



Why Buildings Matter and The Role of ASHRAE 90.1

R. Christopher Mathis
MC² - 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?**

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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...**

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Critical Repeated Message for Today...

“Don’t do what we do!”
(Or did...)

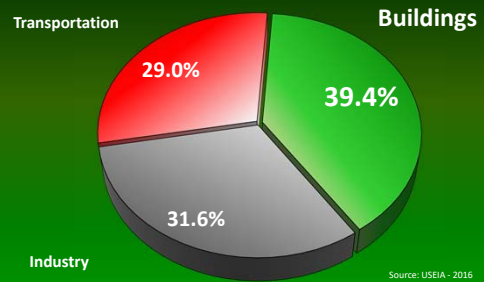
Lessons learned...
Specifics follow...

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**First,
Some Context...**

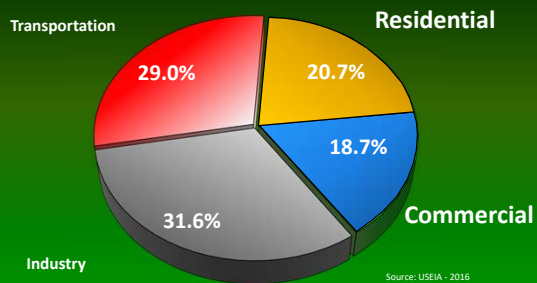
Buildings Matter: US Energy Use



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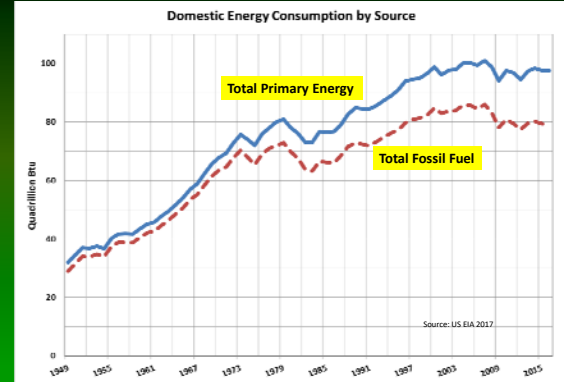
Buildings Matter: US Energy Use



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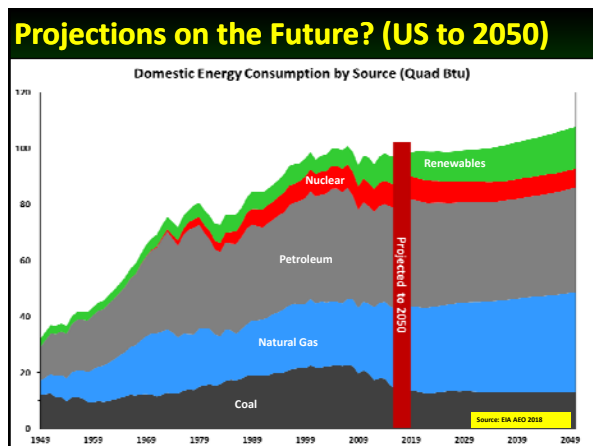
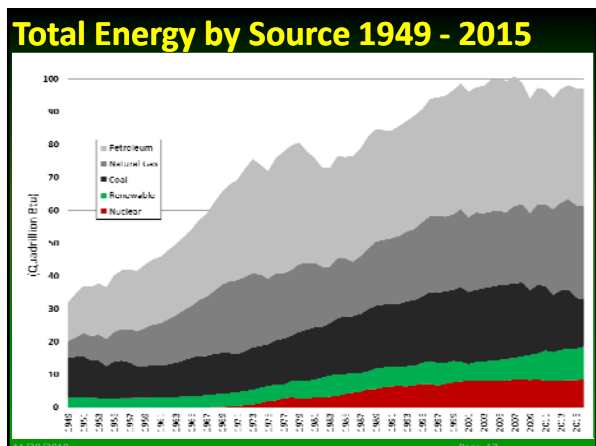
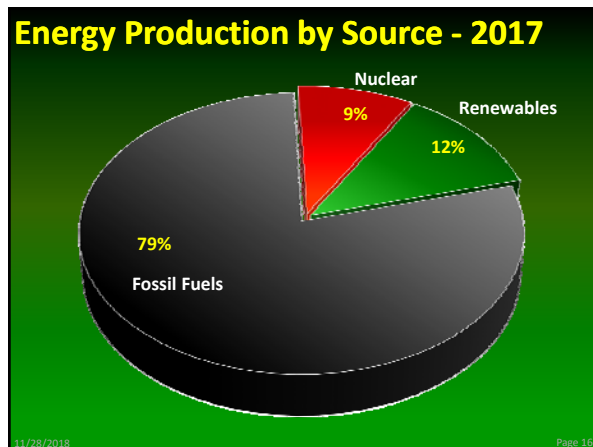
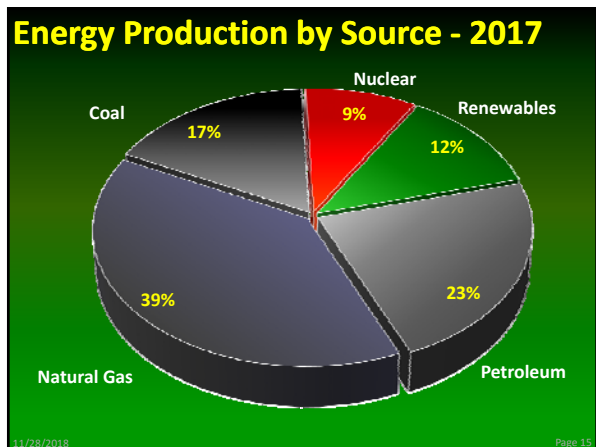
Total US Energy Consumption 1949 - 2015



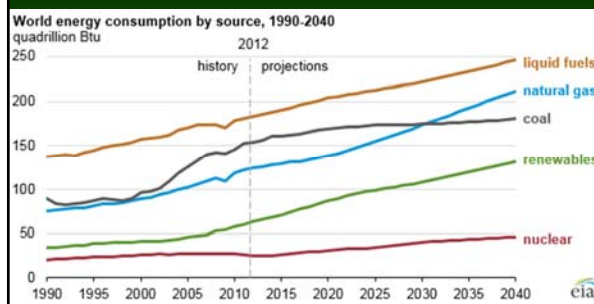
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World Energy Consumption by Fuel 1990 – 2040



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Don't Do What We Do!

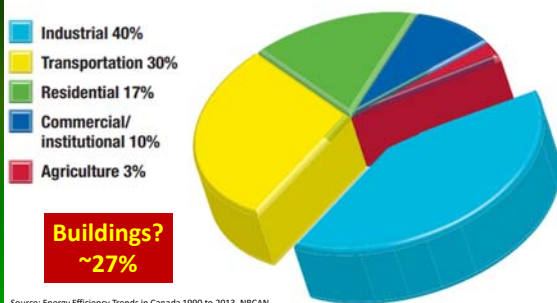
- DIVERSIFY energy and power sources
- Know what "FINITE RESOURCE" means
- DECENTRALIZE where possible
 - Put power production close to need

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Oh, Canada?

Figure 2.1 Secondary energy use by sector, 2013



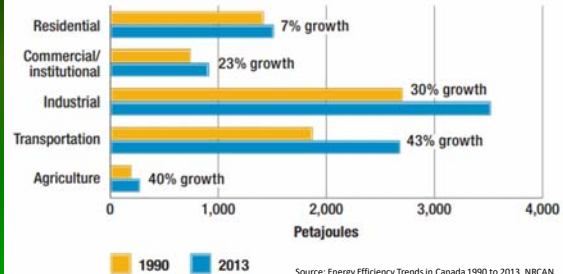
Source: Energy Efficiency Trends in Canada 1990 to 2013. NRCAN

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Canada Energy Use Growth?

Figure 2.5 Total secondary energy use and growth rate by sector, 1990 and 2013



Source: Energy Efficiency Trends in Canada 1990 to 2013. NRCAN

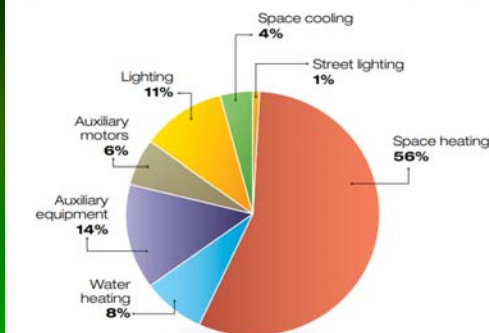
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Commercial Building Energy Use

Figure 5. Commercial and institutional building energy use, 2014



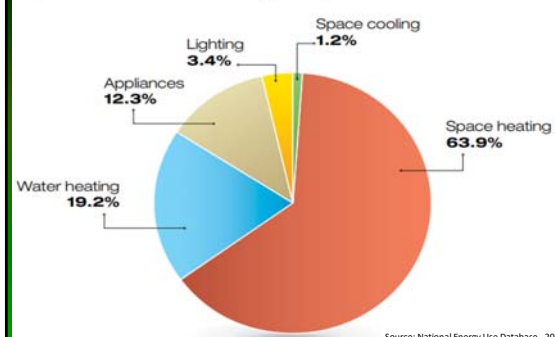
Source: National Energy Use Database - 2014

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Residential Building Energy Use

Figure 4. Residential energy use, 2014



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Canada Savings Perspectives

WHILE ENERGY USE IN CANADA INCREASED 31 PERCENT BETWEEN 1990 AND 2014, IT WOULD HAVE INCREASED **55 PERCENT** WITHOUT ENERGY EFFICIENCY IMPROVEMENTS.

IN 2014, ENERGY EFFICIENCY IMPROVEMENTS AVOIDED **90.5 MEGATONNES** OF GHG EMISSIONS.

CANADIANS **SAVED \$38.5 BILLION** ON ENERGY BILLS IN 2014 AS A RESULT OF ENERGY EFFICIENCY IMPROVEMENTS.

THE ENERGY EFFICIENCY PROGRAM SUITE (2011-2012 TO 2015-2016) ACHIEVED **\$1 BILLION IN COST SAVINGS** FOR CANADIAN INDUSTRY AND CONSUMERS.

