Why Buildings Matter

and
the Role of ASHRAE 90.1 - 2013

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The End in Mind

- **Buildings Matter!**
  - More than we know…
- **Major Trends Impacting Building Decisions**
  - Energy, Power, Water, etc.
- **The Role of ASHRAE 90.1**
  - Key Changes
  - Implications for Building Professionals

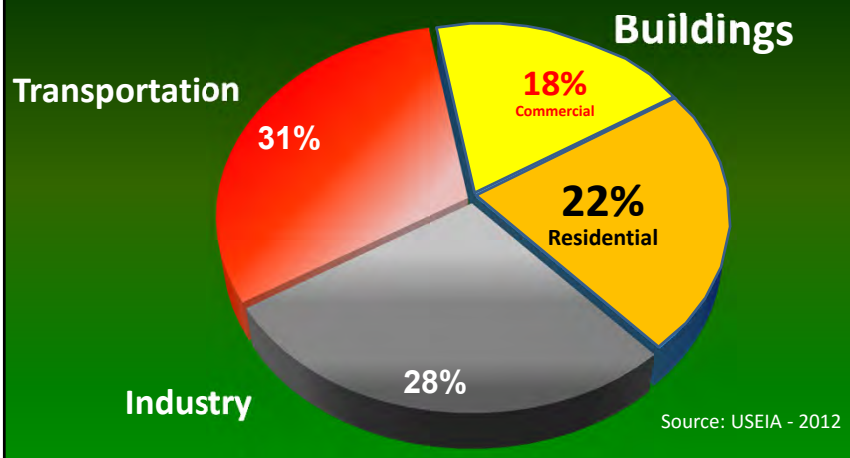
Disclaimers

- **Can't Do an Entire ASHRAE 90.1 Workshop in an hour**
  - A week-long workshop would be a good start…
- **Today Focusing on Key Changes in 2010 and 2013**
  - Especially in those parts of the Standard we don't normally pay attention to…

Who Am I?

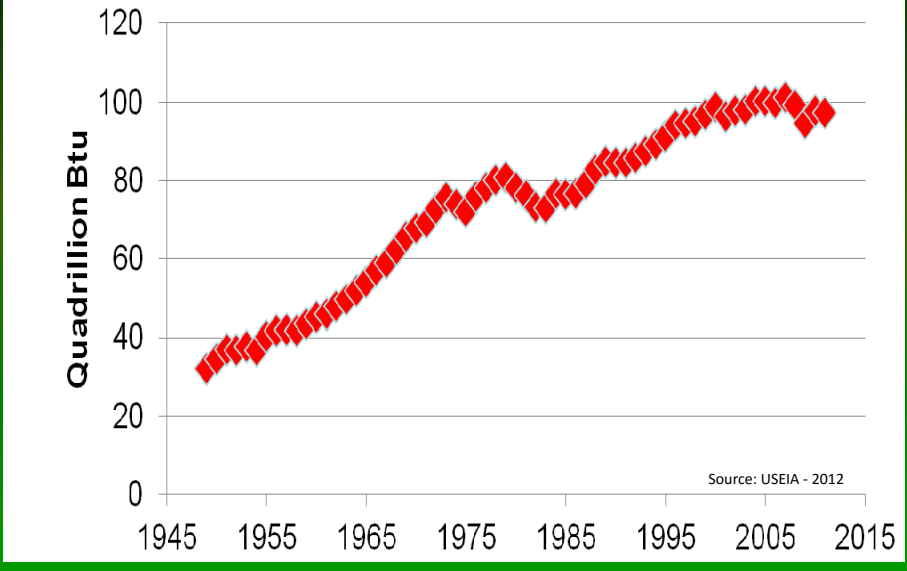
- **Building Scientist for 34+ years**
- **Author, Educator**
- **Standards Developer and User**
  - ASHRAE Member – 30+ years
    - 90.1, 90.2, 189.1, CTTC
- **Code Developer**
  - IECC, IGCC, State Codes, etc.
- **Beekeeper**

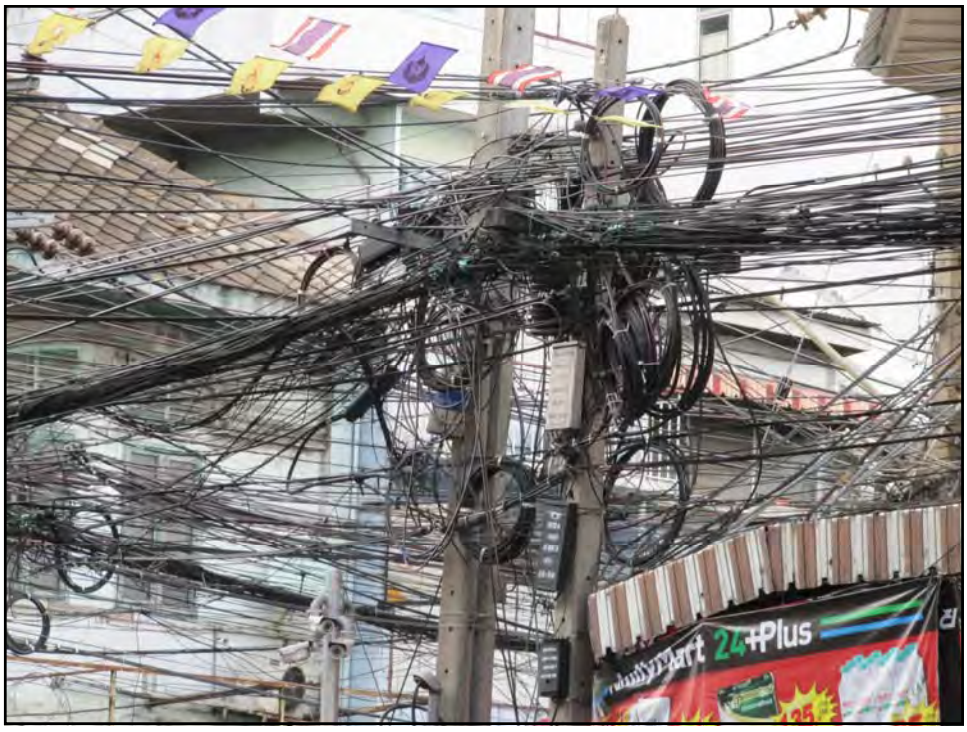
Buildings Matter: US Energy Use

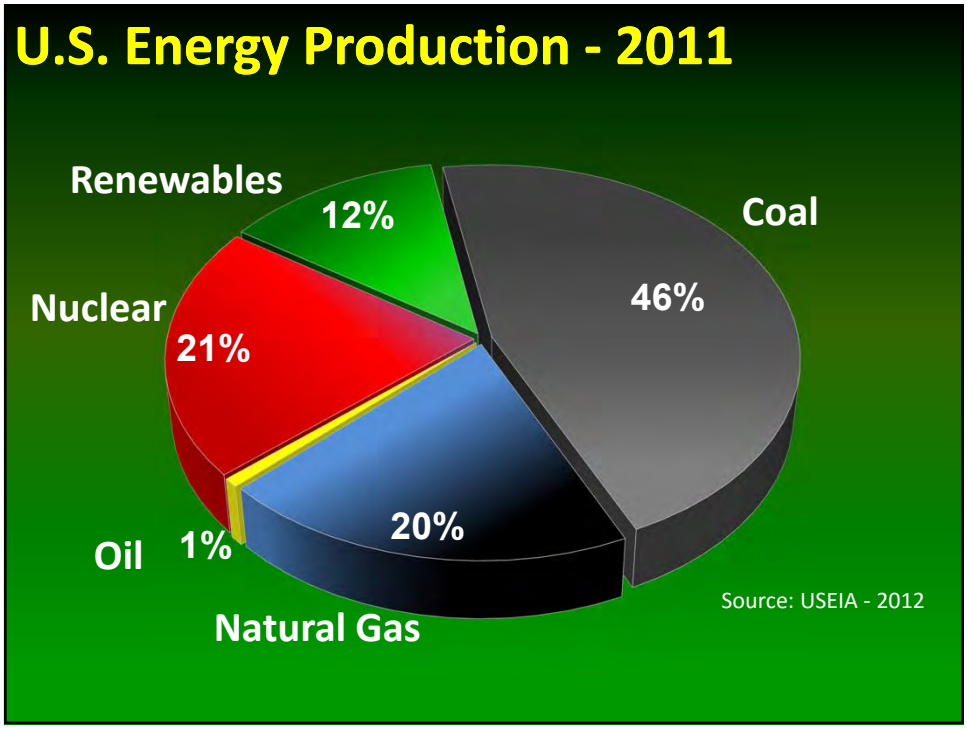


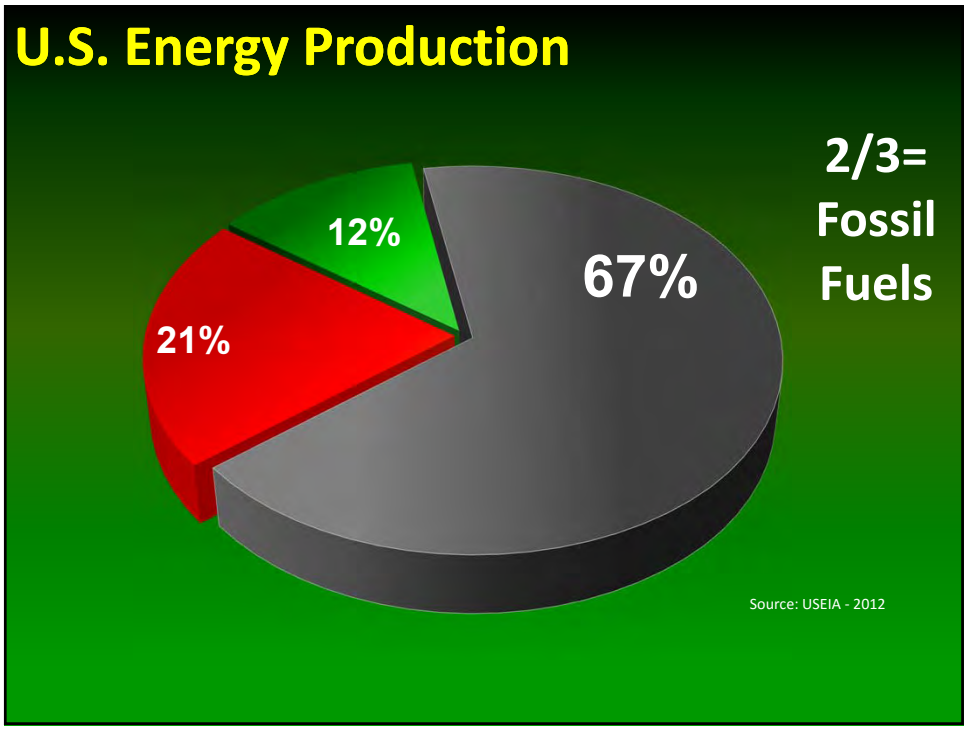
Source: USEIA - 2012

U.S. Energy Consumption

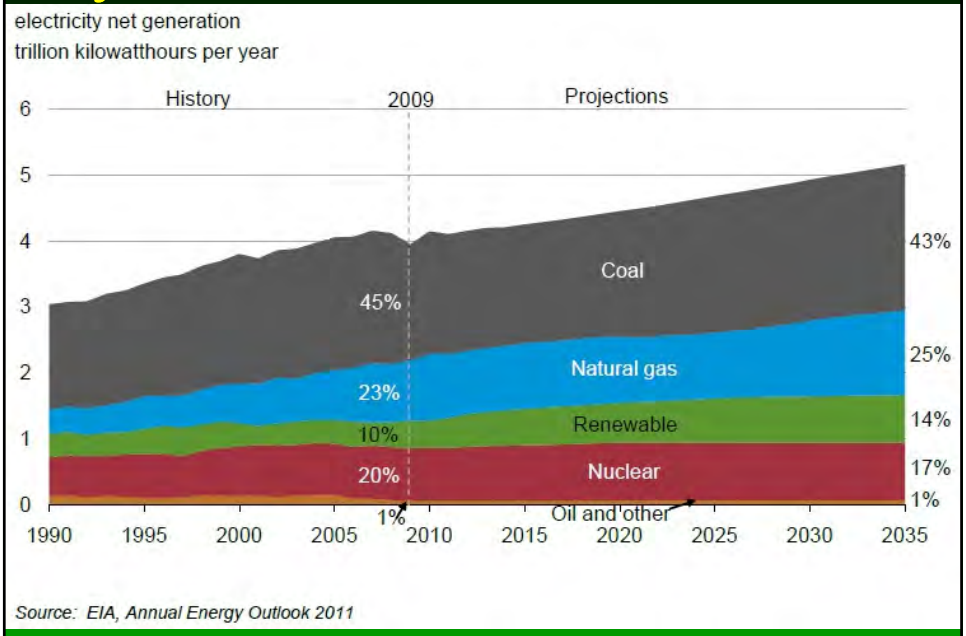



24+Plus


U.S. Energy Production - 2011
Renewables
12%
Coal
46%
Nuclear
21%
20%
Oil
1%
Natural Gas
Source: USEIA - 2012

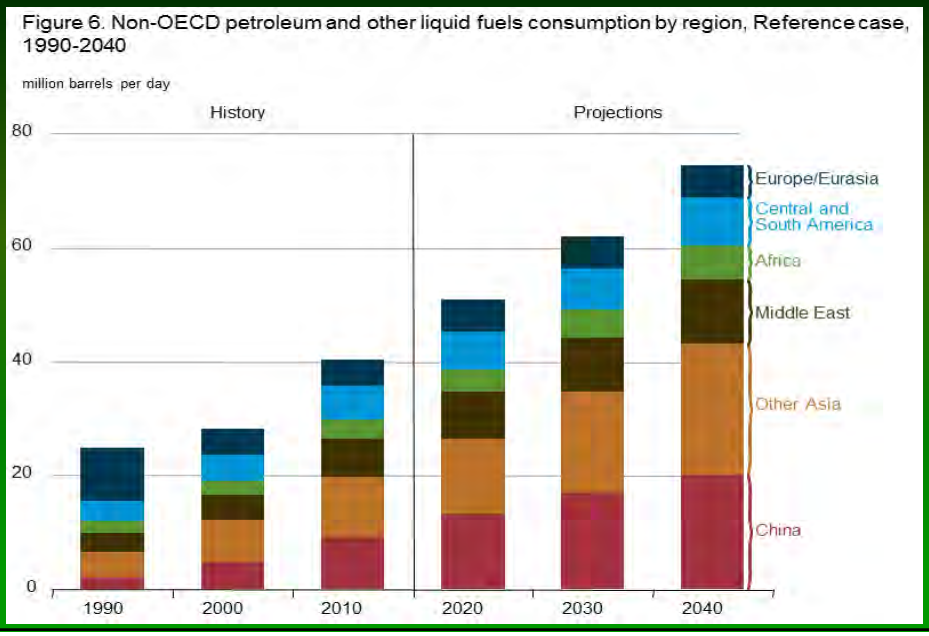

U.S. Energy Production
2/3=
Fossil
Fuels
12%
67%
21%
Source: USEIA - 2012

Projections on the Future?



