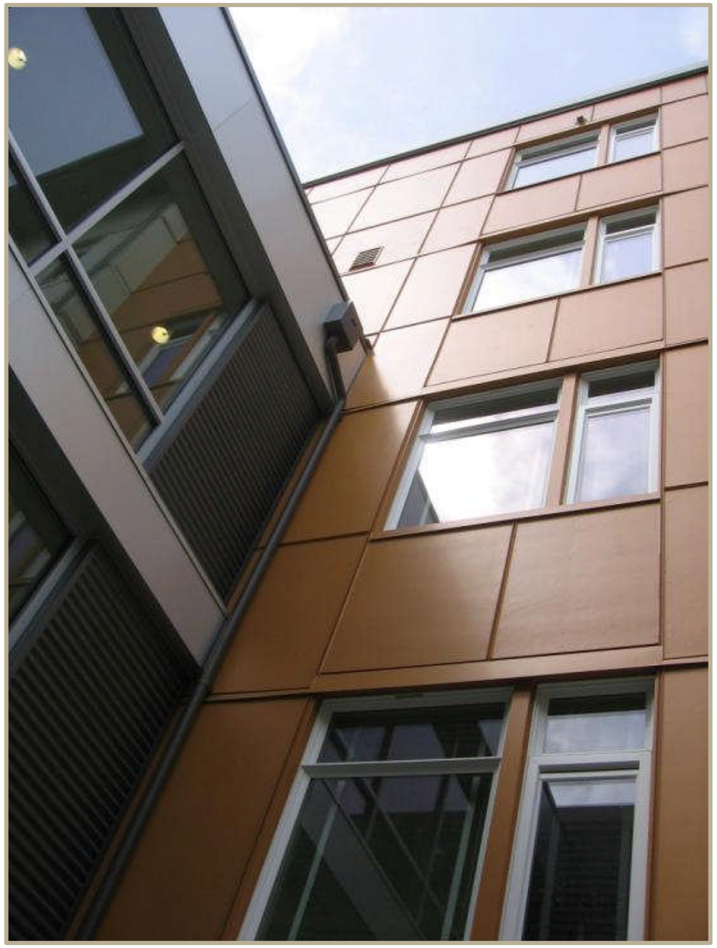
- **National Energy Code for Buildings (NECB 2011)**
- Scheduled for release in November 2011
- Expected to be 25% better than the MNECB 1997 (non-residential)
- Part 9 Buildings to be built to EG80

Increasing Regulation and Mandates

British Columbia

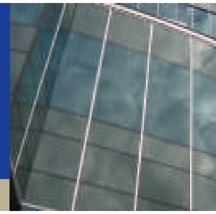
- **“Greening” BC Building Code Sept 2008**
- EG 77 (Part 9) and ASHRAE 90.1 -2004
- **“Further Greening” BC Building Code projected timing … Fall 2012**
- EG 80 (Part 9) – Focus is on Part 9 buildings
- Net Zero Ready Envelopes (continuous insulation required and possibly rainscreen mandatory throughout BC)
- **City of Vancouver – ASHRAE 90.1 2007 (’09)**

Building Envelope



- ✓ A well-designed envelope:
  - is durable
  - reduces heating & cooling requirements
  - enables use of smaller heating & cooling systems
- ✓ Primary goal to reduce heat transfer through increased levels of insulation and air-tightness

Heat Flow



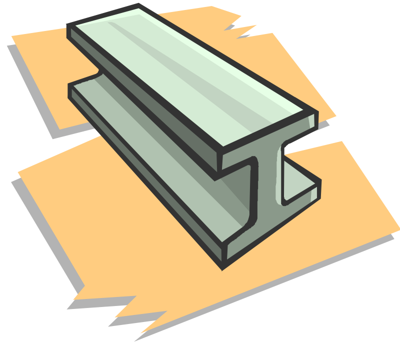
- ✓ Heat flows from regions of higher temperatures to regions of lower temperatures.
- ✓ Modes of heat flow:
  - ***Conduction*** – Transfer of heat through direct contact
  - ***Convection*** – Transfer of heat due to the movement of gas or liquid over a surface (air movement)
  - ***Radiation*** – Transfer of heat from one object to another due to electromagnetic waves

Thermal Resistance

- ✓ ***Thermal resistance*** is a measure of heat flow under uniform conditions. (heat flow per unit area)
- ✓ In construction, thermal resistance is typically expressed as R-value (ft^2•°F•h/Btu)
- ✓ U-value (Btu/ft^2•°F•h) is the reciprocal of R-value

Conduction

✓ Materials that conduct heat well are called *conductors*



- Metal is a good conductor
- High U-values / low R-values

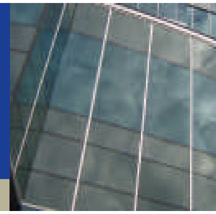
✓ Materials that do not conduct heat well are called *insulators*

- Foamed plastic, batt insulation are good insulators
- Low U-values / high R-values

Thermal Resistance

- ✓ ***R – Value:*** Generally refers to the thermal resistance rating of the insulation only.
- ✓ ***U – Value:*** Refers to the whole assembly.

Assembly R-values



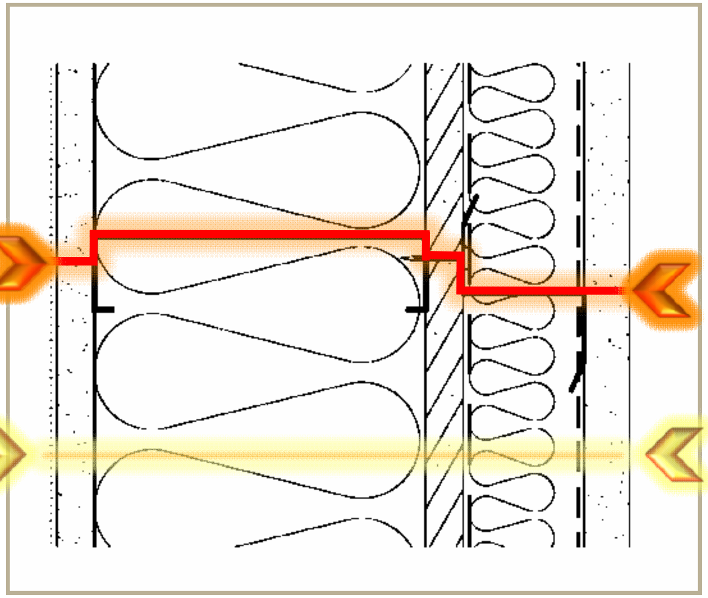
- ✓ Total assembly R-values typically less than insulation R-values, due to parallel heat flows through more conductive materials (wood/metal studs, window/door frames, floor structures)
- ✓ In light-gauge steel-framed assemblies, parallel heat flows through steel studs can reduce R-value by more than half!

Example: Steel Framed Wall Assemblies

Steel framing 16" on centre + 3.5" R-15 cavity insulation	Steel framing 24" on centre + 6.0" R-19 cavity insulation
Effective Insulation R-value = **6.0**	Effective Insulation R-value = **8.6**

Parallel Heat Flow Through Metal Framing

- ✓ Occurs through thermally-conductive parts of assembly
  - Studs, tracks
  - Floor, slab & roof connections
  - Structural members
  - Cladding support
- ✓ Effects
  - Reduces effective R-value; more insulation needed to achieve required R-value
  - Cold or warm spots that can cause stud shadowing and lead to condensation
  - Can result in comfort issues



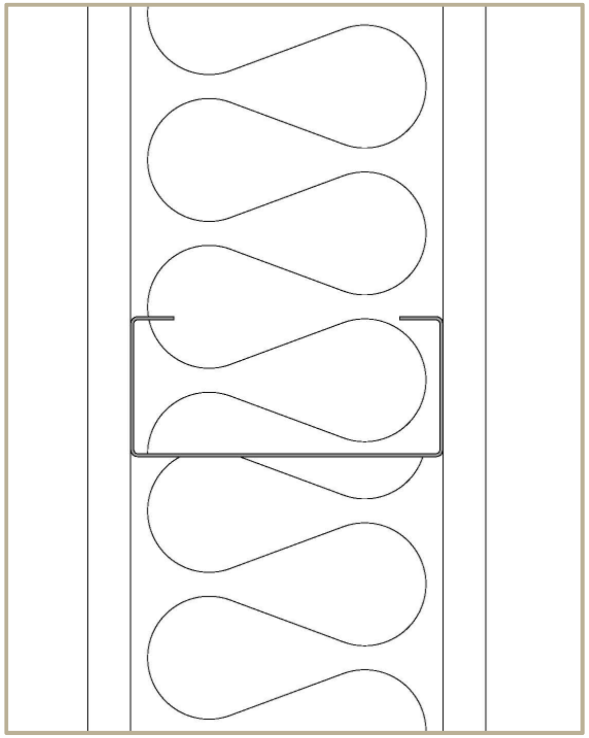
Calculating Effective R values (U)

- ✓ Effective R-value (R_{eff})of an assembly is calculated by area, averaging the R-values of the various components that are parallel and adding the R values that are in series
- ✓ Calculating system R-value is same as an electrical circuit (series and parallel relationship)

$$R_1+R_2+R_3 = R_{total}$$

$R_2 = 1/(A_i x 1/R_i + A_s x 1/R_s)$, where R_i is insulation, R_s is stud, A represents areas

Example: Standard Steel-Frame Wall



Element	R (Insul)	R (Framing)
1. ½" gypsum	0.45	0.45
2. 3 ½" batt Insulation	13.0	-
3. Steel framing	-	0.68
4. ½" gypsum	0.45	0.45
	R_1=13.9	R_2=1.58

U = 0.92(1/13.9) + 0.08(1/1.58) = **0.117**

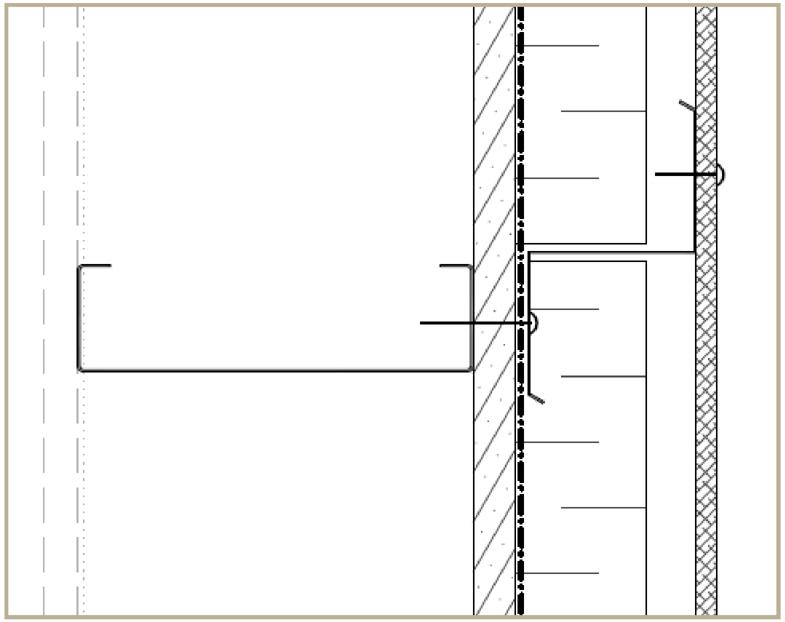
R_{eff} = 1/U= **8.6**

- Window and door openings, corners, etc. contain more framing and further reduce effective R-value

Exterior-Insulated Steel-Frame Wall

Conventional assembly

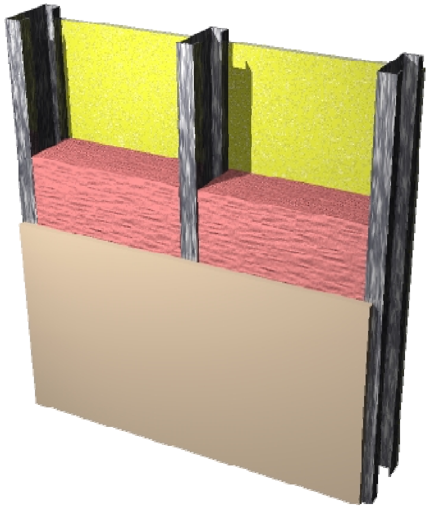
- cladding
- 3" vertical Z-girts
- 2-½" rigid insulation (R-12.5)
- self-adhesive membrane
- exterior gypsum sheathing
- steel framing
- interior gypsum wall board



Attachment girts penetrate exterior insulation, causing thermal bridges

Exterior Insulation ≠ Continuous Insulation

Effect on R-Value



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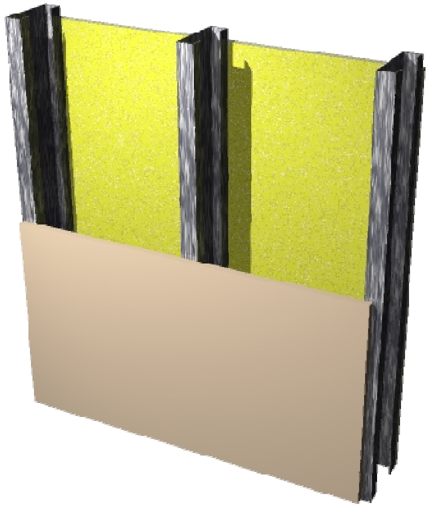