OVER THE COURSE OF THE ENERGY EFFICIENCY PROGRAM SUITE, CANADIANS SAVED APPROXIMATELY **16.7 PJ** OF ENERGY BY USING ENERGY STAR® CERTIFIED PRODUCTS, EQUAL TO THE ANNUAL ENERGY USED BY APPROXIMATELY **30,000 HOUSEHOLDS**

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The Energy Megatrend

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

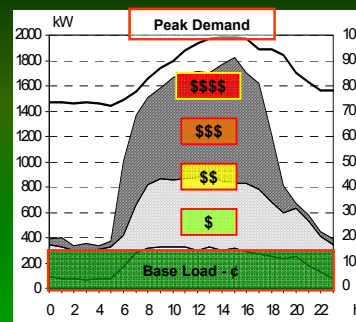
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Utility Concerns

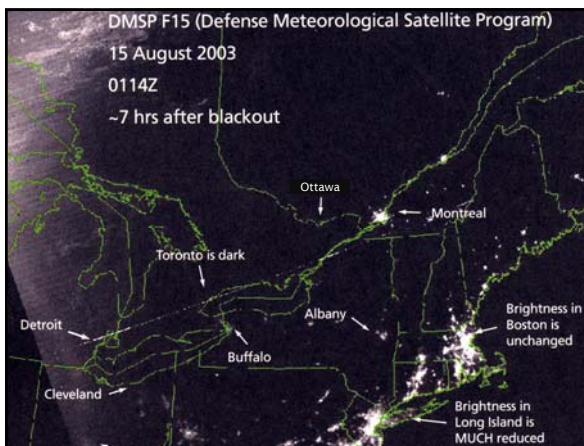
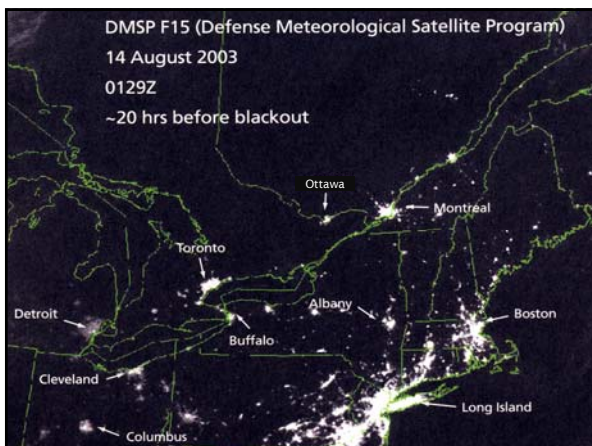
➤ The "Timing" of our Demand

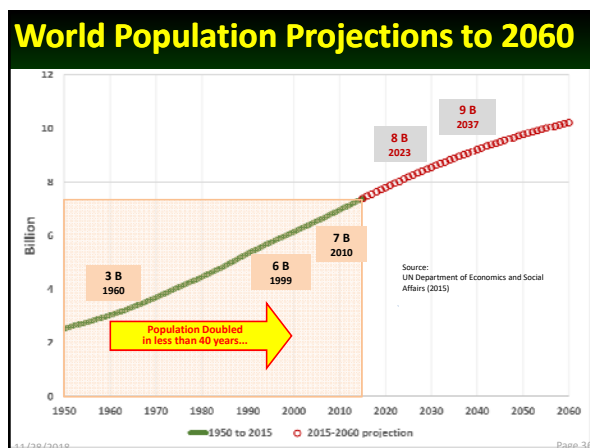
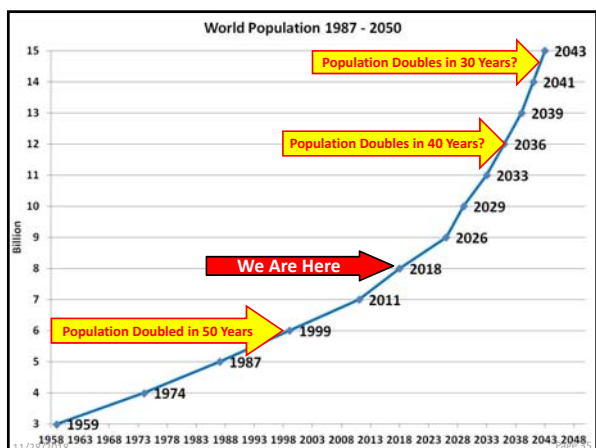
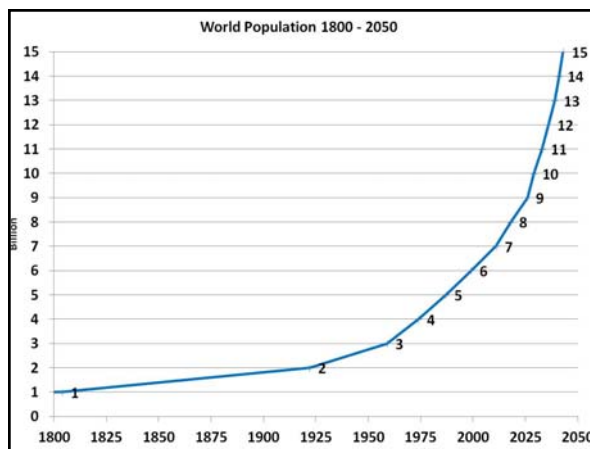
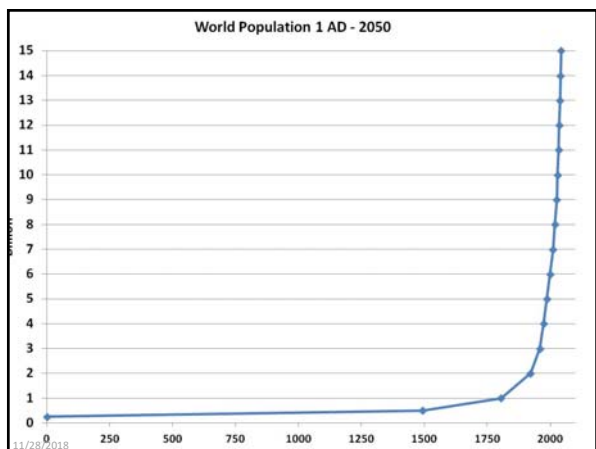
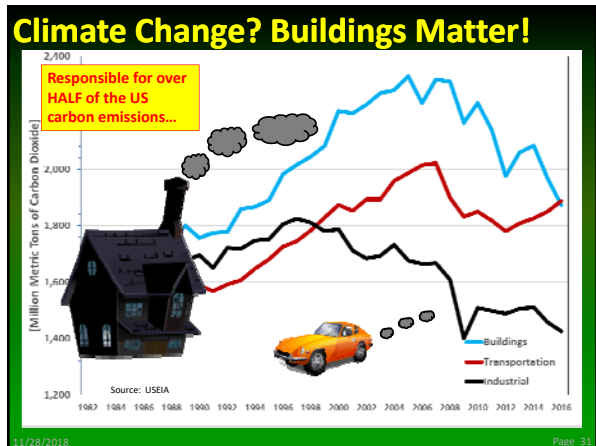
- Base Load
- Peak Demand
- Cooling Driven
- Lighting Driven



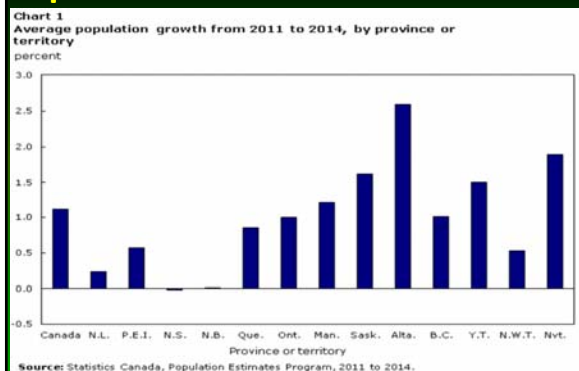
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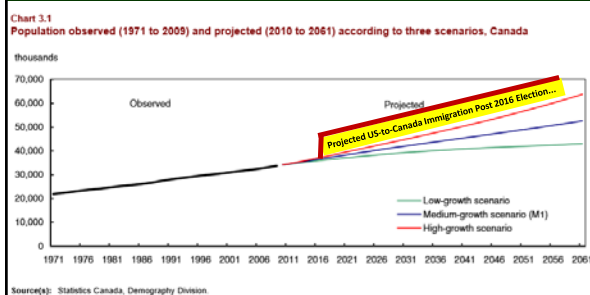
Population Growth 2011-2014



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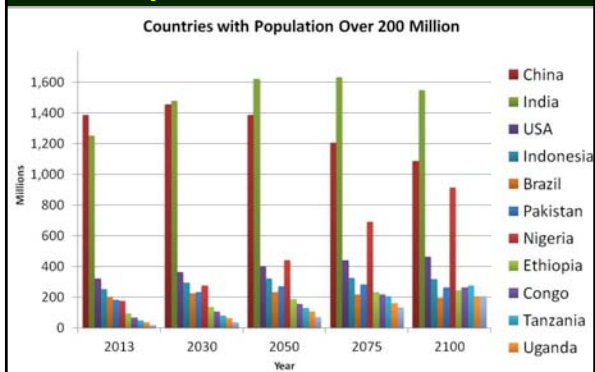
Projected Population Growth...?



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World Population Trends...



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Energy and Water

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

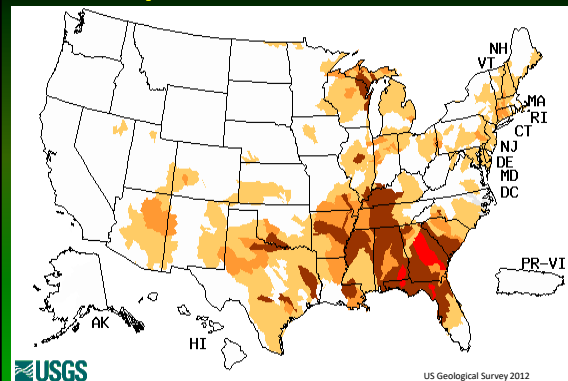


US News, 11/22/2012

11/28/2018

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Water Implications...



