Energy Performance – What factors really matter in the design of masonry buildings

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The Masonry Society
AIA Provider: 505119857

Course Description

This presentation describes the factors that impact energy used in buildings typically constructed of masonry. The results of various studies that investigated energy use in a variety of prototype buildings will be presented and discussed. Guidance of impact of the thermal resistance of the building envelopes, fenestrations, thermal bridging, lights and HVAC systems will be discussed. Recommendations for cost effective energy performance will be presented.

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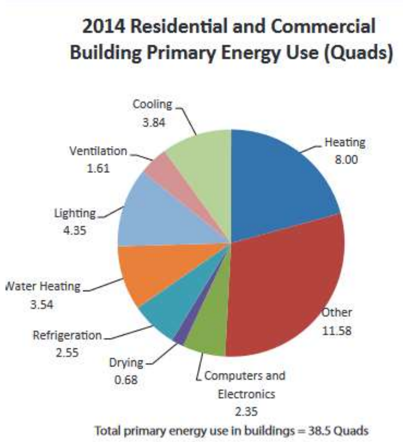
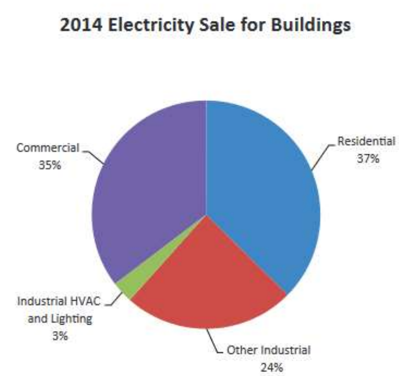
Learning Objectives

- Understand how buildings typically constructed of masonry use energy.
- Learn impact of changes in thermal resistance of building envelopes impact energy use.
- Understand what building systems have the greatest impact on energy use in typical applications.

Introduction





•More than 76% of all U.S. electricity use and more than 40% of all U.S. energy use and associated greenhouse gas (GHG) emissions are used to provide comfortable, well-lit, residential and commercial buildings—and to provide space conditioning and lighting for industrial buildings.
•Depends on Use and climate - https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf

Building Envelope -

- About 60% of the heating load in commercial buildings is due to flow through the walls, foundations and roofs. Varies with climate and windows and air movements can be a significant contributor.

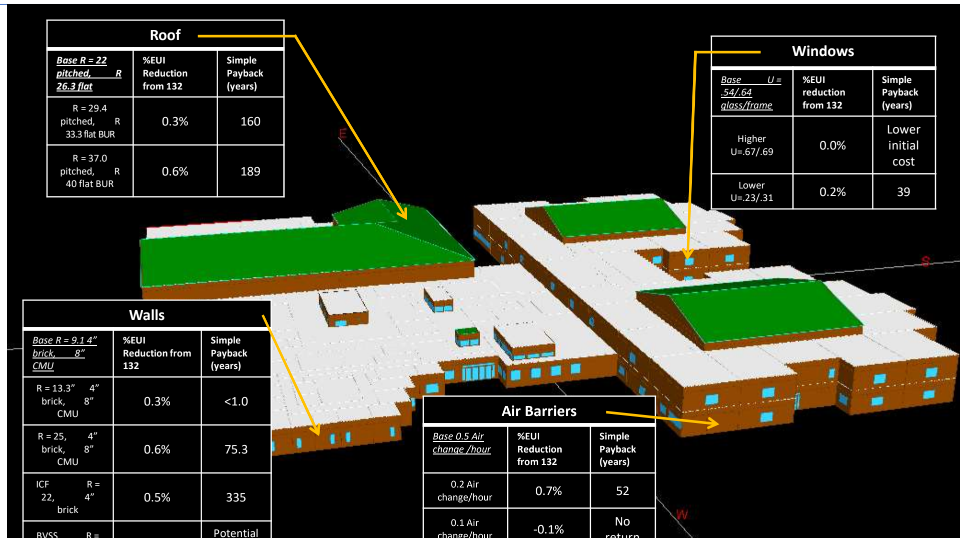
Table 5.2 Energy Flows in Building Shells (Quads)