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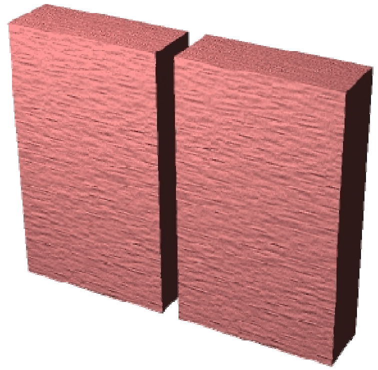
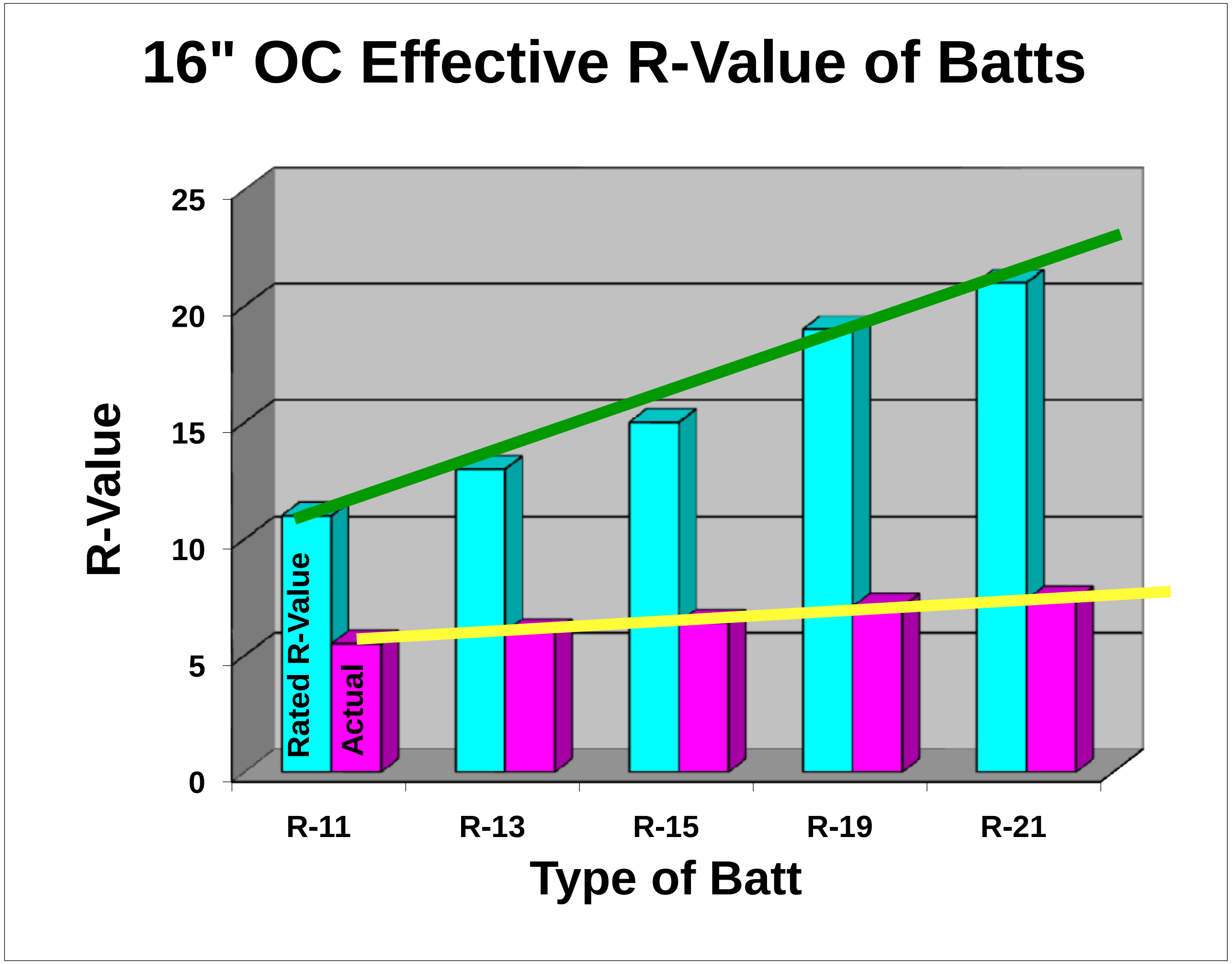
R-19 Batt



9.2 − 2.8 = **6.4**

34%

Effect on R-Value



Want & expect

Get

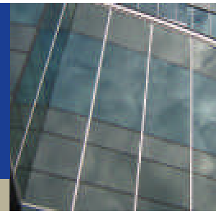
Effect on R-Value

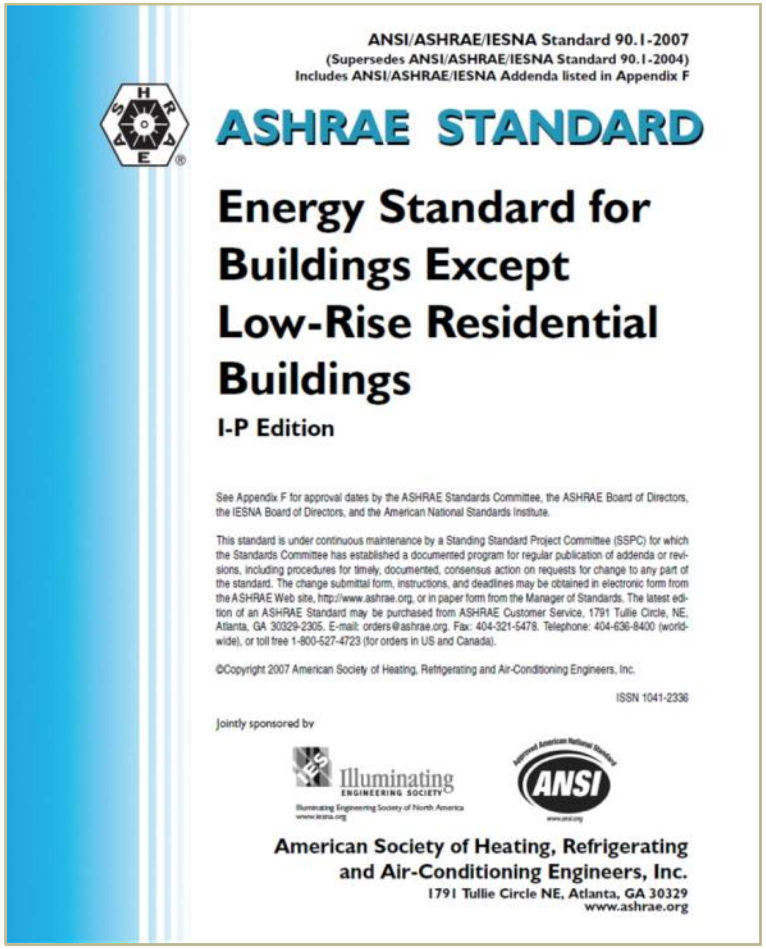
- **Effective R-value = R-value x Correction Factor**

Nominal Framing Depth	Nominal Insulation R-Value	Correction Factor	Effective R-Value
4” @ 16”o.c.	R-11	0.50	R-5.5
	R-13	0.46	R-6.0
	R-15	0.43	R-6.4
4” @ 24”o.c.	R-11	0.60	R-6.6
	R-13	0.55	R-7.2
	R-15	0.52	R-7.8
6” @ 16”o.c.	R-19	0.40	R-7.1
	R-21	0.35	R-7.4
6” @ 24”o.c.	R-19	0.45	R-8.6
	R-21	0.43	R-9.0

Data source: Adapted from ANSI/ASHRAE/IESNA Standard 90.1-2001.

What is Continuous Insulation?





ANSI/ASHRAE/IESNA Standard 90.1-2007
(Supersedes ANSI/ASHRAE/IESNA Standard 90.1-2004)
Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IESNA Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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ISSN 1041-2336

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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
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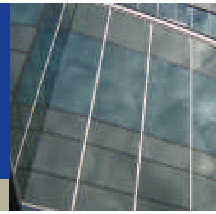
www.ashrae.org

Continuous insulation is defined by ASHRAE as follows:

> "***continuous insulation*** *(c.i.): insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior, exterior, or is integral to any opaque surface of the building envelope."*

Seattle Definition of CI



Seattle revised their energy code in November 2010 and added commentary to the definition of Continuous Insulation as follows:

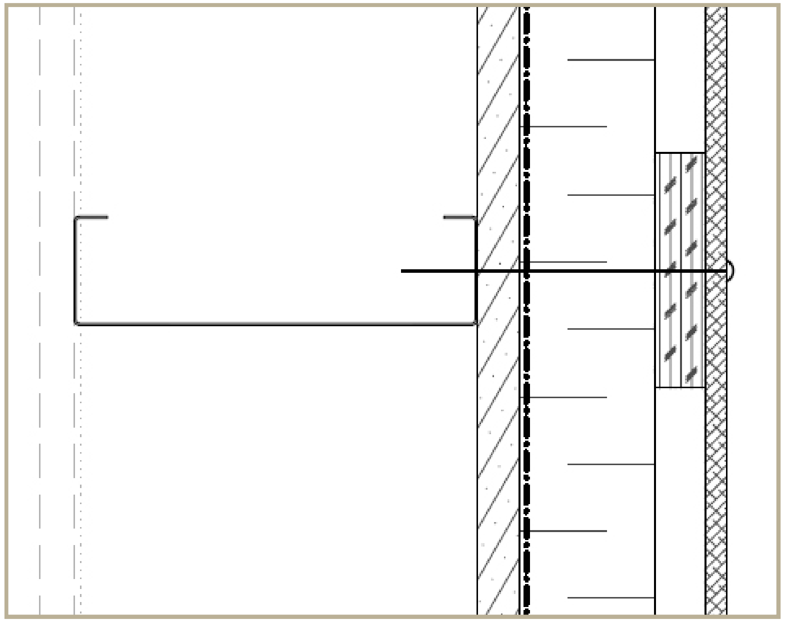
- ✓ *"CONTINUOUS INSULATION (c.i.): Insulation that is continuous across all structural members without thermal bridges other than fasteners (i.e. screws and nails) and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope. For the purposes of this definition of continuous insulation, only screws and nails are considered fasteners. Insulation installed between metal studs, z-girts, z-channels, shelf angles, or insulation with penetrations by brick ties and offset brackets, or any other similar framing is not considered continuous insulation, regardless of whether the metal is continuous or occasionally discontinuous or has thermal break material. (See Section 1332 for determination of U-factors for assemblies that include metal other than screws and nails.)"*

- ✓ *"Even isolated discontinuous metal elements such as brick ties have a thermal impact that is too large to be ignored."*

Continuous Exterior-Insulated Wall

CI-compliant assembly

- cement board / metal / stucco
- 1x4 plywood furring
- 2-½" rigid insulation (R-12.5)
- building wrap
- exterior gypsum sheathing
- 2x6 steel framing
- interior gypsum wall board
- vapor retarder

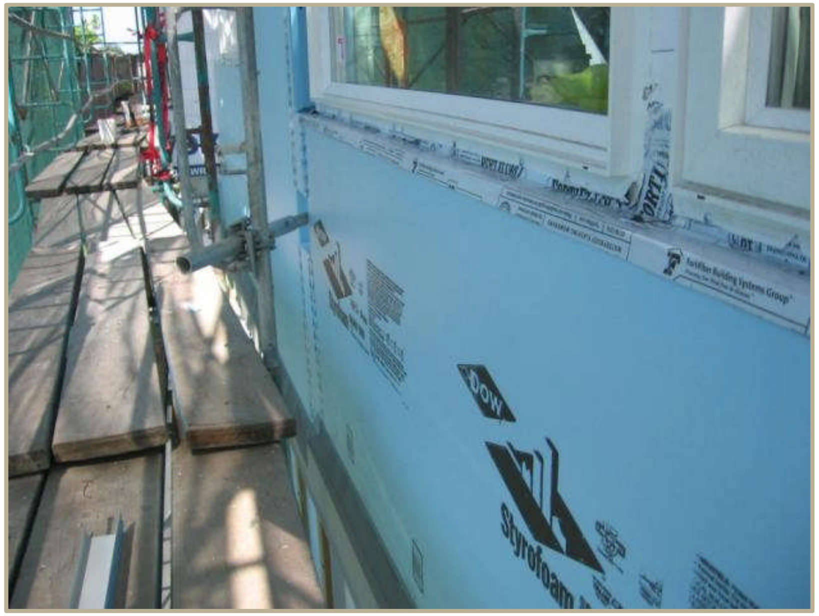


True continuous insulation

Bridging effect of fastener penetrations is considered negligible

Continuous Insulation (CI)

- ✓ No framing or other significant thermal conductors passing through the insulation (fasteners can be ignored)



- ✓ R_{eff} of insulation layer is rated R-value
- ✓ R_{eff} of wall assembly can be very high if combined with insulation in framing cavity (add layers)

Benefits of Continuous Insulation

✓ Advantages of using a CI assembly:

- Maximizes thermal efficiency; R_{eff} = nominal R-value
- Less insulation needed to meet required U-value
- Installed on exterior, keeps wall assembly warmer (in heating climates), reducing risk of condensation
- Eliminates thermal shorts (bridging)
- Improves occupant comfort
- Reduces material costs
- Can reduce labor costs

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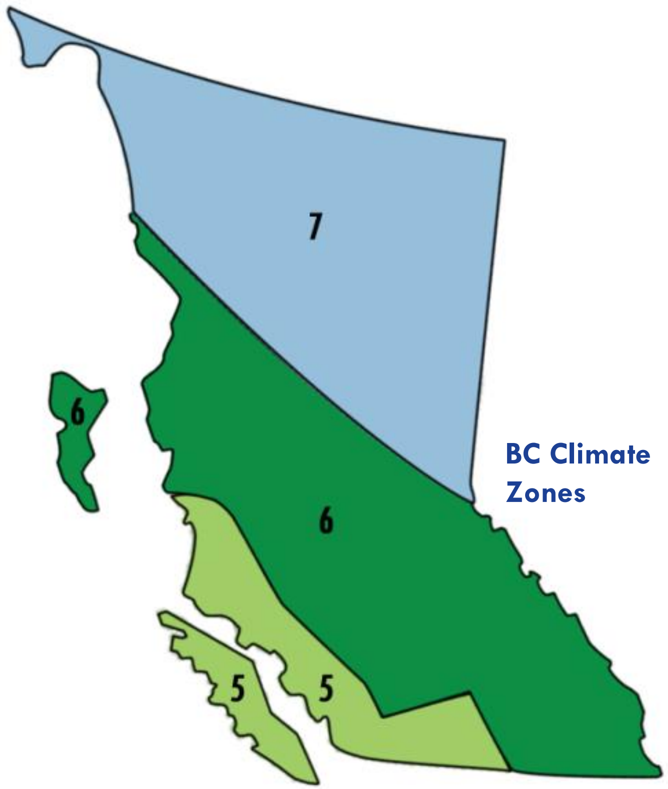
Energy Codes

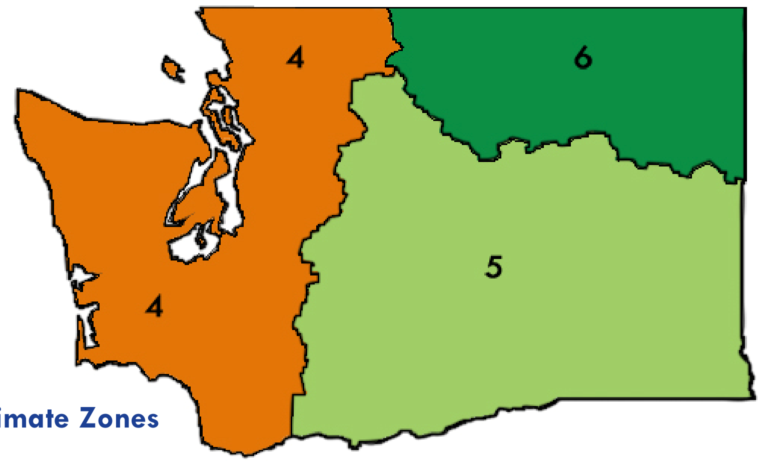
Prescriptive Insulation Requirements for Steel Framed Wall Assemblies (Non Residential)								
CODE	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
ASHRAE 90.1-2004 (BCBC)	13	13	13	13	13+3.8ci	13+3.8ci	13+7.5ci	13+7.5ci
2006 IECC	13	13	13	13	13+3.8ci	13+3.8ci	13+7.5ci	13+7.5ci
2009 IECC	13	13	13+3.8ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci
ASHRAE 90.1-2007 (CoV)	13	13	13+3.8ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci
2012 IECC	13+5ci	13+5ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci	13+7.5ci
Proposed Addendum bb to ASHRAE 90.1-2010 (4th addendum 'bb' out for public comment – 2013 inclusion)	13	13+3.8ci	13+5ci	13+7.5ci	13+10ci	13+12.5ci	13+12.5ci	13+18.8ci

ASHRAE and Energy Codes

- ✓ ASHRAE 90.1 Requires CI in steel-framed walls in almost <u>all</u> climate zones for prescriptive option. Residential occupancy has more stringent CI requirements.



