Why Buildings Matter:

and

The Future of Building Performance

Prioritizing the Building Envelope

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...**

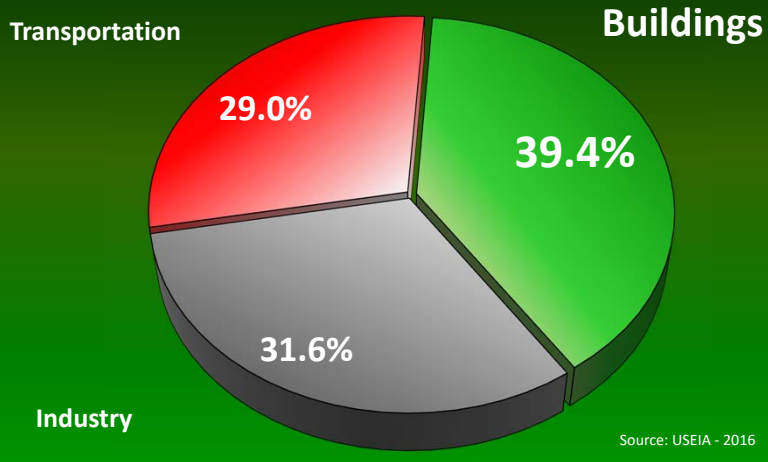
Critical Repeated Message for Today…

“Don’t do what we do!”
(Or did…)

Lessons learned…
Specifics follow…

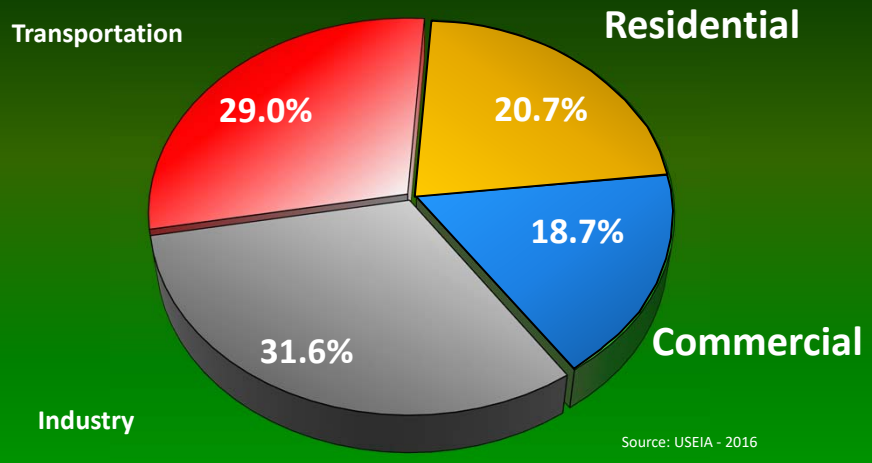
First,
Some Context…

Buildings Matter: US Energy Use

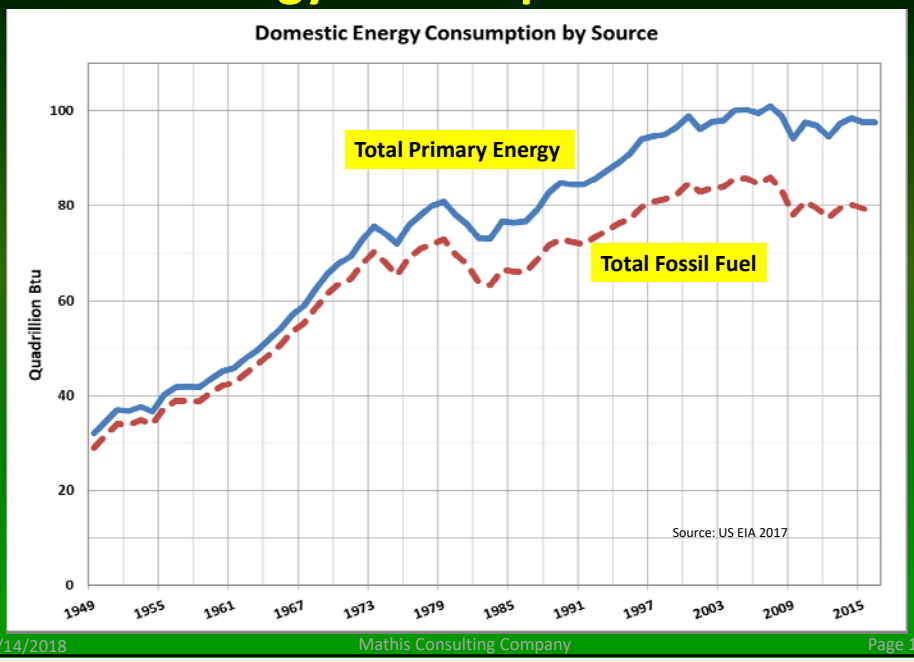


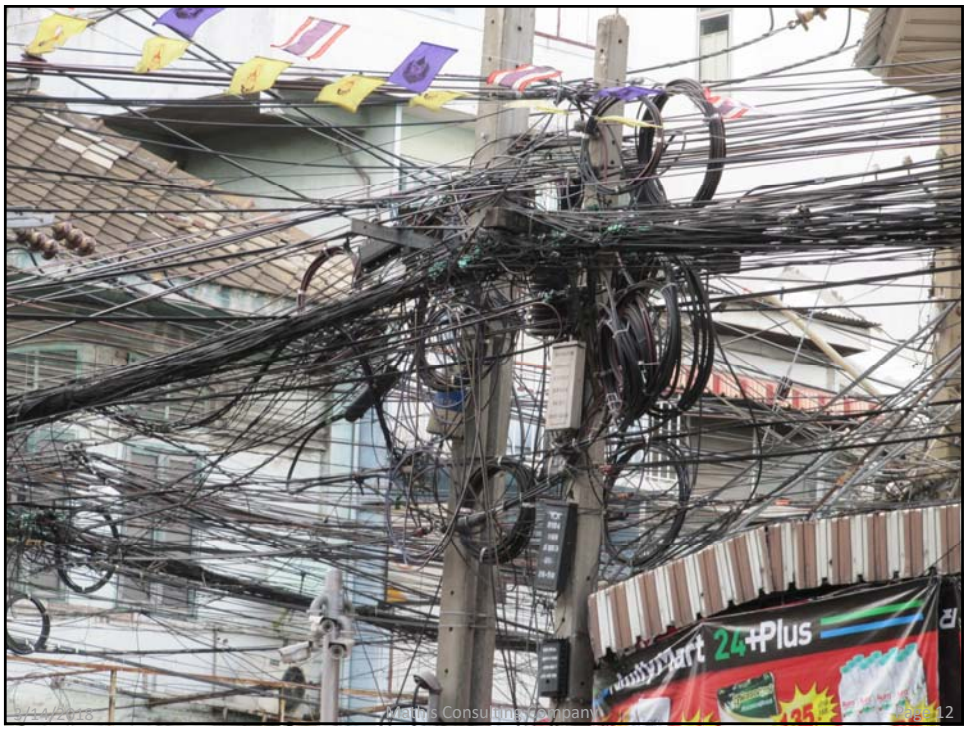
Source: USEIA - 2016

Buildings Matter: US Energy Use

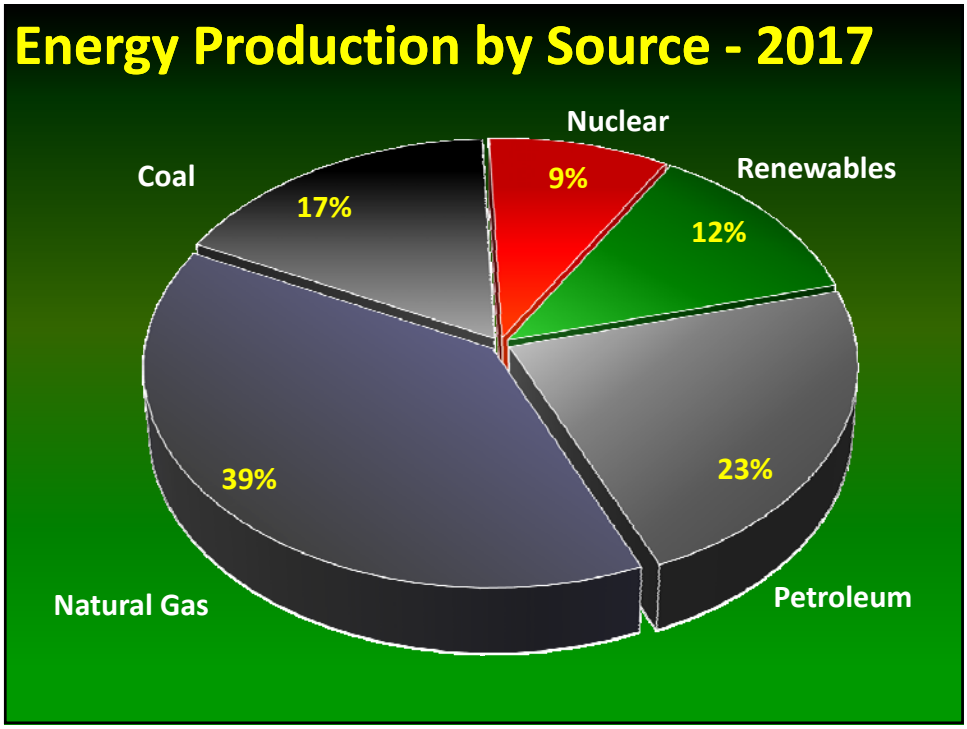


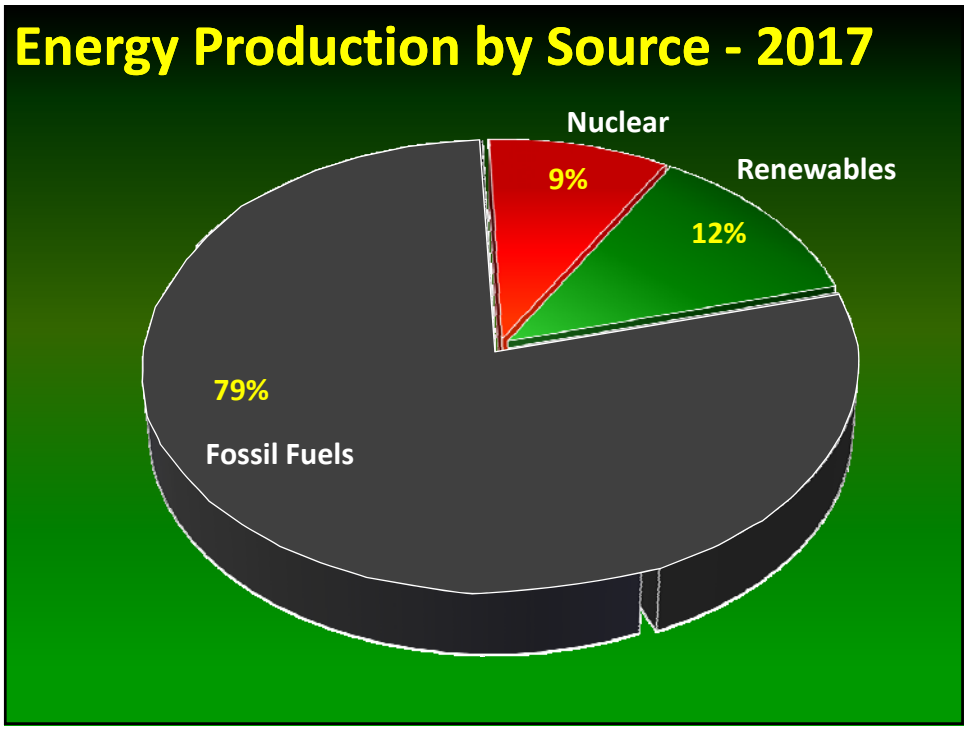
Total US Energy Consumption 1949 - 2015



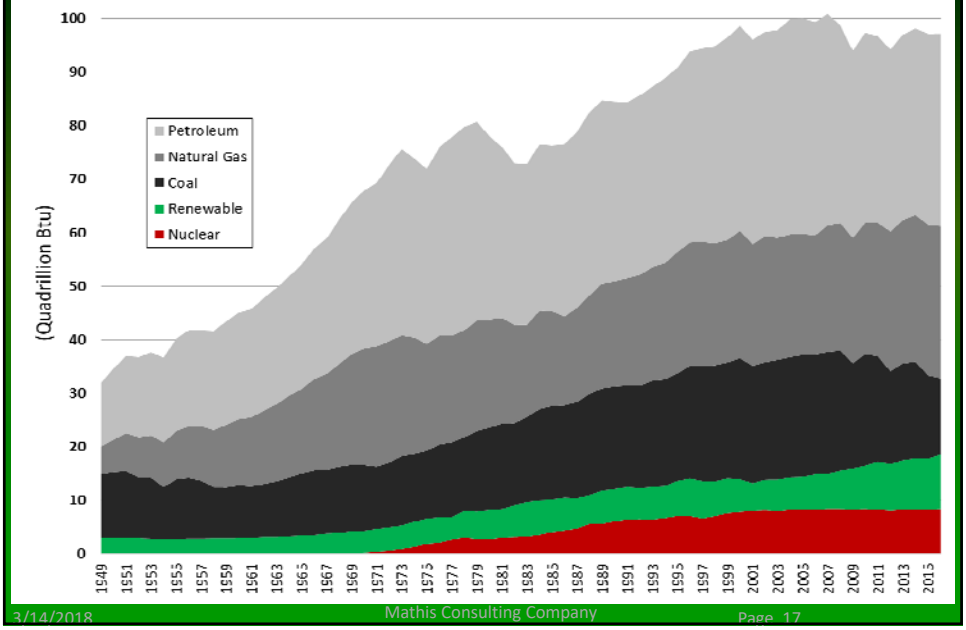

24+Plus


084-58

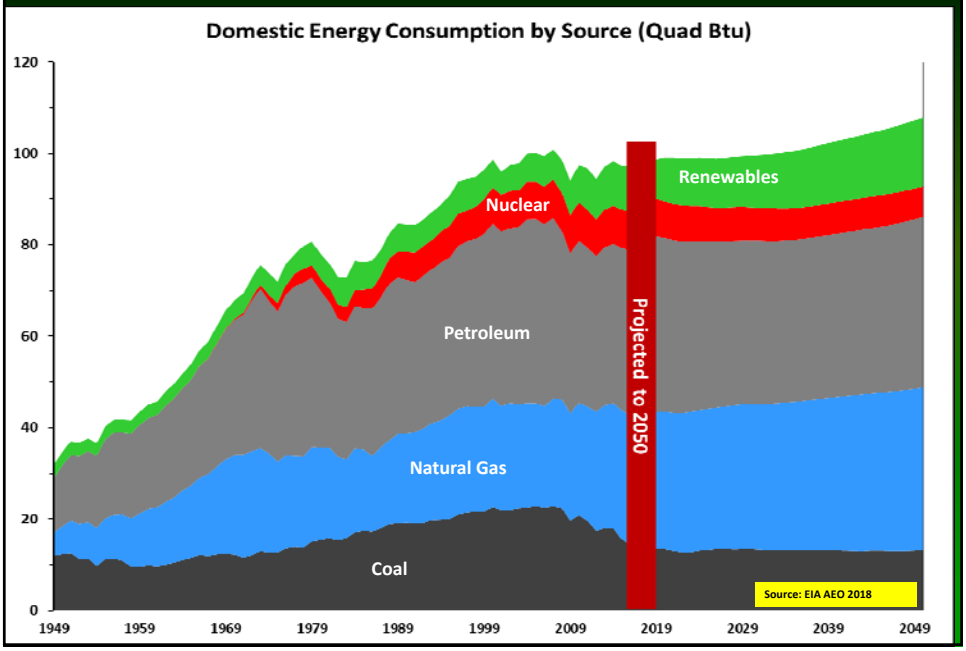

Energy Production by Source - 2017
Nuclear
9%
Renewables
12%
Coal
17%
23%
39%
Natural Gas
Petroleum


