



1

Why Buildings Matter: Perspectives and Priorities for Delivered Building Performance

R. Christopher Mathis
President, MC² Mathis Consulting Company

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The End in Mind

- **Buildings Matter!**
 - More than we know...
- **Major Trends Impacting Building Decisions**
 - Energy, Power, Water, etc.
- **What Does the Future Hold?**
 - Building Performance Priorities
 - Implications for Building Professionals
 - Engineers, Architects, Specifiers, Code Officials, Contractors, Owners, Policy Makers
 - Building Product Manufacturers, Standards Developers

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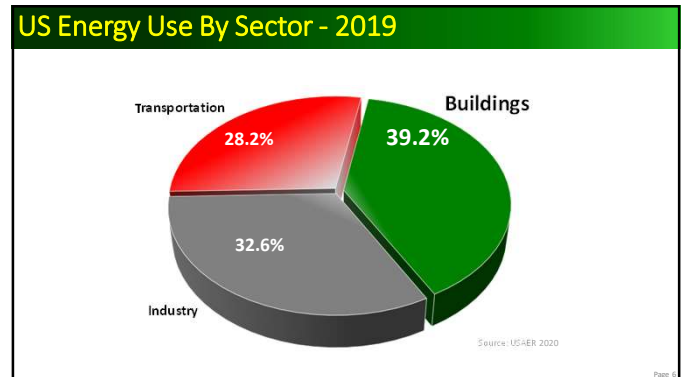
Who Am I?

- **Building Scientist for 40+ years**
- **Author, Educator**
- **Standards Developer and User**
 - ASHRAE Member 38+ years, Distinguished Lecturer, ASHRAE Fellow
 - ASTM Member 38+ years, C16, E06, E60
 - ASTM Board of Directors 2018-2020
- **Code Developer**
 - IECC, IGCC, State Codes, Federal Codes, Green Codes, etc.
- **Beekeeper**

4

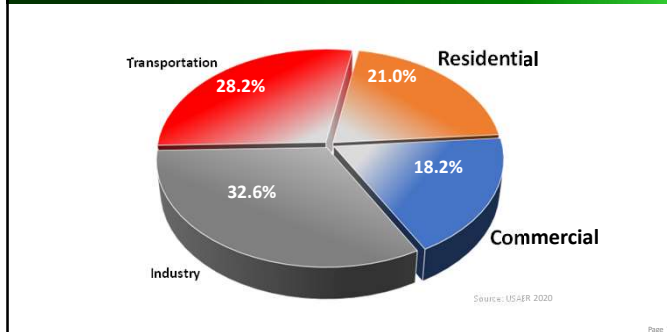


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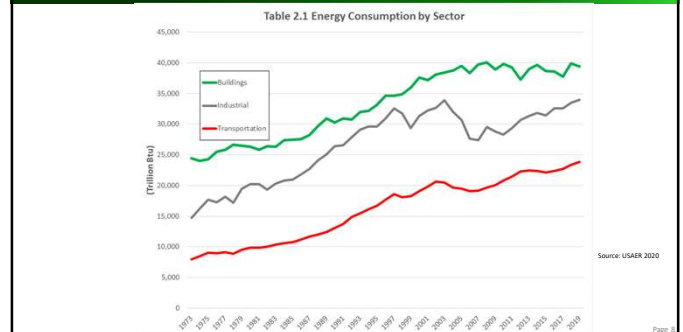
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US Energy Use - 2019



7

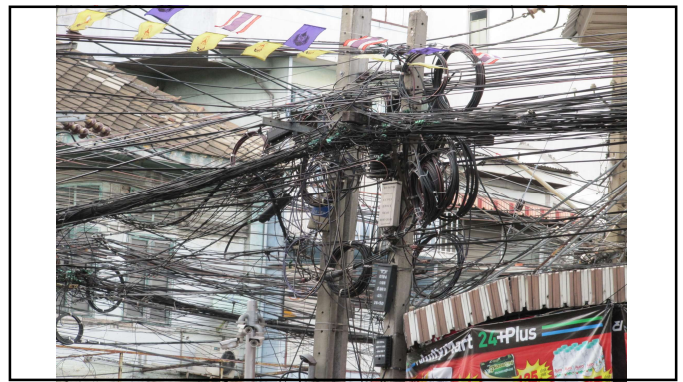
Total US Energy Consumption 1949 - 2019



8

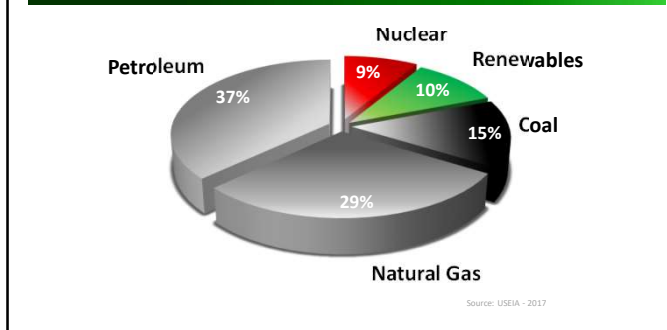


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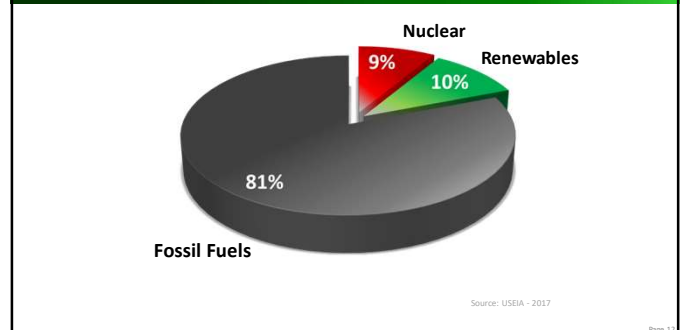
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US Energy Production by Source - 2016



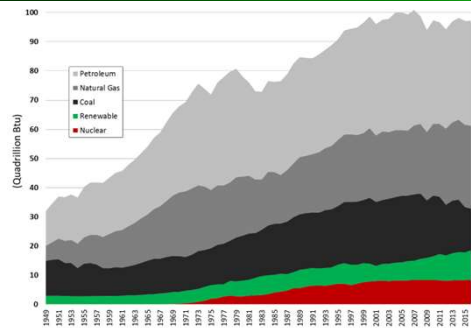
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US Energy Production by Source - 2016



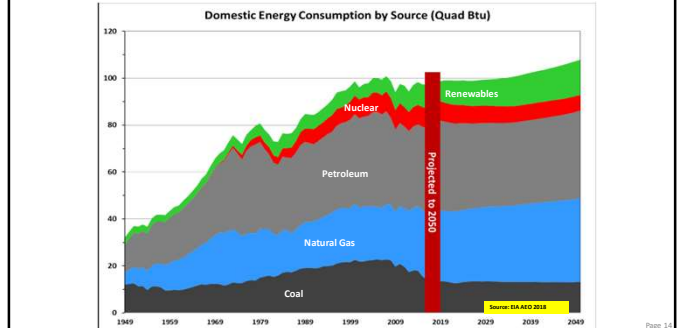
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Total US Energy by Source 1949 - 2015



