air barrier abaa association of america CONFERENCE & TRADE SHOW MAY 8-9 2018 SALT LAKE CITY

AIR BARRIER EDUCATION TRACKS FOR THE CONSTRUCTION INDUSTRY

Why Buildings Matter and The Future of Building Performance

R. Christopher Mathis

Mathis Consulting Company

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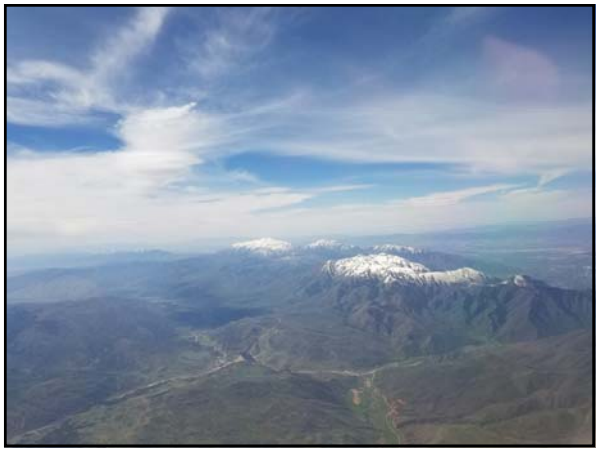
Thank you Wagdy!
(we sure miss you...)

THANK YOU Today's Speakers!

- **Many symbiotic messages!**
  - Fiona – Testing and commissioning, teamwork, measure stuff, repeat...
  - Andrew – Teamwork, planning (for good and for bad), testing, engaging other professionals in your project planning meetings (code officials, Insurers, others)
  - Som – Cool new tools (USE THEM!), minimum code, air leakage when building HVAC is on, better models, size of the opportunity, etc.
  - Andrew – Delivered performance, multiple "barriers"

THANK YOU ABAA!

- **To share a few important messages**
  - Old and new...
- **To see many friends**
  - Old and new...
- **To see some cool buildings**
  - Old and new...



Why Buildings Matter
and
The Future of Building Performance

R. Christopher Mathis
MC^2 - Mathis Consulting Company

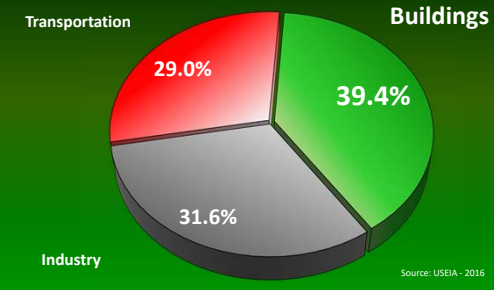
The End in Mind

- **Buildings Matter!**
  - More than we know…
- **Major Trends Impacting Building Decisions**
  - Energy, Power, Water, Climate, etc.
- **What Does the Future Hold**
  - Emerging Building Performance Priorities
  - Implications for Building Professionals
    - Engineers, Architects, Code Officials, Contractors, Owners
- **What is OUR responsibility?**

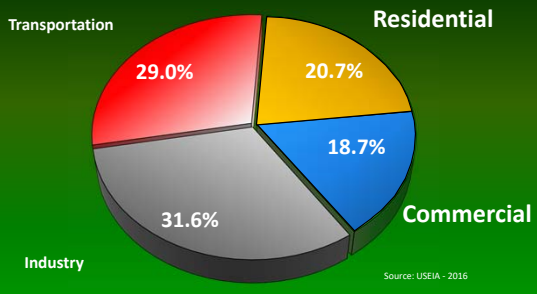
Who Am I?

- **Building Scientist for 35+ years**
- **Author, Educator**
- **Standards Developer and User**
  - ASHRAE Member – 30+ years
    - 90.1, 90.2, 189.1, Distinguished Lecturer
  - ASTM Member 30+ years
    - Insulation, Fenestration, Commissioning, BOD 2018-21
- **Code Developer**
  - IECC, IGCC, State Codes, Federal Codes, etc.
- **Beekeeper...**

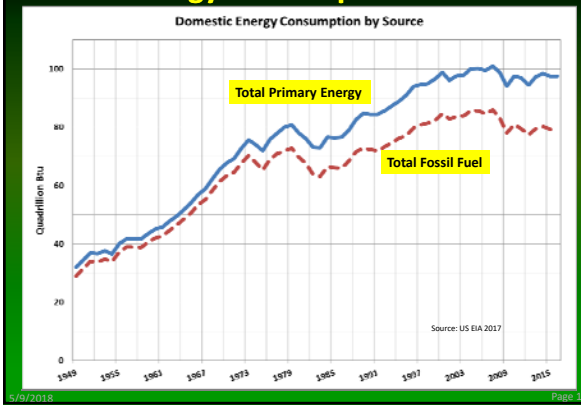
Buildings Matter: US Energy Use

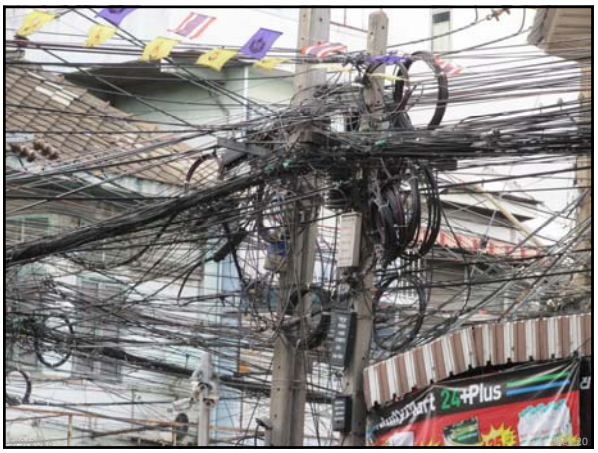


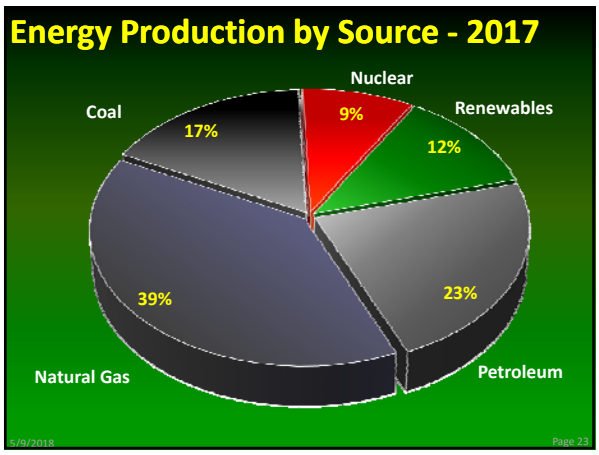
Buildings Matter: US Energy Use

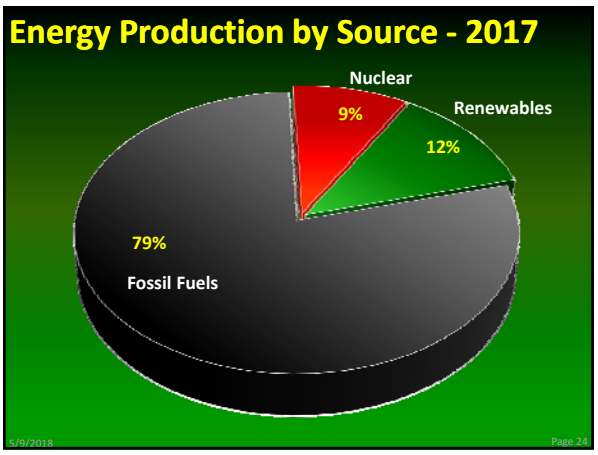


Total US Energy Consumption 1949 - 2015

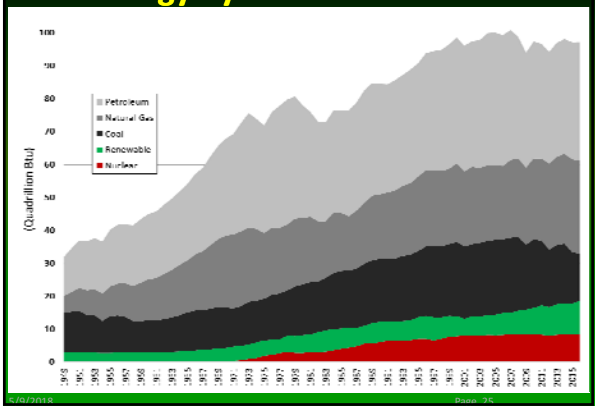




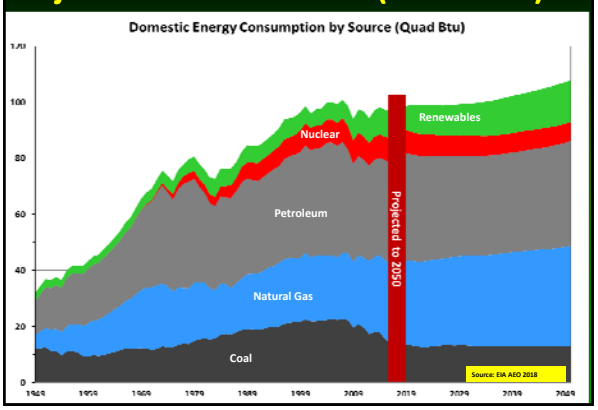

Energy Production by Source - 2017
Nuclear
9%
Renewables
12%
Coal
17%
23%
39%
Natural Gas
Petroleum


Energy Production by Source - 2017
Nuclear
9%
Renewables
12%
79%
Fossil Fuels

Total Energy by Source 1949 - 2015

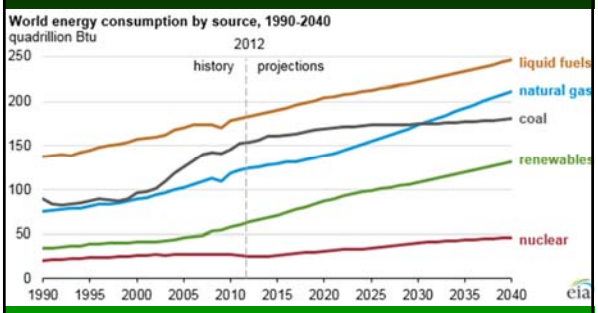


Projections on the Future? (US to 2050)

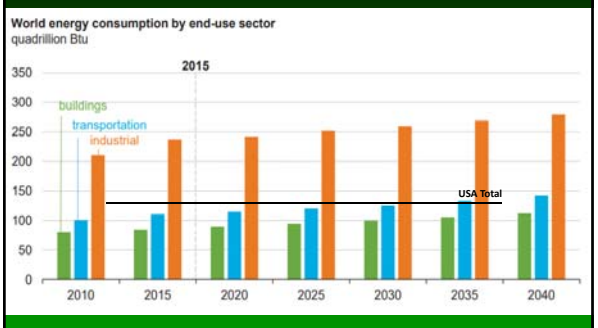


World Energy Consumption by Fuel

1990 – 2040



World Consumption by Sector (AEO 2017)

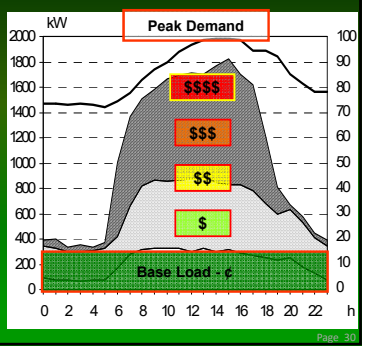


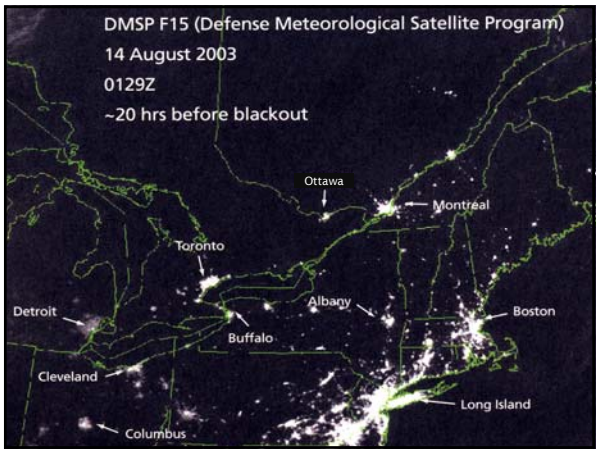
The Energy Megatrend

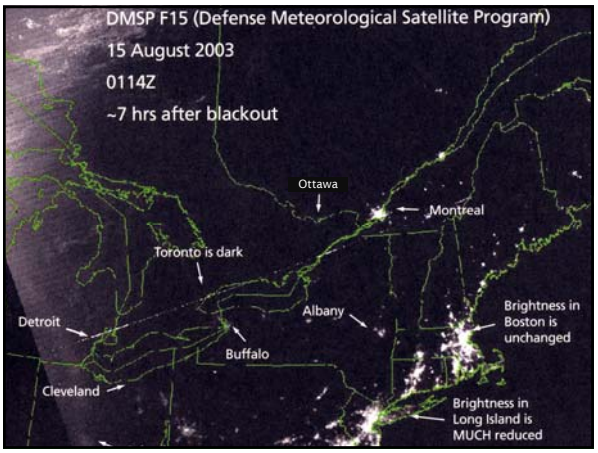
- Increasing demand
- Supply challenges
- Peak power issues
- Economic security
- Population change
- Water demand
- Available resources