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

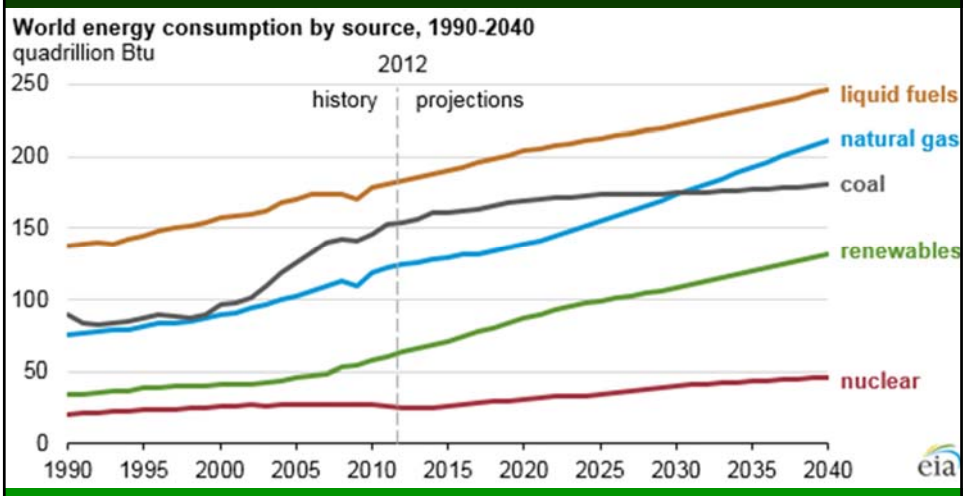
Total Energy by Source 1949 - 2015



Projections on the Future? (US to 2050)



World Energy Consumption by Fuel
1990 – 2040

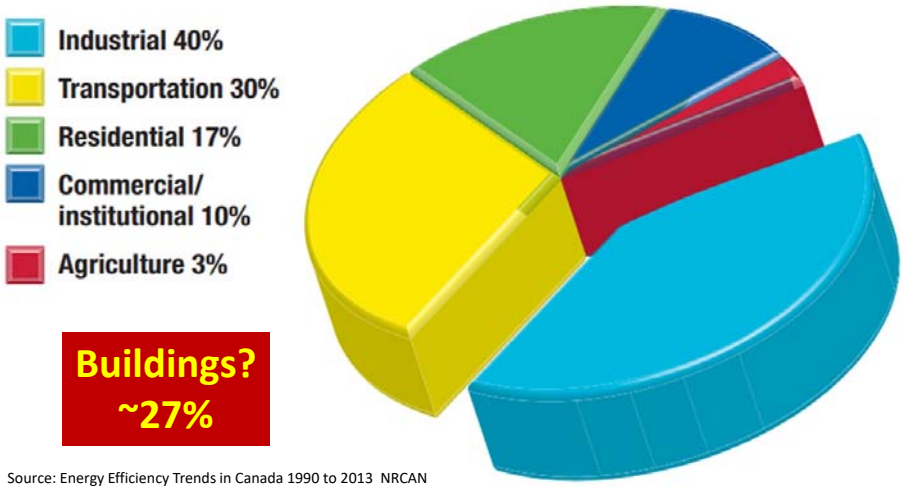


Don't Do What We Do!

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

Oh, Canada?

Figure 2.1 Secondary energy use by sector, 2013

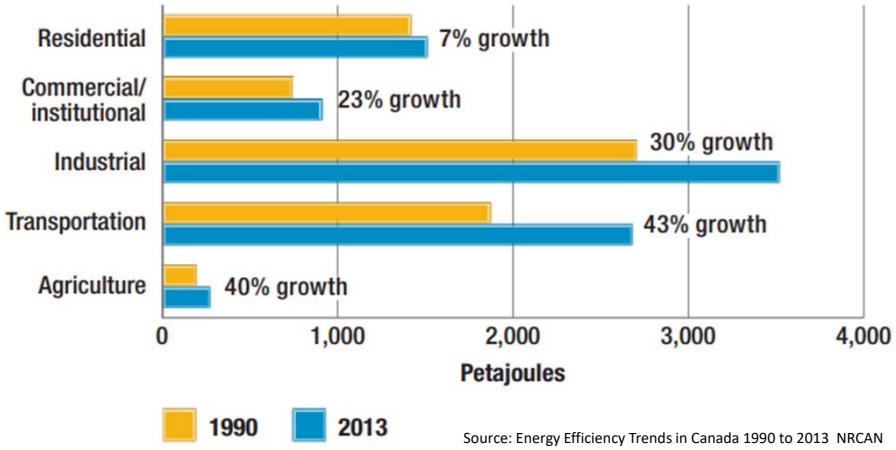


Buildings? ~27%

Source: Energy Efficiency Trends in Canada 1990 to 2013 NRCAN

Canada Energy Use Growth?

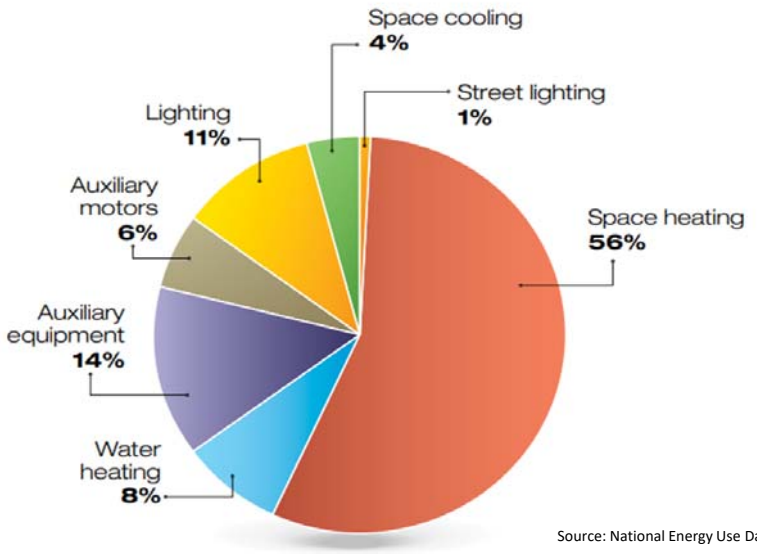
Figure 2.5 Total secondary energy use and growth rate by sector, 1990 and 2013



Source: Energy Efficiency Trends in Canada 1990 to 2013 NRCAN

Commercial Building Energy Use

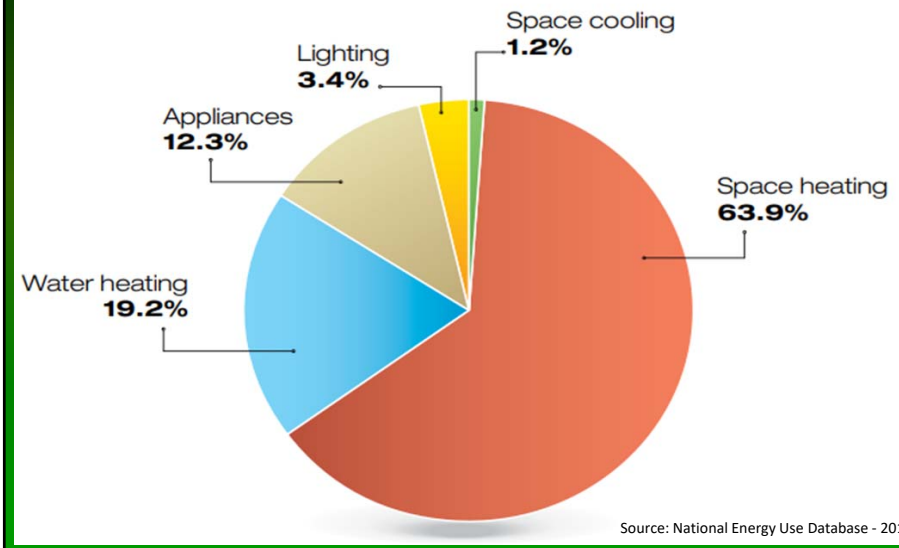
Figure 5. Commercial and institutional building energy use, 2014



Source: National Energy Use Database - 2014

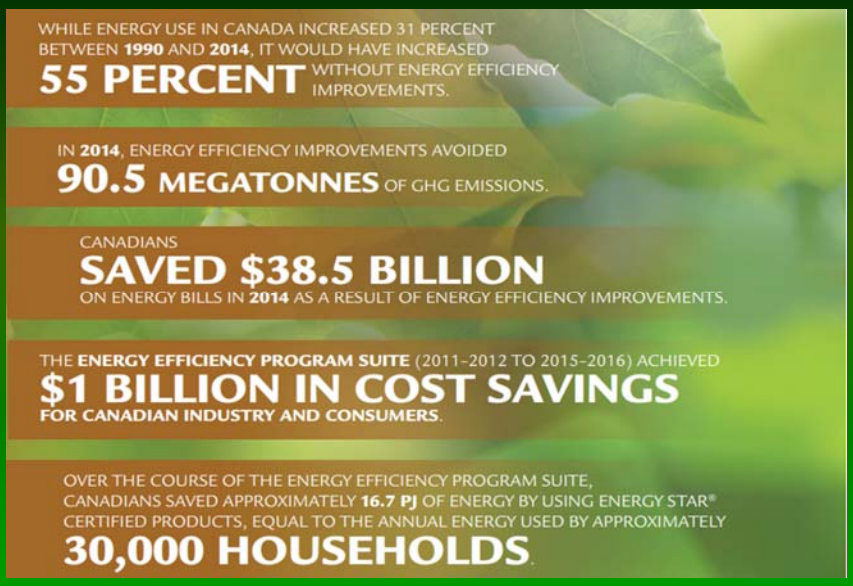
Residential Building Energy Use

Figure 4. Residential energy use, 2014



Source: National Energy Use Database - 2014

Canada Savings Perspectives

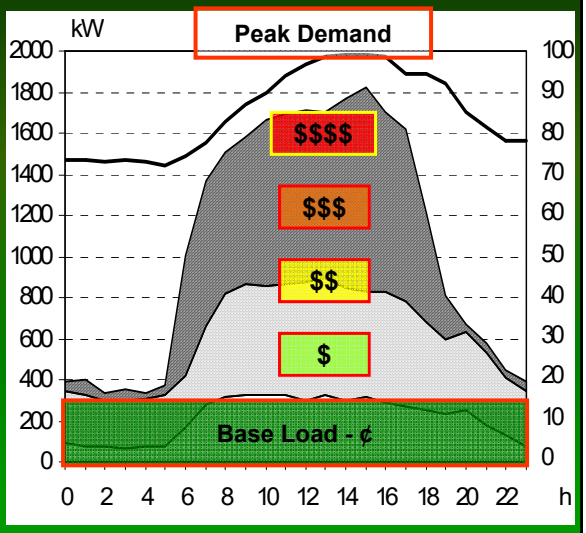


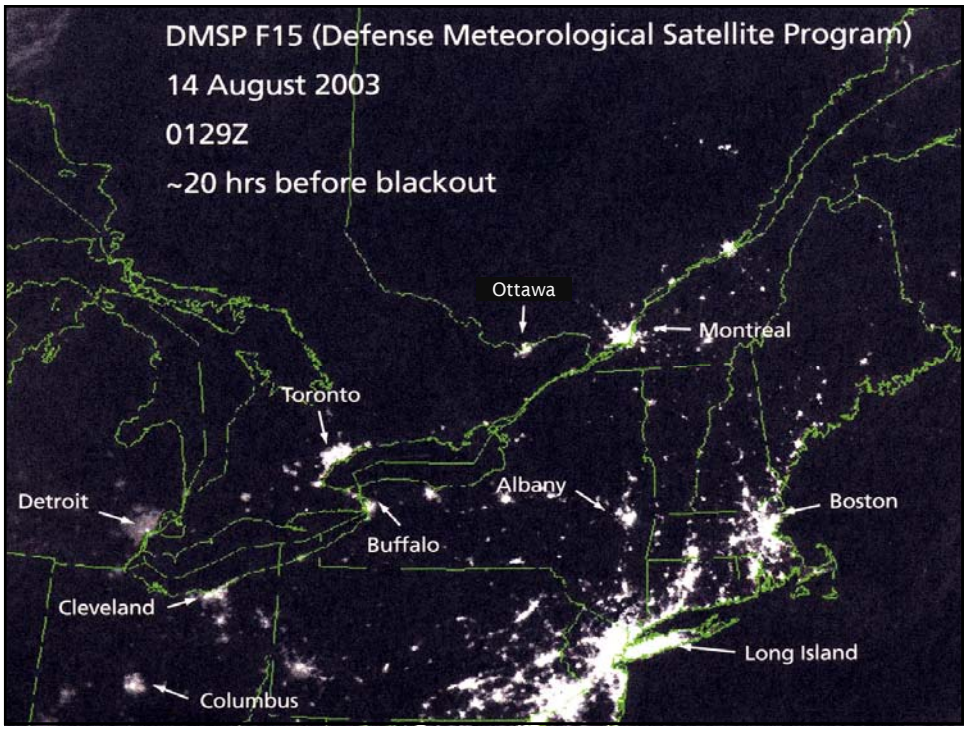
The Energy Megatrend

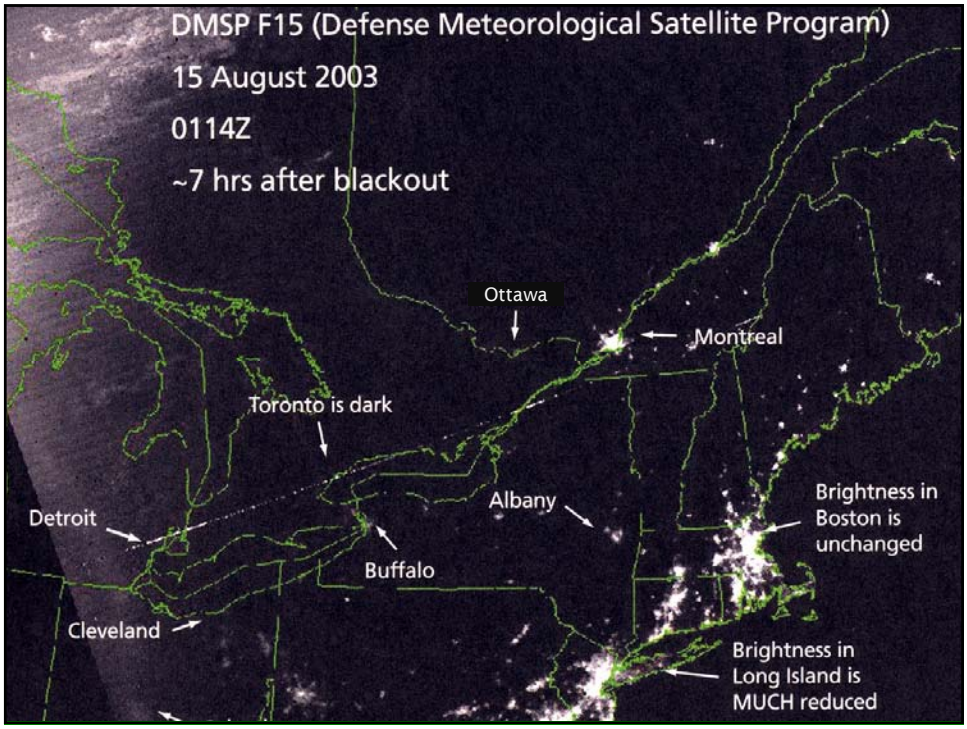
- Increasing demand
- Supply challenges
- Peak power issues
- Economic security
- Population change
- Water demand
- Available resources

