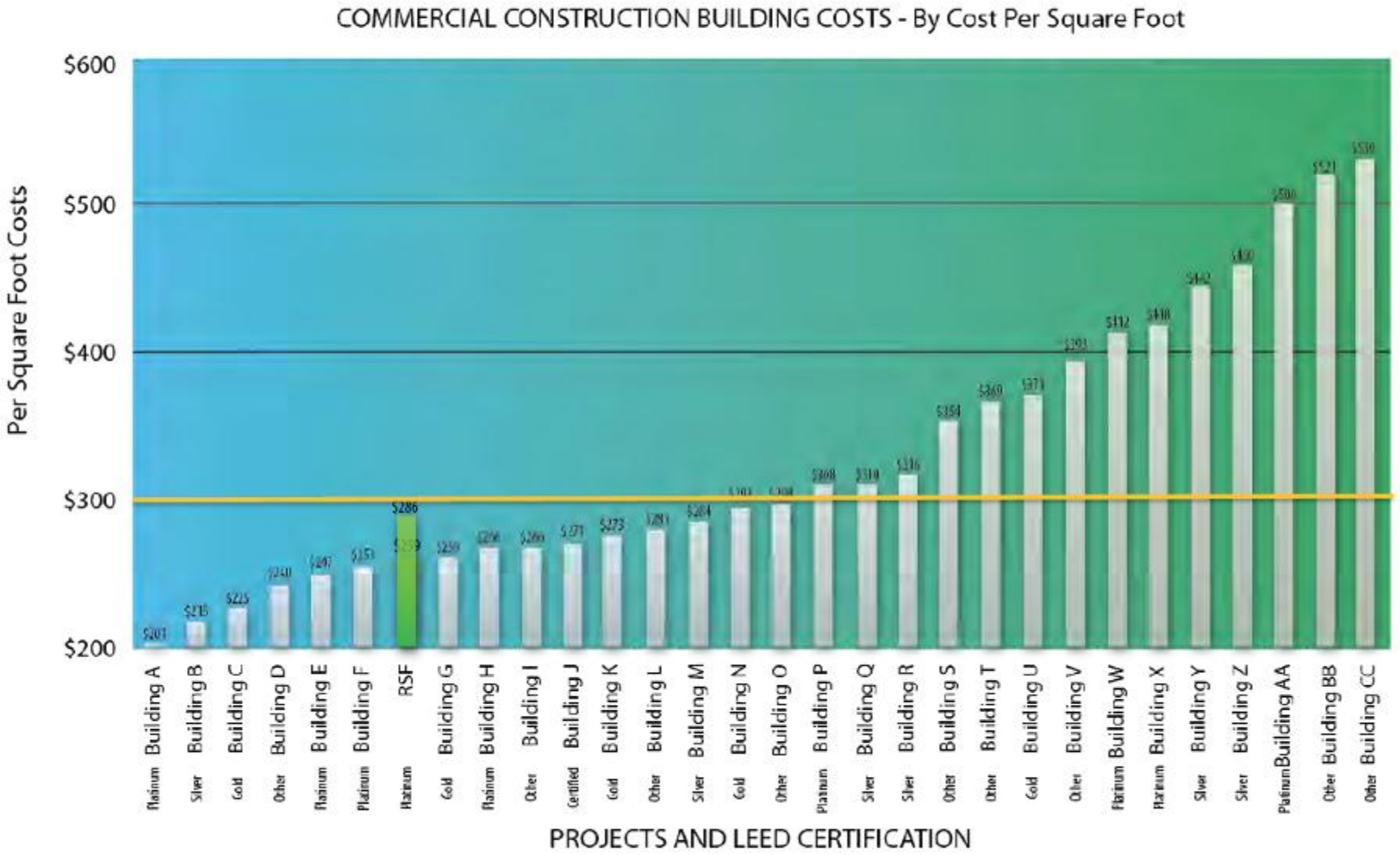
Tucson/Pima County

Net Zero Energy Code

City of Tucson Office of Conservation and Sustainable Development
&
Pima County Development Services, Building Safety and Sustainability

NREL Research Support Facility: A glimpse into the future

Construction Costs



http://www.nrel.gov/director/pdfs/deployment_speed_scale.pdf

If you can not measure it, you can not improve it.

-- Lord Kelvin 1824-1907

Two new Concepts:

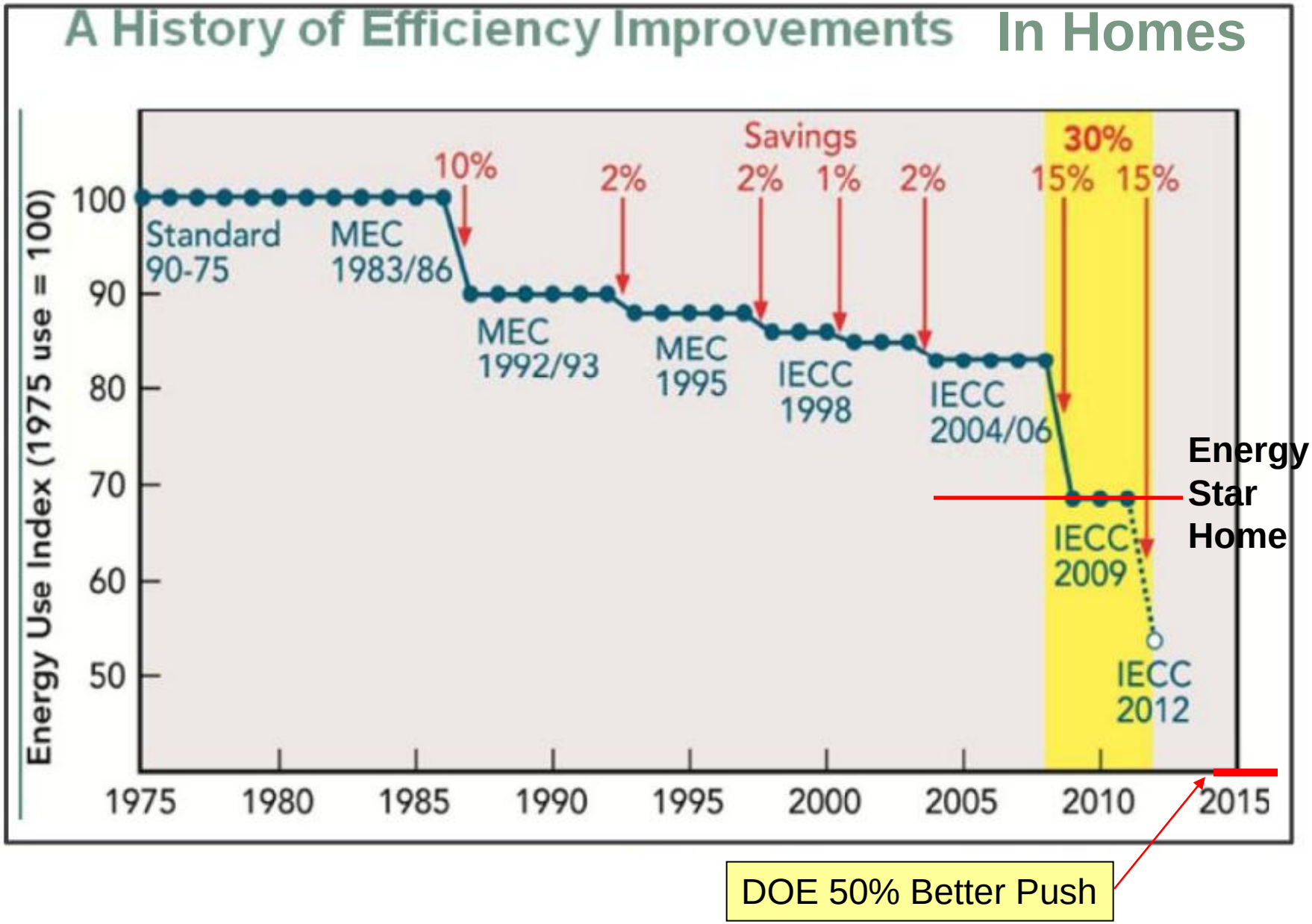
- Energy Use Intensity
- Nega-watts

Agenda

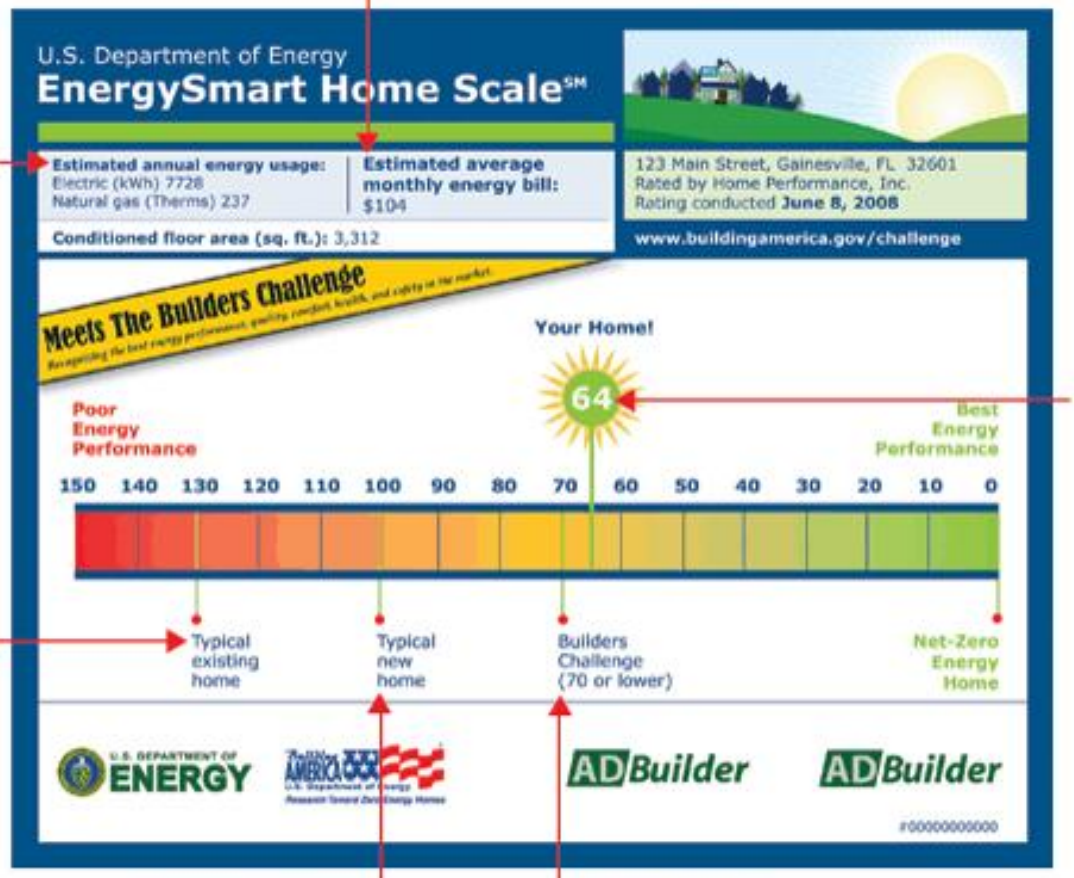
- Background
- Development Process
- Residential Code
- Commercial Code
- Economics
- Green House Gas Emissions

Learning Objectives

- Understand the concept of net-zero energy building at the site
- Understand the concept of energy use intensity (EUI) and how to use this an a energy budget
- Understand the concept of Nega-Watt and how to use this in evaluating envelope energy improvements
- Understand the structure of the Net-Zero Energy Building Code and how to use it to plan a net-zero building


A History of Efficiency Improvements In Homes
Energy Use Index (1975 use = 100)
100
90
80
70
60
50
1975
1980
1985
1990
1995
2000
2005
2010
2015
Standard 90-75
MEC 1983/86
MEC 1992/93
MEC 1995
IECC 1998
IECC 2004/06
IECC 2009
IECC 2012
10%
2%
Savings
2%
1%
2%
30%
15%
15%
Energy Star Home
DOE 50% Better Push

DOE HERS ➡ EScale



EPA HERS Index

EPA Yard Stick

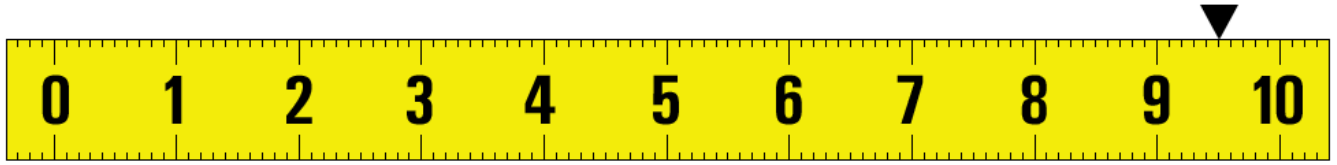
LEARN MORE AT energystar.gov

ENERGY STAR Home Energy Yardstick

YOUR SCORE

EPA's Home Energy Yardstick compares a household's energy use to similar homes and gives it a score between 0 and 10 (10 being the most energy efficient).

Yardstick Score: 9.5*



Home and Energy Use for:

Address: 5701 E Glenn, Tucson AZ
Zip Code: 85712
People living in your home: 2
Square Footage: 1200
Energy Use from 01-Dec-2009 to 30-Nov-2010

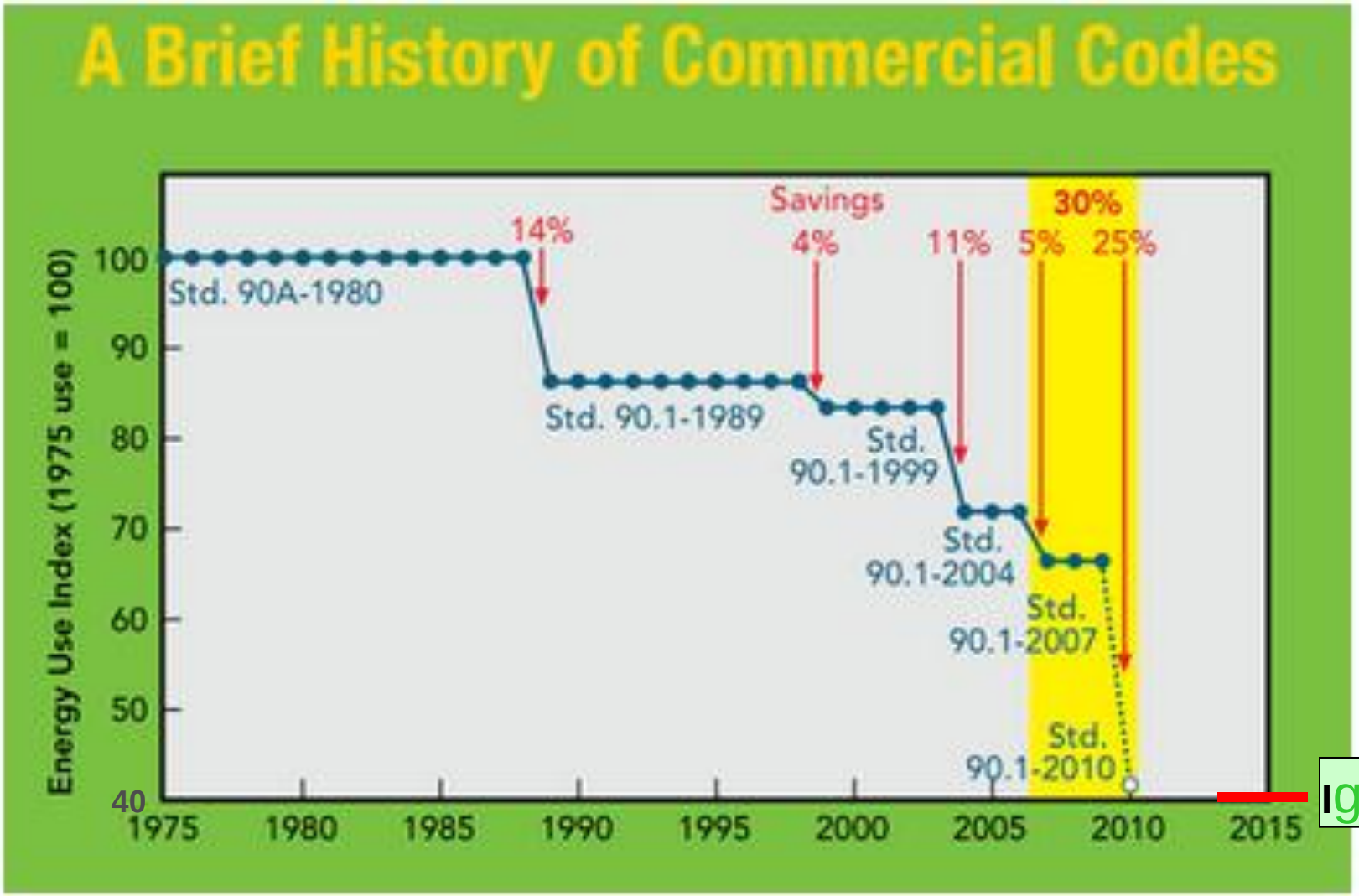
Use (Natural Gas)	Bill Amount (Natural Gas)	Use (Electricity)	Bill Amount (Electricity)
377 Therms	$0	4,770 kWh	$0

