

REACHING NET ZERO

WHAT IT TAKES TO SOLVE
THE GLOBAL CLIMATE CRISIS

CAN WE STOP GLOBAL WARMING?

SECOND EDITION
**THE GLOBAL
CLIMATE CRISIS**
WHAT TO DO ABOUT IT



William D. Fletcher
Craig B. Smith

SANTA BARBARA MUSEUM OF NATURAL HISTORY

April 22, 2024

Craig Smith and
Bill Fletcher

WHAT IS THE PROBLEM?

Craig Smith

WHERE ARE WE TODAY?

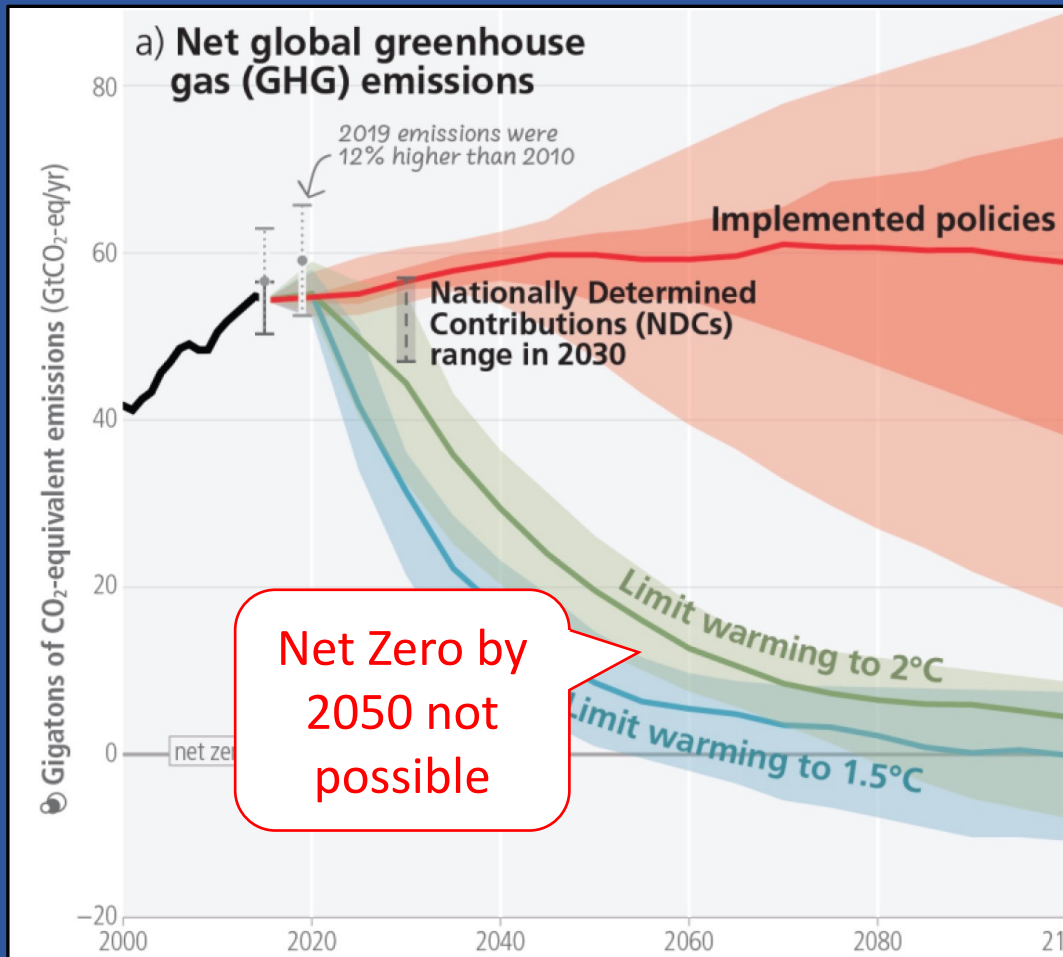
- *Global warming is irreversible*
- Latency is a problem
- We can't reach Net Zero by 2050
- IPCC forecast is 2.2 to 3.5 °C (4.0 to 6.3 °F) by 2100
- We can and should slow rising temperatures

GLOBAL WARMING IS IRREVERSIBLE

- What you put in the atmosphere stays there a very long time!
- So, you can speed up global warming but you can't cool down!
- There are no brakes and no reverse
- If greenhouse gas emissions cease, global warming persists until the gases are slowly reduced naturally