Utility Concerns

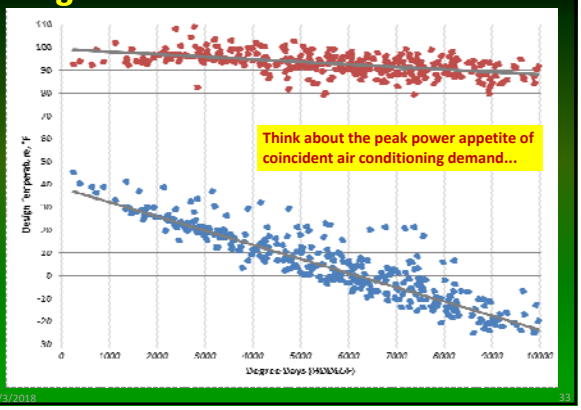
- The "Timing" of our Demand
  - Base Load
  - Peak Demand
  - Cooling Driven
  - Lighting Driven



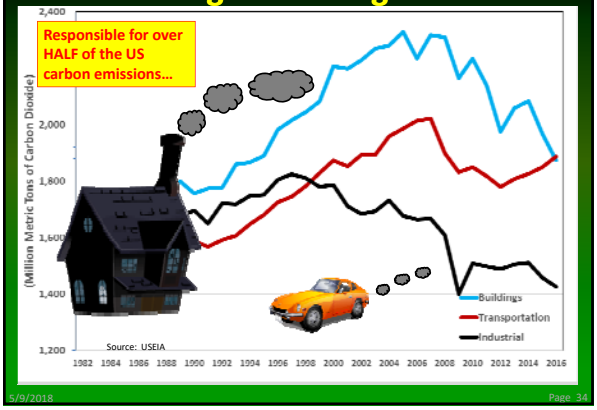




Design Conditions and Location



Climate Change? Buildings Matter!



Other Sources of Greenhouse Gasses...

Global tourism's carbon footprint is four times bigger than thought, study says

By Susan Scutti, CNN
Updated 1:31 PM ET, Mon May 7, 2018

Story highlights

Tourism spending increased 7% annually between 2009 and 2013, a new study says

The industry saw its carbon footprint increase by 3.3% annually in that period

(CNN) — Global tourism accounts for 8% of total worldwide greenhouse gas emissions, four times more than previously believed, new research says.

Some gases, including carbon dioxide and methane, trap heat in the atmosphere, producing a "greenhouse effect," and so make the planet warmer. The amount of greenhouse gases released by a particular activity is referred to as its "carbon footprint."

The increasing carbon footprint of global tourism between 2009 and 2013 represents a 3% annual growth in emissions, according to University of Sydney researchers.

Their paper was published Monday in the journal Nature Climate Change.

$70 oil will create headaches for these companies

by Matt Egan @MattEganCNN
May 7, 2018: 1:48 PM ET

A 50% spike in the price of crude oil over the past year has set off a celebration for Big Oil. But it's sending shudders through other major businesses.

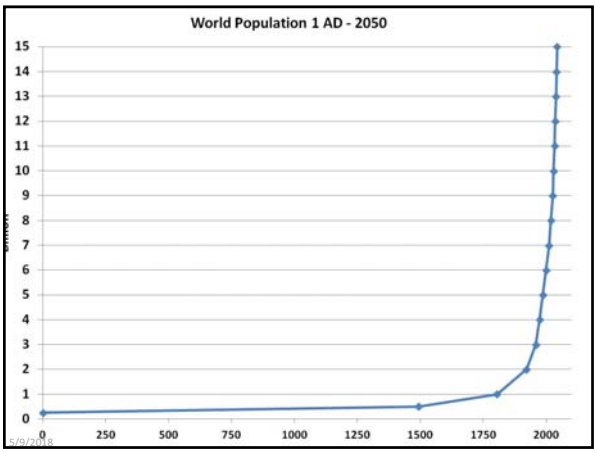
That's especially true for certain chemicals, paper packaging, retail, transportation and packaged food companies.

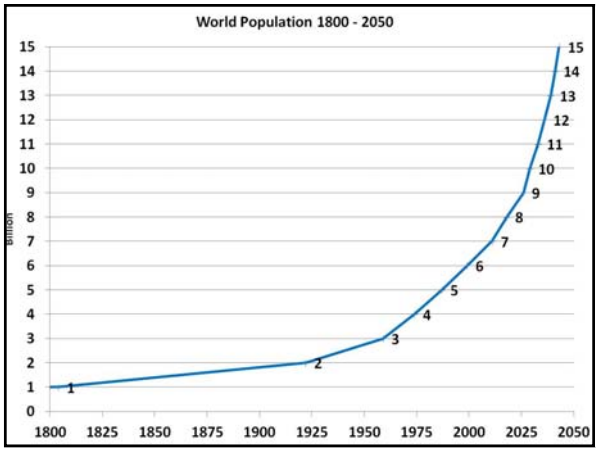
Chemicals makers are particularly vulnerable because they use crude oil as a major ingredient. Polyone (POL), Univar (UNVR) and KMG Chemicals have at least half of their production costs in oil and products derived from petroleum, according to Goldman Sachs.

Eastman Chemical (EMN), Huntsman (HUN) and paint giant Sherwin-Williams spend nearly as much on oil.

Raw materials costs are "all heading in the wrong direction," Sherwin-Williams chief financial officer Allen Mistysyn recently told analysts.

Oil is also a major expense for Goodyear Tire & Rubber (GT), as well as auto parts companies such as AutoZone (AZO), Advance Auto Parts (AAP) and Adient (ADNT).


World Population 1 AD - 2050
Billion
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
250
500
750
1000
1250
1500
1750
2000
5/9/2018


World Population 1800 - 2050
Billion
1
2
3
4
5
6
7
8
9
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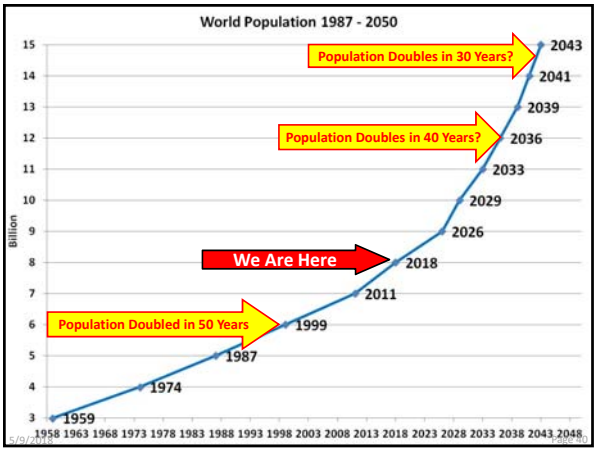
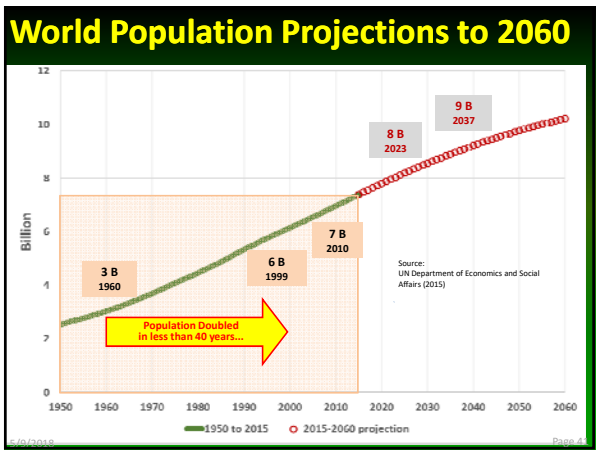
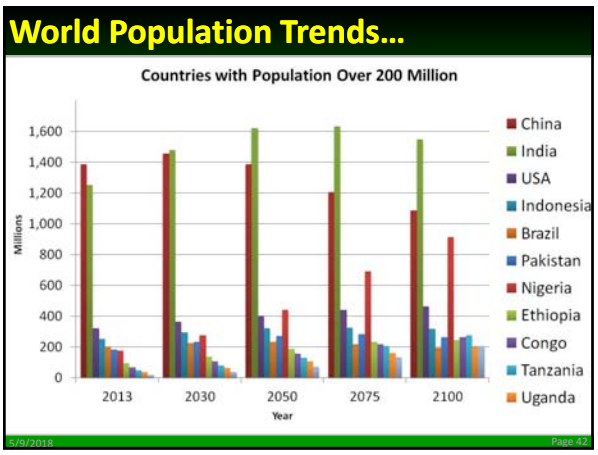
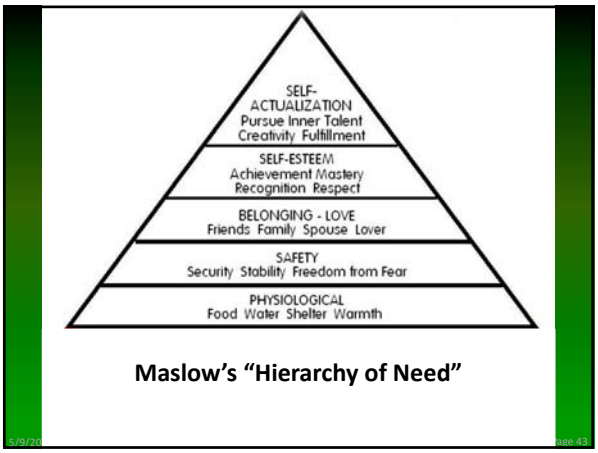
12
13
14
15
1800
1825
1850
1875
1900
1925
1950
1975
2000
2025
2050


World Population 1987 - 2050
Billion
Population Doubles in 30 Years?
Population Doubles in 40 Years?
We Are Here
Population Doubled in 50 Years
1959
1974
1987
1999
2011
2018
2026
2029
2033
2036
2039
2041
2043
1958 1963 1968 1973 1978 1983 1988 1993 1998 2003 2008 2013 2018 2023 2028 2033 2038 2043 2048
5/9/2018


World Population Projections to 2060
Billion
3 B
1960
6 B
1999
7 B
2010
8 B
2023
9 B
2037
Population Doubled
in less than 40 years...
Source:
UN Department of Economics and Social
Affairs (2015)
1950 to 2015
2015-2060 projection


World Population Trends...
Countries with Population Over 200 Million
Millions
China
India
USA
Indonesia
Brazil
Pakistan
Nigeria
Ethiopia
Congo
Tanzania
Uganda
2013
2030
2050
2075
2100
Year
5/9/2018
Page 42



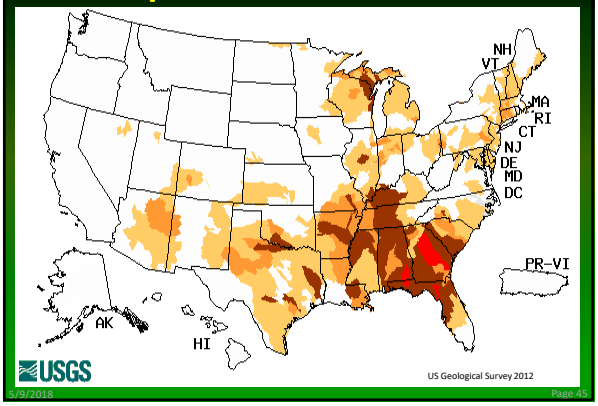
Maslow's "Hierarchy of Need"

Energy and Water

Worst US drought in decades deepens to cover 60 percent of lower 48 states

US News, 11/22/2012

Water Implications…

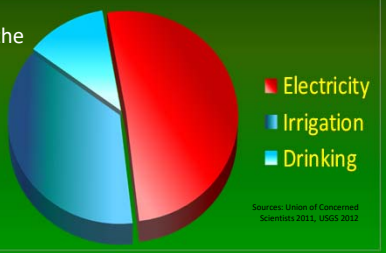


US Geological Survey 2012

Power and Water

- US thermoelectric facilities use over 200 billion gallons of water a day.