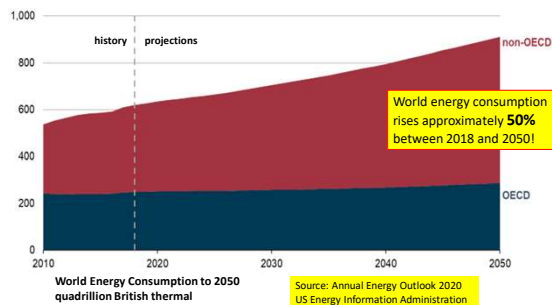
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Projections on the Future? (US to 2050)



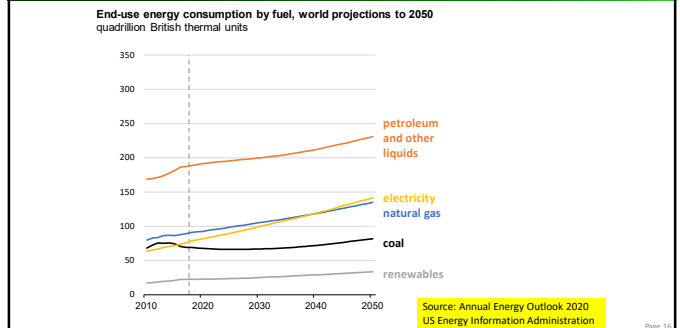
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World Energy Consumption to 2050



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All Fuels, Everywhere...



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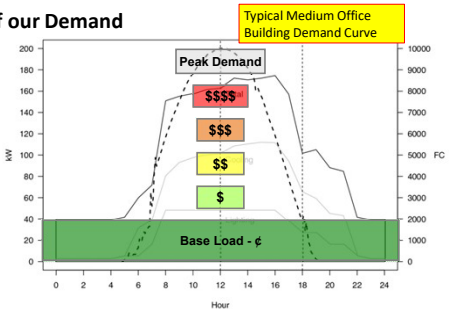
Not Just an "Energy" Issue... Utility Concerns...

➤ The "Timing" of our Demand

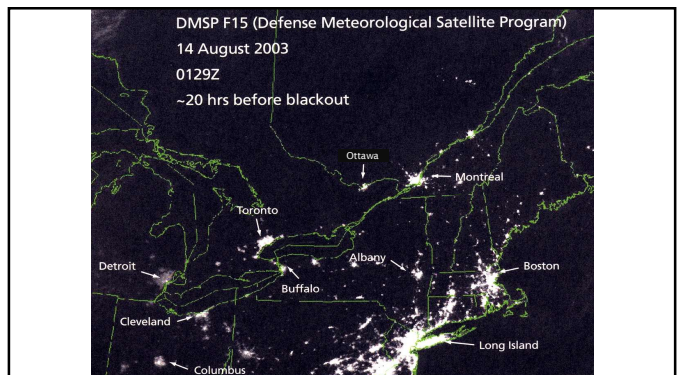
- Base Load
- Peak Demand

➤ Driven by:

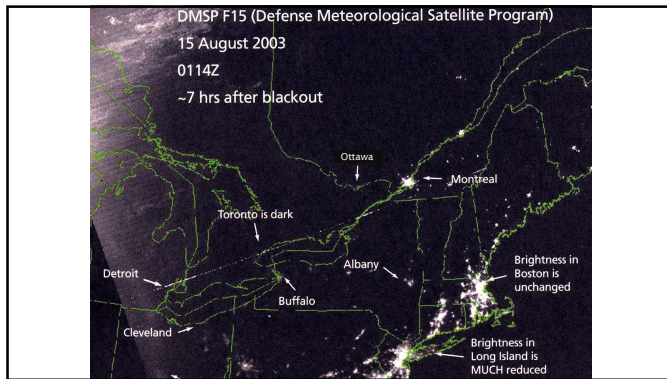
- Cooling Loads
- Lighting Loads



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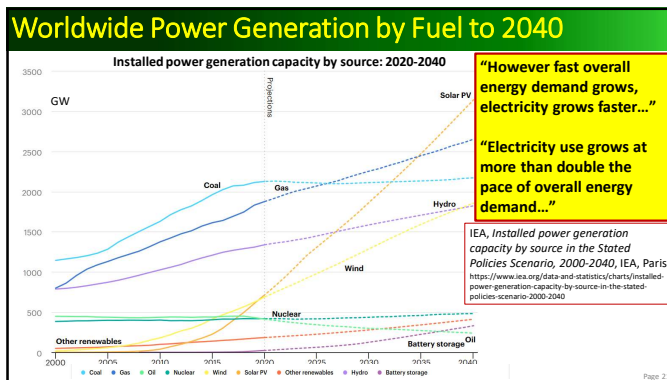
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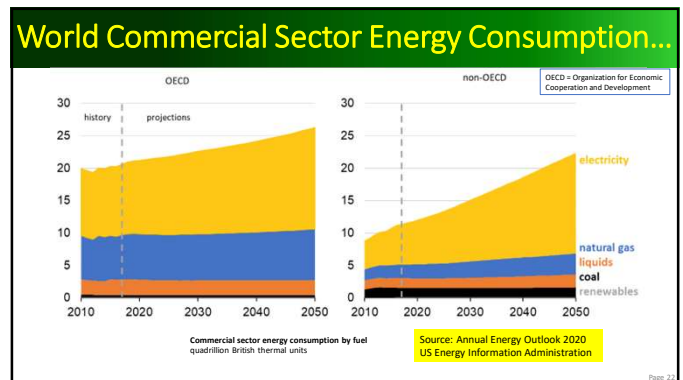
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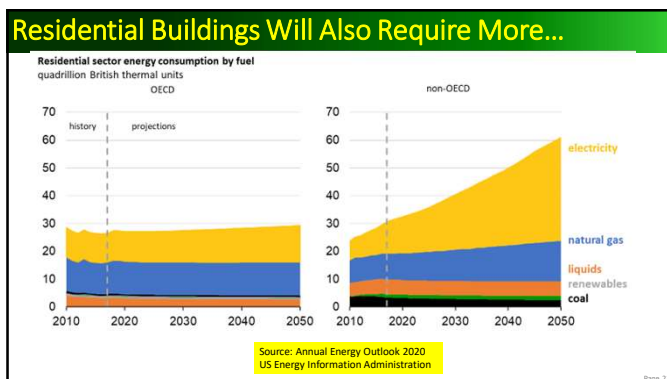
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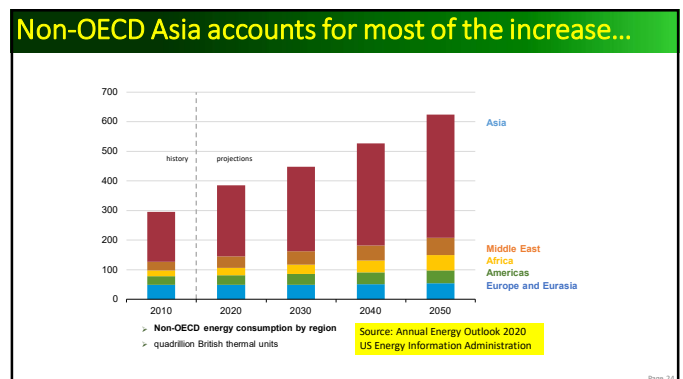
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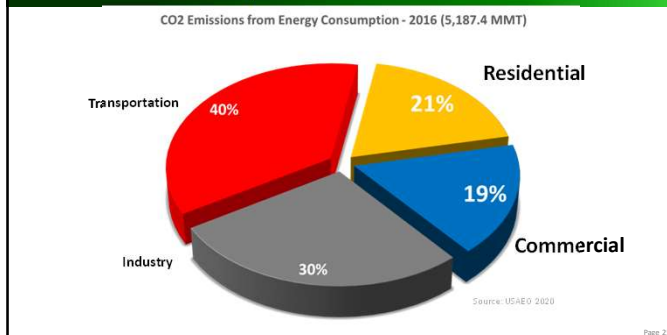


