J.B. SPEED SCHOOL OF ENGINEERING

# Masonry Walls and Energy Codes - Effective Compliance Methods Session 2

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MASONRY SEMINAR
Masonry Institute of Hawaii
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MIH MIH

1

## Introduction

- The prescriptive energy code requirements for building envelopes have increased significantly over the past several years.
- Compliance with these code provisions is becoming increasingly more difficult, and new solutions are necessary.
- This presentation will provide an overview of energy code provisions, review of energy analysis on various building prototypes.

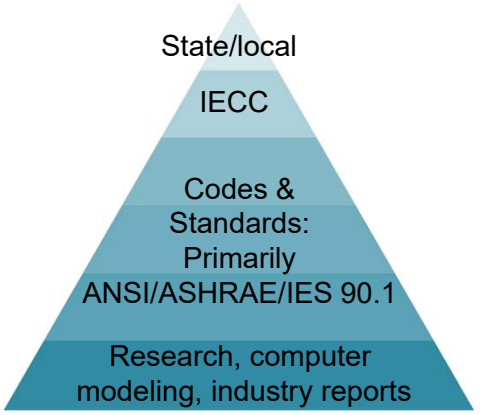
2

## Introduction

- 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 ACI/TMS 122.

3

## Energy Code Hierarchy

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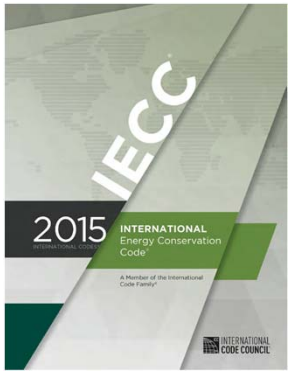
4

# 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

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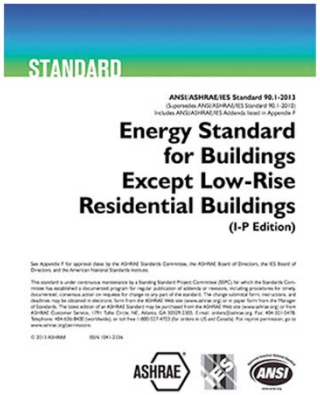
5

# ANSI/ASHRAE/IES Standard 90.1

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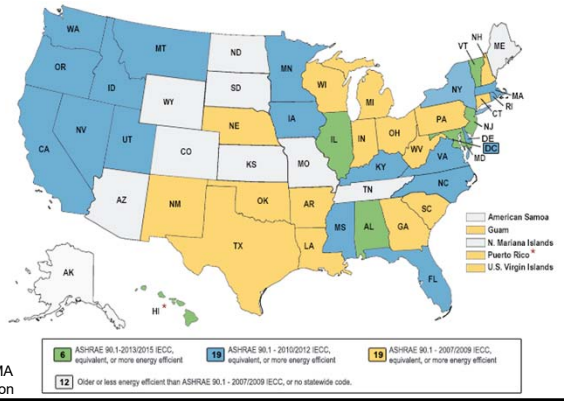
6

# 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.

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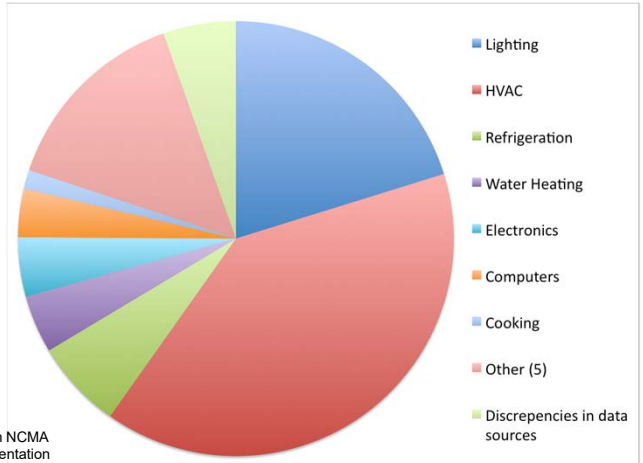
7

# Commercial Building Energy Use

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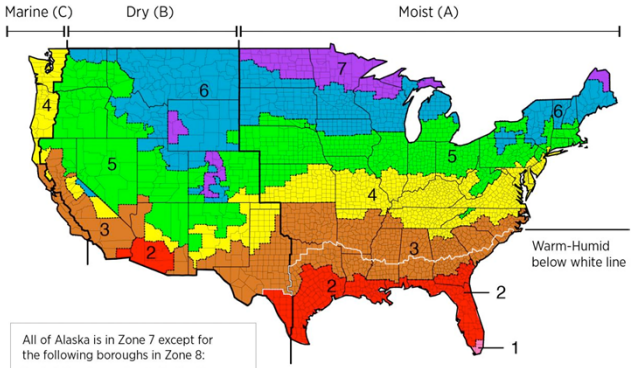
8