BC Climate Zones



WA Climate Zones

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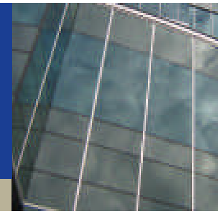
ASHRAE & Energy Codes – Example 1



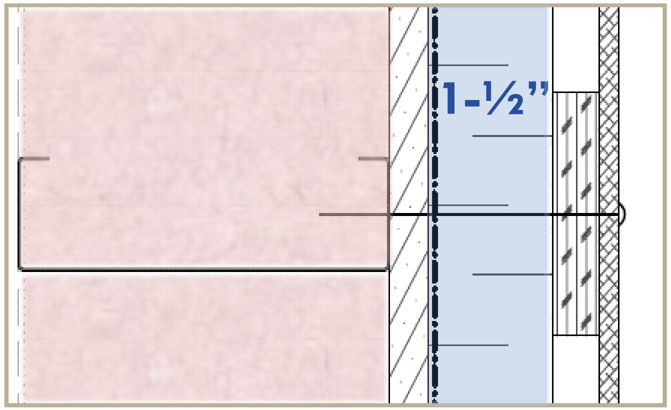
- ✓ Table 5.5-5 (Zone 5) required min. R-value is R-13+R-7.5 c.i. for steel-framed residential & non-residential walls

  U=0.064 or

  Reff = 15.6

TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[a]	R-5.7 c.i.[a]
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						



- ✓ R-value of R-13 + R-7.5 c.i. is equivalent to a 2x4 steel stud with R-13 batt insulation & **1-½ inches** of Type 4 (XPS) rigid foam insulation

ASHRAE & Energy Codes – Example 2

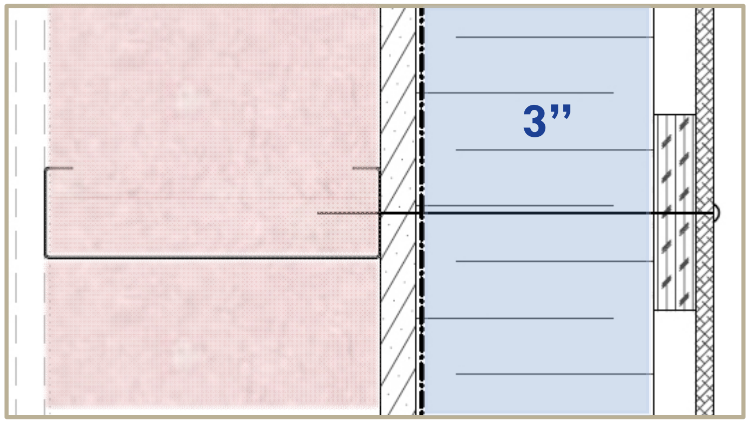
- ✓ Table 5.5-7 states required minimum R-13.0+R-15.6 c.i. for residential (Zone 7)

  U=0.042

  Reff = 23.8

TABLE 5.5-7 Building Envelope Requirements For Climate Zone 7*

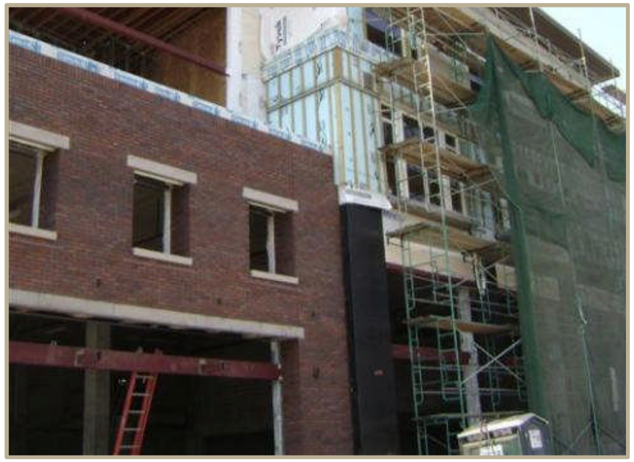
Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.093	R-10.0 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0
Walls, Above-Grade						
Mass	U-0.071	R-15.2 c.i.	U-0.071	R-15.2 c.i.	U-0.123	R-7.6 c.i.
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.042	R-13.0 + R-15.6 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.051	R-13.0 + R-7.5 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grad[illegible]						
Below-[illegible]all	[illegible]-0.119	[illegible]c.i.	C[illegible]	R-10.0 [illegible]	C-1.140	[illegible]



- ✓ R-13.0 + R-15.6 CI is equivalent to a 2x4 steel stud with R-13 batt insulation & **3 inches** Type 4 (XPS) rigid foam insulation

Considerations

- ✓ Assembly R values and thermal bridging often misunderstood
- ✓ Many steel-framed buildings in the Pacific Northwest do not include continuous insulation
- ✓ Most exterior-insulated cladding systems are interrupted by framing members
- ✓ Intended thermal performance often not met.



Thermally Bridged Assemblies

- ✓ Typical exterior insulated system
  - Steel framing members penetrate through spray-applied urethane
  - Framing used to attach cladding, significantly reducing R-value

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Thermally Bridged Assemblies

- Typical aluminum composite panel exterior installation system. Anchoring of panels with metal framing through mineral wool insulation reduces effective R-value.

DESIGN & CONSTRUCTION CONSIDERATIONS FOR CONTINUOUSLY INSULATED CLADDING SYSTEMS

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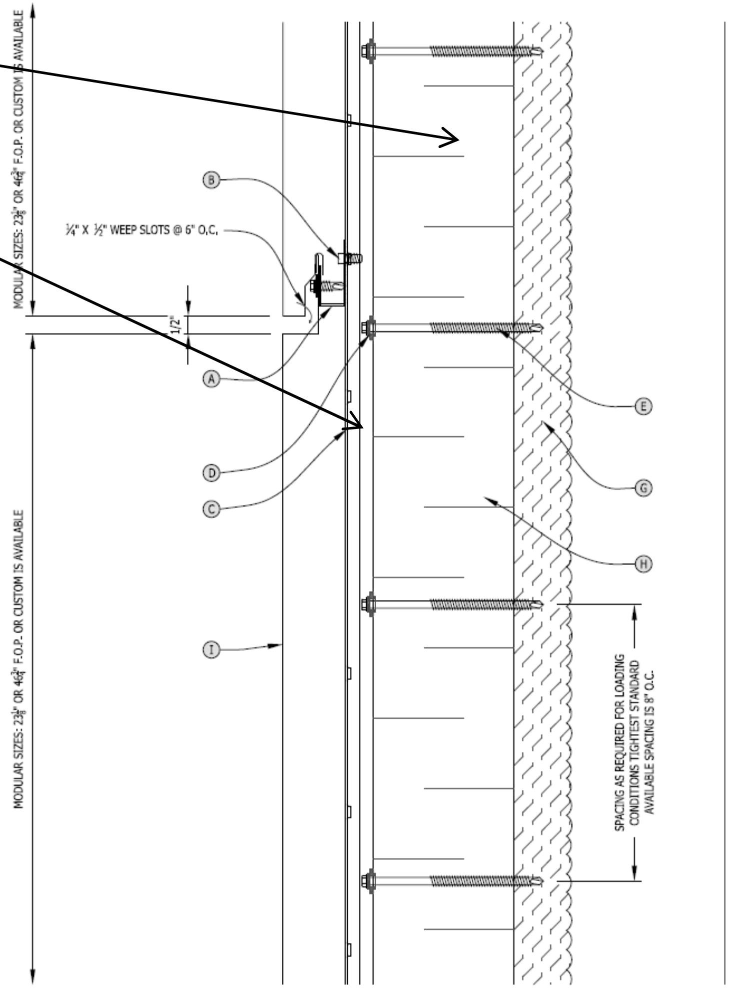
BUILDING ENVELOPE CONSULTANTS

Structural & Attachment

- ✓ Rely on structural characteristics of rigid plastic foam for support of cladding and to resist wind loads. Designer must specify sufficient bearing area to resist gravity and wind loads.
- ✓ Must connect cladding back to framing. This can be quite difficult when dealing with thick insulations and multiple cladding attachments.

Structural & Attachment

- ✓ 25psi = 3600psf
- ✓ Exterior furring strips transfer gravity and wind load through foam
- ✓ Loads are transferred through exterior frame or cladding to foam resulting in <u>compression load on the foam</u> and <u>tension load on the fastener</u>.
- ✓ Shear load similar to conventional attachment.



Structural & Attachment

- ✓ 3,500 lb Concrete Block supported by metal furring on Dow Thermax rigid insulation.
- ✓ Deflection minimal.

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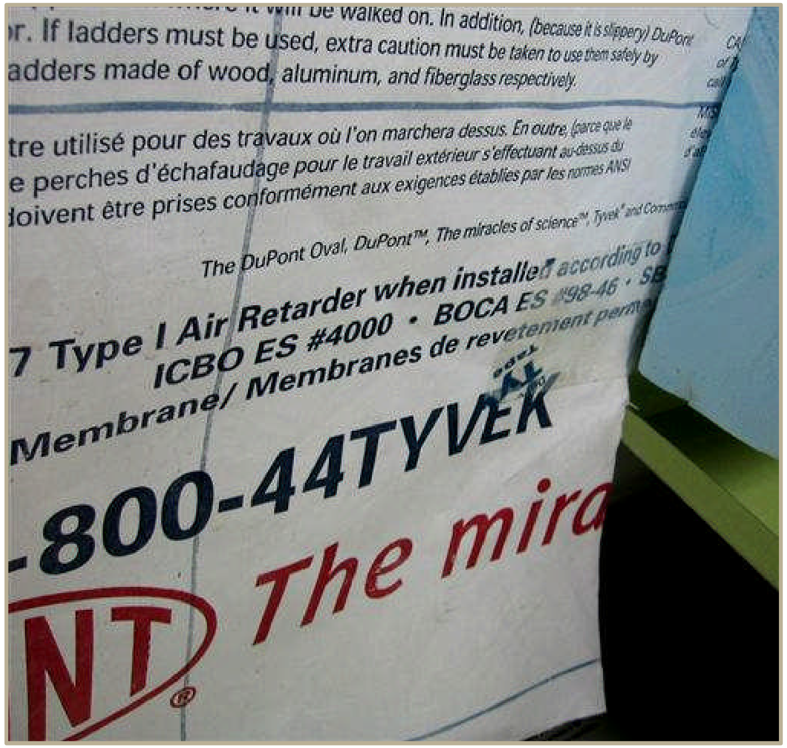
BUILDING ENVELOPE CONSULTANTS

Structural & Attachment

- ✓ Rigid exterior frame or connection system simplifies connections and can allow manufacturers standard connection requirements to be met. But designers must be aware of differences.
- ✓ Optimize number of fasteners. Too many can reduce insulation performance.

Air Barrier

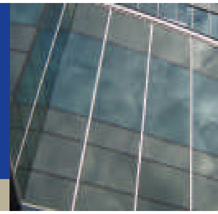
- ✓ Importance of air barrier to energy-efficient wall assemblies cannot be ignored. Air leakage can result in significant energy losses.
- ✓ Must be structurally adequate to withstand wind loads for the design life of the wall assembly.
- ✓ If rigid foam is used as the air barrier, it must fulfill this structural and durability requirement.



Moisture / Vapor Barrier

- ✓ Moisture barrier can be surface of the insulation or an underlying membrane.
- ✓ Insulation can act as a vapor retarder, but will warm the assembly, reducing condensation potential

Systems Approach



- ✓ Applying insulation to the exterior of the building frame is the most practical way to comply with the c.i. requirement.
- ✓ Adapting various claddings to c.i. systems requires systems approach to address, structural attachment, moisture management, vapour and air leakage control.
- ✓ To support the widespread adaptation of c.i. systems, manufacturers could take the route of providing a systems approach to the entire wall assembly, similar to roofing assemblies.

Current Systems

- ✓ Dow Thermax™ Total Wall System – includes exterior rigid insulation sheathing combined with interior closed cell spray foam. This system provides the thermal, air, moisture and vapor barriers. It is adaptable to various cladding systems but careful attention must be paid to design.
- ✓ EIFS systems can include all of the above plus finished cladding. Limitation includes minimal capacity for drainage, limited choice of finishes and poor history of performance.

PROJECTS

JRS ENGINEERING
BUILDING ENVELOPE CONSULTANTS

Everett Fire Hall, Washington

- Replacement of failed face sealed EIFS cladding system with an exterior insulated rainscreen cement board and metal cladding assembly.

- Conventional insulated 2x6 wall with batt insulation and plywood sheathing.
- Covered with building wrap, 2” of XPS and treated plywood furring strips at 16” oc
- Effective R-25.
- Panels nailed to furring.

Everett Fire Hall, Washington

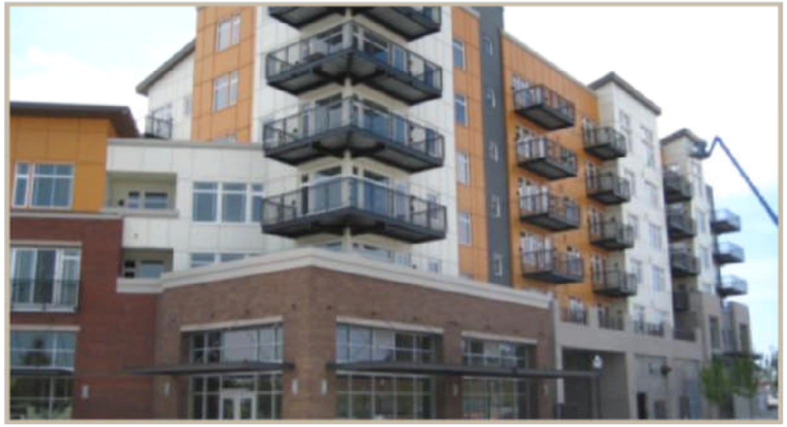
- Building wrap detailed as primary air barrier but detailed to shed to exterior.

- Face of insulation acts as moisture barrier. Building wraps strips installed in horizontal joints to shed to exterior.
- Furring is thick enough to satisfy manufacturer's nailing requirements and rigid to transfer dead and wind loads to insulation.