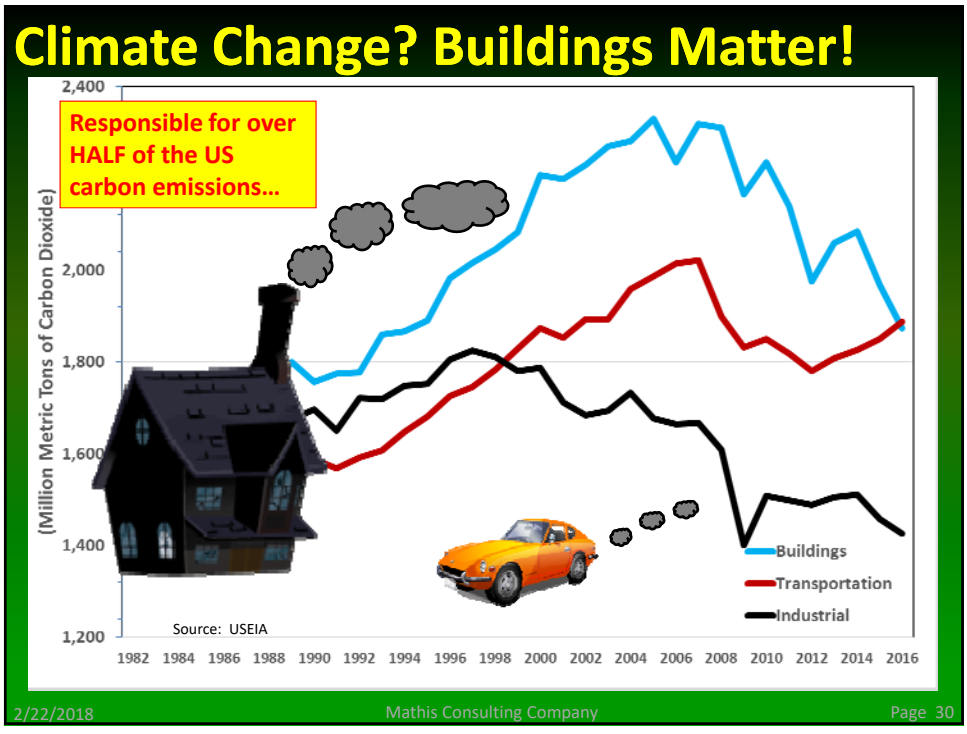
Utility Concerns

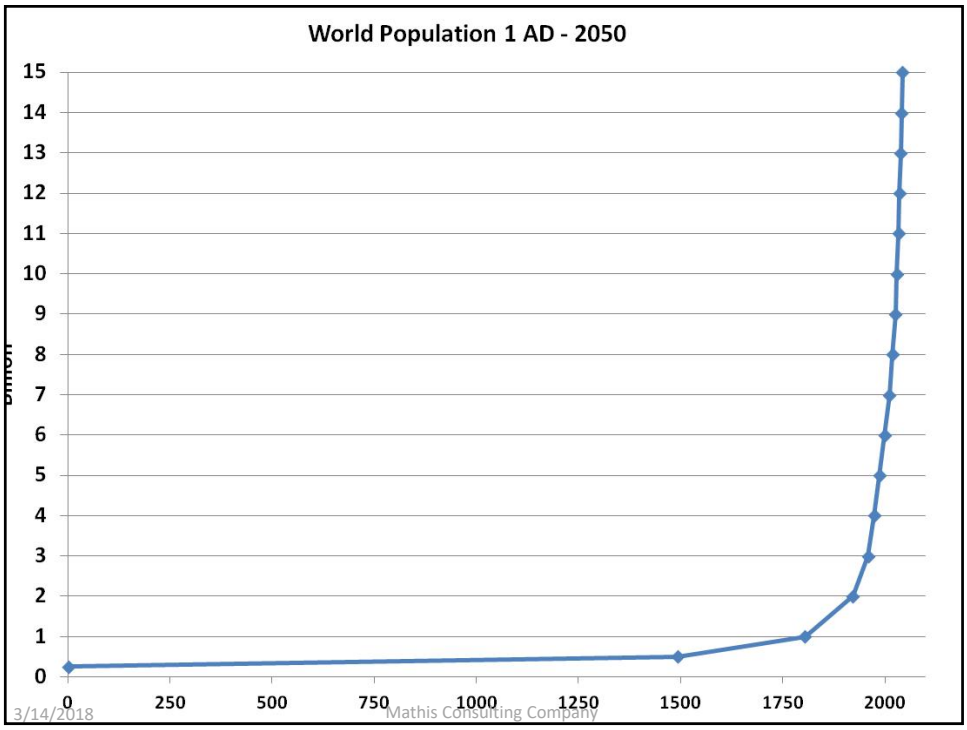
- The "Timing" of our Demand
  - Base Load
  - Peak Demand
  - Cooling Driven
  - Lighting Driven

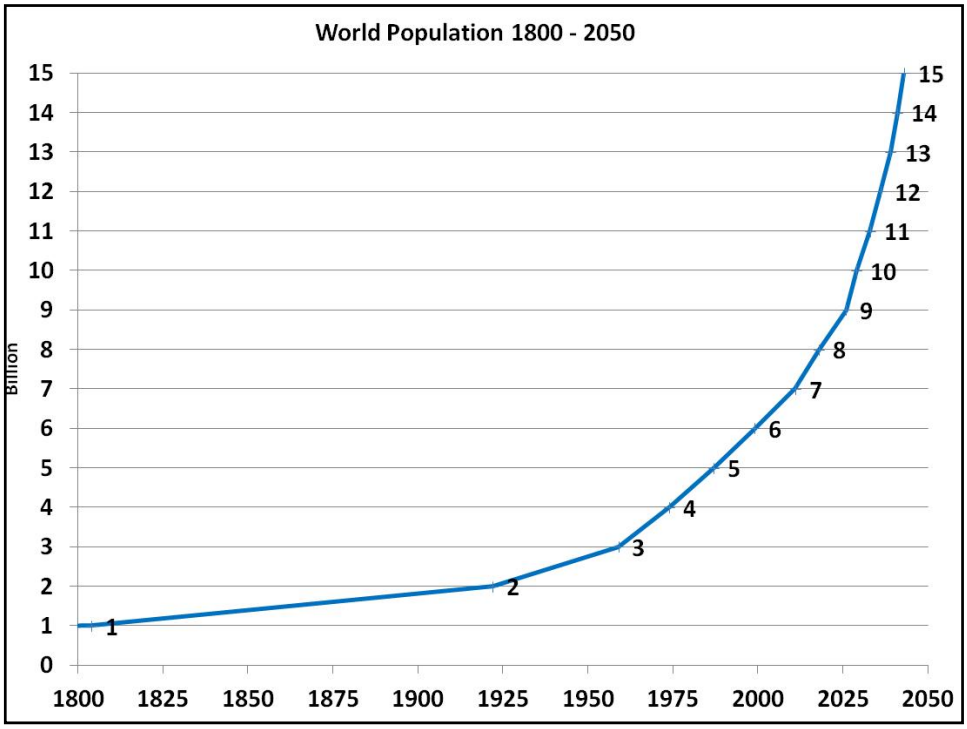


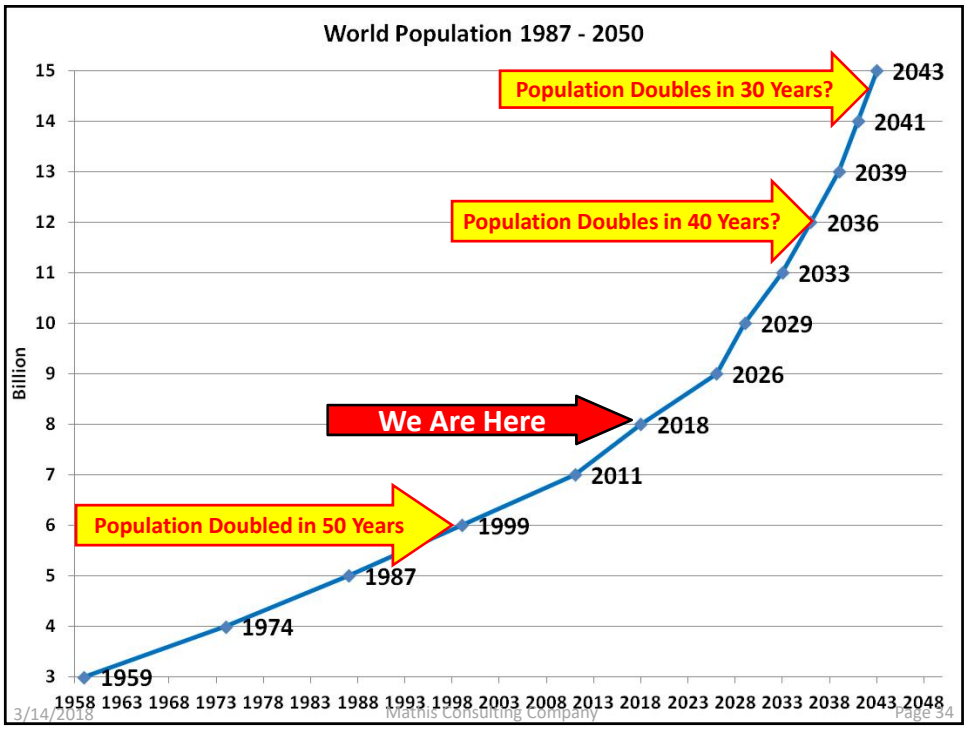



DMSP F15 (Defense Meteorological Satellite Program)
15 August 2003
0114Z
~7 hrs after blackout
Ottawa
Montreal
Toronto is dark
Albany
Detroit
Buffalo
Cleveland
Brightness in Boston is unchanged
Brightness in Long Island is MUCH reduced

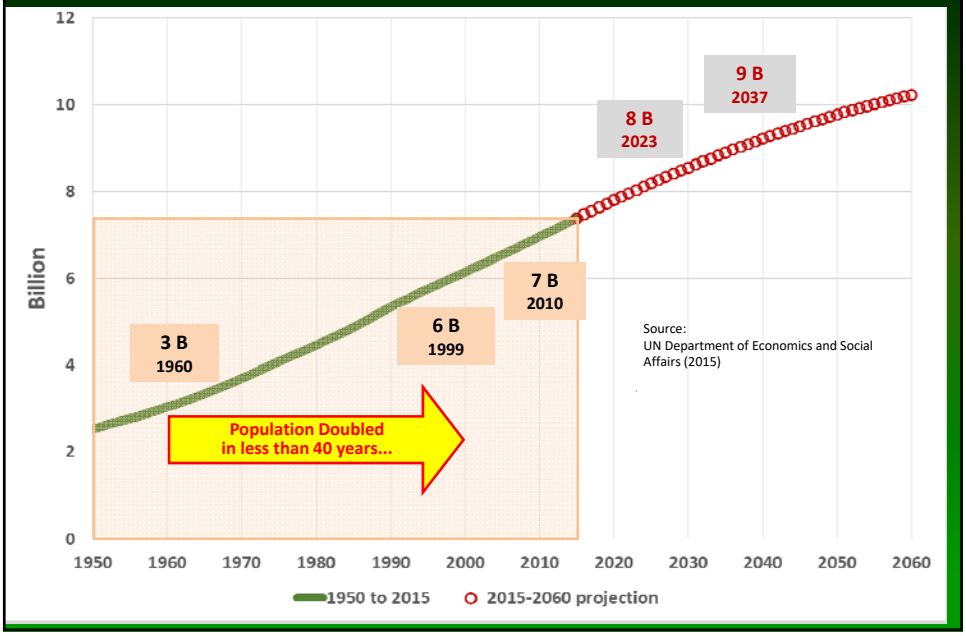

Climate Change? Buildings Matter!
Responsible for over HALF of the US carbon emissions…
(Million Metric Tons of Carbon Dioxide)
2,400
2,000
1,800
1,600
1,400
1,200
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Buildings
Transportation
Industrial
Source: USEIA
2/22/2018
Mathis Consulting Company
Page 30


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

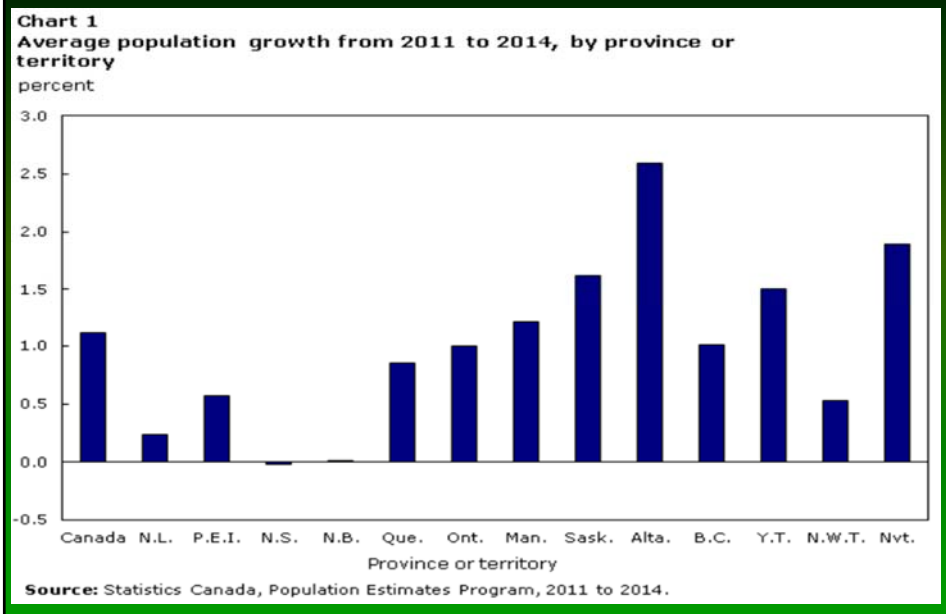

World Population 1800 - 2050
Billion
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1800 1825 1850 1875 1900 1925 1950 1975 2000 2025 2050
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


World Population 1987 - 2050
Billion
3 4 5 6 7 8 9 10 11 12 13 14 15
1958 1963 1968 1973 1978 1983 1988 1993 1998 2003 2008 2013 2018 2023 2028 2033 2038 2043 2048
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

World Population Projections to 2060

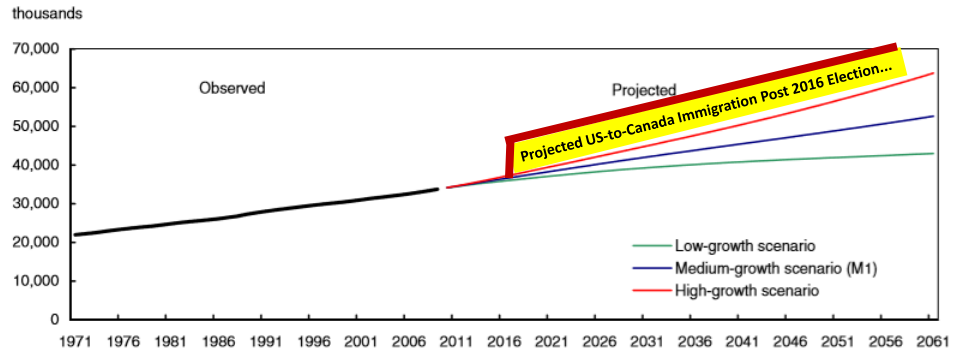


Population Growth 2011-2014



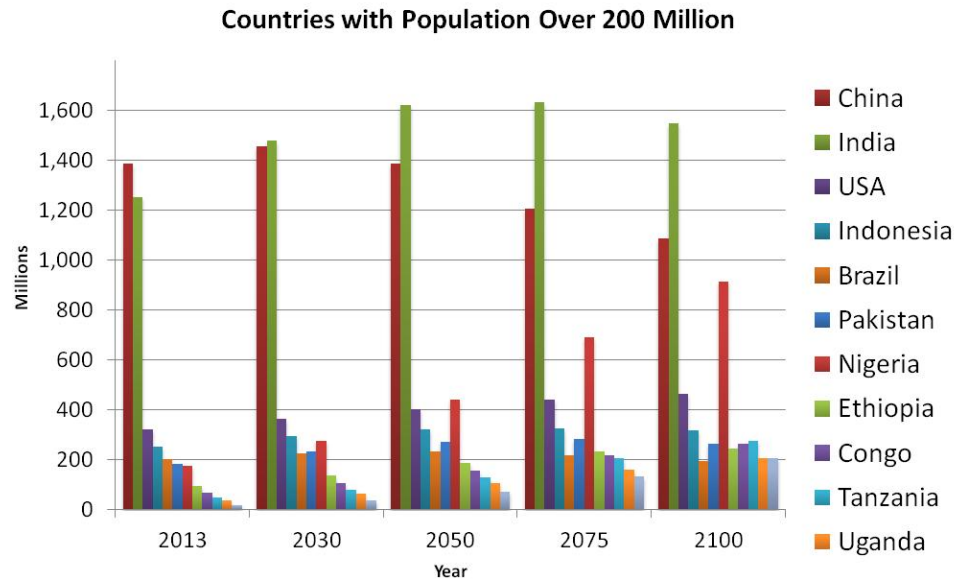
Projected Population Growth...?