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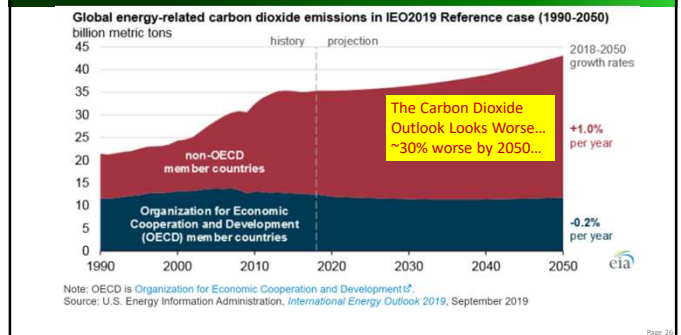
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Carbon Emissions By Sector - 2016



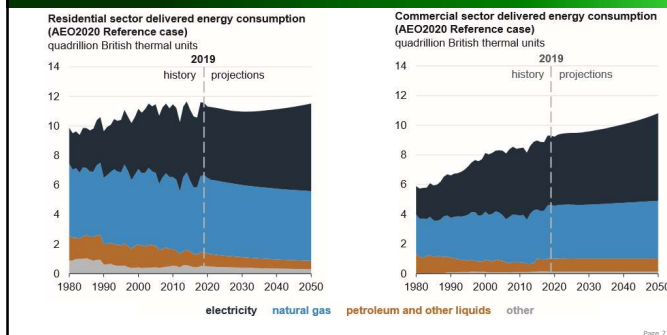
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Even With Expected Growth In Renewables...



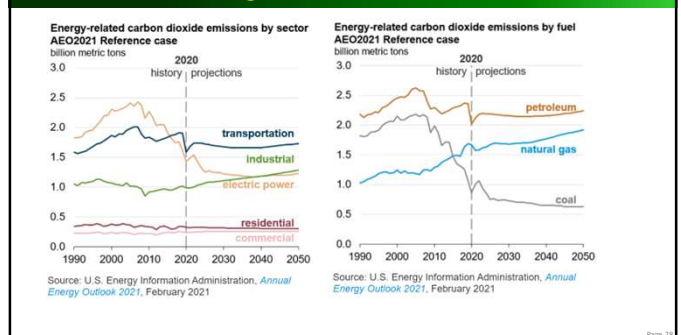
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Buildings Will Want More Energy... Especially Electricity...



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Emissions? Buildings Matter!



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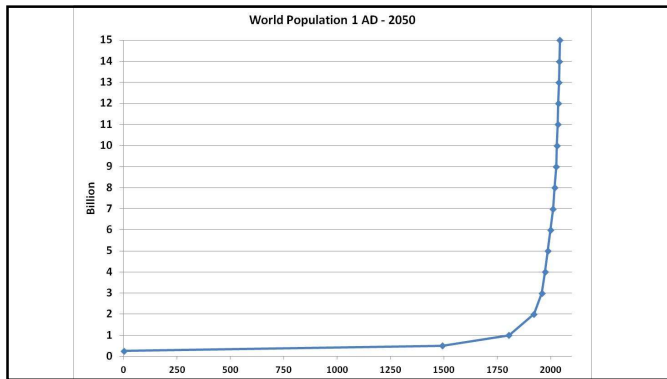
Making it Personal...



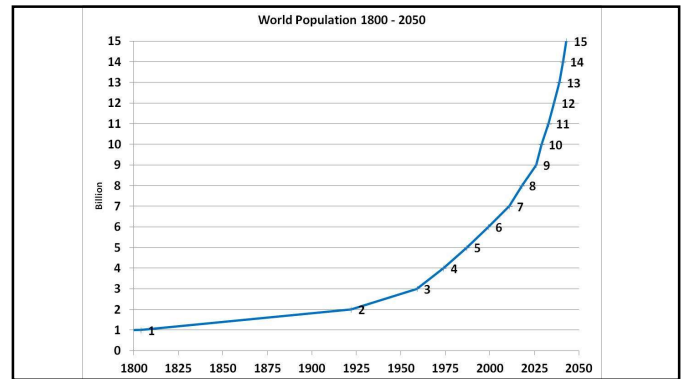
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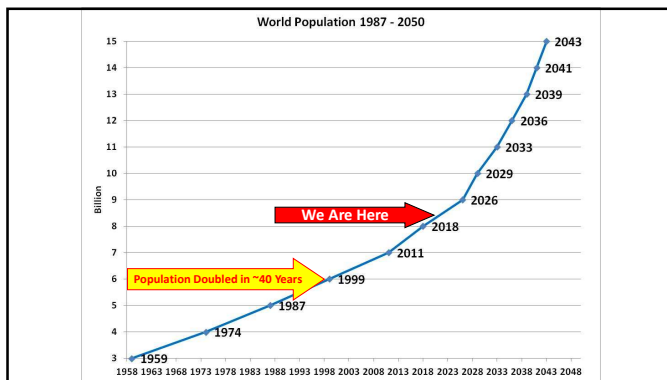
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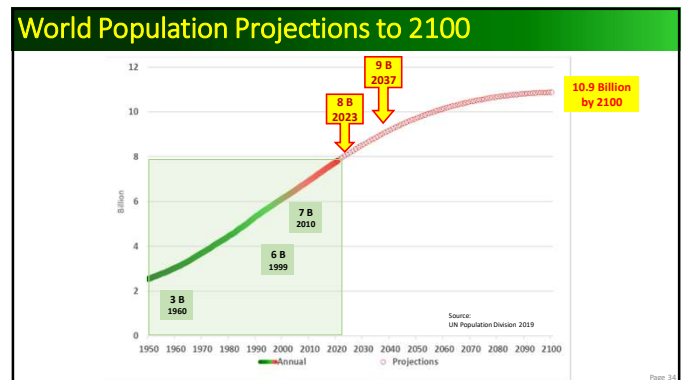
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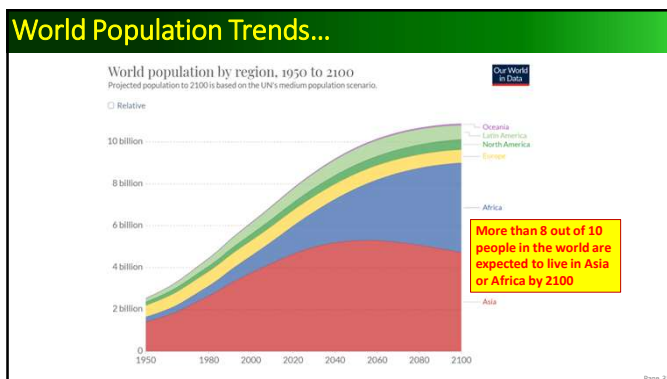
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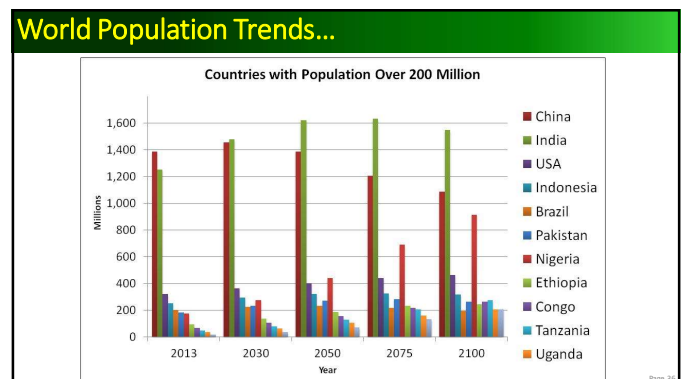
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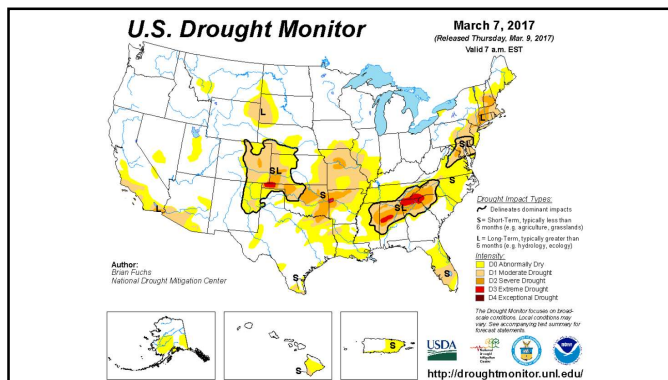
Energy and Water Trends