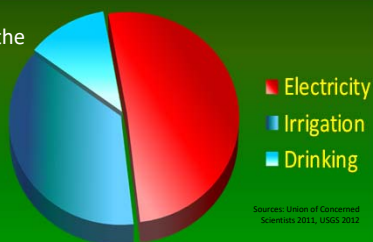
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Power and Water

- 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

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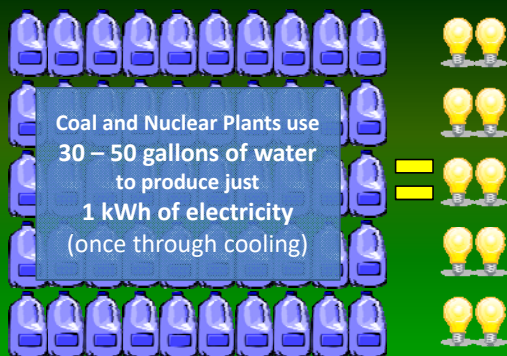
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Niagara Falls



Niagara Falls State Park and USGS

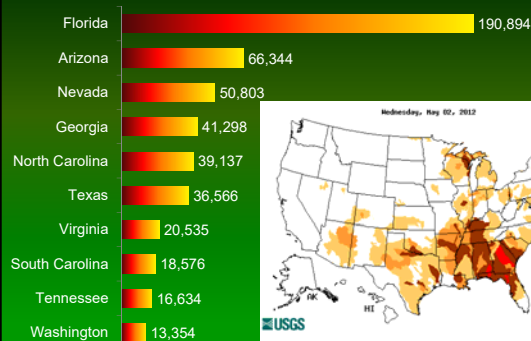
Water and Power Connection...



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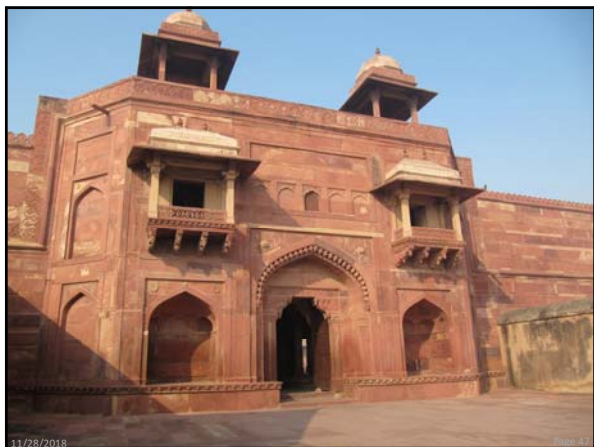
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Annual Net Migration 2000 - 2004



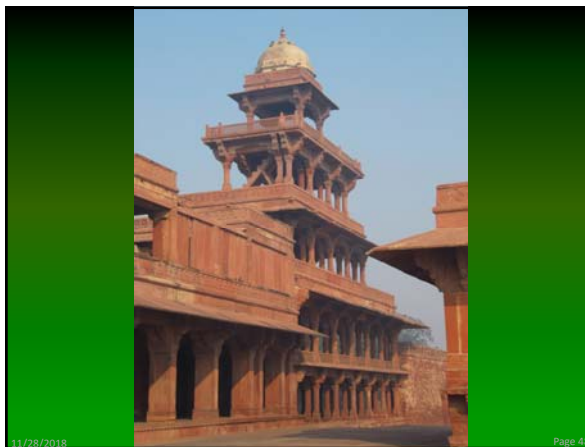
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US Commercial Buildings

**74% was
built
before
1989!**

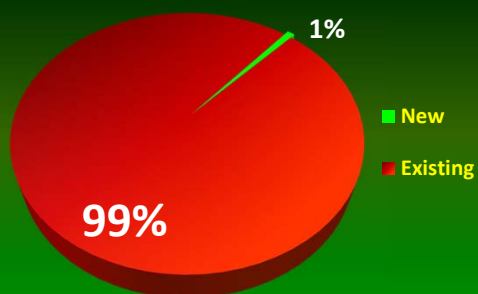
- Before 1989
- 1990 to 1999
- 2000 to 2003

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

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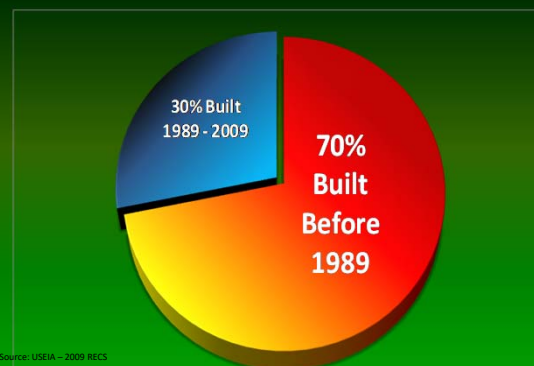
Source: USEIA, 2003 CRECS
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U.S. Residential Buildings

Source: USEIA - 2009 RECS
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Age of U.S. Homes...

Source: USEIA - 2009 RECS
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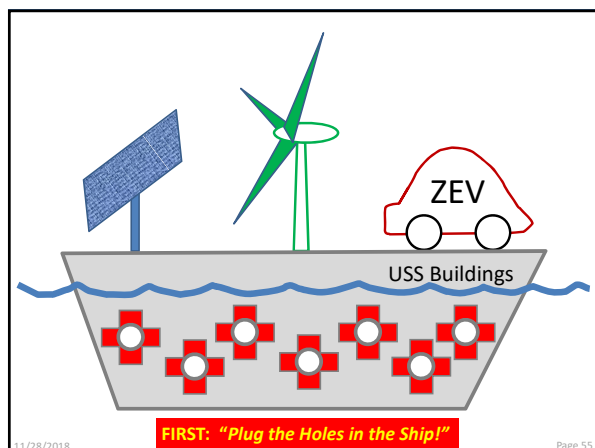


Don't Do What We Do!

- **EXISTING BUILDINGS MATTER!**
 - Recognize, prioritize and bring best your professional skills to addressing the performance of existing buildings!
- **Keep a perspective on their life expectancy**
 - Value their performance for a long time

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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

NOAA – The world broke new heat records in July, marking the hottest month in history and the warmest final month of the year since modern record-keeping began in 1880, US authorities said Tuesday.

The findings by the National Oceanic and Atmospheric Administration showed a continuing trend, as the planet continues to warm due to the burning of fossil fuels, and scientists expect the warming 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 C. Cook, 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 said.

The month's average temperature across land and sea surfaces worldwide was 62.65 Fahrenheit (17.63 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 1980-2013 period," and NOAA is 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 1980-2013 period, surpassing the previous record set in 2010 by 0.34°F (0.19°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.

"Recent 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 southeastern North America were also warmer than average.

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Trends - 2

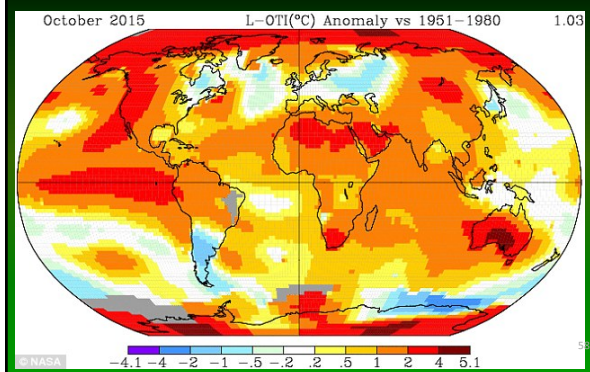
October smashes record for global warmth: Last month keeps 2015 on track to be the hottest year since 1880

- 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 greenhouse gases and a strong El Niño

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Hottest October Since 1880...



Legacy of 2015...

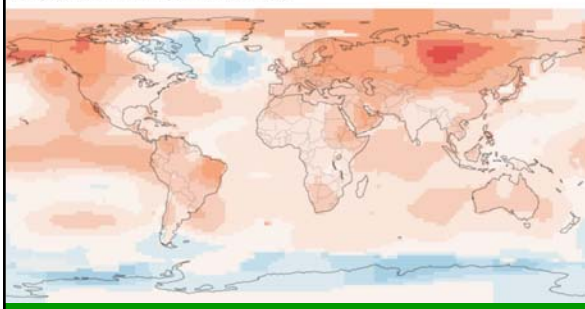
US: 2015 was hottest on Earth by a wide margin



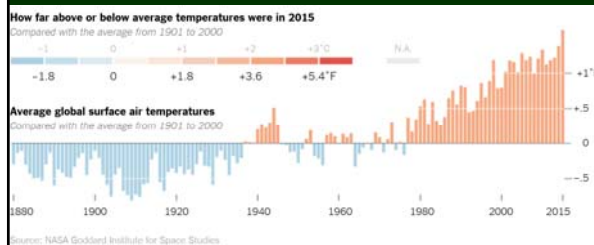
The World is Getting Warmer...

The Hottest Year on Record

Globally, 2015 was the warmest year in recorded history.



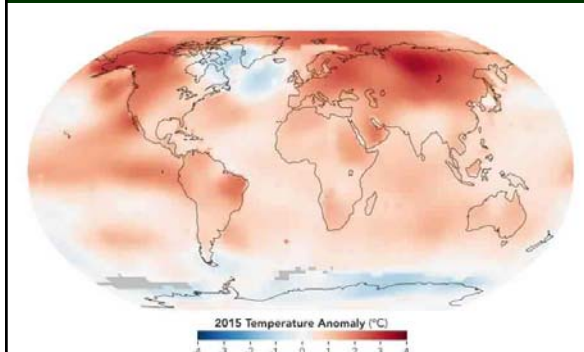
2015: Warmest Year in Modern Record Keeping



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How Far From "Normal"?



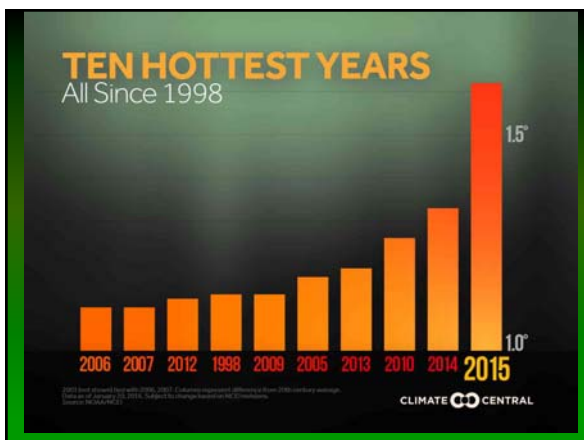
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3/9/16...

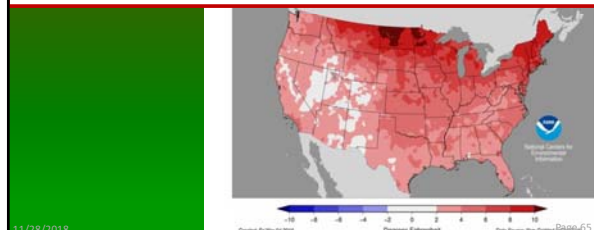
Winter Tops Charts As Warmest on Record For U.S.

Published March 9, 2016

Twitter Facebook YouTube LinkedIn Instagram RSS

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

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



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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, 10:05 AM

Twitter Facebook YouTube LinkedIn Instagram RSS

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.