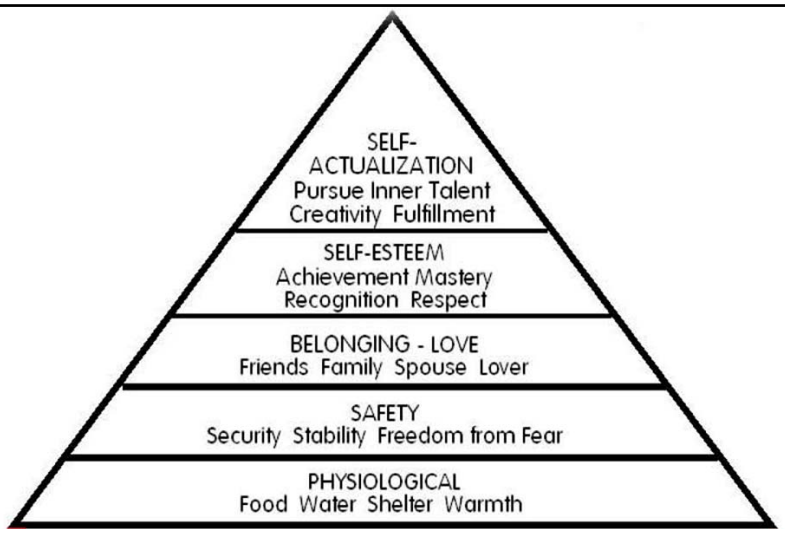
Chart 3.1
Population observed (1971 to 2009) and projected (2010 to 2061) according to three scenarios, Canada



Source(s): Statistics Canada, Demography Division.

World Population Trends...





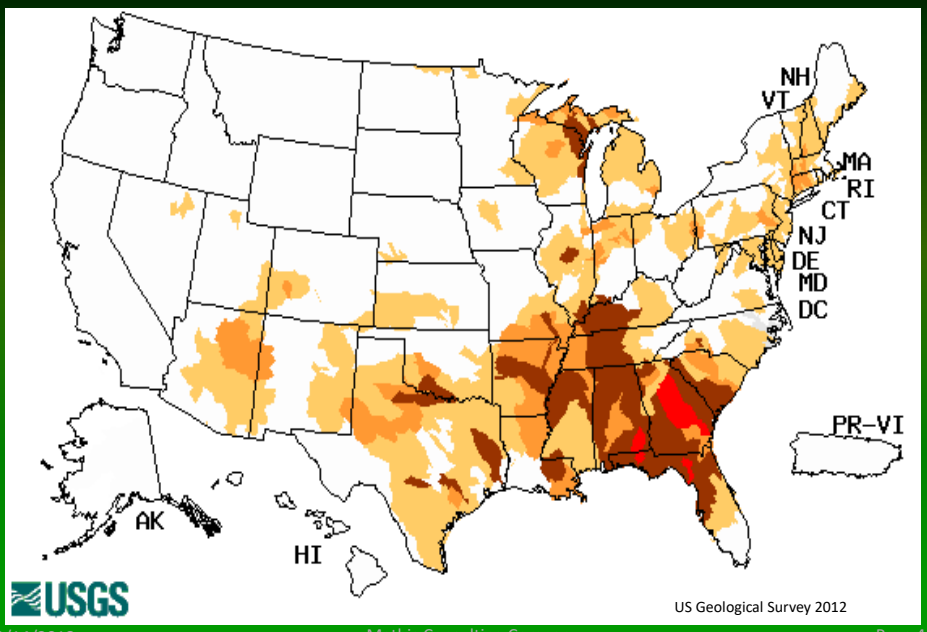
Maslow's "Hierarchy of Need"

Energy and Water

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

US News, 11/22/2012

Water Implications…



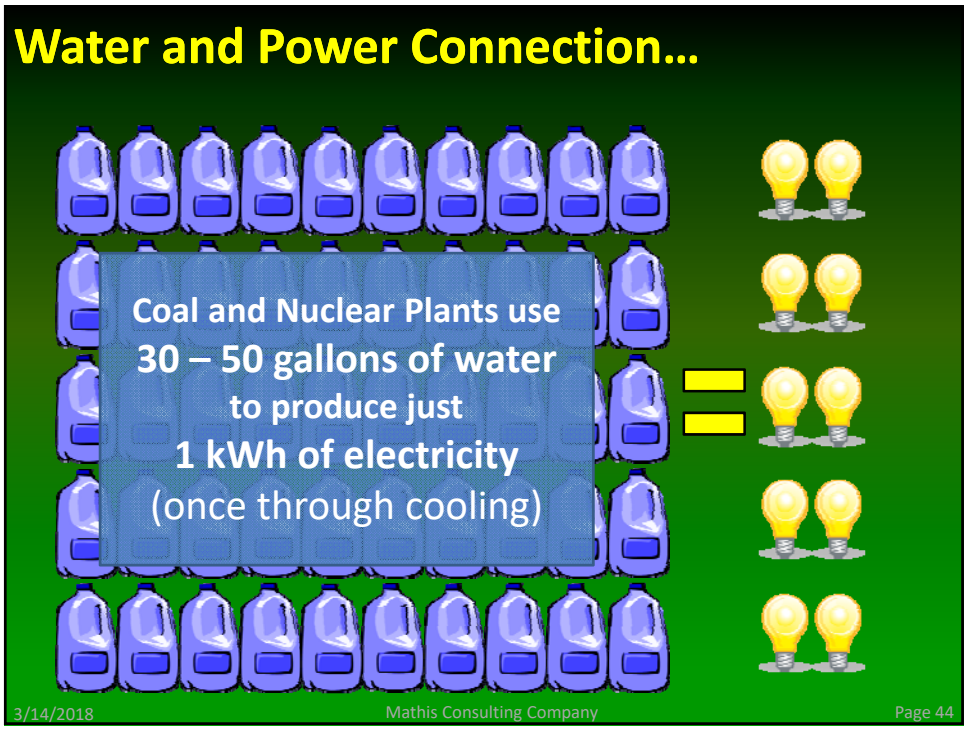
Power and Water

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

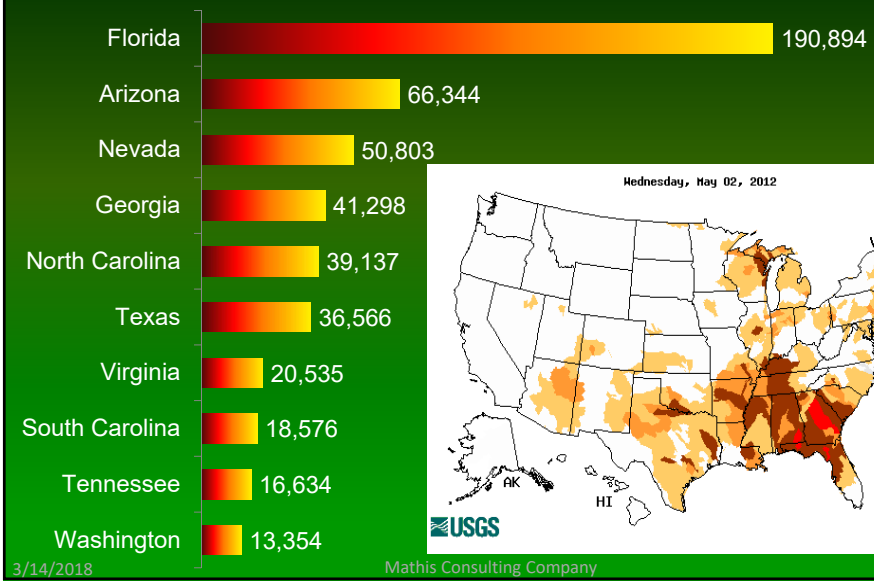
Over half of the withdrawn water in the US…

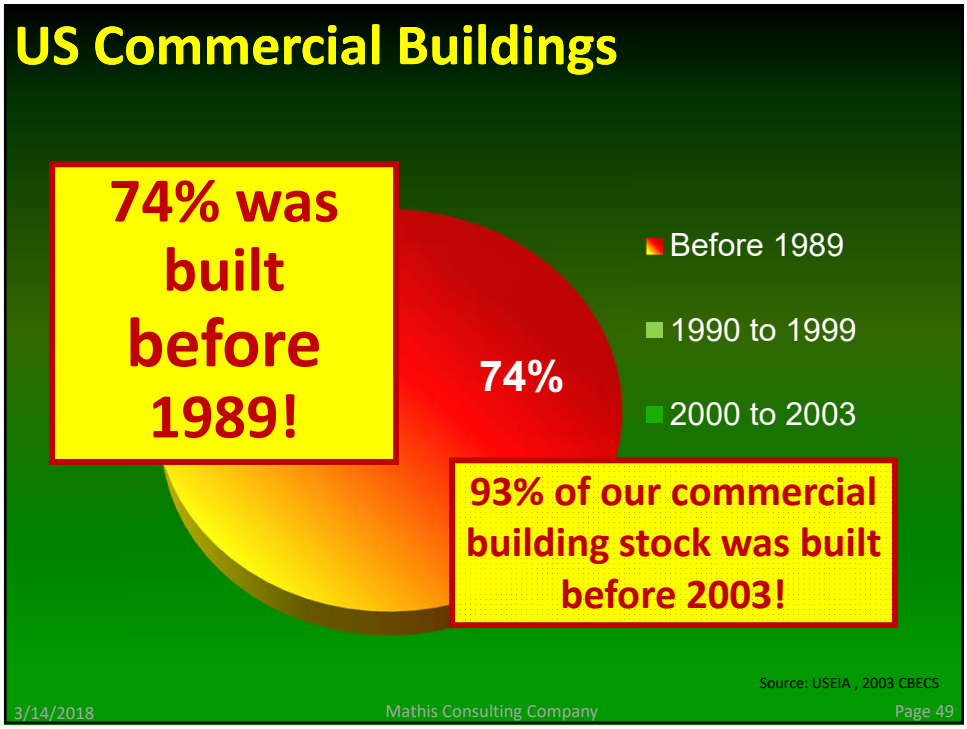
Sources: Union of Concerned Scientists 2011, USGS 2012

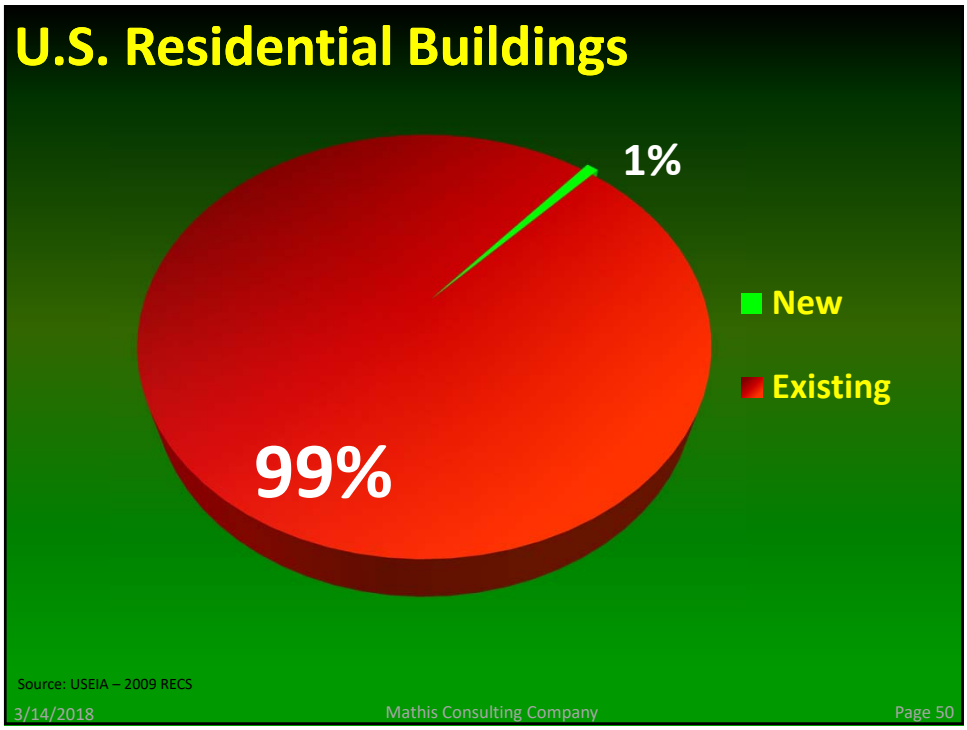

Niagara Falls
The volume of water flowing through America's electric utilities is 3 TIMES the amount flowing over Niagara Falls!
Niagara Falls State Park and USGS
Mathis Consulting Company


Water and Power Connection…
Coal and Nuclear Plants use
30 – 50 gallons of water
to produce just
1 kWh of electricity
(once through cooling)
3/14/2018
Mathis Consulting Company
Page 44

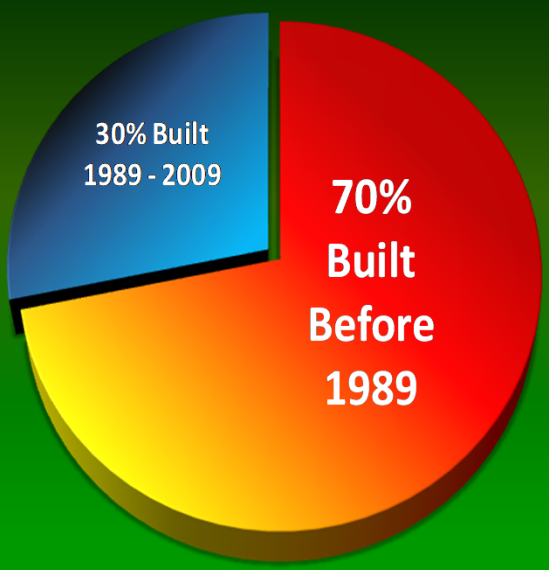
Annual Net Migration 2000 - 2004




US Commercial Buildings
74% was built before 1989!
74%
Before 1989
1990 to 1999
2000 to 2003
93% of our commercial building stock was built before 2003!
Source: USEIA , 2003 CBECS
3/14/2018
Mathis Consulting Company
Page 49


U.S. Residential Buildings
1%
99%
New
Existing
Source: USEIA – 2009 RECS
3/14/2018
Mathis Consulting Company
Page 50