# Climate Zones

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9

# Compliance Options - IECC

Prescriptive → R-value table, U-factor table

Trade-off Envelope → COMcheck

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

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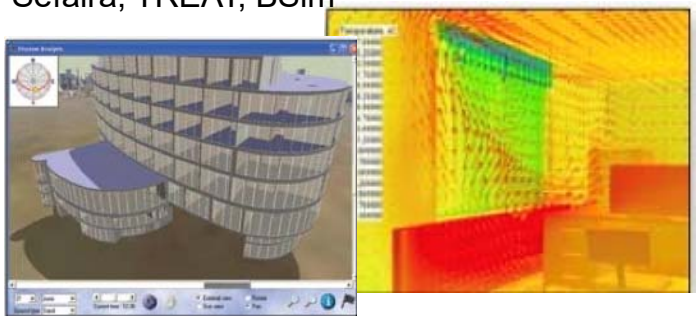
10

# Total Building Performance

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



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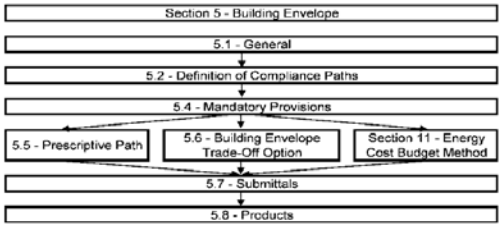
www.buildingenergysoftwaretools.com

11

# 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




12

## 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 Element | 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)[f] | U-0.40 | | U-0.40 | | U-1.20 | |
| Metal framing (curtainwall/storefront)[d] | U-0.50 | SHGC-0.40 all | U-0.50 | SHGC-0.40 all | U-1.20 | SHGC-NR all |
| 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.

13

## 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)

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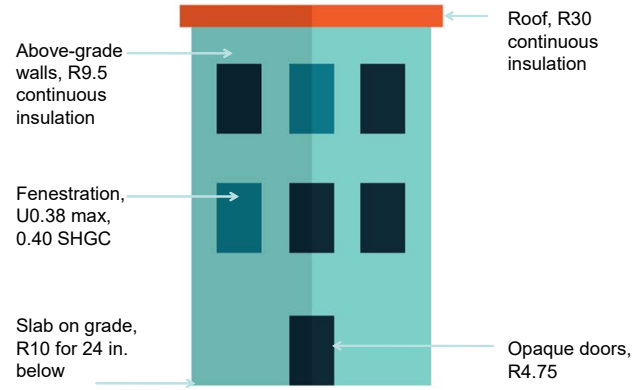
14

## Prescriptive Compliance Example Zone 4 – Envelope – R values

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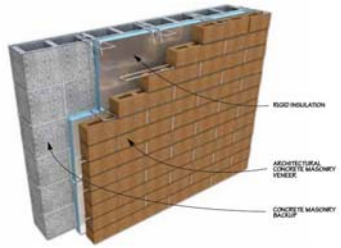
15

## 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

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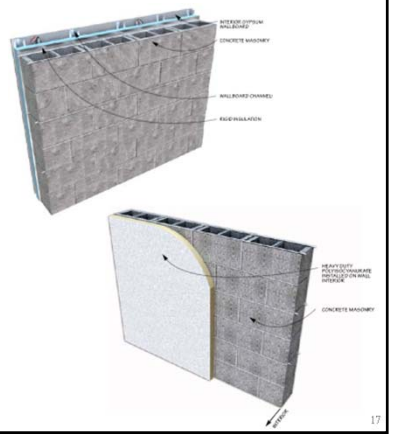
16

# Prescriptive R-Value Compliance

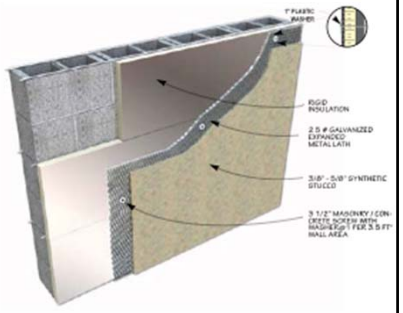
Continuous interior insulation:
- R-values independent of grout schedule
- allows exterior exposed masonry
- furring space can be used for wiring and utilities



17

## Prescriptive R-Value Compliance

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



18

## 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 |

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[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-f² °F.