	Residential		Commercial	
Building component	Heating	Cooling	Heating	Cooling
Roofs	1.00	0.49	0.88	0.05
Walls	1.54	0.34	1.48	-0.03
Foundation	1.17	-0.22	0.79	-0.21
Infiltration	2.26	0.59	1.29	-0.15
Windows (conduction)	2.06	0.03	1.60	-0.30
Windows (solar heat gain)	-0.66	1.14	-0.97	1.38

Looked at Schools In Climate Zone 4 -

- A prototype school building analyzed using Holistic analysis – **Energy Budget Method**
- Conducted an economic differential cost analysis – Pay back and Self-funding
- Focused on envelope and then HVAC , lighting and controls started with 2004 energy code prescriptive values.

Energy Savings and Payback in Typical Middle School
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**

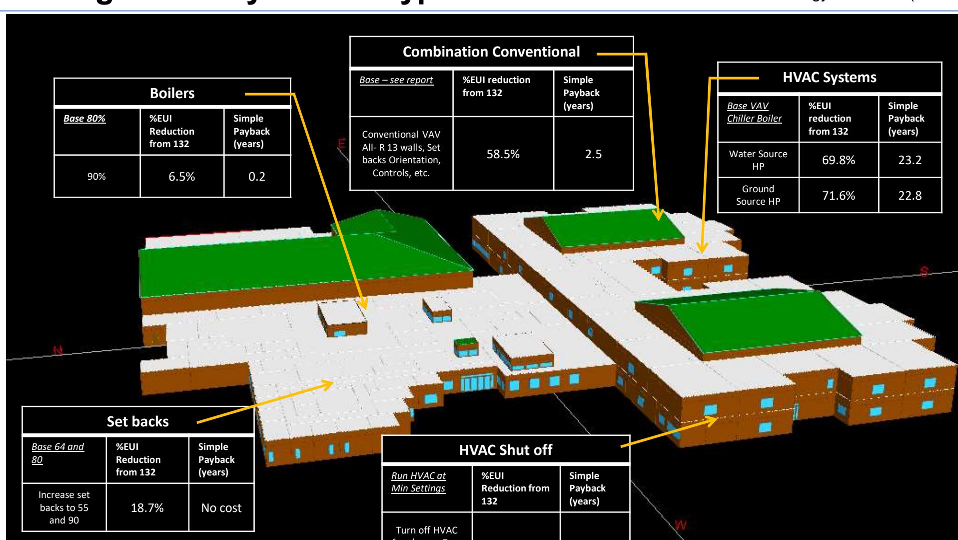
Air Barriers

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)

Energy Savings and Payback in Typical Middle School
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)

Looked at other Building types and climates Archetype 1 – Warehouse - US

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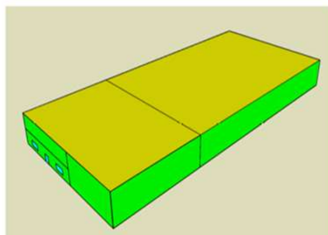
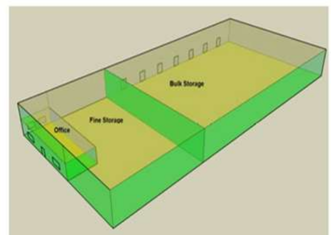
Prototype Warehouse for the Energy Modelling (≈50000 ft^2)

One of 16 reference buildings from DOE developed to be representative of over 80% of typical warehouse configurations