Everett Fire Hall, Washington

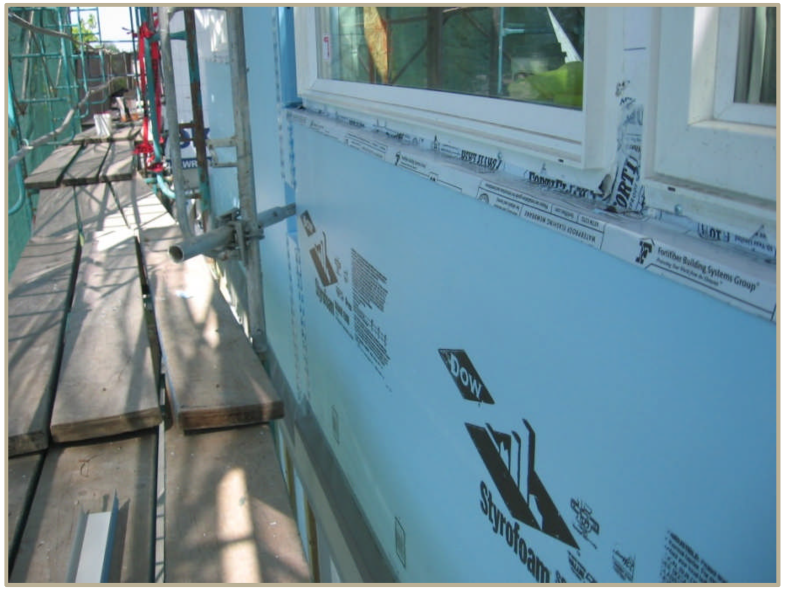
- 1x3 borate-treated plywood furring strips.
- 4-½” corrosion-resistant wood screws.
- Siding and trims nailed to furring.

Burien Town Square, Washington



- New 7 storey condominium building.
- Exterior insulated rainscreen cement board, metal, stucco and brick claddings.
- 2x6 steel stud back-up wall covered with fibreglass reinforced gypsum sheathing.
- 2-½" Type 4 (XPS) rigid insulation with no cavity insulation, Reff = 15.5

Burien Town Square, Washington



- Face of insulation detailed as the moisture barrier. Joints are taped and details shed over insulation.
- Building wrap detailed as air barrier but detailed to shed moisture to exterior.
- 1x4 borate-treated plywood furring strips screwed to steel stud walls with 5" self-tapping roofing screws.
- Siding systems nailed to plywood furring.

Hugh Bird Residence, Vancouver

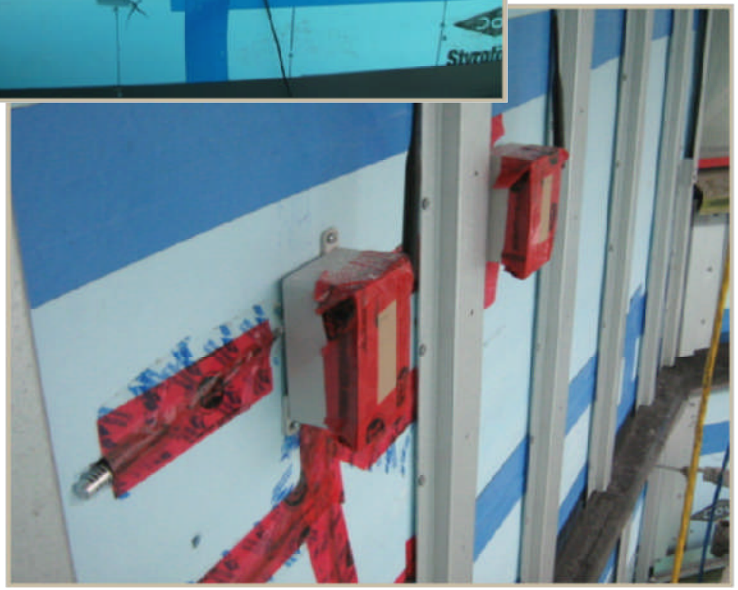
- Restoration of failed face-sealed stucco wall assembly with new exterior insulated rainscreen stucco, new windows and roofing.

- Wall assembly includes new drained stucco over vertical metal furring.
- Metal furring installed over 3” XPS insulation.
- 2x4 steel stud infill wall with fibreglass-faced gypsum sheathing.

Hugh Bird Residence, Vancouver

- Self adhered membrane installed over the sheathing acts as the air, vapour and moisture barriers.
- Insulation detailed as moisture shedding surface.
- Galvalume Z-girt furring channels transfer cladding weight and wind loads back through insulation to steel stud wall.

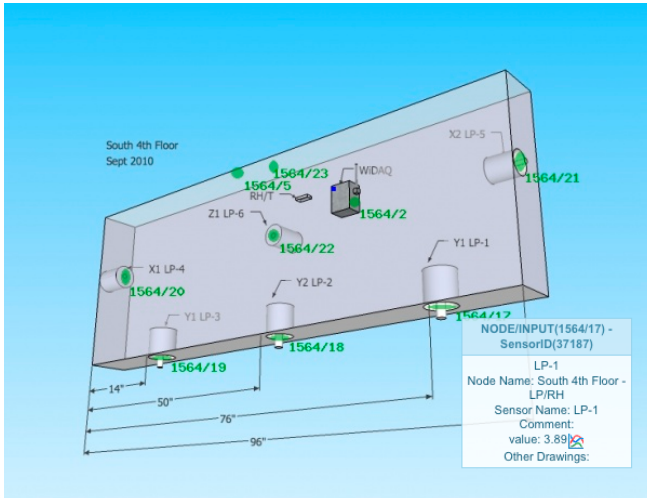
Hugh Bird Residence, Vancouver

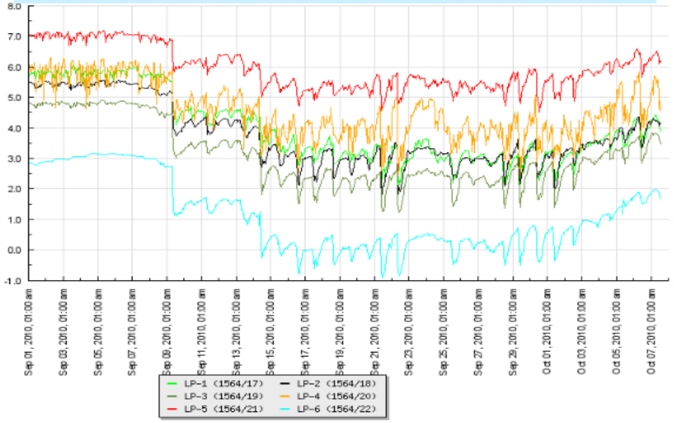


- Building was instrumented in six locations to measure cladding movement, temperature, humidity and heat loss.
- Data collection in initial stages.
- Deflection measured in x, y and z direction to 0.1mm.
- Interior side of wall at interior temperature and humidity.

Hugh Bird Residence, Vancouver

- Project monitored for 5 years





SMT
Structure Monitoring Technology

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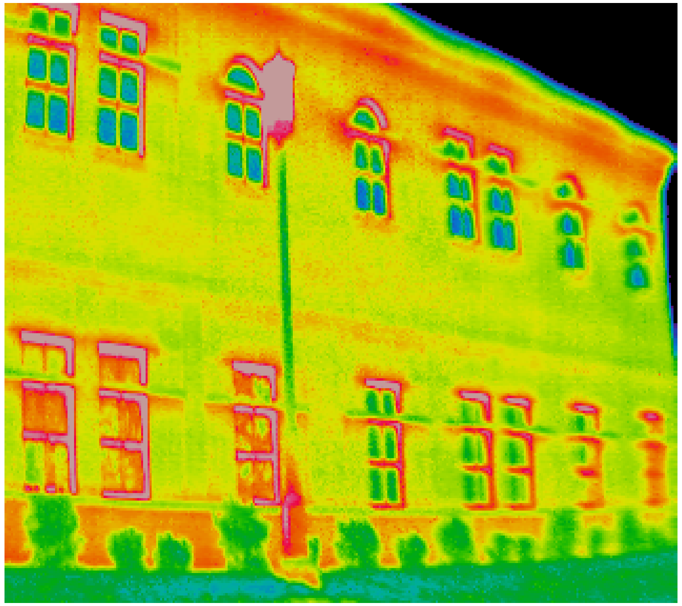
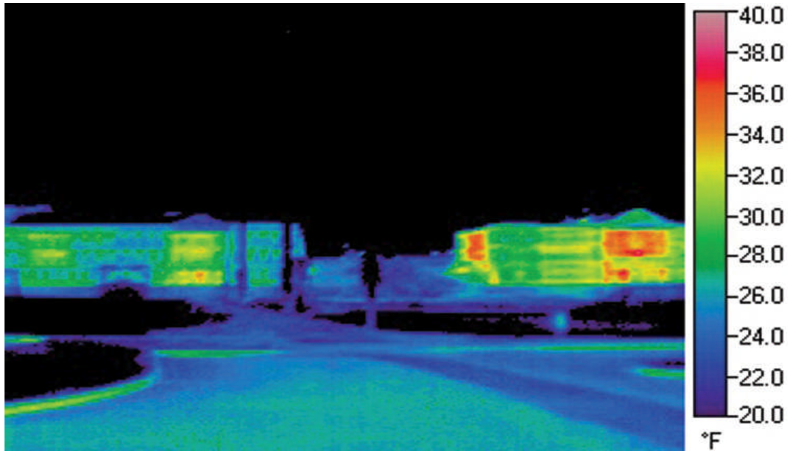
Moisture and Dust

Ghosting/Aesthetics

Cold or Warm Spots

Energy Loss/IR





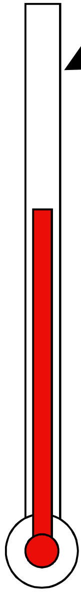
Responsibility to Clients

Energy Use

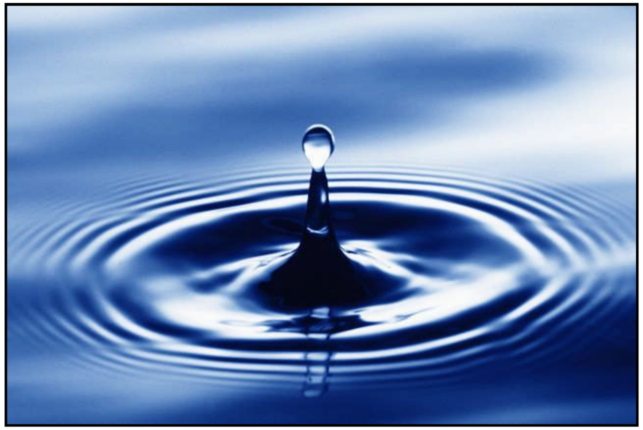
Environment

What about moisture?

What is Condensation?



Dewpoint

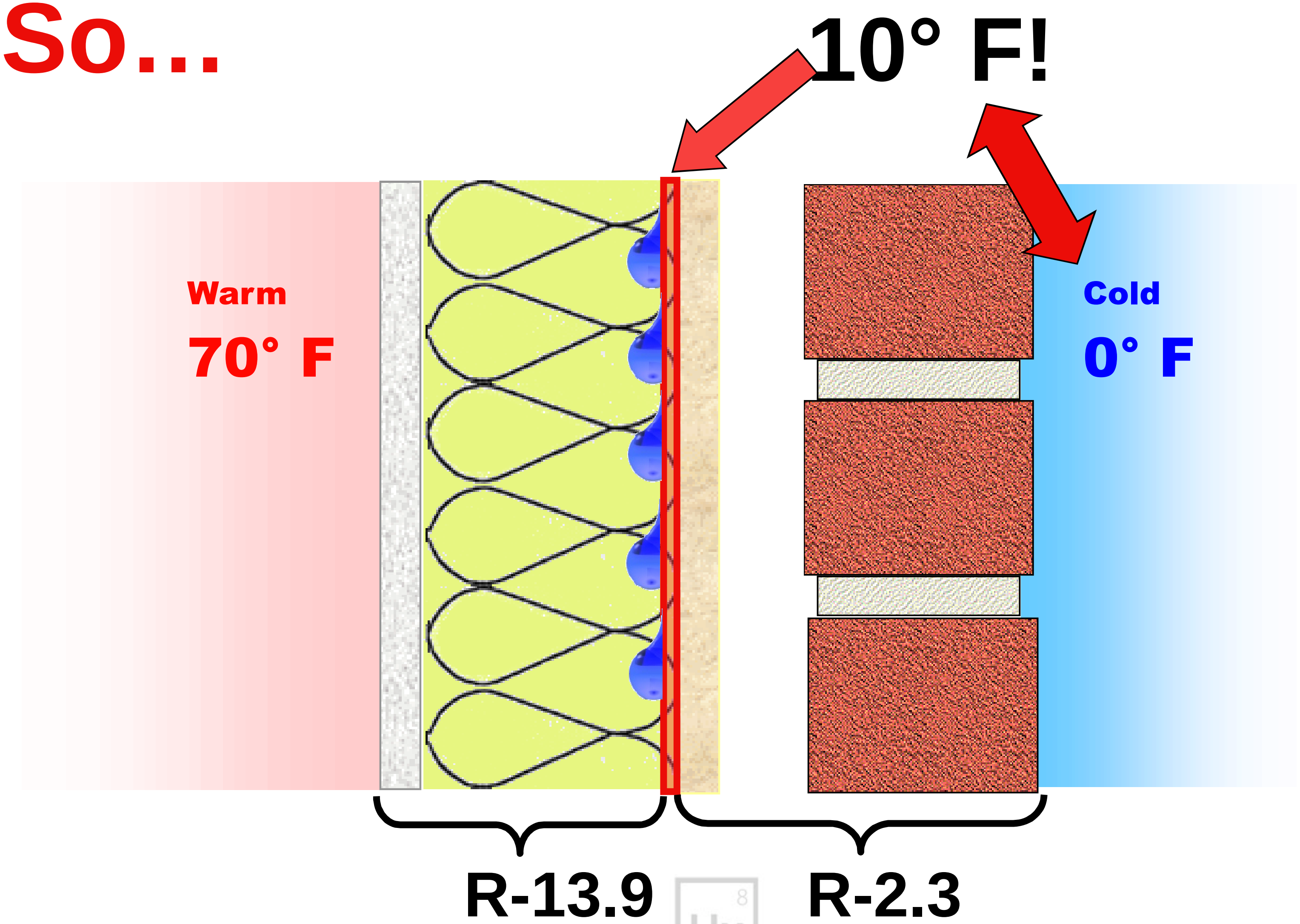


Vapor
(fog)

Liquid
(water)