Over half of the withdrawn water in the US…



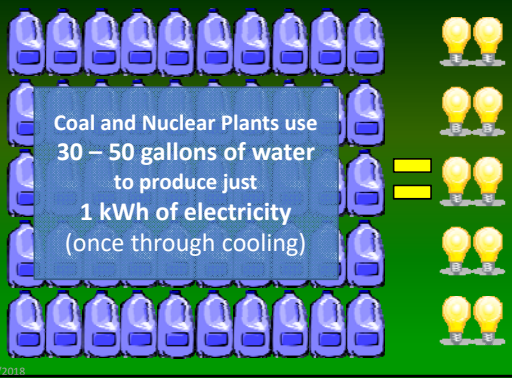
Sources: Union of Concerned Scientists 2011, USGS 2012

Niagara Falls

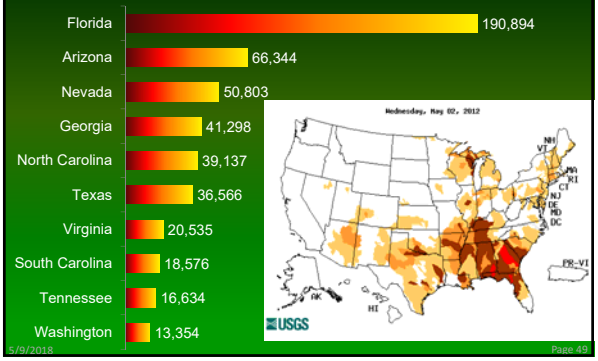
The volume of water flowing through America's electric utilities is 3 TIMES the amount flowing over Niagara Falls!

Niagara Falls State Park and USGS

Water and Power Connection…

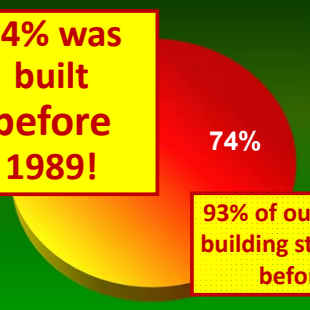


Annual Net Migration 2000 - 2004



US Commercial Buildings

74% was built before 1989!



- Before 1989
- 1990 to 1999
- 2000 to 2003

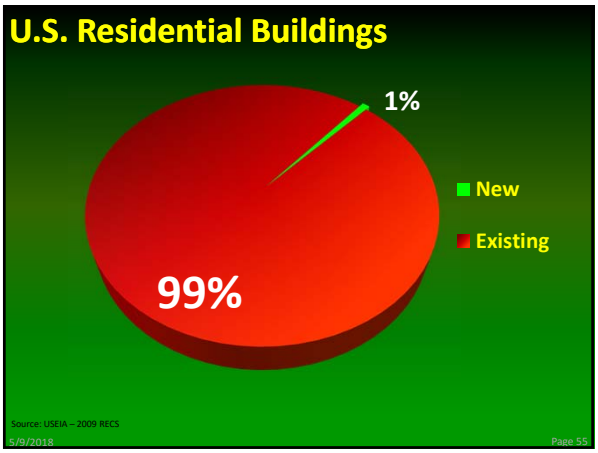
93% of our commercial building stock was built before 2003!

Source: USEIA , 2003 CBECS

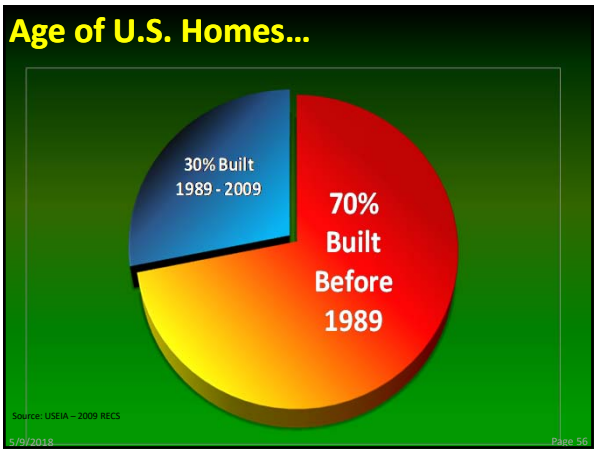
Existing Commercial Commonalities?

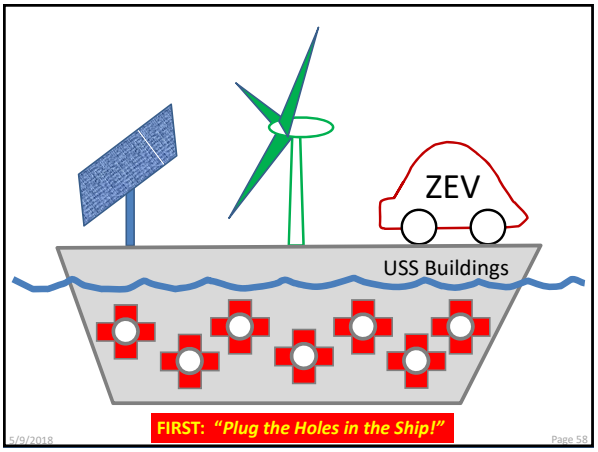
- **Substandard:**
  - Wall insulation
  - Roof insulation
  - Fenestration
  - Envelope air tightness
  - HVAC systems
  - Lighting systems
  - Control systems
- Human comfort…

U.S. Residential Buildings



Age of U.S. Homes…





Built Environment Trends - 1

- More severe climate events
  - "Superstorms"
  - Extreme cold - "Polar Vortex"
  - Extreme heat

August 22, 2015

World breaks new heat records in July – US scientists

MIAMI – The world broke new heat records in July, marking the hottest month in history and the warmest first seven months of the year since modern record-keeping began in 1880, US authorities said Thursday.

The findings by the National Oceanic and Atmospheric Administration showed a troubling trend, as the planet continues to warm due to the burning of fossil fuels, and scientists expect the scorching temperatures to get worse.

"The world is warming. It is continuing to warm. That is being shown time and time again in our data," said Jake Crouch, physical scientist at NOAA's National Centers for Environmental Information.

"Now that we are fairly certain that 2015 will be the warmest year on record, it is time to start looking at what are the impacts of that? What does that mean for people on the ground?" he told reporters.

The month's average temperature across land and sea surfaces worldwide was 61.86 Fahrenheit (16.61 Celsius), marking the hottest July ever.

The previous record for July was set in 1998.

"This was also the all-time highest monthly temperature in the 1880-2015 record," said NOAA in its monthly climate report.

"The first seven months of the year (January-July) were also all-time record warm for the globe," NOAA said.

When scientists looked at temperatures for the year-to-date, they found land and ocean surfaces were 1.53°F (0.85°C) above the 20th century average.

"This was the highest for January-July in the 1880-2015 record, surpassing the previous record set in 2010 by 0.14°F (0.09°C)."

Scientists also calculated the rate of temperature increase for July at an average of 1.12°F (0.63°C) per century.

Large parts of the Earth were much warmer than average, including Africa which saw its second hottest July on record.

"Record warmth was also observed across much of northern South America, parts of southern Europe and central Asia and the far western United States," said the NOAA report.

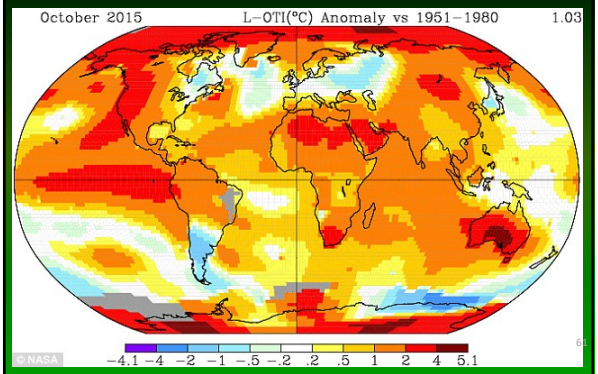
Parts of eastern Scandinavia and western Russia, eastern and southern Asia and scattered areas in central and northern North America were cooler than average.

Trends - 2

October smashes record for global warmth: Last month keeps 2015 on track to be the hottest year since 1880

- Global temperatures last month were 1.04°C above long-term average
- This figure is the greatest increase of any month since record began
- There is 99.9% chance this year will beat 2014 as the warmest year ever
- Scientists blame increase in greenhouses gases and a strong El Niño

Hottest October Since 1880…



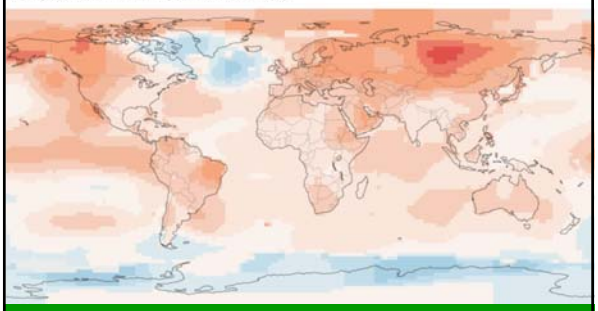
Legacy of 2015…

US: 2015 was hottest on Earth by a wide margin

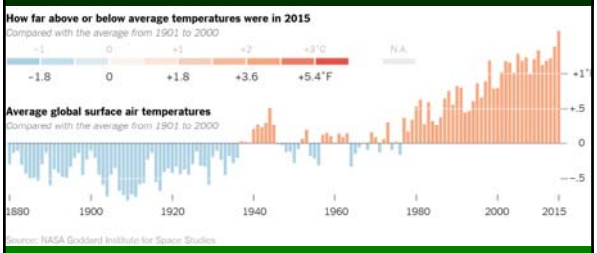
The World is Getting Warmer…

The Hottest Year on Record

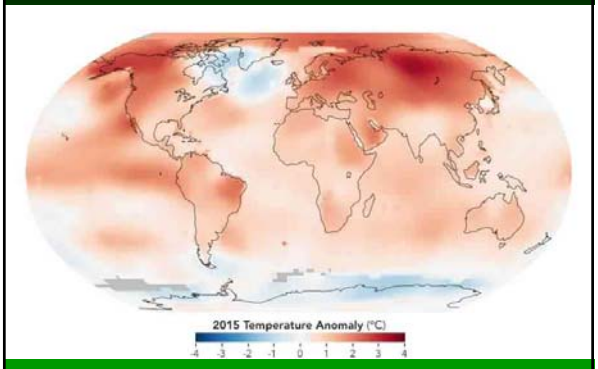
Globally, 2015 was the warmest year in recorded history.



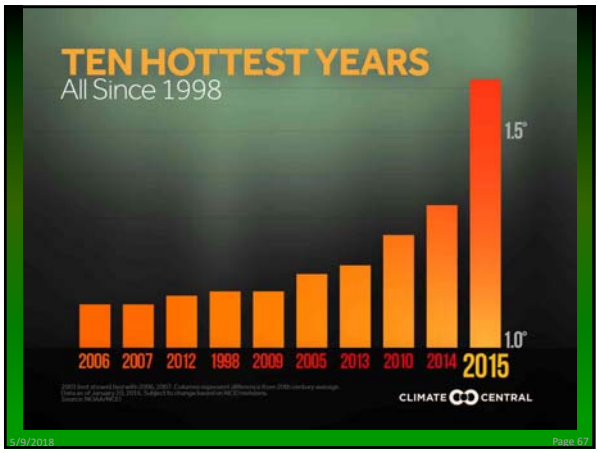
2015: Warmest Year in Modern Record Keeping



How Far From "Normal"?



2015: BLISTERING FINISH

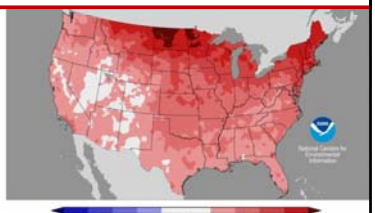


3/9/16…

Winter Tops Charts As Warmest on Record For U.S.

U.S. breaks record for hottest winter — nearly 5 degrees above normal

THE ASSOCIATED PRESS / Wednesday, March 9, 2016, 8:57 AM



4/20/16…

Science Home · Archaeology · Air & Space · Planet Earth · Wild Nature · Natural Science · Dinosaurs · Slideshows

CLIMATE

March set even more global temperature records, NOAA reports

Published April 20, 2016 · FoxNews.com

The month of March broke temperature records, making it the eleventh month in a row to do so, the National Oceanic and Atmospheric Association reported Tuesday, with North America having the warmest March ever since records began in 1910.

