Exterior Masonry Walls and Energy Code Compliance

NOV 9, 2017

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, FASTM

The Masonry Society

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Program Description: Achieving energy code compliance is becoming increasingly more difficult using the code prescriptive methods. Whole building analysis is one alternative method that will produce more cost effective designs for exterior masonry assemblies. This presentation provides an overview of energy code provisions, reviews energy studies performed utilizing whole building analysis, and provides recommendations for cost effective energy efficient solutions for energy efficient exterior masonry wall designs.

Learning Objectives

- Contrast prescriptive energy code compliance with whole building analysis. Understand what building systems most affect energy use in buildings
- Describe how thermal bridging and thermal mass affect energy code compliance.
- Discuss payback cost of whole building analysis identified energy improvements.
- Understand cost effective energy efficient exterior masonry wall design.

Introduction

- Prescriptive energy code requirements for building envelopes have significantly increased. Compliance is becoming increasingly more difficult.

- This presentation will provide an overview of energy code provisions, review of energy analysis on various building prototypes.

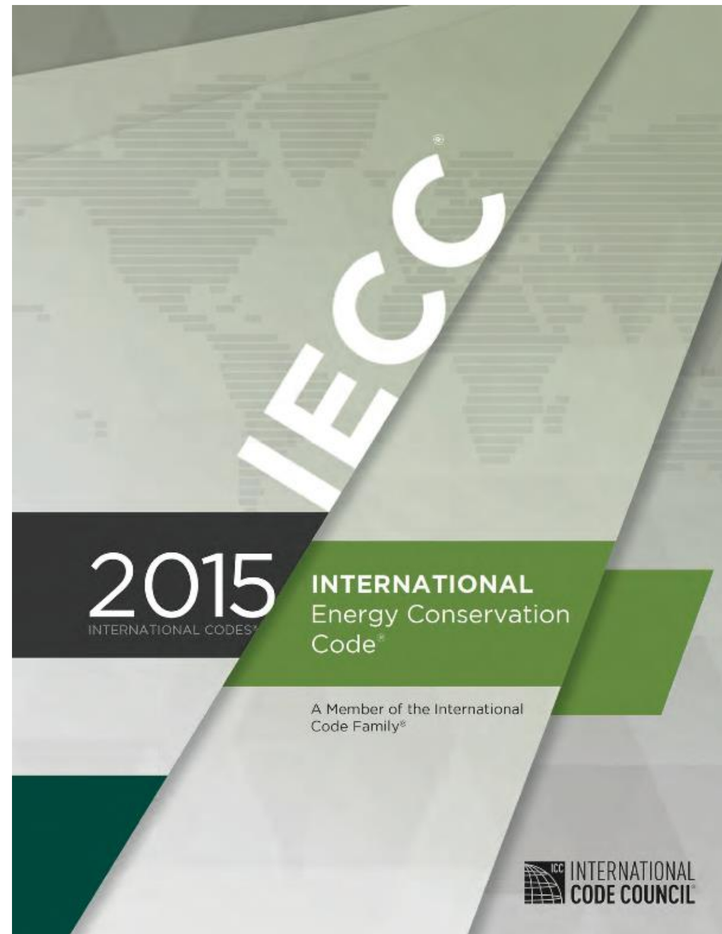
- Look at thermal bridging, U and R values, and payback costs analysis for energy improvements using whole building analysis

- Throughout discuss resources available for designers, such as NCMA and ACI/TMS 122.

International Energy Conservation Code

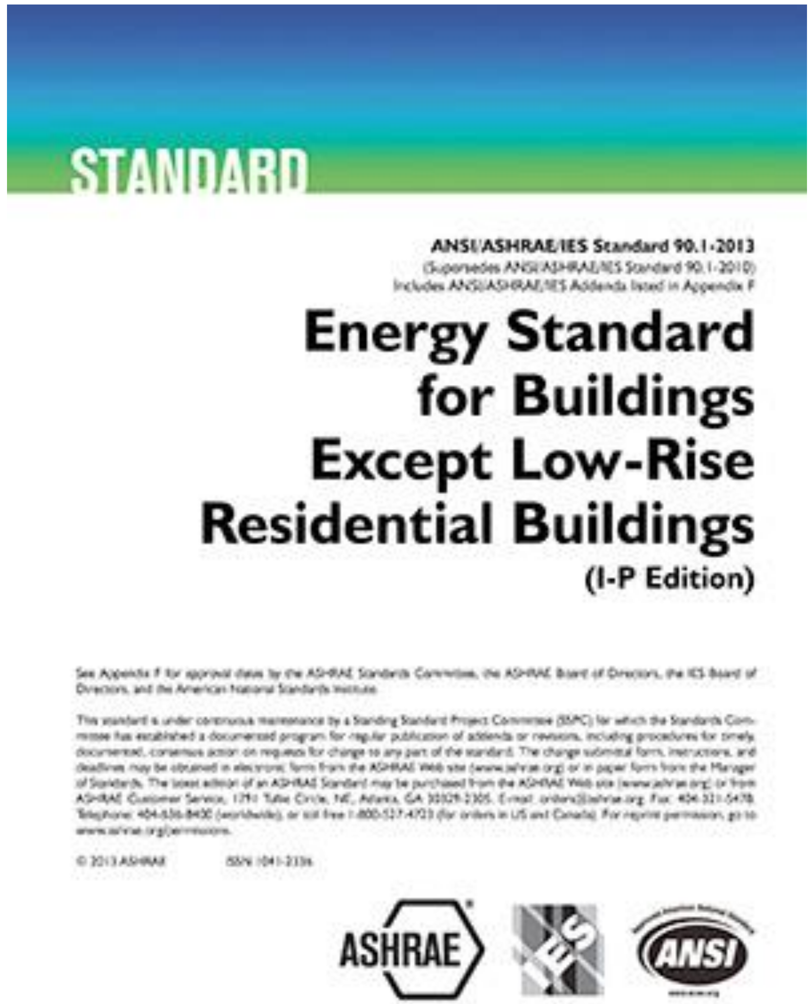
Energy codes continue to become more stringent…

- 2012 is about 15% more efficient than 2009
- 2015 is about 11% more efficient
- References ASHREA 90.1



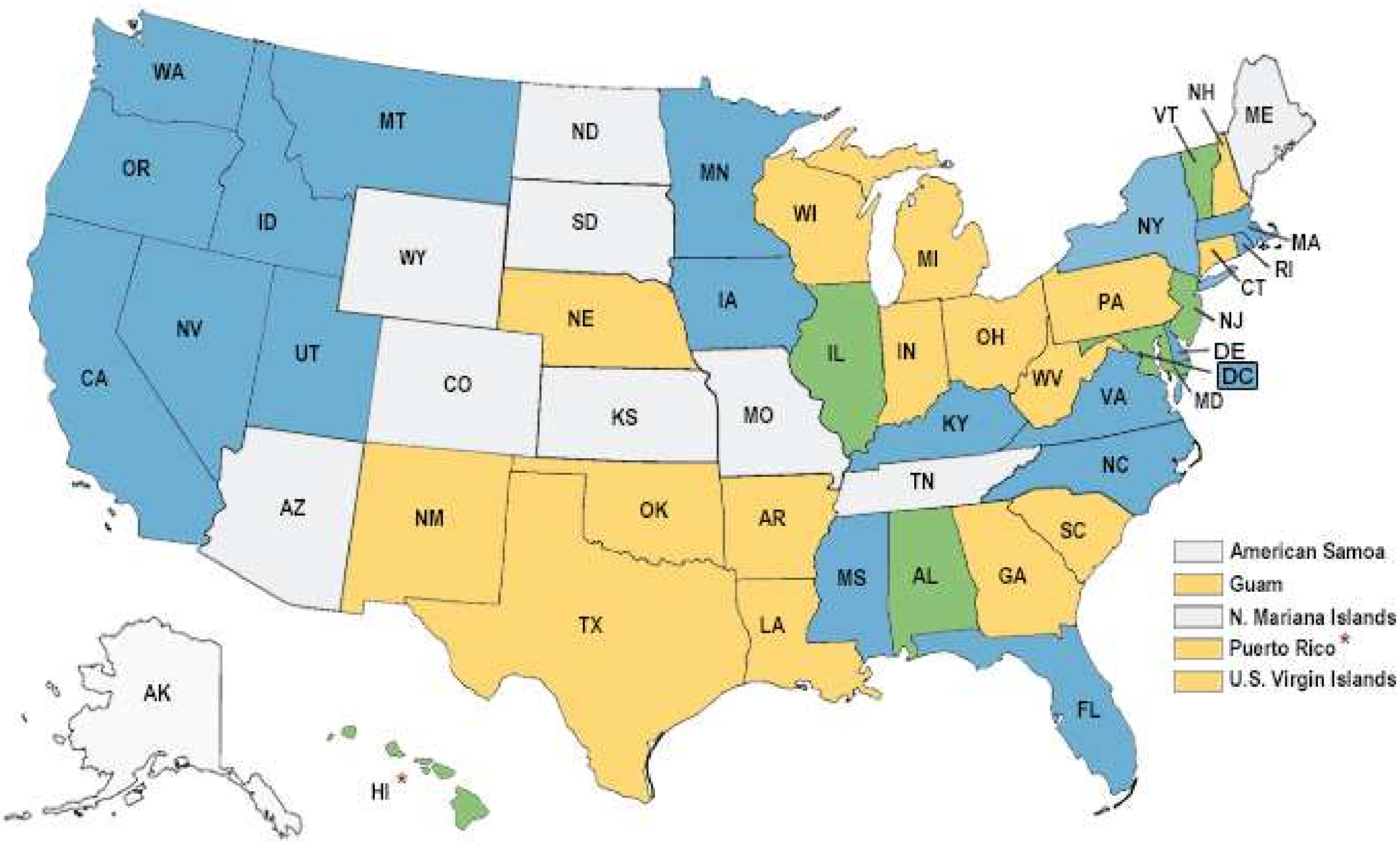
From NCMA Presentation

ANSI/ASHRAE/IES Standard 90.1



From NCMA Presentation

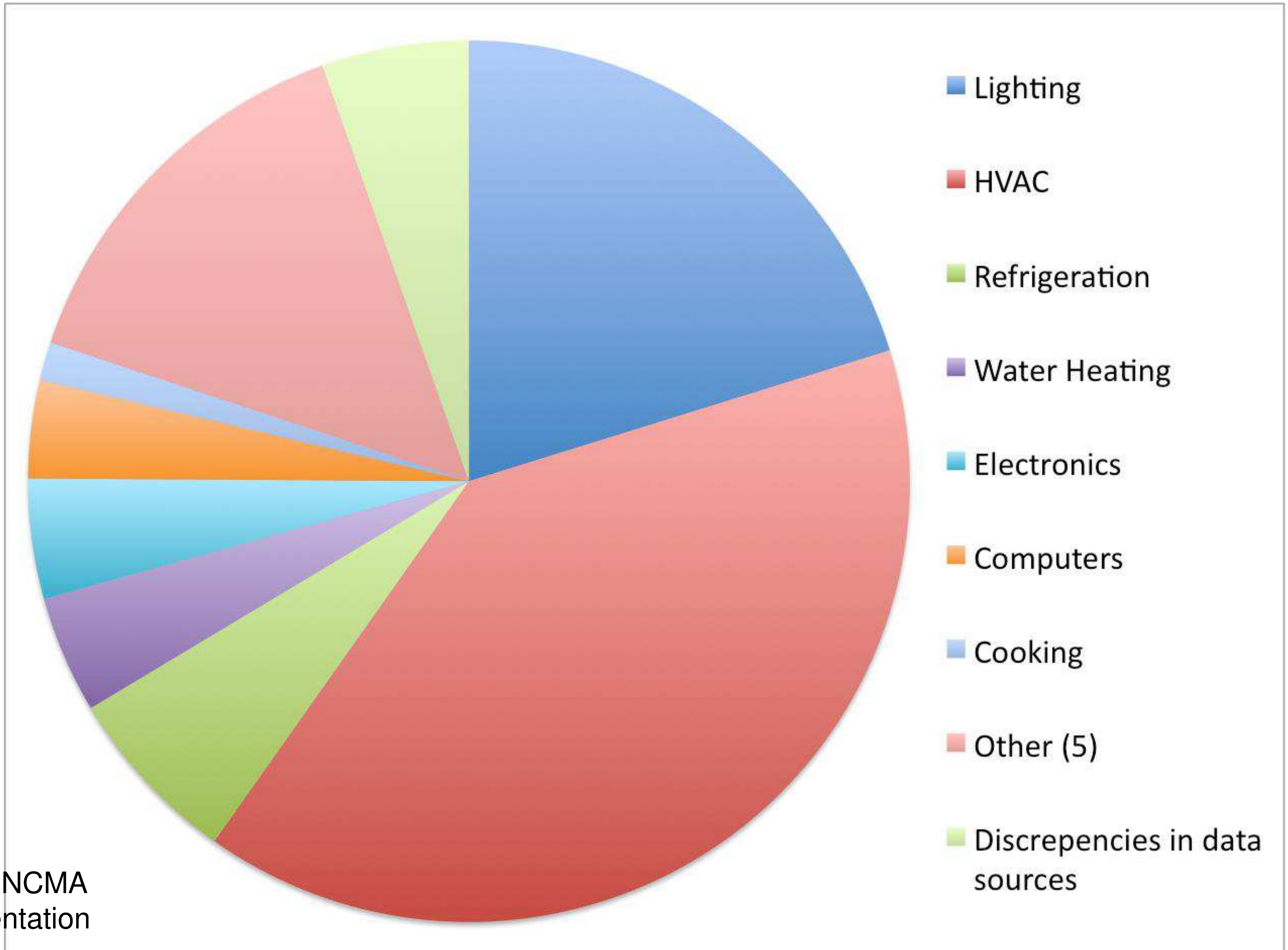
International Energy Conservation Code (IECC)



6	ASHRAE 90.1-2013/2015 IECC, equivalent, or more energy efficient
19	ASHRAE 90.1 - 2010/2012 IECC, equivalent, or more energy efficient
19	ASHRAE 90.1 - 2007/2009 IECC, equivalent, or more energy efficient
12	Older or less energy efficient than ASHRAE 90.1 - 2007/2009 IECC, or no statewide code.

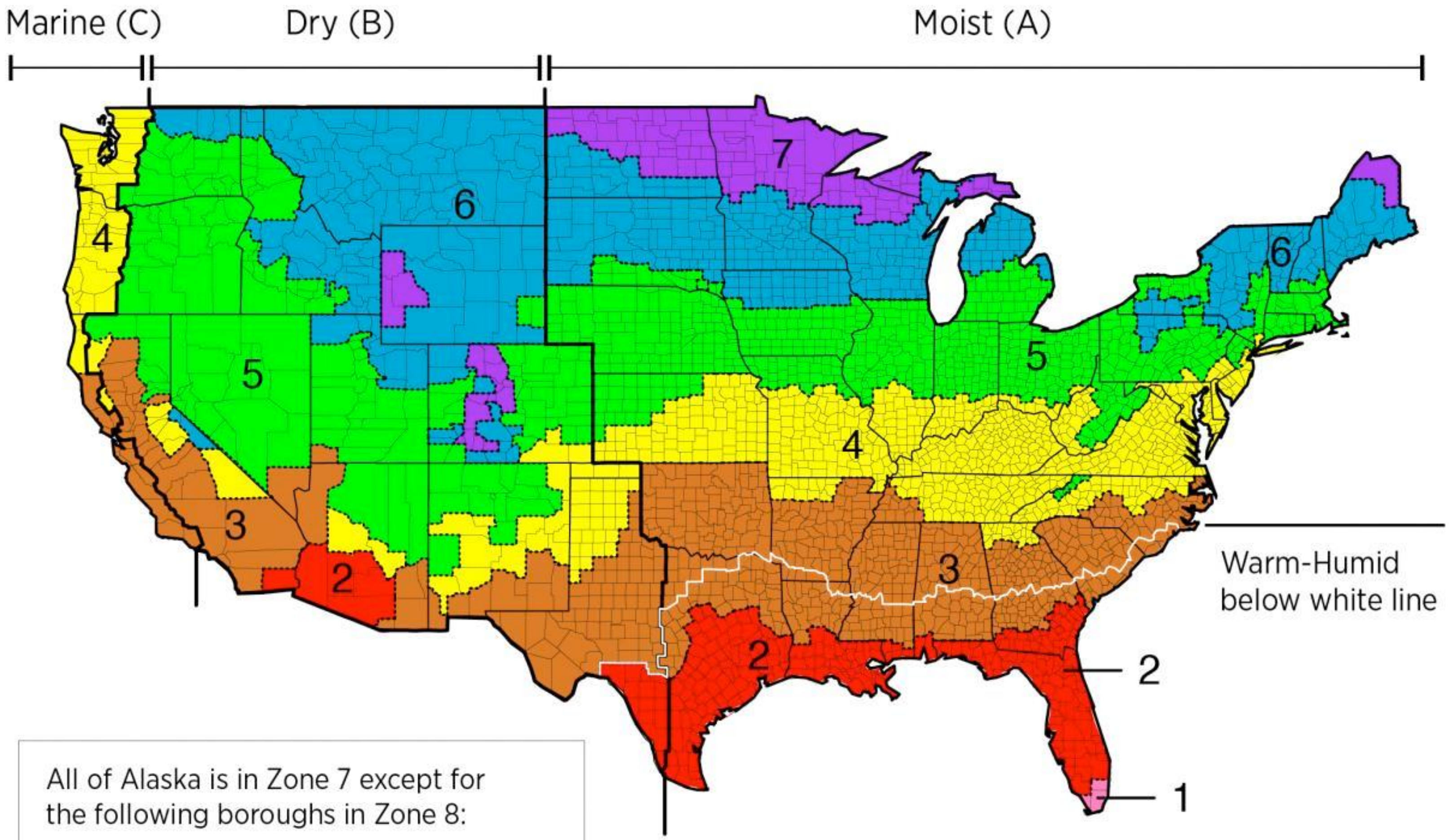
From NCMA Presentation

Commercial Building Energy Use



From NCMA Presentation

Climate Zones



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:

Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

From NCMA Presentation

Compliance Options - IECC

Prescriptive → R-value table
→ U-factor table

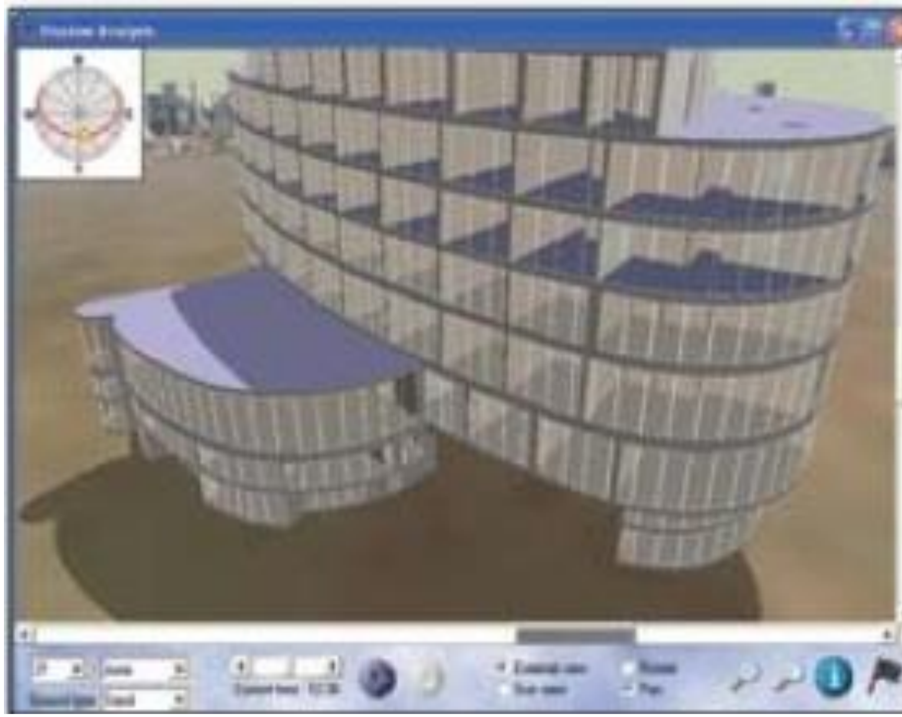
Trade-off - Envelope → COMcheck

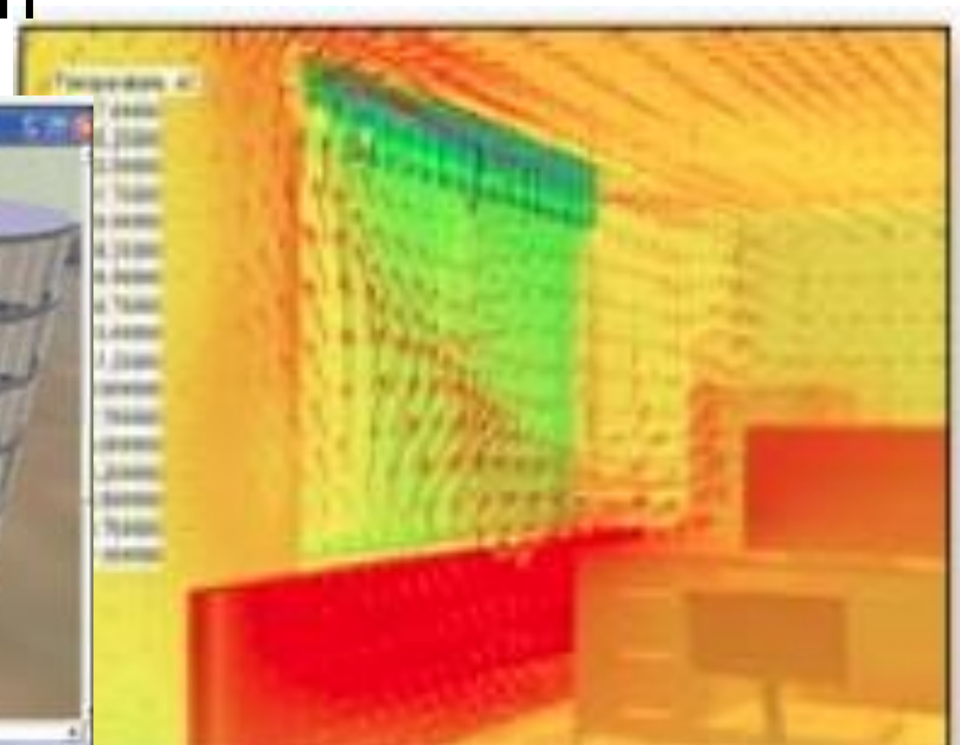
Total building performance → EnergyPlus/Design Builder, Sefaira, TREAT, BSim, etc.

From NCMA Presentation

Total Building Performance

Tools include: EnergyPlus/DesignBuilder, Sefaira, TREAT, BSim





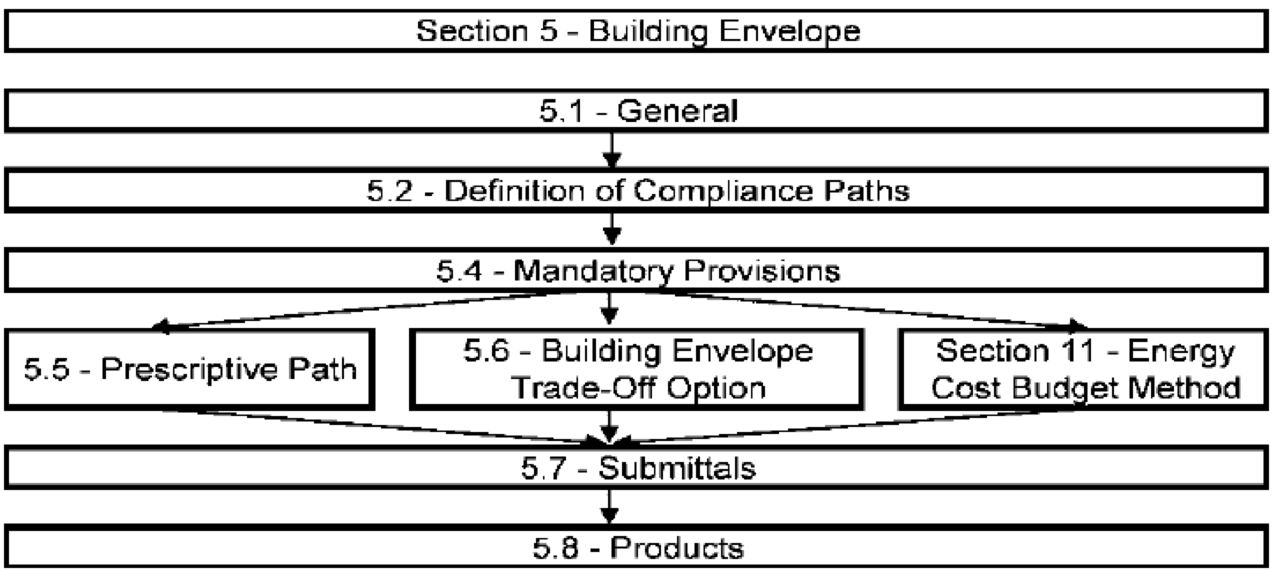
www.buildingenergysoftwaretools.com

From NCMA Presentation

Energy Code Design ASHREA 90.1

STD. generally allows 3 methods to be used for design of the various energy related building systems (IECC – references -ASHRAE 90.1) **Similar in other Systems**

5. BUILDING ENVELOPE



Energy Code Design

Prescriptive requirements – Envelope – Varies with Climate Zone

Climate Zone 4 B

TABLE 5.5-4 Building Envelope Requirements for Climate Zone 4 (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-0.173	R-5.0 c.i.
Metal Building[a]	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	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-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal Building	U-0.084	R-19.0	U-0.084	R-19.0	U-0.113	R-13.0
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-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wa						
Floors						
Mass						
Steel-Joist						
Wood-Framed an						
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	

Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[c]	U-0.40	SHGC-0.40 all	U-0.40	SHGC-0.40 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[d]	U-0.50		U-0.50		U-1.20	
Metal framing (entrance door)[d]	U-0.85		U-0.85		U-1.20	
Metal framing (all other)[d]	U-0.55		U-0.55		U-1.20	

Walls, Above-Grade

Mass	U-0.104	R-9.5 c.i.

Terminology

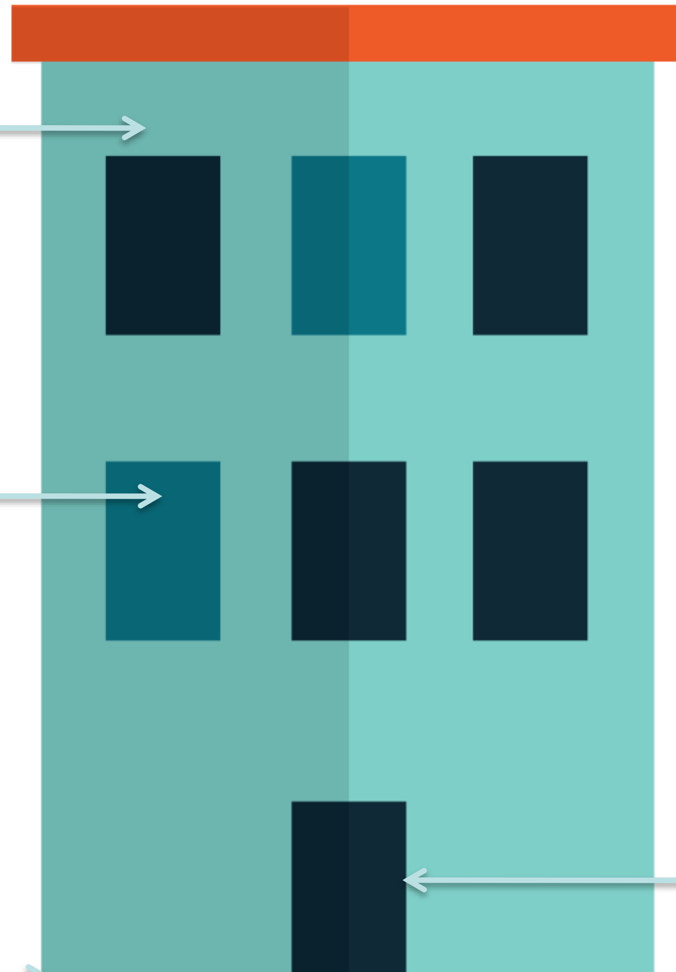
R-value: describes how well a material insulates under steady state temperature conditions; R = 1/U

U-factor: describes how well a material conducts heat under steady state temperature conditions; U = 1/R

Heat capacity (HC): describes how well a material stores and releases heat under transient temperature conditions (thermal mass)

From NCMA Presentation

Prescriptive Compliance Example Zone 4 – Envelope – R values



Roof, R30 continuous insulation

Above-grade walls, R9.5 continuous insulation

Fenestration, U0.38 max, 0.40 SHGC

Slab on grade, R10 for 24 in. below

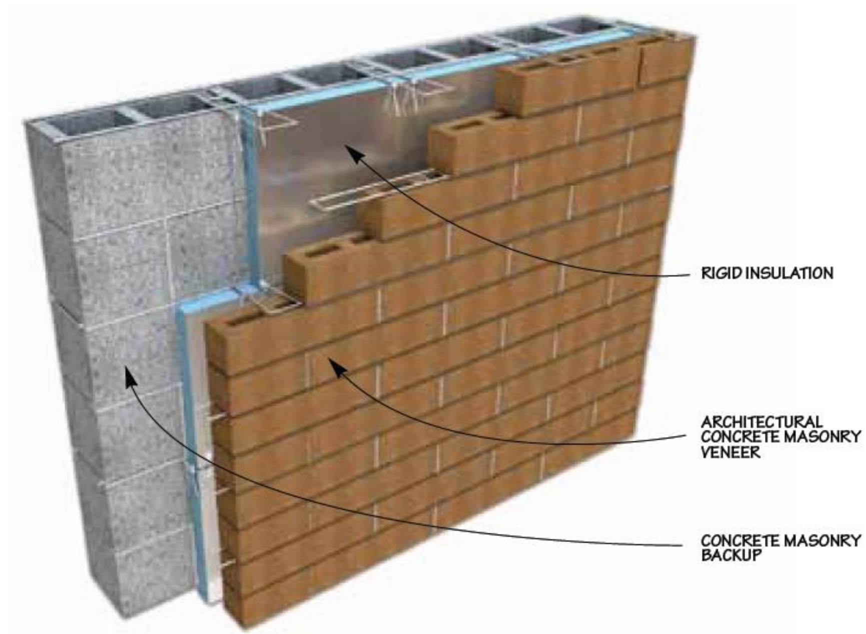
Opaque doors, R4.75

From NCMA Presentation

Prescriptive R-Value Compliance

Masonry cavity wall:

- cavity width can be varied to accommodate insulation
- R-values largely independent of grout schedule
- exposed masonry provides maximum durability



From NCMA Presentation

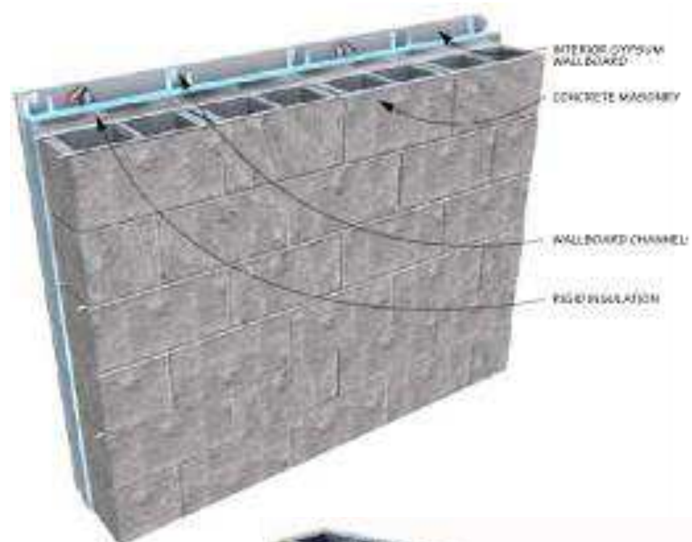
Prescriptive R-Value Compliance

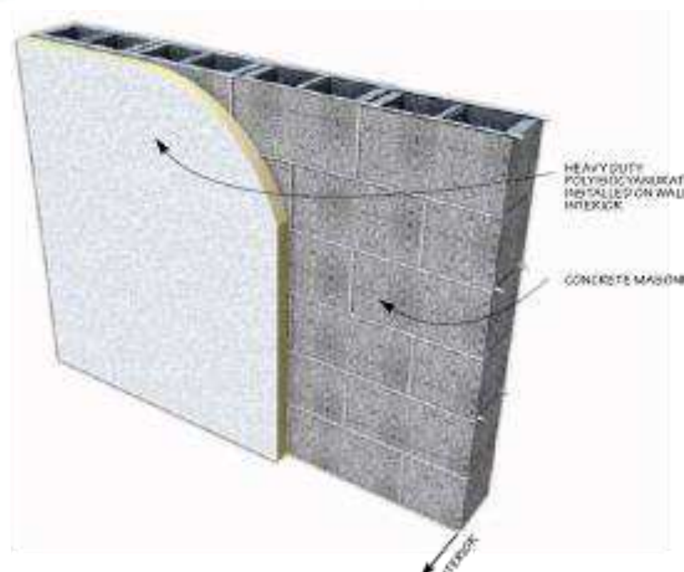
<u>Continuous interior insulation</u>:

• R-values independent of grout schedule

• allows exterior exposed masonry

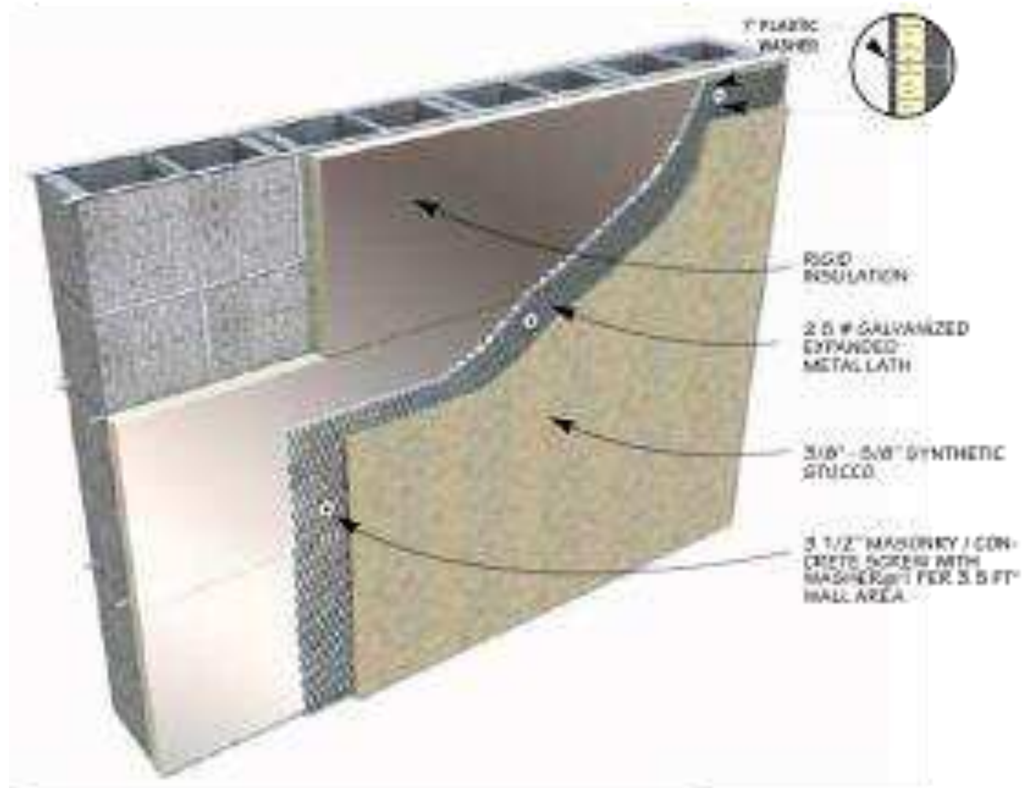
• furring space can be used for wiring and utilities





Prescriptive R-Value Compliance

Continuous exterior insulation:
- R-values independent of grout schedule
- allows interior exposed masonry, maximizing thermal mass benefits



Prescriptive R-Value Compliance
Internal insulation

CLIMATE ZONE	1		2		3	
	All other	Group R	All other	Group R	All other	Group R
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38
Mass	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci

From NCMA Presentation

[c] R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.

WHAT IF MY BUILDING DOESN'T MEET PRESCRIPTIVE INSULATION R-VALUES?

Prescriptive U-Factor Compliance

Note this is assembly U

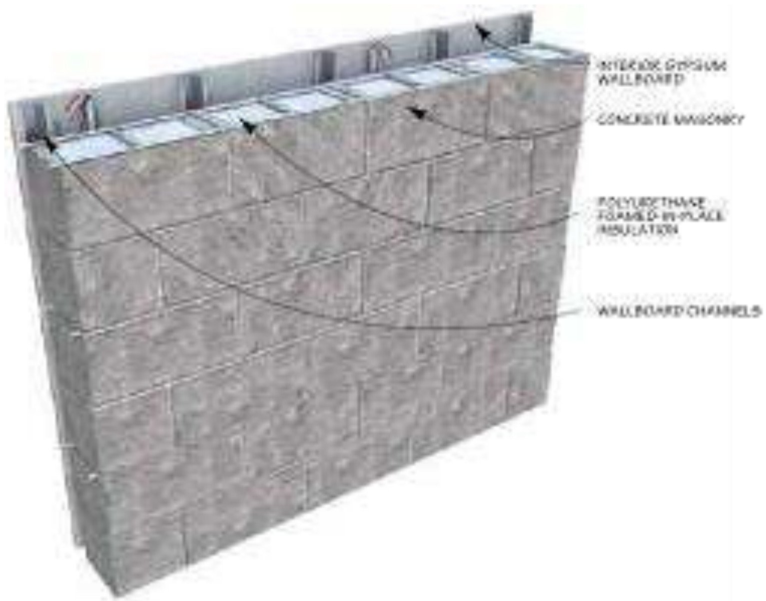
Walls, Above-Grade		
Mass	U-0.104	R-9.5 c.i.

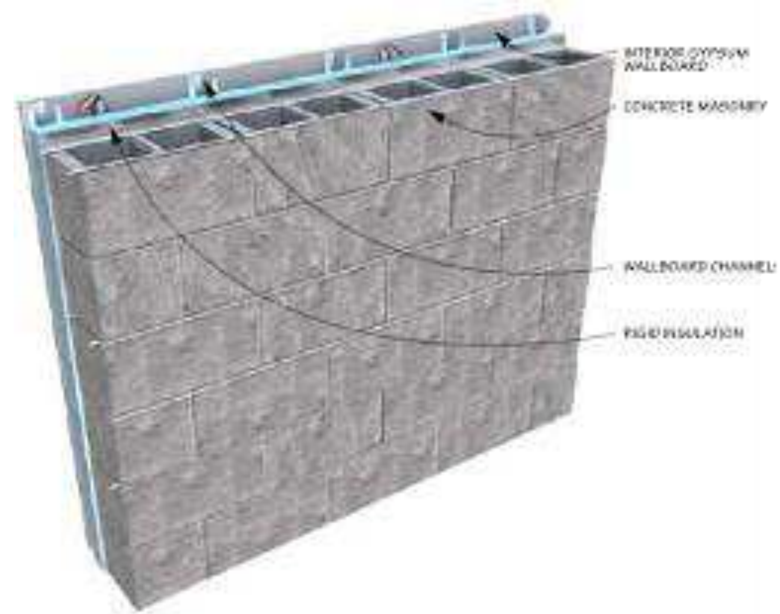
ASHRAE Provisions

IECC – Has a Separate U value table – Assembly U

Prescriptive U-Factor Compliance

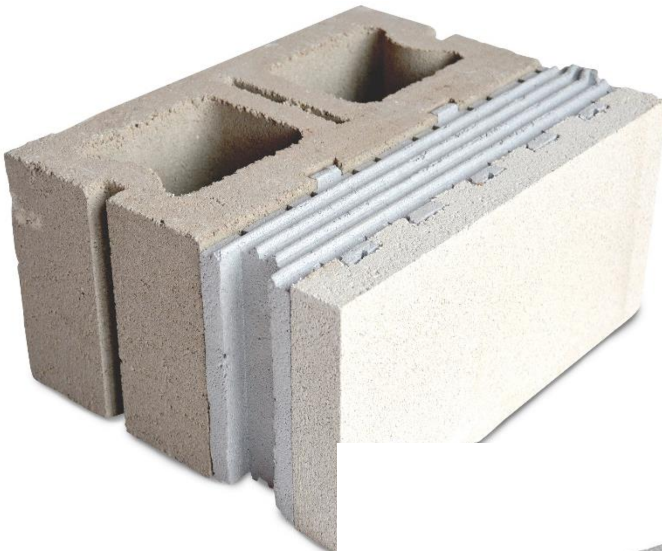
Makes sense any time the preferred wall meets the prescriptive U-factor requirement.

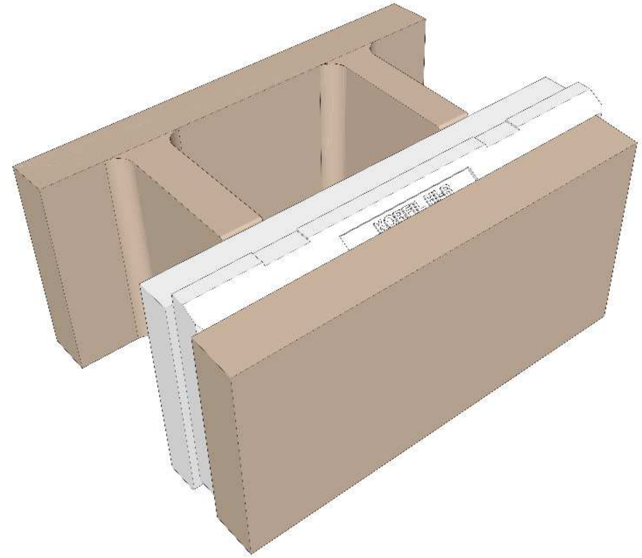




From NCMA Presentation

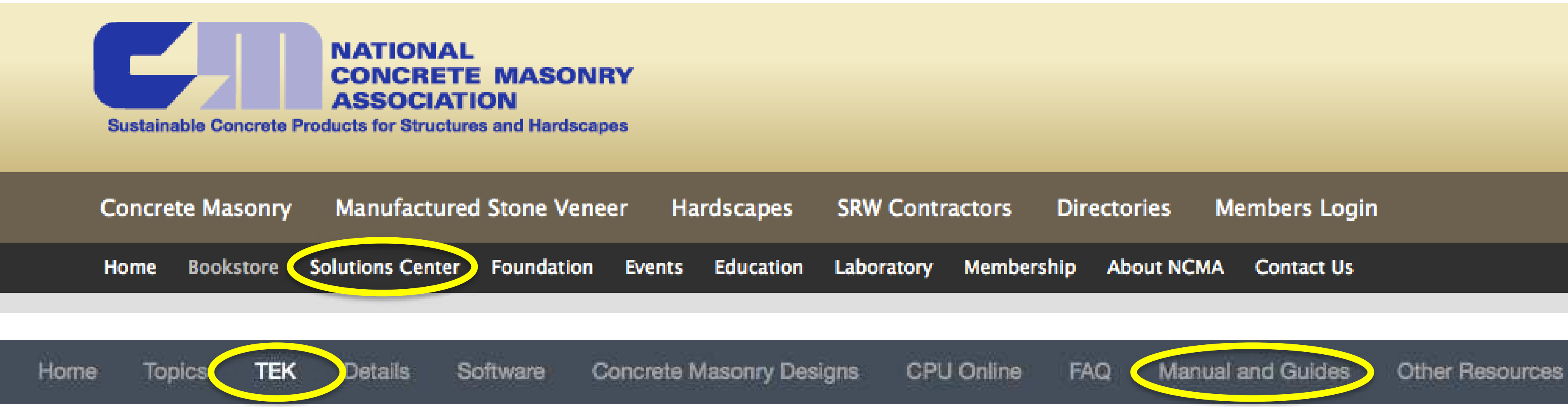
CMU Products for Energy Efficiency

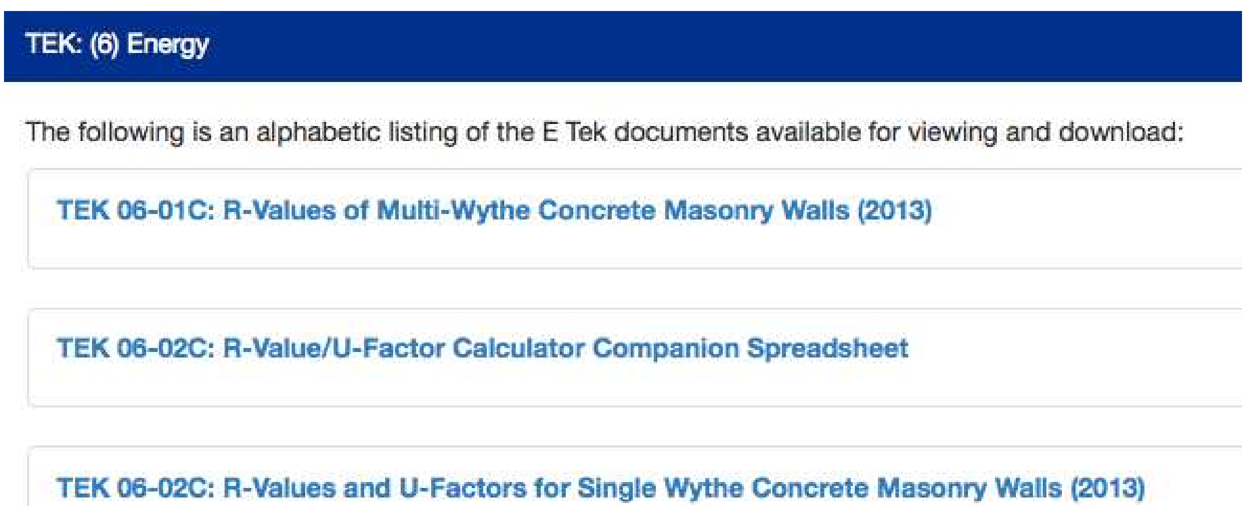




From NCMA Presentation

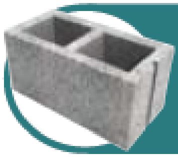
Where Do I Find Masonry U-Factors?



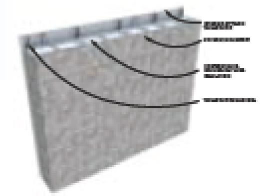


From NCMA Presentation

Where Do I Find Masonry U-Factors?



SINGLE WYTHE CONCRETE MASONRY ASSEMBLIES
CELL INSULATION



Assembly 1-2: Polyurethane foamed-in-place insulation in ungrouted cells, exposed exterior masonry, 1/2 in. gypsum wallboard on furring on interior

Concrete Masonry Assembly R-Values (hr·ft²·°F/Btu) and U-Factors (Btu/hr·ft²·°F)

Density of CMU, PCF	6-in. Concrete Masonry				8-in. Concrete Masonry			
	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted
85	7.48 (0.134)	5.55 (0.180)	4.39 (0.228)	2.90 (0.345)	9.68 (0.103)	6.73 (0.148)	5.11 (0.196)	3.21 (0.312)
95	6.64 (0.151)	5.11 (0.196)	4.13 (0.242)	2.81 (0.356)	8.50 (0.118)	6.17 (0.162)	4.80 (0.208)	3.10 (0.323)
105	5.90 (0.169)	4.71 (0.212)	3.90 (0.257)	2.73 (0.366)	7.48 (0.134)	5.65 (0.177)	4.50 (0.222)	3.00 (0.334)
115	5.27 (0.190)	4.35 (0.230)	3.68 (0.272)	2.66 (0.375)	6.59 (0.152)	5.18 (0.193)	4.23 (0.236)	2.91 (0.344)
125	4.73 (0.212)	4.02 (0.249)	3.48 (0.287)	2.60 (0.384)	5.83 (0.172)	4.75 (0.210)	3.98 (0.251)	2.83 (0.354)
135	4.26 (0.235)	3.73 (0.268)	3.30 (0.303)	2.55 (0.393)	5.18 (0.193)	4.37 (0.229)	3.75 (0.267)	2.76 (0.363)

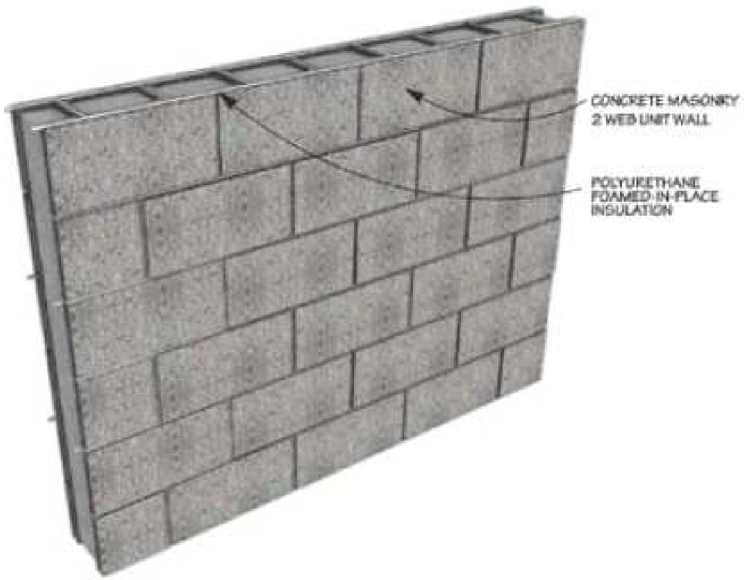
Density of CMU, PCF	10-in. Concrete Masonry				12-in. Concrete Masonry			
	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted	Ungrouted	Lightly Reinforced	Heavily Reinforced	Fully Grouted
85	11.57 (0.086)	7.70 (0.130)	5.70 (0.176)	3.45 (0.290)	14.09 (0.071)	8.81 (0.113)	6.32 (0.158)	3.68 (0.271)
95	10.08 (0.099)	7.04 (0.142)	5.34 (0.187)	3.33 (0.300)	12.20 (0.082)	8.06 (0.124)	5.93 (0.168)	3.56 (0.281)
105	8.79 (0.114)	6.42 (0.156)	5.01 (0.200)	3.23 (0.310)	10.57 (0.095)	7.36 (0.136)	5.57 (0.179)	3.45 (0.289)
115	7.67 (0.130)	5.86 (0.171)	4.70 (0.213)	3.13 (0.319)	9.17 (0.109)	6.71 (0.149)	5.23 (0.191)	3.35 (0.298)
125	6.72 (0.149)	5.36 (0.187)	4.41 (0.227)	3.05 (0.328)	7.97 (0.125)	6.11 (0.164)	4.90 (0.204)	3.26 (0.307)
135	5.92 (0.169)	4.90 (0.204)	4.14 (0.242)	2.96 (0.337)	6.96 (0.144)	5.57 (0.180)	4.59 (0.218)	3.17 (0.315)

From NCMA Presentation

Where Do I Find Masonry U-Factors?