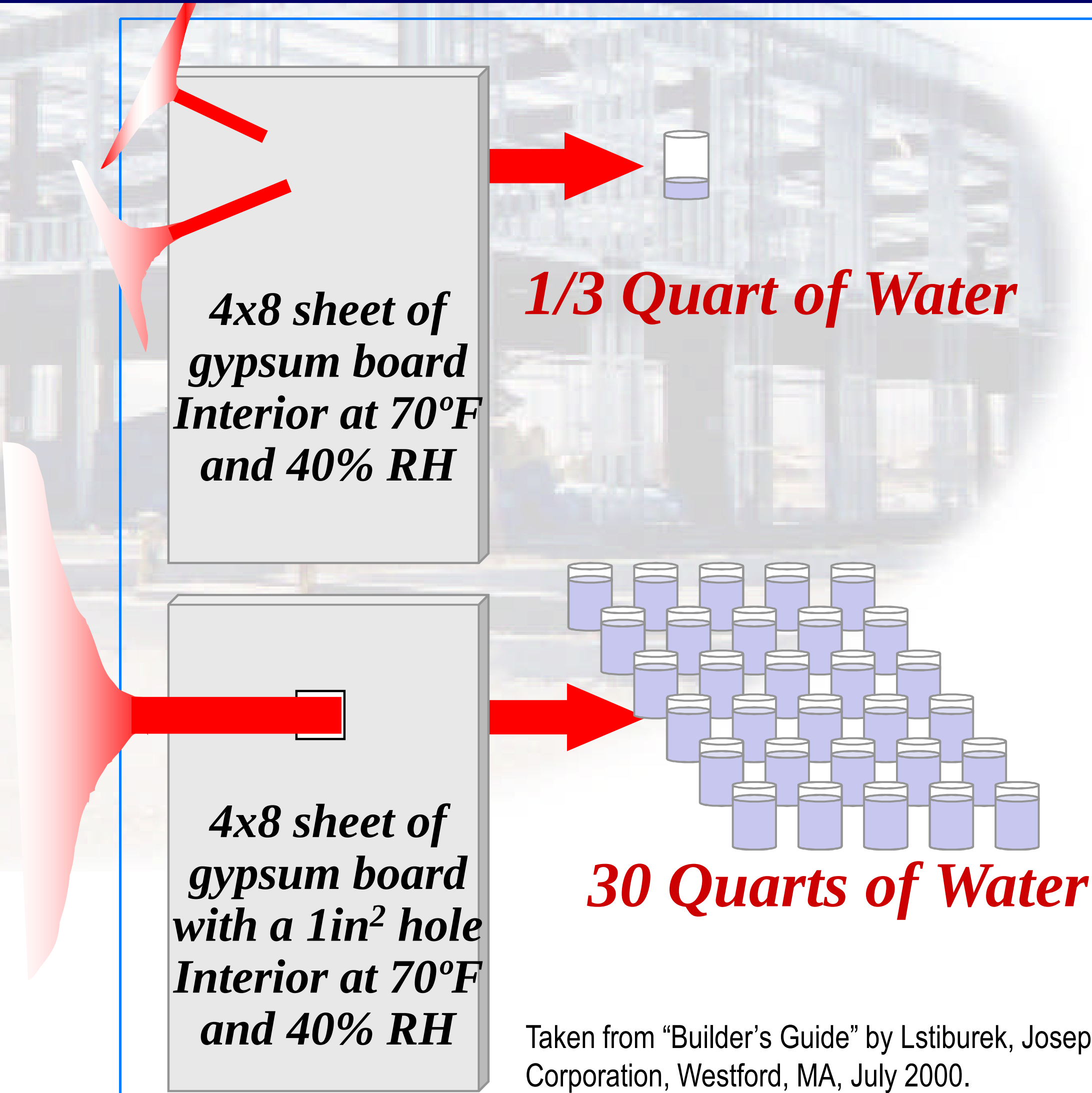
Condensation in Walls

So...



Moisture in Steel Stud Assemblies

Effects of Air Exfiltration/Infiltration



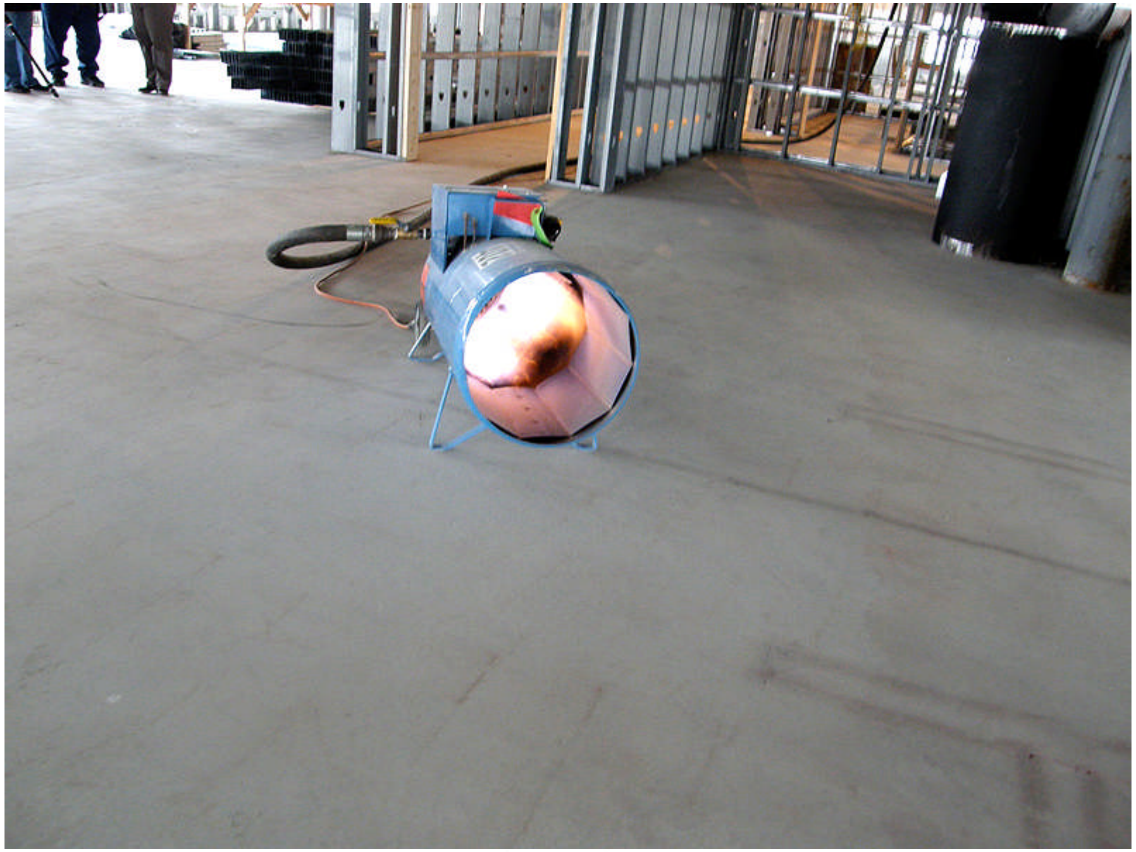
Vapor Diffusion

Air Exfiltration / Infiltration

Taken from "Builder's Guide" by Lstiburek, Joseph of Building Science Corporation, Westford, MA, July 2000.

Dow Building Solutions

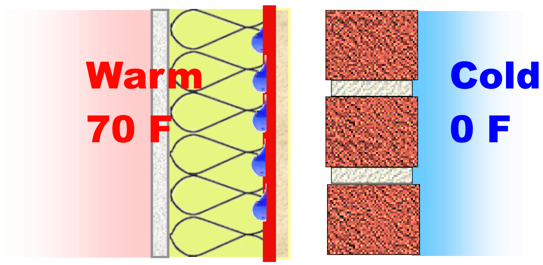
What about Construction Moisture?

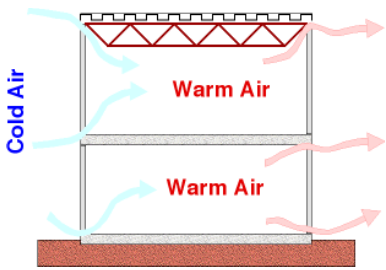


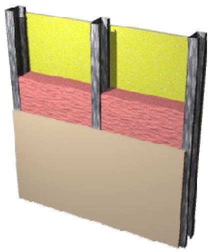
Regardless of it’s source… Moisture and Walls – not a good combination…

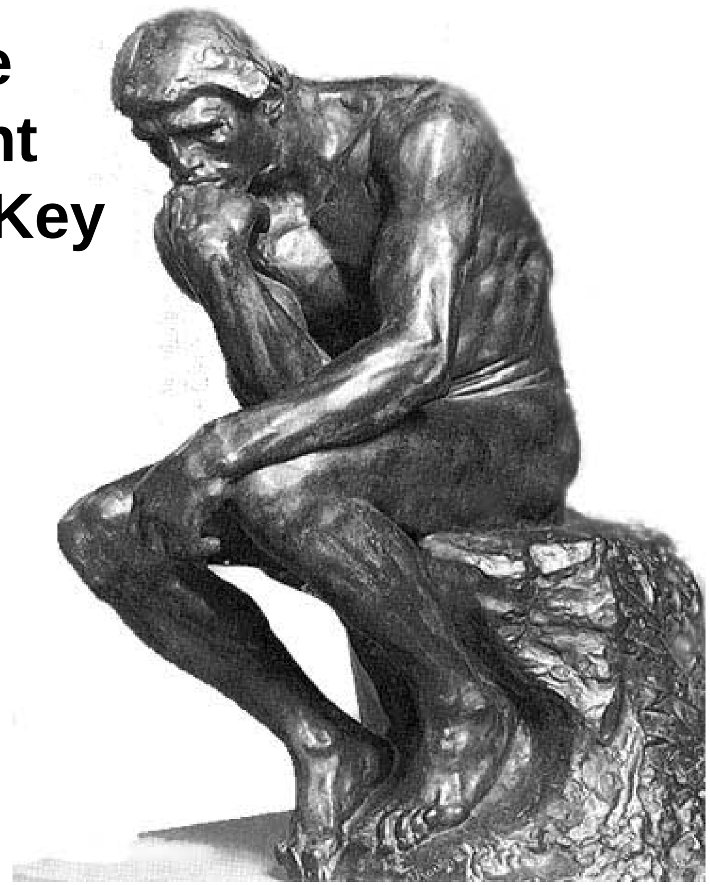
Summary of Challenges

- Codes Require Effective R-Value
- Resistance to Moisture Important
- Resistance to Air In/Exfiltration Key



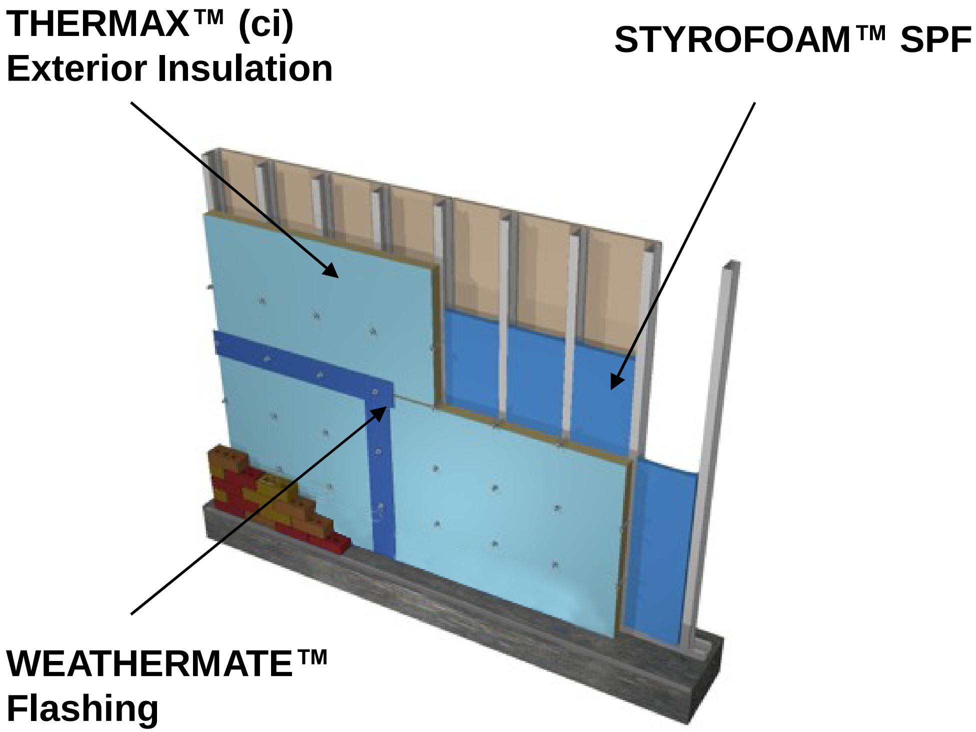






What to do?

THERMAX™ Total Wall System

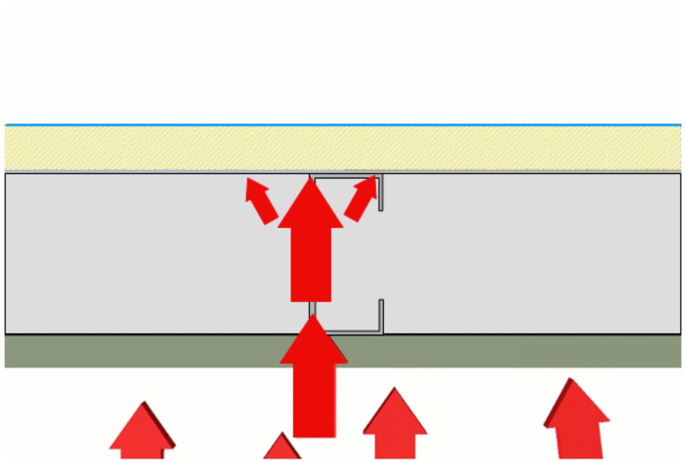


Coming to Canada in 2011!

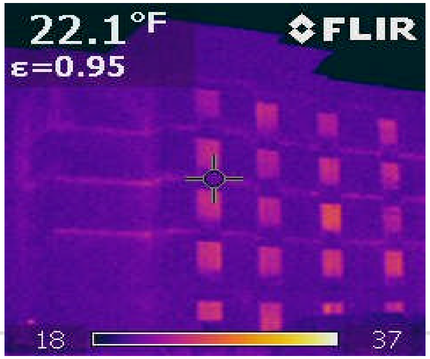
US Test Approvals

CTQ	TEST	PASS/FAIL	Comments
Fire Performance BRICK	NFPA285	PASS	NFPA285 is IBC Code Requirement for all plastic foam insulations within commercial wall construction.
Fire Performance METAL	NFPA285	PASS	NFPA285 is IBC Code Requirement for all plastic foam insulations within commercial wall construction.
Fire Performance STUCCO	NFPA285	PASS	NFPA285 is IBC Code Requirement for all plastic foam insulations within commercial wall construction.
Fire Performance Terracotta	NFPA285	PASS	NFPA285 is IBC Code Requirement for all plastic foam insulations within commercial wall construction.
CLASS A THERMAX ci	ASTM E84	PASS	Commercial insulation must achieve CLASS A ratings in order to used within commercial wall assemblies.
CLASS A CM2060	ASTM E84	PASS	Commercial insulation must achieve CLASS A ratings in order to used within commercial wall assemblies.
CLASS A CM2045	ASTM E84	PASS	Commercial insulation must achieve CLASS A ratings in order to used within commercial wall assemblies.
AIR Barrier	ASTM E2357	PASS	Systems must now be tested in the new Full Scale Wall test.
Water Barrier	ASTM E331	PASS	Systems must now be tested in the new Full Scale Wall test.