Globally in March, the average temperature across the land and oceans smashed the record, measuring 2.2 degrees Fahrenheit above the 20th-century average, NOAA said. That measurement breaks last year's record for March by over half a degree Fahrenheit, making it the warmest average temperature for the month across the globe since 1880.

2016: The Trend Continues…

April 2016, Hottest April Ever, Breaks Global Temperature Records

Hottest April ever recorded as temperatures soar globally

By Leah NY

May 19, 2016 06:17 AM EDT

ENVIRONMENT

APRIL'S TEMPERATURES BROKE RECORDS FOR THE 12TH CONSECUTIVE MONTH

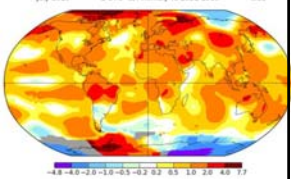
AND THAT'S NOT ALL OF THE BAD NEWS

By Mary Beth Griggs Posted Yesterday at 2:31pm

July 2016

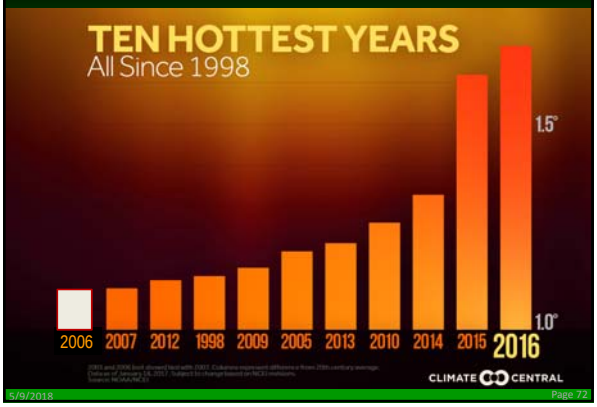
July was Earth's hottest month in recorded history — the 10th record hot month in a row: NASA

Hottest month in recorded history…

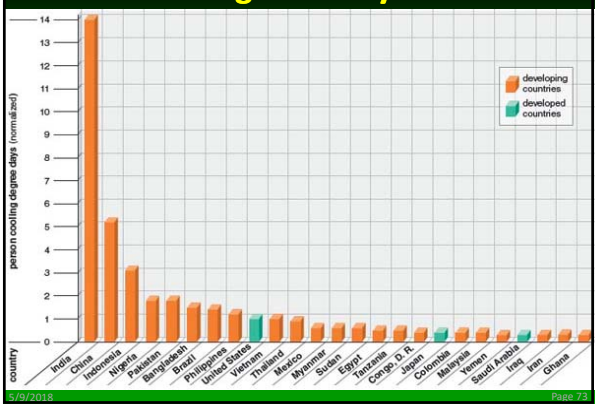


WASHINGTON -- Earth just broiled to its hottest month in recorded history, according

2016: The Trend Continues…



Air Conditioning for Everyone?



Built Environment Trends - 3

- **Increased expectations for building performance**
  - Energy
  - Health and IEQ
  - Safety
  - Durability
  - Resilience
    - Against the forces of nature
    - Against changing climate
  - Sustainable, Green
- For how long?

In the US, we spend an average of 94% of our time indoors!

But we've got the building codes to handle these issues…

Right?

What is the Code?

- **Least safe…**
- **Least strong…**
- **Least energy efficient…**
- **…building allowed by law.**

We're not allowed to build it any crappier…

Disaster Breeds Codes

Disaster Breeds Codes…

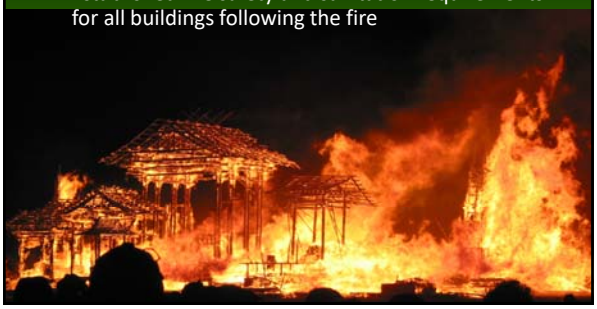
- **Code of Hammurabi – 1750 BC**
  - 6th King of Babylonia
  - Over 3750 years ago…
  - Contains five key elements designed to protect the occupants

"Regulatory Simplicity"

- **"If a builder build a house for a man and do not make its construction firm and the house which he has built collapse and cause the death of the owner of the house, the builder shall be put to death…"**

Disaster Breeds Codes…

- **The Burning of Rome – 64 AD**
  - Nero didn't like the slums and stench
  - Established fire safety and sanitation requirements for all buildings following the fire



Europe Learns…

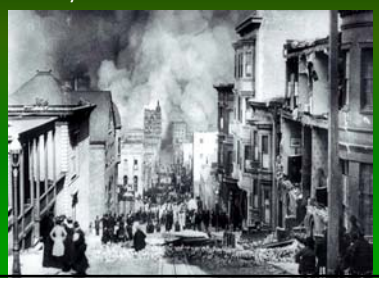
- **The Great London Fire – 1666**
  - Black Plague, raw sewage, tightly spaced buildings
  - Two-thirds of the city destroyed
  - "London Building Act" adopted after the fire

US Code Milestones…

- **The Chicago Fire – 1871**
  - Mrs. O'Leary's cow…
  - Destroyed 17,000 buildings
  - Killed 250 people
  - Left 100,000 homeless
  - Bankrupted the insurance industry
  - New code adopted in 1875 regulating building construction and fire prevention.

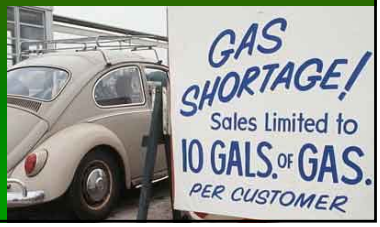
More US Code Milestones

- **The San Francisco Earthquake – 1906**
  - What the earthquake didn't get, the fire did
  - One of the major influencers of today's structural, fire and life safety codes



First Energy Code Milestone

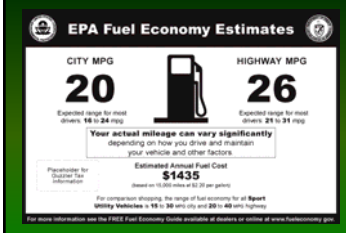
- **Arab Oil Embargo – 1973-4**
  - President Carter's Fireside Chat ("Turn your thermostat down to 65 and wear a sweater" and "Drive 55")
  - Precipitated the first energy codes for buildings – ASHRAE 1975



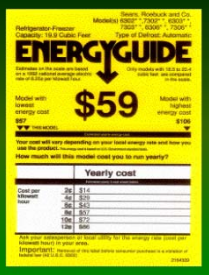
What Did We Do After 1973?

- **Adopted our FIRST Energy Code**
  - ASHRAE 1975
- **Tried to Save Energy**
  - Developed Standards and Ratings
    - Insulation, Appliances, Cars
- **Innovated (developed new technologies)**
  - Insulation, Glazing Technologies, HVAC, Lighting
- **New Market Forces Evolved**
  - Utility Programs, Rebates, etc.

Why Standards?



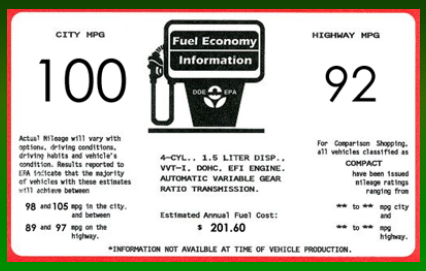
Automotive



Appliances

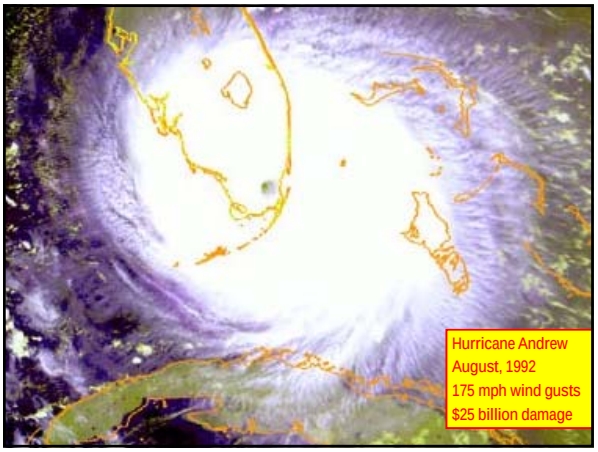
Consumer Signals About Energy!
A Means of Comparison…

What's Possible?



Energy Code Evolution…

Early Energy Code Solutions



Recent Code Milestones

- **Hurricane Andrew – 1992 AD**
  - 90% of all homes in Dade County Florida had roof damage
    - 117,000 homes were destroyed or had major damage
  - Primary driver of today's hurricane protection codes
    - Improved Roof Attachment Systems
    - Impact-resistant Glazing in high wind zones

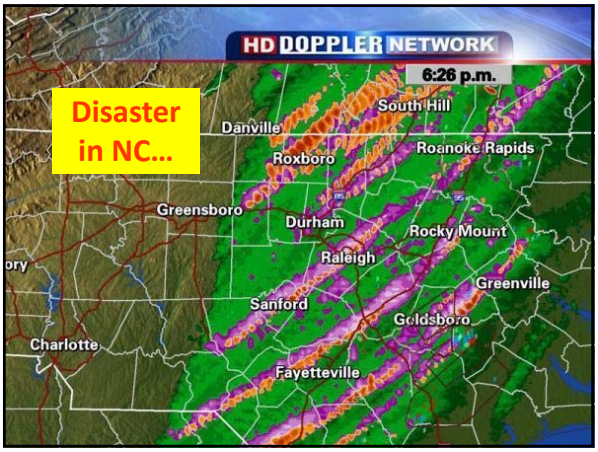
Perspective...

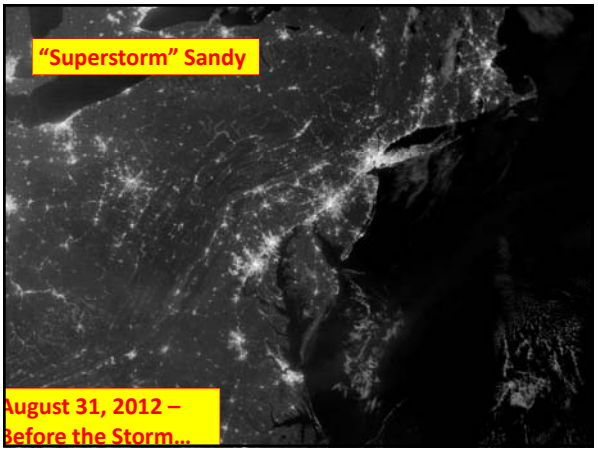
Katrina...

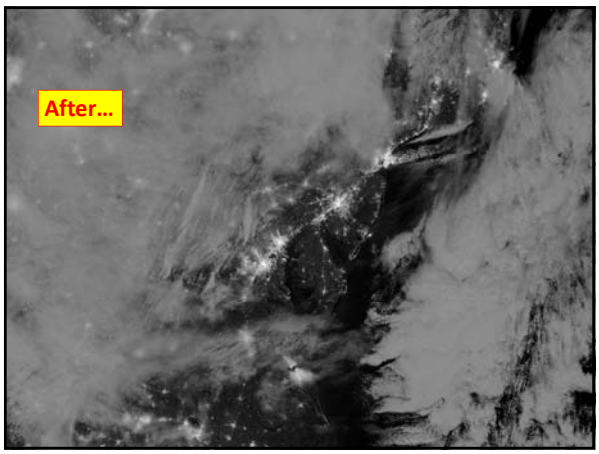
Katrina's Legacy...

- **Hurricane Katrina – 2005**
  - Costliest hurricane in US history – est. $80 billion
  - Over 1300 confirmed deaths
  - 3200 still missing

Following Katrina, Louisiana and Mississippi adopted their first mandatory building codes...