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



US News, 11/22/2012

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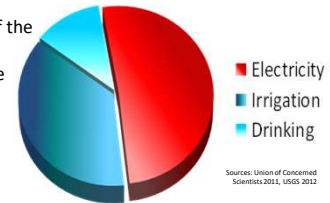


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Power and Water

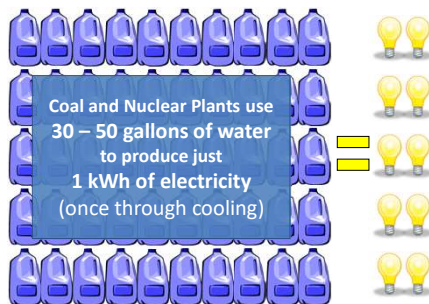
➤ US thermoelectric facilities use over 200 billion gallons of water a day.

Over half of the withdrawn water in the US...



40

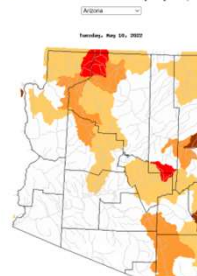
Water and Power Connection...



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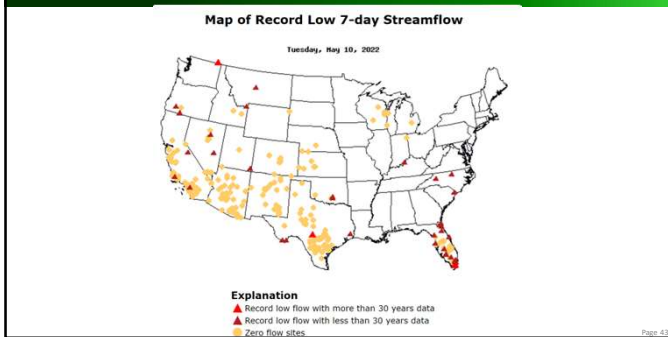
Arizona and Water: 2 days ago...

Map of below normal 7-day average streamflow compared to historical streamflow for the day of year (Arizona)



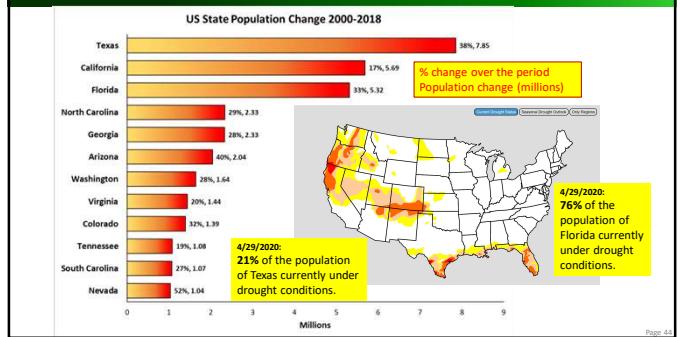
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US Record Low Flow?



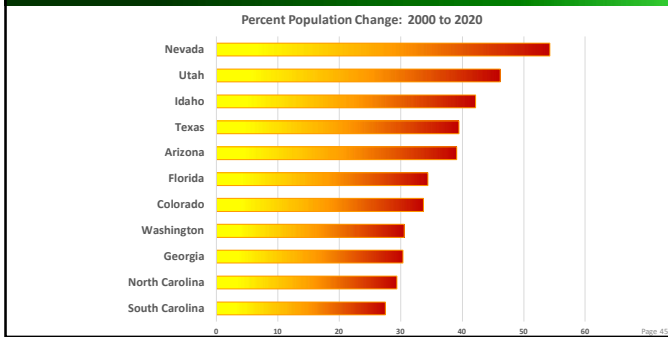
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US State Population Change 2000 - 2018



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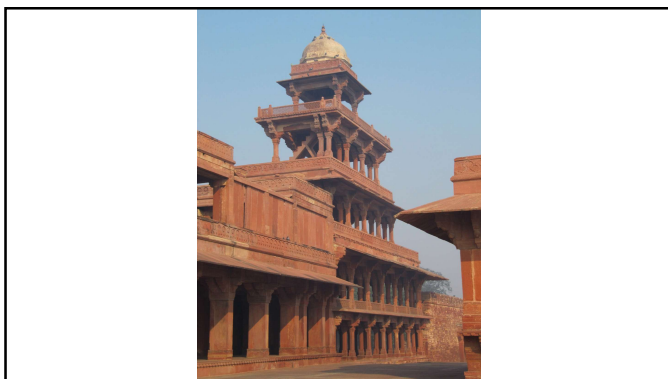
Updated: 2000 to 2020 Population Change (%)



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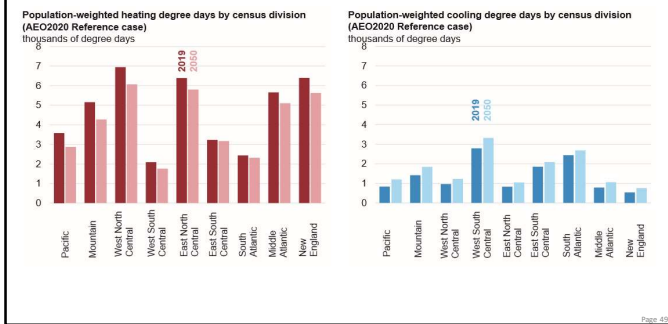


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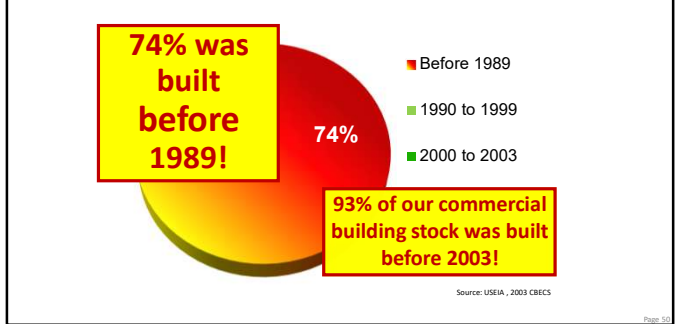
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Population Shifts = More Energy, More Electricity