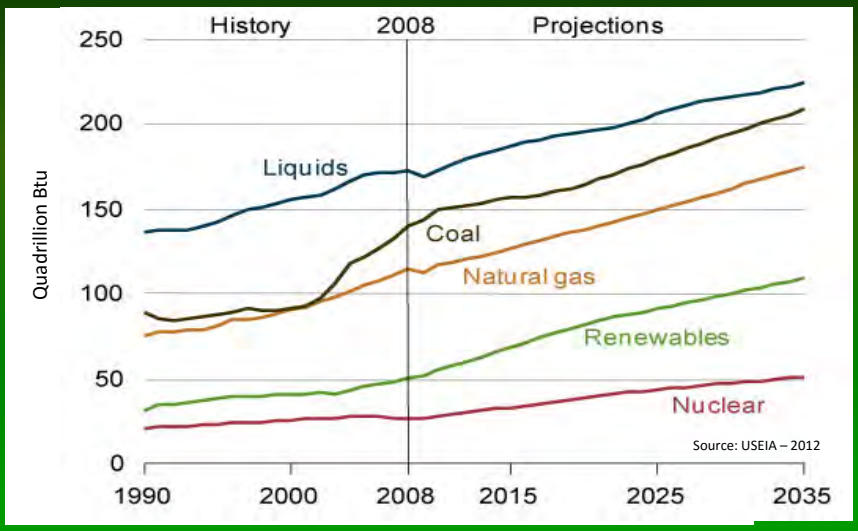
Source: EIA, Annual Energy Outlook 2011

World Liquid Fuel Demand Projections



World Energy Consumption by Fuel

1990 – 2035

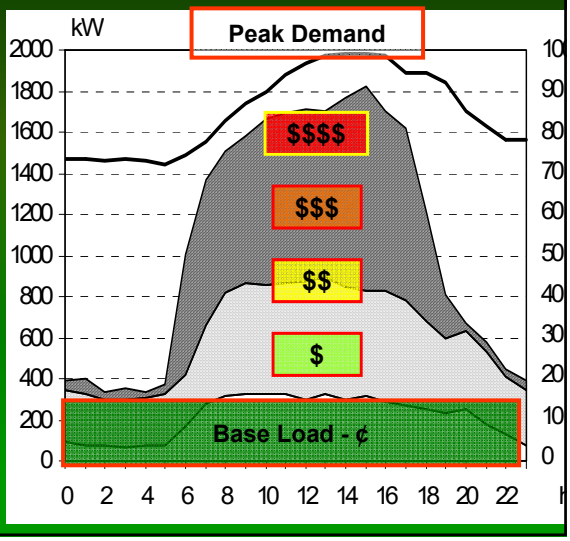


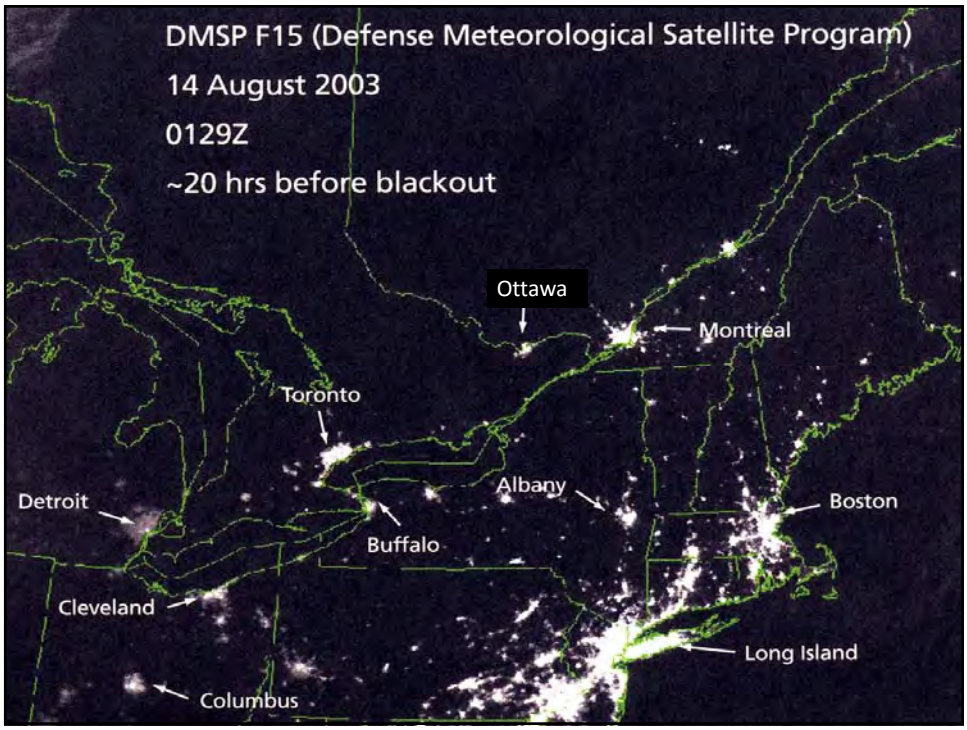
The Energy Megatrend

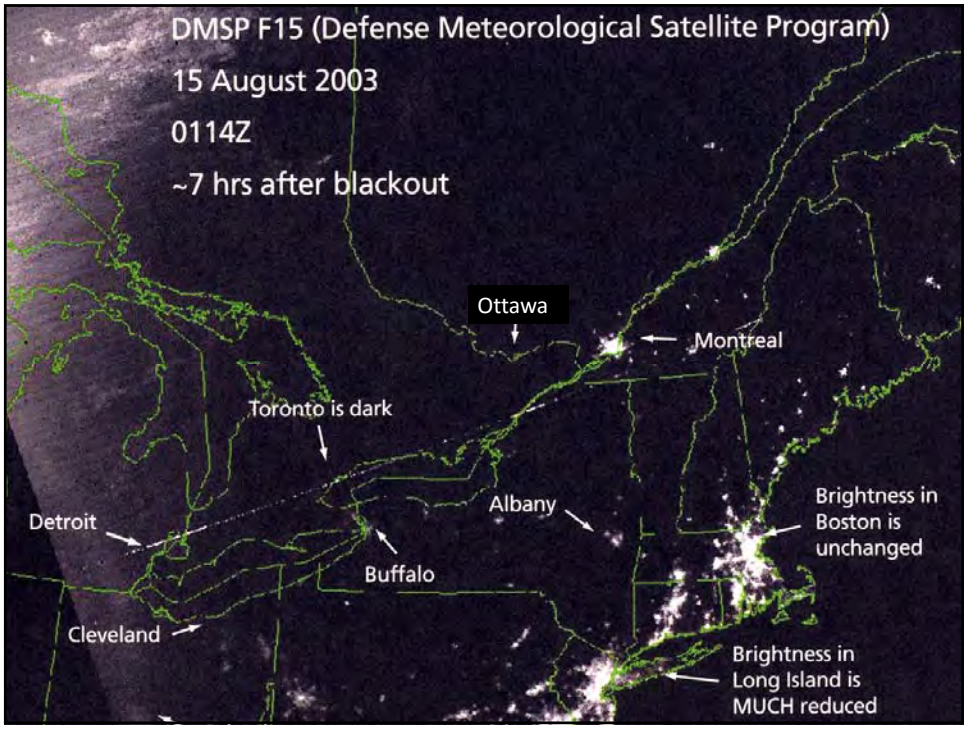
- Increasing demand
- Supply challenges
- Peak power
- Energy security
- Economic security

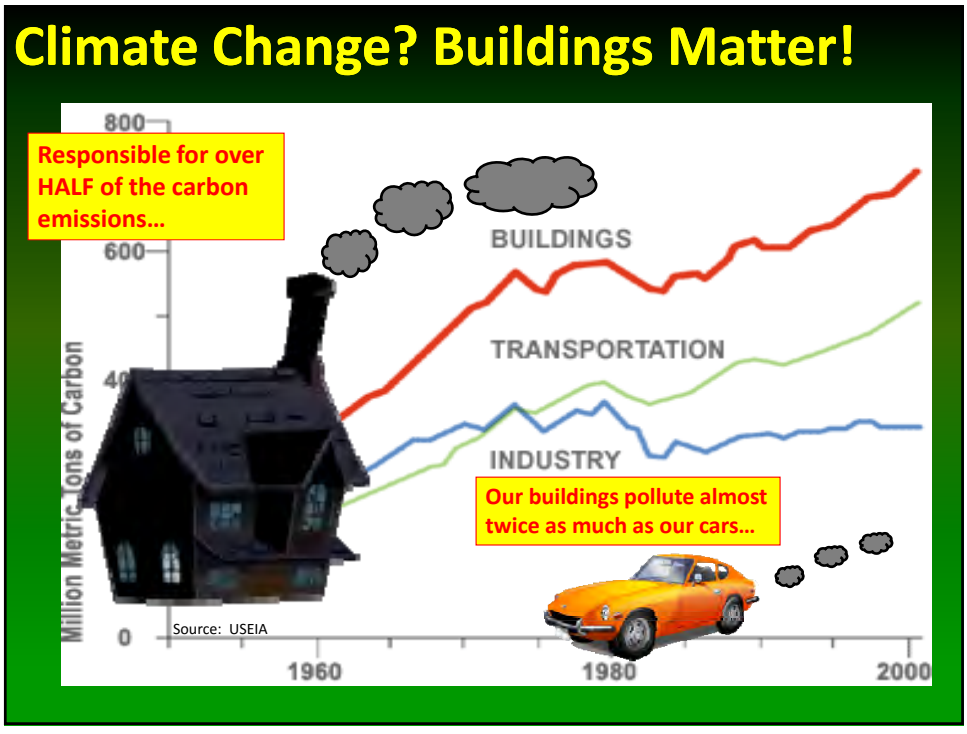
Utility Concerns

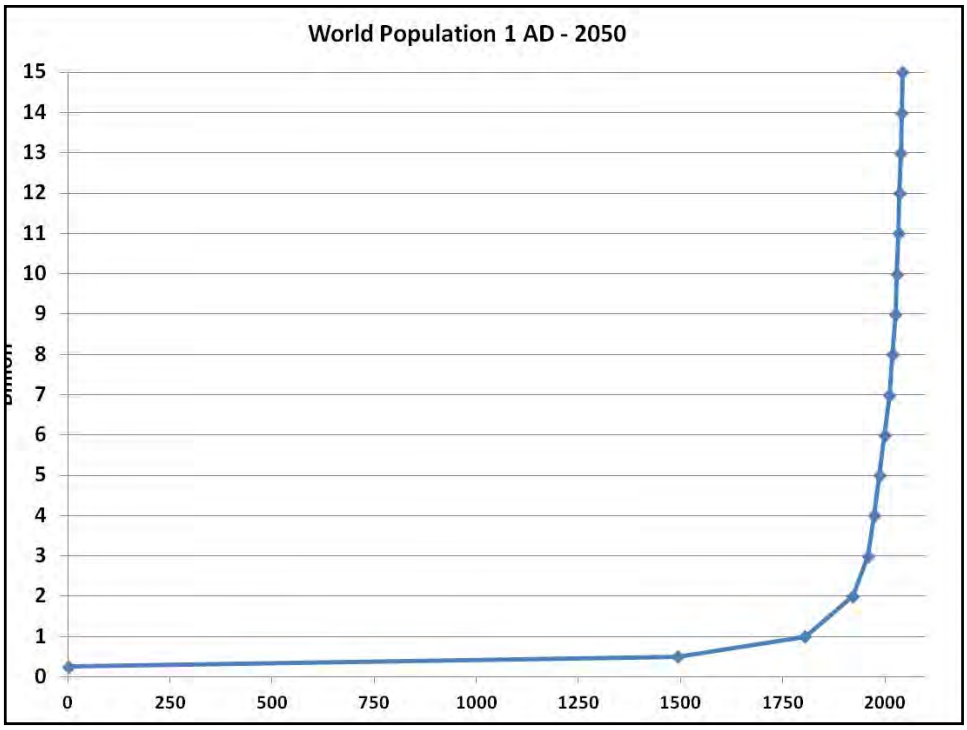
- The "Timing" of our Demand
  - Cooling Driven
  - Lighting Driven

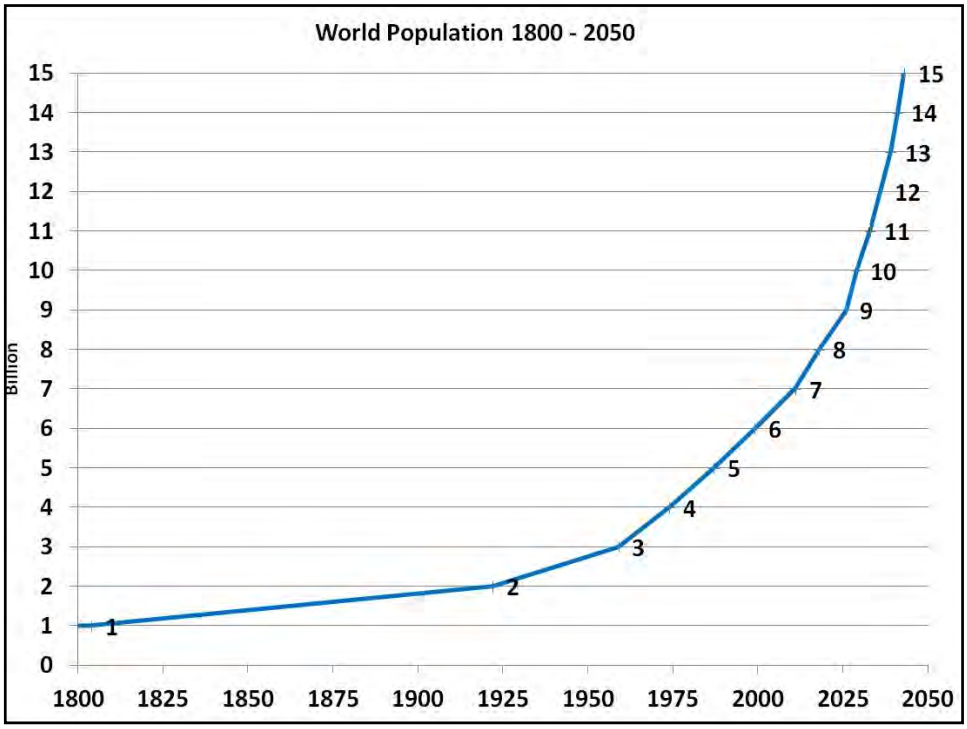


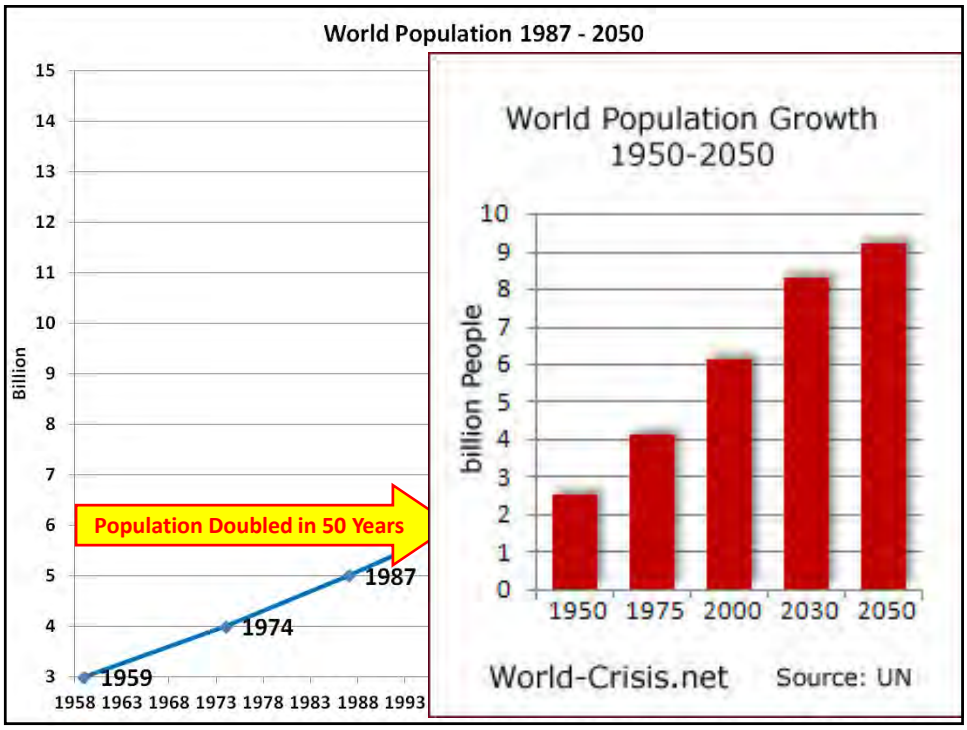



DMSP F15 (Defense Meteorological Satellite Program)
15 August 2003
0114Z
~7 hrs after blackout
Ottawa
Montreal
Toronto is dark
Albany
Detroit
Buffalo
Cleveland
Brightness in Boston is unchanged
Brightness in Long Island is MUCH reduced

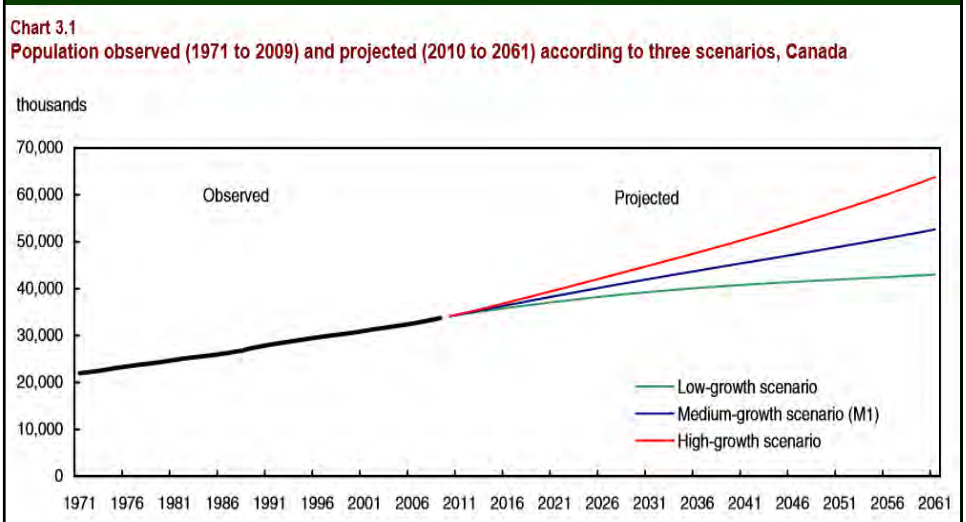

Climate Change? Buildings Matter!
Responsible for over HALF of the carbon emissions…
800
600
400
0
Million Metric Tons of Carbon
BUILDINGS
TRANSPORTATION
INDUSTRY
Our buildings pollute almost twice as much as our cars…
Source: USEIA
1960
1980
2000