How To Improve a Low Score

- ✔ Seal air leaks (or drafts).
- ✔ Add more insulation in the attic.
- ✔ If the HVAC equipment is more than 10 years old, consider replacing with models that have earned the ENERGY STAR.
- ✔ Purchase lighting, appliances, home electronics, and other products that have earned the ENERGY STAR.
- ✔ Hire a professional to evaluate the home's energy efficiency.
- ✔ Visit energystar.gov/homeadvisor for more ways to improve efficiency and comfort.

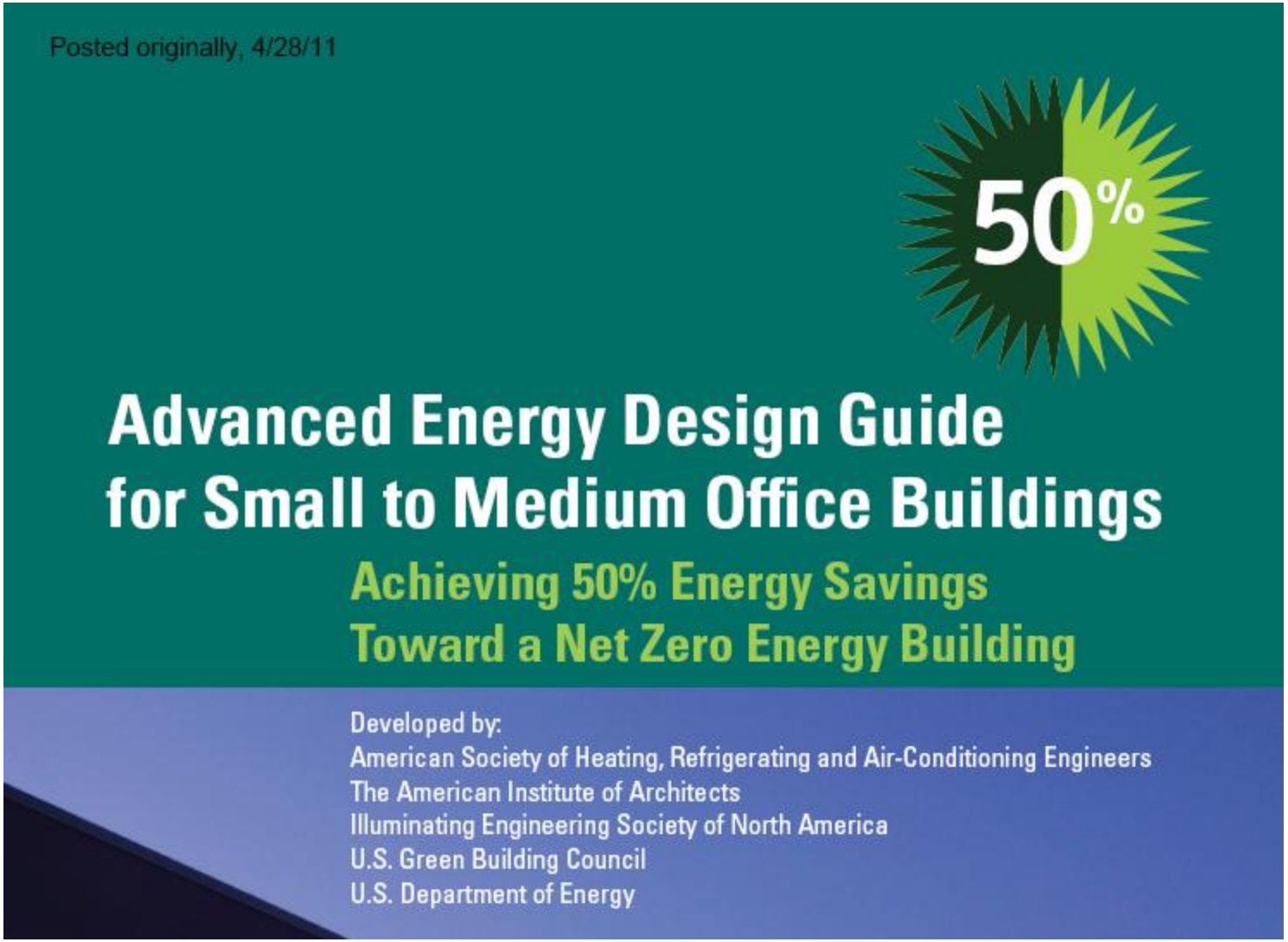
* How you operate or use your home may lower your score. Activities and Equipment that often impact a household's score include: a home office or home business, swimming pool, spa, sauna, pottery kiln, or well pump, as well as a thermostat setting above 72°F for heating or below 76° for cooling.

https://www.energystar.gov/index.cfm?fuseaction=HOME_ENERGY_YARDSTICK.showGetStarted



ASHRAE Advanced Design Guides 50% "better" 20

Source: http://usgbcblog.blogspot.com/2011/02/from-cutting-edge-to-common-practice.html
Accessed 3/3/11



http://www.ashrae.org/publications/page/aedg50pct

Detail from ASHRAE AEDG

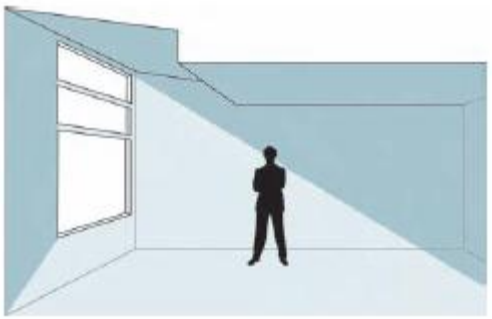
DL6 Window-to-Wall Ratio (WWR) (Climate Zones: all)

There are two steps to approaching window configuration and sizing. The first is that the fenestration design should follow interior-driven design criteria such as occupancy type and requirements for view, daylight, and outdoor connectivity. The second step targets peak load and energy use, which limit window size to comply with the mechanical systems target. For office buildings to achieve 50% savings, the overall WWR should not exceed 40%.