19

## 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. |

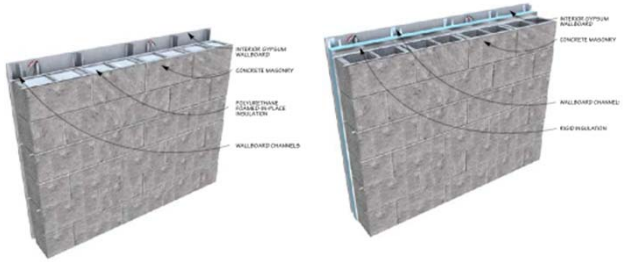
ASHRAE Provisions

IECC – Has a Separate U value table – Assembly U

20

## Prescriptive U-Factor Compliance

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



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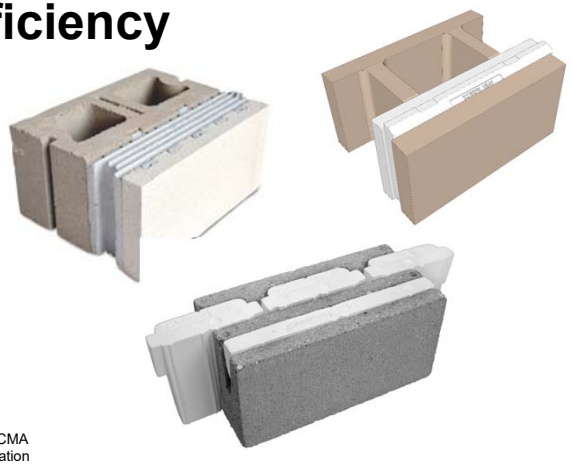
21

## CMU Products for Energy Efficiency



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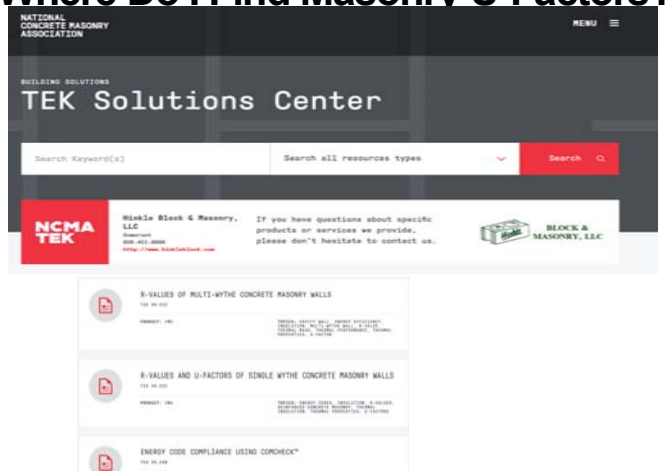
22

## Where Do I Find Masonry U-Factors?




## Where Do I Find Masonry U-Factors?
## NCMA WEB SITE CHANGING – No Spread sheet


24

## 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, ½ 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) |

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25

## 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.).

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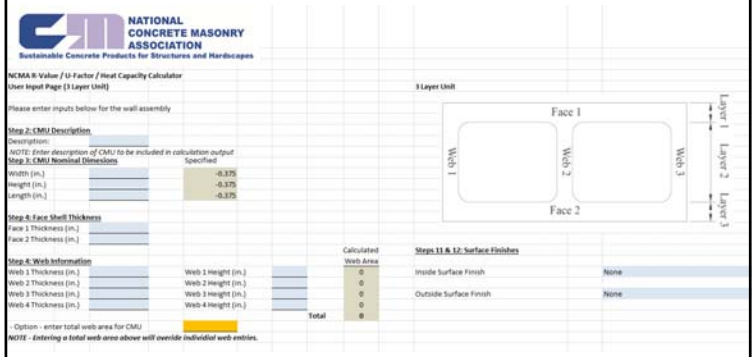
26

## Where Do I Find Masonry U-Factors?

**Use to have a Spread sheet that allowed Parallel and series analysis**




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

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27

## Second Compliance Method

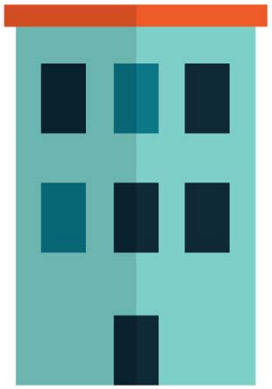
### Trade-Off Compliance/COMcheck

Three overall budgets:

Envelope

Mechanical

Lighting



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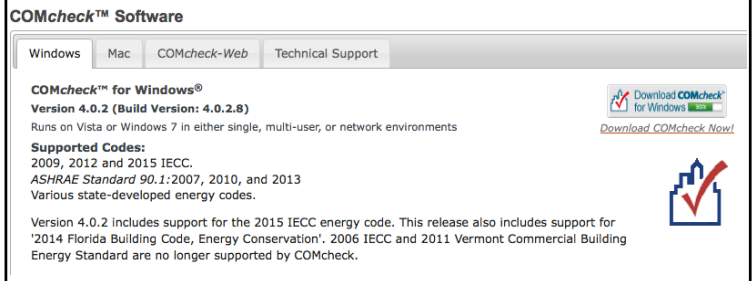
28

# COMcheck

www.energycodes.gov/comcheck

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29

# 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>**

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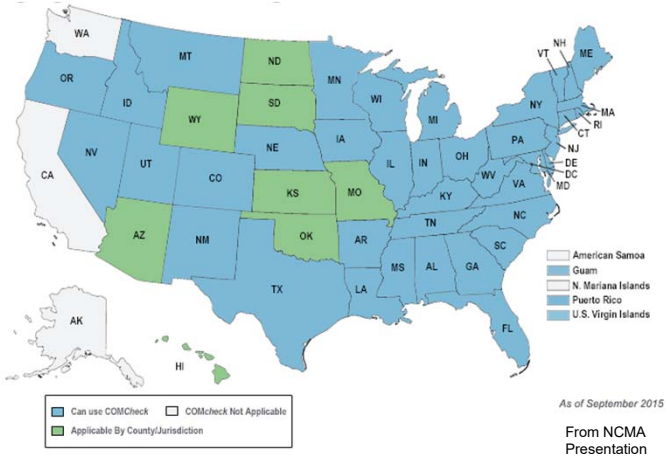
30

# Where Can I Use

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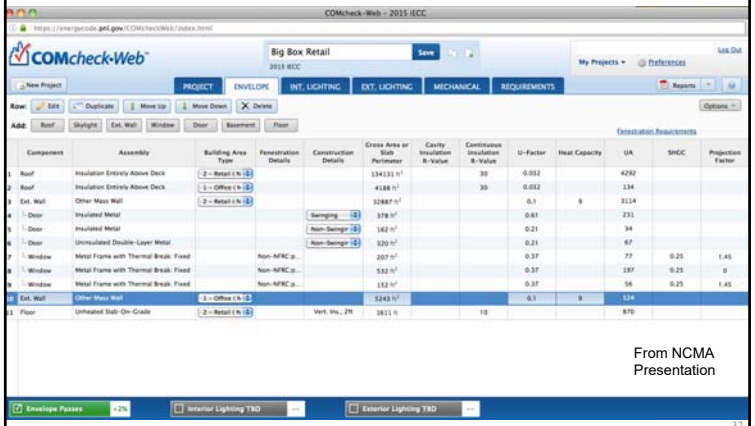
31

# COMcheck Input

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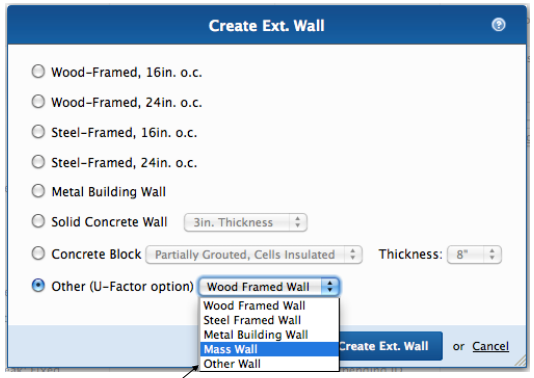
32

# COMcheck Input




**Always use Other (mass) exterior wall input**
**Default value for CMU very conservative.**

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33

# 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

34

# 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) |

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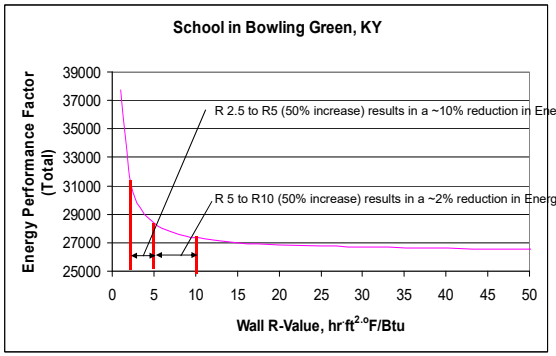
35