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

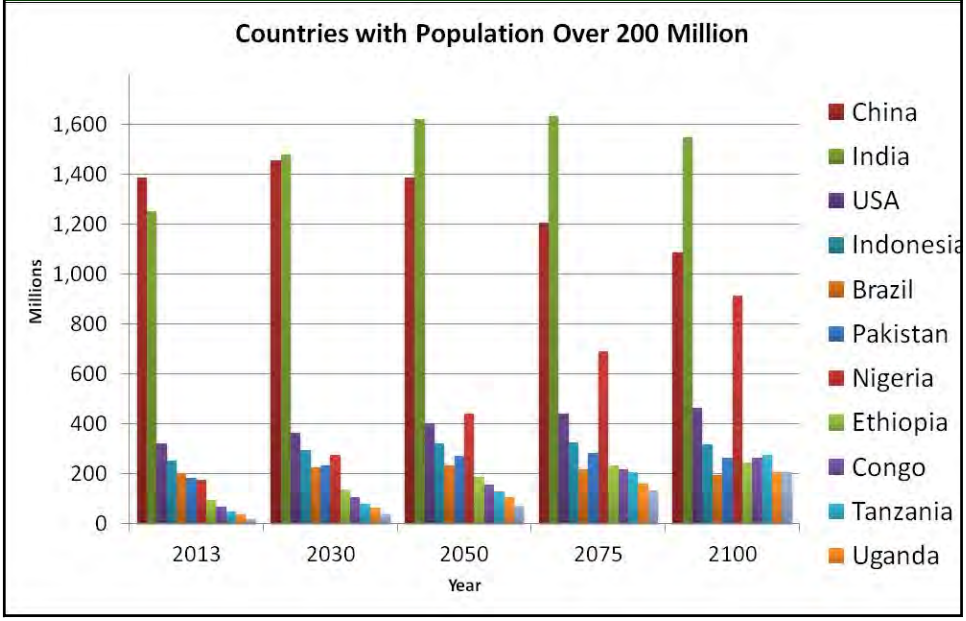

World Population 1800 - 2050
Billion
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1800
1825
1850
1875
1900
1925
1950
1975
2000
2025
2050

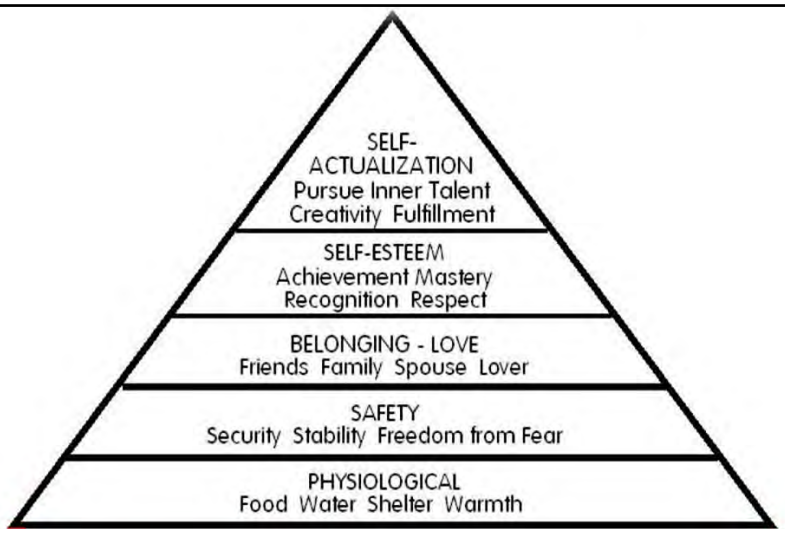

World Population 1987 - 2050
Billion
Population Doubled in 50 Years
1959
1974
1987
1958 1963 1968 1973 1978 1983 1988 1993
World Population Growth
1950-2050
billion People
1950 1975 2000 2030 2050
World-Crisis.net
Source: UN

Canada's Population Growth Expectations



World Population Trends…



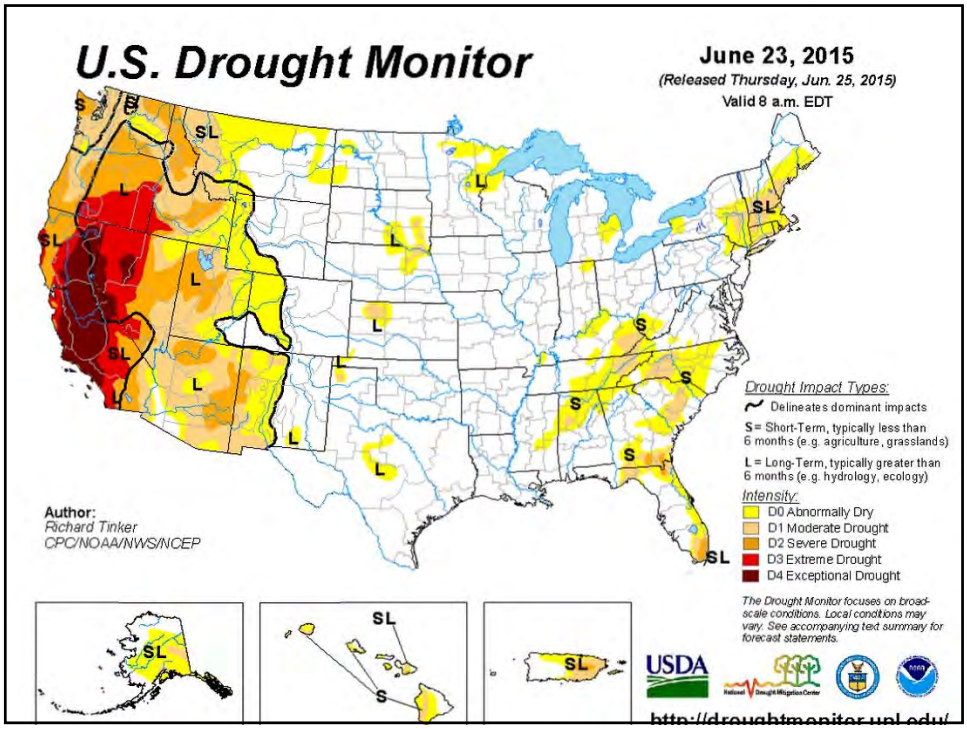


Maslow's "Hierarchy of Need"

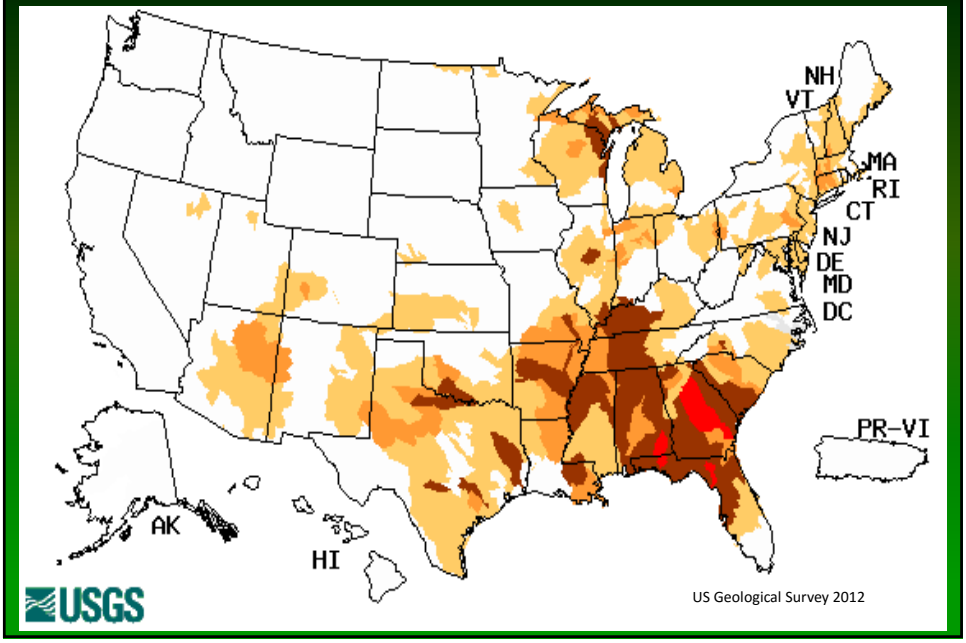
Energy and Water

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

US News, 11/22/2012



Water Implications…



Power and Water

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

Over half of the withdrawn water in the US…

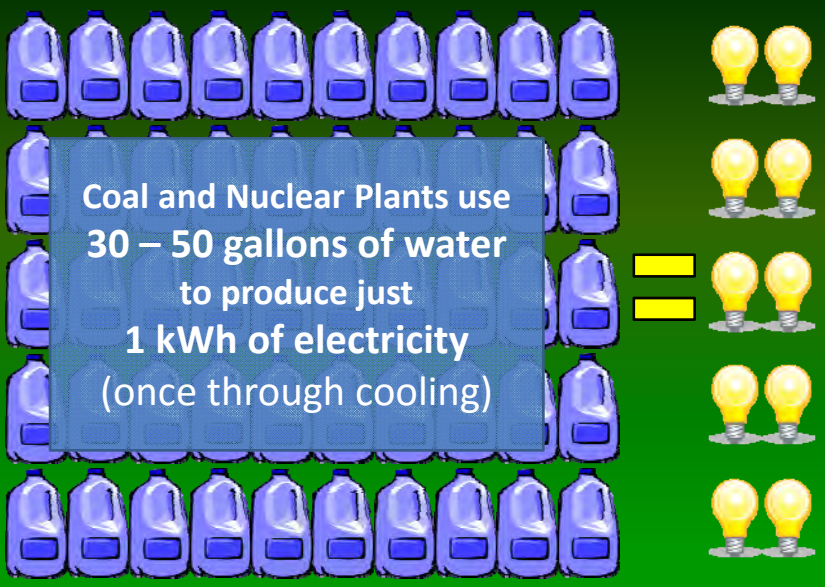
Sources: Union of Concerned Scientists 2011, USGS 2012

Niagara Falls

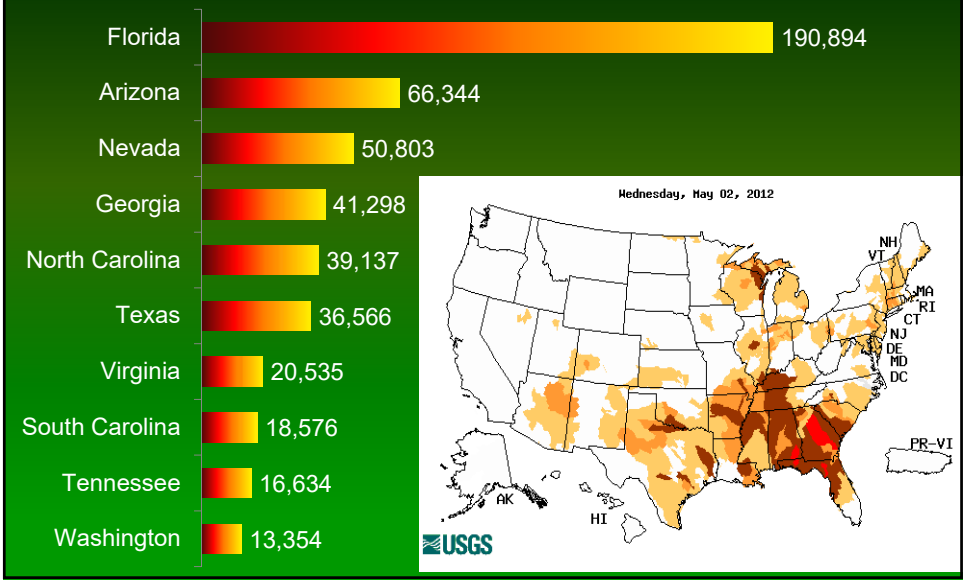
The volume of water flowing through America's electric utilities is 3 TIMES the amount flowing over Niagara Falls!

Niagara Falls State Park and USGS

Water and Power Connection…

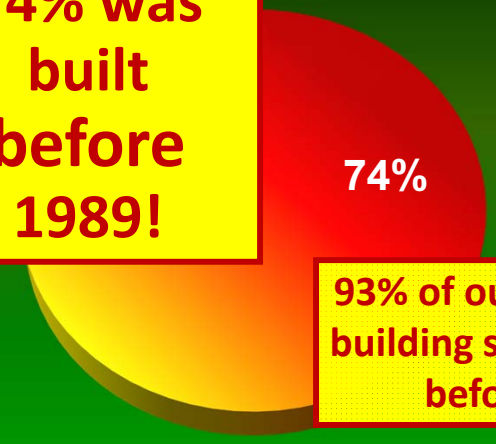


Annual Net Migration 2000 - 2004



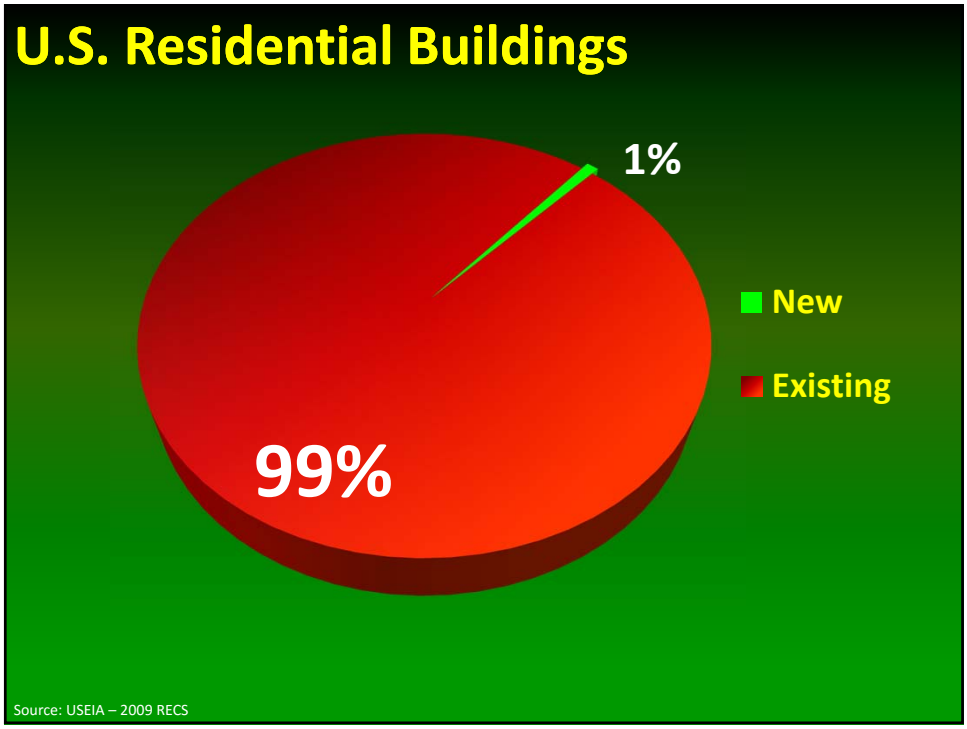
US Commercial Buildings

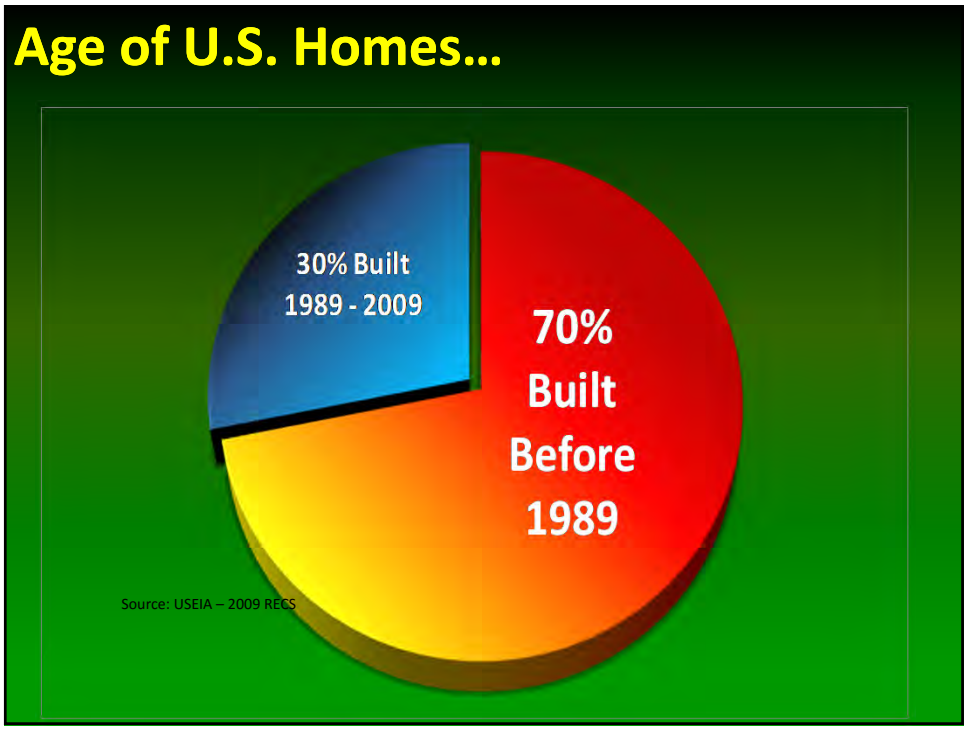
74% was built before 1989!