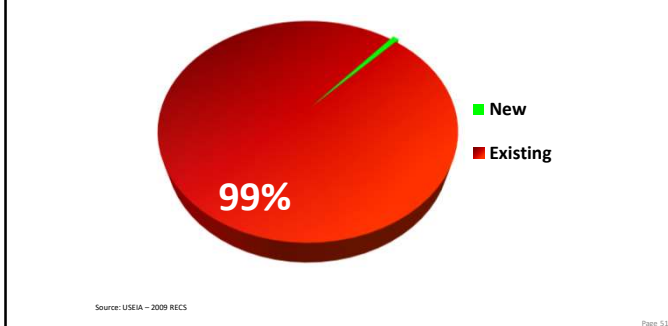
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US Commercial Buildings



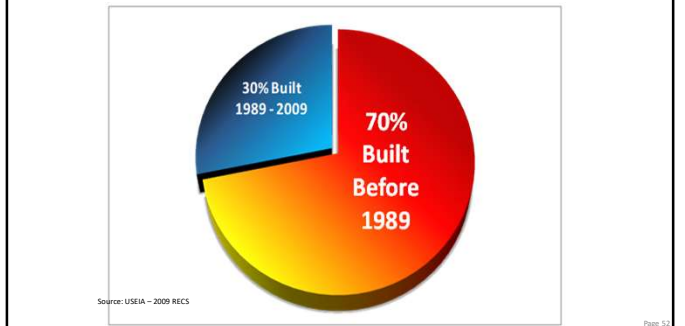
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U.S. Residential Buildings



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Age of U.S. Homes...

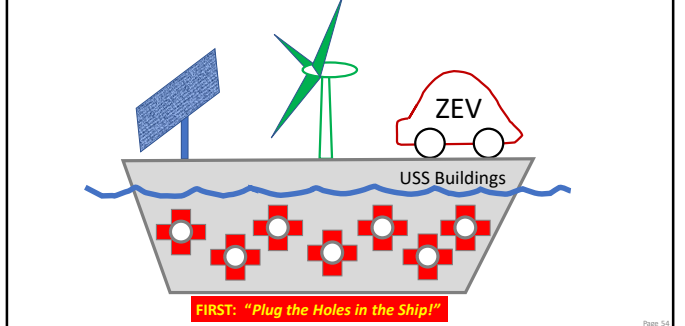


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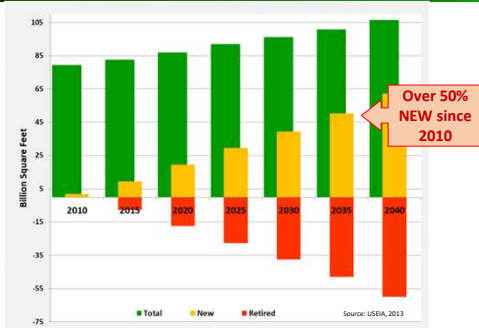
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Meaningful Energy Efficiency = Plug the Holes!



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New US Commercial Construction Expectations...



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Let's Examine
Some Other Pesky Trends that
MAY Influence the Buildings Industry...

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Built Environment Trends – Climate...

- More severe climate events predictions
 - More "Superstorms"
 - More Extreme Cold
 - More Extreme Heat

August 22, 2015



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Climate Trends: October 2015

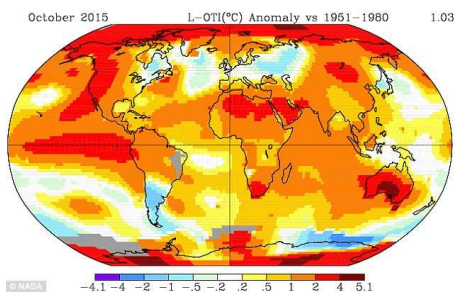
October smashes record for global warmth:
Last month keeps 2015 on track to be the
hottest year since 1880

November, 2015

- 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...



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By the End of 2015...

US: 2015 was Hottest on Earth by a wide margin

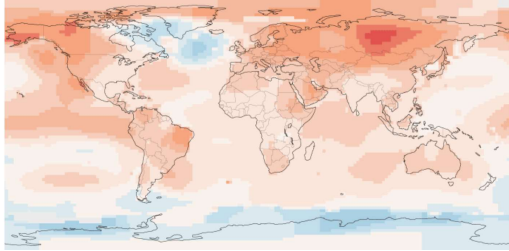


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The World is Getting Warmer...

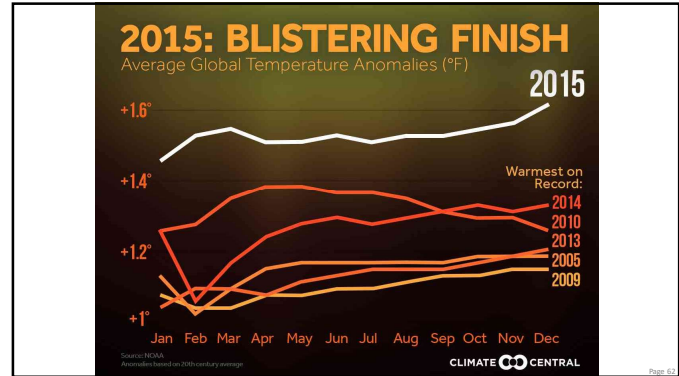
The Hottest Year on Record

Globally, 2015 was the warmest year in recorded history



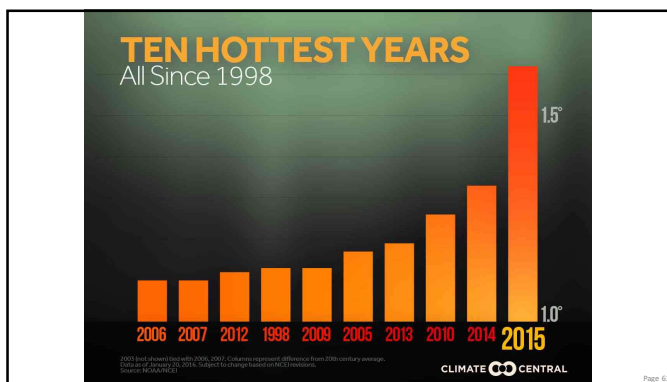
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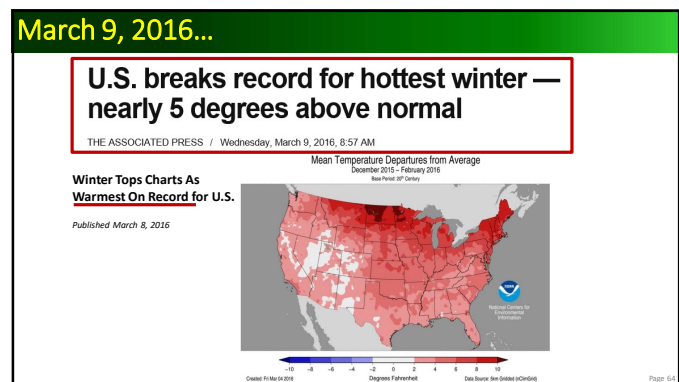
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April 4, 2016...

Science Home Archaeology Air & Space Planet Earth Wild Nature Natural Science Diseases 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.

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July 2016 – A New Record

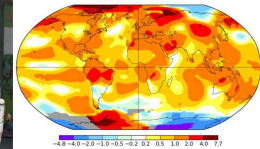
July was Earth's hottest month in recorded history — the 10th record hot month in a row: NASA

DETA BLOOMSTEIN, THE ASSOCIATED PRESS / August 10, 2016 8:47 AM ET



Hottest month in recorded history...