# 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

36

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

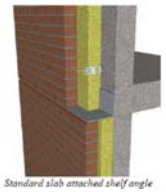
37

## Thermal Bridging

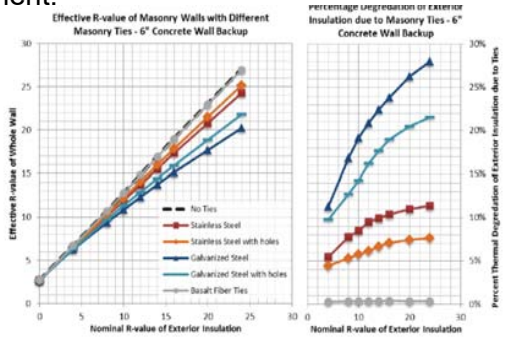
Thermal bridging can have a significant effect on Thermal resistance of the envelope – Thus the $C_i$ or U requirement.

***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

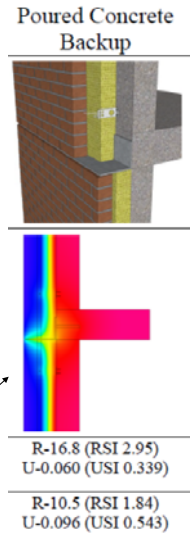
38

## 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

39

## 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 –

40

## 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.

41

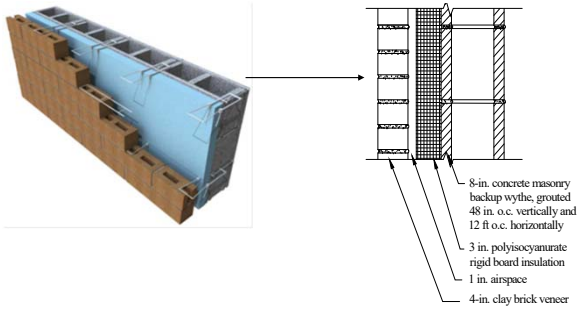
## Designed a Base Prototype Middle School to Meet prescriptive provisions -4B

- 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 ft² 2 Story- Prototype

42

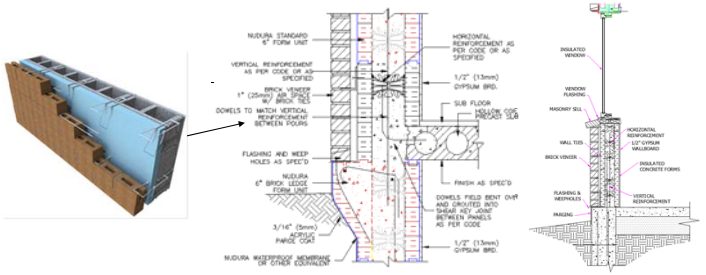
## Evaluated Select Alternatives (ECM's):
## •Variety of Building Envelopes - Walls & roofs




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.**

43

## 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.

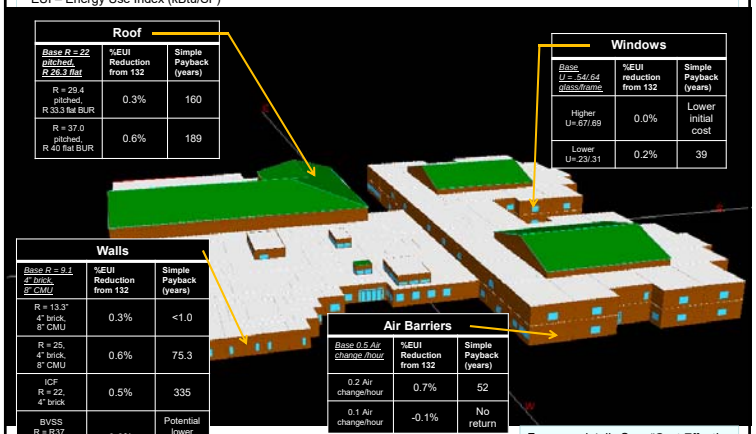
44

## 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)




** 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
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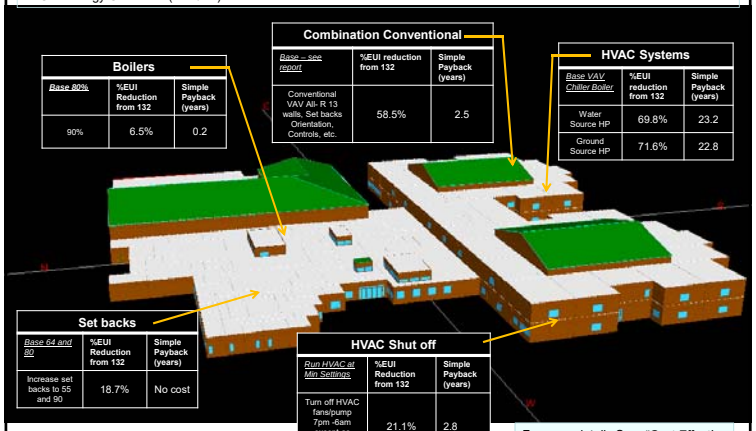