SECTION TWO
2-WEB CMU ASSEMBLIES

Assembly 2-1: Polyurethane foamed-in-place insulation in ungrouted cells, exposed masonry (interior and exterior)



- Masonry exposed on both the interior and exterior provides maximum durability.
- Values in table assume no insulation in grouted cells. Note that some rigid inserts are configured to accommodate insulation, reinforcing steel and grout in the same cell, which can improve R-values.
- Other masonry cell insulations include molded polystyrene inserts, other types of foamed-in-place insulations and expanded perlite or vermiculite granular fills. These insulations will have different thermal properties than polyurethane which will affect the resulting R-value.
- Cell insulation, in contrast to additional insulation on either side of the wall, allows some of the thermal mass (masonry) to be in direct contact with the indoor air, providing excellent thermal mass benefits.
- Insulation should occupy all ungrouted cells.
- "Lightly reinforced" = grout 8 ft o.c. both vertically and horizontally (or vertical reinforcement only at 48 in. o.c.). "Heavily reinforced" = grout 32 in o.c. vertically and 48 in. o.c. horizontally (or vertical reinforcement only at 24 in. o.c.).

From NCMA Presentation

Where Do I Find Masonry U-Factors?

Home Topics TEK Details Software Concrete Masonry Designs CPU Online FAQ Manual and Guides Other Resources

TEK: (6) Energy

The following is an alphabetic listing of the E Tek documents available for viewing and download:

- TEK 06-01C: R-Values of Multi-Wythe Concrete Masonry Walls (2013)
- TEK 06-02C: R-Value/U-Factor Calculator Companion Spreadsheet
- TEK 06-02C: R-Values and U-Factors for Single Wythe Concrete Masonry Walls (2013)
- TEK 06-03: Shifting Peak Energy Loads with Concrete Masonry Construction (1991)
- TEK 06-04B: Energy Code Compliance Using COMcheck (2012)
- TEK 06-05A: Passive Solar Design Strategies (2006)

From NCMA
Presentation

Where Do I Find Masonry U-Factors?

NATIONAL CONCRETE MASONRY ASSOCIATION
Sustainable Concrete Products for Structures and Hardscapes

NCMA R-Value / U-Factor / Heat Capacity Calculator
User Input Page (3 Layer Unit)

Please enter inputs below for the wall assembly

Step 2: CMU Description
Description:
NOTE: Enter description of CMU to be included in calculation output

Step 3: CMU Nominal Dimesions

		Specified
Width (in.)		-0.375
Height (in.)		-0.375
Length (in.)		-0.375

Step 4: Face Shell Thickness

Face 1 Thickness (in.)	
Face 2 Thickness (in.)	

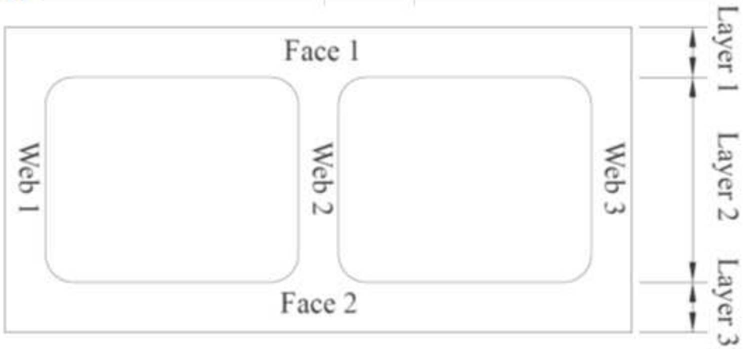
Step 4: Web Information

				Calculated Web Area
Web 1 Thickness (in.)		Web 1 Height (in.)		0
Web 2 Thickness (in.)		Web 2 Height (in.)		0
Web 3 Thickness (in.)		Web 3 Height (in.)		0
Web 4 Thickness (in.)		Web 4 Height (in.)		0
			Total	**0**

- Option - enter total web area for CMU

NOTE - Entering a total web area above will overide individial web entries.

3 Layer Unit



Steps 11 & 12: Surface Finishes

Inside Surface Finish	None
Outside Surface Finish	None

New – Changes to ASTM C 90 allow 2 web Blocks – will reduce block U

From NCMA Presentation

Second Compliance Method

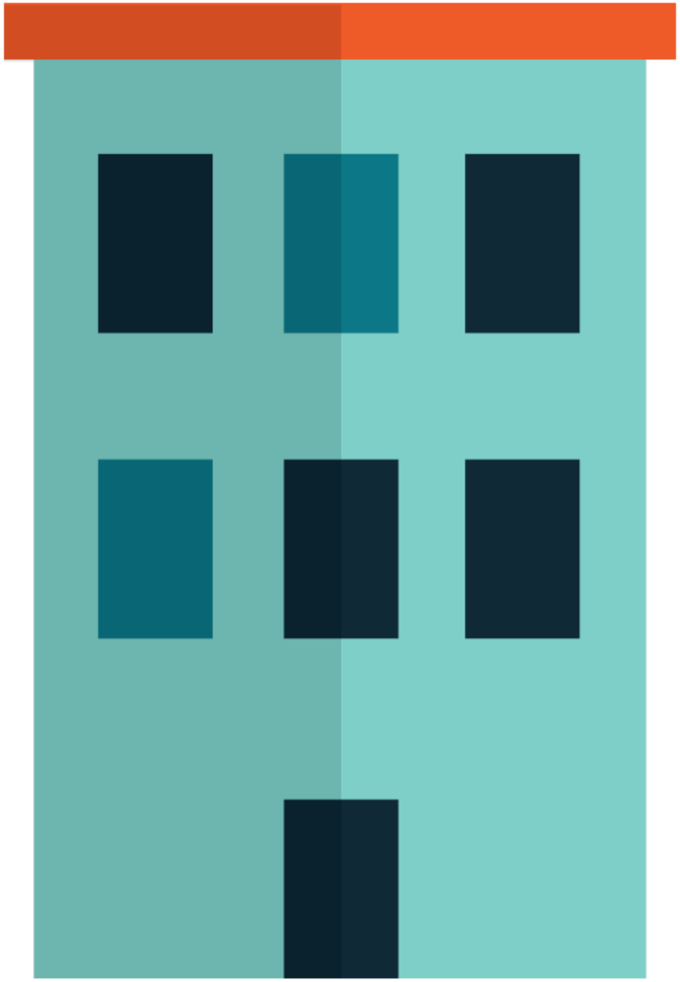
Trade-Off Compliance/COMcheck

Three overall budgets:

Envelope

Mechanical

Lighting



From NCMA
Presentation

COMcheck

www.energycodes.gov/comcheck

COM*check*™ Software

Windows | Mac | COM*check-Web* | Technical Support

COM*check*™ for Windows®

Version 4.0.2 (Build Version: 4.0.2.8)

Runs on Vista or Windows 7 in either single, multi-user, or network environments

Download COM*check* for Windows

Download COMcheck Now!

Supported Codes:

2009, 2012 and 2015 IECC.
*ASHRAE Standard 90.1:*2007, 2010, and 2013
Various state-developed energy codes.

Version 4.0.2 includes support for the 2015 IECC energy code. This release also includes support for '2014 Florida Building Code, Energy Conservation'. 2006 IECC and 2011 Vermont Commercial Building Energy Standard are no longer supported by COMcheck.

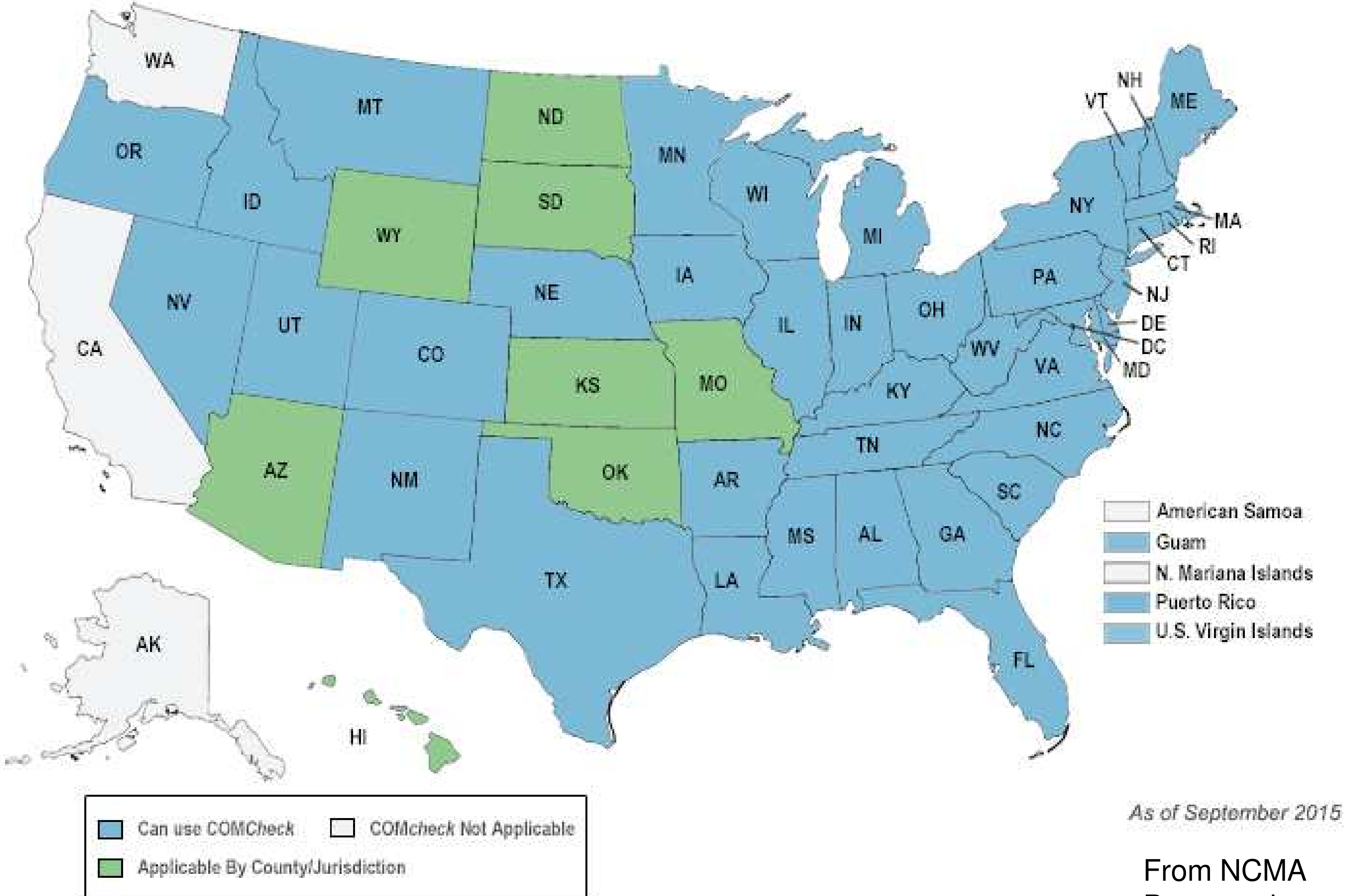
From NCMA
Presentation

COMcheck

- easy way to take advantage of trade-offs, ie, increase roof insulation to reduce wall or window requirements.
- program shows if the envelope complies, and how close it is to compliance
- allows individual elements to be tweaked for compliance, revisions are quick and easy.
- **<u>Trade offs are for envelope only</u>**

From NCMA
Presentation

Where Can I Use



From NCMA Presentation

COMcheck Input

COMcheck-Web - 2015 IECC

https://energycode.pnl.gov/COMcheckWeb/index.html

COMcheck-Web™

Big Box Retail | Save

2015 IECC

Log Out

My Projects ▾ | Preferences

New Project

PROJECT | ENVELOPE | INT. LIGHTING | EXT. LIGHTING | MECHANICAL | REQUIREMENTS

Reports | Options

Row: Edit | Duplicate | Move Up | Move Down | Delete

Add: Roof | Skylight | Ext. Wall | Window | Door | Basement | Floor

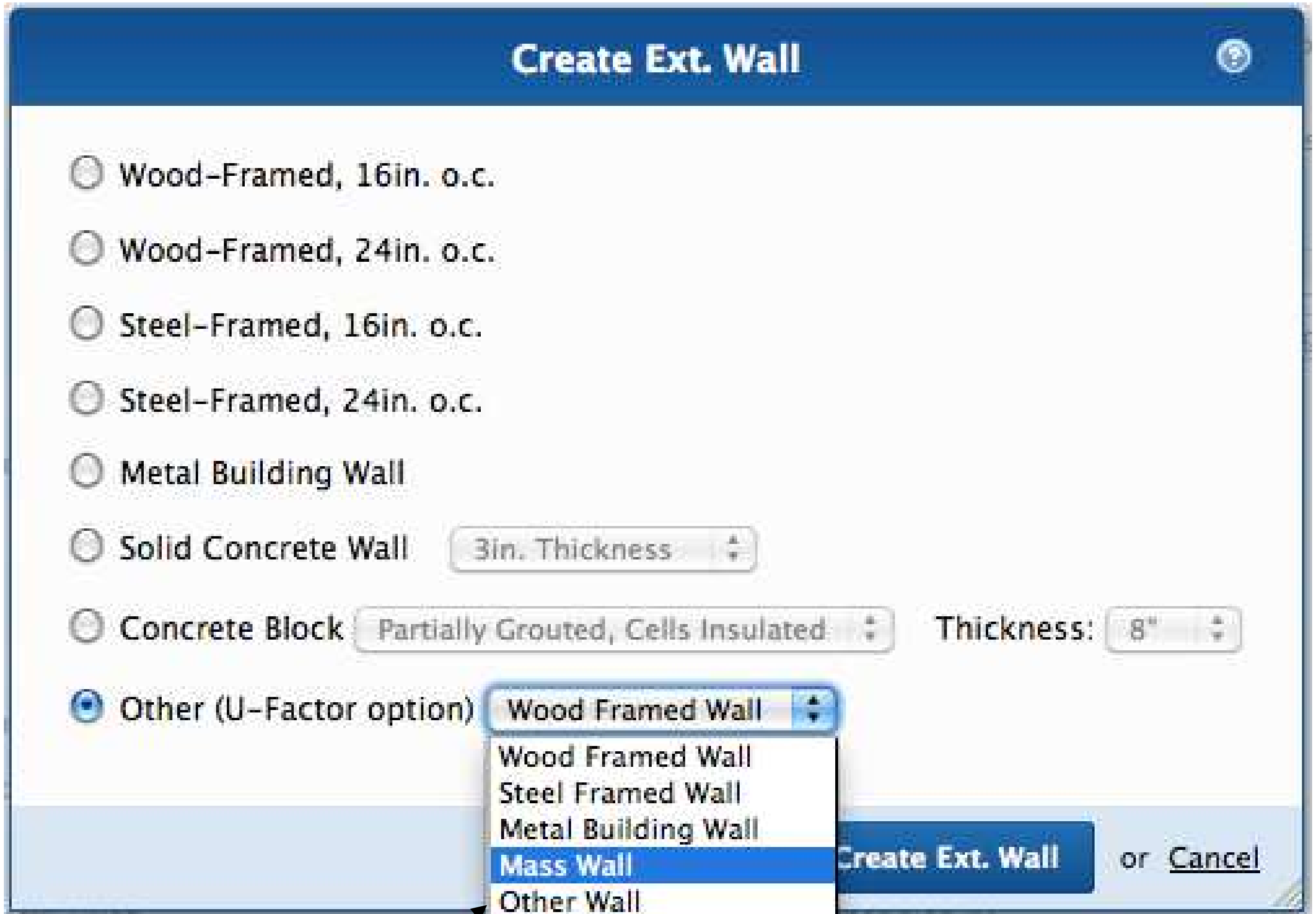
Fenestration Requirements

	Component	Assembly	Building Area Type	Fenestration Details	Construction Details	Gross Area or Slab Perimeter	Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	Heat Capacity	UA	SHGC	Projection Factor
1	Roof	Insulation Entirely Above Deck	2 - Retail (N			134131 ft²		30	0.032		4292		
2	Roof	Insulation Entirely Above Deck	1 - Office (N			4188 ft²		30	0.032		134		
3	Ext. Wall	Other Mass Wall	2 - Retail (N			32887 ft²			0.1	9	3114		
4	Door	Insulated Metal			Swinging	378 ft²			0.61		231		
5	Door	Insulated Metal			Non-Swingir	162 ft²			0.21		34		
6	Door	Uninsulated Double-Layer Metal			Non-Swingir	320 ft²			0.21		67		
7	Window	Metal Frame with Thermal Break: Fixed		Non-NFRC:p...		207 ft²			0.37		77	0.25	1.45
8	Window	Metal Frame with Thermal Break: Fixed		Non-NFRC:p...		532 ft²			0.37		197	0.25	0
9	Window	Metal Frame with Thermal Break: Fixed		Non-NFRC:p...		152 ft²			0.37		56	0.25	1.45
10	Ext. Wall	Other Mass Wall	1 - Office (N			5243 ft²			0.1	9	524		
11	Floor	Unheated Slab-On-Grade	2 - Retail (N		Vert. Ins., 2ft	1611 ft		10			870		

Envelope Passes +2% | Interior Lighting TBD -- | Exterior Lighting TBD --

From NCMA Presentation

COMcheck Input



Always use Other (mass) exterior wall input

Default value for CMU very conservative.