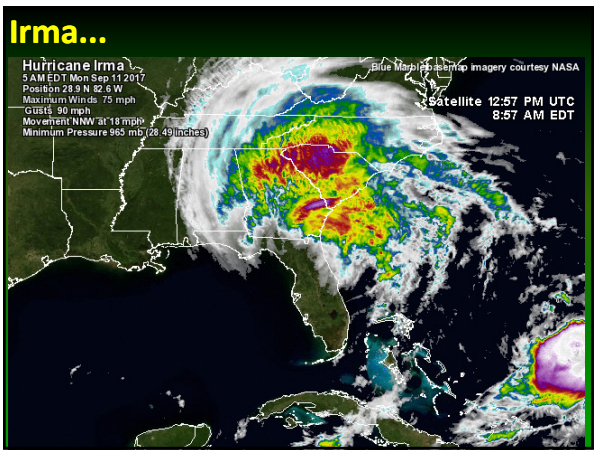

"Superstorm" Sandy
August 31, 2012 –
Before the Storm…


After…

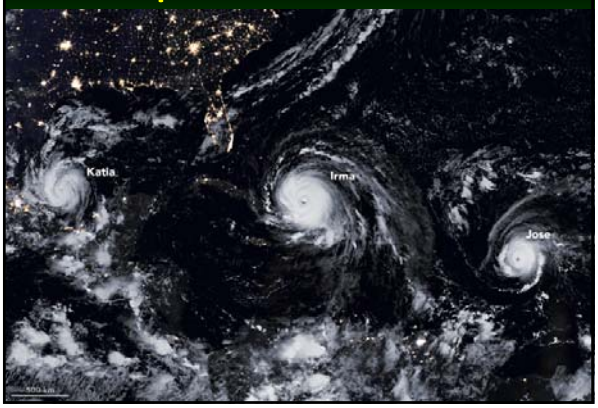

Route 35/Ocean Blvd
Mantoloking Bridge
August 31, 2012 –
Before the Storm…

Perspective:

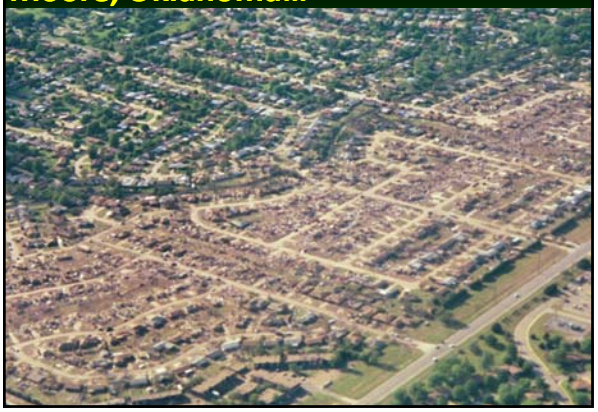
When the grid went down in India, over 350,000,000 people were without power…



"More Frequent Severe Storm Events..."

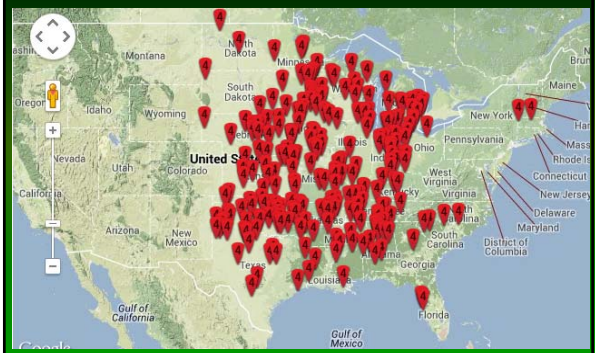


Moore, Oklahoma…



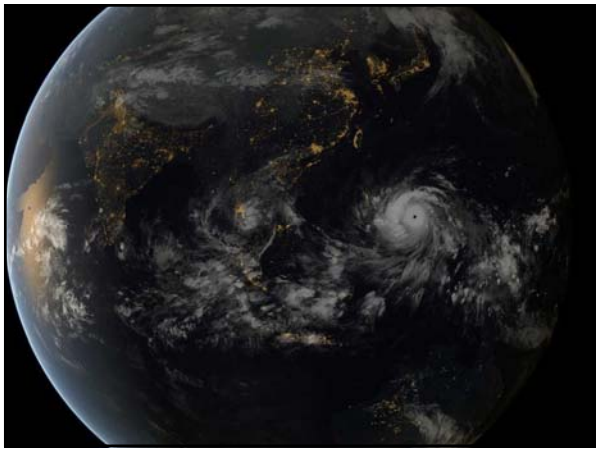
F5 Tornadoes Since 1950…

F4 Tornadoes Since 1950



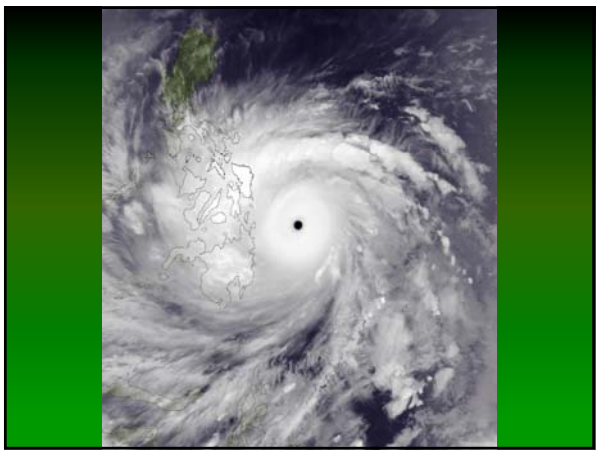
F3s…

F2s…



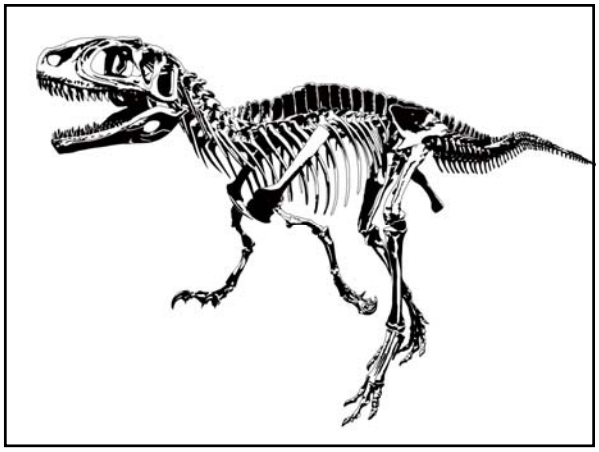
"Super Typhoon" Haiyan: 2013

- **The strongest storm in recorded history**
  - Category 5 Event
  - Sustained winds **of over 96 mph for several hours**
  - **Wind speeds in excess of 260 mph**
- **Storm surge alone estimated to be responsible for over 10,000 deaths**
- **The same area experienced 7.1 magnitude earthquake less than a month before…**
- **What lessons will we learn?**



History has shown that we wait for disaster before we act…

There are consequences to waiting…



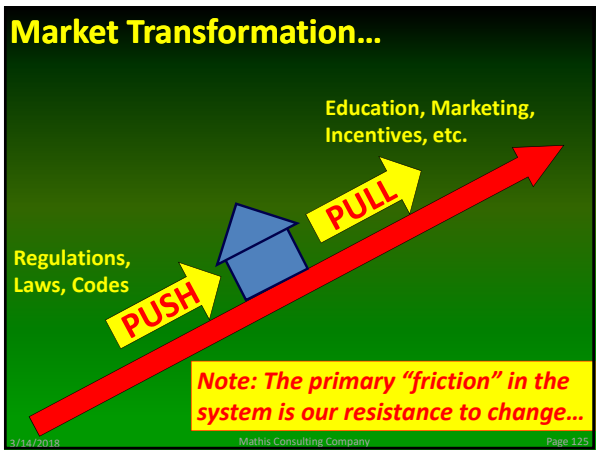
Recap: What is the Code?

- Least safe…
- Least strong…
- Least energy efficient…

…building allowed by law.

We're not allowed to build it any crappier…!

Market Transformation…



Recent Energy Code History

The 70s – "The Insulation Decade"

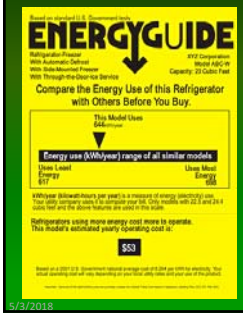
1970 → 1980

- Oil Embargo 1973
- ASHRAE 1975
- FTC R-Value Rule 1978

5/3/2018 Page 127

The 80s – "The Appliance Decade"

1980 → 1990



- NAECA 1985
- ASHRAE 1989

5/3/2018 Page 128

The 90s – "The Window Decade"

1990 → 2000

- Energy Policy Act of 1992
- ASHRAE 1999

World's Best Window Co.
Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing - Argon Fill - Low E
Product Type: Vertical Slider

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
0.51	0.2
Condensation Resistance	
51	—

5/3/2018 Page 129

2000-2010 – "The 30% Decade"

2000 → 2010

- ASHRAE 2001
- ASHRAE 2004
- ASHRAE 2007
- ASHRAE 2010

R-15 IS Now R-20

Target: 30% more efficient than 2004

5/3/2018 Page 130

"The 30% Decade" - Residential

2000 → 2010

- IECC 2003
- IECC 2006
- IECC 2009
- Recovery Act

30% more efficient than IECC 2006?

5/3/2018 Page 131

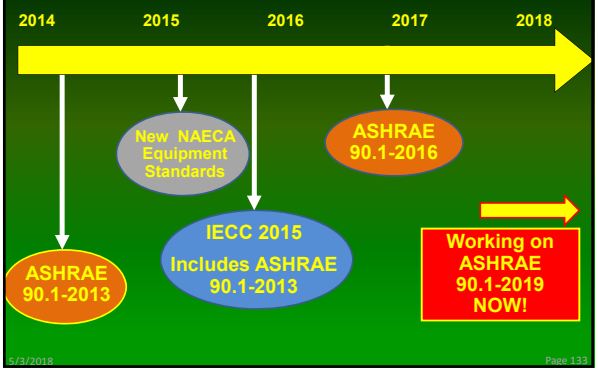
Evolving Regulatory Landscape

2010 → 2011 → 2012

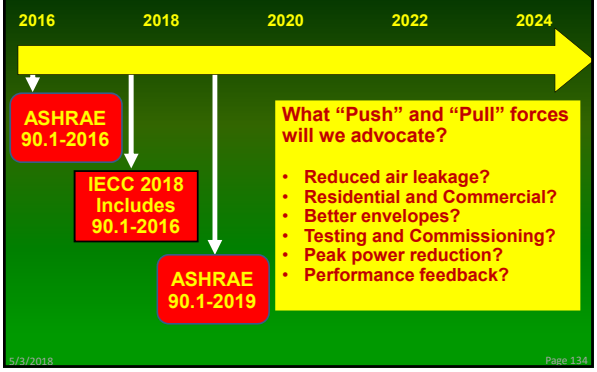
- ASHRAE 2010 is 30% more efficient than 2004**
- Green Code development dominated regulatory landscape
- IECC 2012 is 30% more efficient than 2006**

5/3/2018 Page 132

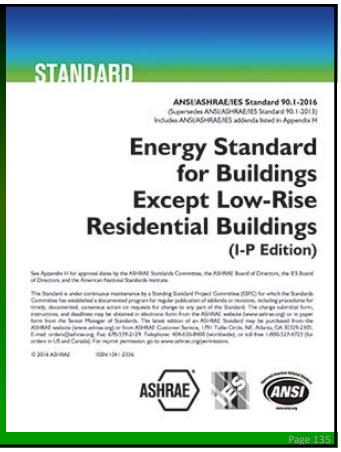
Recent Regulatory Landscape



What is Our Next Focus?