For more details See: *"Cost Effective Energy Efficient School Design" Report* (McGinley 2011)

Courtesy of the Indiana-Kentucky Structural Masonry Coalition

47

## 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

48

# 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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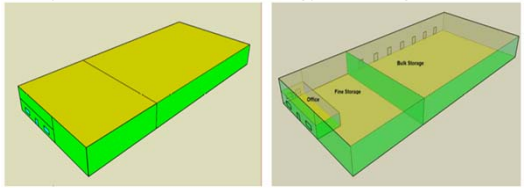
**Prototype Warehouse for the Energy Modelling (≈50000 ft²)**

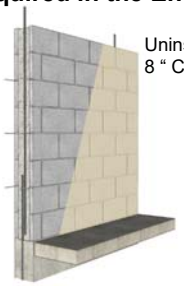



**Evaluated Climate Zones and cities.**

| 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 | | | |

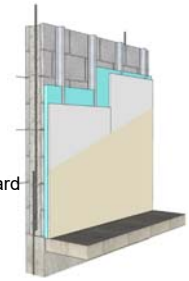
49

**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/ft²)

**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**

50

# 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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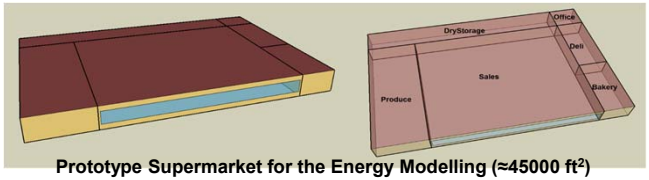
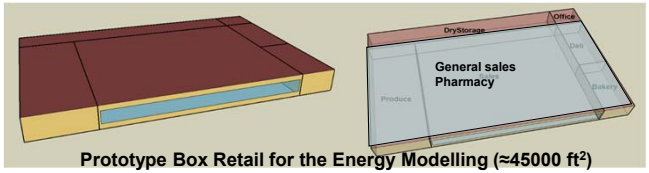


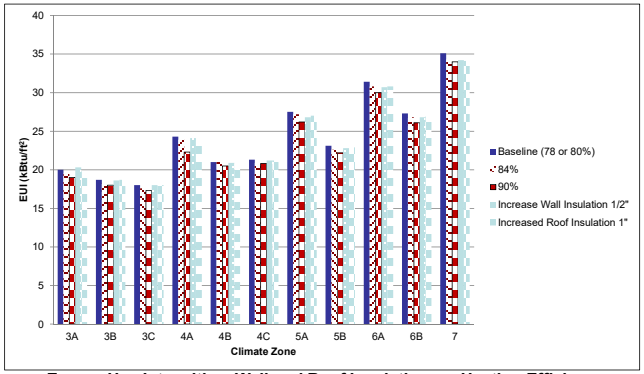

**Prototype Supermarket for the Energy Modelling (≈45000 ft²)**




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

51

# Warehouse Sensitivity Analysis- US




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

52

## Warehouse Sensitivity Analysis- US


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

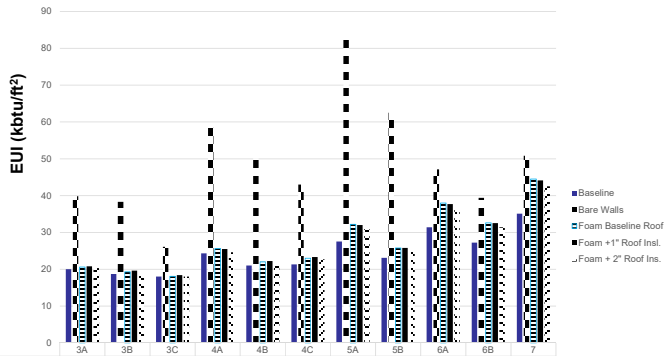
By NCMA TEK Note 6B [14] U- and R-values = 0.287 Btu/ft$^2$-h-°F and 3.48 ft$^2$-h-°F/Btu

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-°F- partially grouted).