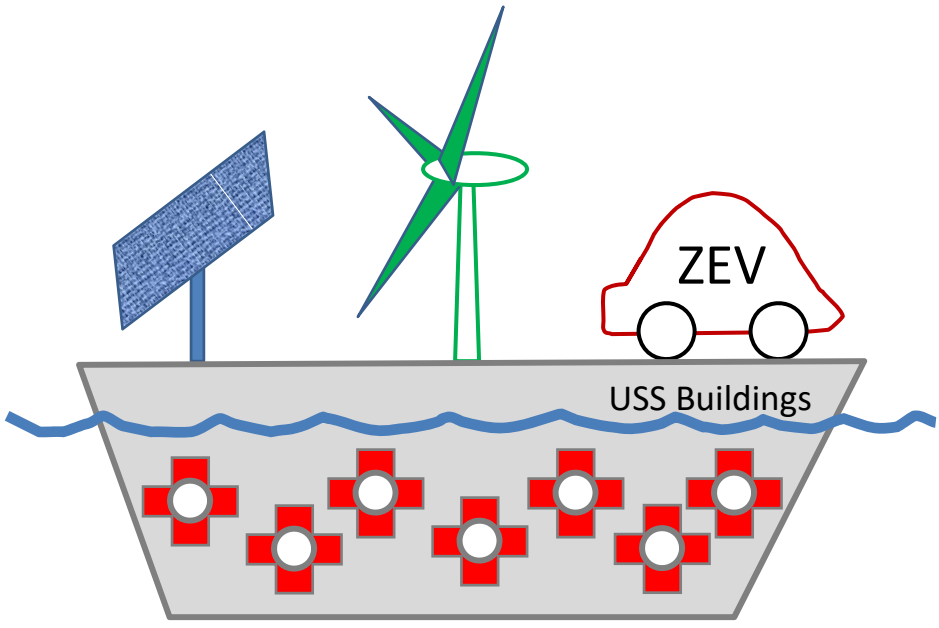
Age of U.S. Homes…



Source: USEIA – 2009 RECS

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



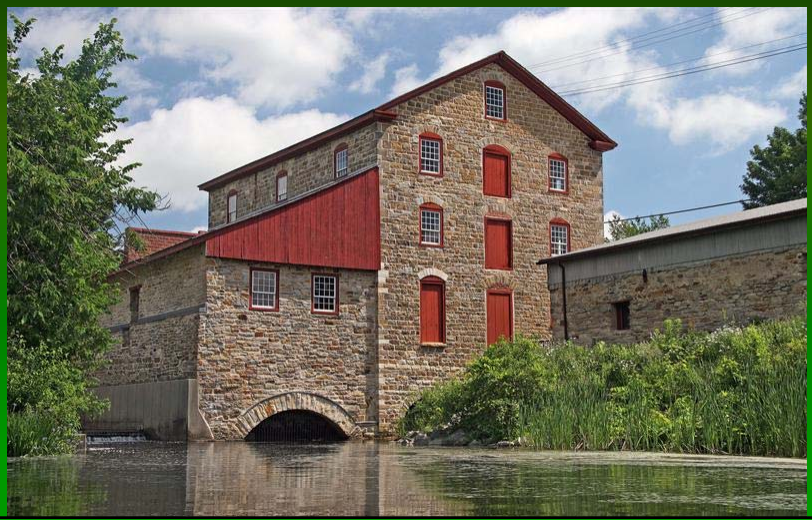
FIRST: *"Plug the Holes in the Ship!"*

Some of the Oldest Buildings in Canada

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

Old Stone Mill, Delta, Ontario

- **1810**
  - ~207 years old…



157 years…

- Holy Trinity Anglican Church, Saskatchewan
  - 1860

267 years…

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

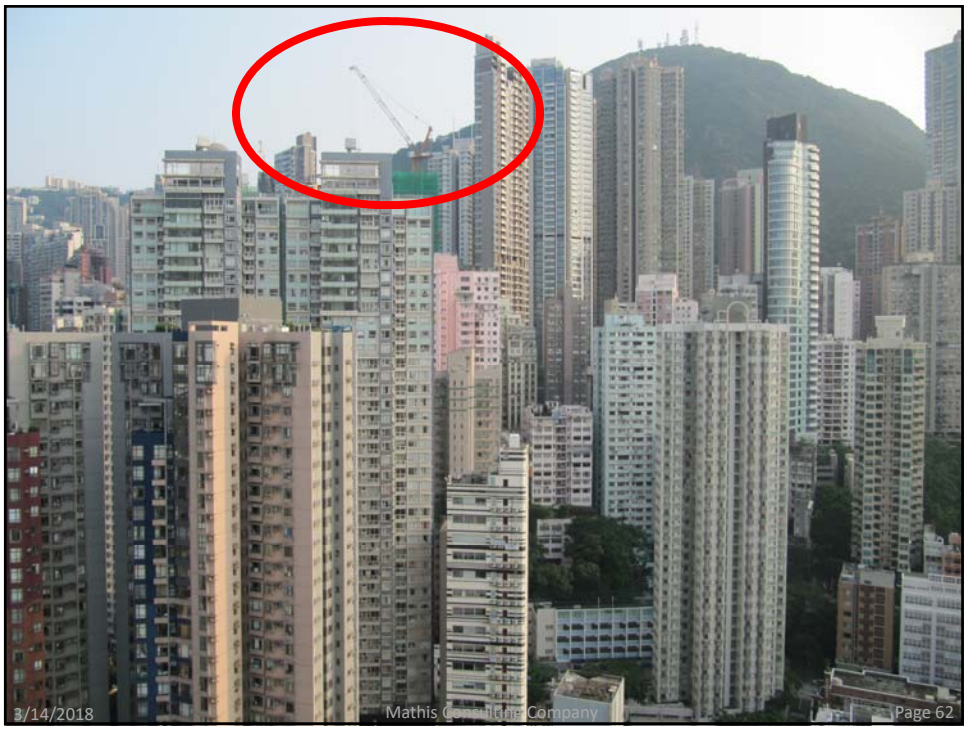
333 years and counting…

- Le Séminaire de Saint-Sulpice, Quebec
  - 1684

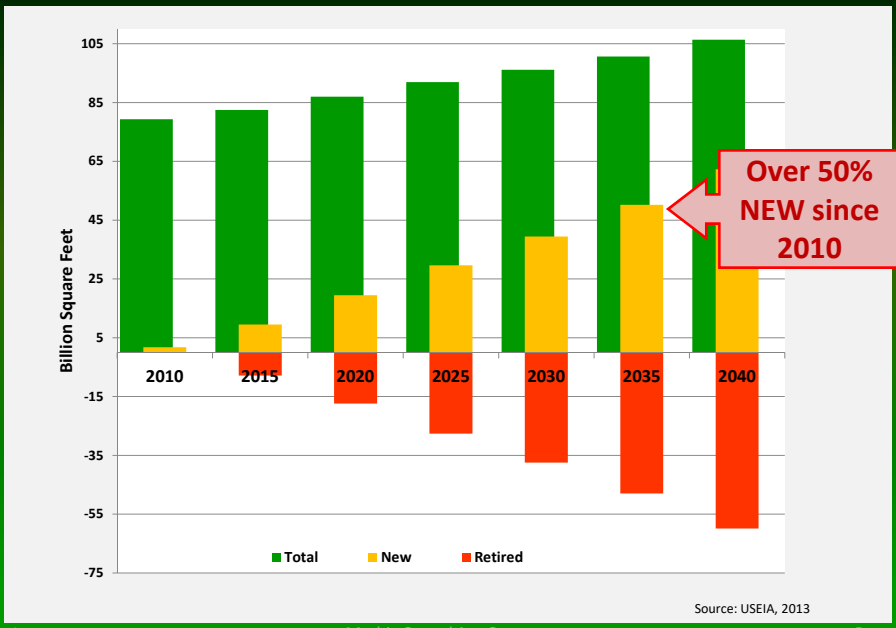
370 years and counting…

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

Some Trends…



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 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

"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.

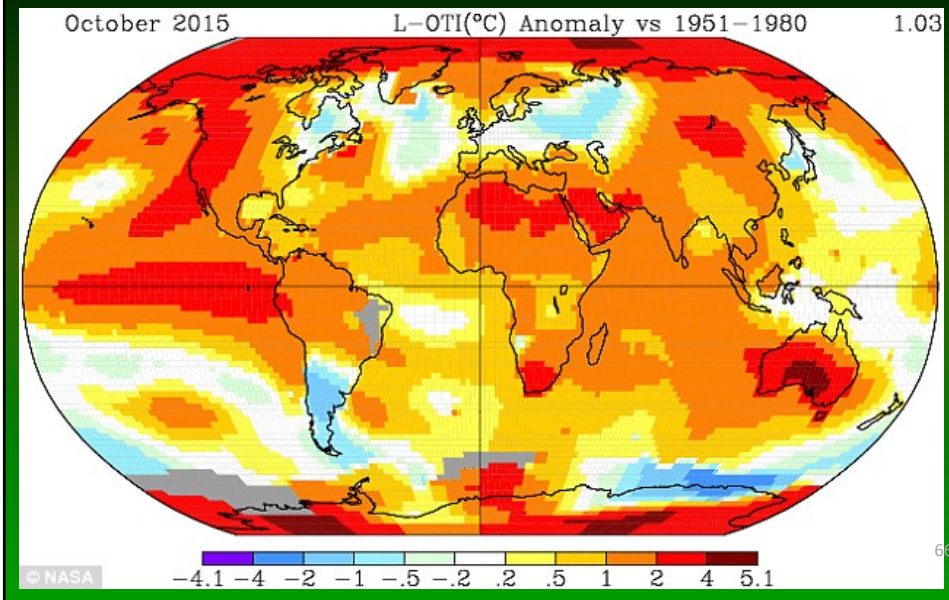
Parts of eastern Scandinavia and western Russia, eastern and southern Asia and scattered areas in central and northern North America were cooler than average.

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

SHARE

TWEET

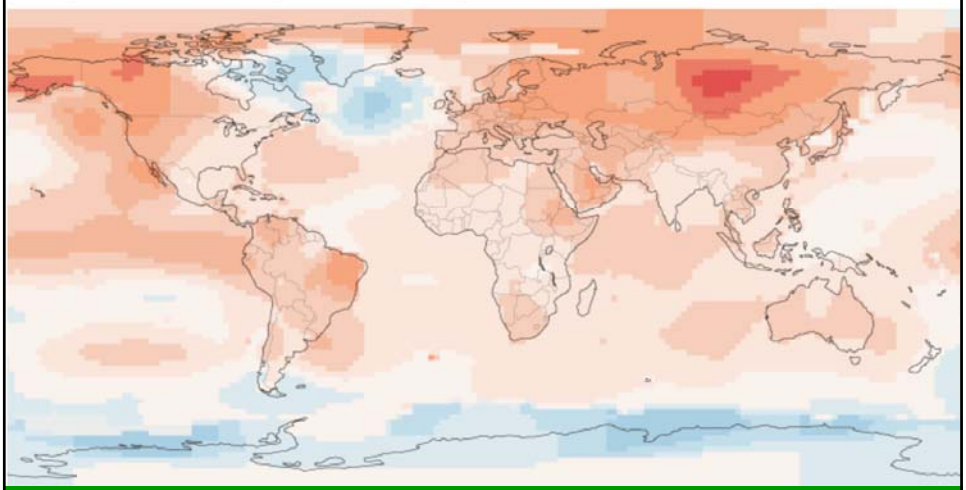
SHARE

EMAIL

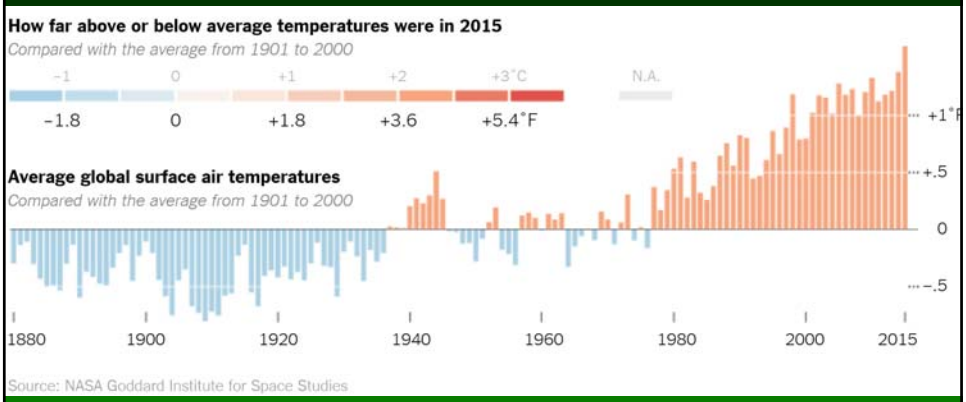
The World is Getting Warmer…

The Hottest Year on Record

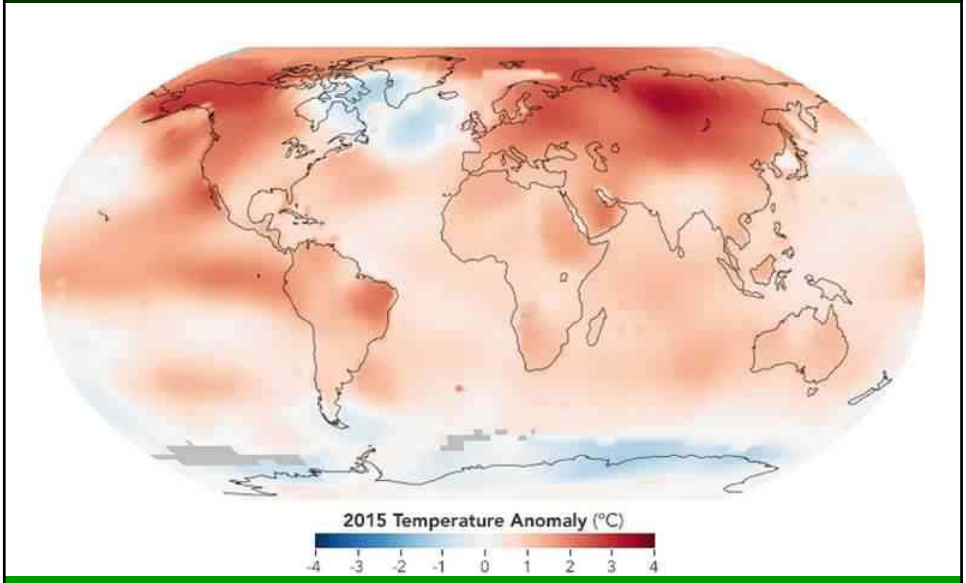
Globally, 2015 was the warmest year in recorded history.

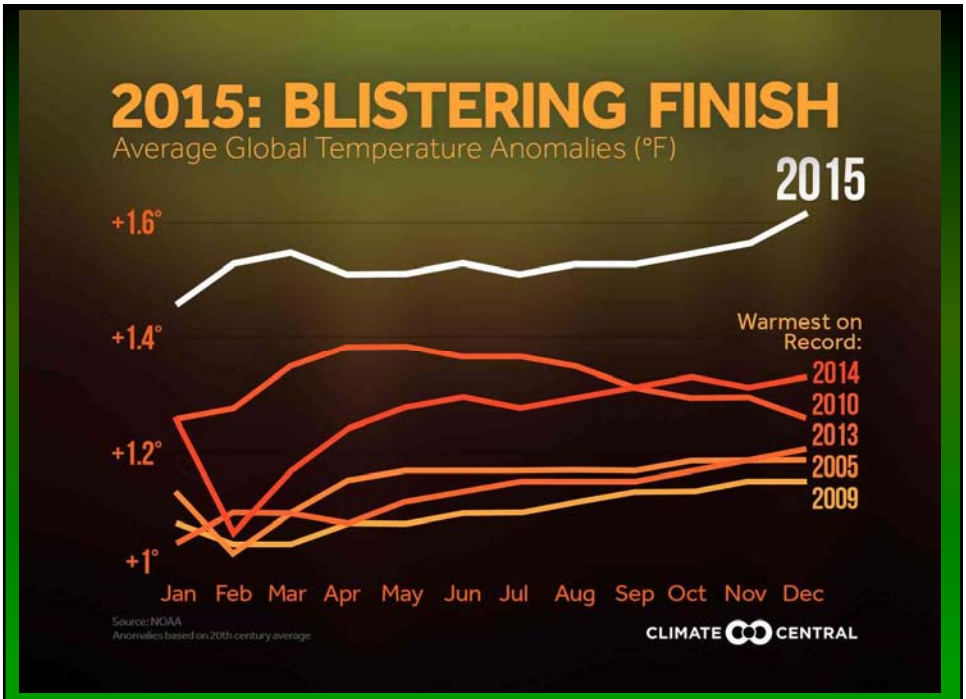


2015: Warmest Year in Modern Record Keeping



How Far From "Normal"?