From NCMA Presentation

COMcheck Input – Other Mass Wall

Assembly	Orier
Other Mass Wall	North

Continuous Insulation R-Value	U-Factor	Heat Capacity
	0.091	9

Thermal Catalog
NCMA TEKs 6-1C & 6-2C
R-Value/U-Factor
Calculator

NCMA TEK 6-16A

Also ACI 122R Guide to Thermal Properties of Concrete and Masonry Systems

From NCMA
Presentation

COMcheck Results

- Using COMCheck allows slightly higher U-factor for mass wall than prescriptive
- Using trade-offs can change required efficiency for walls (or other components)

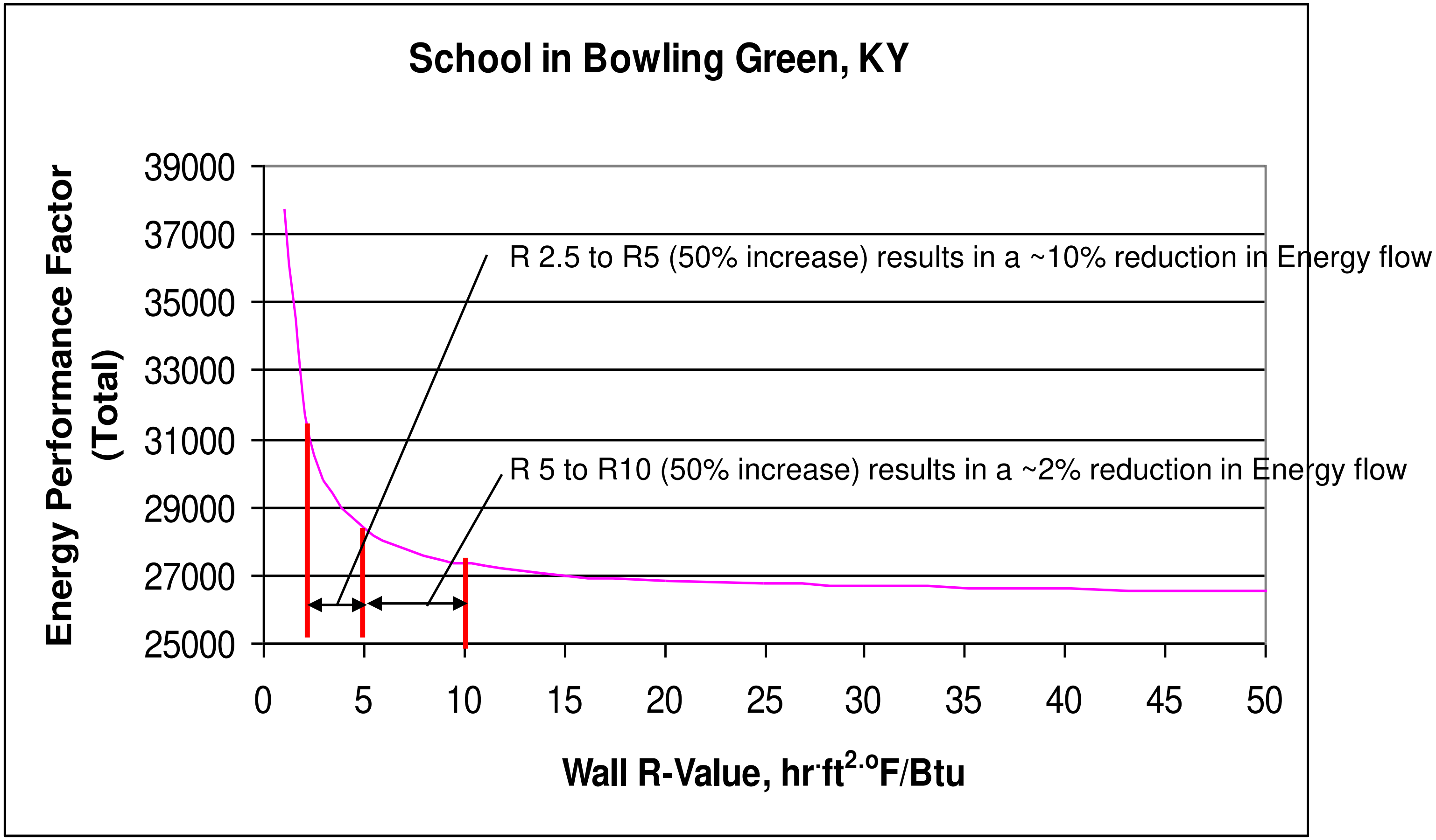
Method	Mass wall requirement
Prescriptive R-value	R9.5 ci
Prescriptive U-factor	U-0.104 (R9.6)
COMcheck code max U	U-0.109 (R9.2)
Trade-off: max roof R (R60)	U-0.164 (R6.1)

From NCMA Presentation

COMcheck

- If close to prescriptive can help
- But prescriptive R/U values close to max effective values.
- Large increases in R have less impact at higher R values
- See following slide

Envelope Performance Factor (EPF) is a relative term that approximates the total heating and cooling energy associated with an average square foot of surface or square meter of building envelope



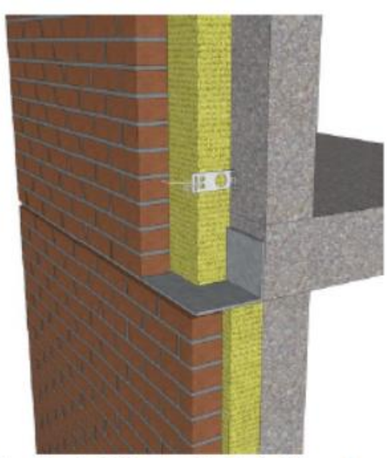
COMCheck accounts for this effect so adding a lot of R on roof only minimally effective if on flat part of curve

Thermal Bridging

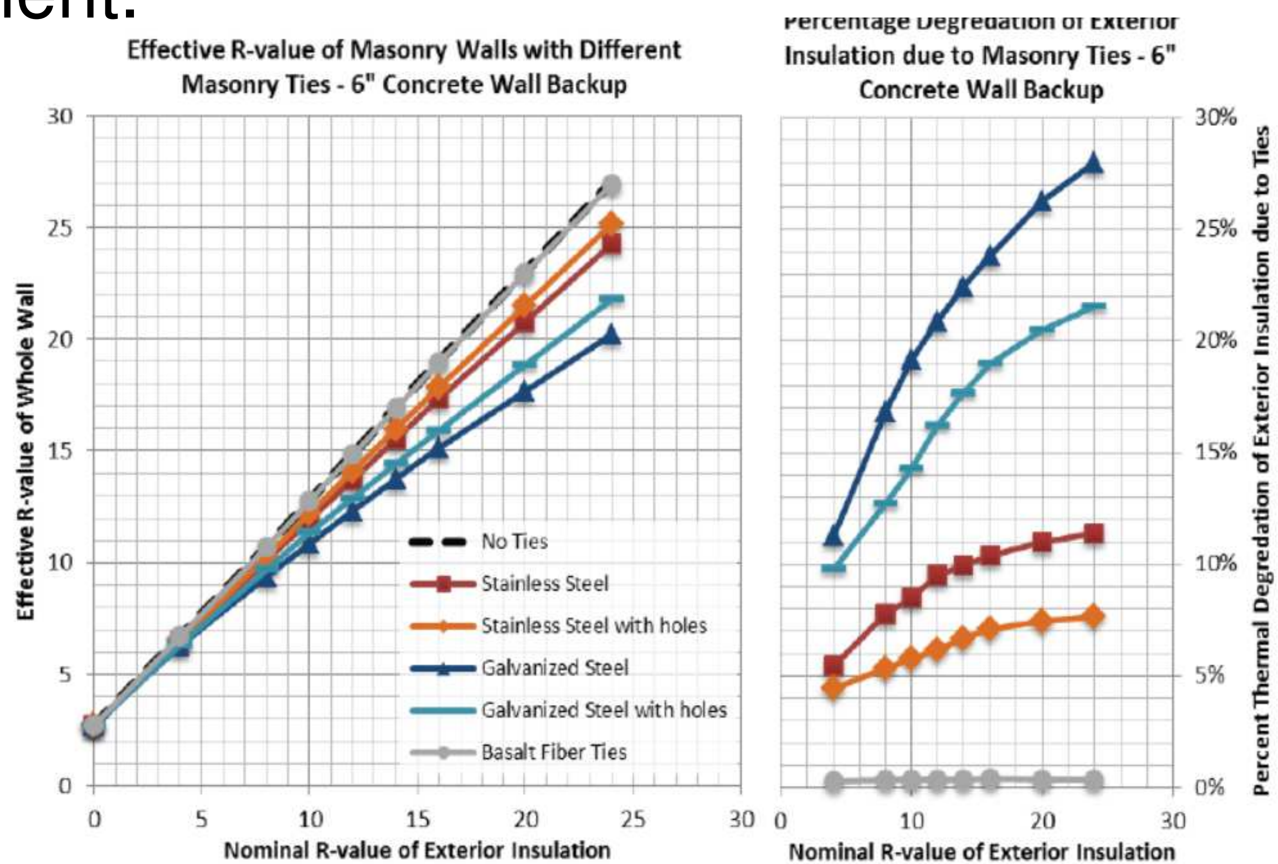
Thermal bridging can have a significant effect on Thermal resistance of the envelope – Thus the C_i or U requirement.

Ties(anchors) angles can reduce steady state thermal resistance significantly

16” x 24”



Standard slab attached shelf angle



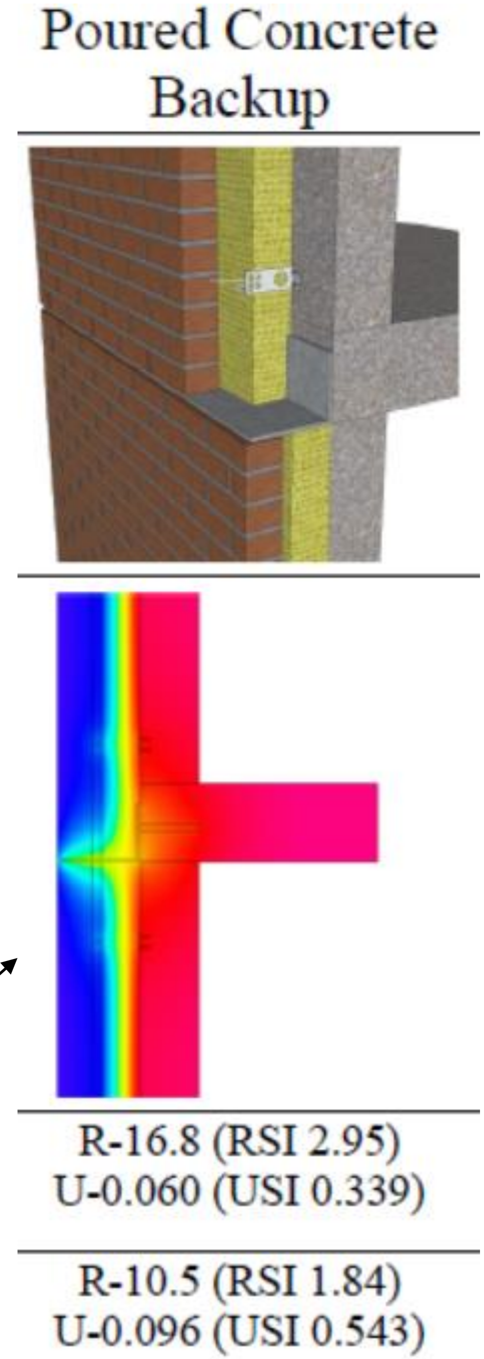
THERMAL BRIDGING OF MASONRY VENEER CLADDINGS AND ENERGY CODE COMPLIANCE, 12th Canadian Masonry Symposium
Vancouver, British Columbia, June 2-5, 2013
Michael Wilson1, Graham Finch2 and James Higgins3

Thermal Bridging

Thermal bridging can have a significant effect on Thermal resistance of the envelope – Thus the Ci requirement.

Shelf angles can reduce steady state thermal resistance significantly

~40% reduction



MASONRY VENEER SUPPORT DETAILS: THERMAL BRIDGING, 12th Canadian Masonry Symposium
Vancouver, British Columbia, June 2-5, 2013
Michael Wilson1, Graham Finch2 and James Higgins3

Metal Thermal bridges can impact Steady state thermal resistance.

- What impact does reduction in the exterior wall thermal resistance have?
- Do changes in envelope thermal resistances produce proportional increases in energy loss and thus energy use?
- Looked at this issue further by addressing energy use in a few typical masonry buildings –

BEST WAY TO EVALUATE THESE EFFECTS IS TO USE HOLISTIC ENERGY ANALYSIS – ENERGYPLUS, DOE 2.

- Basis of 3rd compliance method, Energy Budget method – Proposed building must have ≤ Energy cost to prescriptive methods – Also new Appendix G method index.

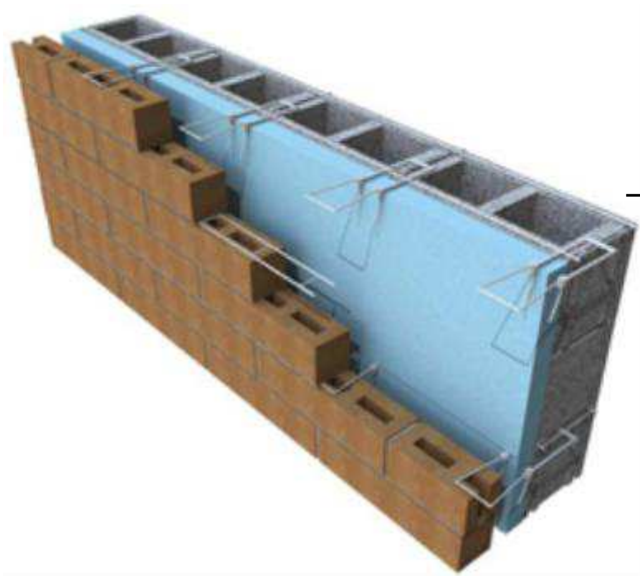
- Better accounts of thermal mass effects – dynamic weather and internal loads, etc.