DL7 Sidelighting—Ceiling and Window Height (Climate Zones: all)

For good daylighting in office-type spaces, a minimum ceiling height of 9 ft is recommended. In public spaces and lobbies that extend to greater depth, ceiling height, at least partially, should be 10 to 12 ft. When daylighting is provided exclusively through sidelighting, it is important to elevate the ceiling on the perimeter and extend glazing to the ceiling. Additional reflectance to increase lighting levels can be achieved by sloping the ceiling up toward the outside wall. (See Figure 5-19.)

The effective aperture (EA) for sidelighting is the area of glazing in an unobstructed wall multiplied by the VT of vertical glazing, divided by the floor area in the primary daylight zones. The EAs in the recommendation tables in Chapter 4 of this Guide were derived from energy analysis for the Pacific Northwest National Laboratory (PNNL) *Technical Support Document: 50% Energy Savings Design Technology Packages for Medium Office Buildings* (Thornton, et al. 2009).



(a)

Figure 5-19 (DL7) (a) Raised Ceiling

The % Better Problem

% Better does not answer the question:

How much energy do I use, and therefore need to produce to offset my use?

1908 Model T

How many gallons of gas do I need to go 100 miles?

1960 Ford Falcon: 20% “better”

2012 Ford Focus: 3% “better”

The % Better Problem

% Better does not answer the question:

A Primary Metric is required

1908 Model T: 25 mpg **4.0**

1960 Ford Falcon: 30 mpg **3.2**

2012 Ford Focus: 31 mpg **3.1**

The % Better Problem

% Better does not answer the question:

A Primary Metric is required

1908 Model T: 25 mpg **4.0**

1960 Ford Falcon: 30 mpg **3.2**

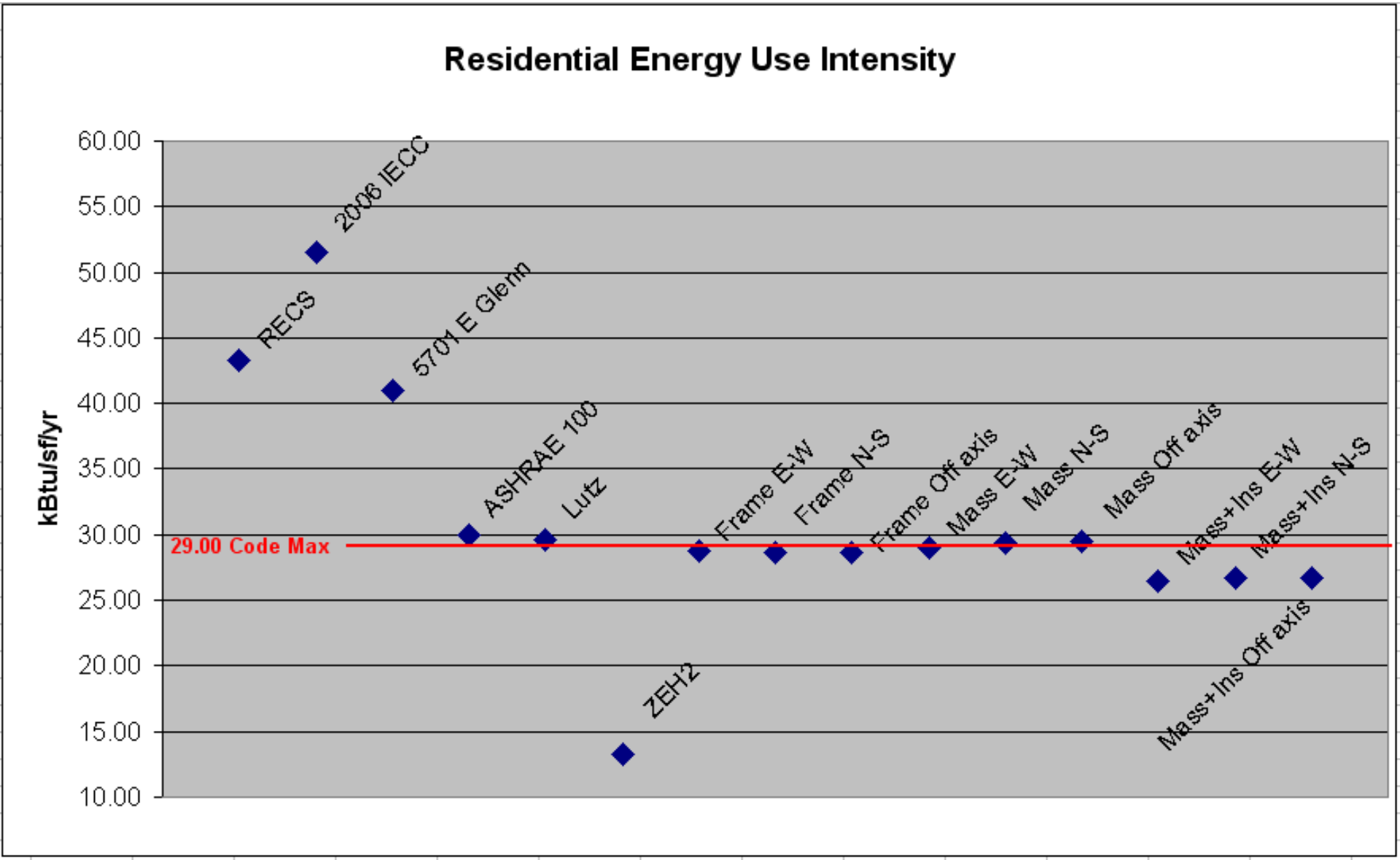
2012 Ford Focus: 31 mpg **3.1**

EUI **PV**

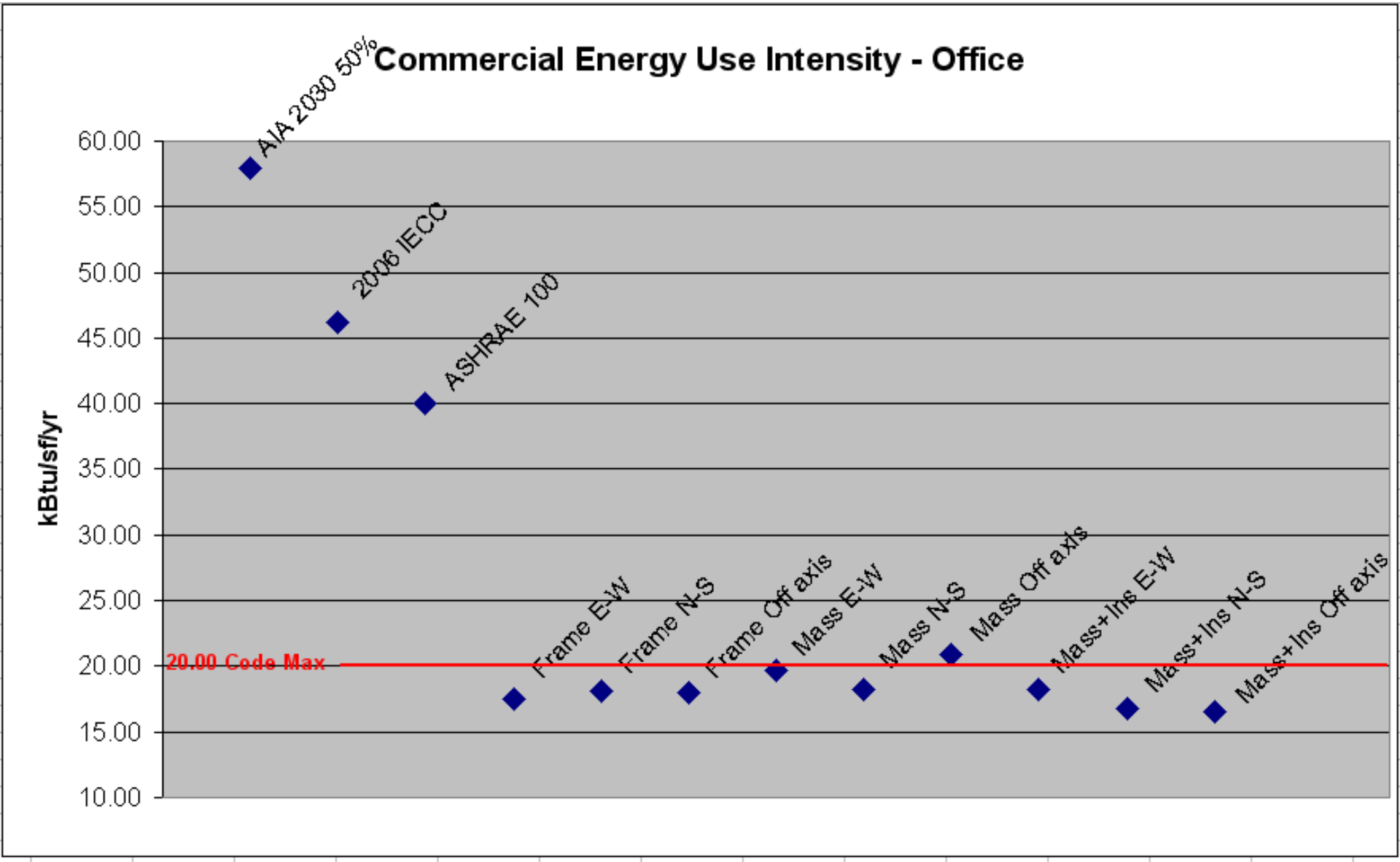
Energy Use Intensity

- A Primary Metric
- Total building site energy use divided by the building's gross floor area. The units of building energy use intensity are typically kBtu/SF/yr.
  - ASTM E2797-11 Building Energy Performance

Energy Use Intensity = MPG



Energy Use Intensity = MPG



Energy Use Intensity

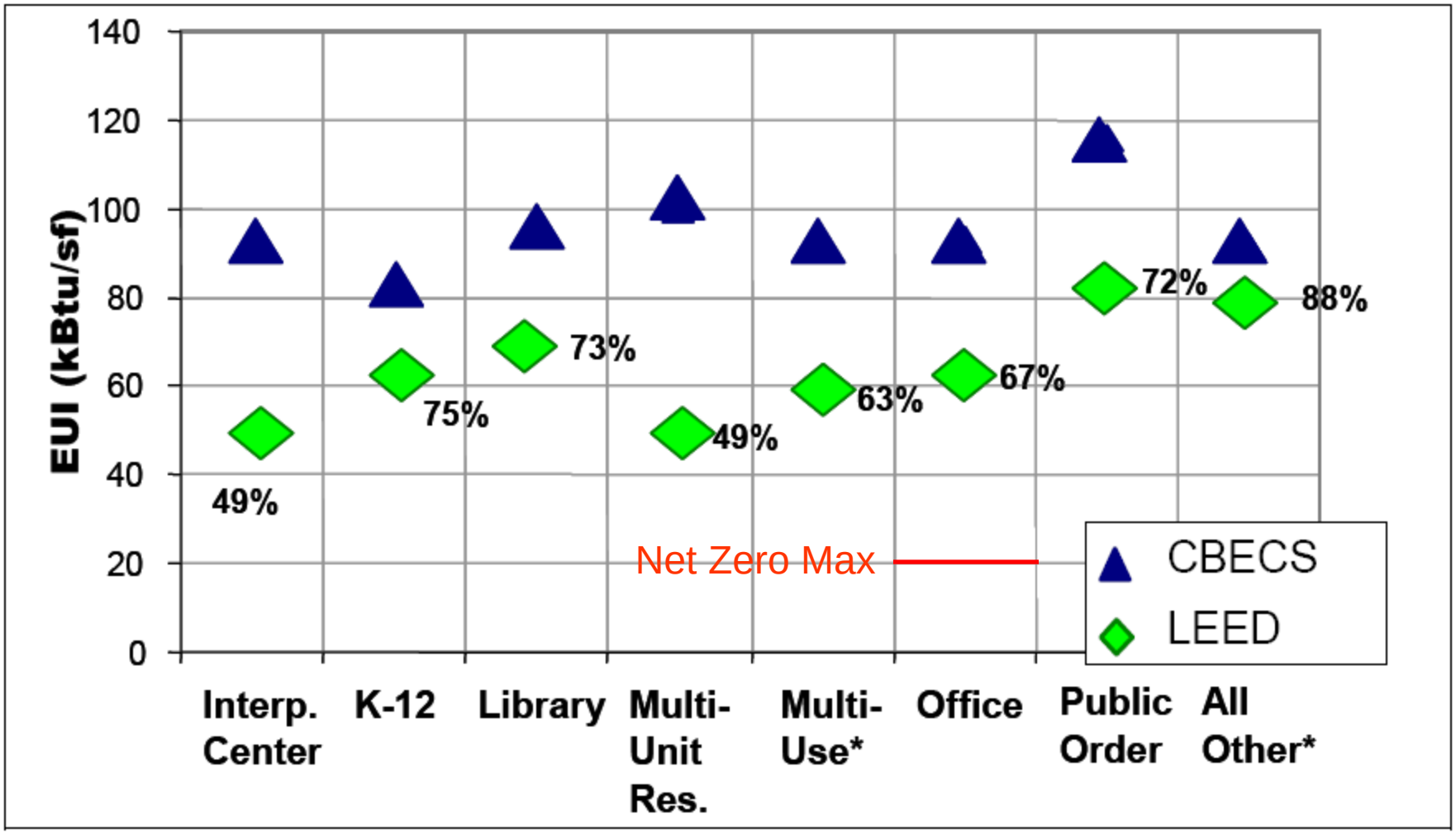


Figure 10: LEED-NC and CBECS EUIs (kBtu/sf) by Type

Energy Use Intensity

2030 CHALLENGE Targets: U.S. National Averages

U.S. Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Space/Building Type[1]

From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets

Primary Space / Building Type[2]	Available in Target Finder[3]	Average Source EUI[4] (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI[4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Residential Space / Building Type[6, 7]									
Single-Family Detached		76.6	-	43.8	**21.9**	17.5	13.1	8.8	4.4
Single-Family Attached		70.7	-	43.7	**21.9**	17.5	13.1	8.7	4.4
Multi-Family, 2 to 4 units		93.2	-	58.2	**29.1**	23.3	17.5	11.6	5.8
Multi-Family, 5 or more units		99.4	-	49.5	**24.8**	19.8	14.9	9.9	5.0
Mobile Homes		153.2	-	73.4	**36.7**	29.4	22.0	14.7	7.3

http://www.architecture2030.org/files/2030_Challenge_Targets_National.pdf

Agenda

- Background
- Development Process
- Residential Code
- Commercial Code
- Economics
- Green House Gas Emissions

Research Design

- Internet Research
  - Build America Program
  - ASHRAE Advanced Energy Design Guides
- 2012 and 2015 IECC
- Energy Modeling
  - by Dr. Nader Chalfoun and Virginia Cardona, University of Arizona
- Water use statistics from Tucson Water

Key Concepts:

1. Energy Use Intensity is the metric

Energy IN Water

- Energy = Water

  4,800 kwh of electricity to pump
  1 acre foot of water to our homes

  Typical Tucson home with four people will use .51 acre feet/year

  4,800 kwh/acre foot x .51 acre feet = 2,472 kwh/year

Water is the fourth largest user of Electricity in the home using a little more than your lights!