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July 2016

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

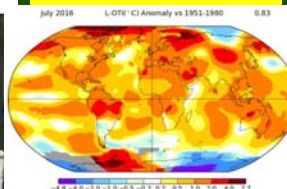
KEITH BURNETT, THE ASSOCIATED PRESS / August 16, 2016 8:47 AM ET
View from The Associated Press



People cool off in England's July, where temperatures soared to 91°F. NASA indicated that July 2016, an average of 1.68 degrees Celsius warmer than the 1951-1980 global average, ranked the hottest month in recorded history.

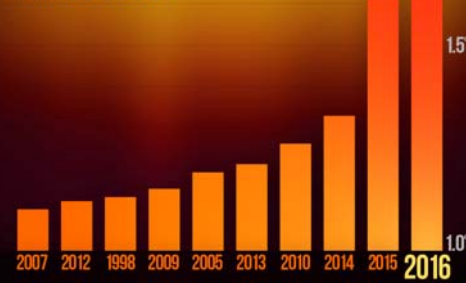
WASHINGTON — Earth just landed to its hottest month in recorded history, according to NASA.

Hottest month in recorded history...



2016: The Trend Continues...

TEN HOTTEST YEARS
All Since 1998



2015 and 2016 tied as the hottest years with 2013. 2016 is the warmest year since 1998, with an average of 1.68°C above the 1951-1980 global average.

(Data as of January 15, 2017) Subject to final seasonal adjustments.

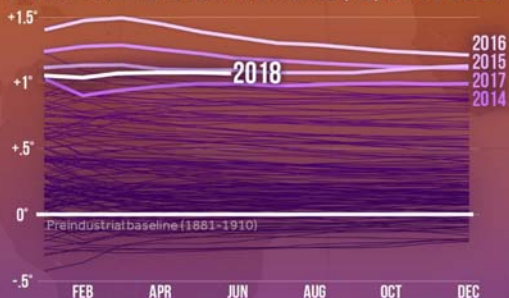
CLIMATE CENTRAL

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HOTTEST YEARS

Global Year-to-Date Anomalies (°C) Since 1880



Source: NASA (GS) & NOAA (NC) 2.5 global temperature anomalies, averaged and adjusted for early industrial baseline (1881-1910).

CLIMATE CENTRAL

NEW YORK STATE FAIR

Tuesday could be hottest day ever at NY State Fair

Updated Aug 27, 1:21 PM; Posted Aug 27, 9:37 AM



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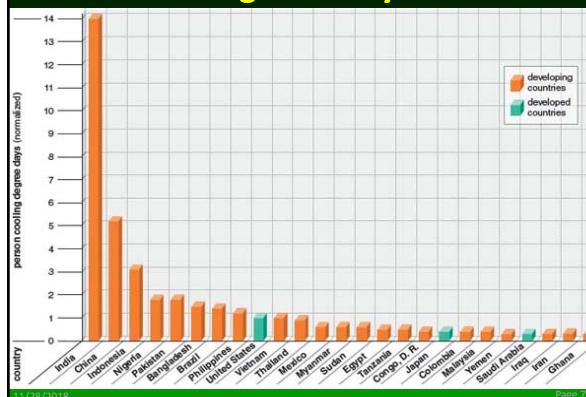
Worldwide 2018...

- **Glasgow, Scotland** had its hottest day on record, reaching 89°F on June 28.
- **Montreal, Canada** set a new all-time high, reaching 98°F on June 29.
- **Ouargla, Algeria** had the highest temperature on record in Africa, reaching 124°F on July 5.
 - This is believed to be the hottest temperature reliably measured in Africa.
- **Tianxiang, Taiwan** had the hottest temperature on record in Taiwan, reaching 105°F on July 10.

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Air Conditioning for Everyone?



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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!

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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



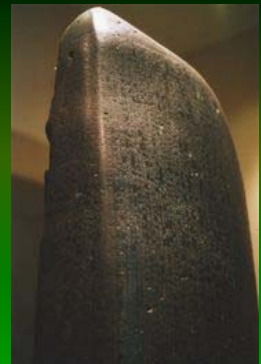
Disaster Breeds Codes...

- **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.



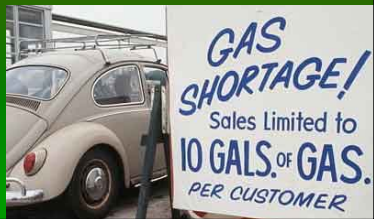
More US Code Milestones

- **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

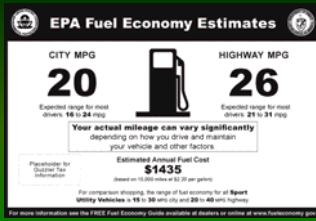
- **Arab Oil Embargo – 1973-4**
 - President Carter's Fireside Chat ("Turn your thermostat down to 65 and wear a sweater" and "Drive 55")
 - Precipitated the first energy codes for buildings – ASHRAE 1975



What Did We Do After 1973?

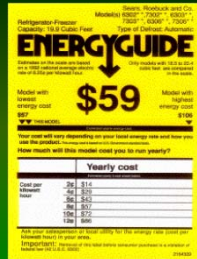
- **Tried to Save Energy**
 - Developed Standards and Ratings
 - Insulation, Appliances, Cars
- **Innovated (developed new technologies)**
 - Insulation, Glazing Technologies, HVAC, Lighting
- **Adopted our FIRST Energy Codes**
- **New Market Forces Evolved**
 - Utility Programs, Rebates, etc.

Why Standards?



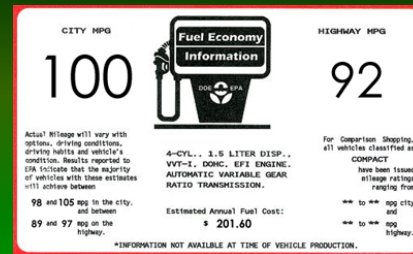
Automotive

Consumer Signals About Energy! A Means of Comparison...



Appliances

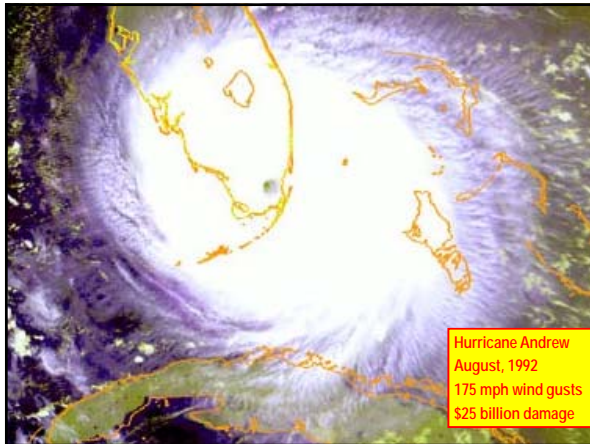
What's Possible?



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

Perspective...



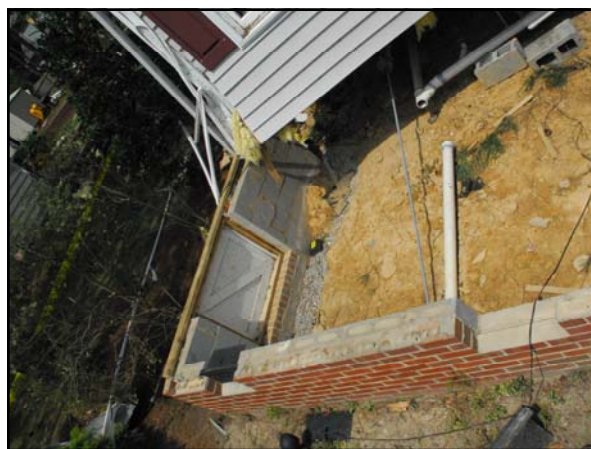
Katrina...

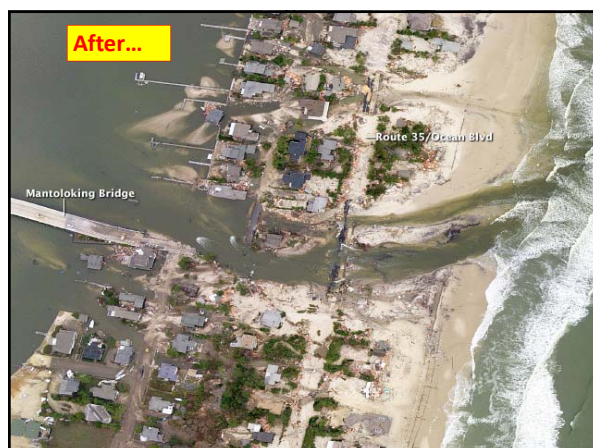
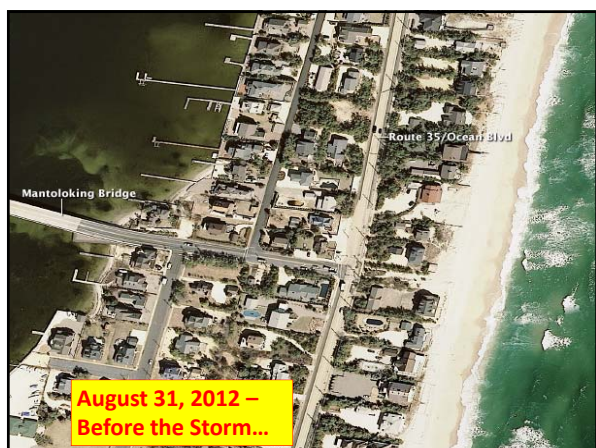
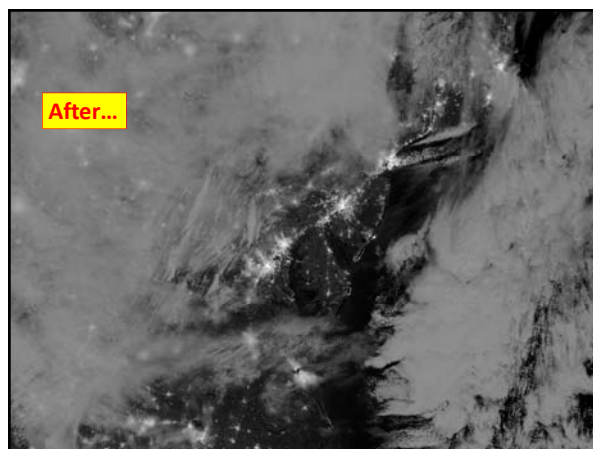
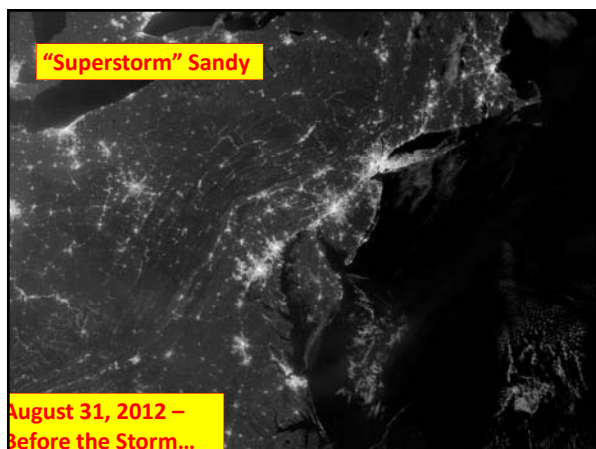
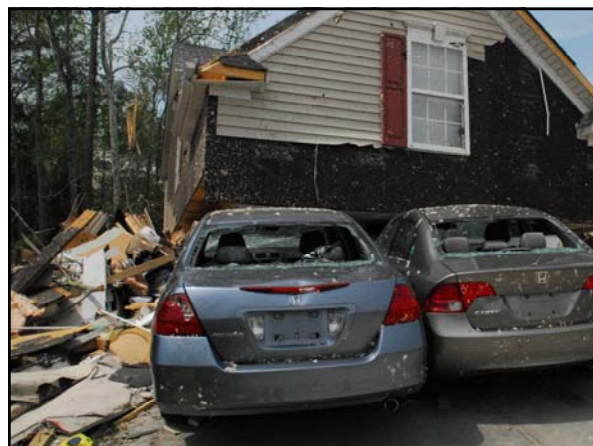