2015: BLISTERING FINISH
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

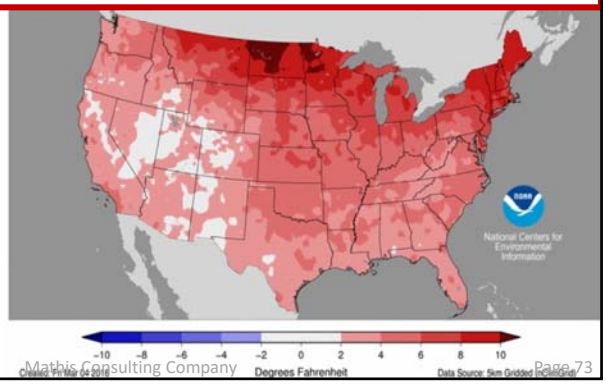
3/9/16…

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

Published: March 8th, 2016

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 48 28 339

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.

July 2016

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

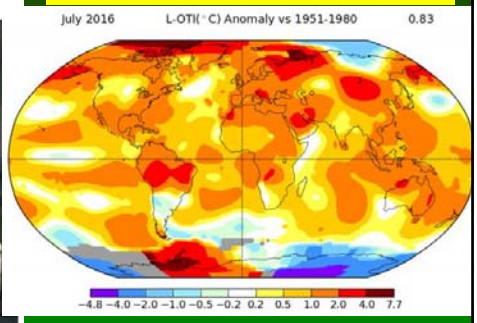
NP SETH BORENSTEIN, THE ASSOCIATED PRESS | August 16, 2016 8:47 AM ET
More from The Associated Press

People cool off in Baghdad in July, where temperatures soared to 51 C. NASA calculated that July 2016 was 0.84 degrees Celsius warmer than the 1950-1980 global average, making it the hottest month in recorded history. AP Photo / Karim Kadim

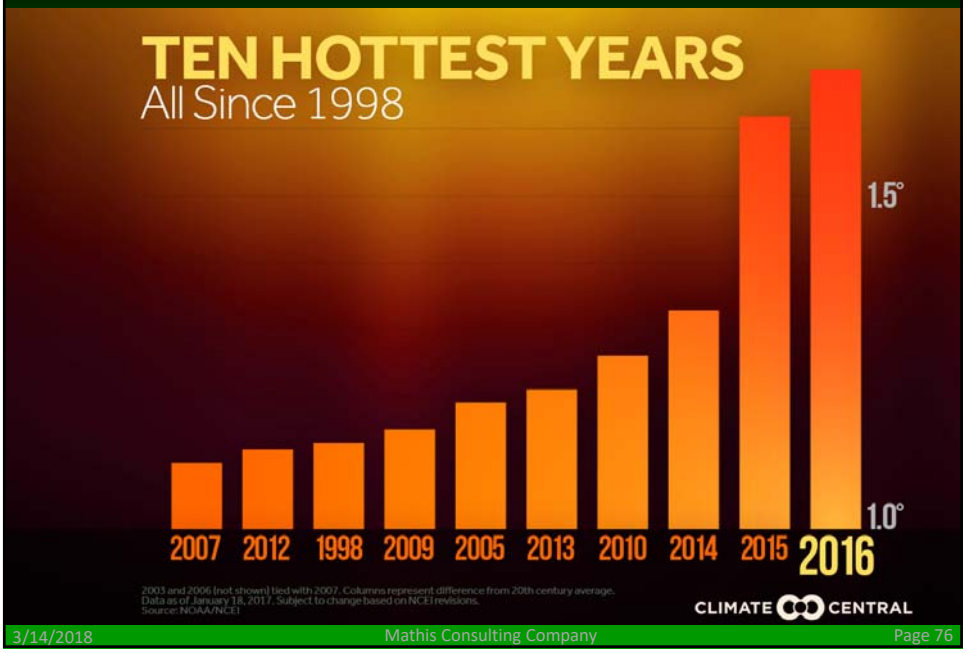
Twitter | Google+ | Reddit | Email | Typo? | More

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

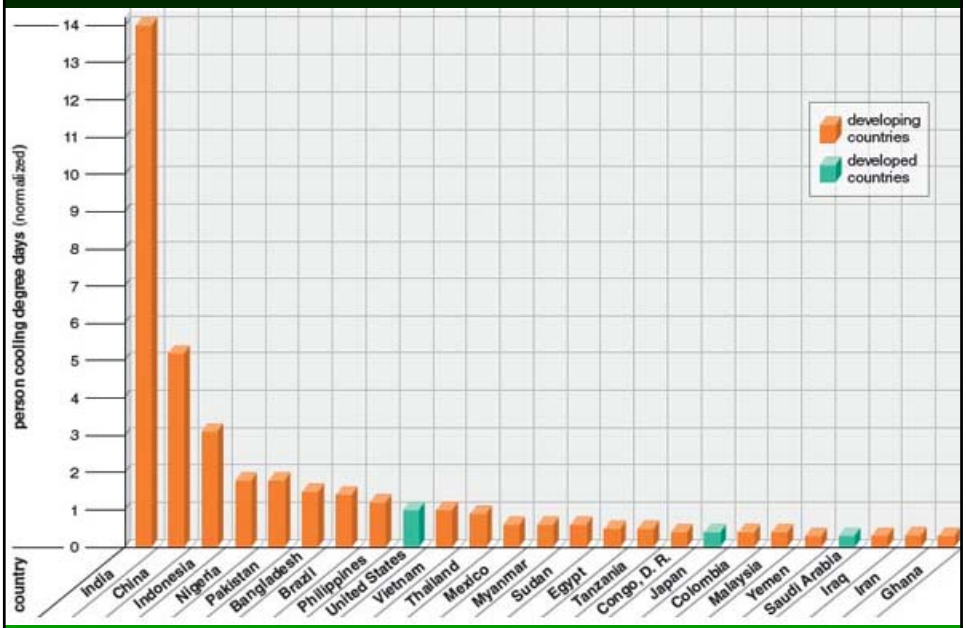
Hottest month in recorded history…



2016: The Trend Continues…



Air Conditioning for Everyone?

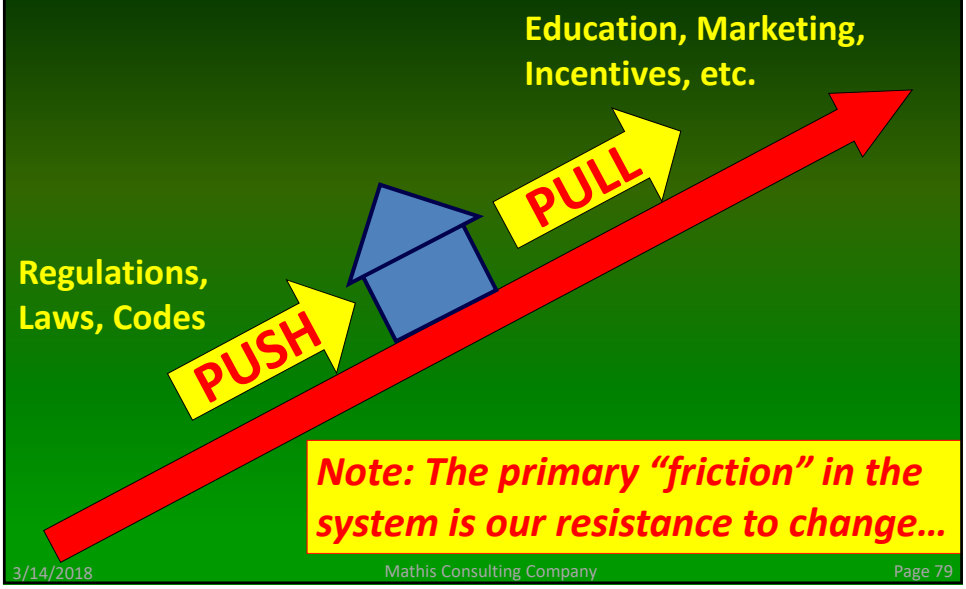


Built Environment Trends - 3

- **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 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 3760 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

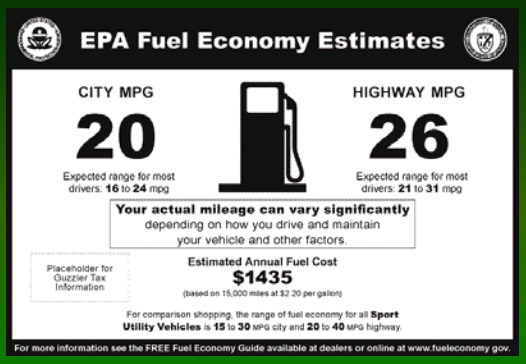
First Energy Code Milestone

- **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

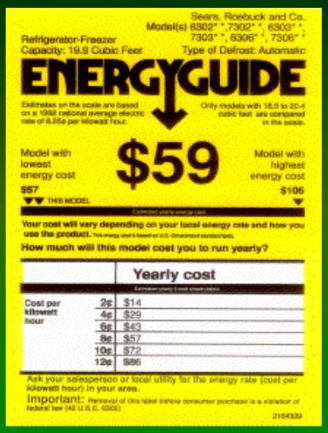
What Did We Do After 1973?

- **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?



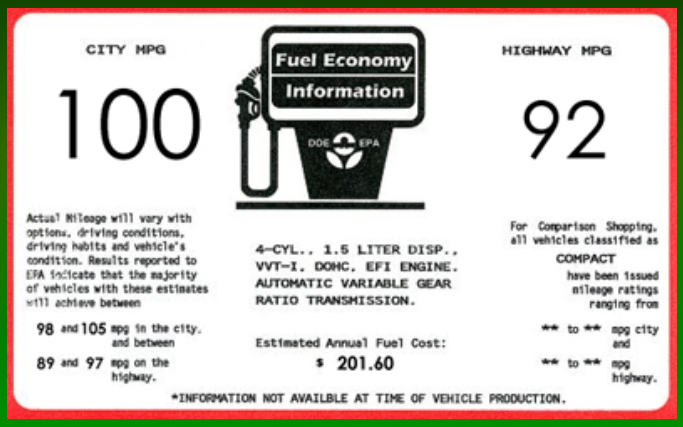
Automotive



Appliances

Consumer Signals About Energy!
A Means of Comparison…

What's Possible?

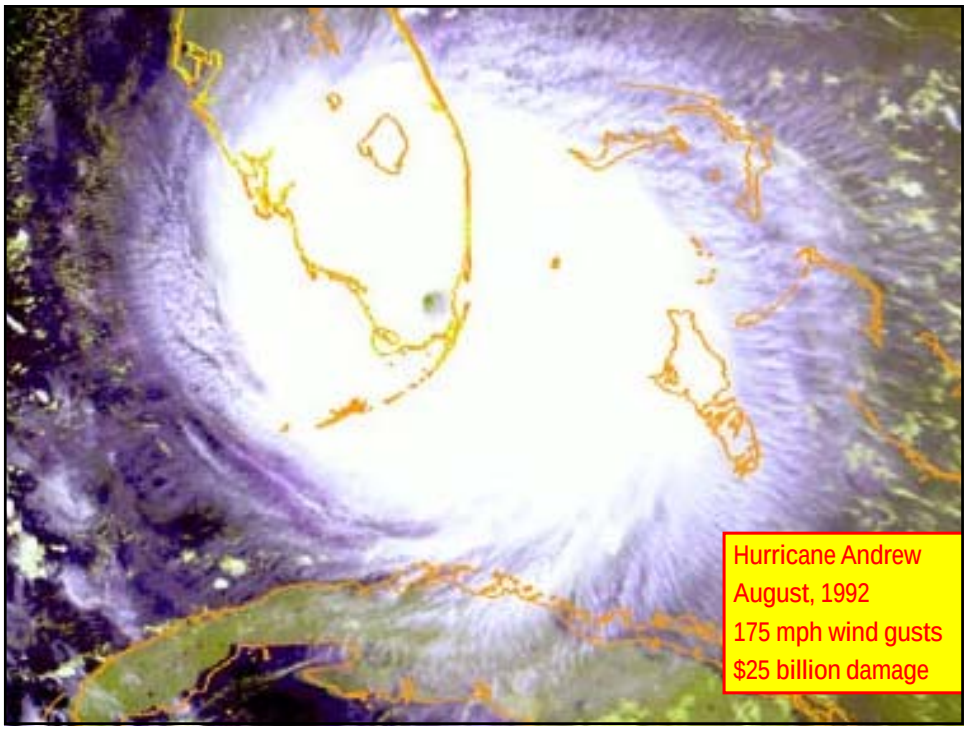


Energy Code Evolution…

Early Energy Code Solutions

Do you suspect a "Floor Insulation Challenge"

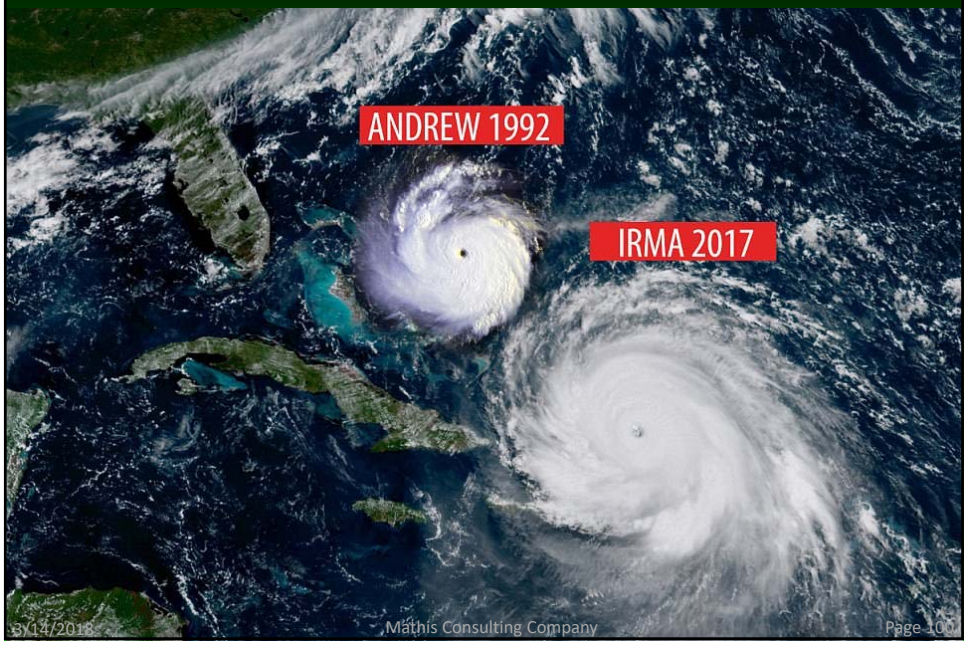

How about
MANY
"Floor Insulation
Challenges"?