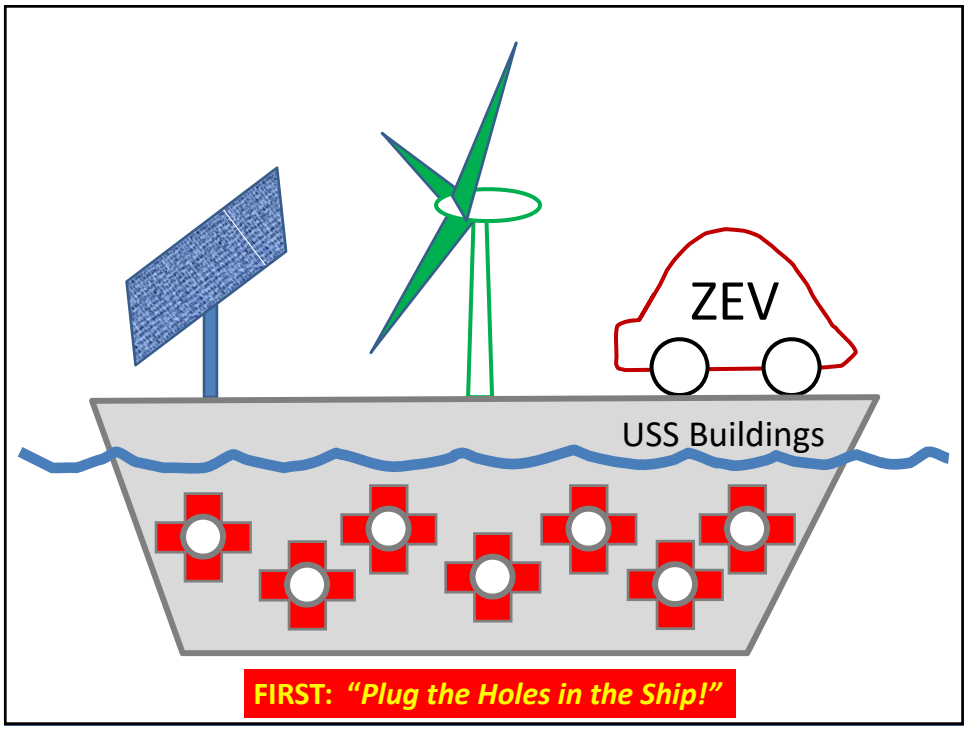


93% of our commercial building stock was built before 2003!

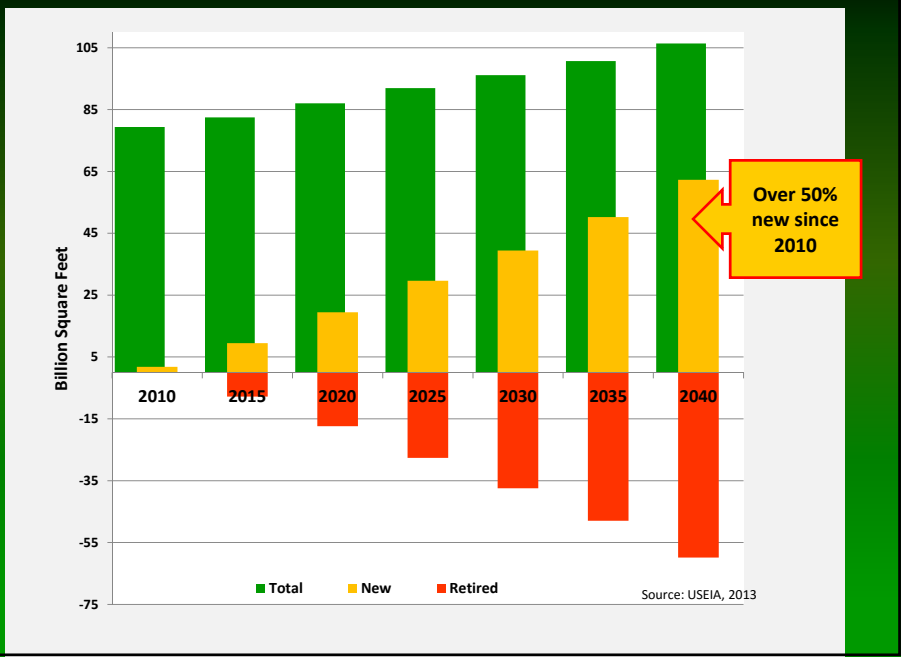
Source: USEIA , 2003 CBECS


U.S. Residential Buildings
1%
99%
New
Existing
Source: USEIA – 2009 RECS


Age of U.S. Homes…
30% Built
1989 - 2009
70%
Built
Before
1989
Source: USEIA – 2009 RECS


ZEV
USS Buildings
FIRST: "Plug the Holes in the Ship!"

U.S. Commercial Construction



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 0.16°F (0.09°C)."

Scientists also calculated the rate of temperature increase for July at an average of 1.17°F (0.65°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.

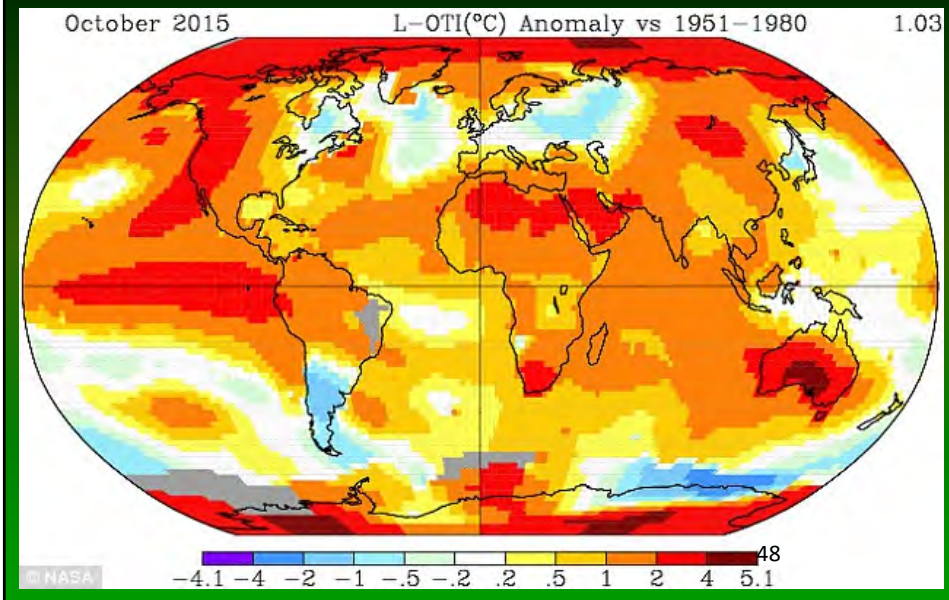
Parts of eastern Scandinavia and western Russia, eastern and southern Asia and scattered areas in central and northern North America were cooler than average. – AFP

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

AP

Associated Press

Get the app

By SETH BORENSTEIN, AP Science Writer

1 day ago

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TWEET

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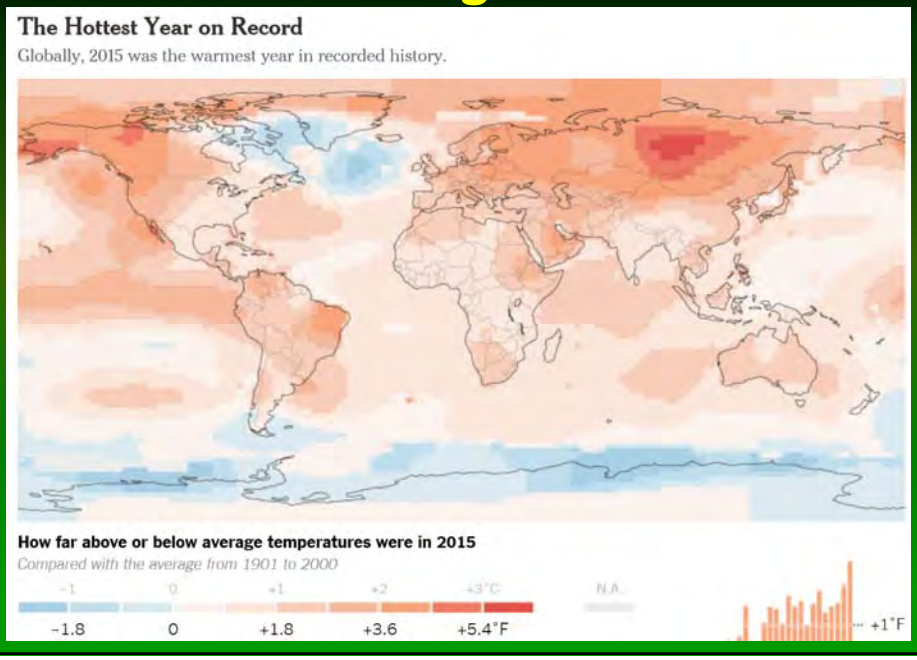
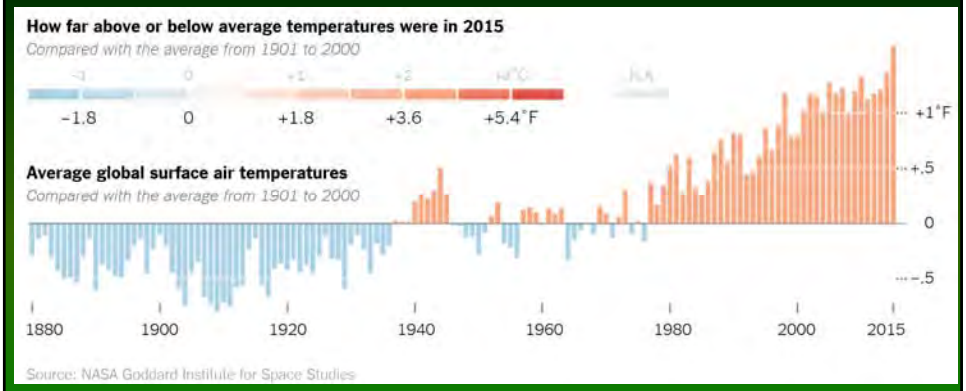
EMAIL

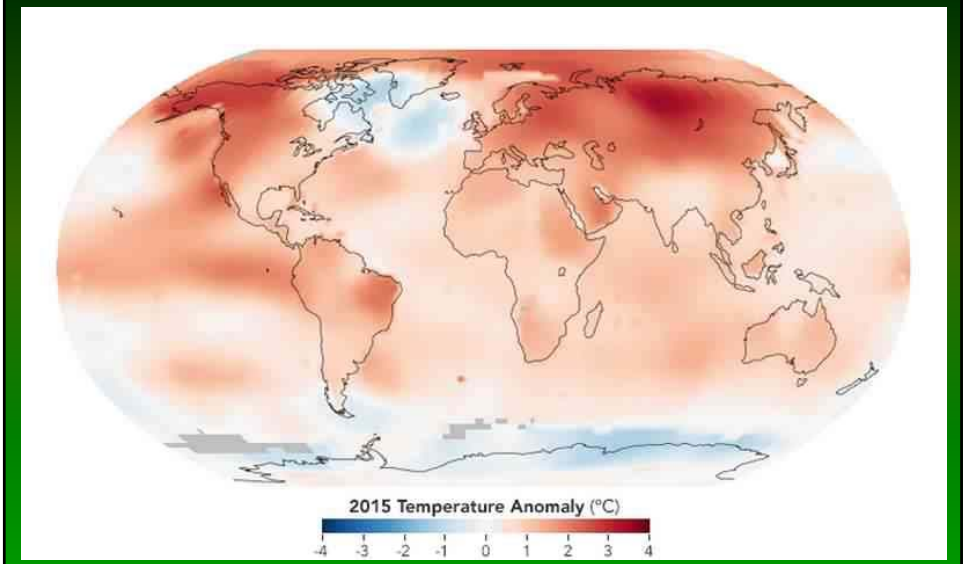
The World is Getting Warmer…

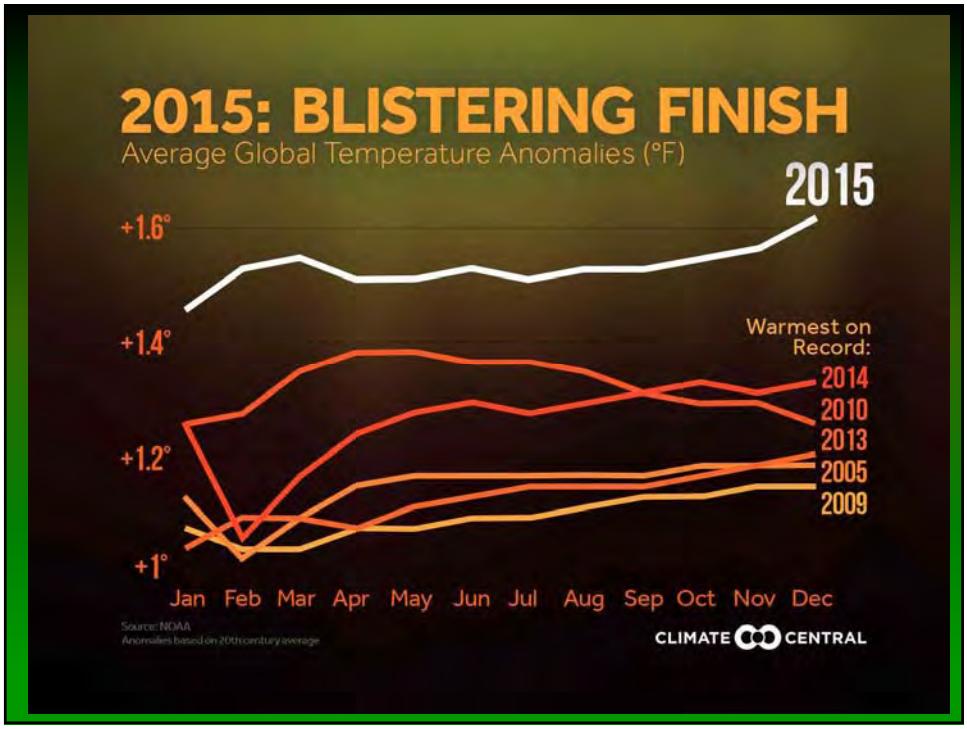


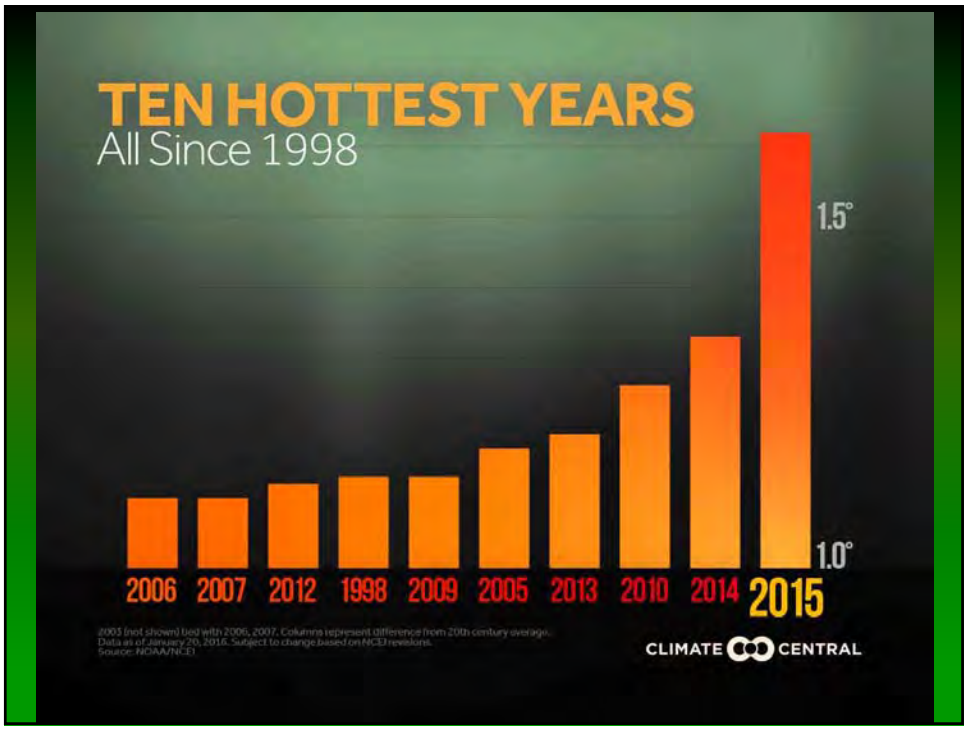
2015: Warmest Year in Modern Record Keeping



How Far From "Normal"?




2015: BLISTERING FINISH
Average Global Temperature Anomalies (°F)
2015
+1.6°
+1.4°
+1.2°
+1°
Warmest on Record:
2014
2010
2013
2005
2009
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Source: NOAA
Anomalies based on 20th century average
CLIMATE CENTRAL


TEN HOTTEST YEARS
All Since 1998
1.5°
1.0°
2006 2007 2012 1998 2009 2005 2013 2010 2014 2015
2003 (not shown) tied with 2006, 2007. Columns represent difference from 20th century average.
Data as of January 20, 2016. Subject to change based on NCEI revisions.
Source: NOAA/NCEI
CLIMATE CENTRAL

Last Week…

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

Published: March 8th, 2016

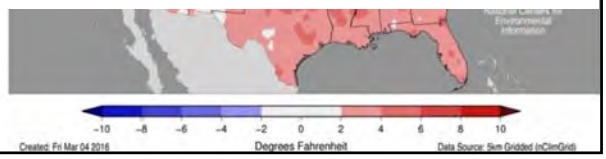
By Andrea Thompson

Follow @AndreaTWeather 2,584 followers

On the heels of a record warm autumn for the contiguous U.S., winter has also topped the temperature charts.