Evaluated 7 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			

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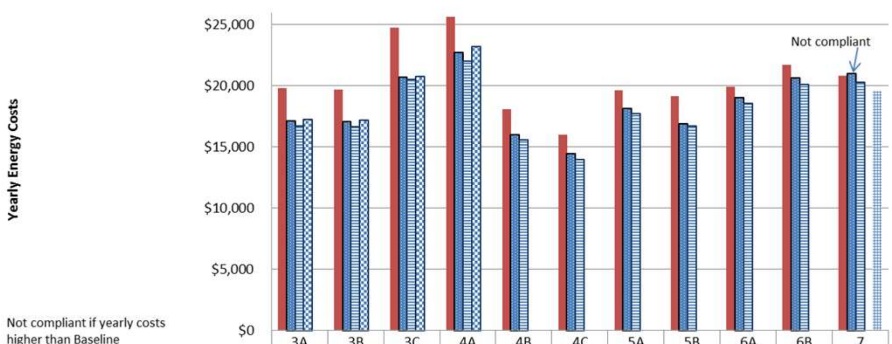
Alternative Designs US Code Compliance - Warehouse



	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)

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Holistic Analysis of the three protypes using different Masonry Wall densities and internal insulation

- Code compliant requirement for building envelopes in seven Climate Zones:

Climate Zone	City	Roof	Floor	Wall
1A	Miami	0.273	1.828	0.863
2A	Houston	0.221	0.608	0.863
3B	Las Vegas	0.221	0.432	0.698
4C	Seattle	0.182	0.432	0.591
5A	Chicago	0.182	0.420	0.511
6A	Minneapolis	0.182	0.363	0.454
7	Duluth	0.159	0.312	0.403

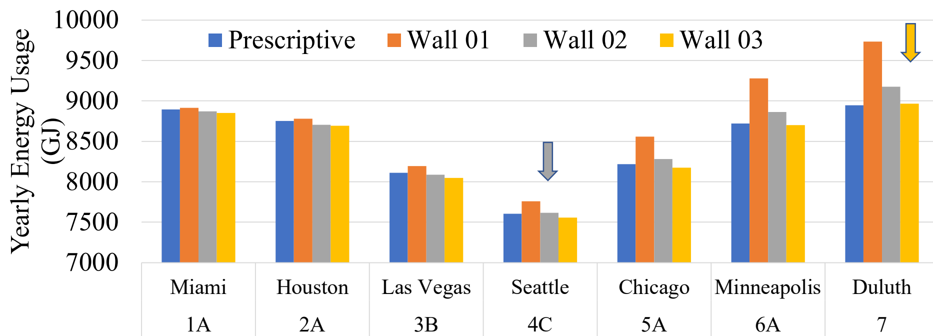
Wall-01: 1.100

Wall-02: 0.591

Wall-03: 0.386

Holistic Analysis of the three protypes using different Masonry Wall densities and internal insulation

- Energy usage of Secondary School prototype



Wall-01	×/×	×/×	×/×	×/×	×/×	×/×	×/×
Wall-02	√/√	√/√	√/√	√/×	×/×	×/×	×/×
Wall-03	√/√	√/√	√/√	√/√	√/√	√/√	√/×

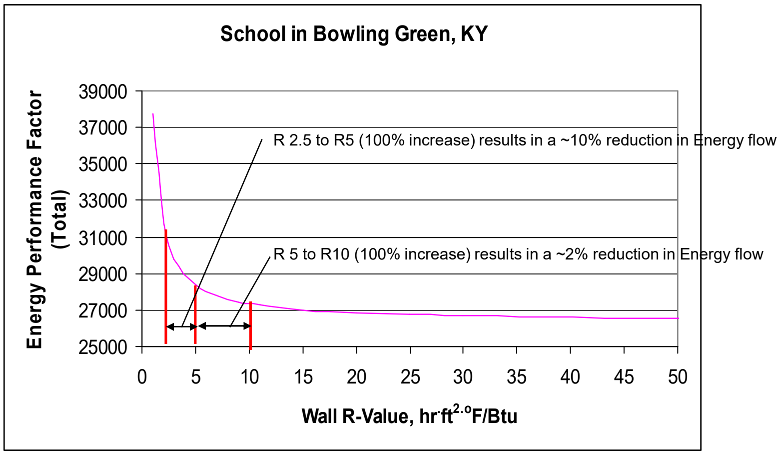
Impact of Wall Insulation ? More is not always better