Katrina's Legacy...

- 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 codes...**

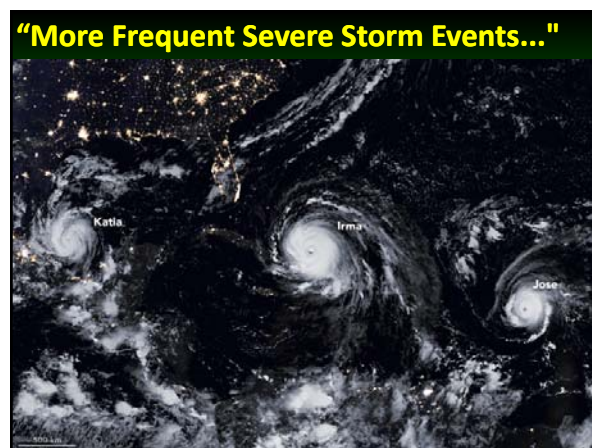
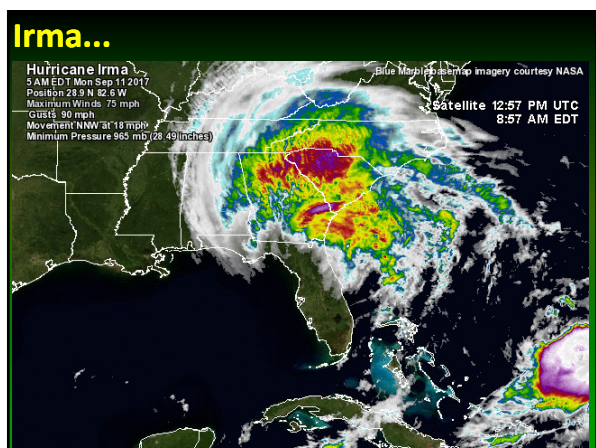






Perspective:

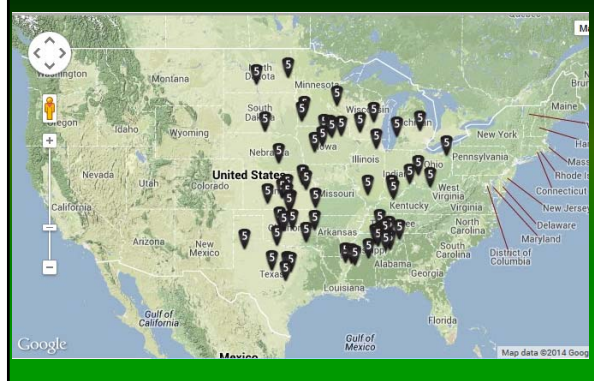
**When the grid went down in India,
over 350,000,000 people
were without power...**



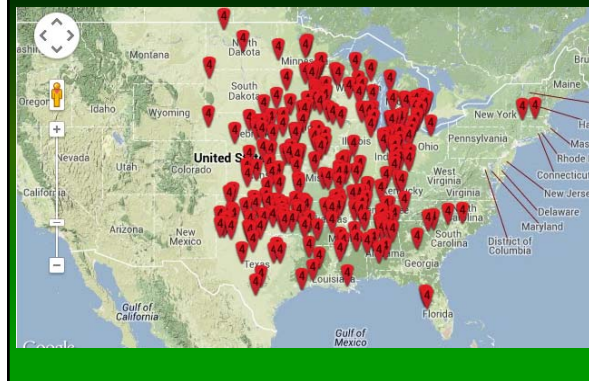
Moore, Oklahoma...



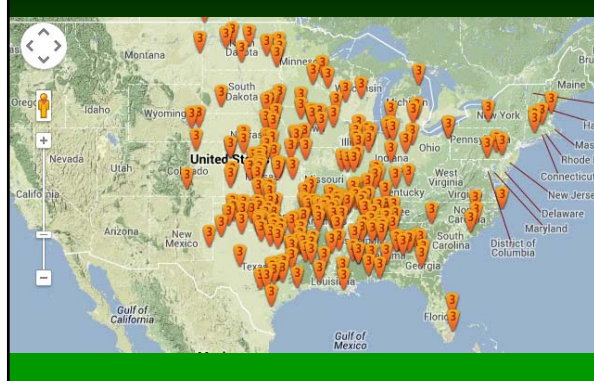
F5 Tornadoes Since 1950...



F4 Tornadoes Since 1950

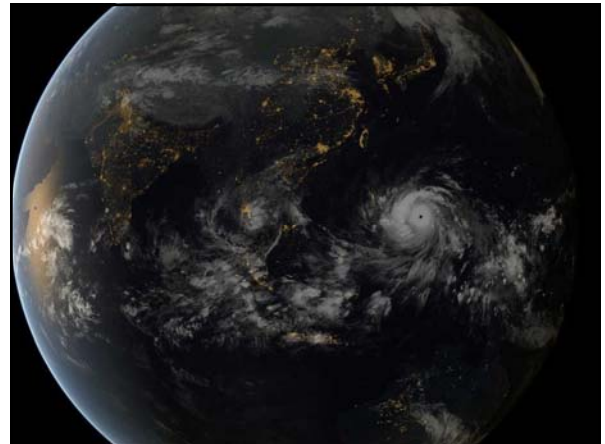


F3s...



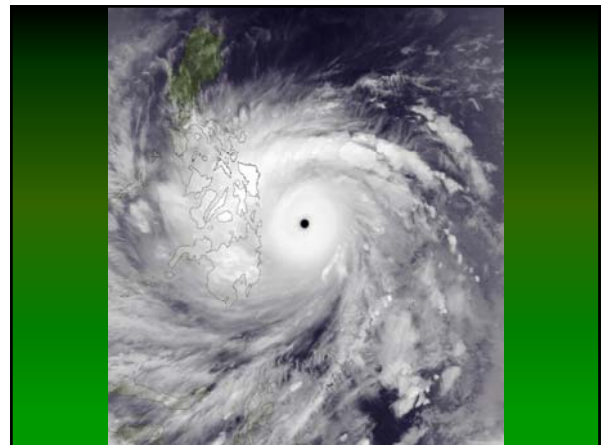
F2s...





“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?



Florence 2018...



Florence 2018...



More Storms, More Severe... 2018



NC Outer Banks... 2018



11/28/2018

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Asheville, NC 2018...

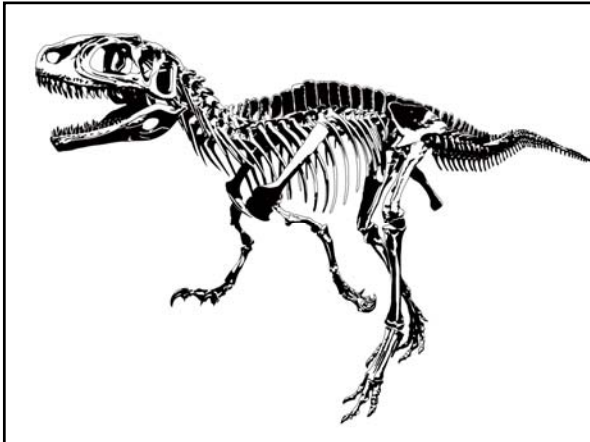


11/28/2018

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

There are
consequences
to waiting...



Don't Do What We Do!

- **Don't wait to engage other building professionals in your common goals!**
 - Architects
 - Specifiers
 - Commissioning agents
 - Policy makers
- **"Be a "TEAM" in your shared building performance objectives.**



Think About What We Are Building...



Think About What We Are Building...

How much energy? For how long?



What are our responsibilities as knowledgeable building professionals?

Canada's Model Energy Code 2017

2017
**National
Energy Code of
Canada for
Buildings**



Our ASHRAE Leadership Role

ASHRAE Mission

To advance the arts and sciences of heating, ventilating, air conditioning and refrigerating to serve humanity and promote a sustainable world.

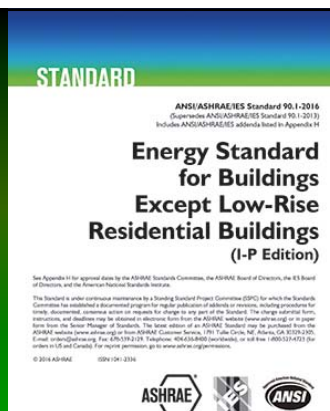
ASHRAE Vision

ASHRAE will be the global leader, the foremost source of technical and educational information, and the primary provider of opportunity for professional growth in the arts and sciences of heating, ventilating, air conditioning and refrigerating.

ASHRAE 90.1

Our Model Energy Code

90.1-2016



3/14/2018

Mathis Consulting Company

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Our Flagship 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

5/3/2018

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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...