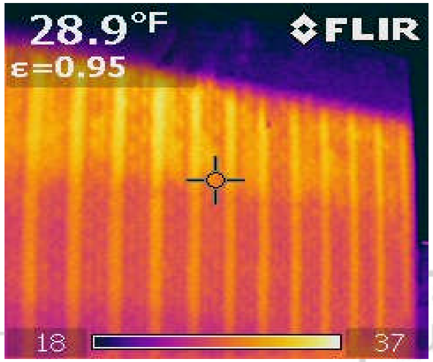
Thermax Wall System
SOLVES Thermal Shorts / Energy Loss

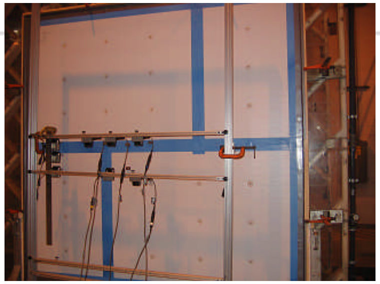


Thermax Wall System

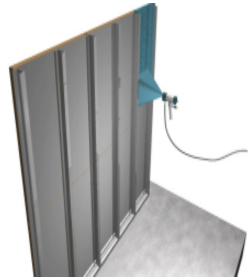


NO "ci"





Air Leakage Rates



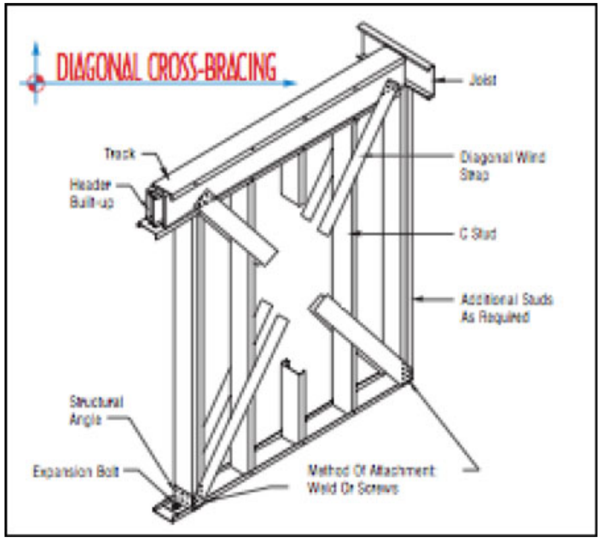
0.4 CFM 75/ft2 equates to a 1.5 in2 hole in 100 ft2 of wall area

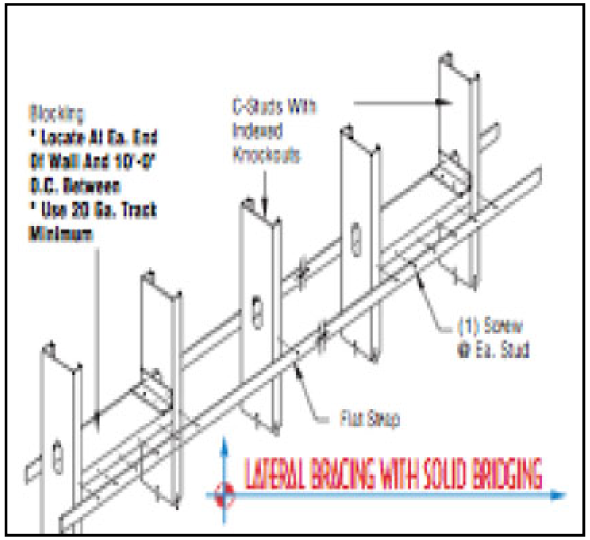
Standard	CFM 75/ft^2
UK, Good Practice	0.71
ASHRAE – Leaky	0.6
Washington State - Proposed	0.4
UK, Normal	0.36
ASHRAE – Average	0.3
LEED	0.3
Army Corps of Engineers	0.25
2012 Seattle Energy Code - Predicted	0.25
UK, Best Practice	0.14
ASHRAE – Tight	0.1
THERMAX WALL SYSTEM	less than .01 cfm at 75, 750 and 7500 Pa

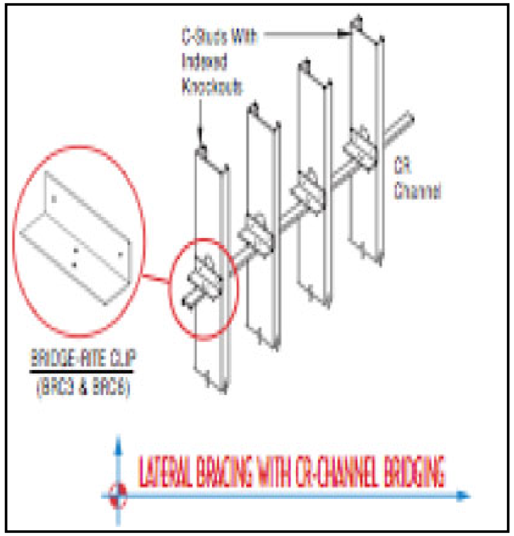
Canadian Code Compliance

CAN/ULC S705.1 and S705.2

Building Code Structural Options:

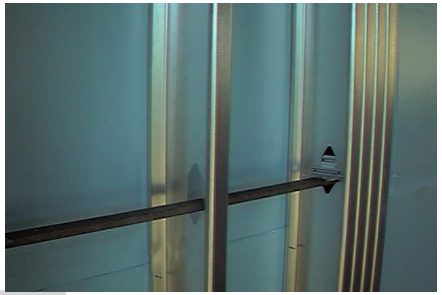


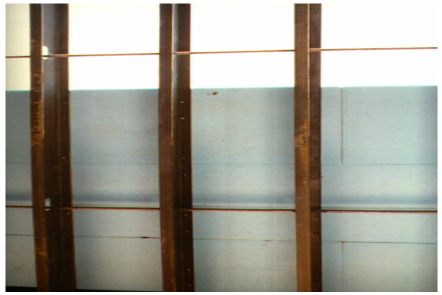




X Bracing

Channel Bracing





Multi-Storey Fire Test

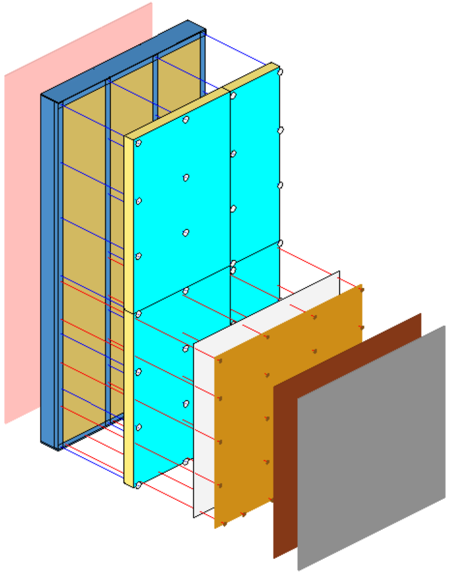
NFPA 285 Test with numerous claddings including metal panels

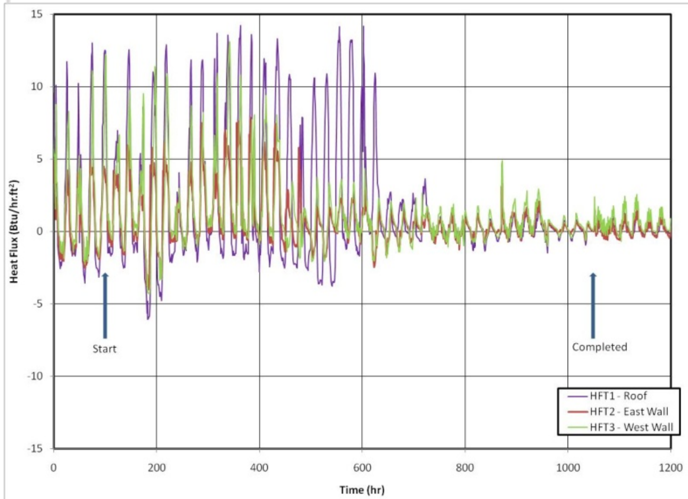
Is that the end of the story?

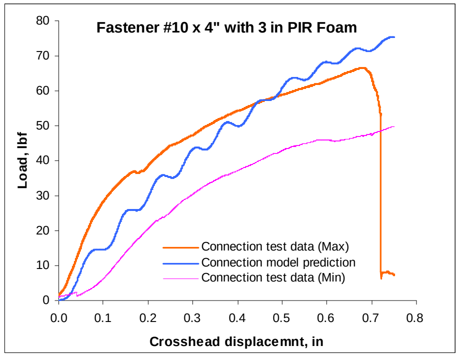
No… it is just the beginning…What is Dow doing…?

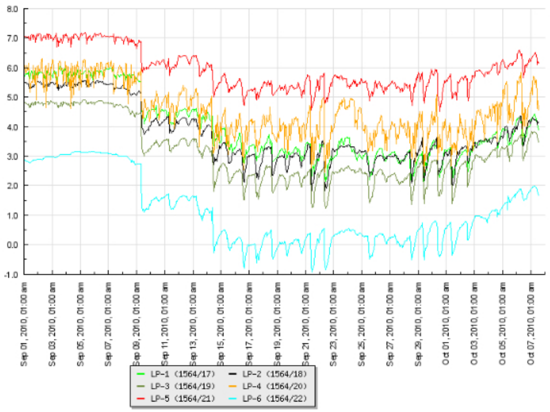
Dow Building Solutions

"ci" Case Studies









ORNL Case Study

Building Solutions

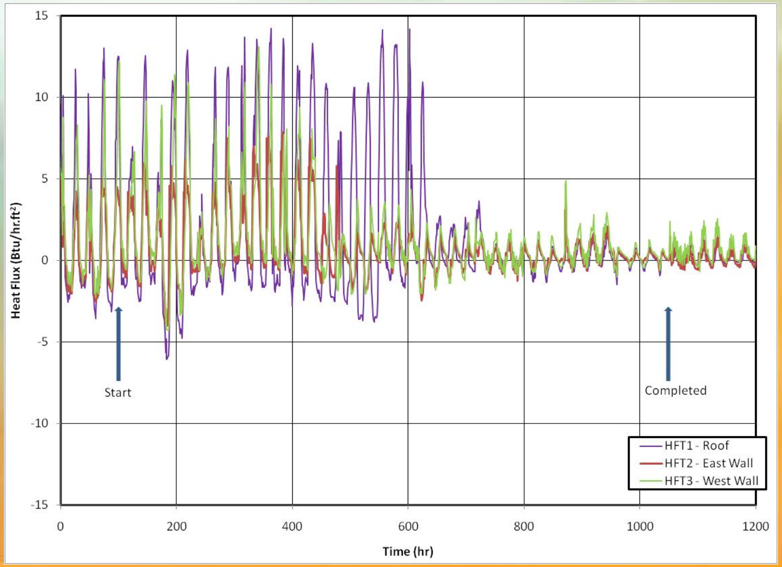
- B3114 Energy Performance Project
- 2,300 sq.ft. total building envelope
- Oakridge National Labs in Tennessee
- Insulation and air sealing retrofit occurred between June – July, 2010
  - Solution Used: THERMAX™ and FROTH PAK™ Foam Insulation (Class A)

Note: Project photos courtesy of Paramount Metal Systems

ORNL B3114 Case Study

Dow Building Solutions

- **Before Continuous Insulation**
- Estimated Heat Flux 8 BTU/hr/sqft
- Heat Loss through Walls and Roof
  - **11, 500 BTU/hr**



- **After Continuous Insulation**
  - **5" of THERMAX™ on Walls and 7" on the Roof**
  - **Air sealing with FROTH PAK™**
- Estimated Heat Flux 1 BTU/hr/sqft
- Heat Loss through Walls and Roof
  - **2,300 BTU/hr**

Look at the impact of continuous insulation!

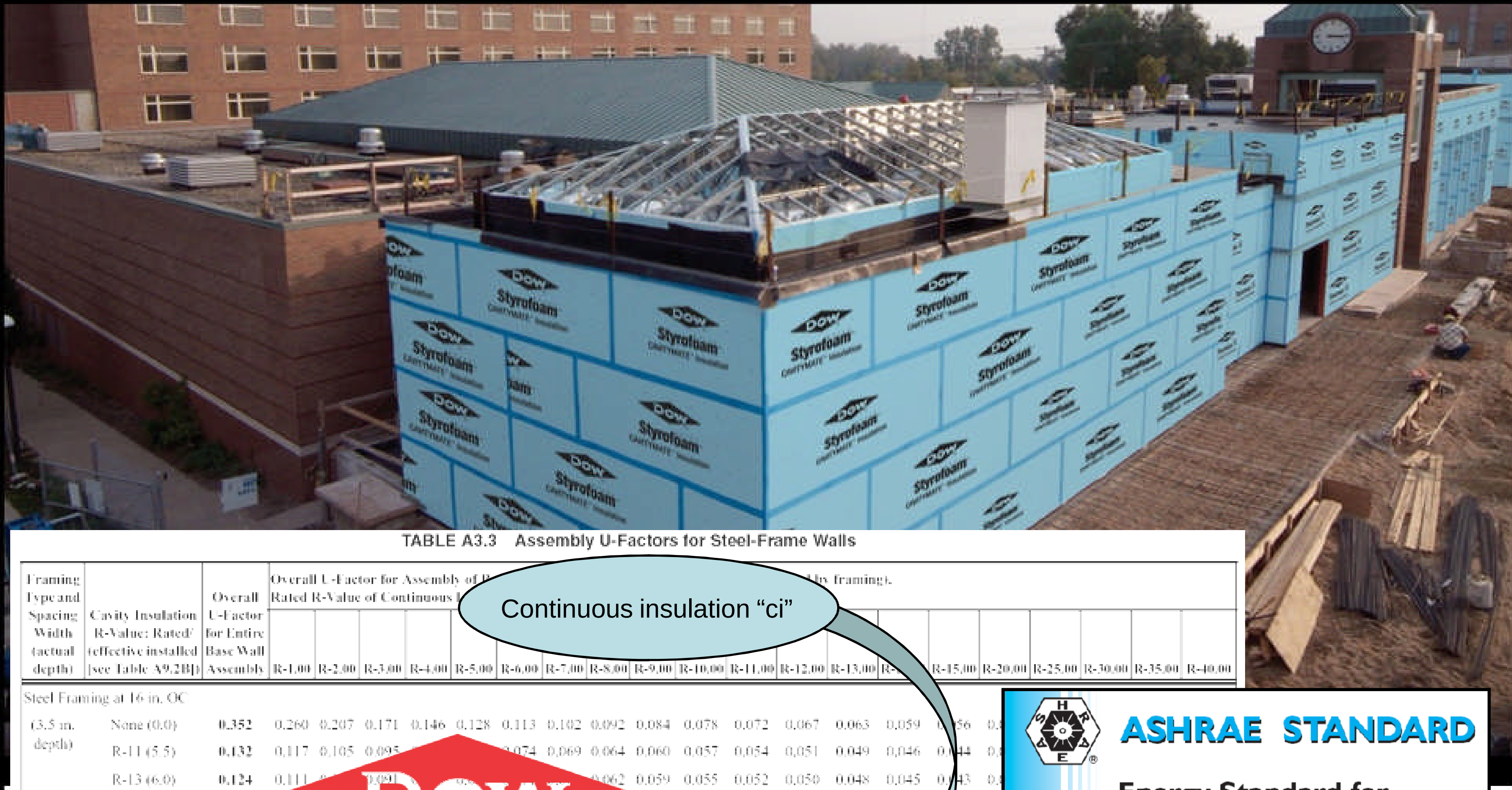


TABLE A3.3 Assembly U-Factors for Steel-Frame Walls

Continuous insulation "ci"

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/(effective installed [see Table A9.2B])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of B[illegible] Rated R-Value of Continuous I[illegible] [illegible]by framing).																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-[illegible]	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Steel Framing at 16 in. OC																						
(3.5 in. depth)	None (0.0)	0.352	0.260	0.207	0.171	0.146	0.128	0.113	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R-11 (5.5)	0.132	0.117	0.105	0.095	[illegible]	[illegible]	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.046	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R-13 (6.0)	0.124	0.111	[illegible]	0.091	[illegible]	[illegible]	[illegible]	[illegible]	0.062	0.059	0.055	0.052	0.050	0.048	0.045	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R-15 (6.4)	0.118	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.057	0.054	0.051	0.049	0.047	0.045	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(6.0 in. depth)	R-19 (7.1)	0.109	0.099	0.090	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.050	0.047	0.045	[illegible]	0.041	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R-21 (7.4)	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	[illegible]	[illegible]	0.043	0.041	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steel Framing at 24 in. OC																						
(3.5 in. depth)	None (0.0)	0.338	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.077	[illegible]	[illegible]	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (6.6)	0.116	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.035	0.030	0.026	0.023	0.021
	R-13 (7.2)	0.108	0.098	0.089	0.082	0.075	0.070	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
	R-15 (7.8)	0.102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.050	0.048	0.046	0.044	0.042	0.040	0.034	0.029	0.025	0.022	0.020
(6.0 in. depth)	R-19 (8.6)	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.022	0.020
	R-21 (9.0)	0.090	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	0.045	0.043	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020

DOW®

Thermax™ ci
Exterior Insulation

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

DOW®

Are These Continuous???