90.1-2016



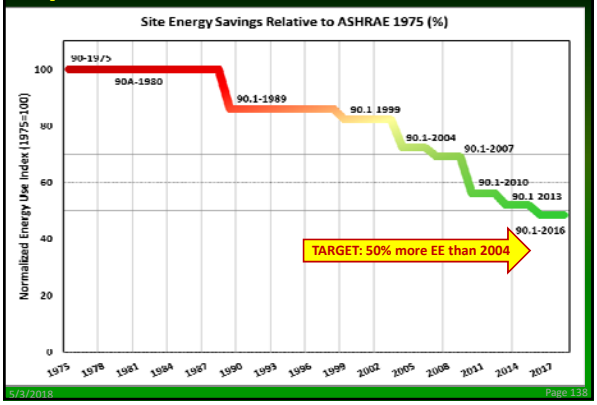
Standard 90.1

- **The US "Model Energy Code"**
  - Referenced in the Energy Policy Act of 1992
  - The Standard against which all state commercial energy codes are evaluated
- **Defines the Minimum Energy Efficiency for**
  - Commercial buildings
  - High-rise residential
  - Semi-conditioned
- **On "Continuous Maintenance"**
  - Updated every 3 years
  - Current edition – 2016

Latest Version of 90.1-2016

- **Published October 2016**
- **Goal was to be 50% more efficient than 2004**
  - Didn't get there most places
  - Some improvements in each climate zone
- **A few BIG changes…**
  - **Many** impact architects, specifiers and engineers
    - Envelopes, Air sealing, Lighting, Commissioning
  - Pay **particular** attention to building envelope changes since 2007…

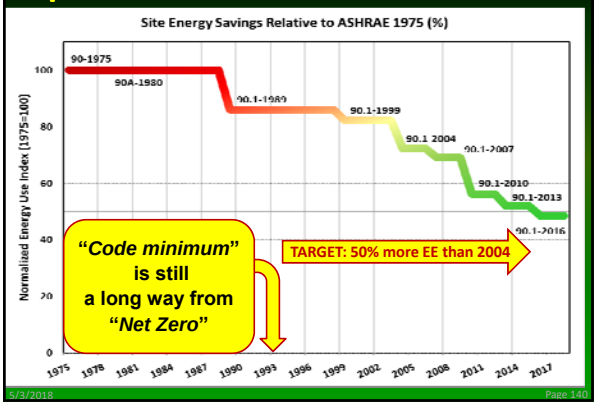
Improvements in EUI: 1975 to Present



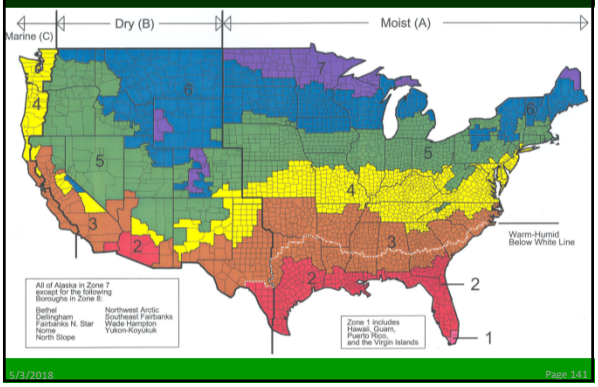
Audience Survey

Net Zero?
Deep Green?

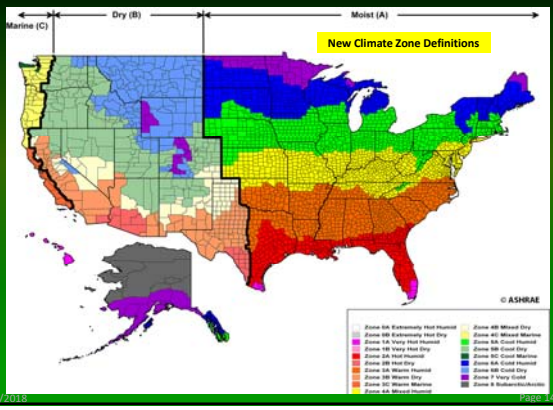
Improvements in EUI: 1975 to Present

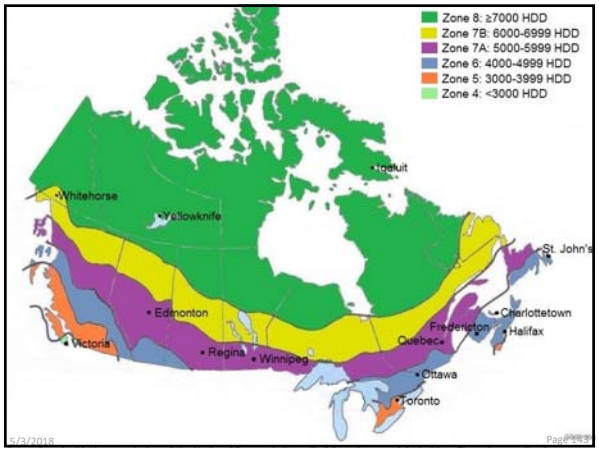


Climate Zones (Current)



Standard 169: New Climate Zones





ASHRAE 169-2013

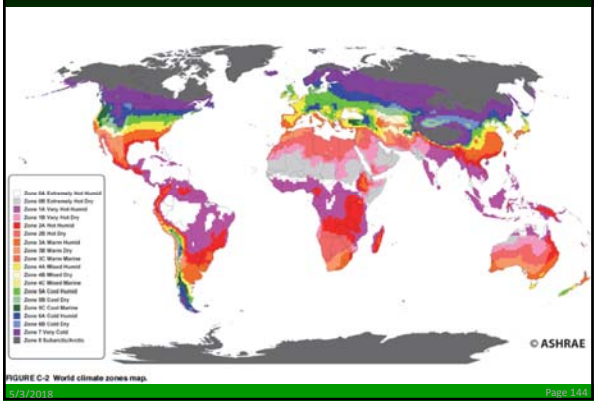
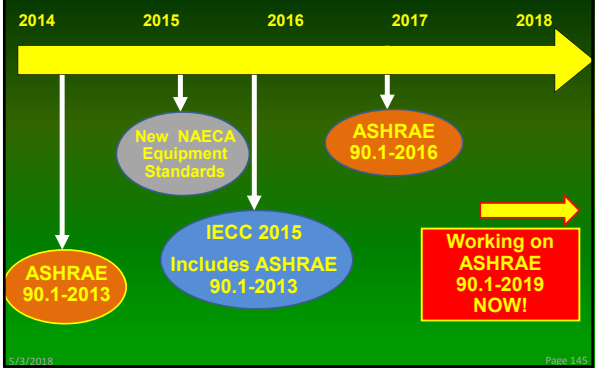
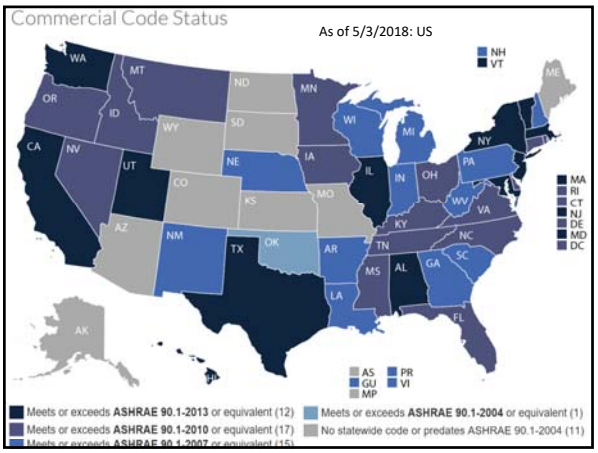


FIGURE C-2 World climate zones map.

Where is YOUR Code Today?



5/3/2018 Page 145



Economic Foundation: LCC

- 90.1 performance levels are based on Life-Cycle Cost Analyses
  - Each cycle, key variables in valuation are assessed
    - Costs
    - Savings
    - Tax rates
    - Fuel escalation rates
    - Inflation rates
    - Etc.

5/3/2018 Page 147

Life-Cycle Cost Economic Analysis

(ASTM E917)

$$LCC = FC + M + R + E - RV$$

where:

LCC = Life-Cycle Cost ($)
FC = First Cost ($)
M = Maintenance and Repair Costs ($)
R = Replacement Costs ($)
E = Energy Costs ($)
RV = Resale Value or Salvage Value ($)

5/3/2018 Page 148

Scalar Ratio

Energy Savings

- Economic Life
- Fuel Escalation Rates
  - Heating
  - Cooling
- Discount Rate

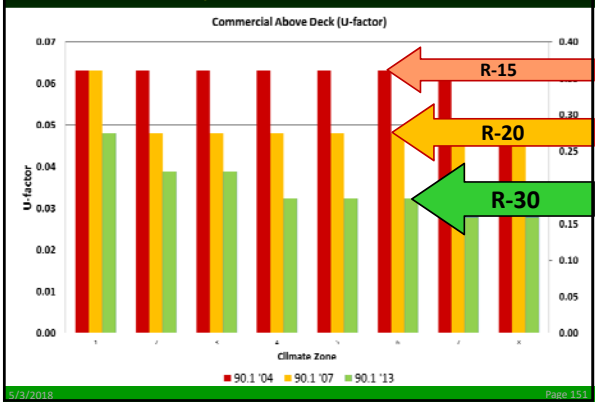
First Costs

- Loan Life
- Inflation Rate
- Tax Rate
  - Federal
  - State
- Loan Interest Rate

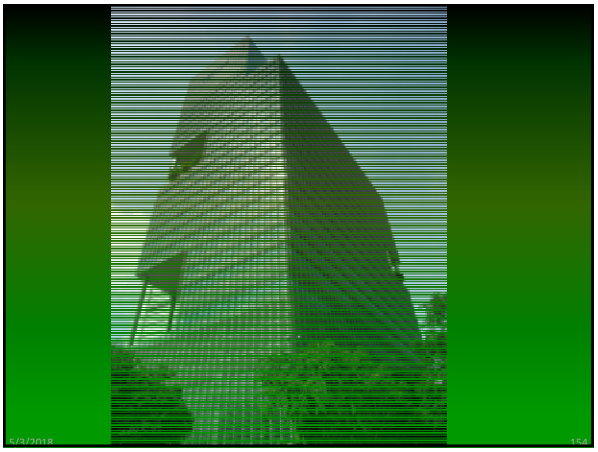
5/3/2018 149

2004 versus 2016 Examples

2004 to 2013/16: Roofs



2004 versus 2016: Walls

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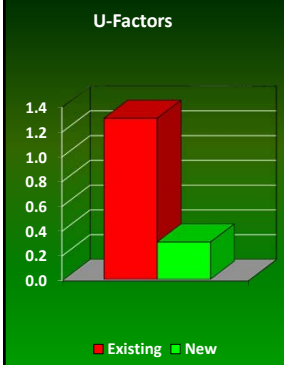
Heat Loss (winter)



- Common aluminum-framed, single glazed windows **lose 3 to 4 times more heat** in winter than today's most basic energy efficient technologies
- Cold glass surfaces with recurring condensation
- BIG impact on comfort
- BIG impact on heating costs

Compare the Heat Transfer...

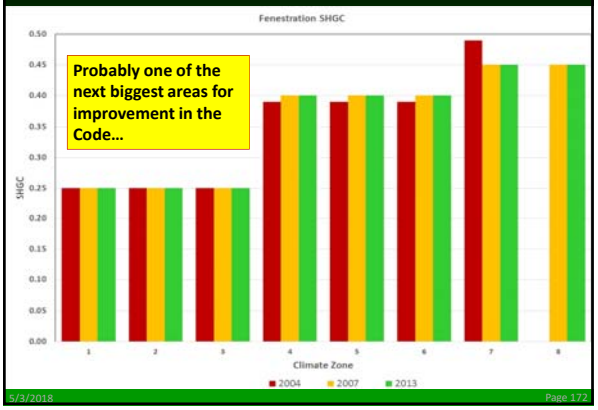
Opaque versus Fenestration...

	Steel-framed Walls	Curtain Wall (metal, fixed)	
CZ 5	0.055	0.38	6.9 times
CZ 6	**0.049**	**0.36**	**7.3 times**
CZ 7	0.049	0.33	6.7 times

ASHRAE 90.1-2016

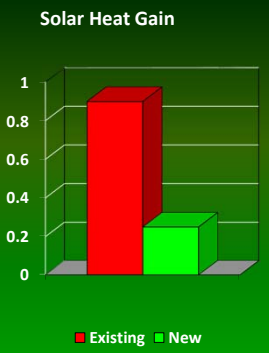
5/3/2018 Page 169

Solar Heat Gain Coefficient



5/3/2018 Page 172

Heat Gain (summer)



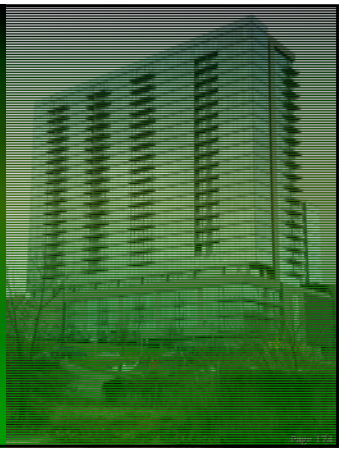
- Air conditioning energy is very expensive
- Today's code minimum window technologies **are over 3 times more efficient at blocking unwanted heat gain** than common aluminum-framed, single glazed windows
- Windows generally drive the air conditioning load (residential)
- Windows generally determine the perimeter load (commercial)

5/3/2018 173

Think about...

- **Comfort?**
- **Resilience?**
- **Durable?**
- **Code Compliant?**
- **Thermal Bridges?**

- **Energy?**
- **Peak power?**
- **Carbon?**



5/3/2018 Page 174

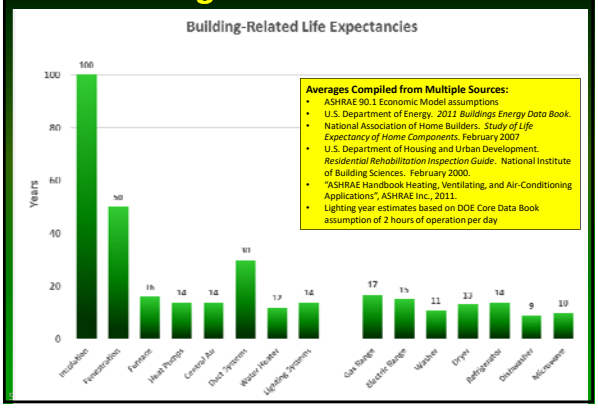
Think About What We Build...