July 2016 L-OTW 'C' Anomaly vs 1951-1980 0.83

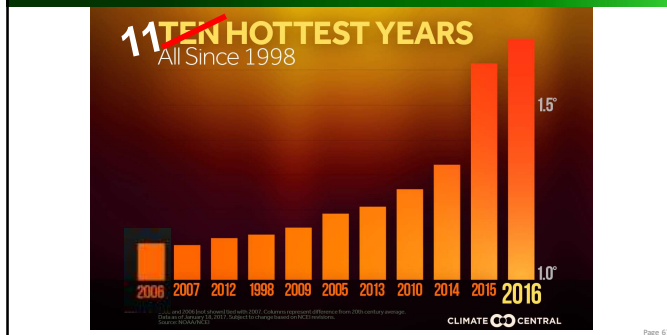


WASHINGTON — Earth just broke to its hottest month in recorded history, according to NASA.

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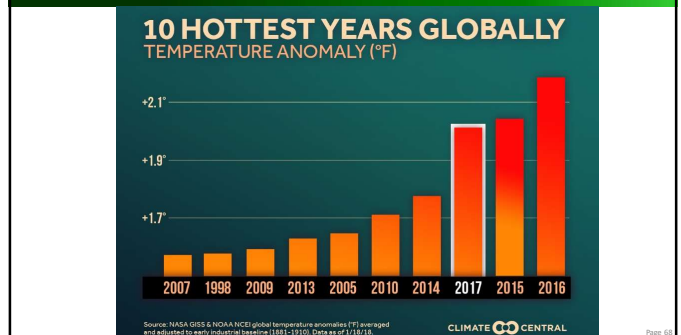
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2016: The Trend Continues...



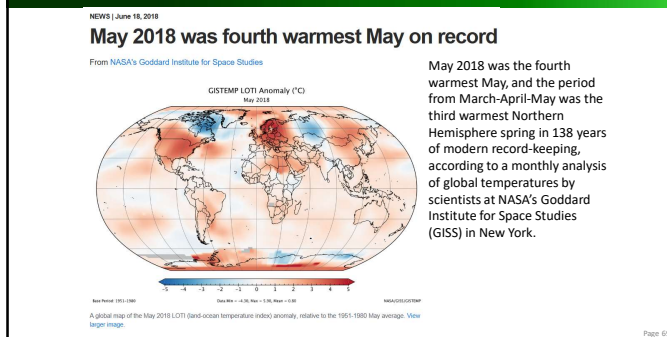
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2017 Came in at #3



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What about 2018?



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August 2018



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Legacy of 2018...



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Worldwide in 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.
- CLIMATE CENTRAL

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And the MOST Troubling Trend...



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And Time Marches On... June 2019

Worldwide, June 2019 was the hottest June ever, according to more than a century of weather records

By Susan Scutti, CNN
Updated 8:41 AM ET, Fri July 19, 2019

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June 2019 in Europe...



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European Heatwave, June 28, 2019...

European heatwave: Hottest day ever recorded in France as temperatures swell to 44 degrees

Joe Gamp
Contributor, Yahoo News UK
Yahoo News UK, June 28, 2019

A temperature of 44 degrees Celsius was recorded in Carpentras, south-eastern France (GETTY)

France's all-time temperature record has been broken after 44.3C (111.7F) was reached in the southern town of Carpentras.

The country has been gripped by a Saharan heatwave drifting across Europe.

It is the first time in history that France has raised its heat alert to red, with Spain, Italy and Switzerland also issuing red warnings.

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France, June 2019...

Notably, 13 locations in France surpassed their highest temperature ever recorded. The heat wave's highest temperature of 114.6 degrees Fahrenheit (45.9 Celsius), posted in Gallargues-le-Montueux, was 3.2 degrees above the old record, set during an infamous heat wave in July and August 2003.

NASA is the second institution to confirm that it was the Earth's hottest June, as the Copernicus Climate Change Service had already determined that June 2019 was the warmest such month on record for Europe and globally.

People cool off in the fountain of the Trocadero, as the Eiffel Tower is visible in background, in Paris, Tuesday, June 25, 2019. (AP Photo/Alexandra Tarantini)

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France Hits 115F...

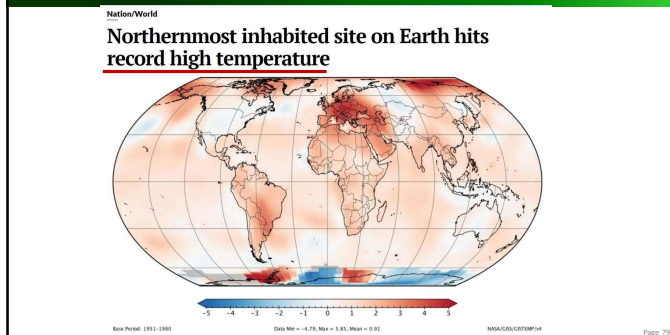
At Nearly 115 Degrees, France Experiences Its Hottest Day on Record

A wildfire burning near Milla, in the northeastern Spanish region of Catalonia on Thursday. Officials said up to 50,000 acres were threatened. (AP Photo/Agencia France-Press) - Getty Images

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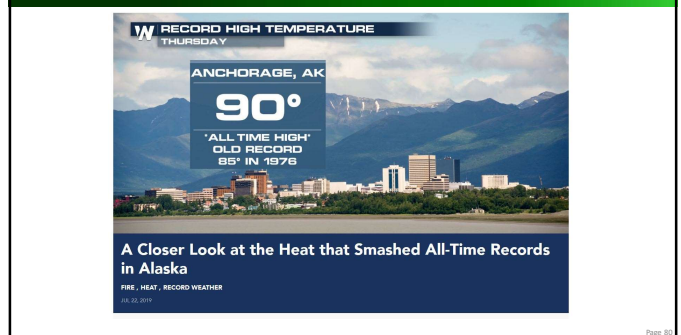
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Alaska, June 2019...



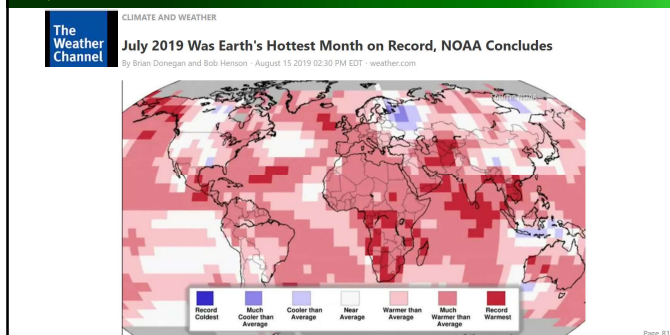
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Alaska, June 2019...



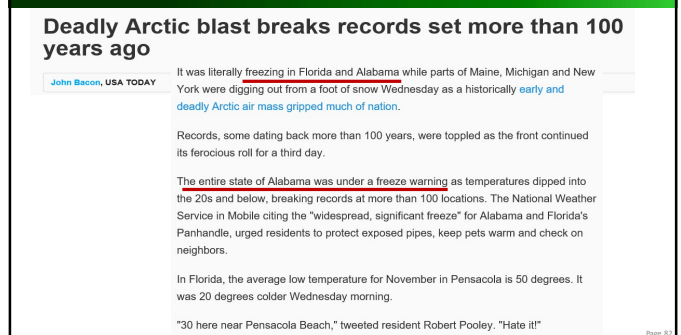
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July 2019...