The news, announced Tuesday by the National Oceanic and Atmospheric Administration (NOAA), may come as a surprise for those who experienced summer-like heat waves in Southern California or the often spring-like weath the Northeast. It comes amid speculation that February may have also set a global heat record.

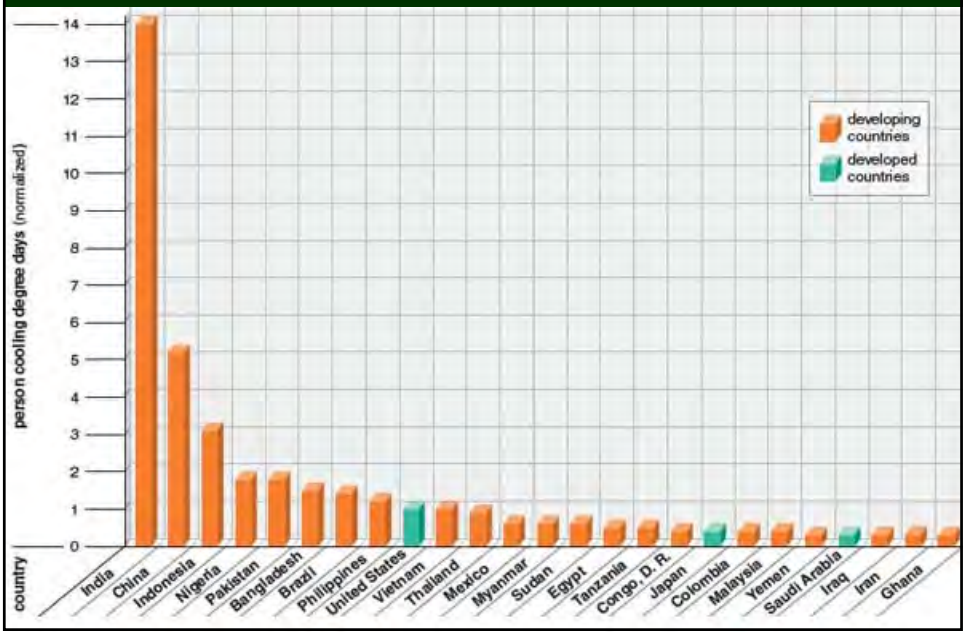
Mean Temperature Departures from Average
December 2015 – February 2016



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

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

Air Conditioning for Everyone?

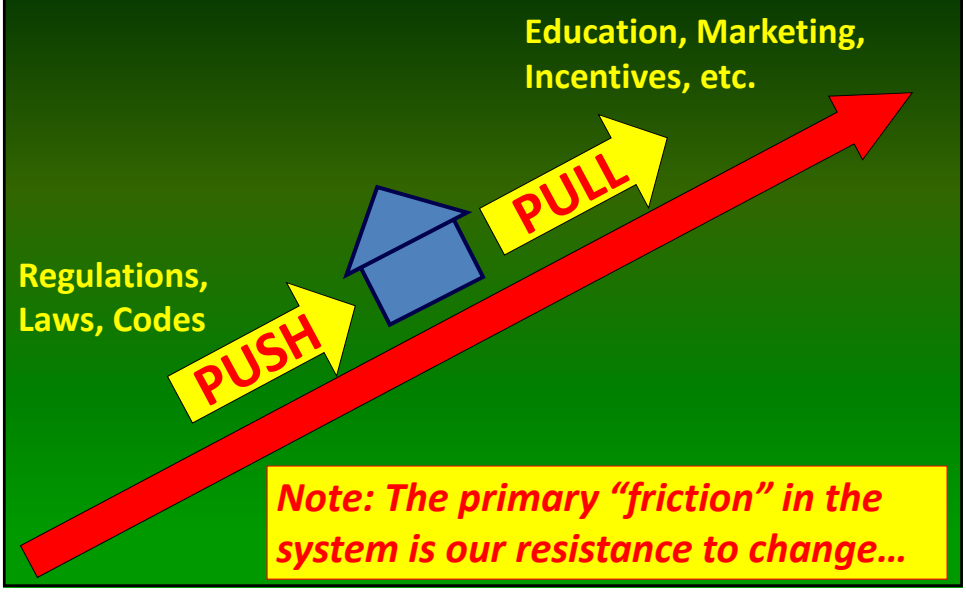


Built Environment Trends - 3

- **Increased expectations for building performance**
  - Energy
  - Health and IEQ
  - Safety
  - Durability
  - Resilience – especially against changing climate
  - Sustainable

  - For how long?

Market Transformation…



But we've got the building codes to handle that… 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

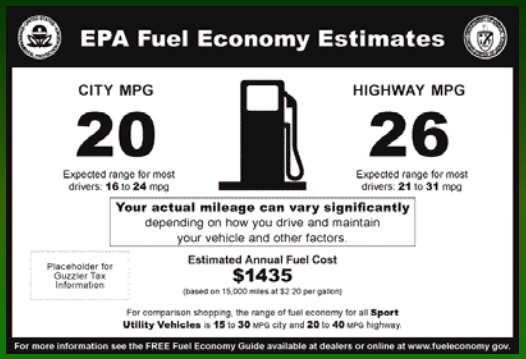
First Energy Code Milestone

- **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

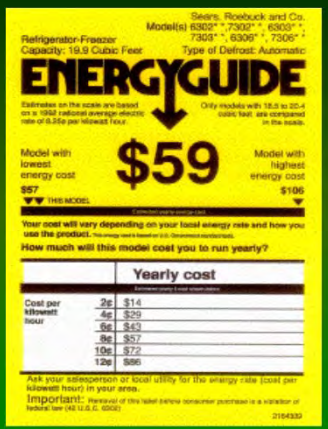
What Did We Do After 1973?

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

Why Standards?



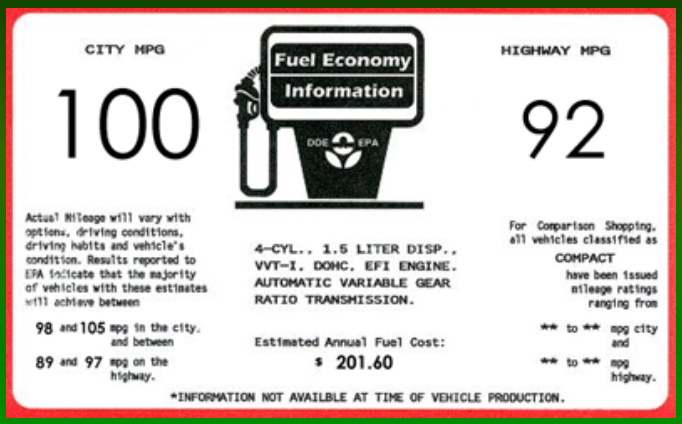
Automotive



Appliances

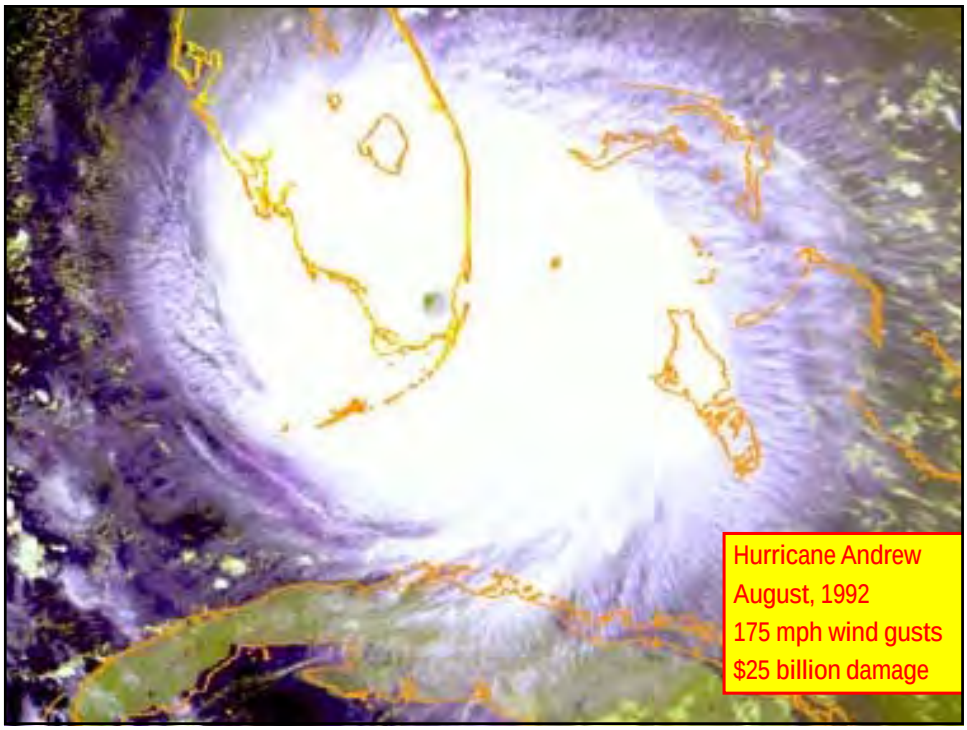
Consumer Signals About Energy!
A Means of Comparison…

What's Possible?



Energy Code Evolution…

Early Energy Code Solutions



Recent Code Milestones

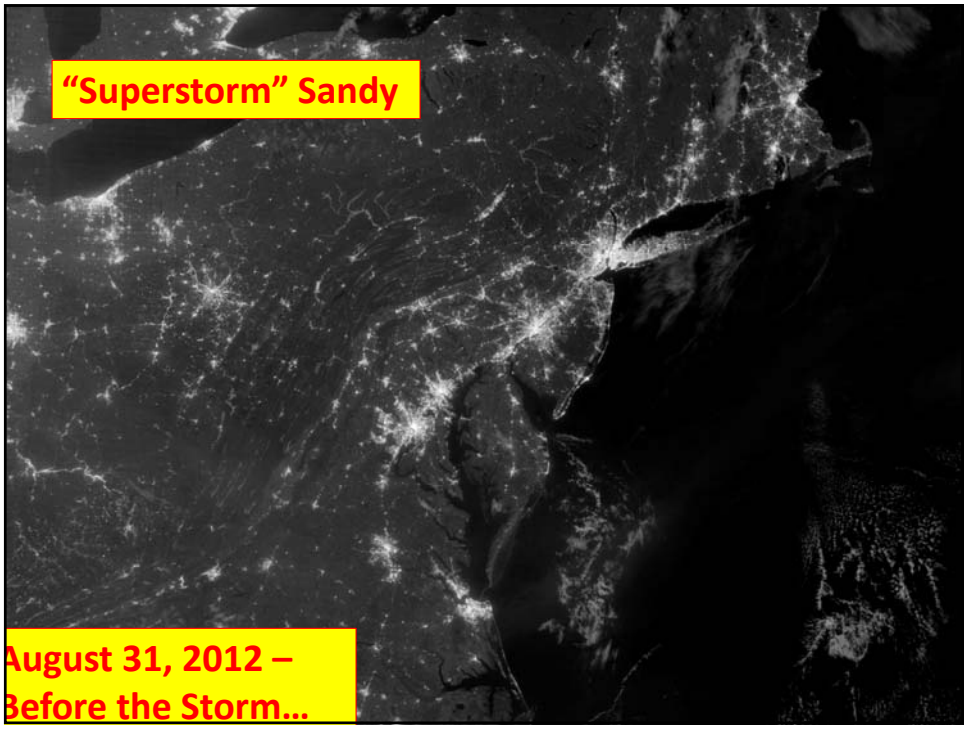
- **Hurricane Andrew – 1992 AD**
  - 90% of all homes in Dade County Florida had roof damage
  - 117,000 homes were destroyed or had major damage
  - Primary driver of today's hurricane protection codes

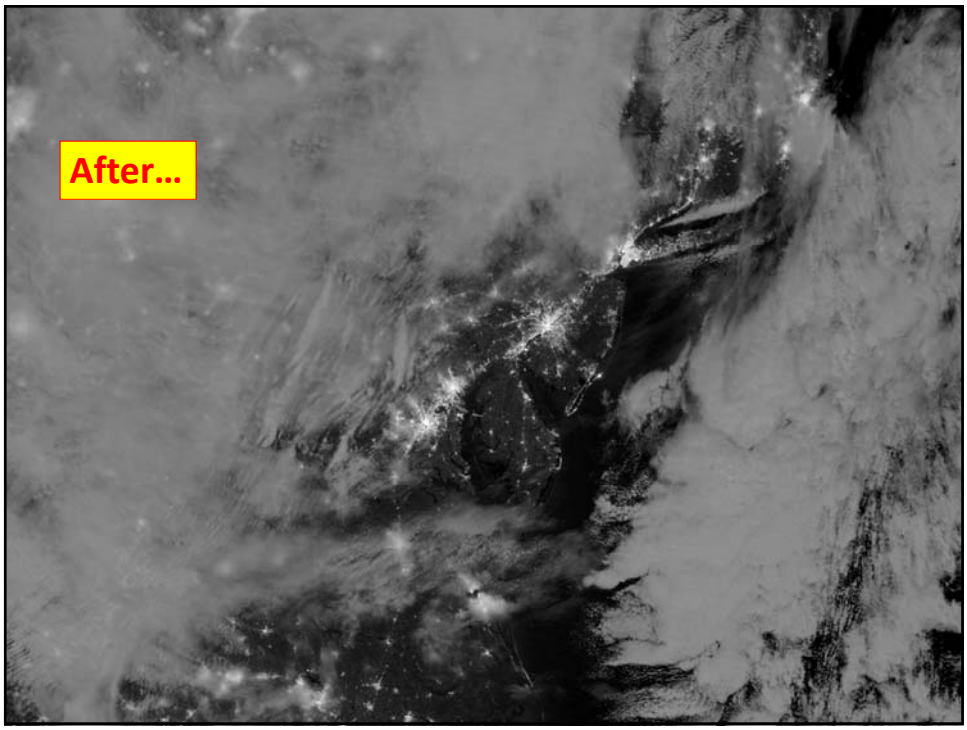
More Recently…

Katrina's Legacy…

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

Louisiana and Mississippi just adopted their first codes…


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


After…


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


After…
Route 35/Ocean Blvd
Mantoloking Bridge

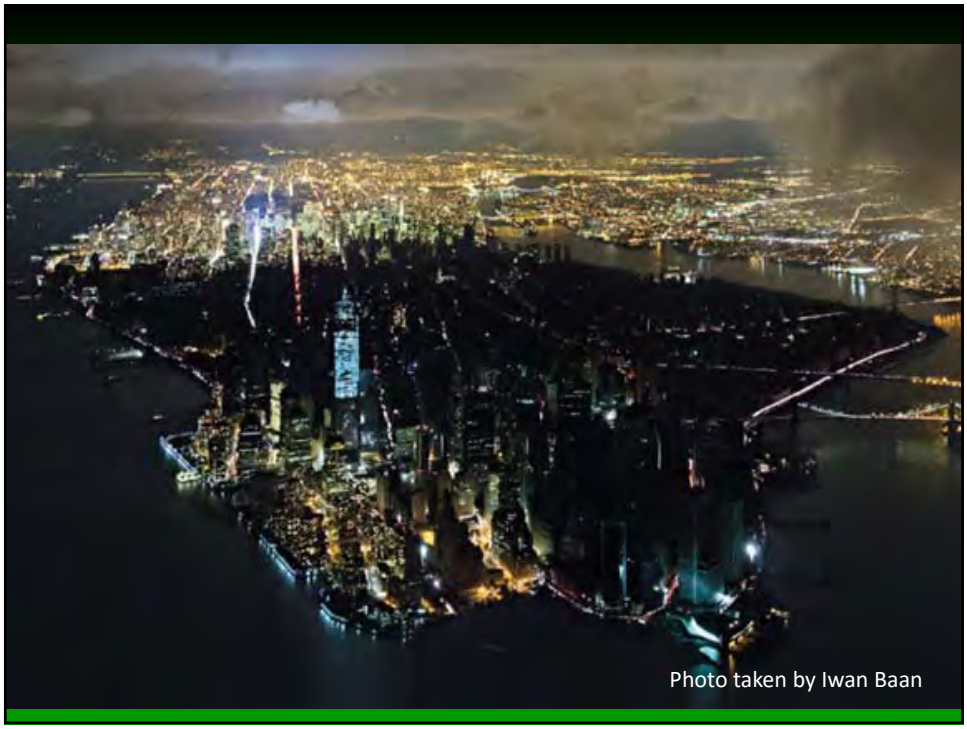
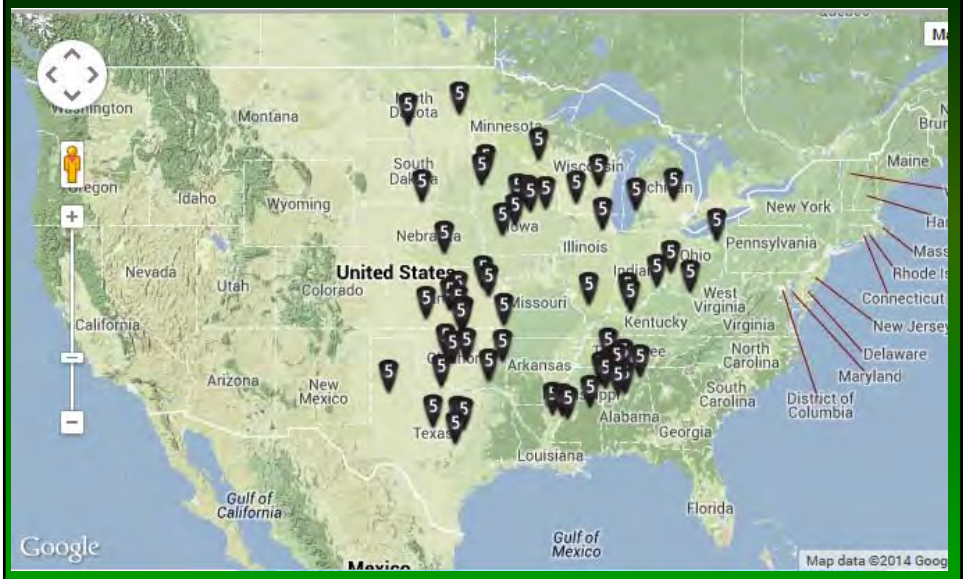