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

53

## Warehouse Sensitivity Analysis- US

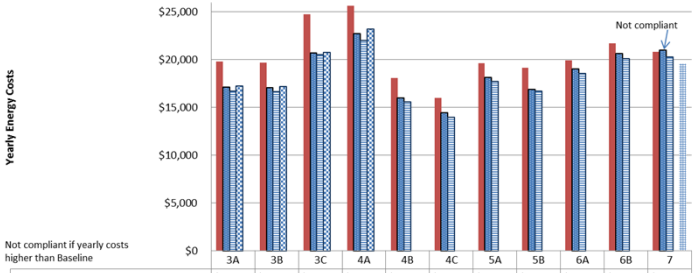



| | 3A | 3B | 3C | 4A | 4B | 4C | 5A | 5B | 6A | 6B | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | 20 | 18.7 | 18 | 24.3 | 21 | 21.3 | 27.5 | 23.1 | 31.4 | 27.2 | 35.1 |
| Bare Walls | 39.8 | 38.3 | 26.1 | 58.4 | 50.1 | 43 | 84.2 | 62.5 | 47.1 | 39.4 | 50.8 |
| Foam Baseline Roof | 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

54

## Alternative Designs US Code Compliance - Warehouse

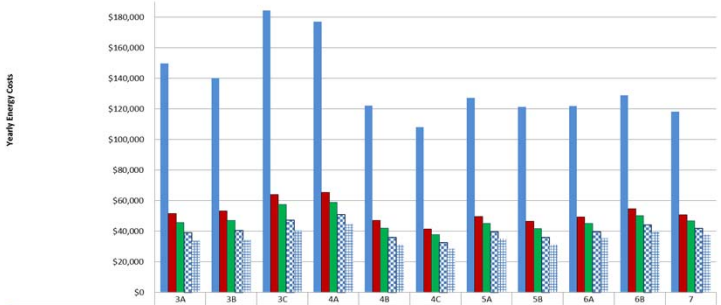



| | 3A | 3B | 3C | 4A | 4B | 4C | 5A | 5B | 6A | 6B | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | $19,792 | $19,701 | $24,728 | $25,665 | $18,076 | $16,008 | $19,616 | $19,162 | $19,915 | $21,722 | $20,833 |
| 8CMU 2roof Lower Ballast | $17,100 | $17,059 | $20,699 | $22,737 | $16,003 | $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)**

55

## Alternative Designs US Code Compliance- Supermarket-Box Retail

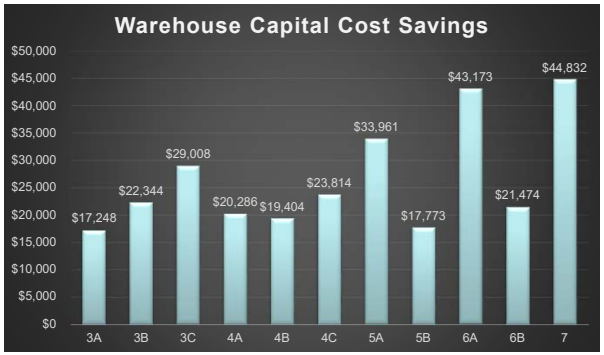



| | 3A | 3B | 3C | 4A | 4B | 4C | 5A | 5B | 6A | 6B | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Supermarket Baseline (Refrig.) | $149,777 | $140,225 | $184,437 | $177,234 | $122,257 | $108,122 | $127,295 | $121,389 | $121,820 | $128,828 | $118,097 |
| Supermarket Baseline (no Refrig.) | $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. (see next slide)**

56

# Alternative Designs US Differential Construction Cost

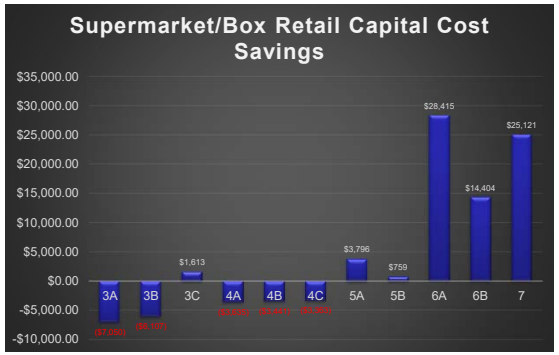



**8"CMU Foam core Walls, Lower Ballast Factors**
**For 4B and above - +2" Roof insulation**
**For 7 - Occupancy Sensors**