Think About What We Build...

How much energy? For how long?

What are our responsibilities as knowledgeable building professionals?

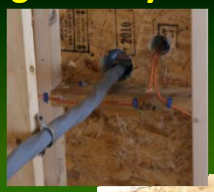
For How Long? "Economic Life"

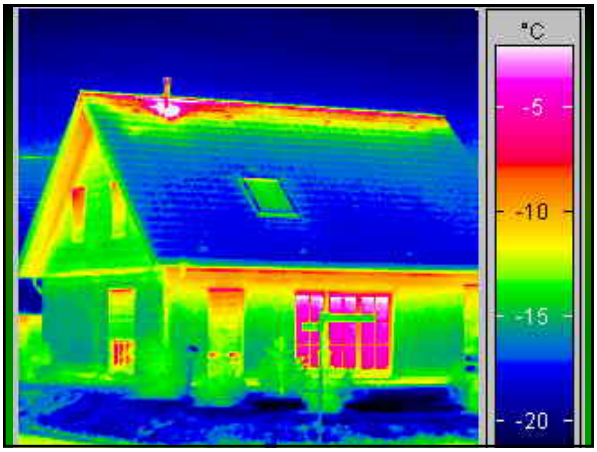


How Long Will It Last?

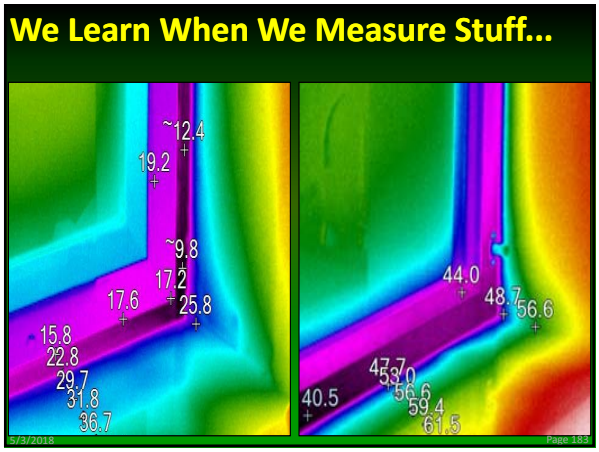
Small Problems in Long-Lived Systems

- Envelope deficiencies have a "trickle-down" effect on the performance of other critical building systems
  - HVAC Sizing
  - Controls Effectiveness
  - Human Comfort
- It's easier (and cheaper) to "get it right the first time!"






Existing Fenestration Performance Deficiencies...

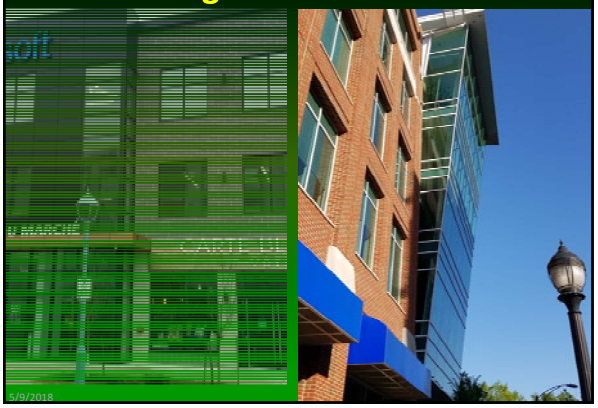

We Learn When We Measure Stuff...
~12.4
19.2
~9.8
17.2
17.6
25.8
15.8
22.8
29.7
31.8
36.7
44.0
48.7
56.6
40.5
59.4
61.5
5/3/2018
Page 183


Sometimes the message is pretty simple...
5/3/2018
Page 184


Page 185


Do you suspect a "Floor Insulation Challenge"
5/3/2018

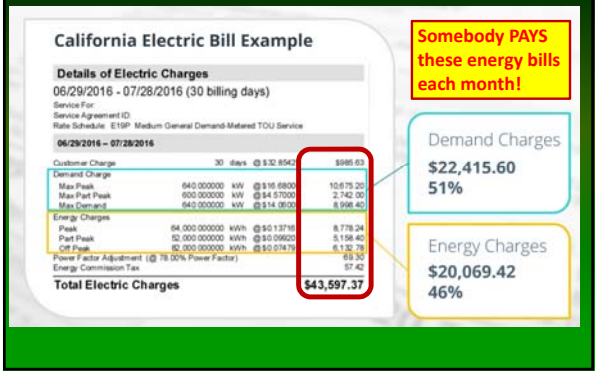
Thermal Bridges...



Connections?

Buildings? Or Heat Exchangers?

Someone Pays for Our Energy Decisions...



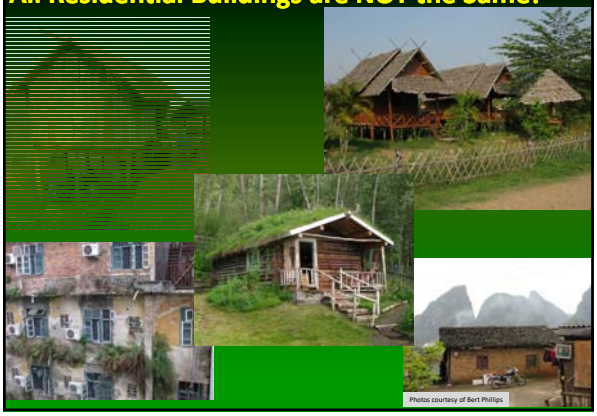
Residential Buildings: Low-rise

Residential Buildings: Multi-Family

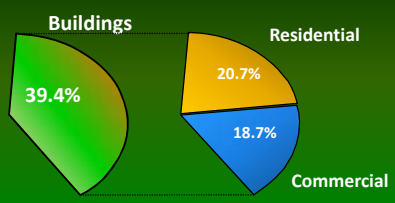
Residential Buildings: Mid- to High Rise

Residential Buildings: Mid- to High Rise

All Residential Buildings are NOT the Same!

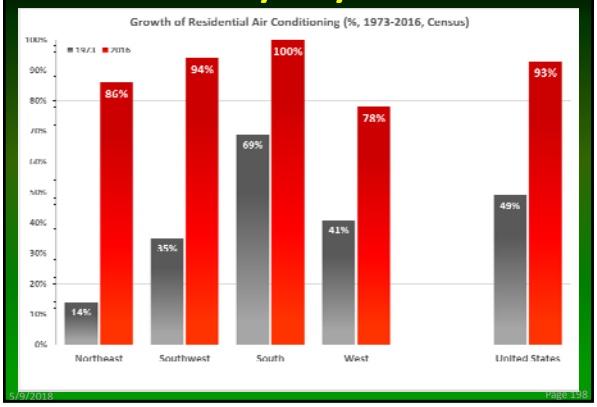


Reminder: Residential Energy Demand is Huge!



Source: USEIA - 2016

Remember: Everybody Wants AC!



"Mixed-Use" – Multiple Occupancies

Renovation and Repurposing – A New Life

- Cotton Mills to Condos…
- Tobacco Warehouse to Arts District Studios…
- Furniture Mill to Small Business Incubator…

Often Diverse Project Objectives

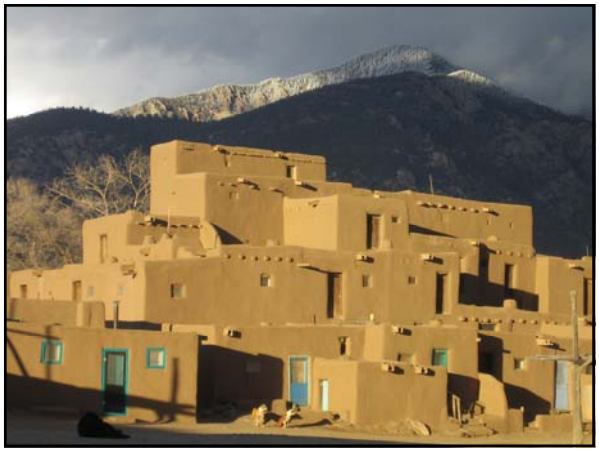
- Child care to health care?
- Housing and work space?
- Retail and Residential?
- Schedule Implications
  - 8-to-5 versus 24/7?
- Peak power management
  - When is the utility's peak?
  - Is there more than one?
- Different comfort conditions needed for different occupancies?

Audience Survey – How Long?

- House you grew up in
- House one of your parents grew up in
- House one of your grandparents grew up in
- ?Great-grandparents?
- What about the projects you are working on today? How long will they last?

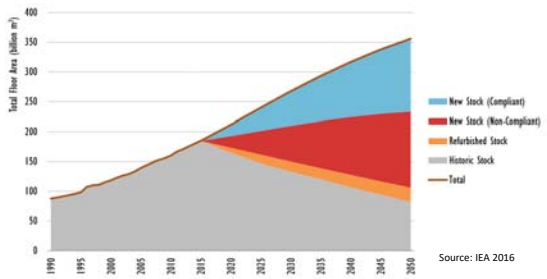
Some of the Oldest US Buildings…

- Palace of the Governors, Santa Fe, NM – 1610
  - ~400 years old
  - Oldest governmental building
- St. Luke's Church, Smithfield, VA – 1632
  - ~382 years old
  - Oldest church
- Fairbanks House, Dedham, MA – 1637
  - 377 years old
  - Oldest house
- Another hand full around 350…



Lots of Residential Need...

Global residential floor area growth to 2050



Source: IEA 2016

Buildings Are Systems...

Avoid Performance Silos...

Delivered Building Performance...

These, and all the many other elements that go into delivering a successful NEW building or RENOVATION project MUST WORK TOGETHER!

5/3/2018 Page 212

Building Envelope Considerations

Elements

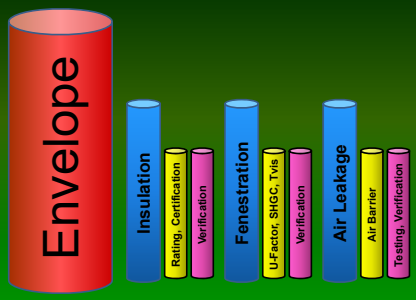
- **Opaque elements**
  - Insulation, exterior surfaces, floors, roofs, etc.
- **Fenestration**
  - Windows, glazing, curtain walls, skylights, etc.
- **Joints**
  - Everywhere things go together...
- **Location**
  - Climate zone, elevation, microclimate
- **Orientation**
  - Solar sensitivity, prevailing weather

Performance

- Insulation, Water Management, U-factor, Durability
- Solar Heat Gain Coefficient, U-factor, Visible Transmittance, Durability
- Air Leakage Control, Durability
- Appropriate performance to the location?
- Appropriate performance to the orientation?

5/3/2018 213

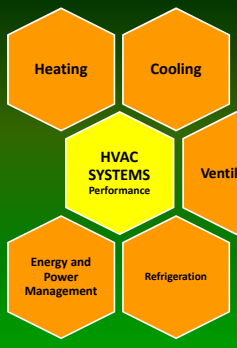
What IS Envelope Performance?



5/3/2018 Page 214

HVAC: From Parts to Systems

The many parts of HVAC systems have to deliver on their performance expectations holistically.

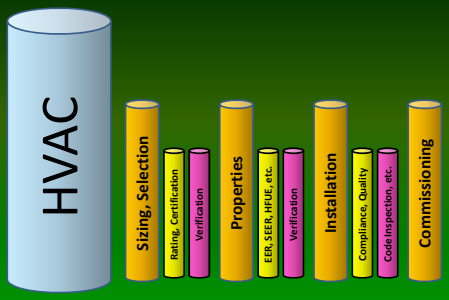


Sizing?
Integration?
Controls?

Maintenance?
Durability?
IEQ?
Comfort?

5/3/2018 Page 215

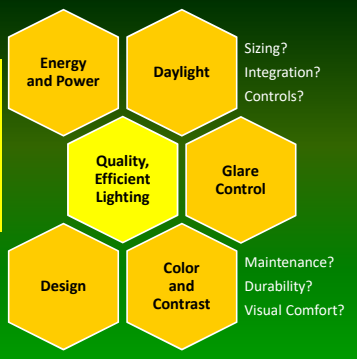
What IS HVAC Performance?