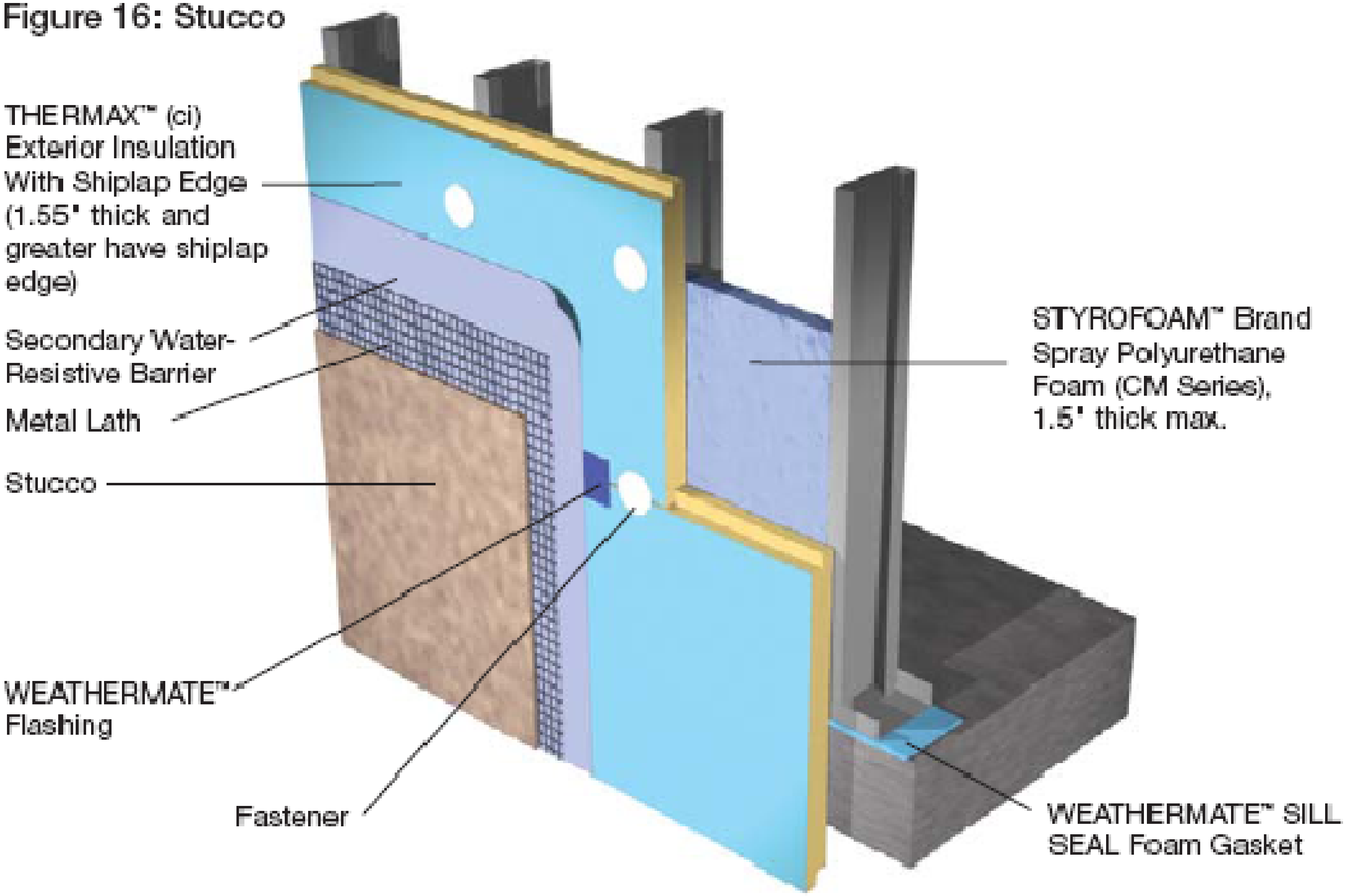
How do we attach claddings without compromising ci insulation???

Brick Cladding

Shelf Angle? / Brick Ties OK…

Attachment of 3-Coat Stucco Cladding over 3.0” ci*

Figure 16: Stucco

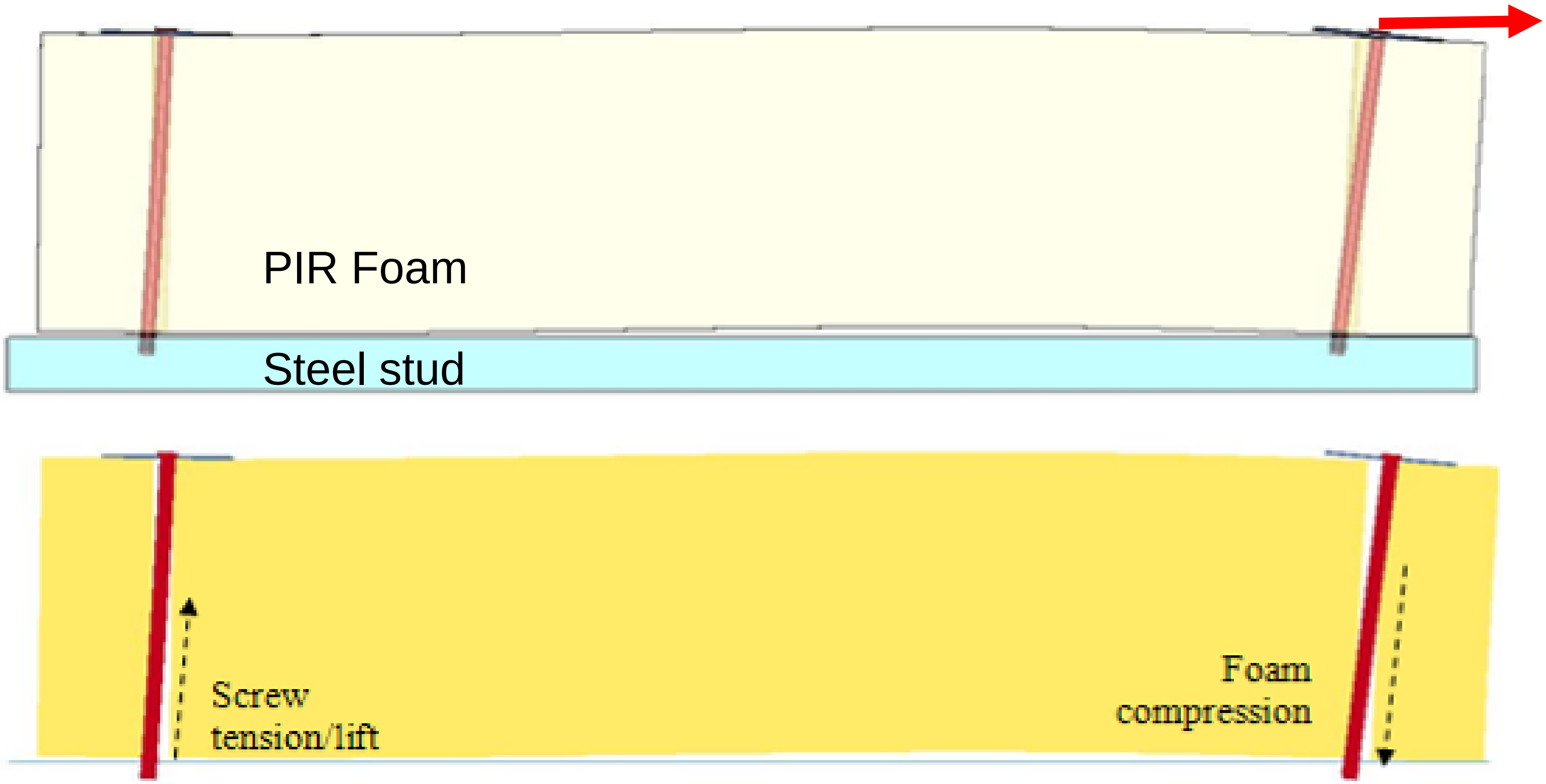


The Conundrum – HOW do I properly attach the Stucco?

* Type I, Class II Proprietary Polyisocyanurate Foam Insulation

Component Modeling:

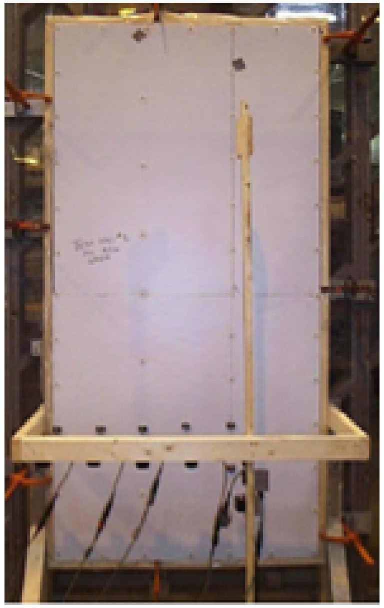
3-D Model of Fastener Connection



System Modeling and Experimental Testing:

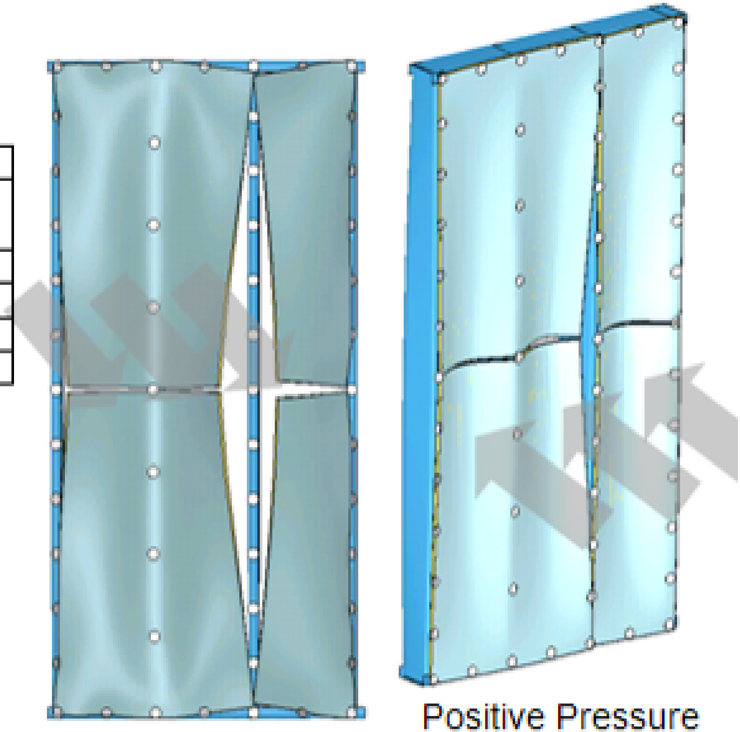
FE Model of PIR ci 0.625" Exterior Insulation for Wind Pressure Testing

Wind pressure testing (ASTM 330)



PIR ci 0.625"

	Pressure (PSF)	
Test wall configuration	Test*	CAE
TW1	-50	-53
TW2	75	72
TW9	-60	-59
TW11	-40	-37



Negative Pressure

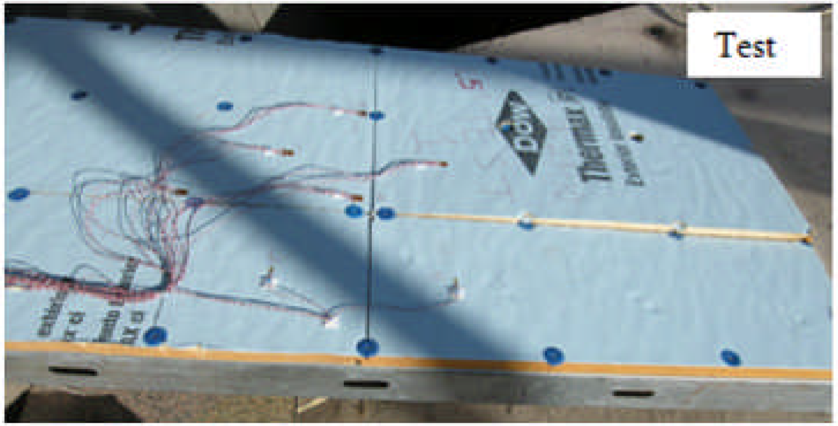
Positive Pressure

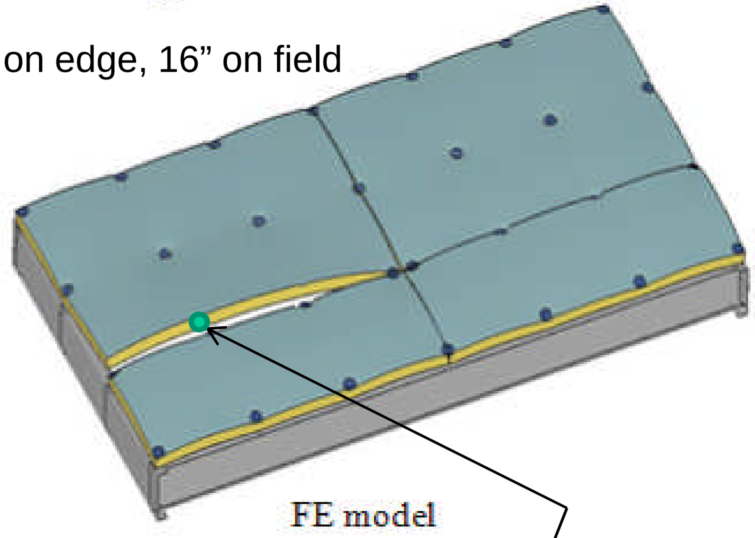
Tests performed by: Architectural Testing