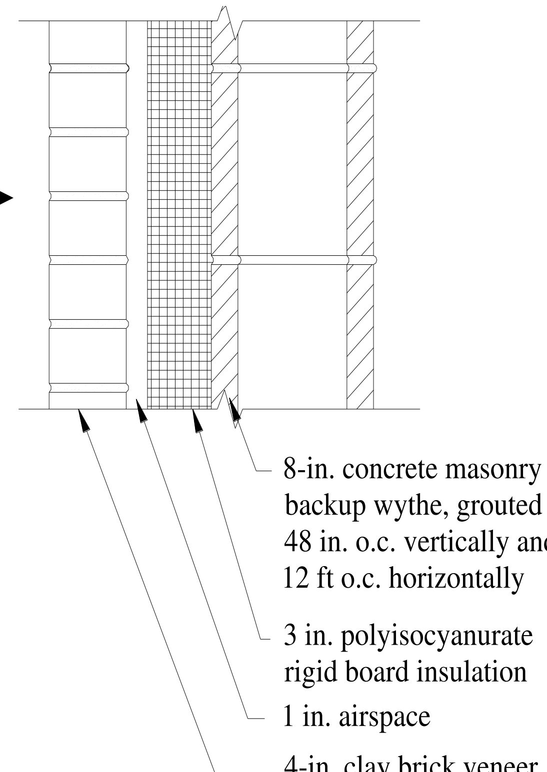
Designed a Base Prototype Middle School to Meet prescriptive provisions -4B

- Most Lights T 12- 2 and 4 lamp systems
- High bay halides
- HVAC VAV - Gas boilers and Chillers
- Typical school use schedules.
- Minimum Envelope U and R values ~ R 26 Roof, ~R 9.8 Walls
- Base EUI - ~132

www.schoolclearing house.org) ~158,000 ft^2 2 Story- Prototype

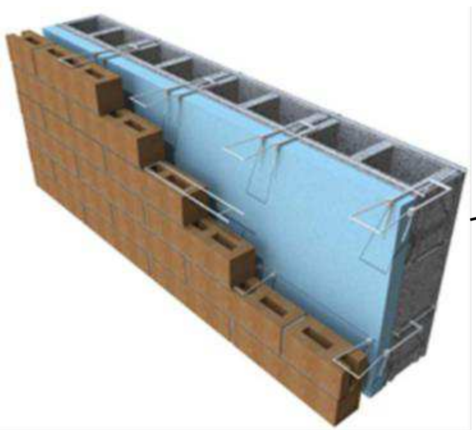
Evaluated Select Alternatives (ECM's):
•Variety of Building Envelopes - Walls & roofs

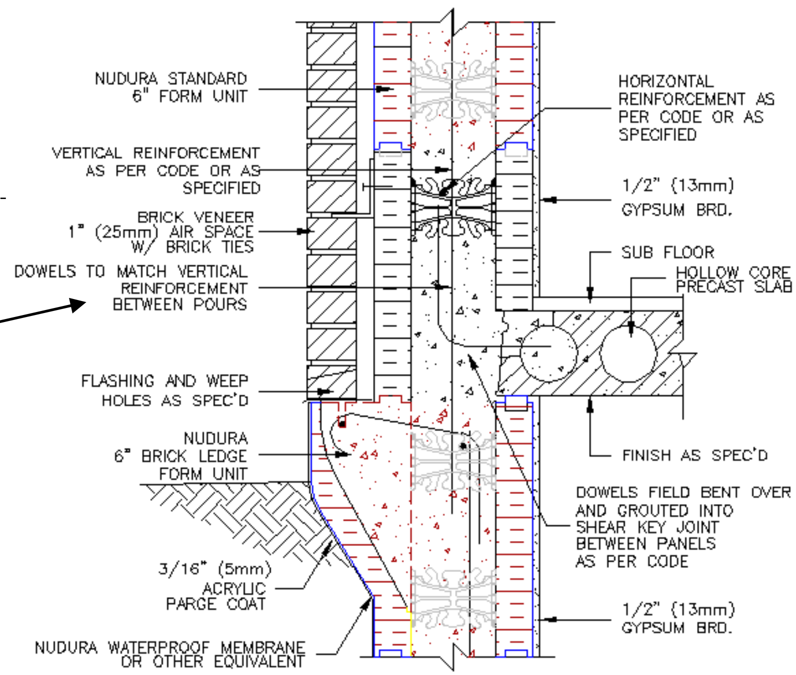


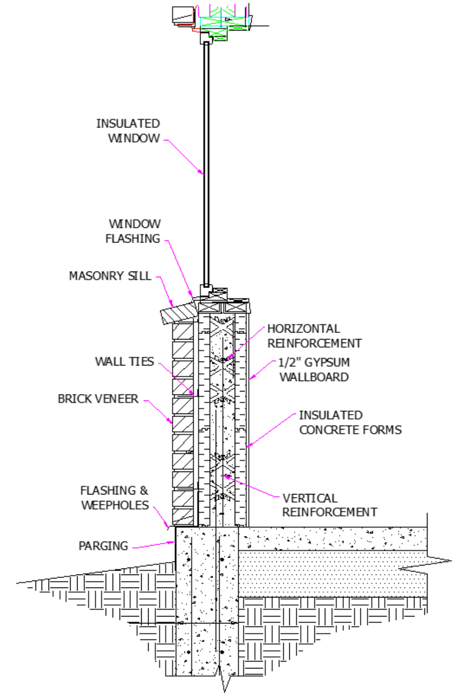


Vary the exterior masonry cavity wall insulation: 1 ¼" thick polystyrene, 1 ½" thick polystyrene, 2" thick polyisocyanurate foam board, 3" polyisocyanurate foam board. **Over 100% swing in insulation values.**

Evaluated Select Alternatives (ECM's):
•Variety of Building Envelopes - Walls







Exterior CMU wall structure to an insulated concrete form (ICF) wall system; 4" face brick, air space, 1 ½" polyurethane, 6" 140lb concrete, 1 ½" polyurethane, and ½" gypsum board.

Investigated Energy Conservation Measures

- Each of the Mature alternative energy conservation measures (ECM's) technologies were incorporated into the building.
- Prototype building was re-analyzed using eQuest (DOE2) for each ECM singly and in groups - 5 KY cities. Holistic analysis **– Energy Budget Method**
- Conducted an economic differential cost analysis – Pay back and Self-funding

Energy Savings and Payback in Typical Middle School*

*Louisville, KY – other climates similar
EUI – Energy Use Index (kBtu/SF)

Roof

Base R = 22 pitched, R 26.3 flat	**%EUI Reduction from 132**	**Simple Payback (years)**
R = 29.4 pitched, R 33.3 flat BUR	0.3%	160
R = 37.0 pitched, R 40 flat BUR	0.6%	189

Windows

Base U = .54/.64 glass/frame	**%EUI reduction from 132**	**Simple Payback (years)**
Higher U=.67/.69	0.0%	Lower initial cost
Lower U=.23/.31	0.2%	39

Walls

Base R = 9.1 4" brick, 8" CMU	**%EUI Reduction from 132**	**Simple Payback (years)**
R = 13.3" 4" brick, 8" CMU	0.3%	<1.0
R = 25, 4" brick, 8" CMU	0.6%	75.3
ICF R = 22, 4" brick	0.5%	335
BVSS R = R37 , 4" brick, 6 " Steel Stud	0.6%	Potential lower initial cost**

Air Barriers

Base 0.5 Air change /hour	**%EUI Reduction from 132**	**Simple Payback (years)**
0.2 Air change/hour	0.7%	52
0.1 Air change/hour	-0.1%	No return

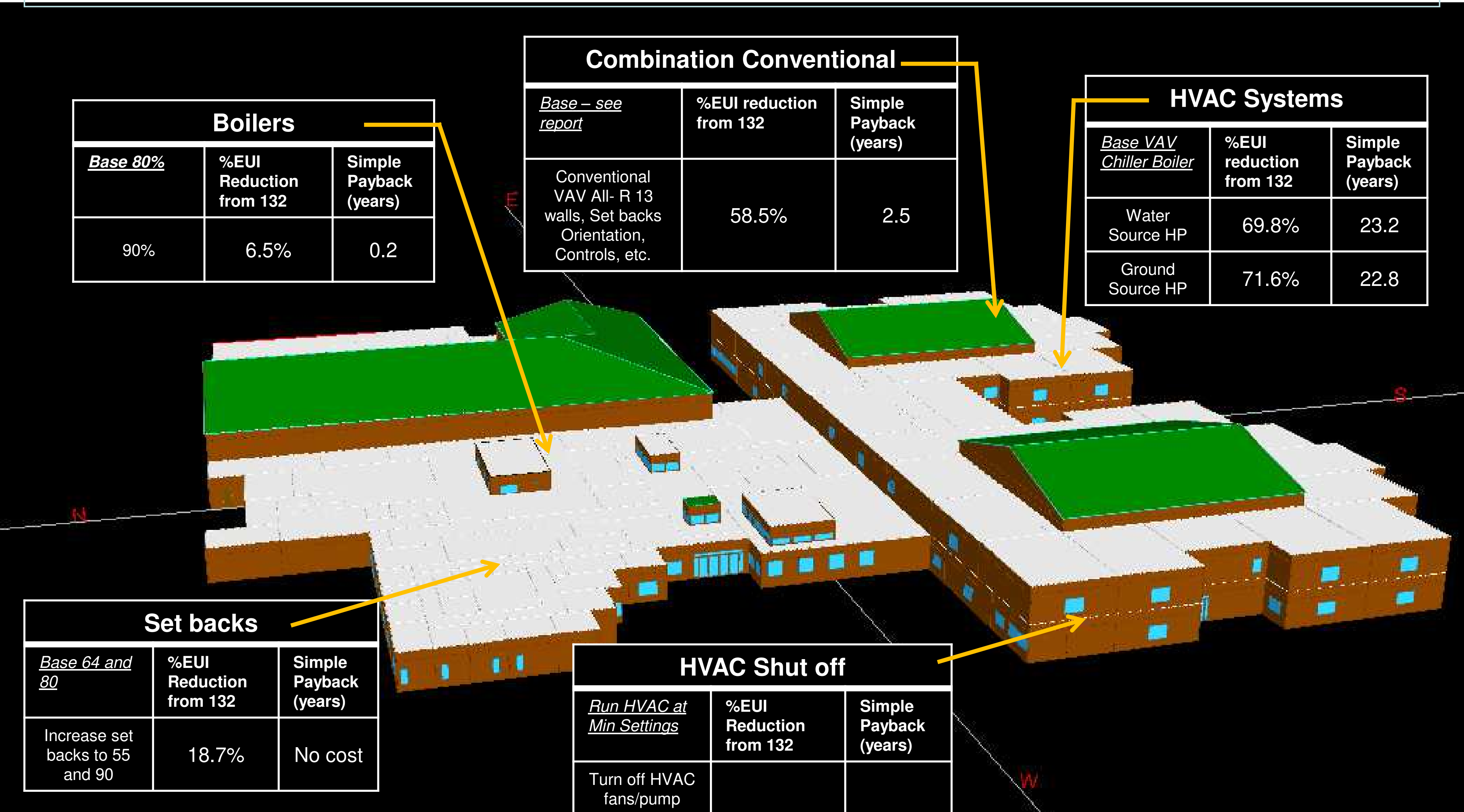
** lower initial cost ignores structural steel frame costs and probable condensation and maintenance issues

For more details See: *"Cost Effective Energy Efficient School Design" Report* (McGinley 2011)

Courtesy of the Indiana-Kentucky Structural Masonry Coalition

Energy Savings and Payback in Typical Middle School*

*Louisville, KY – other climates similar
EUI – Energy Use Index (kBtu/SF)



Boilers

Base 80%	%EUI Reduction from 132	Simple Payback (years)
90%	6.5%	0.2

Combination Conventional

Base – see report	%EUI reduction from 132	Simple Payback (years)
Conventional VAV All- R 13 walls, Set backs Orientation, Controls, etc.	58.5%	2.5

HVAC Systems

Base VAV Chiller Boiler	%EUI reduction from 132	Simple Payback (years)
Water Source HP	69.8%	23.2
Ground Source HP	71.6%	22.8

Set backs

Base 64 and 80	%EUI Reduction from 132	Simple Payback (years)
Increase set backs to 55 and 90	18.7%	No cost

HVAC Shut off

Run HVAC at Min Settings	%EUI Reduction from 132	Simple Payback (years)
Turn off HVAC fans/pump 7pm -6am except as needed for set back temp	21.1%	2.8

For more details See: *"Cost Effective Energy Efficient School Design" Report* (McGinley 2011)

Courtesy of the Indiana-Kentucky Structural Masonry Coalition

ALTERNATIVE ENERGY DESIGNS IN SINGLE WYTHE MASONRY BUILDINGS

- U of L looked at design alternatives to the simple prescriptive solutions offered by the energy code for three building archetypes that are typically constructed with single wythe masonry exterior wall systems.
- For each archetype, various code-compliant [ASHRAE 90.1 2010, NECB 2011] alternative construction configurations were examined for energy efficiencies, energy costs and construction costs (for various climate zones).
- Also conducted a differential capital cost and payback analysis
- Also looked at Canadian Code

Archetype 1 – Warehouse - US

One of 16 reference buildings used for the evaluation of energy analysis software by the Department of Energy and developed to be representative of over 80% of typical warehouse configurations [Deru, et-al 2011], [NREL 2013].

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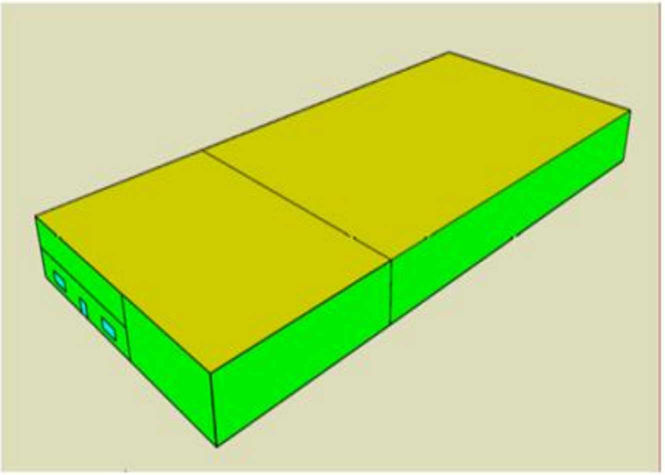
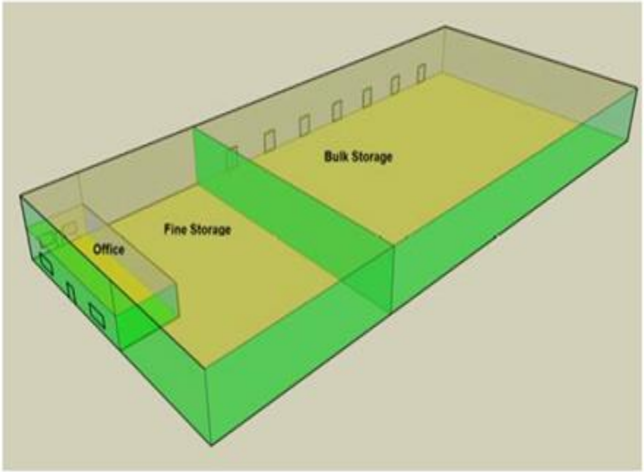
Prototype Warehouse for the Energy Modelling (≈50000 ft^2)

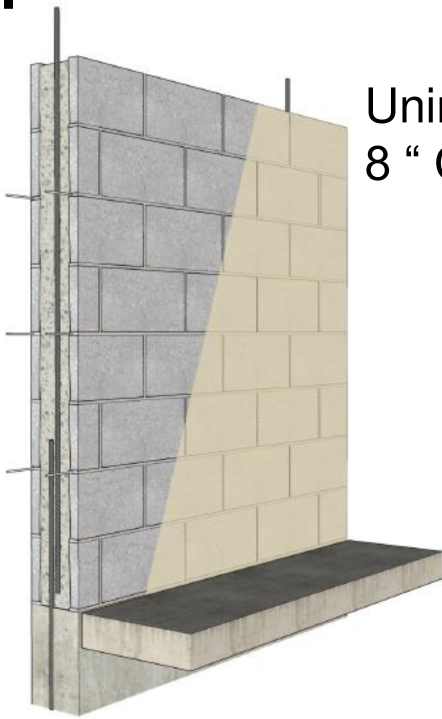




Evaluated Climate Zones and cities.

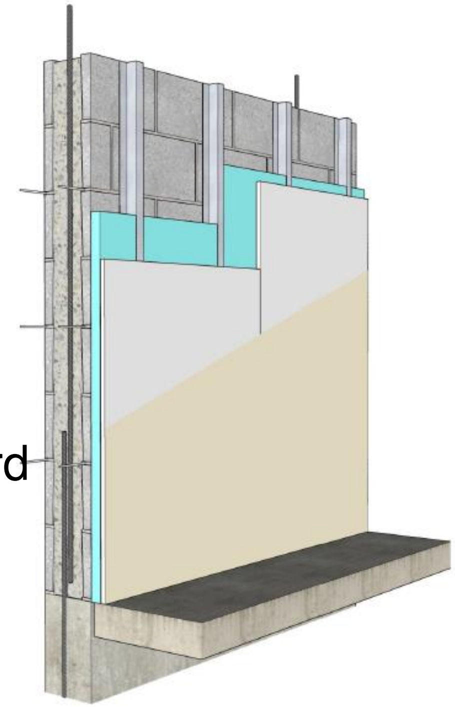
City	State	Climate Zone	City	State	Climate Zone
Atlanta	Georgia	3A	Chicago	Illinois	5A
Las Vegas	Nevada	3B	Boulder	Colorado	5B
San Francisco	California	3C	Minneapolis	Minnesota	6A
Baltimore	Maryland	4A	Helena	Montana	6B
Albuquerque	New Mexico	4B	Duluth	Minnesota	7
Seattle	Washington	4C			

Prototype Warehouse <u>BASELINE DESIGNS - US</u> Configured to Code Prescriptive levels and Analyzed using the Energyplus program for cities in Table 1 as required in the Energy Budget Code Compliance method



Uninsulated
8 “ CMU

Insulated
8 “ CMU
Z channels
½ Gypsum wall board



(Infiltration rate of 0.038 cfm/ft^2)

Some climate zone required the exterior walls of the bulk storage to be insulated, some did not. The office and fine storage areas were insulated with varying R values

Archetype 2 &3 Supermarket & Box Retail-US

One of 16 reference buildings used for the evaluation of energy analysis software by the Department of Energy [Deru, et-al 2011], [NREL 2013].