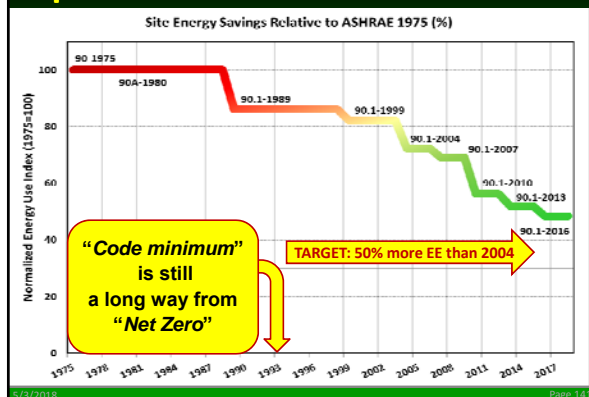
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Audience Survey

Net Zero?
Deep Green?

Improvements in EUI: 1975 to Present



5/3/2018

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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

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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 (\$)

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Scalar Ratio

Energy Savings

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

First Costs

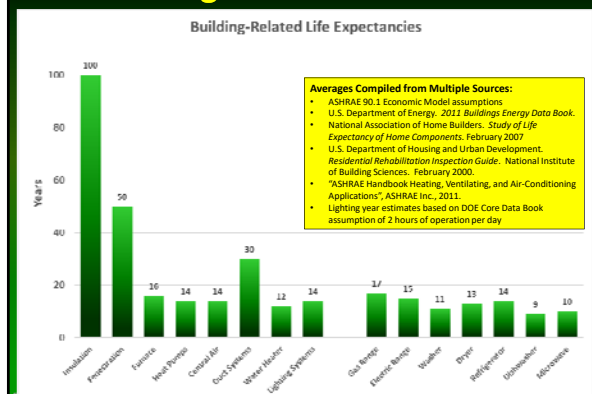
- Loan Life
- Inflation Rate
- Tax Rate
 - Federal
 - State
- Loan Interest Rate

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For How Long? "Economic Life"



Economic Applications

1 - Single Measure, Long Life

- Opaque Envelope Elements
- U-factors, 40 years

2 - Multiple Measures, Long Life

- Fenestration
- U-factors, SHGC, 40 years

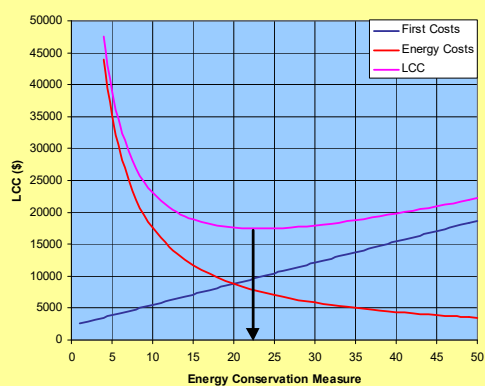
3 - Single Measure, Short Life

- HVAC Equipment
- COP, 15 years

5/3/2018

1-146

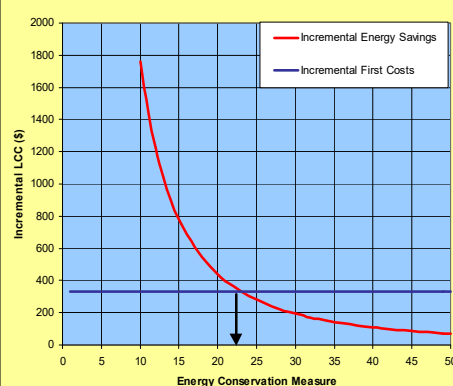
LCC Theory



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Incremental LCC



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Scalar Ratios for Std. 90.1-2019

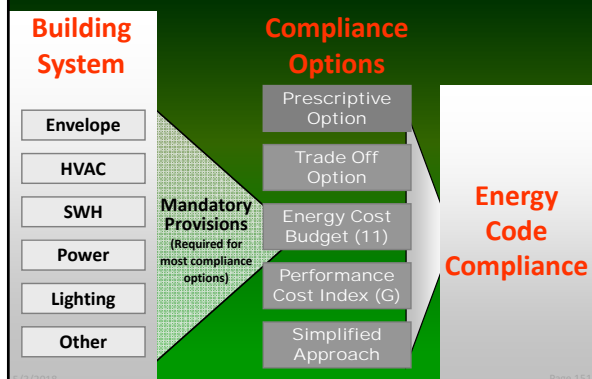
Life	SRh	SRc	Life	SRh	SHc
1	1.0	1.0	26	19.8	17.7
2	1.8	1.9	27	20.3	18.1
3	2.7	2.8	28	20.8	18.5
4	3.6	3.6	29	21.2	18.8
5	4.6	4.5	30	21.7	19.2
6	5.5	5.4	31	22.1	19.5
7	6.4	6.2	32	22.5	19.9
8	7.3	7.0	33	22.9	20.2
9	8.1	7.8	34	23.3	20.5
10	9.0	8.5	35	23.6	20.8
11	9.8	9.3	36	24.0	21.1
12	10.6	10.0	37	24.3	21.4
13	11.4	10.7	38	24.7	21.6
14	12.2	11.3	39	25.0	21.9
15	13.0	12.0	40	25.2	22.1
16	13.7	12.6	41	25.5	22.3
17	14.4	13.2	42	25.8	22.6
18	15.1	13.8	43	26.1	22.8
19	15.7	14.3	44	26.3	23.0
20	16.4	14.9	45	26.5	23.2
21	17.0	15.4	46	26.8	23.4
22	17.6	15.9	47	27.0	23.5
23	18.2	16.3	48	27.2	23.7
24	18.7	16.8	49	27.4	23.9
25	19.3	17.2	50	27.6	24.0

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Basic Compliance Structure 2016

Multiple Compliance Approaches...



New Compliance Option in 2016

- **Performance Rating Method (Appendix G)**
 - Now Appendix G can be used as a path for compliance, not just modeling rules!
 - Alternative to Chapter 11: Energy Cost Budget
 - Single path for demonstrating minimum code compliance as well as for above-code programs!
 - New metric: Performance Cost Index (PCI) accommodates various climate zones and prominent commercial building types
 - Common baseline, allowing buildings of any vintage to be rated.

Example: Prescriptive Envelope Tables

Table 5.5-6 Building Envelope Requirements for Climate Zone 6 (A,B)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation entirely above deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.063	R-15 c.i.
Metal building ^a	U-0.031	R-25 + R-11 Ls	U-0.029	R-30 + R-11 Ls	U-0.060	R-19 + R-19
Attic and other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above Grade						
Masonry	U-0.080	R-13.3 c.i.	U-0.071	R-15.2 c.i.	U-0.151 ^b	R-5.7 c.i. ^b
Metal building	U-0.050	R-0 + R-19 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.094	R-0 + R-9.8 c.i.
Steel-framed	U-0.049	R-13 + R-12.5 c.i.	U-0.049	R-13 + R-12.5 c.i.	U-0.084	R-13 + R-3.8 c.i.
Wood-framed and other	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.089	R-13

Appendix G: Focus on PERFORMANCE!

Table G3.4-6 Performance Rating Method Building Envelope Requirements for Climate Zone 6 (A,B)*

Opaque Elements	Nonresidential	Residential	Semiheated
	Assembly Maximum	Assembly Maximum	Assembly Maximum
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-0.173
Walls, Above-Grade			
Steel-framed	U-0.084	U-0.064	U-0.124
Wall, Below-Grade			
Below-grade wall	C-1.140	C-0.119	C-1.140
Floors			
Steel-joist	U-0.038	U-0.038	U-0.069
Slab-on-Grade Floors			
Unheated	F-0.730	F-0.730	F-0.730
Opaque Doors			
Swinging	U-0.700	U-0.500	U-0.700
Nonswinging	U-0.500	U-0.500	U-1.450

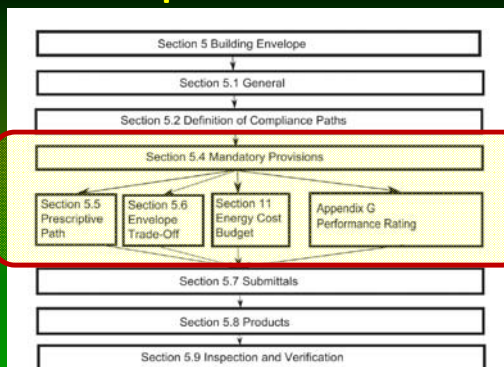
Prescriptive Fenestration Example

Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC
Vertical Fenestration, 0% to 40% of Wall		(for all frame types)	
Nonmetal framing, all	0.30	0.40	1.10
Metal framing, fixed	0.36		
Metal framing, operable	0.45		
Metal framing, entrance door	0.68		

Appendix G: Focus on PERFORMANCE

Fenestration	Assembly Max. U	Assembly Max. SHGC
Vertical Glazing, % of Wall		
0% to 10.0%	U _{air} 0.57	SHGC _{air} 0.49
10.1% to 20.0%	U _{air} 0.57	SHGC _{air} 0.39
20.1% to 30.0%	U _{air} 0.57	SHGC _{air} 0.39
30.1% to 40.0%	U _{air} 0.57	SHGC _{air} 0.39

General Compliance Structure



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New Envelope Requirements 2016

- **Mandatory requirements for:**
 - Envelope verification regarding air leakage
 - Reduced leakage for overhead coiling doors
- **More efficient Prescriptive requirements for:**
 - Metal building roofs and walls
 - Fenestration (in some climate zones)
 - Opaque doors (in some climate zones)
- **Improved definitions and clarifications for:**
 - Exterior walls and building orientation
 - Effective R-value of enclosed air spaces
- **Added prescriptive requirements for CZ 0**

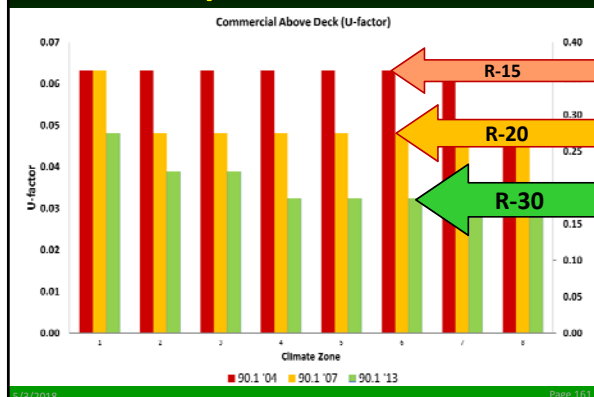
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The Thermal Envelope: Prescriptive Tables and Changes