Key Concepts:

1. Energy Use Intensity is the metric
2. Include the embedded energy in water in the Energy Use Intensity

Why Build More Efficient?

Design a rule system that does not require more footprint than is already used by the building.

Design a rule system that reduces the standby power requirements of the grid, thereby reducing capital expenditure for traditional power generation.

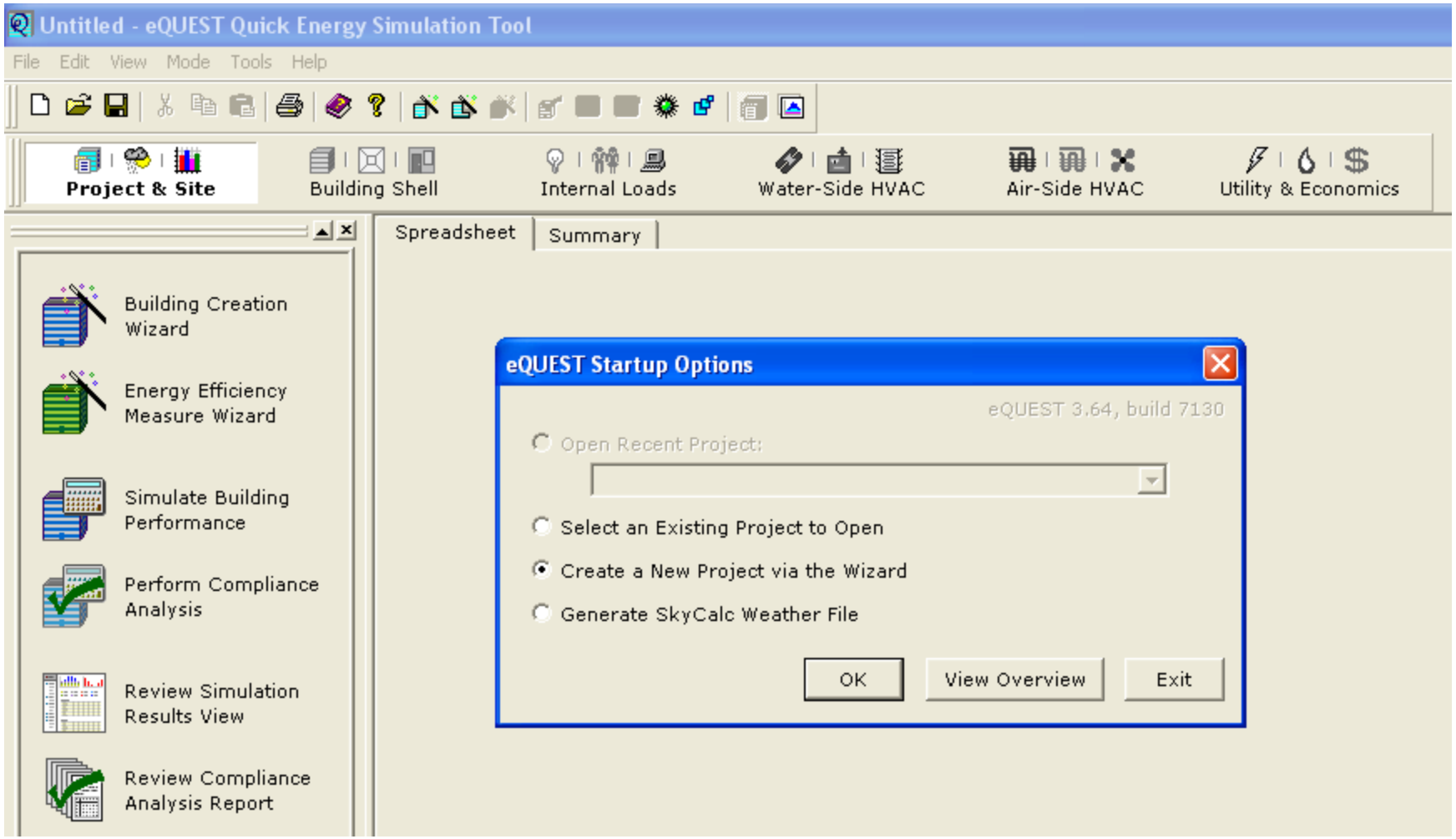
Key Concepts:

1. Energy Use Intensity is the metric
2. Include the embedded energy in water in the Energy Use Intensity
3. Limit area of PV production to the roof of the home (and potentially covered parking for commercial buildings) to reduce the buildings EUI

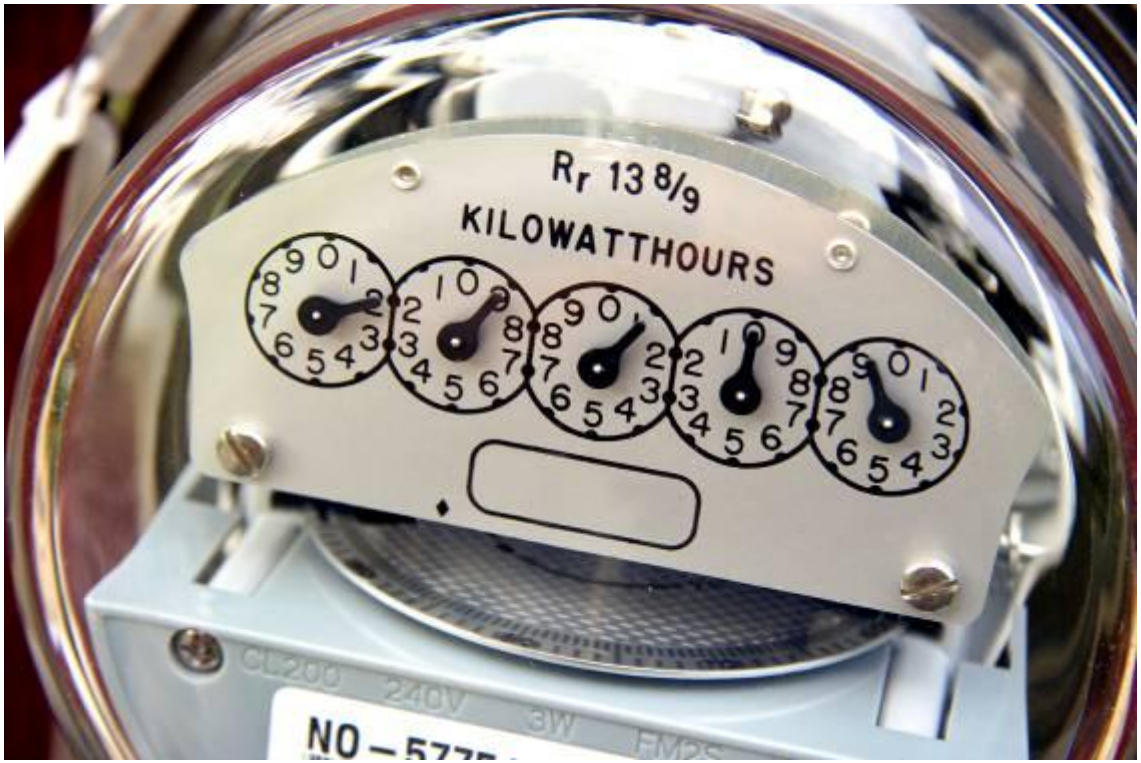
Energy Modeling is Cool...

http://hes.lbl.gov/consumer

Energy Modeling is Cool...