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November 13, 2019: "Extremes More Extreme"

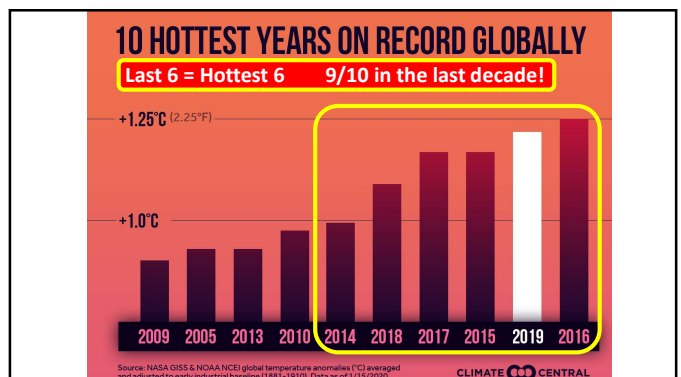


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January 2020...

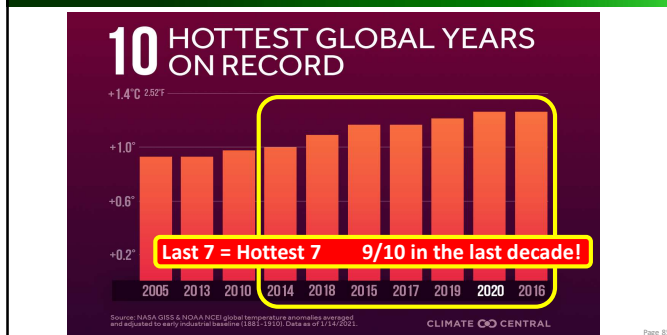
- **Hottest January in 141 years of global record keeping**
 - By biggest margin – 1.14C above 20th Century average
 - With NO El Niño event in Pacific Ocean
 - **FOUR** hottest Januarys on record all since 2016
 - **TEN** hottest Januarys on record all since 2002
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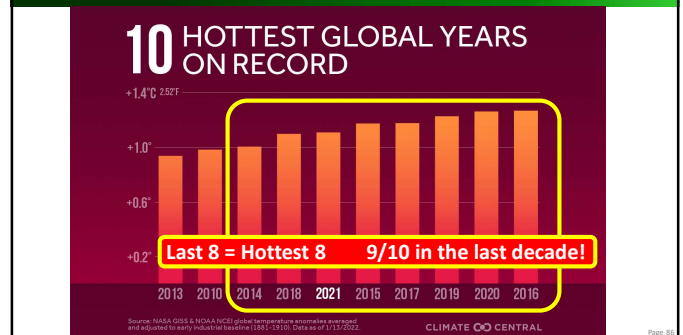
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2020...

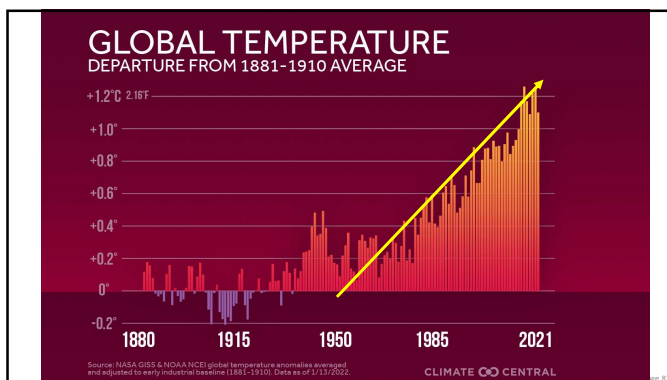


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And as of 2021...

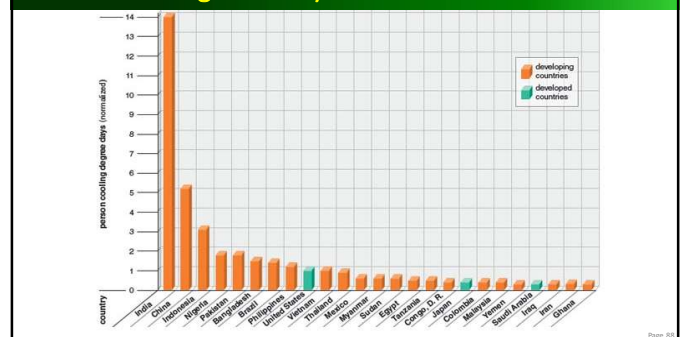


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Air Conditioning for Everyone?



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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!

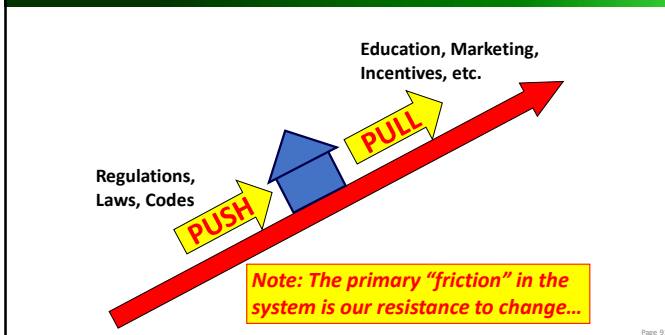
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Where Do We Go From Here?

Prioritizing Building Performance

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Market Transformation...



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We Must Change...

- Change is hard
- Change is risky
- Change usually brings opposition
- Change MAY create allies
- Change MAY bring benefits
- Change may NOT be what we originally envisioned...



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History vs. Future

- What weather should we use for **2020 building performance modeling**?
 - 1961 – 1990? (30 year average?)
 - 1971 – 2000? (30 year average?)
 - 1995 – 2010? (15 year average?)
 - 1998 – 2018? (20 year average?)



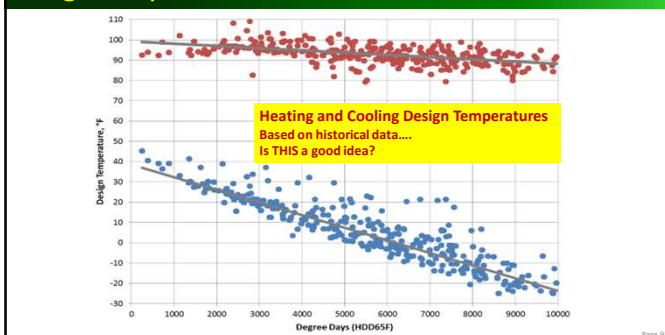
- But this building is going to be functioning (hopefully) thru:
 - **2050?** (30 years from now...)
 - **2070?** (50 years from now...)
 - **2120?** (100 years from now...)

Shouldn't we be using projected weather – what's expected – for the life of the building?

IF we used TODAY as the baseline, what will be the "typical year's weather" in 2050? 2075?

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Design Temperatures...



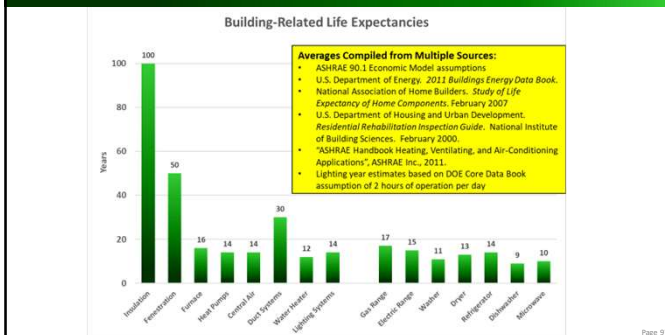
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Future Building Performance Challenges....