2004 versus 2016 Examples

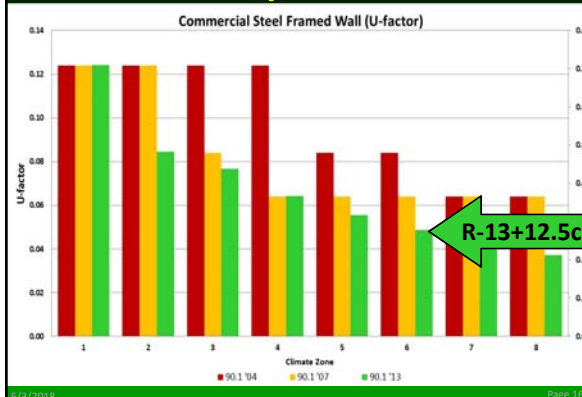
2004 to 2013/16: Roofs



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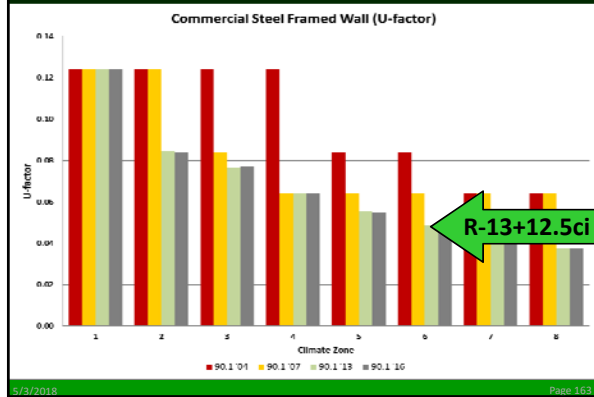
2004 versus 2013/16: Walls



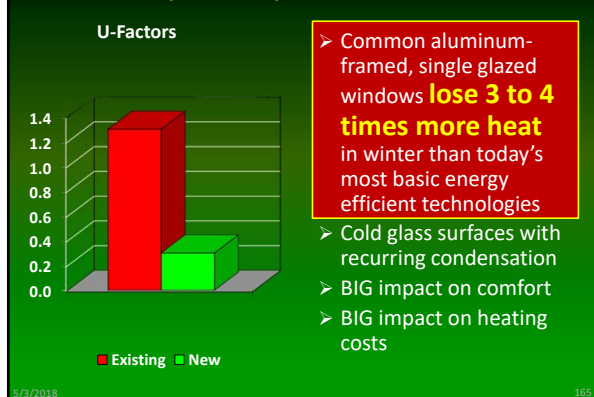
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2013 versus 2016 Opaque?



Heat Loss (winter)



Compare the Heat Transfer...

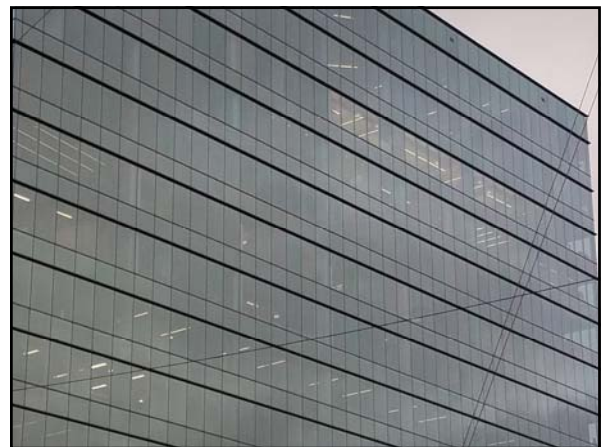
Opaque versus Fenestration...

	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

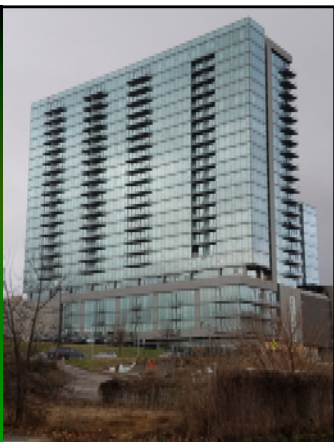
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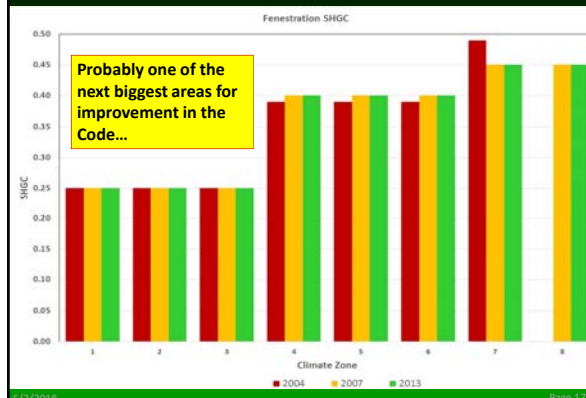
Think about...

- Comfort?
- Resilience?
- Durable?
- Code Compliant?
- Thermal Bridges?
- Energy?
- Peak power?
- Carbon?



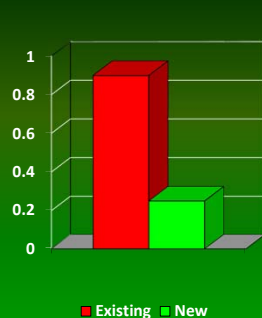
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Solar Heat Gain Coefficient



Heat Gain (summer)

Solar Heat Gain



- 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)

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Think About What We Build...



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Think About What We Build...

How much energy? For how long?



What are our responsibilities as knowledgeable building professionals?

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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

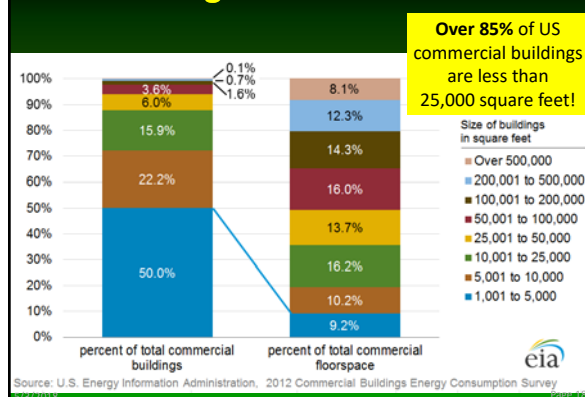
Controlling Envelope Air Leakage - 2

- **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.

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Most Buildings Are SMALL!



We CAN Test Large Building Air Leakage...



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Envelope Tools Examples



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Load Calculation Example

What is the Impact of
Envelope Air Leakage?

Mechanical Systems Improvements 2016

- Chilled water plant metering
 - Large electric-driven chilled water systems must be monitored for electric use and efficiency
- Added energy efficiency and rating requirements for Dedicated Outdoor Air Systems (DOAS)

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Mechanical Systems 2016 – (B)

- Improved elevator efficiency requirements
- Added fault detection and diagnostics to economizers
- New requirements for replacement equipment such as:
 - Adding economizers
 - Adding fan speed controls
 - Etc.

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New Lighting Requirements 2016 (A)

- Dwelling Units must use high efficacy lighting or controls (like dimmers and sensors)
- Alterations of more than 20% of the lighting load must meet nearly all the mandatory lighting control requirements as for new construction
- Partial-off occupancy sensor control required for parking lot lighting poles 24 feet or less above ground.

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Example: Lighting Power Allowances

Whole Building Method (W/sq.ft. of lighting power)

Building Type	90.1-2007	90.1-2010	90.1-2013	90.1-2016
Office	1.0	0.9	0.82	0.79
School/University	1.2	1.2/0.99	0.87	0.81
Retail	1.5	1.4	1.26	1.06

Space-by-space Method (W/sq.ft. of lighting power)

Space Type	90.1-2007	90.1-2010	90.1-2013	90.1-2016
Office Open	N/A / 1.1	1.0/0.98	0.98	0.81
Classroom	N/A /1.4	1.3/1.24	1.24	0.96/0.92
Sales Area	N/A /1.7	1.6/1.68	1.59/1.44	1.22

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Other Major Improvements - 2016

- 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?

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Architects and Specifiers:

What do these new envelope requirements mean for your decisions about amount of glass, wall insulation system, and air sealing plans?

- Does your favorite engineer know about these new (now old) code requirements?

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Engineers:

What do these new envelope requirements mean for your load calculations, equipment sizing and selection?

- Does your favorite architect and specifier know about these new (now old) code requirements?

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Contractors:

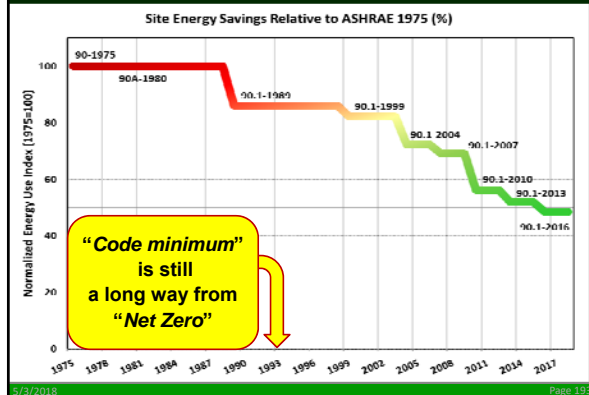
What do these new envelope requirements mean for your Quality Control Programs, scheduling and oversight on fenestration, wall insulation system, and envelope air sealing plans?

- Does everyone on your team know about these new (now old) code requirements?

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Improvements in EUI: 1975 to Present



Audience Survey

How Long Will It Last?

Audience Survey

- House either one of your parents grew up in is still standing
- House one of your four GRANDparents grew up in still standing
- GREAT-grandparents' homes?

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Some of the Oldest Buildings in Canada

- Andersen House, St. John's – 1804
- ~213 years



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Old Stone Mill, Delta, Ontario

- 1810
- ~207 years old...



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157 years...

- Holy Trinity Anglican Church, Saskatchewan
- 1860



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267 years...

- St. Paul's Anglican Church, Halifax
- 1750
- ~265 years



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333 years and counting...

- Le Séminaire de Saint-Sulpice, Quebec
- 1684



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370 years and counting...

- Cathedral-Basilica of Notre-Dame de Québec
- 1647
- 1786-1822
- 1931



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Gravity...