Hurricane Andrew
August, 1992
175 mph wind gusts
$25 billion damage

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…

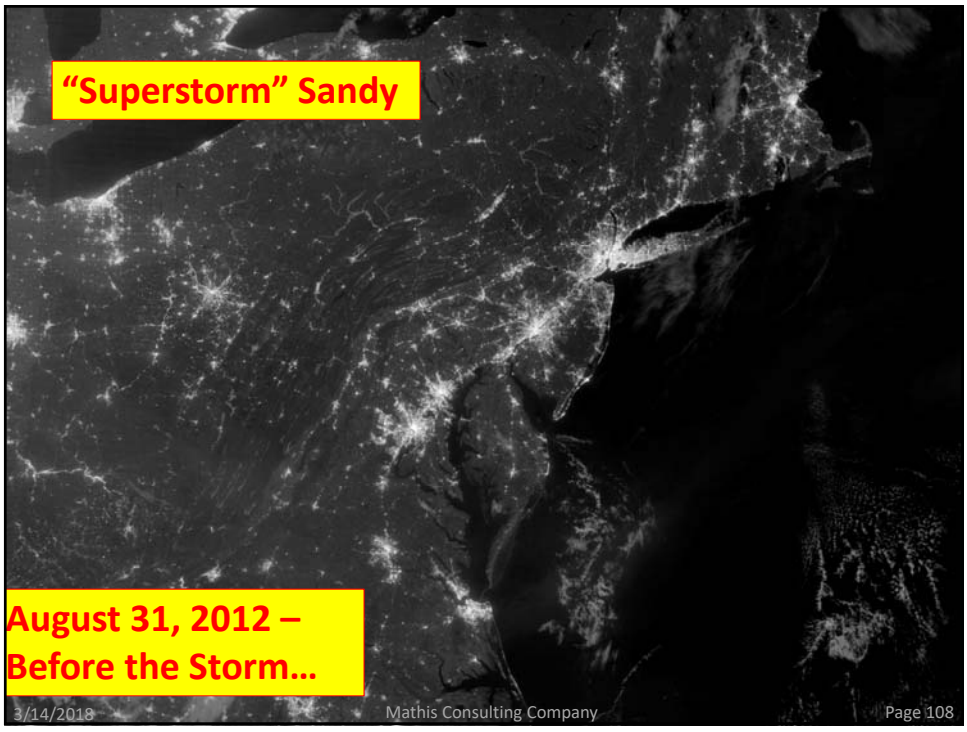
Katrina's Legacy…

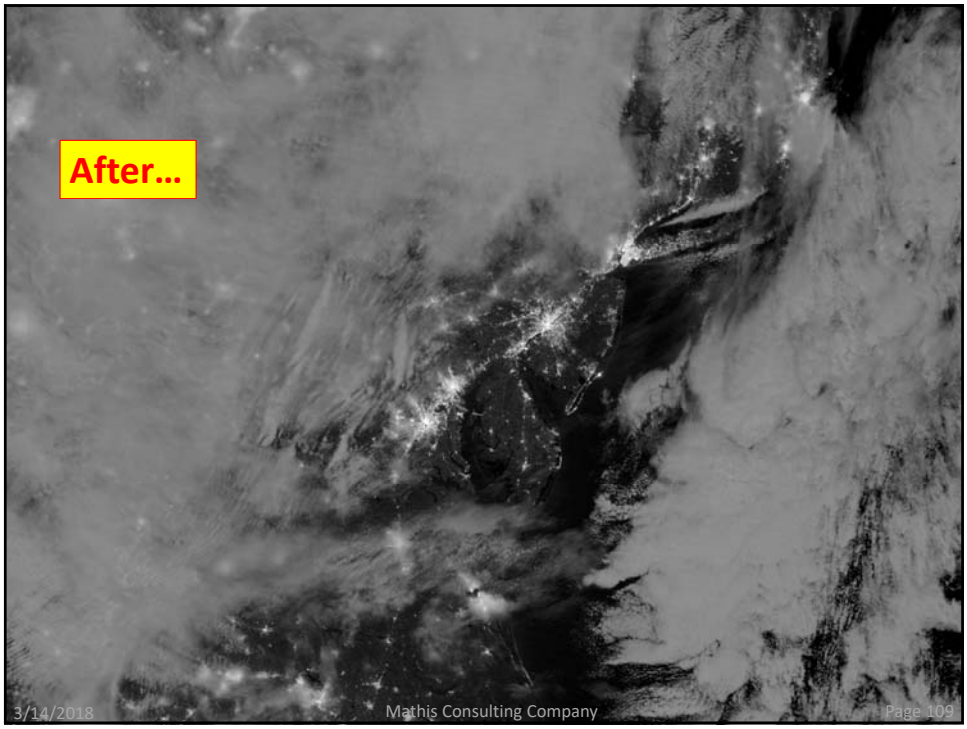
- **Hurricane Katrina – 2005**
  - Costliest hurricane in US history – est. $80 billion
  - Over 1300 confirmed deaths
  - 3200 still missing

**Following Katrina,
Louisiana and Mississippi
adopted their first building codes…**


HD DOPPLER NETWORK
6:26 p.m.
Disaster in NC…
South Hill
Danville
Roanoke Rapids
Roxboro
Greensboro
Durham
Rocky Mount
Raleigh
ory
Greenville
Sanford
Goldsboro
Charlotte
Fayetteville


OSFM


"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

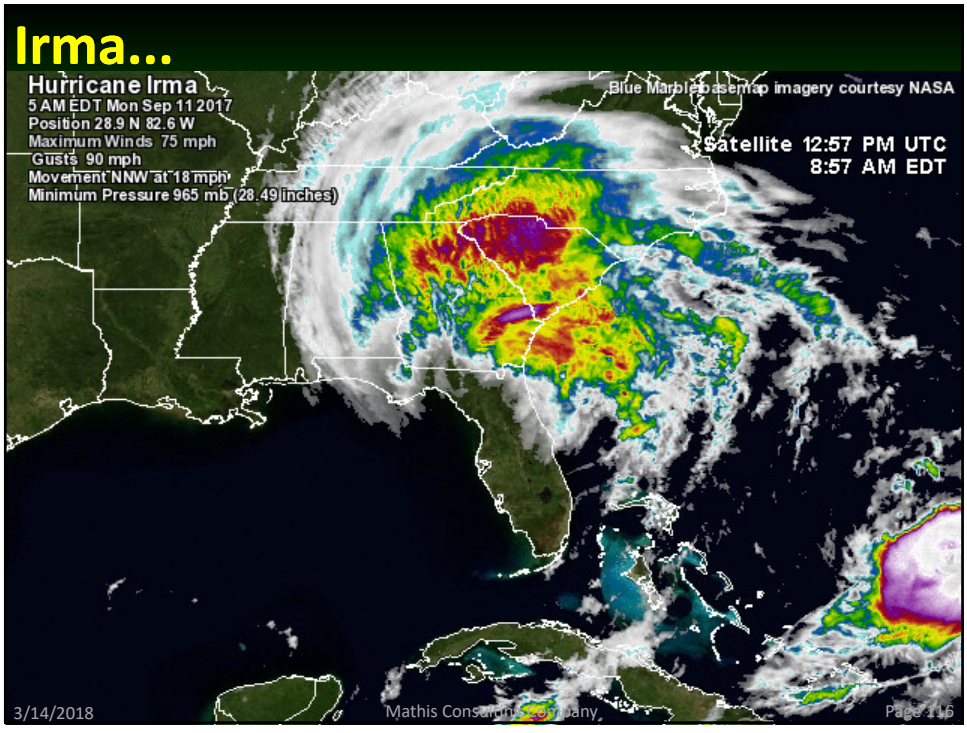

Photo taken by Iwan Baan

Perspective:

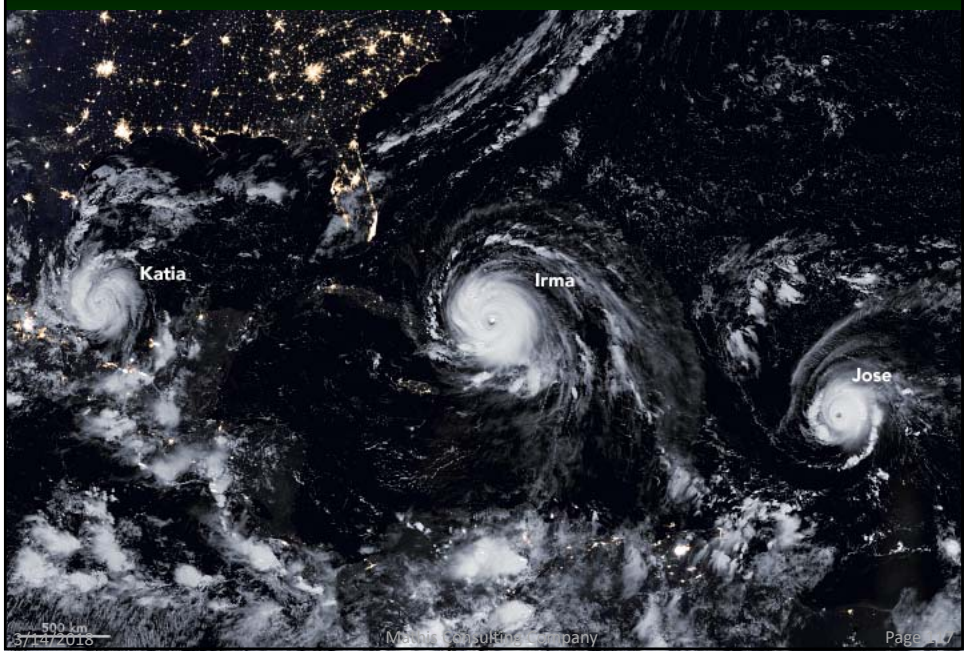
When the grid went down in India, over 350,000,000 people were without power…

Harvey...

Irma...


Hurricane Irma
5 AM EDT Mon Sep 11 2017
Position 28.9 N 82.6 W
Maximum Winds 75 mph
Gusts 90 mph
Movement NNW at 18 mph
Minimum Pressure 965 mb (28.49 inches)
Blue Marble basemap imagery courtesy NASA
Satellite 12:57 PM UTC
8:57 AM EDT

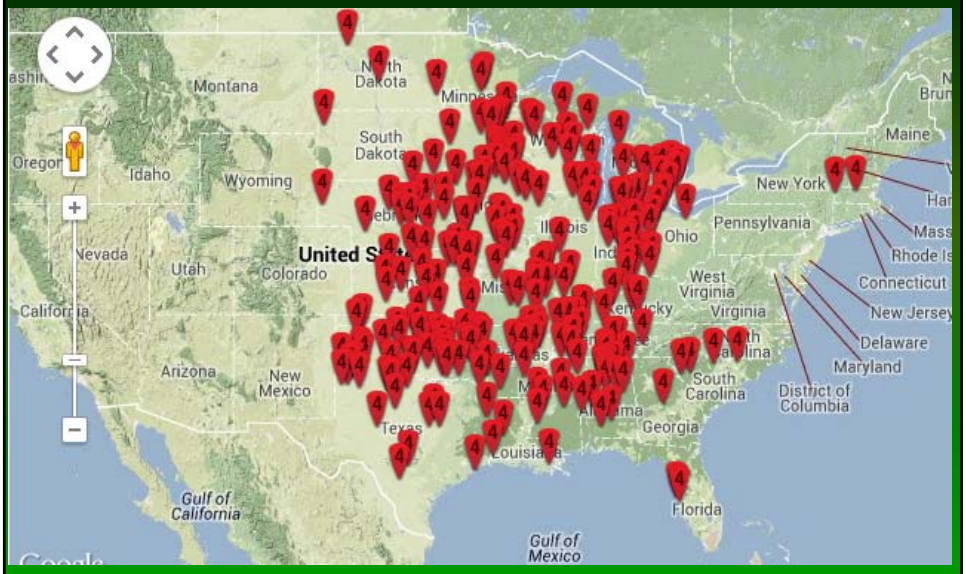
"More Frequent Severe Storm Events..."



Moore, Oklahoma…

F5 Tornadoes Since 1950…

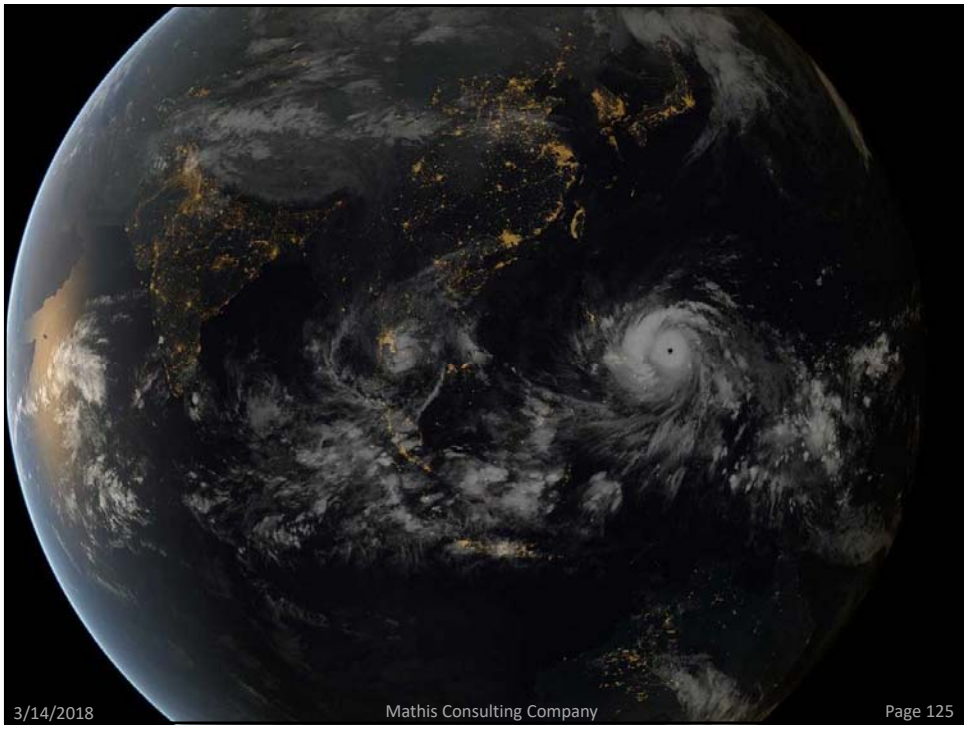
F4 Tornadoes Since 1950



F3s…

F2s…


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

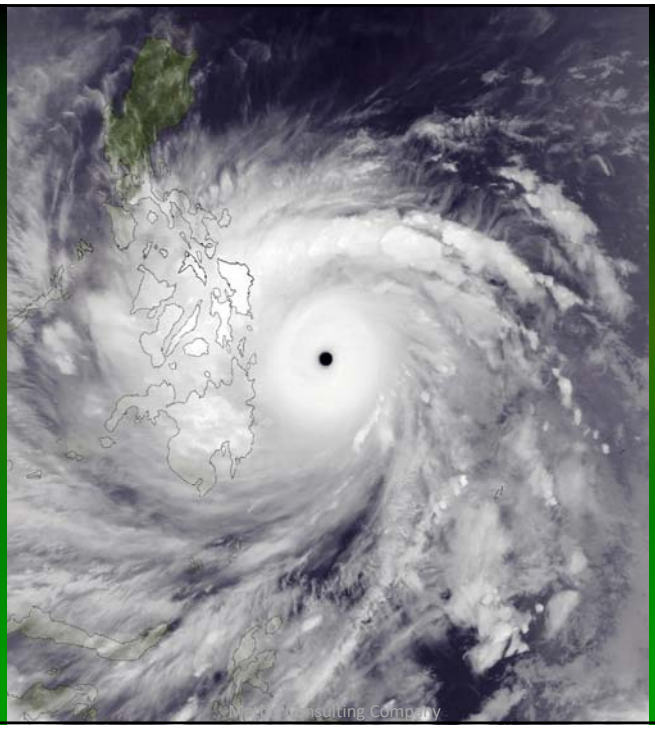


"Super Typhoon" Haiyan: 2013

- **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?**


3/14/2018
Mathis Consulting Company
Page 127


3/14/2018
Mathis Consulting Company
Page 128



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 on disaster or difficulty to ACT!**
- **Prioritize building performance now!**
  - Energy Performance
  - Durability
  - Resilience
  - Water Use
  - IEQ
  - Etc.

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.

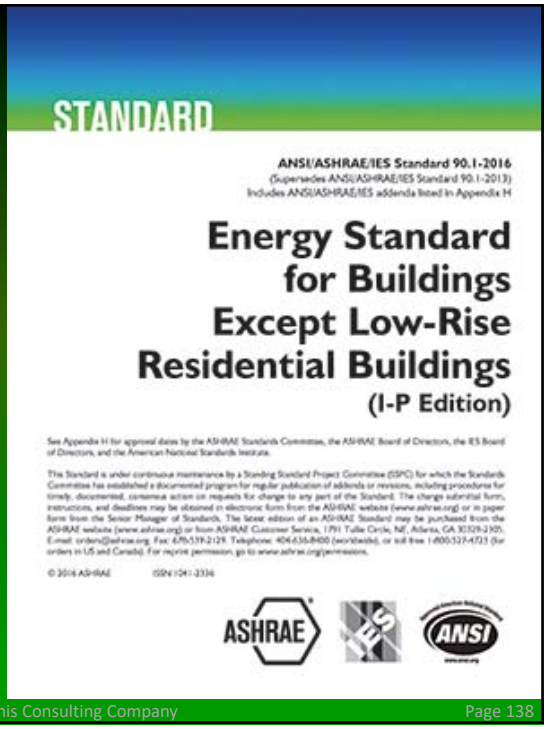
ASHRAE Vision

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.