Proof is in the Use



Key Concepts:

1. Energy Use Intensity is the metric
2. Include the embedded energy in water in the Energy Use Intensity
3. The Energy Budget is determined by the area of PV on the roof of the home (and potentially covered parking for commercial buildings)
4. Net-zero must be proven with 12 months continuous use prior to issuing certificate

Agenda

- Background
- Development Process
- Residential Code
- Commercial Code
- Economics
- Green House Gas Emissions

Code Structure

This voluntary standard amends the 2006 International Energy Conservation Code as follows:

- Add new section 406 to read:
- **Section 406 Residential Net Zero Energy Building Voluntary Alternative**
  - Scope.
  - Definitions
  - Prescriptive Path Compliance
    - Energy Budget Development.
    - *Energy Use Intensity* Development.
    - Base Case *Energy Use Intensity* for nine cases, 3 construction types and 3 Orientations
    - List of Energy Efficiency Measures
    - Additional Measures to offset other uses such as pools and spas
    - Documentation.
  - Simulated Performance Path Compliance
  - Net-Zero Energy Retrofit
  - Performance Documentation.

Summary of Residential Energy Efficiency Measures

Net Zero Minimum	IRC Minimum	Energy Star BOP
Roof Insulation R-50	R-30	R-30
Walls Insulation R-30	R-13	R-13
Roof Reflection .75		
Wall Reflection .60		
Windows U=0.24 SHGC=0.25 + Interior blinds	U=0.75 SHGC=0.40	U=0.55 SHGC=0.35
Location and Area of windows limited		
Infiltration = 3 ACH50	(2012 IECC = 5 ACH50)	7 ACH50
Lighting all energy star (CFL or LED)		50% E*
Equipment (TV, Computer, etc) all E*		
Programmable T-Stat 78/68 w set back		Programmable T Stat
SEER 19.1 HSPF=10.3	SEER 13	SEER 14.5
Solar Hot Water		
Efficient Water Fixtures		
Xeriscaping		
Option for thermal mass and natural ventilation		

Energy Use Intensity

< Energy Budget (Residential)

Energy Use Intensity Factor in kBtu/sf/yr				
		SFR		
		Baseline	DSWH	Bonus
	EW	48.64	28.76	28.49
Frame	NS	49.30	28.68	28.55
	Off	49.25	28.63	28.63
	EW	51.76	29.10	28.27
Mass	NS	53.35	29.42	29.26
	Off	53.35	29.49	29.05
	EW	51.76	26.48	25.61
Insul Mass	NS	53.35	26.67	26.51
	Off	53.10	26.65	26.21
Maximum Energy Budget Factor	Ave:	51.54	29.00	
Embedded energy in water Factor		2.1		

Proof

- **Performance Documentation**. After one year of continuous operation by applicant, submit a calculation and utility bills confirming net zero as follows:

  PV production – [Gas + Electric + (water * energy)] ≥ 0

  (Note: A positive number means that the building is an annual net positive producer of energy.)

  - PV production = AC electrical production of on site photovoltaic panels converted to kBtu
  - Gas = gas use for the year in kBtu
  - Electric = electricity use for the year in kBtu
  - Water = gallons of water used for the year
  - Energy = 0.0503 kBtu/gal for the *energy embedded in water*
  - Note: solar thermal production is automatically accounted for by the deferment of gas or electrical consumption.

- The building official will issue a certificate of Net-Zero Compliance

Roof Energy Production?

Table 406.3.1.5(1) One Story Residential *Energy Budget Factor* kBtu/sf/yr – Rectangle or Square

Orientation	Type of Roof			
	Flat-Perimeter Parapets Only	Flat- Perimeter and Interior Parapets	Pitch ≤ 2:12	Pitch > 2:12
E-W	37.5[1] (50%)	22.5 (30%)	67.6 (90%)	33.8 (45%)
N-S	33.8 (45%)	22.5 (30%)	67.6 (90%)	33.0 (44%)
Off Axis	30 (40%)	18.8 (25%)	67.6 (90%)	Note[2]

[1] First number is kBtu/sf/yr (Number in parenthesis is the percentage of roof covered with photo voltaic and/or solar thermal panels used to model the Energy Budget)
[2] Use Section 406.4

Roof Energy Production?

Table 406.3.1.5 (2) One Story Residential *Energy Budget Factor* kBtu/sf/yr – **Irregular**

Orientation	Type of Roof			
	Flat-Perimeter Parapets Only	Flat- Perimeter and Interior Parapets	Pitch ≤ 2:12	Pitch > 2:12
E-W	28.1[1] (38%)	16.9 (23%)	50.7 ((68%)	25.3 (34%)
N-S	25.3 ((34%)	16.9 (23%)	50.7 (68%)	24.8 (33%)
Off Axis	22.5 (30%)	14.1 (19%)	50.7 (68%)	Note[2]

[1] First number is kBtu/sf/yr (Number in parenthesis is the percentage of roof covered with photo voltaic and/or solar thermal panels used to model the Energy Budget)
[2] Use Section 406.4

Fun Stuff

- Determine your Energy Budget
- Model web page calculator

Building Strategies Table

4.		Wall Insulation	
	4.1		Total insulation value is R-30 with minimum R-9 continuous exterior insulation.
	4.2		Mass walls per 406.3.4 (10) R-9 continuous exterior insulation.
5.		Roof Reflection	Roof exterior shall have minimum short wave reflection value of 0.65 for specific materials, textures, or colors.
6.		Wall Reflection	Wall exterior shall have minimum short wave reflection value of 0.60 for specific materials, textures, or colors.
7.		Window Type	
	7.1.	Assembly U-value	Window assembly (frame and glass) shall have a maximum U-value of 0.24.
	7.2.	Assembly Solar Heat Gain Coefficient (SHGC)	Window assembly (frame and glass) shall have a maximum SHGC of 0.25.
	7.3.	Glass Visual Transmittance (VT)	Window glass shall have a maximum visual transmittance value of 0.40.
8.		Window Shading	See Appendix A
	8.1.	South	Choose between 8.1.1 or 8.1.2.
		8.1.1. Overhang Only	Window overhang depth shall have a projection factor equal to 0.4 x window height and overhang extensions on both sides equal to 1.0 x window height.
		8.1.2. Overhang and Vertical Fins	Window overhang depth shall have a projection factor equal to 0.4 x window height and vertical fins depth projection factor equal to 0.4 x window width on both sides of that window.
	8.2.	North Vertical Fins	Window vertical fins depth shall have a projection factor of 0.2 x window

Agenda

- Background
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- Commercial Code
- Economics
- Green House Gas Emissions

Code Structure

This voluntary standard amends the 2006 International Energy Conservation Code as follows:
add new section 507 to read:

- **Section 507 Commercial Net Zero Energy Building Voluntary Alternative**
  - Scope
  - Definitions
  - Prescriptive Path Compliance
    - *Energy Use Intensity* Development.
    - Base Case *Energy Use Intensity*
    - Requirements by building type and use
    - Additional Measures to reduce *Energy Use Intensity*
    - Additional Measures to offset other uses such as pools and spas
    - Documentation
  - Simulated Performance Path Compliance
  - Net Zero Energy Retrofit
  - Performance Documentation

Energy Use Intensity

< Energy Budget (MultiFamily)

Energy Use Intensity Fa		Energy Use Intensity Factor in kBtu/sf/yr			
			MF		
		Baseline	DSWH	Bonus	
	EW	46.68	20.96	20.80	
Frame	NS	47.66	21.53	21.35	
	Off	47.80	21.17	21.00	
	EW	52.14	23.30	23.29	
Mass	NS	53.82	23.99	23.98	
	Off	53.38	23.76	23.75	
	EW	52.14	19.96	19.95	
Insul Mass	NS	53.82	20.15	20.14	
	Off	53.38	20.06	20.05	
Maximum Energy Budget Factor	Ave:	51.20	23.50		Ave:
Embedded energy in water Factor		2.10			

Energy Use Intensity

< Energy Budget (Office)