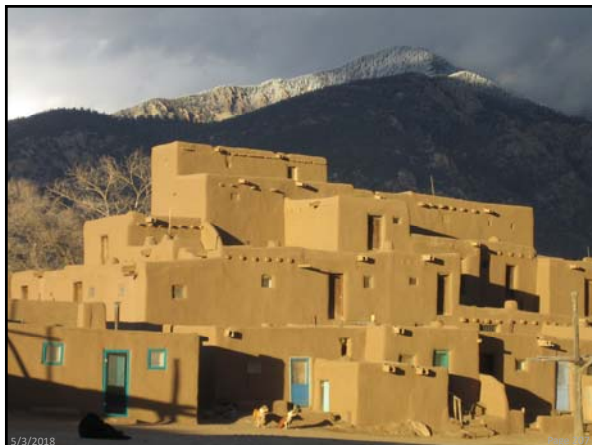
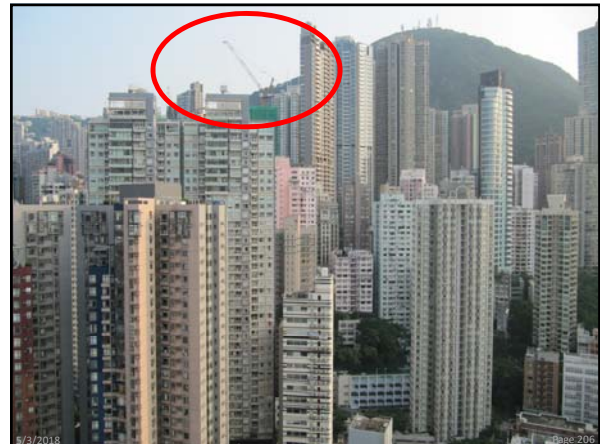


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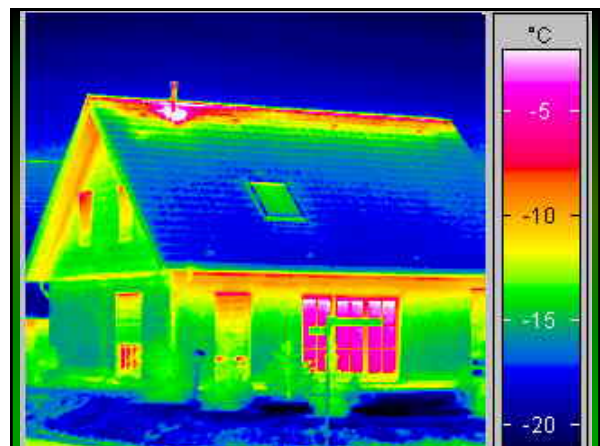
5/3/2018

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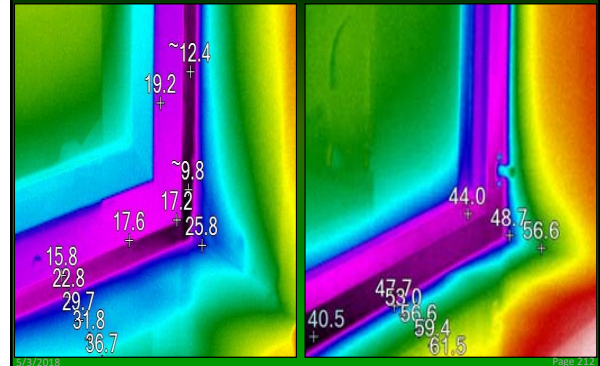
Small Problems in Long-Lived Systems

- 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!”





We Learn When We Measure Stuff...



Sometimes the message is pretty simple...

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...!

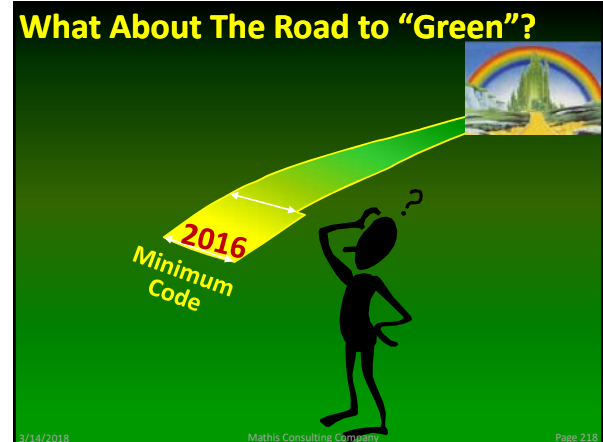
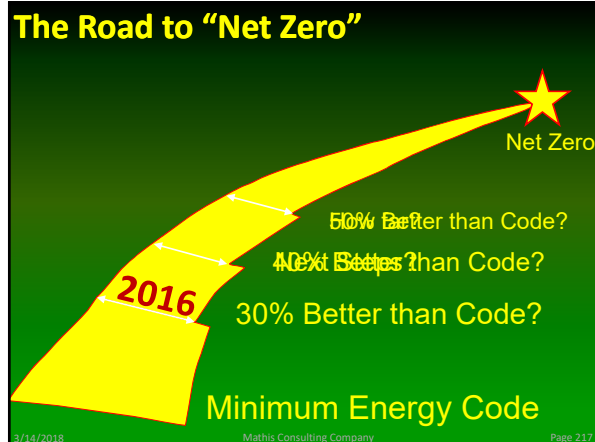
What the Code is NOT

- 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

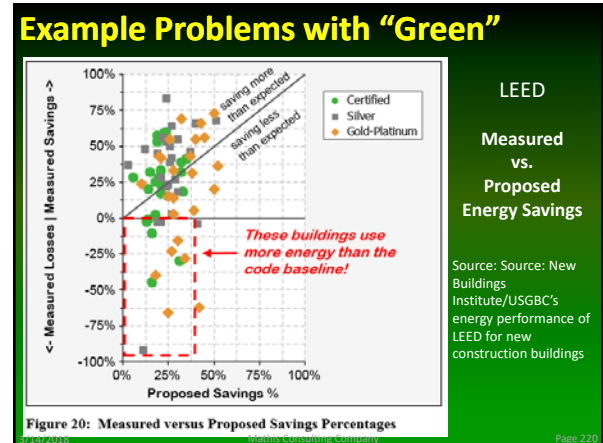
- Energy Star
- LEED
- Green Globes
- Building America
- Houses That Work
- And every other "beyond code" program...



Everybody Wants to be Green...

- ASHRAE 189
- ICC International Green Construction Code
- "It ain't easy..."
 - Standards
 - Ratings
 - Metrics
 - Boundary Conditions
 - How long?

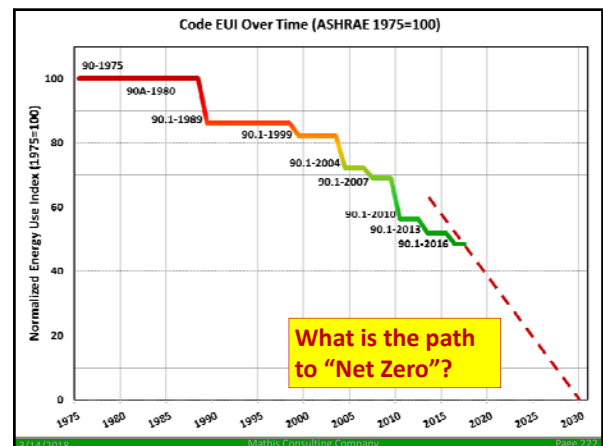
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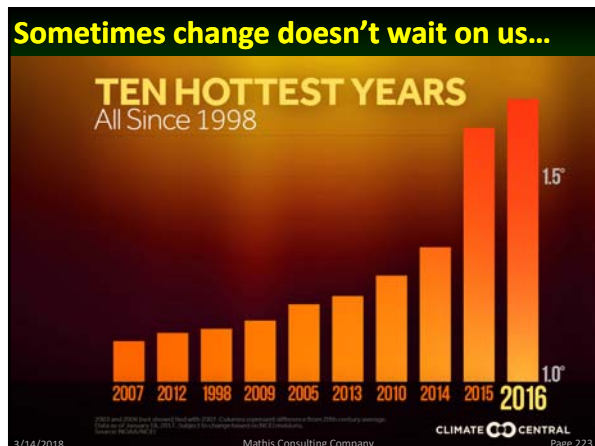


What About Those Other Objectives?

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

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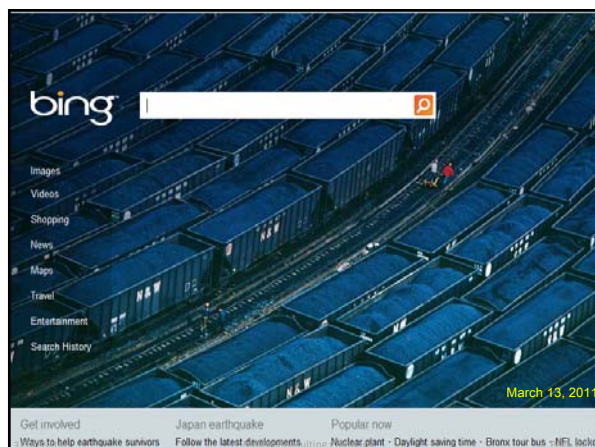




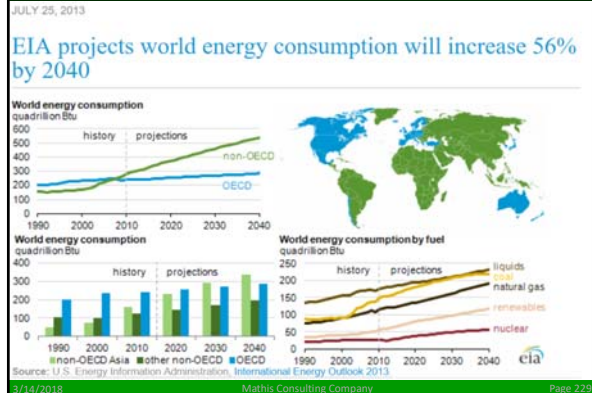
Our Leadership Responsibility

- **Get engaged! TEACH!**
 - Get engaged in local code adoption and 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

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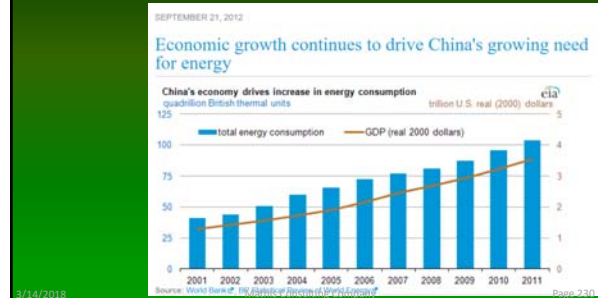
Recent Scary Numbers



Recent Scary Numbers

- 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...
- **The Latest Energy Code**
 - The Starting Point for Building Performance
 - Major Implications for Building Professionals
 - Critical Step in Building Industry Leadership

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The Future is in Our Hands



Thank You!

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