Photo taken by Iwan Baan

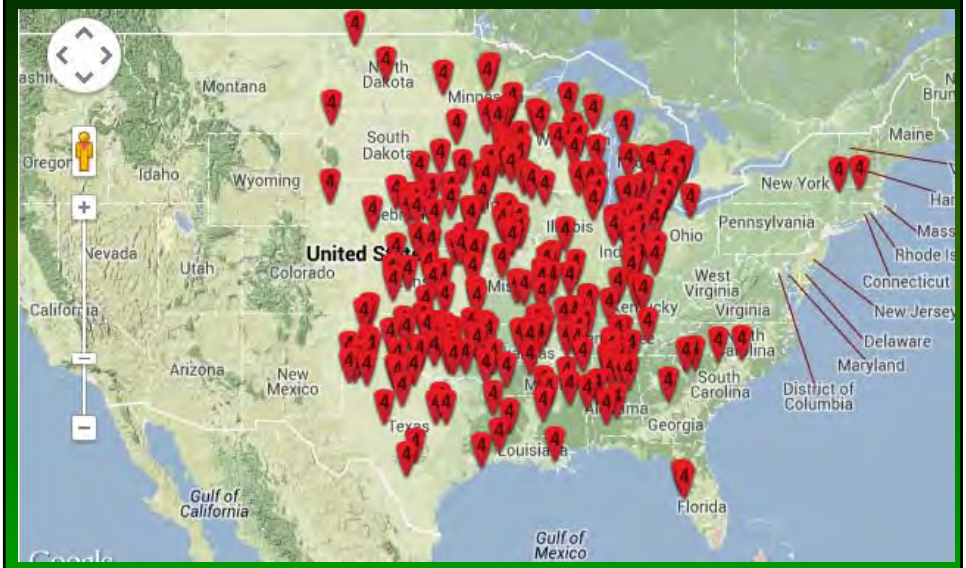

Hurricane Sandy
110 mph wind gusts (Category 1)
Estimated $20-$30 billion damage
>6 million people without power

Moore, Oklahoma…

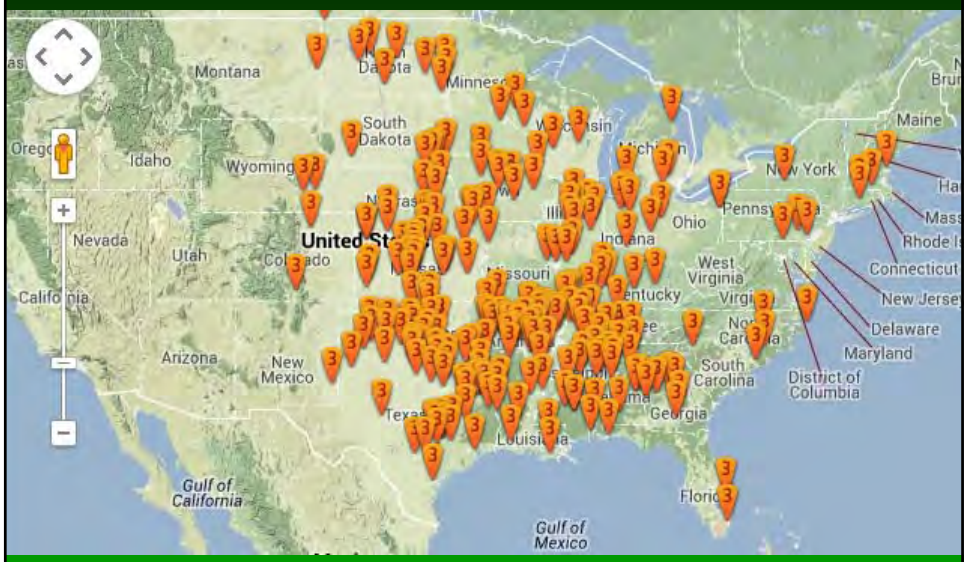
F5 Tornadoes Since 1950…



F4 Tornadoes Since 1950

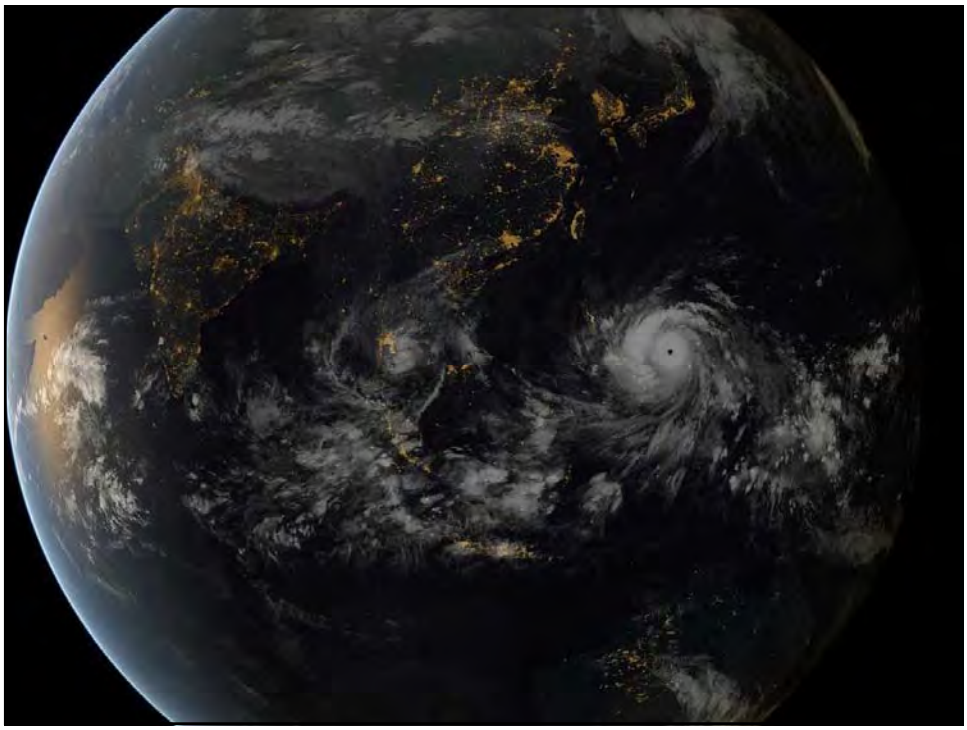


F3s…


Montana
South Dakota
Idaho
Wyoming
Nevada
Utah
Arizona
New Mexico
Ohio
West Virginia
Maine
New York
Connecticut
Delaware
Maryland
South Carolina
District of Columbia
Georgia
Gulf of California
Gulf of Mexico

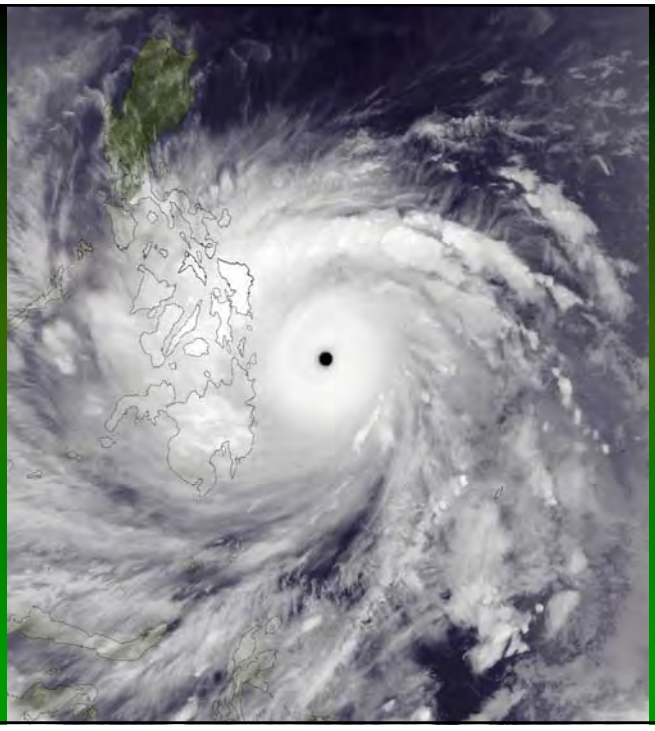
F2s…


Map
Washington
Montana
North Dakota
South Dakota
Oregon
Idaho
Wyoming
Nevada
Utah
Colorado
California
Arizona
New Mexico
Iowa
Ohio
West Virginia
New York
Maryland
South Carolina
District of Columbia
Florida
Gulf of California
Gulf of Mexico



"Super Typhoon" Haiyan

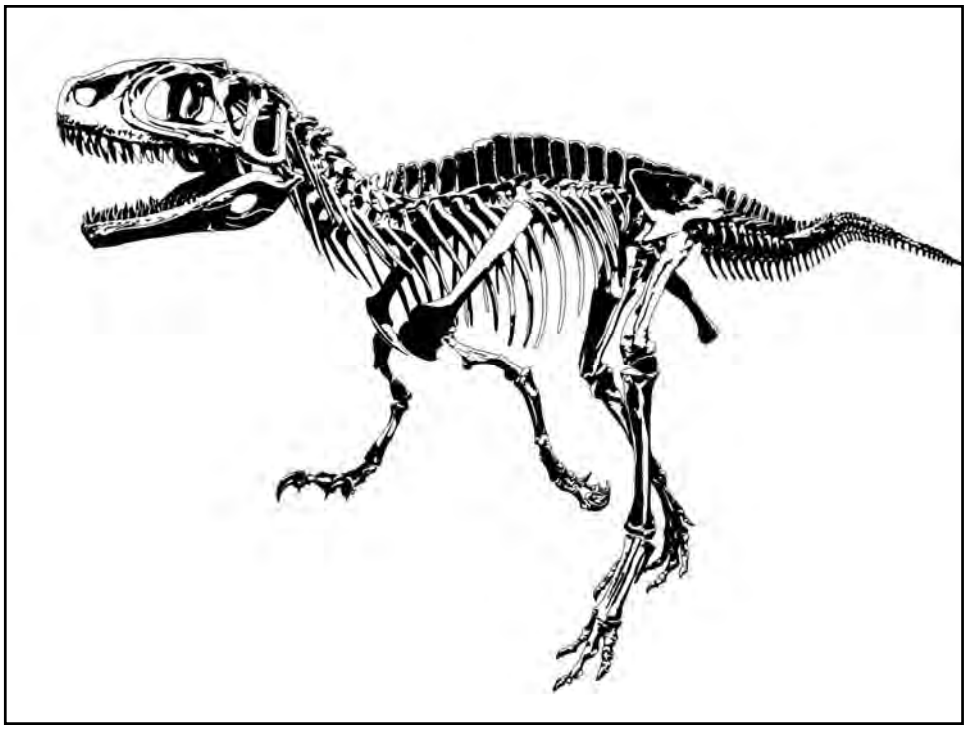
- **Possibly the strongest storm in recorded history**
  - Category 5 Event
  - Sustained winds of over 96 mph for several hours
  - Wind speeds in excess of 260 mph
- **Storm surge estimated to be responsible for over 10,000 deaths**
- **The same area experienced 7.1 magnitude earthquake less than a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



We Wait for Disaster

- History has shown that we WAIT for disaster, THEN we react.

There are consequences to waiting…



ASHRAE 90.1

Our Model Energy Code

Standard 90.1

- **The US "Model Energy Code"**
  - Referenced in the Energy Policy Act of 1992
  - The Standard against which all state codes are evaluated
- **Defines Minimum Energy Efficiency for buildings covered under the standard**
  - Commercial buildings
  - High-rise residential
  - Semi-conditioned
- **On "Continuous Maintenance"**
  - Updated every 3 years
  - Current edition - 2013

Good News/Bad News: 90.1-2013

- **Published October 2013**
- **Goal was to be 50% more efficient than 2004**
  - Won't get there most places
  - Some improvements in each climate zone
- **A few big changes…**
  - Many impact your architect friends
    - Envelopes, Air sealing, Lighting
  - Pay particular attention to building envelope changes

Structure of the Standard - 1

- **Section 1 - Purpose**
- **Section 2 - Scope**
- **Section 3 - Definitions**
- **Section 4 - Administration and Enforcement**
- **Section 5 - Building Envelope**
- **Section 6 - Heating, Ventilating, and Air Conditioning**

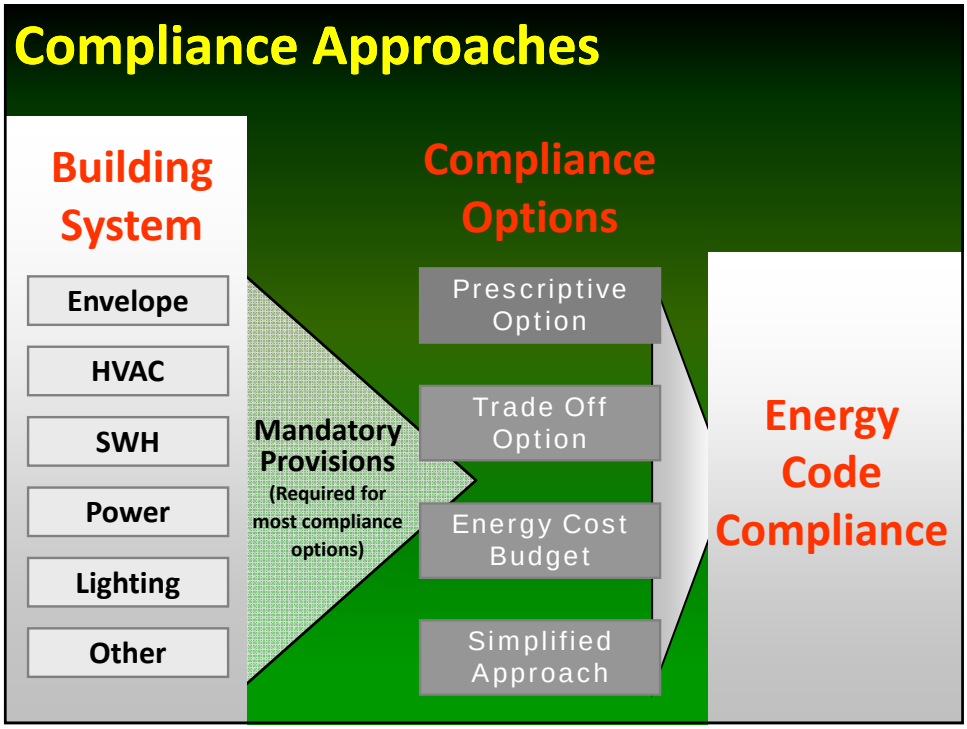
Structure - 2

- Section 7 - Service Water Heating
- Section 8 - Power
- Section 9 - Lighting
- Section 10 - Other Equipment
- Section 11 - Energy Cost Budget Method
- Section 12 - Normative References