Energy Use Intensity Factor in kBtu/sf/yr						
		Office				
					Bonus	
		Baseline	DSWH	Economize	VAV	ERV
	EW	44.63	17.54	17.49	13.55	16.62
Frame	NS	46.69	18.11	18.06	14.09	17.15
	Off	45.70	17.94	17.89	13.87	17.02
	EW	45.16	19.64	17.49	16.48	18.79
Mass	NS	47.68	18.29	18.28	15.48	17.32
	Off	46.62	20.87	20.85	17.97	19.29
	EW	45.16	18.21	18.20	15.34	17.37
Insul Mass	NS	47.68	16.78	16.77	14.09	15.79
	Off	46.62	16.55	16.53	13.74	15.59
Maximum Energy Budget Factor	Ave:	46.22	20.00			
Embedded energy in water Factor		1.3				

Energy Use Intensity

< Energy Budget (Retail)

Energy Use Intensity Factor in kBtu/sf/yr						
		Retail				
					Bonus	
		Baseline	DSWH	Economize	VAV	ERV
	EW	46.43	19.34	19.29	15.35	18.42
Frame	NS	48.49	19.91	19.86	15.89	18.95
	Off	47.50	19.74	19.69	15.67	18.82
	EW	46.96	21.44	19.29	18.28	20.59
Mass	NS	49.48	20.09	20.08	17.28	19.12
	Off	48.42	22.67	22.65	19.77	21.09
	EW	46.96	20.01	20.00	17.14	19.17
Insul Mass	NS	49.48	18.58	18.57	15.89	17.59
	Off	48.42	18.35	18.33	15.54	17.39
Maximum Energy Budget Factor	Ave:	48.02	21.80			
Embedded energy in water Factor		3.1				

Agenda

- Background
- Development Process
- Residential Code
- Commercial Code
- **Economics**
- Green House Gas Emissions

Economics

- What do energy efficiency improvements cost?
- **Nega-watt** = the energy saved over the life of an energy efficiency improvement
- The Nega-watt Tipping point:
  - when the cost of a nega-watt costs more than a PV watt

Fun Stuff

- Nega-watt calculator
- Nega-watt = <3 to 5 cents
- PV watt = 7 cents with incentives
  (16 cents without incentives)
- Solar Hot water = 3 cents with incentives
- TEP watt = 11 cents

SAVE Act

(Sensible Accounting to Value Energy

Arizona Daily Star www.azstarnet.com

Housing: Energy efficiency soon may be factored into mortgage applications

WASHINGTON

When you apply for a mortgage to buy a house, how often does the lender ask detailed questions about monthly energy costs or tell the appraiser to factor in the energy-efficiency features of the house when coming up with a value?

Hardly ever. That's because the big three mortgage players - Fannie Mae, Freddie Mac and the Federal Housing Administration, who together account for more than 90 percent of all loan volume - typically don't consider energy costs in underwriting. Yet utility bills can be larger annual cash drains than property taxes or insurance - key items in standard underwriting - and can seriously affect a family's ability to afford a house.

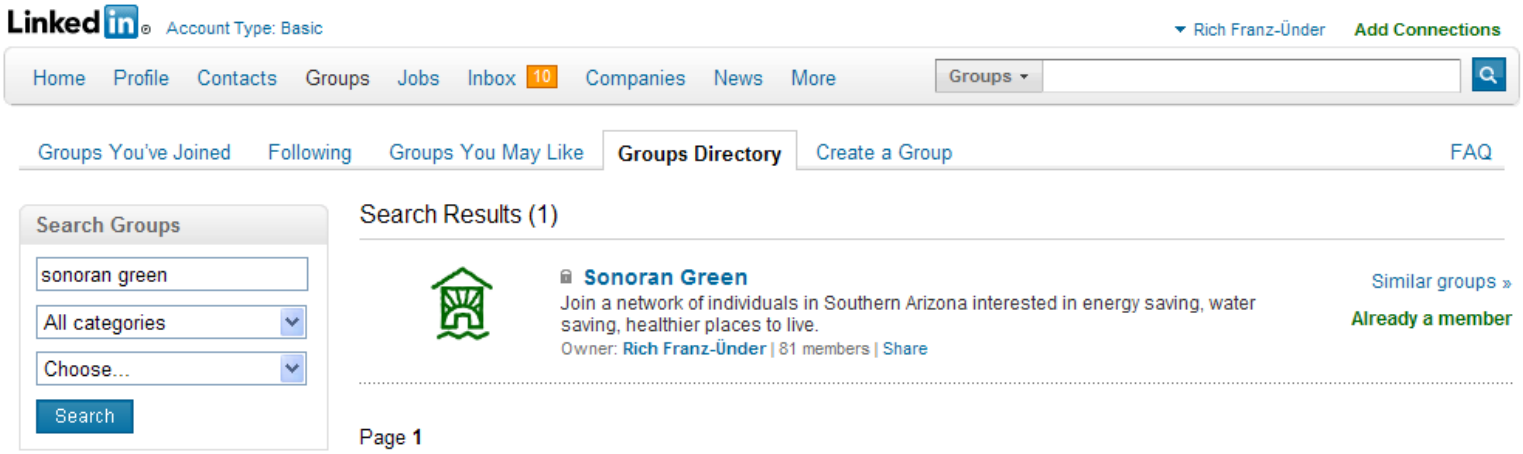
A new, bipartisan effort on Capitol Hill could change all this dramatically and for the first time put energy costs and savings squarely into standard mortgage underwriting equations. A bill introduced Oct. 20 would force the big three mortgage agencies to take account of energy costs in every loan they insure, guarantee or buy. It would also require them to instruct appraisers to adjust their property valuations upward when accurate data on energy efficiency savings are available.

Titled the SAVE Act (Sensible Accounting to Value Energy), the bill is jointly sponsored by Sens. Michael Bennet, a Democrat from Colorado, and Johnny Isakson, a Republican from Georgia. Here's how it would work: Along with the traditional principal, interest, taxes and insurance (PITI) calculations, estimated energy-consumption expenses for the house would be included as a mandatory underwriting factor.

http://azstarnet.com/business/national-and-international/housing-energy-efficiency-soon-may-be-factored-into-mortgage-applications/article_d6805a2d-3c06-5e6b-b85e-1a786395af67.html

How to Keep Informed

- Join the linked in group Sonoran Green:



www.pimaxpress.com/Green

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Pima County Development Services

pima.gov

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Home | Building Permitting | Code Enforcement | *Green Building* | Land Planning & Regulation | Subdivision & Development Review

Contact

Rich Franz-Ünder,
RA/LEED AP
Green Building Program Manager
Email

Yves Khawam, PhD
Chief Building Official
Email

Phone: 520-740-6490
Fax: 520-740-6888

SOLAR One Stop
southern arizona's connection to a solar energy future

Betty Stamper
Regional Solar Coordinator
520-740-6463
Email

- Click here Solar Farm Site Development Plan and Permitting Requirements
- Click here for residential scale solar and wind installation requirements

Organizations

- US Green Building Council
- Arizona Chapter US Green Building Council
- ICC Green Building

LEED™ FOR HOMES

LEED for Homes Program

Providing services to builders and home owners in Arizona, New Mexico and Southern California

Getting Started with LEED
LEED Rating System
Fees
Related Information

Regional Residential Green Building Program
For Use in Pima County and City of Tucson

Getting Started
New Construction
Remodeling
Calculators and Guidance
Related Publications

Tucson/Pima County Net-Zero Energy Code

Net Zero Energy Code
Energy Budget Calculator
Economic Benefits Report
Nega-watt Tipping Point Calculator
Related Publications

What is Green and which program is best for me?

Resources and Tools

Seminars and Presentations

HVAC and Manual J

Case Studies

News

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