- Do we have the **ABILITY** to talk meaningfully about long term building performance?
- Do we have the **LANGUAGE** for meaningful discussions about long term building performance?
- Can we agree on what is "Long Term"?
- The challenge of **Boundary Conditions...**

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Life Expectancies of Some Building Products

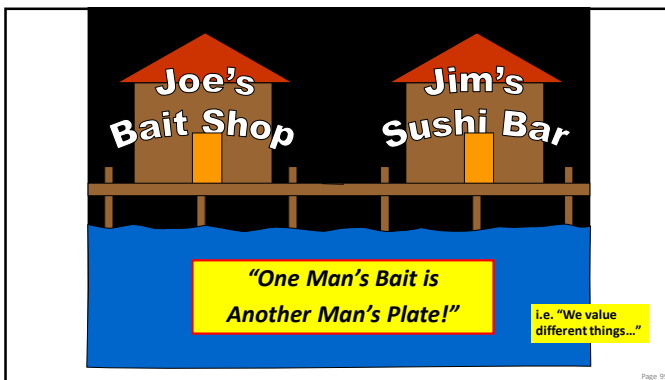


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ONE of Our Biggest Strengths...

- **High performance envelope systems that last a long time!**
 - (compared to many other building elements...)
- **How does that long lasting performance figure into:**
 - Economic assumptions of multiple users?
 - Code development assumptions?
 - Mortgage lender assumptions?
 - Builder risk assumptions?
 - Utility load prediction assumptions?
 - Occupant safety and comfort assumptions?

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Opportunity or Threat? What Happens When:

- Technology Innovations meet Walls and Roofs?
- Information Innovations meet Walls and Roofs?

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What Happens When...

- Our WALLS start telling us how they are performing?
 - Energy
 - Water
 - Air Leakage
- How much they COST us this month?
 - Or saved...



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Signals... Your Building Calls...



"Excuse me...
We have a slight problem...
We have detected a water leak
on the NW corner of the building
at the 3rd floor at the
curtainwall/brick interface.

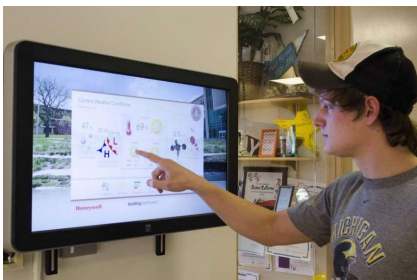
Important Note:
These performance signals will NOT be limited
to HVAC performance, or wait on an unhappy or
"at risk" occupant to say something...

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**Does a Fire Sprinkler
Require Human Activation
Before it Responds?**

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Technology Now SHOWS What the Building is Doing!



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Behavior Modification

- **Give Performance Signals!**
 - Behavior modification will be required
- **Building Performance Feedback**
 - Technology integration, Dashboards, Feedback
- **Teach Children NOW!**
 - They are not invested in Business-as-Usual
 - Collaborative problem solving will be their norm

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"In God We Trust..."
The Rest Bring Data

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OUR Responsibilities....

- **Buildings MUST Get Better!**
 - We must integrate across ALL building disciplines
 - Integrated Design, Commissioning, Verification, Maintenance
 - **MEASURE STUFF, COMMISSION STUFF, REPEAT...**
- **We must become better teachers!**
 - Why Buildings Matter
 - What We CAN Accomplish!
- **Occupant Behavior Modification is Essential**
 - We have to help show the cost/price of inaction...

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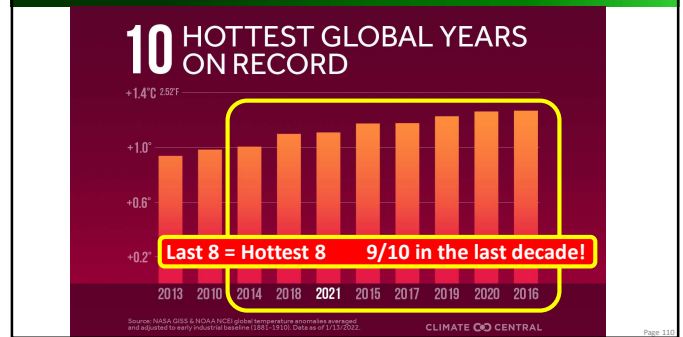
"Responsibilities" Lead to Opportunities!

- **Change the code minimums!**
 - A decade of delay...
 - We already have an array of technical solutions!
 - We have proven, life-cycle economics winners!
- **Expand your existing building solutions**
 - Lots more of those
 - Be prepared to fill the order!
 - "Be careful what you wish for..."
- **Embrace change...**

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Sometimes change doesn't wait on us...



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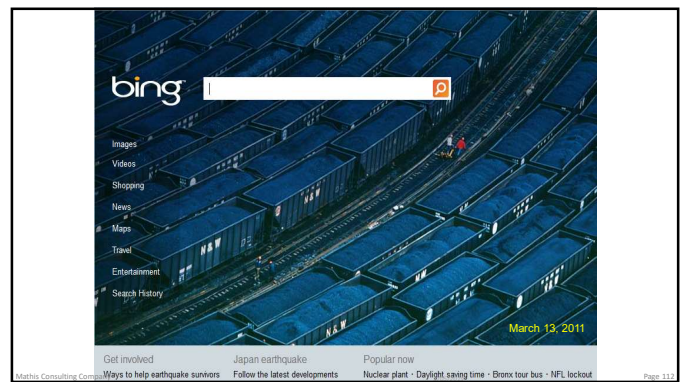
110

Chris's Recipe for Action = LEAD!

- **DRIVE – don't ride the bus...**
 - The Better Building Performance Bus
 - The Latest Energy Code Bus
 - The State Code Adoption Bus
 - The Utility Incentives Bus
 - The Code Education Bus
 - The Architect Education Bus
 - The Owner Education Bus
- **Get better at Life Cycle Economics**
 - Durable, high-performance systems WIN!

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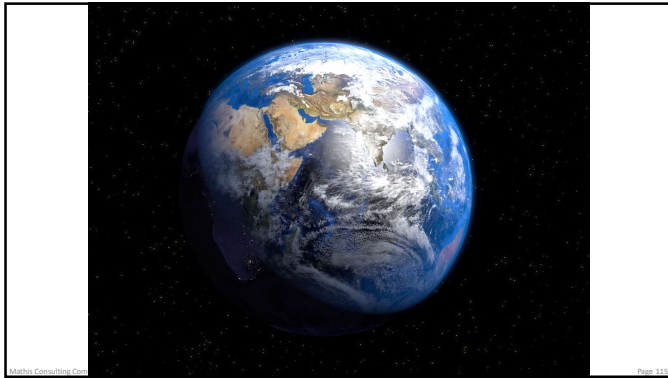
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The End in Mind

- **Buildings Matter!**
 - It is up to knowledgeable building industry professionals to deliver this message.
- **Major Trends Impacting Building Decisions**
 - Environmental Trends
 - Human Expectation Trends
 - Energy, Power, Water, Population...
- **What Does the Future Hold?**
 - We must build better buildings – for 100+ years!
 - Major Implications/Opportunities for Building Industry Professionals
 - We must change...

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*“It is not the strongest
of the species that survives,
nor the most intelligent,
but the one
most responsive to change...”*

Charles Darwin

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The Future is in Our Hands

Thank you!

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R. Christopher Mathis

$E=mc^2$

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