57

# Alternative Designs US Differential Construction Cost

**Construction Cost Savings of Alternative Designs Box Retail and Supermarkets – 8" CMU Foamed wall and LED Lights**



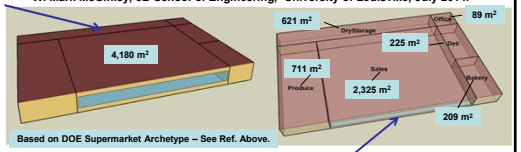

58

# Single Wythe Masonry Walls, Supermarkets & Box Retail Bldgs.– Alternative Energy Code Compliant Designs

**(To the National Energy Code for Buildings – NECB 2011)**

**Prescriptive Baseline: Exterior Walls 200 mm CMU variable XP Insulation, Steel furring, 12 mm Gypsum board**

**From: "An Investigation of Alternative Energy Efficient Designs for Medium Sized Single Wythe Masonry Buildings Phase 2 – Supermarket and Low-Rise (Box) Retail", W. Mark McGinley, JB School of Engineering, University of Louisville, July 2014.**




| Maximum Prescribed Envelope Thermal Transmittances (U-values)- NECB-2011 (W/m²K) | | | | | |
|---|---|---|---|---|---|
| **Climate Zone** | 4 | 5 | 6 | 7A | 7B |
| **Wall** | 0.315 | 0.278 | 0.247 | 0.210 | 0.210 |
| **Roof** | 0.227 | 0.183 | 0.183 | 0.162 | 0.162 |
| **Floor** | 0.227 | 0.183 | 0.183 | 0.162 | 0.162 |
| **Windows** | 2.4 | 2.2 | 2.2 | 2.2 | 2.2 |
| **Doors** | 2.4 | 2.2 | 2.2 | 2.2 | 2.2 |



59

# Single Wythe Masonry Walls, Supermarkets & Box Retail Bldgs.– Alternative Energy Code Compliant Designs

| Table1 | Annual Energy Use Index EUI – GJ/m² (kBtu/ft²) | | | | |
|---|---|---|---|---|---|
| **Location** | **Victoria** | **Windsor** | **Montreal** | **Edmonton** | **Ft. McMurray** |
| Climate Zone | 4 | 5 | 6 | 7A | 7B |
| Supermarket Reference Baseline, No Refrig., (Max FDWR) | 0.732 (64.5) | 0.809 (71.2) | 0.937 (82.5) | 0.966 (85.1) | 1.06 (93.1) |
| Supermarket, 20 cm CMU Foamed, LED Lights, No Refrigeration | 0.674 (59.4) | 0.750 (66.0) | 0.899 (79.2) | 0.947 (83.4) | 1.07 (94.2) |
| Supermarket, 20 CMU Foamed, LED, 0.9 Heating Coil, No Refrig. | | | | | 0.990 (87.1) |
| Box Retail, Reference Baseline, (Max FDWR) | 0.696 (61.3) | 0.773 (68.1) | 0.913 (80.4) | 0.927 (81.6) | 1.015 (89.4) |
| Box Retail, 20 cm CMU Foamed, LED Lights | 0.635 (55.9) | 0.709 (62.4) | 0.872 (76.8) | 0.921 (81.1) | 1.046 (92.1) |
| Box Retail, 20 cm CMU Foamed, LED Lights, 0.9 Heating Coil | Denotes non NCEB code compliant | | | | 0.961 (84.6) |

**Alternative: 20 cm CMU, grouted at 1200mm OC, XP Foam in Cores (U=1.64 W/m²K)**

| Table 2 Alternative NECB Code Compliant Costs Compared to Prescriptive Configs. | Victoria | Windsor | Montreal | Edmonton | Ft. McMurray |
|---|---|---|---|---|---|
| **Climate Zone** | **4** | **5** | **6** | **7A** | **7B** |
| Supermarket and Box Retail Construction Savings | $64,270 | $52,041 | $56,095 | $59,844 | $20,351 |
| Supermarket Yearly Energy Cost Savings | $3,479 | $4,592 | $2,762 | $5,131 | $4,336 |
| Box Retail Yearly Energy Cost Savings | $6,454 | $6,690 | $2,660 | $3,925 | $2,640 |



60

## 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.

61

## Conclusions

- Envelope improvements beyond code minimums have little effect on yearly energy consumption.
- Thermal Bridging may have minimal effect on energy consumption and may be compensated with a little additional insulation.

62

J.B. SPEED SCHOOL OF ENGINEERING

# THANK YOU !

# QUESTIONS?

MIH Masonry Institute of Hawaii

MIH Masonry Institute of Hawaii

63