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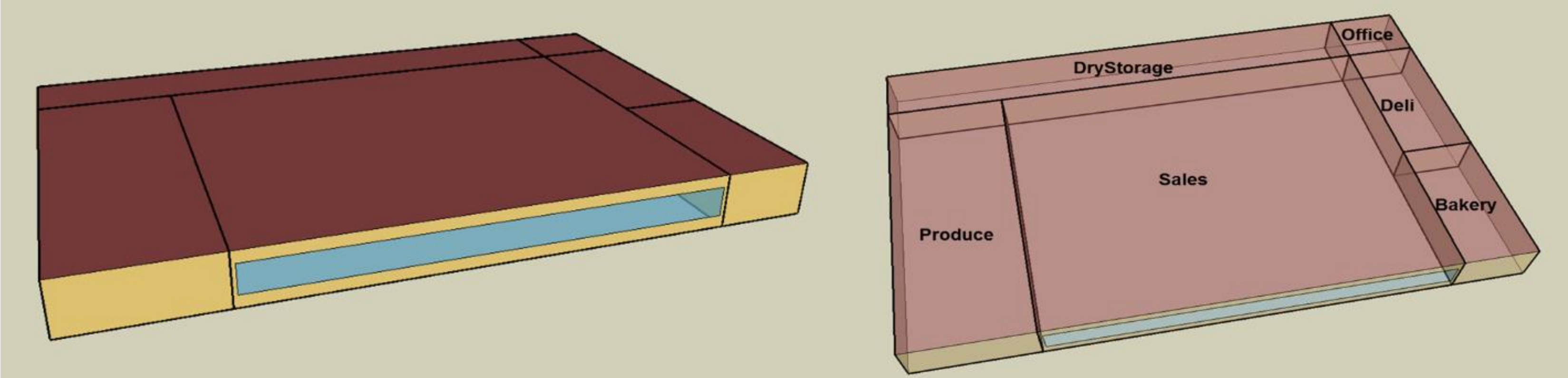
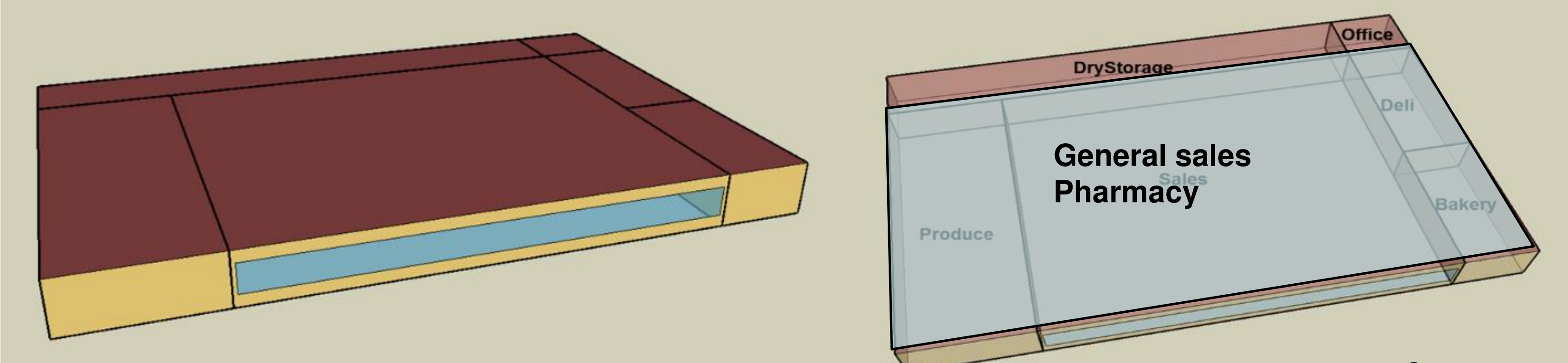
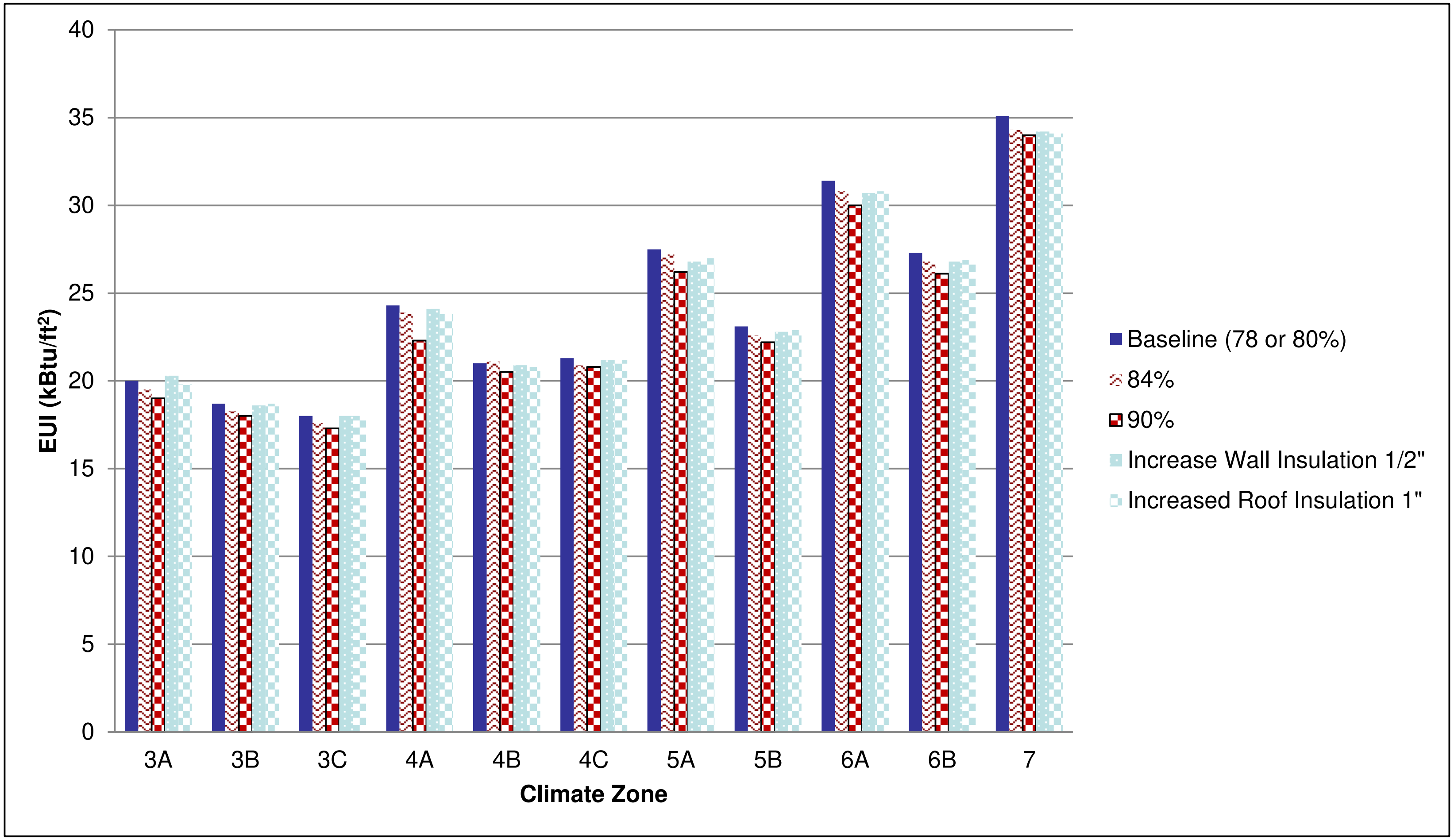


Prototype Supermarket for the Energy Modelling (≈45000 ft²)



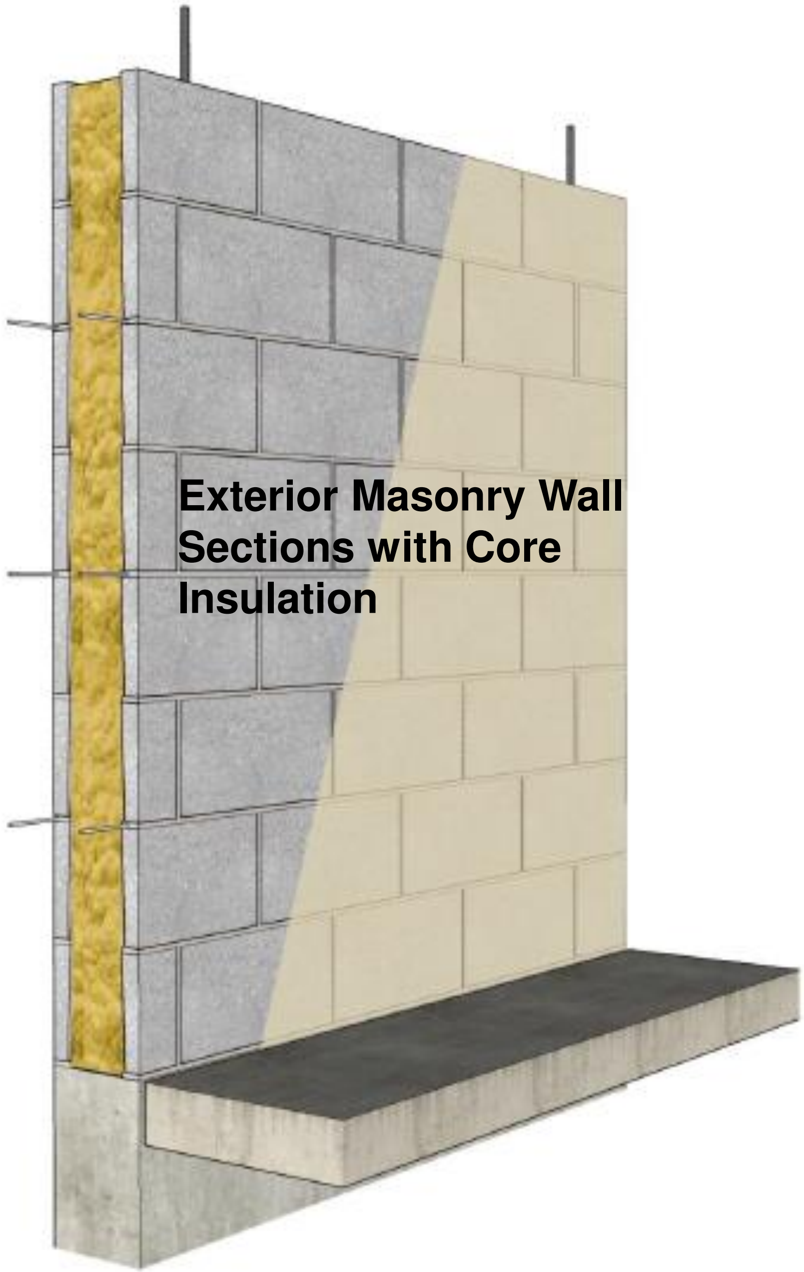
Prototype Box Retail for the Energy Modelling (≈45000 ft²)

Warehouse Sensitivity Analysis- US



Energy Use Intensities: Wall and Roof Insulation vs. Heating Efficiency
Less effect of insulation more effect of HVAC effciency

Warehouse Sensitivity Analysis- US



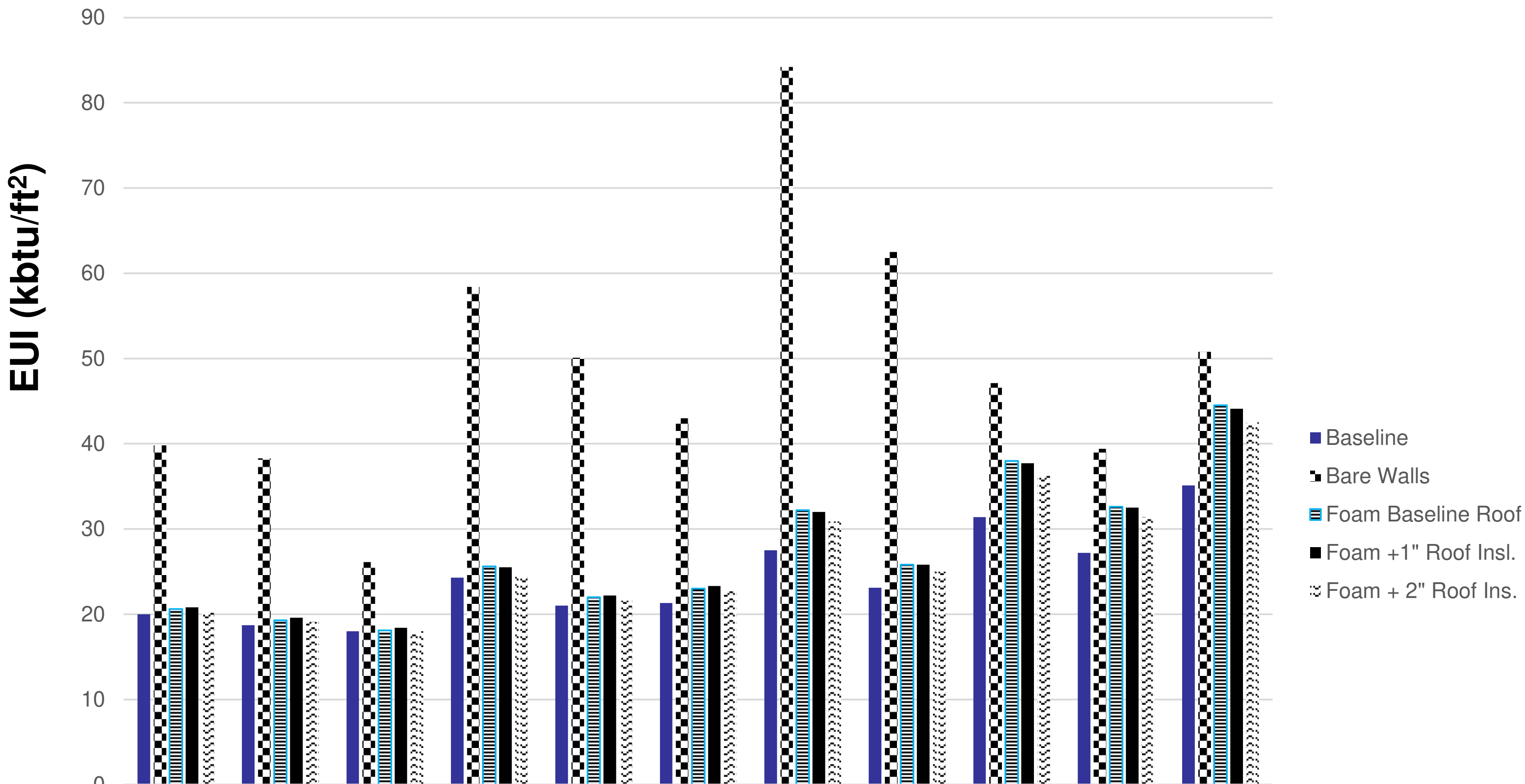
8” CMU wall, partially grouted and reinforced at 48 inches OC -all other cores filled with foam insulation

By NCMA TEK Note 6B [14] U- and R-values = 0.287 Btu/ft^2-h-$^\circ$F and 3.48 ft^2-h-$^\circ$F/Btu

This is a significant decrease in thermal transmittance when compared to the bare masonry wall (with U-value of 0.580 Btu/ft^2-h-$^\circ$F-partially grouted).

(8” CMU wall having a continuous insulation of R-7.2 ft^2-h-$^\circ$F/ Btu (U-value of 0.125 Btu/ft^2-h-$^\circ$F)).