System Modeling and Experimental Testing:

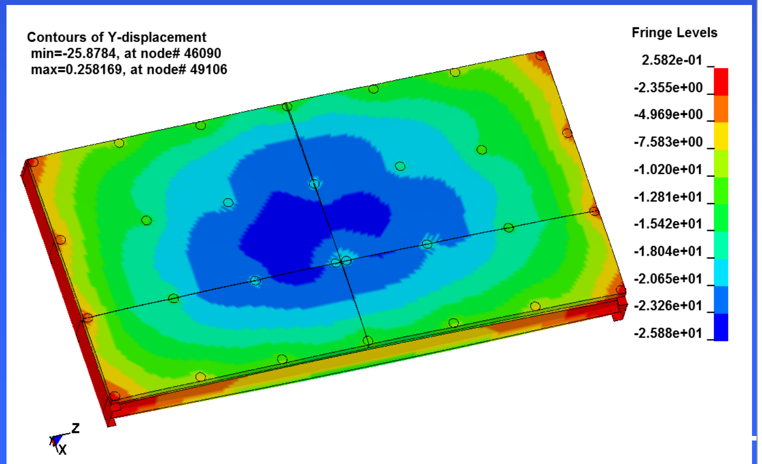
Wind Pressure Testing – PIR ci 1.55”

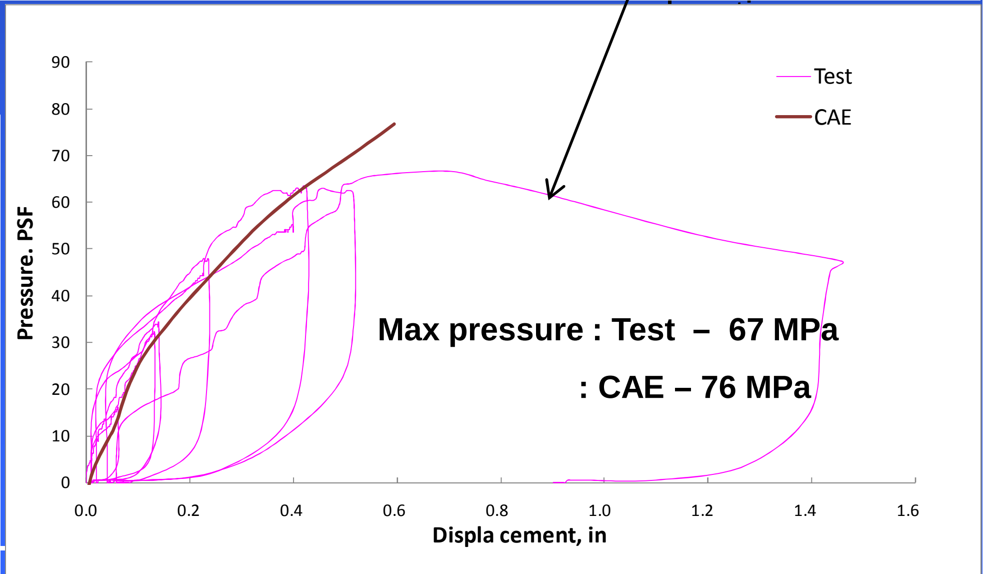
**1.55” PIR ci exterior insulation - ** Fastener Spacing : 16” on edge, 16” on field



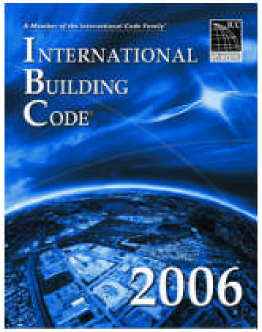


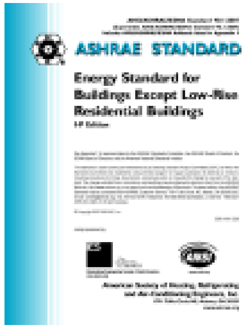
Failure criteria for CAE – max. displacement ≈ 1” at any point on the insulation (air leakage results in pressure drop in test)

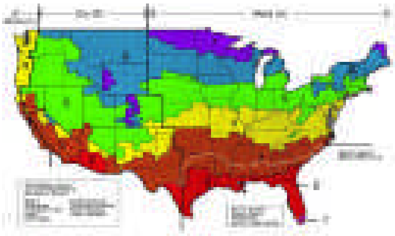




Building Code / ASHRAE 90.1
<u>PLUS</u>



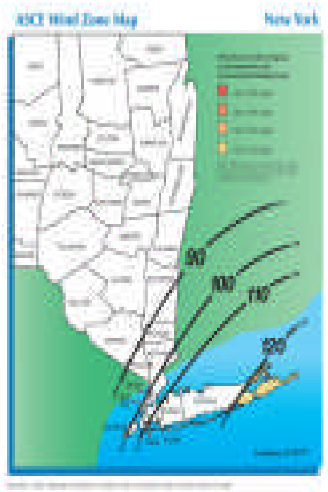




Climate Zone –
Thermax ci Thickness

Design Wind Pressure -
Thermax ci Fastener Layout

Cladding Type & Gravity Load -
Cladding Fastener Layout



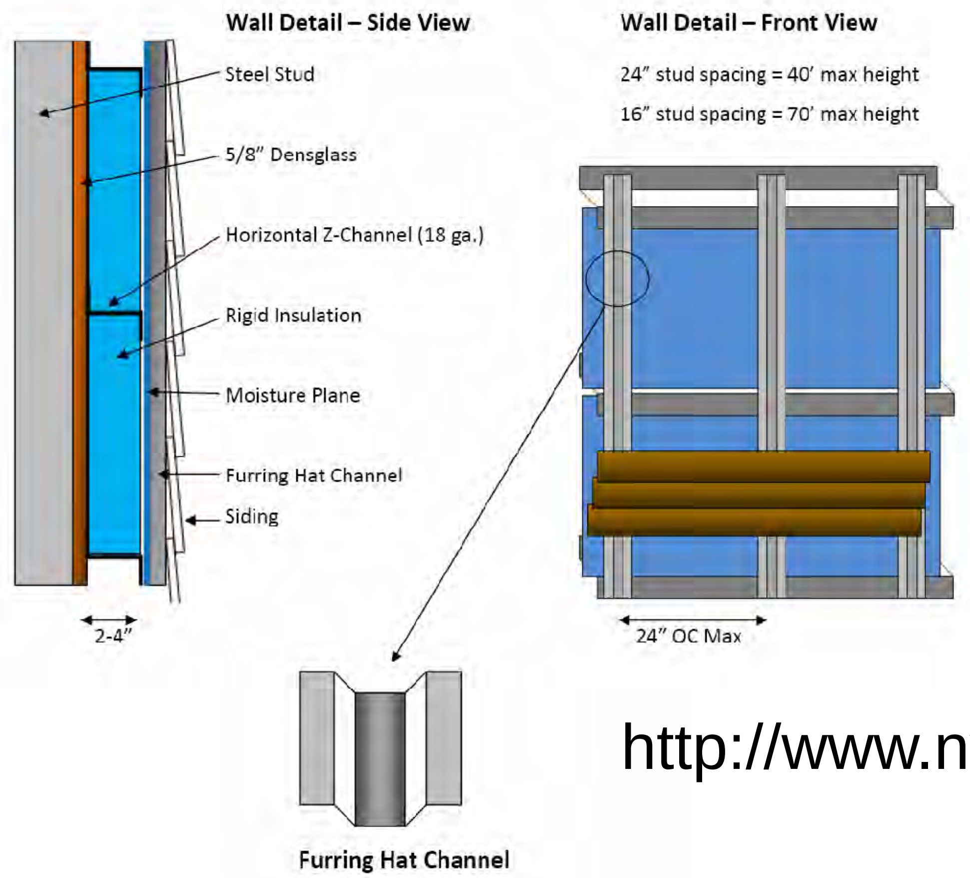
Other Cladding Attachment Efforts…

Foam Sheathing Coalition Study

http://www.foamsheathing.org/

Other Cladding Attachment Efforts…

"Fastening Systems for Continuous Insulation" by the New York State Energy Research and Development Authority



Energy. Innovation. Solutions.

http://www.nyserda.org/publications/

Other Cladding Attachment Efforts…

Also… research and work by:

Morrison Hershfield

Read Jones Christoffersen
Consulting Engineers

and others…

JRS Engineering
Building Envelope Consultants

Other Dow… Net Zero Home

Some Highlights…

• 2/3's of the way to net zero by the envelope alone…

•Minus 4 HERS Points
(Home Energy Rater System
with US Energy Star)
***NOTE: *Zero would equal net zero energy*

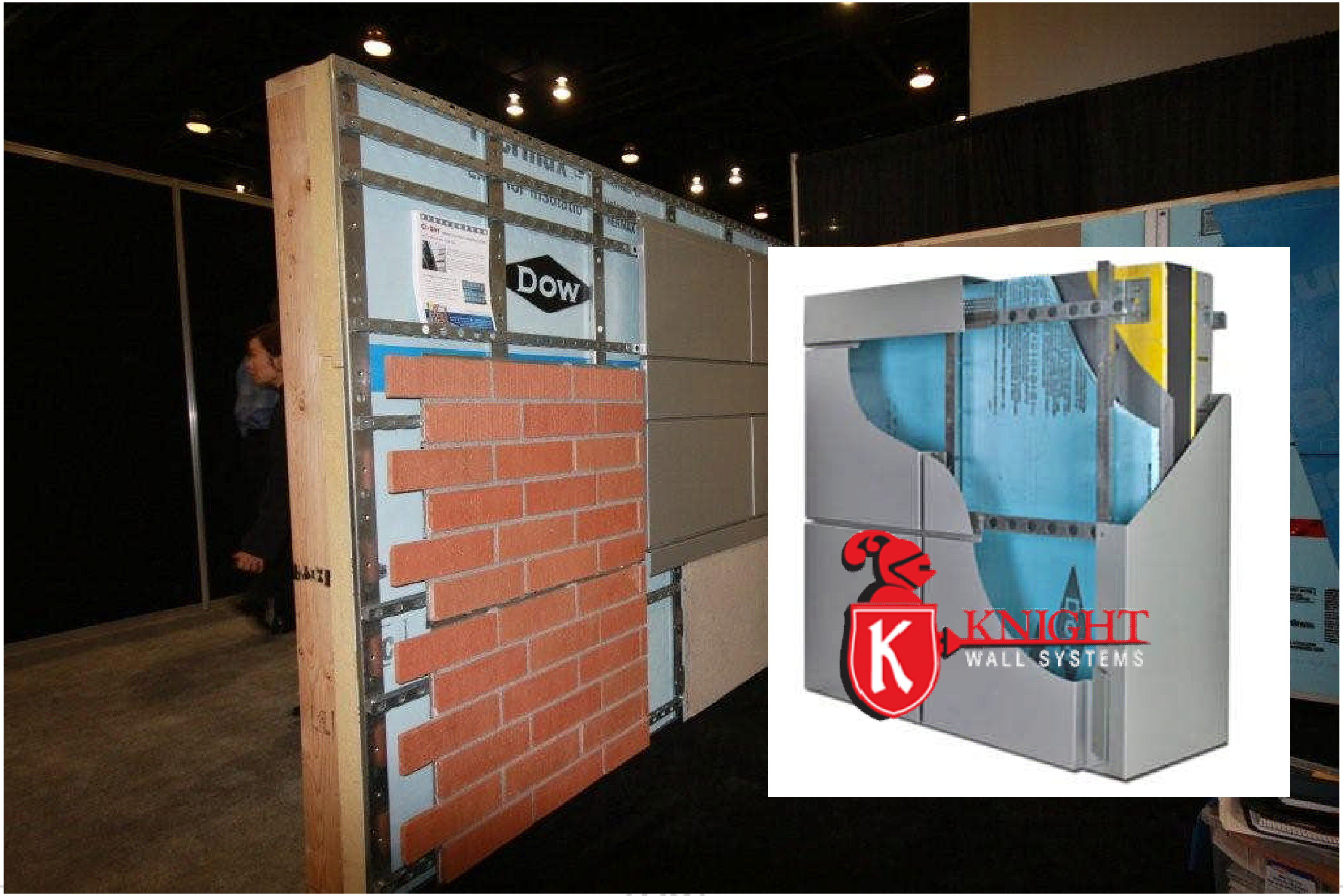
•*Selling $100 per month back to the grid*

•*$325,000 home using 15 DBS products (current technology)*

•*Saves 44,855 lbs of CO2 annually over conventionally built home*

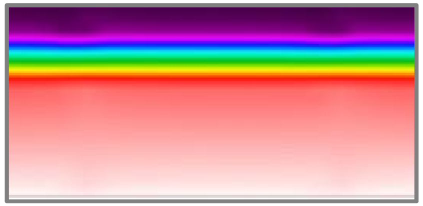
http://www.visionzerohome.com/

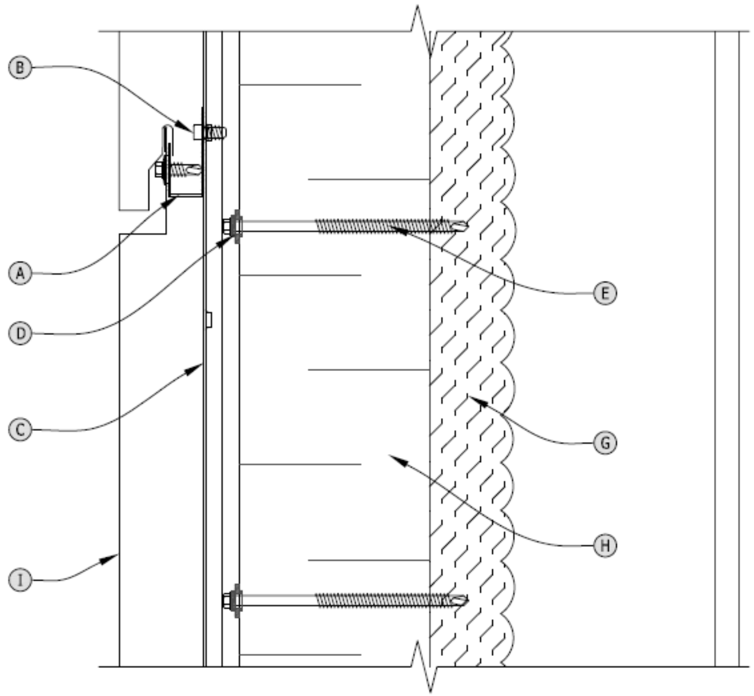
Other Cladding Attachment Efforts…



Building Solutions

Thermax™ Wall System and CI Girt™, a "CI" compliant assembly





http://building.dow.com/na/en/dowknightsolutions/

True Continuous Insulation

Bridging effect of fastener penetrations is considered negligible

Bottom Line … on your way to Net Zero Energy…Start with Your Building Envelope

Building Solutions

www.thermaxwallsystem.com/

http://building.dow.com/na/en/dowknightsolutions/