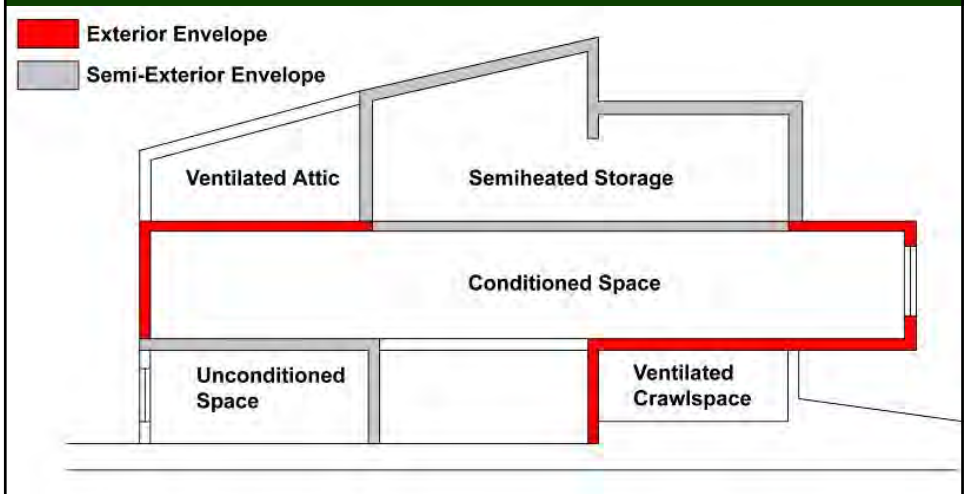
Appendices

- A – Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations
- B – Building Envelope Climate Criteria
- C – Methodology for Building Envelope Trade-Off Option in Subsection 5.6
- D – Climatic Data
- E – Informative References
- F – Addenda Description Information (Informative)
- G – Performance Rating Method (Informative)

Compliance Approaches



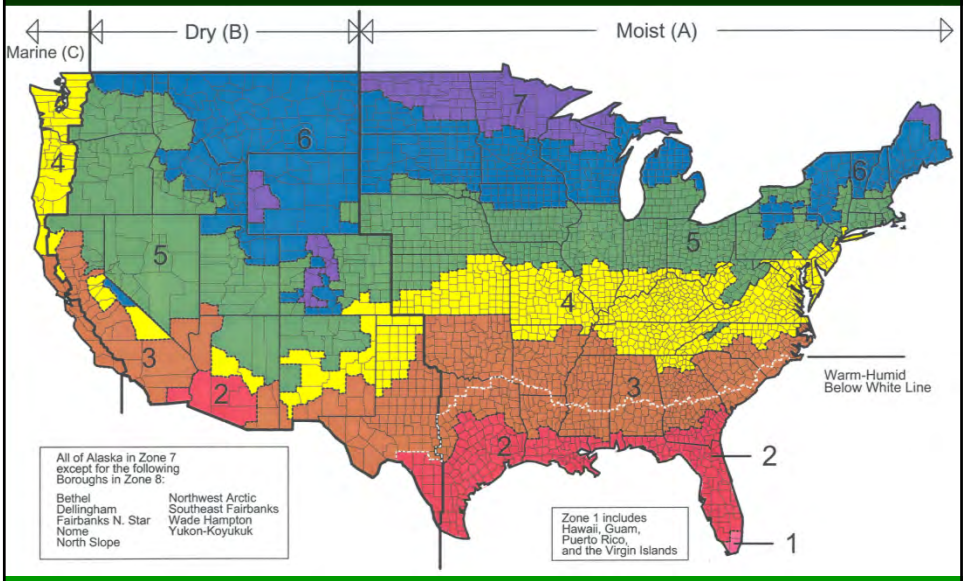
Building Envelope



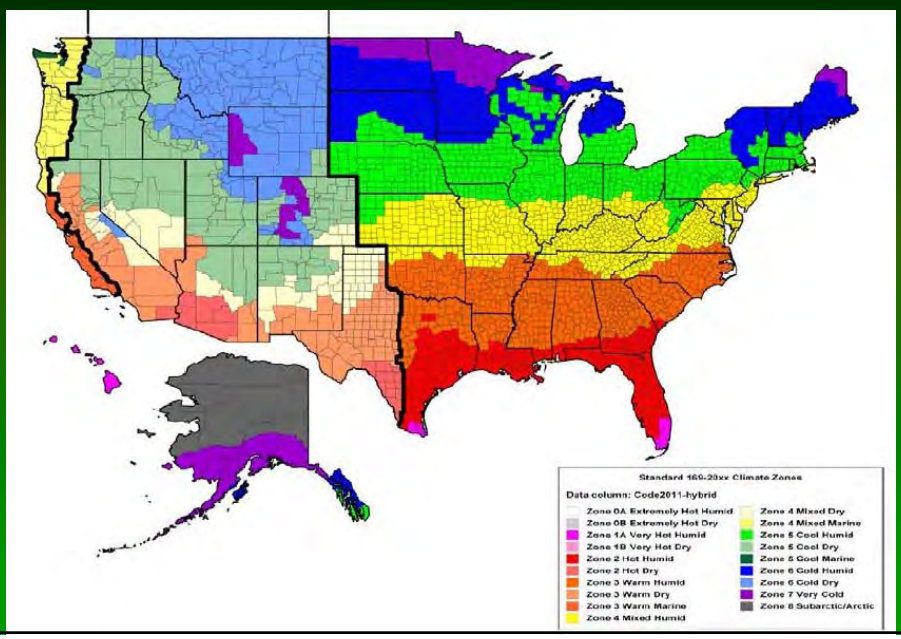
So… where is the
Current Minimum Code
(90.1-2013)
in comparison to
90.1-2004?

Improvements in EUI: 1975 to Present

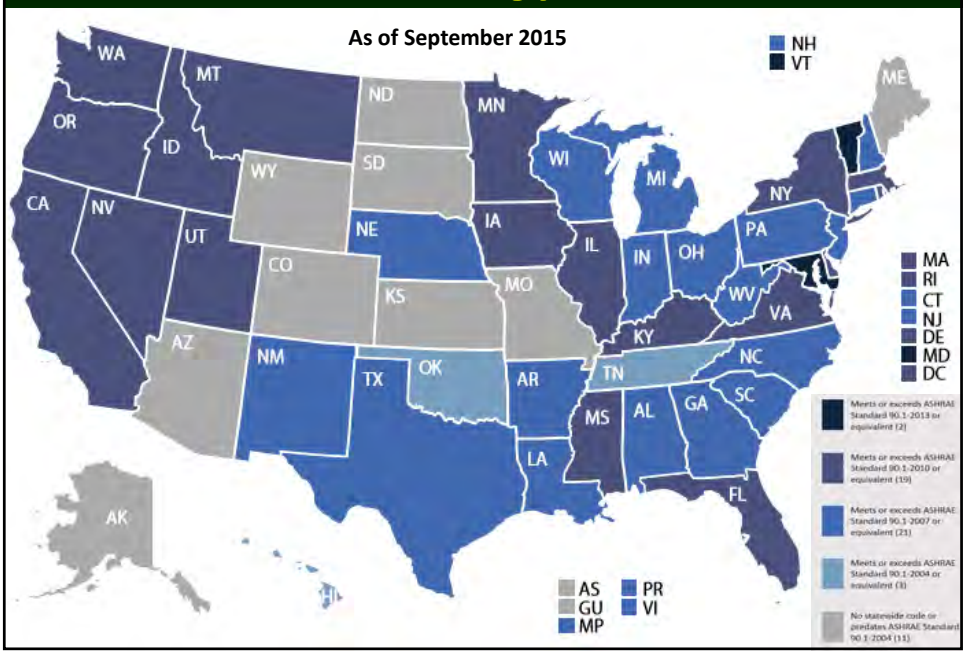
Climate Zones (Current)



Climates Changing? New Standard 169



US Commercial Energy Code Status



ASHRAE 169-2013

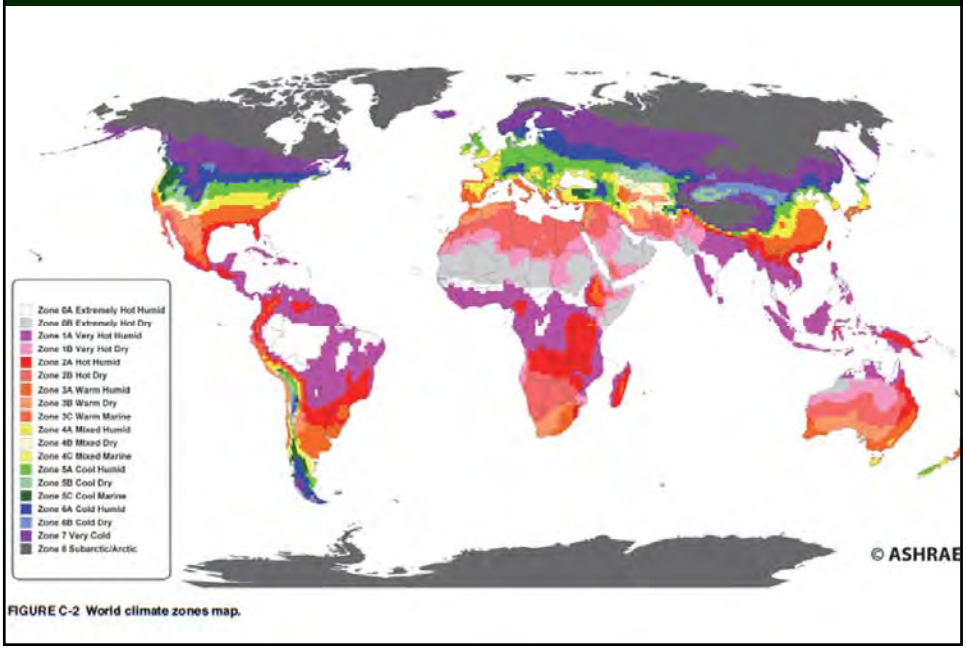
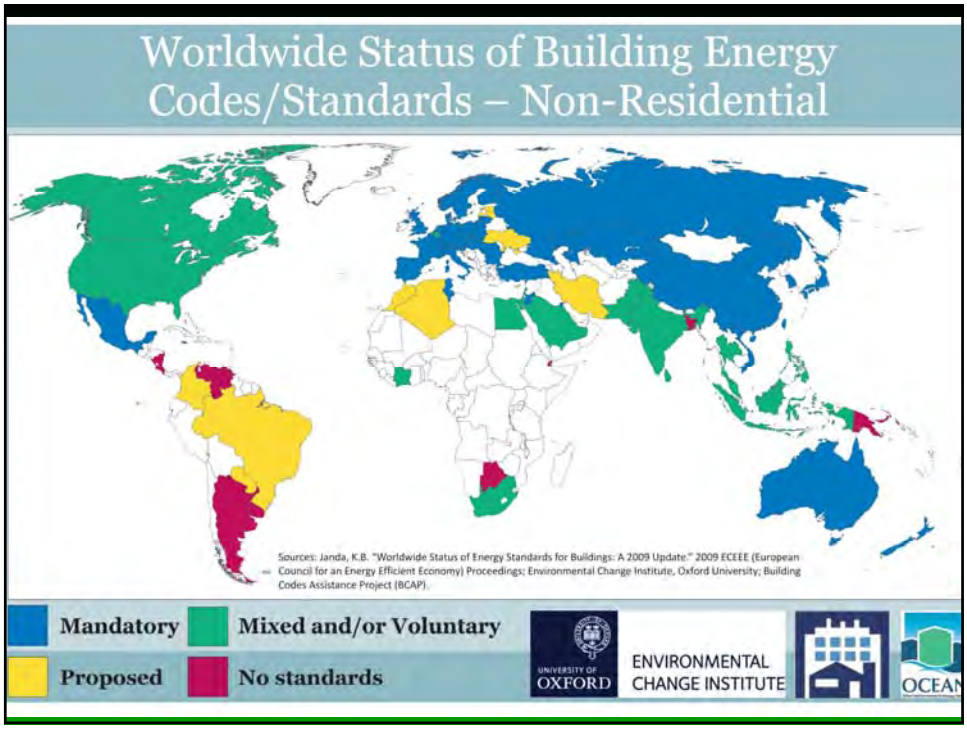
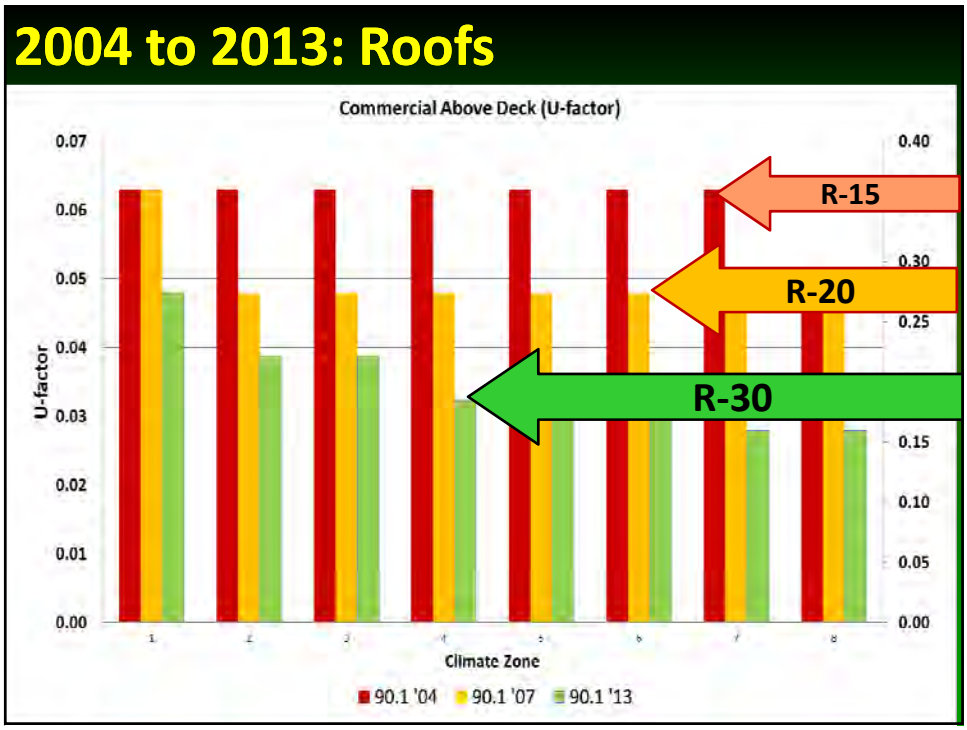
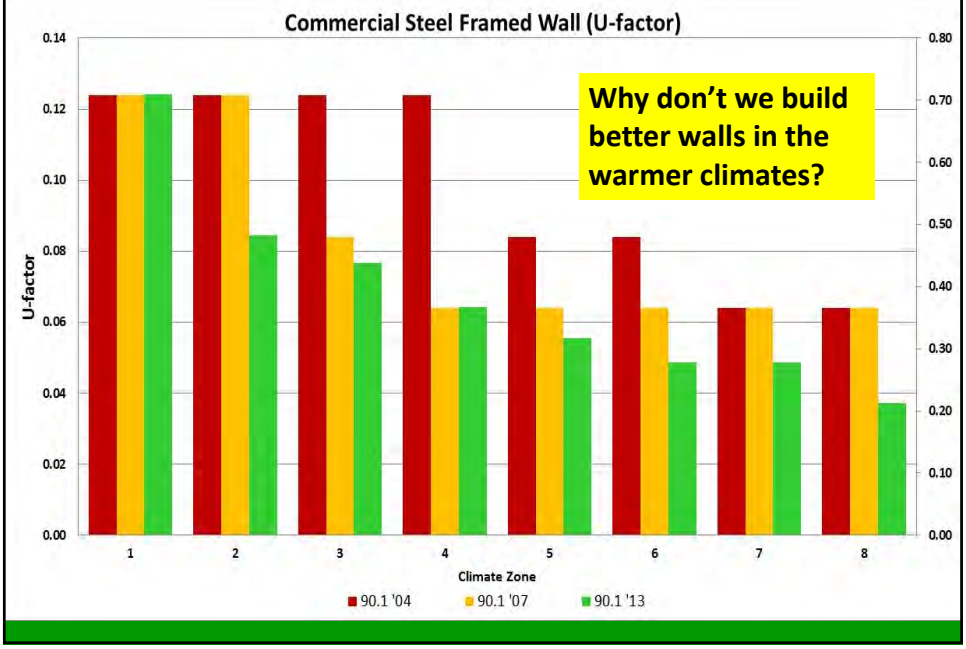


FIGURE C-2 World climate zones map.