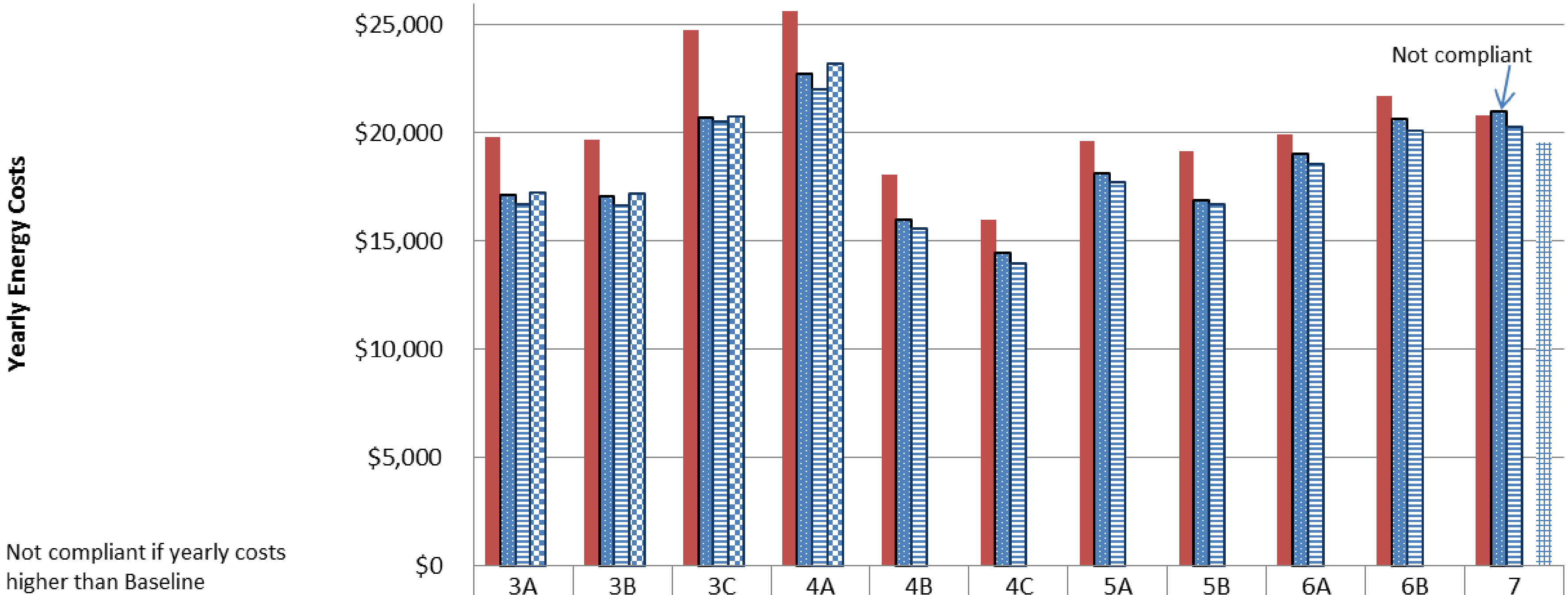
Warehouse Sensitivity Analysis- US



	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
Baseline	20	18.7	18	24.3	21	21.3	27.5	23.1	31.4	27.2	35.1
Bare Walls	39.8	38.3	26.1	58.4	50.1	43	84.2	62.5	47.1	39.4	50.8
Foam Baseline Roof	20.6	19.3	18.1	25.6	22	23	32.2	25.8	38	32.6	44.5
Foam +1" Roof Insl.	20.8	19.6	18.4	25.5	22.2	23.3	32	25.8	37.7	32.5	44.1
Foam + 2" Roof Ins.	20.3	19.1	18	24.6	21.6	22.7	30.9	25	36.4	31.4	42.5

Climate Zone

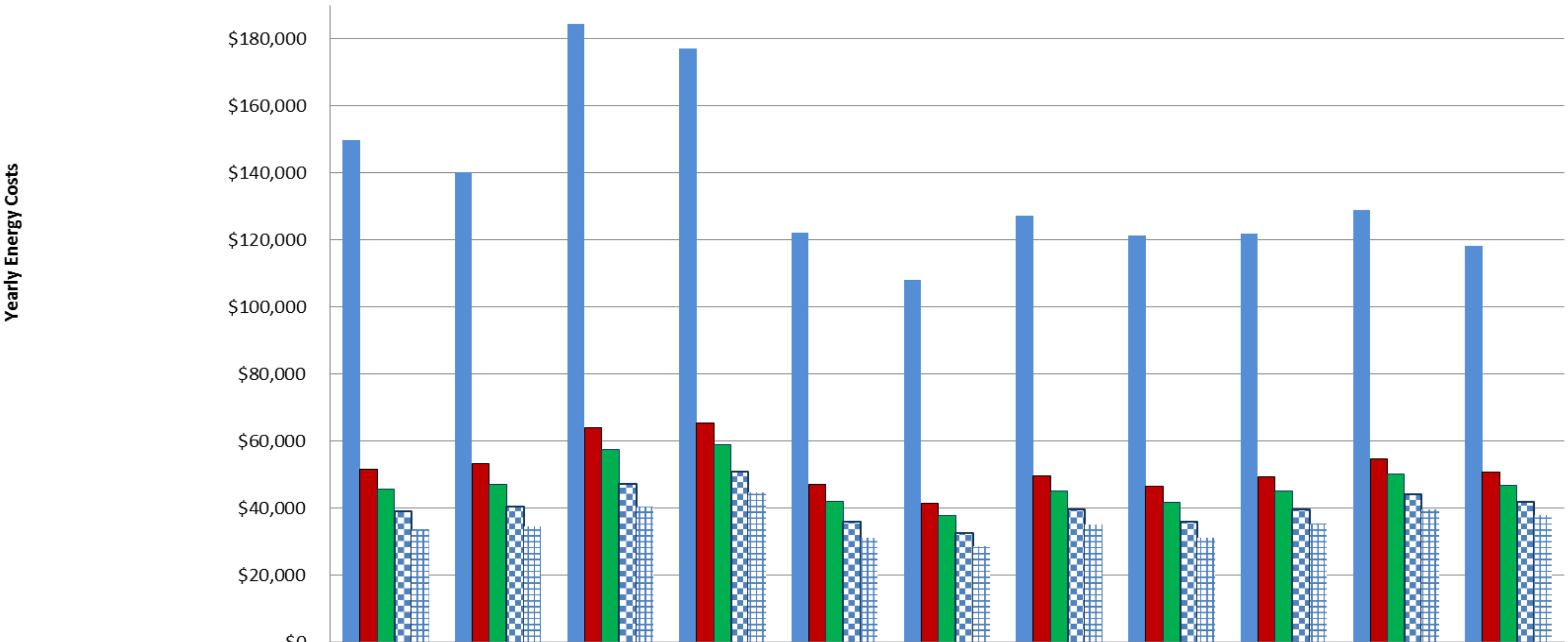
Alternative Designs US Code Compliance - Warehouse



	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
Baseline	$19,792	$19,701	$24,728	$25,665	$18,076	$16,008	$19,616	$19,162	$19,915	$21,722	$20,833
8CMU 2roof Lower Ballast	$17,100	$17,059	$20,699	$22,737	$16,003	$14,424	$18,119	$16,863	$19,009	$20,663	
12CMU 2roof lower ballast	$16,708	$16,626	$20,540	$22,027	$15,603	$13,986	$17,699	$16,682	$18,530	$20,126	$20,284
8CMU Lower Ballast	$17,261	$17,197	$20,771	$23,176							
8CMU 2roof Lower Ballast Occ. Sensor											$19,546

Figure: Yearly Prototype Warehouse Energy Costs. (based on State Averages)

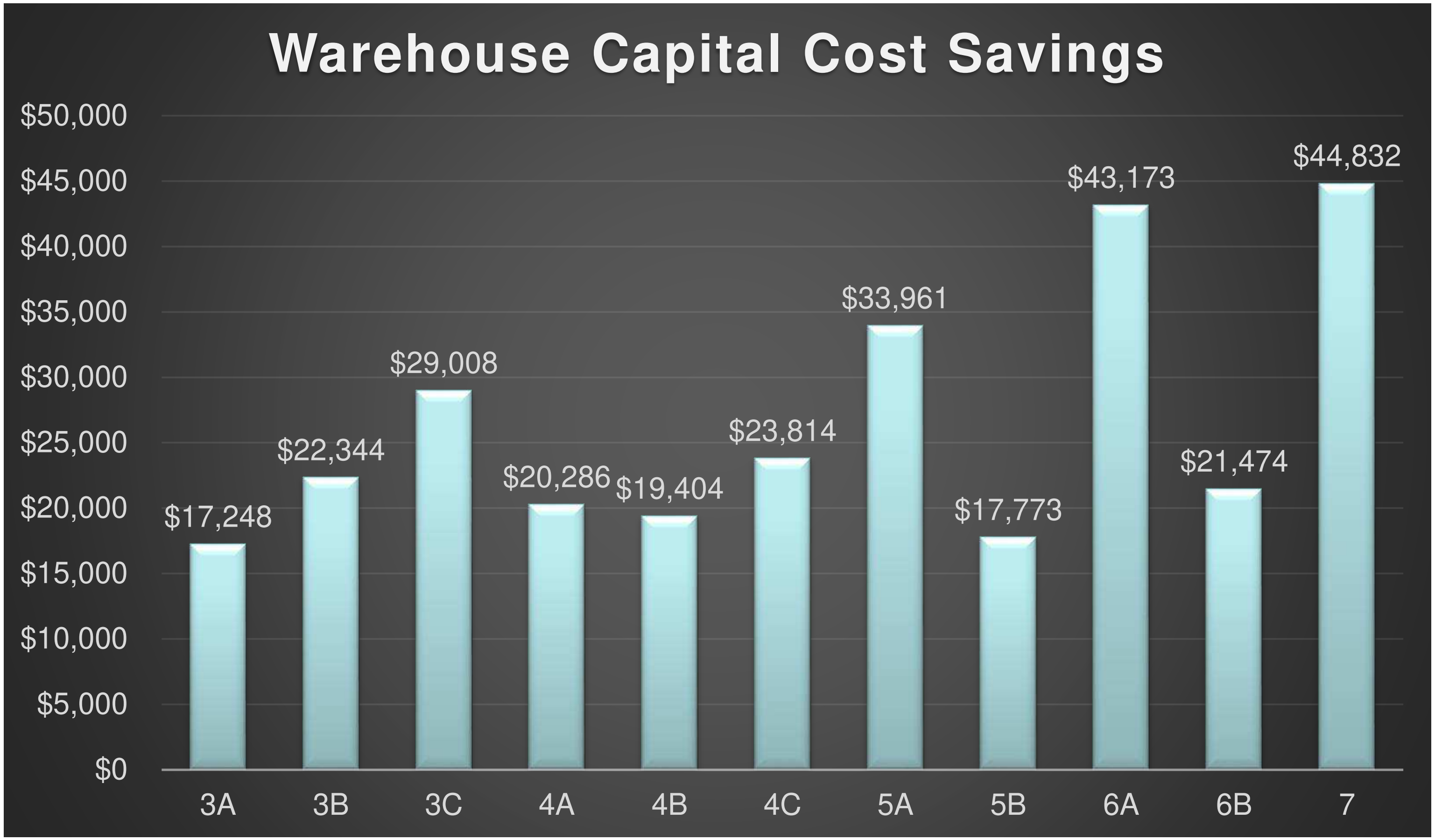
Alternative Designs US Code Compliance- Supermarket-Box Retail



	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7
Supermarket Baseline (Refrig.)	$149,777	$140,225	$184,437	$177,234	$122,257	$108,122	$127,295	$121,389	$121,820	$128,828	$118,097
Supermarket Baseline (no Refrig.)	$51,461	$53,287	$63,925	$65,257	$46,958	$41,391	$49,524	$46,528	$49,231	$54,722	$50,770
Box Retail Baseline	$45,812	$47,091	$57,441	$58,869	$42,015	$37,706	$45,015	$41,857	$45,044	$50,137	$46,890
Supermarket No Refrig. 8CMU LED	$39,068	$40,483	$47,104	$50,992	$36,053	$32,490	$39,532	$35,896	$39,556	$44,162	$41,735
Box Retail 8CMU LED	$33,600	$34,455	$40,447	$44,658	$31,286	$28,760	$35,096	$31,303	$35,499	$39,686	$37,948

Yearly Prototype Energy Costs.

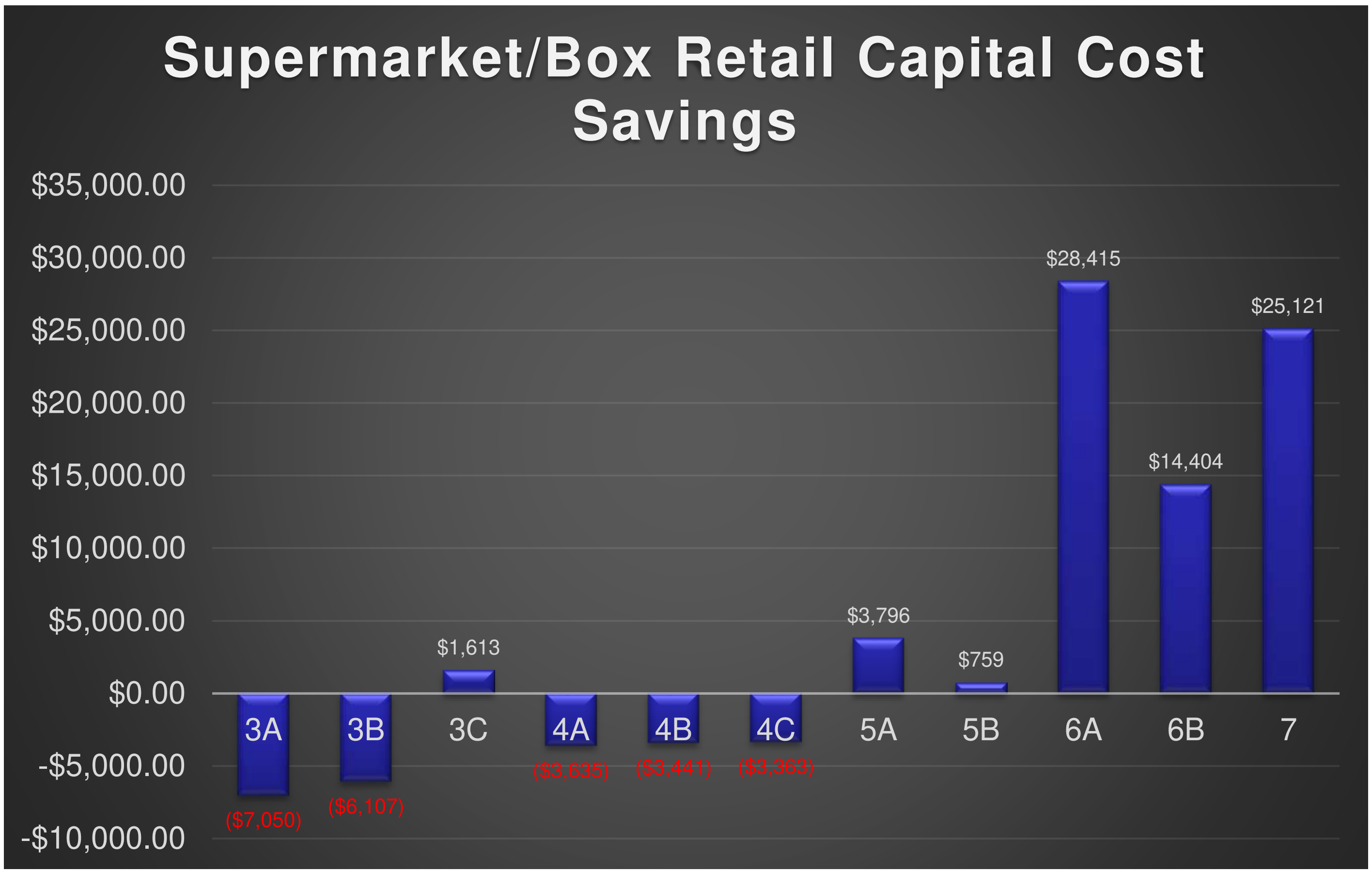
Alternative Designs US Differential Construction Cost



8"CMU Foam core Walls, Lower Ballast Factors
For 4B and above - +2" Roof insulation
For 7 - Occupancy Sensors

Alternative Designs US Differential Construction Cost

Construction Cost Savings of Alternative Designs <u>Box Retail and Supermarkets – 8” CMU Foamed wall and LED Lights</u>



Conclusions

- Prescriptive Methods can be used but assembly U values may be the best way to achieve this especially with 8” or 12” CMU and foamed cores, or two web blocks.
- COM check – Envelope trade offs can work where your designs are close to prescriptive code configurations. Use OTHER Walls.
- Energy Budget method showed significant potential energy savings of over 50% for typical prescriptive configurations. Better lighting, HVAC systems and aggressive control strategies -paybacks < 3 years.

This concludes The American Institute of Architects Continuing Education Systems Course

The Masonry Society

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