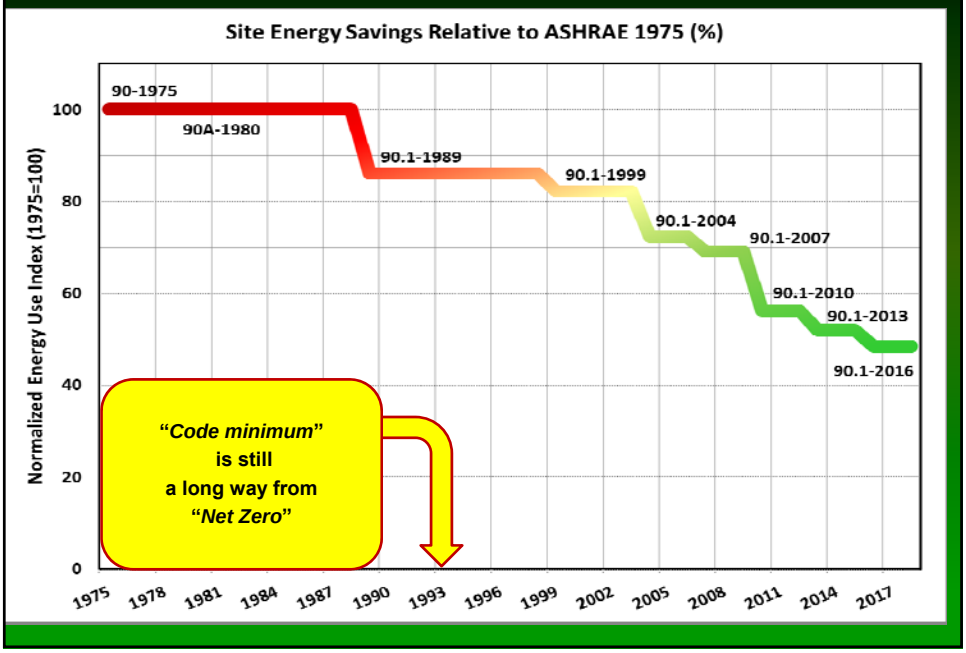
ASHRAE 90.1

Our Model Energy Code

90.1-2016



Improvements in EUI: 1975 to Present



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…!

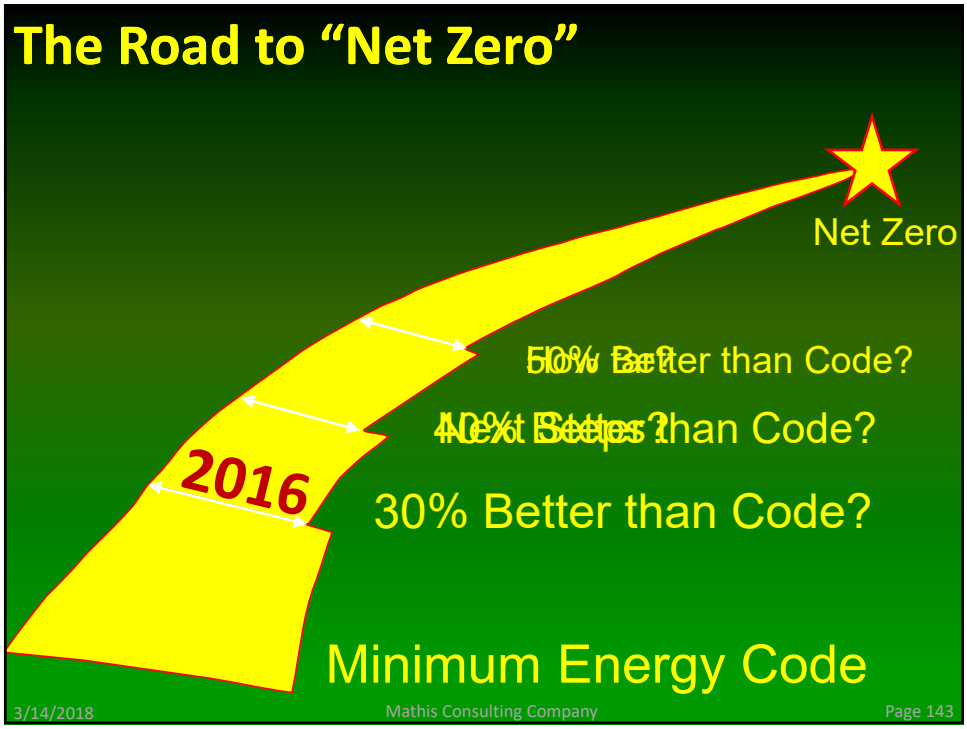
What the Code is NOT

- 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"
Net Zero
50% Better than Code?
40% Better than Code?
30% Better than Code?
2016
Minimum Energy Code
3/14/2018
Mathis Consulting Company
Page 143


What About The Road to "Green"?
2016
Minimum Code
3/14/2018
Mathis Consulting Company
Page 144

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"

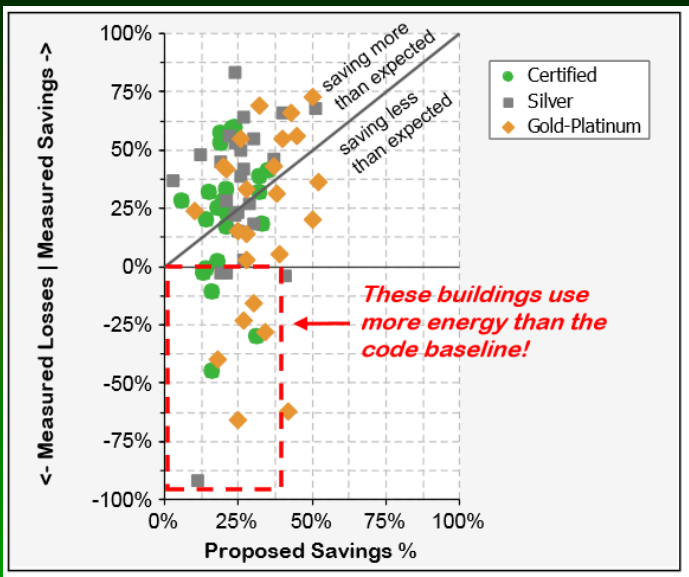


Figure 20: Measured versus Proposed Savings Percentages

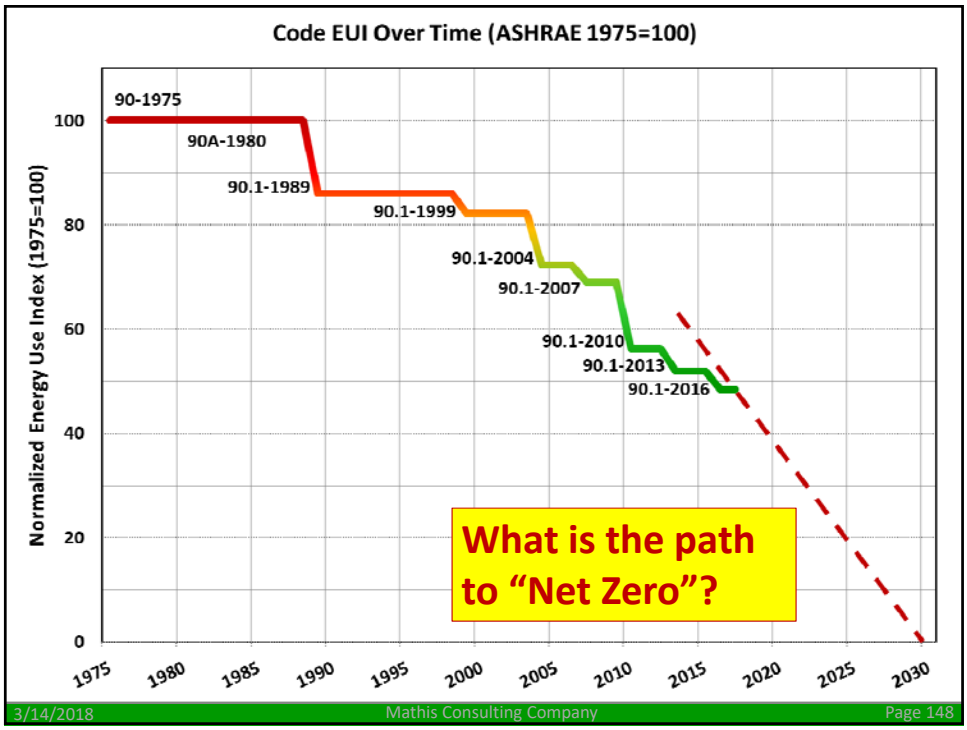
LEED

Measured vs. Proposed Energy Savings

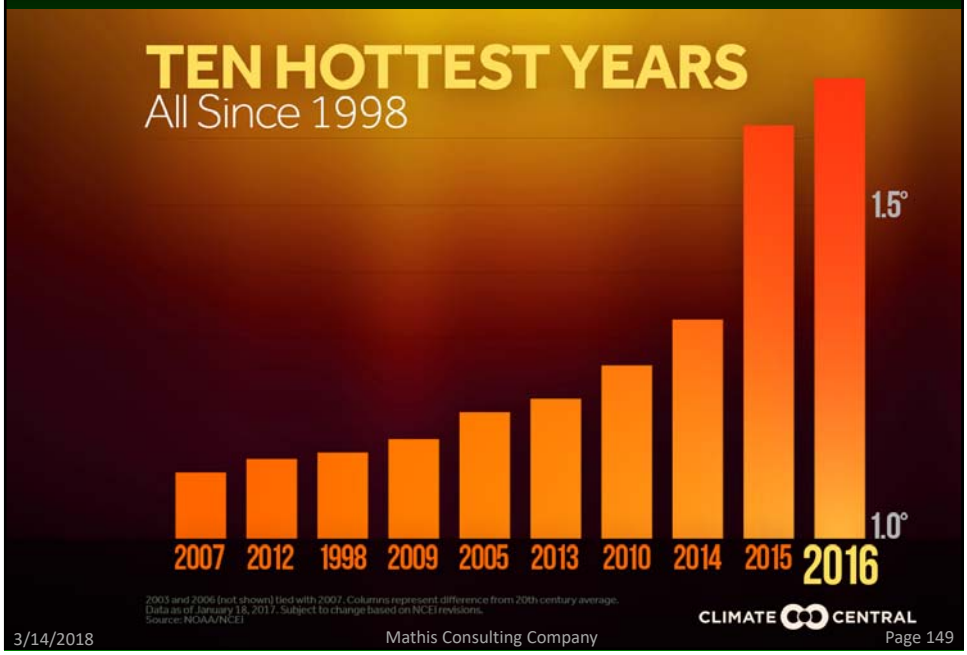
Source: Source: New Buildings Institute/USGBC's energy performance of LEED for new construction buildings

What About Those Other Objectives?

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

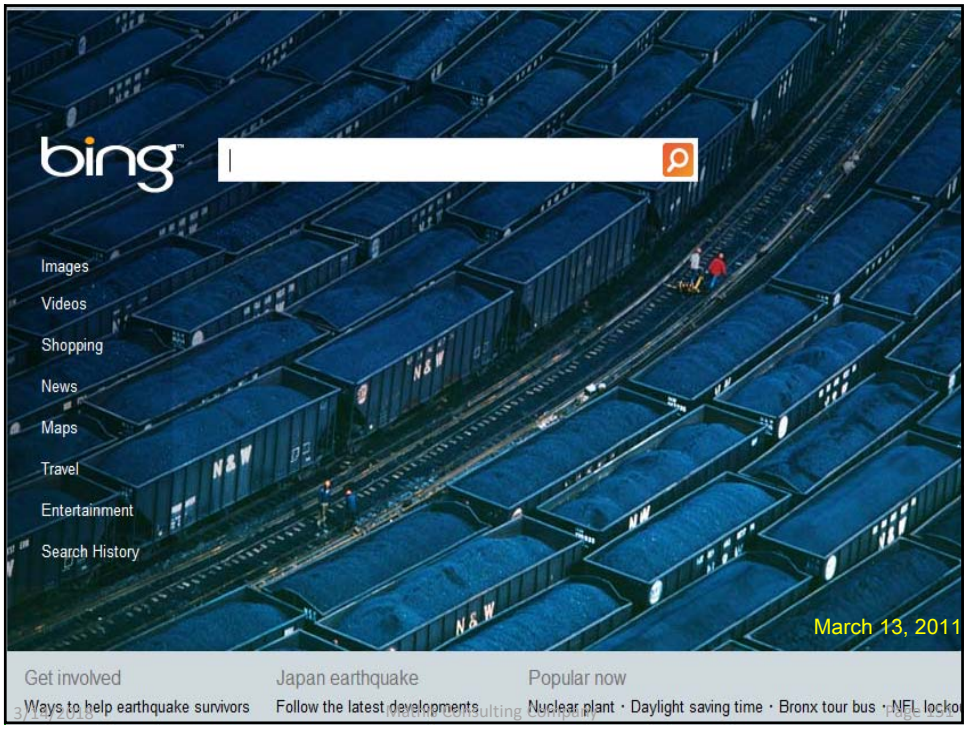


Sometimes change doesn't wait on us…



Our Leadership Responsibility

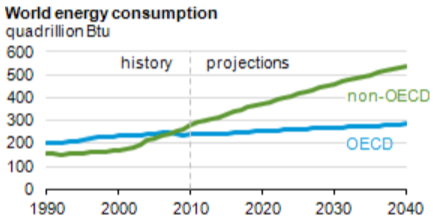
- **Get engaged! TEACH!**
  - Get engaged in local code adoption and compliance
  - Support local building performance education
  - Collaborate! Architects, Building Officials, Developers, Product Suppliers, etc.
- **Commission Stuff!**
  - Envelopes, HVAC, Lighting systems, Controls
- **Measure Stuff!**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

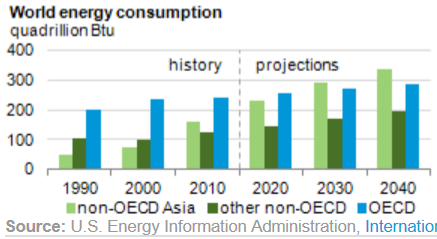

bing
Images
Videos
Shopping
News
Maps
Travel
Entertainment
Search History
March 13, 2011
Get involved
Ways to help earthquake survivors
Japan earthquake
Follow the latest developments
Popular now
Nuclear plant · Daylight saving time · Bronx tour bus · NFL lockou

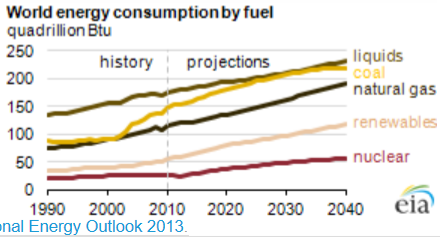
Recent Scary Numbers

JULY 25, 2013

EIA projects world energy consumption will increase 56% by 2040







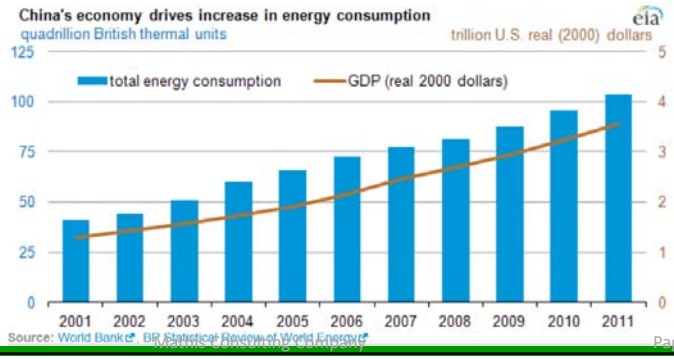
Source: U.S. Energy Information Administration, International Energy Outlook 2013.

Recent Scary Numbers

- China's energy consumption will DOUBLE between 2010 and 2020
  - Source: McKinsey 2009

SEPTEMBER 21, 2012

Economic growth continues to drive China's growing need for energy



Source: World Bank, BP Statistical Review of World Energy

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

Thank You!

R. Christopher Mathis
President – Mathis Consulting Company
Asheville, NC, USA
chris@mathisconsulting.com