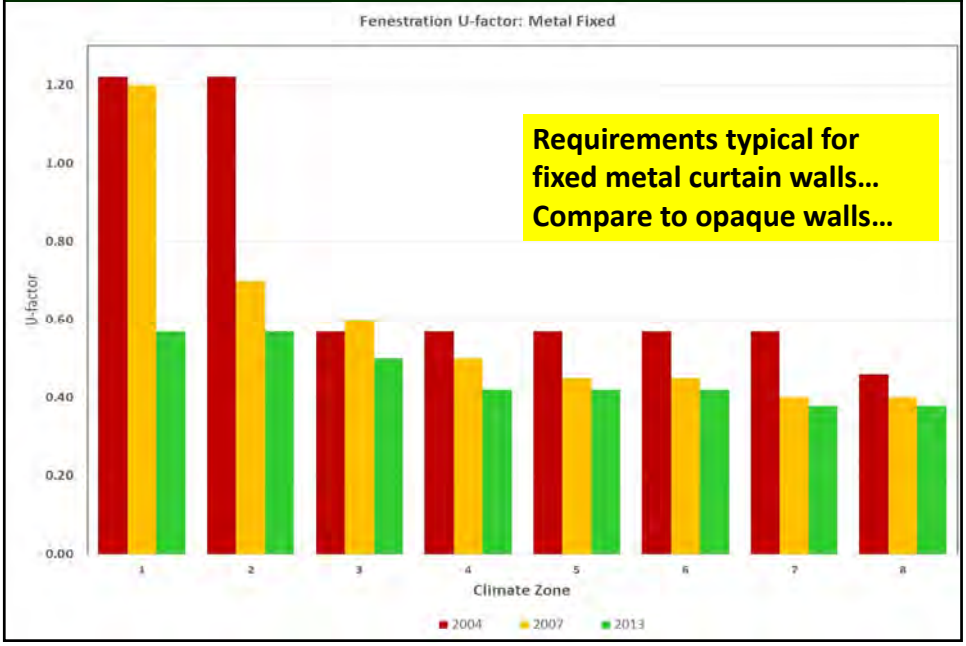

Worldwide Status of Building Energy Codes/Standards – Non-Residential
Sources: Janda, K.B. "Worldwide Status of Energy Standards for Buildings: A 2009 Update." 2009 ECEEE (European Council for an Energy Efficient Economy) Proceedings; Environmental Change Institute, Oxford University; Building Codes Assistance Project (BCAP).
Mandatory
Mixed and/or Voluntary
Proposed
No standards
UNIVERSITY OF OXFORD
ENVIRONMENTAL CHANGE INSTITUTE


2004 to 2013: Roofs
Commercial Above Deck (U-factor)
U-factor
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.40
0.30
0.25
0.15
0.10
0.05
0.00
R-15
R-20
R-30
Climate Zone
90.1 '04
90.1 '07
90.1 '13

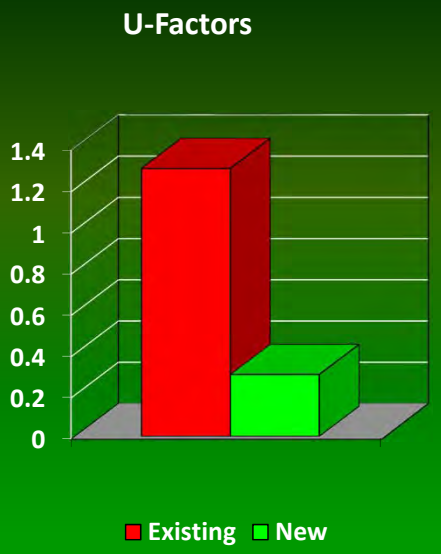
2004 versus 2013: Walls



Fenestration U-factor: 2004 - 2013



Heat Loss (winter)



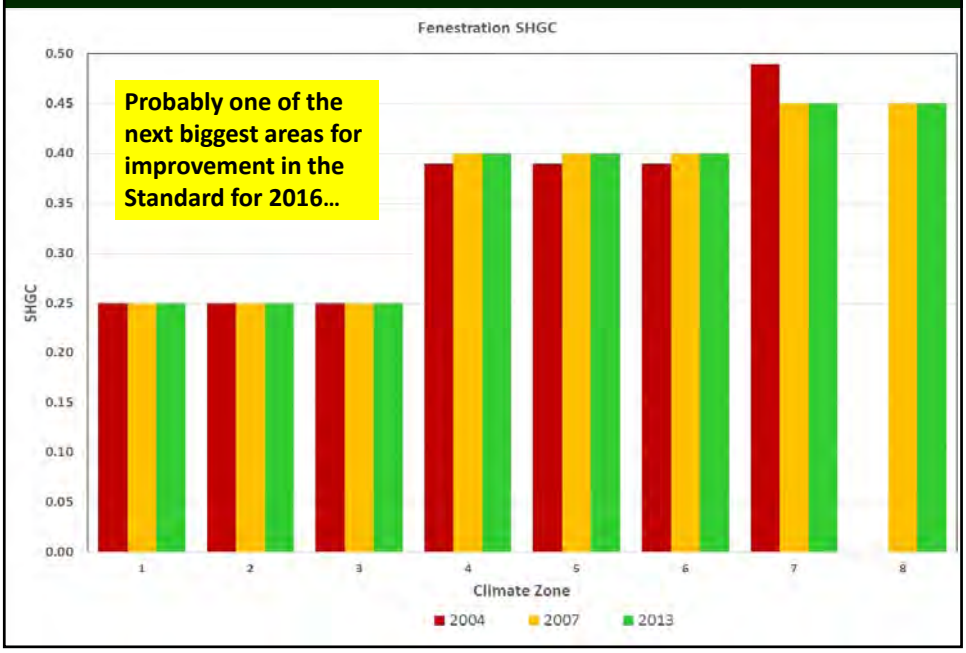
- Common aluminum-framed, single glazed windows **lose 3 to 4 times** more heat in winter than today's most basic energy efficient technologies
- Cold glass surfaces with recurring condensation
- BIG impact on comfort
- BIG impact on heating costs

Even with Efficiency Increases…

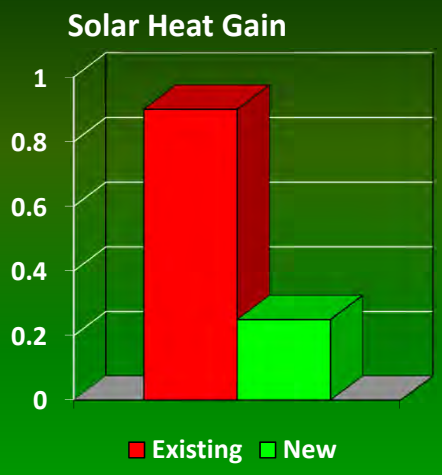
Compare…

	Opaque Walls	Curtain Wall
CZ 4	.065	0.42
CZ 5	.055	0.42

Solar Heat Gain Coefficient



Heat Gain (summer)



- Air conditioning energy is very expensive
- New window technologies are **over three 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)

Controlling Envelope Air Leakage

- **2004 – General language about minimizing air leakage, specific reference to window and door leakage**
- **2007 – Same language as 2004**
- **2010/13 – A FOCUS on controlling and limiting air leakage**
  - Requires a continuous air barrier
  - Lists approved materials and assemblies
  - Revised vestibule requirements
- **Proposal out right now for comments hoping to further improve this area of the Standard**

What do these new envelope changes mean for your load calcs?

Does your favorite architect
know about these
improvements to the Standard?

Other Major Improvements

- **Lighting Power Densities**
- **Lighting and Daylighting Controls**
- **Improved Equipment Efficiencies**
- **Improved Equipment Controls**
  - Deadbands, setbacks, off-hour, damper controls, etc.
- **Economizers (that actually function)**
- **Heat Recovery**
- **Refined Energy Modeling Rules**
- **Commissioning of Critical Systems - !!**

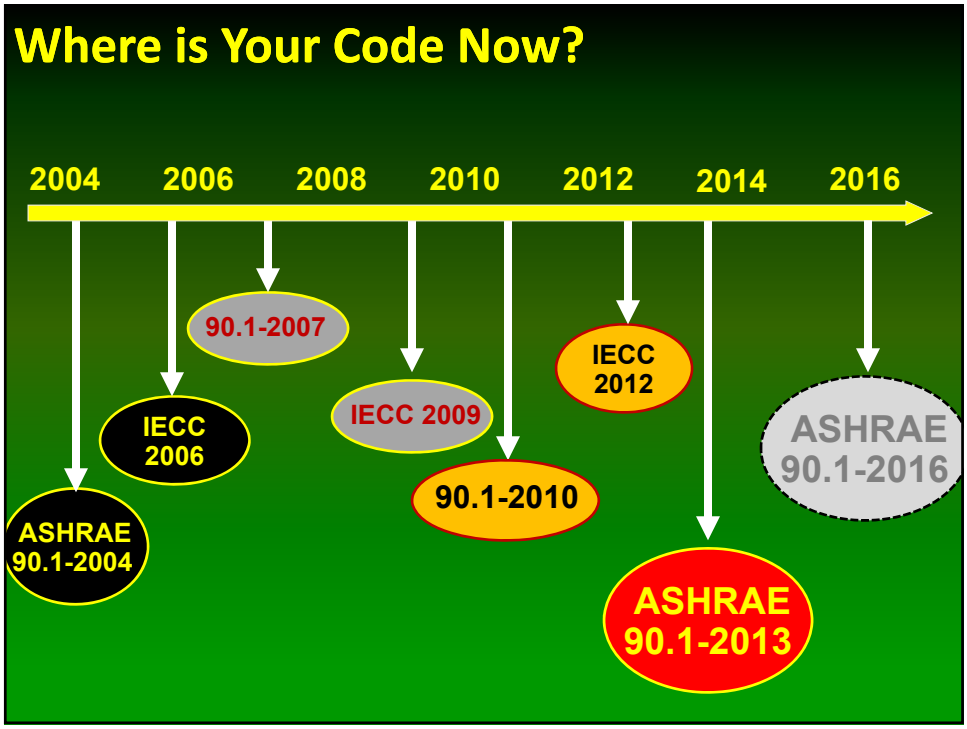
Thinking about those recent load calcs again?

What Does the Future Look Like?

- **Better envelopes**
  - 90.1-2013 tables look very different than 2010
    - Same as Approved Addenda to 2010
    - Should already be familiar
- **More daylighting and daylighting controls**
  - Better management of fenestration heat gain
  - Greater visible light availability and utilization
  - More sophisticated controls
- **More efficient HVAC equipment**
  - Federal minimums likely to continue to improve
- **Expansion to More Climate Zones**

Climate Zone Zero in 2016?

- **Envelope requirements?**
  - Better than CZ 1 – especially for large glazing areas
    - Orientation-specific SHGC?
    - Extra shading provisions?
    - Tvis implications on lighting?
    - Better insulation values?
    - Reduced/quantified air leakage?
  - Commissioning of critical systems?
    - Envelope
    - HVAC
    - Lighting
    - Controls
  - Proper sizing critical!


Where is Your Code Now?
2004
2006
2008
2010
2012
2014
2016
ASHRAE 90.1-2004
IECC 2006
90.1-2007
IECC 2009
90.1-2010
IECC 2012
ASHRAE 90.1-2013
ASHRAE 90.1-2016


X 97
GREAT NORTHERN RAILWAY
X 97
YOUR SAFETY IS UP TO YOU
X 97

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…!

What the Code is NOT

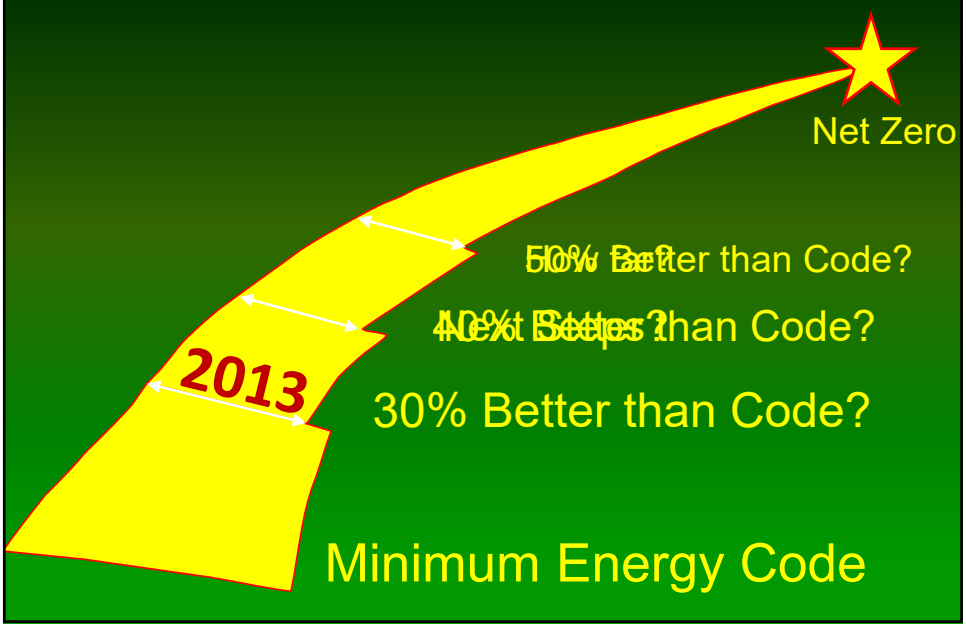
- Not leading edge
- Not superior performance
- Not exemplary
- Not green
- Not sustainable
- Not differentiating

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"



Everybody Wants to be Green…

- **ASHRAE 189**
- **ICC International Green Construction Code**

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

Example Problems with "Green"

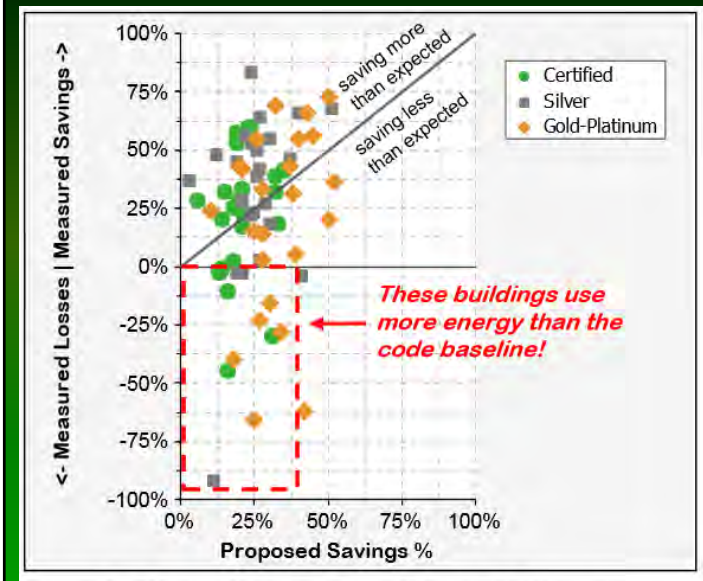


Figure 20: Measured versus Proposed Savings Percentages

LEED

Measured vs. Proposed Energy Savings

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

What About The Road to "Green"?

What About Those Other Objectives?

- Green?
- Sustainable?
- Water Management?
- Energy Star?
- LEED 4?
- 189?
- Net Zero?

Trends?

- Better buildings?
- Retrofit?
- Remodel?
- Reclaim?
- Reuse?

- Energy?
- Power?
- Water?
- IEQ?

Sometimes change doesn't wait on us…

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 0.16°F (0.09°C)."

Scientists also calculated the rate of temperature increase for July at an average of 1.17°F (0.65°C) per century.

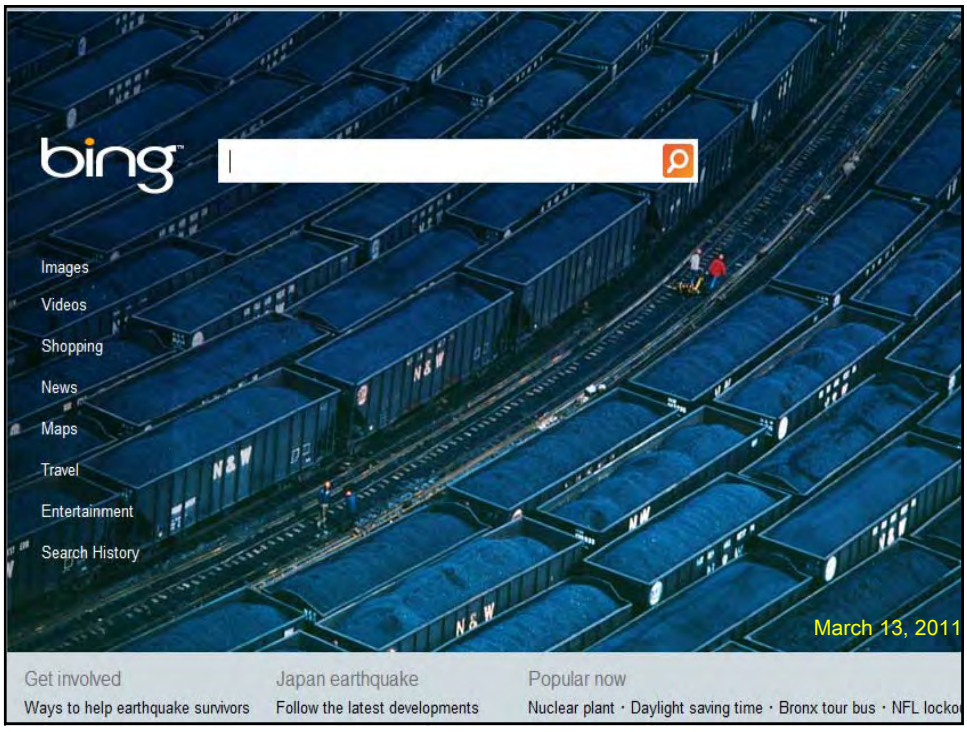
Large parts of the Earth were much warmer than average, including Africa which saw its second hottest July on record.

"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. – AFP

Our Leadership Responsibility

- **Get engaged!**
  - Get engaged in local code adoption/compliance
  - Support local building performance education
  - 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, etc.
- **New and Existing Buildings!**
  - Commercial AND Residential



Recent Scary Numbers

- **World energy consumption will increase by 53% between 2008 and 2035**
  - Source: USEIA, IEO 2011
- **China's energy consumption will DOUBLE between 2010 and 2020**
  - Source: McKinsey 2009

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…
- **ASHRAE 90.1-2013**
  - The Starting Point for Building Performance
  - Major Implications for Building professionals
  - Critical Step in Our Industry Leadership