Looked at Hawaiian Climate and insulation on exterior masonry walls

Payback Analyses

Wall Config.	Description	Stand-alone Retail		Secondary School		Midrise Apartment		Low Rise Apartment	
		Energy Saved ($/yr.)	Payback Period (yr.)	Energy Saved ($/yr.)	Payback Period (yr.)	Energy Saved ($/yr.)	Payback Period (yr.)	Energy Saved ($/yr.)	Payback Period (yr.)
105 pcf Fully Grouted	Wall Replaced	-7460	31	-47038	25	-11224	27	-3098	31
	Reflectance	-195	944	-8351	112	-3029	79	-421	181
	Overhang	-7022	33	-34110	33	-9681	31	-2628	36
	Reflectance + Overhang	219	-	3591	-	-1671	139	-5	14579
	Double Roof Insulation	-5740	30	-39280	22	-10697	27	-2911	26
120 pcf Poured Concrete	Wall Replaced	-7141	33	-47479	25	-10159	30	-2815	35
	Reflectance	-47	3918	-7605	123	-2199	109	-178	429
	Overhang	-6638	35	-35551	32	-8651	35	-2329	41
	Reflectance + Overhang	320	-	4108	-	-844	275	234	-
	Double Roof Insulation	-5713	30	-40891	21	-9639	30	-2609	29
150 pcf Poured Concrete	Wall Replaced	-10513	22	-66843	18	-14176	22	-4073	24
	Reflectance	-1596	115	-16367	54	-3796	63	-660	116
	Overhang	-10056	23	-53701	21	-12569	24	-3602	26
	Reflectance + Overhang	-1153	157	-5589	156	-2494	93	-253	290
	Double Roof Insulation	-8564	20	-59523	14	-13672	21	-3894	19

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



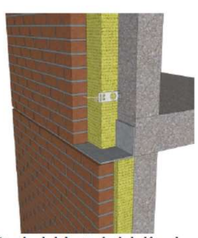
Some insulation in walls needed – lots does not get you anything - especial as much of the energy movement will be dominated by air movement and thermal movement through windows
Colder climates need more R – Heating dominated and walls have greater impact

Thermal Bridging

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

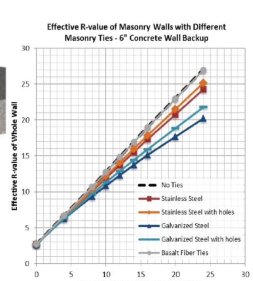
Ties(anchors) angles can reduce steady state thermal resistance significantly

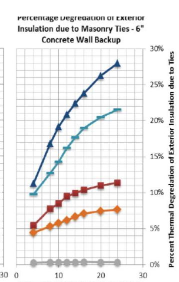
16" x 24"



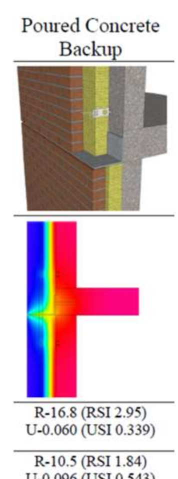
Standard slab attached shelf angle

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





Steady state Analysis up to 40% reduction



Actual thermal bridging impact on holistic behavior is small.
Small Increase in R address this – See new ACI 122 Y doc.

Conclusion

- Buildings in colder regions are more sensitive to building envelopes – but an optimum U values (R) near code minimums will give good performance.
- Dynamic masonry wall energy flow relative insensitive to U values(R) near Code prescriptive levels.
- Buildings in colder regions are more sensitive to building envelopes R values
- HVAC, controls Lighting fenestration
- Holistic analysis can show masonry walls with relatively high U (low R values will produce cod compliant performance

This concludes The American Institute of Architects Continuing Education Systems Course

THE MASONRY SOCIETY

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