5/3/2018 Page 216

The Holistic Lighting Challenge

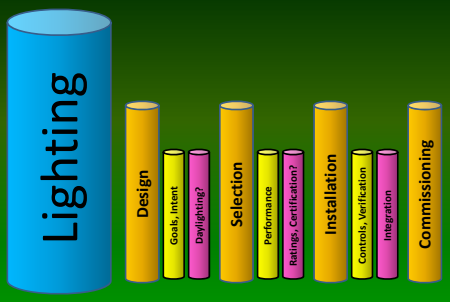
Not just "Illumination". We must use INTEGRATED APPROACHES to deliver QUALITY illumination.



Sizing?
Integration?
Controls?

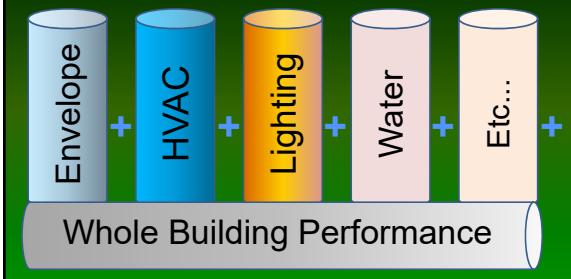
Maintenance?
Durability?
Visual Comfort?

What IS Lighting Performance?

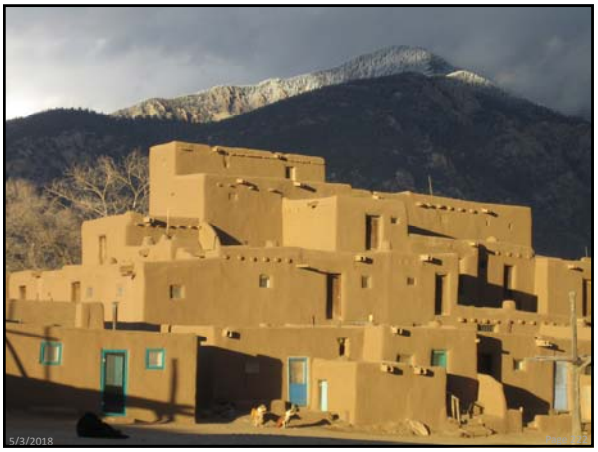


Diversity of Silos: What Is Our Focus?

Are we Assured "Delivered Performance"?



For How Long?



What is Sustainable?

Key Message:

Code Compliance is NOT "Performance Assurance"!

Don't be afraid to MEASURE STUFF!
Especially stuff that is supposed to last a long time!

What Does the Future Look Like? (1)

- **Better Building Envelopes**
  - The 90.1-2016 Envelope tables look very different than 2004 or 2007 or 2010
    - You should already be familiar with these changes
- **Greater focus on reducing uncontrolled air leakage**
  - Continuous air barrier
  - Testing or commissioning
  - (Note: This focus is continuing for the 2019 edition of the Standard)
    - Thank you Wagdy for setting us on this path...

Controlling Envelope Air Leakage - 1

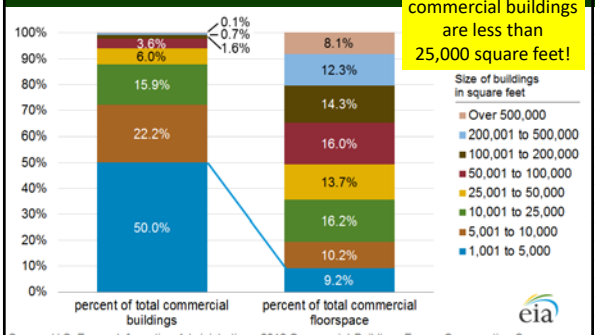
- **90.1 - 2004**
  - General language about minimizing air leakage, sealing cracks, specific references to window and door leakage
- **90.1-2007**
  - Same language

Controlling Envelope Air Leakage - 2

- **90.1 - 2010**
  - A **FOCUS** on controlling and limiting air leakage
    - Requires a continuous air barrier
    - Lists approved materials and assemblies
    - Revised vestibule requirements, loading docks
- **90.1-2013**
  - More refining air leakage language
- **90.1-2016**
  - Air leakage testing or air barrier commissioning
  - Maximum leakage: 0.4 cfm/sq.ft.

Most Buildings Are SMALL!

Over 85% of US commercial buildings are less than 25,000 square feet!



Source: U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey

Air Leakage Testing

- **We can do this...**
  - Test methods
  - Standards
  - Professional development
  - Quality assurance

We CAN Test Large Building Air Leakage...

Even VERY Large Buildings!!

Remember: Over 85% of US commercial buildings are less than 25,000 square feet!

Lessons from Recent Symposium (1)

- **Minimum Standards:**
  - The more we test whole building air leakage, better envelopes and better building control result.
- **Achieving the value of 0.4 cfm/ft^2 is easy-peasy.**
  - In fact some jurisdictions have voluntarily lowered that value.
  - Most new buildings are coming in much lower.
- **Low-rise buildings (less than 4 stories) are easily achieving envelope air leakage values around 0.1 cfm/ft^2 with building enclosure commissioning.**

Recent Lessons (2)

- **The US Army Corps of Engineers minimum standard of 0.25 cfm/ft^2 becomes easy-peasy after a single code cycle of testing experience.**
  - USACE is piloting a further target reduction to 0.15 cfm/ft^2 with success.
- **Multiple speakers noted that the "ASHRAE value of 0.4" is about twice what the minimum should be.**
  - Several presenters promoted 0.1 for all small buildings (<50,000 ft^2)
- **All the speakers agreed, commissioning the envelope is key to delivered building envelope performance.**

Recent Lessons (3)

- **Common Leaks identified:**
  - Vented roof assemblies
  - Doors, frames – all types – swinging, rolling, coiling, etc.
  - Mechanical penetrations – All. Critical to delivered envelope performance.
  - Roof/Parapet intersections – wow. Huge.
  - Roof/Wall intersections. Huge.
  - Fans – especially those in elevators and stairwells
  - Ducts.
  - Elevator shafts – from parking garage to roof decks.
  - Electrical penetrations.
  - Chutes, shafts and chases – of all types – trash, laundry, roof access hatches, mechanical chases, etc.

What Else Does the Future Include?

- **More daylighting and daylighting controls**
  - Better management of fenestration heat gain
  - Greater visible light availability and utilization
  - More sophisticated controls
- **Improvements to HVAC Systems**
  - Equipment efficiencies
  - Commissioning critical systems and controls
- **Expansion to More Climate Zones**
  - Climate Zone zero!

What Else Does the Future Include (2)

- **Measurement!**
  - New building air barrier commissioning and testing
  - New building critical systems commissioning
    - HVAC, Controls, Lighting, etc.
  - Existing building forensic investigations
    - Air leakage, IEQ, Structural, etc.
- **Energy Signals!**
  - Dashboards, Feedback, Real time signals...
- **Other Performance Signals!**
  - Advanced controls provide rapid feedback and potential to minimize risks

Sometimes the message is pretty simple...

What the Code is NOT

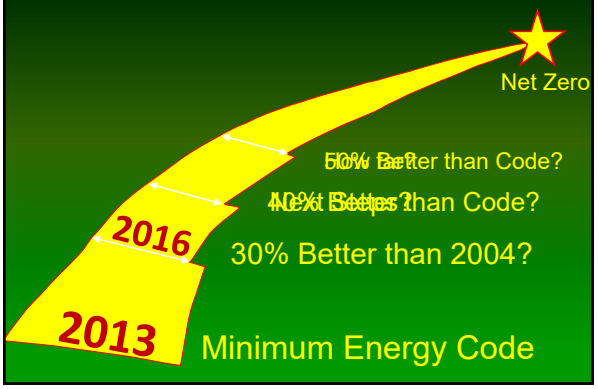
- **Not leading edge**
- **Not superior performance**
- **Not exemplary**
- **Not green**
- **Not sustainable**
- **Not differentiating**

It is the starting point for all differentiation…

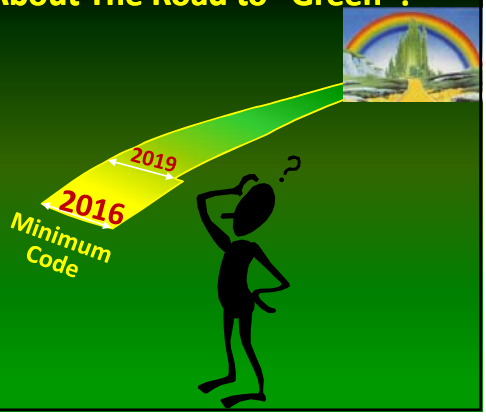
The Starting Point for

- Energy Star
- LEED
- Green Globes
- Building America
- Houses That Work
- And every other "beyond code" program…

The Road to "Net Zero"



What About The Road to "Green"?



Everybody Wants to be Green…

- ASHRAE 189
- ICC International Green Construction Code

- "It ain't easy…"
  - Standards
  - Ratings
  - Metrics
  - Boundary Conditions
  - How long?

Early Problems with "Green"

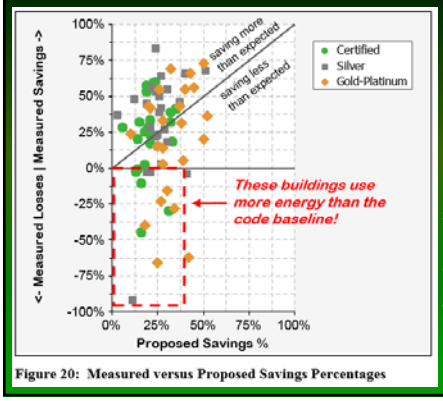


Figure 20: Measured versus Proposed Savings Percentages

LEED

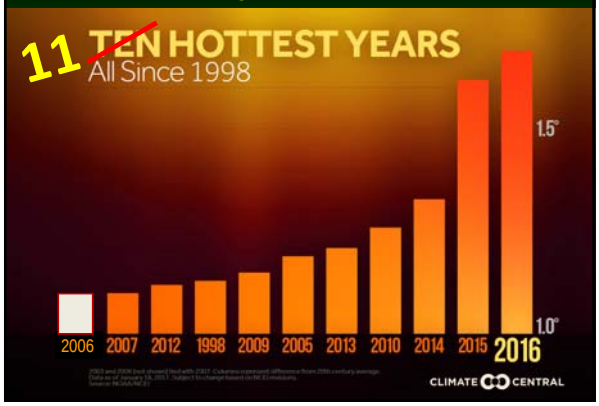
Measured vs. Proposed Energy Savings

Source: Source: New Buildings Institute/USGBC's energy performance of LEED for new construction buildings

What About Those Other Objectives?

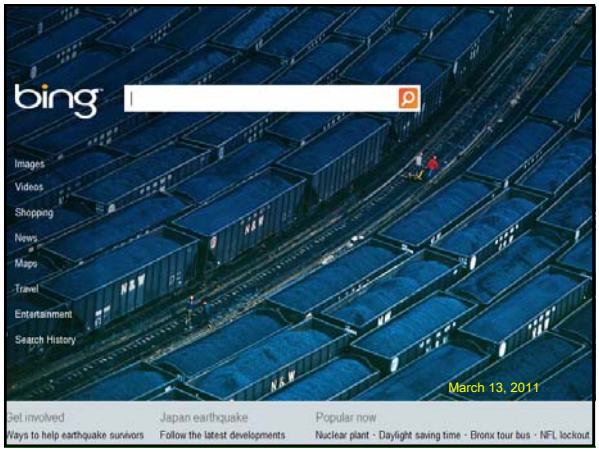
- Durability?
- Resilience?
- IEQ?
- Comfort?
- Water Savings?
- Carbon?

Sometimes change doesn't wait on us…



Our Leadership Responsibility

- **Get engaged!**
  - Support local building performance education
  - Get engaged in local code adoption and compliance
  - Collaborate!
    - Architects, Building Officials, Developers, Product Suppliers, etc.
- **Commission Stuff!**
  - Envelopes, HVAC, Lighting systems, Controls
- **Measure stuff!**
  - Leakage, comfort conditions, air flows, radiant asymmetry, water use, energy use, peak power, etc.
- **New and Existing Buildings!**
  - Commercial AND Residential



The End in Mind

- **Buildings Matter!**
  - It is up to **knowledgeable building industry professionals** to deliver this message.
- **Major Trends Impacting Building Decisions**
  - Environmental Trends
  - Human Expectation Trends
  - Population, Water, Power…
- **The Latest Code?**
  - The **Starting Point** for Building Performance
  - Major Implications for Building Professionals
  - Critical Step in our Building Industry Leadership

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