PRESENT IPCC COMMITMENTS



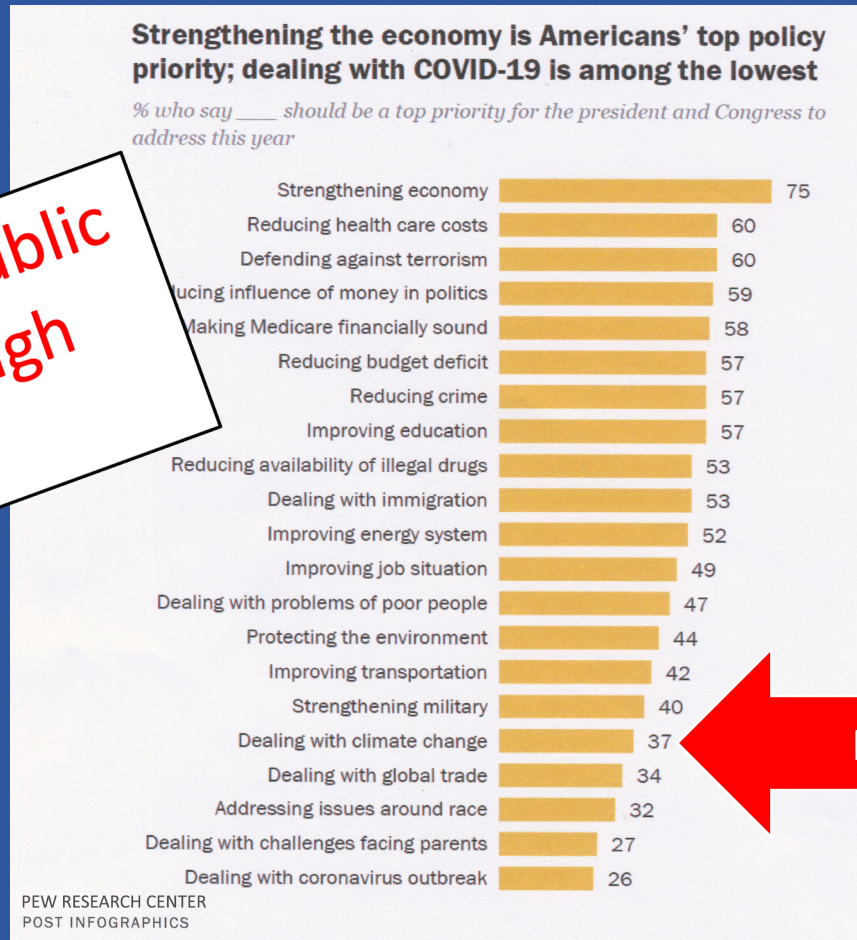
May do worse

National commitments not sufficient

May do better

CLIMATE CHANGE NOT A HIGH PRIORITY

Educating the public has to be a high priority



Number 17

HOW DO WE STOP GLOBAL WARMING?

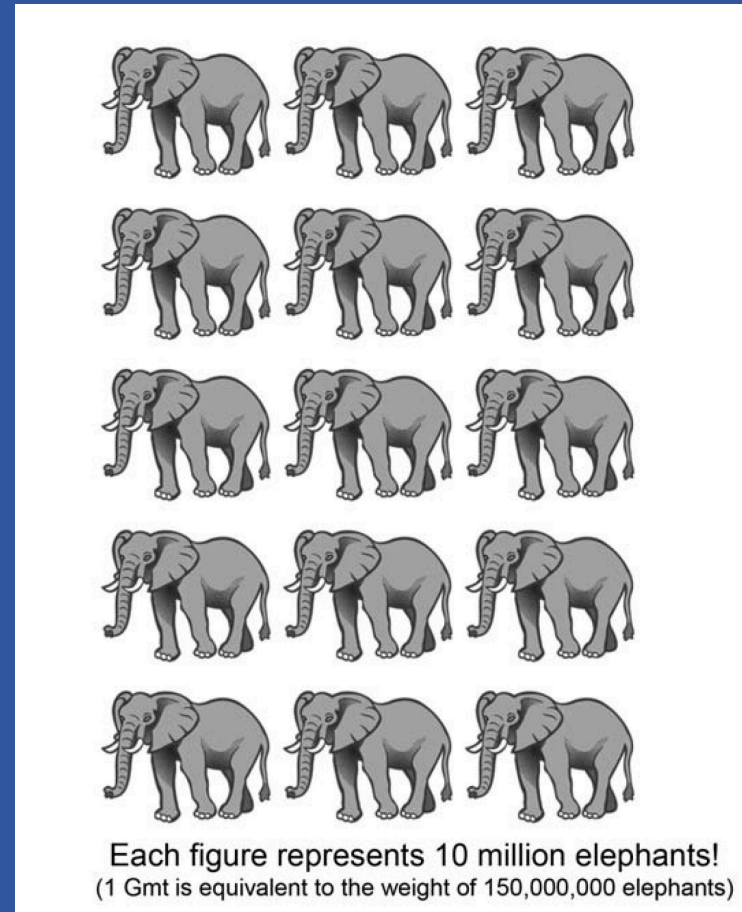
- To stop global warming and climate change, we have to **REACH NET ZERO** emissions
- **NET ZERO** is when no additional human-caused greenhouse gases are added to the atmosphere
- Emissions that can't be eliminated have to be offset by natural means or technology
- Carbon removal not practical

Can we continue to discharge 54 billion metric tons per year of green house gases indefinitely?

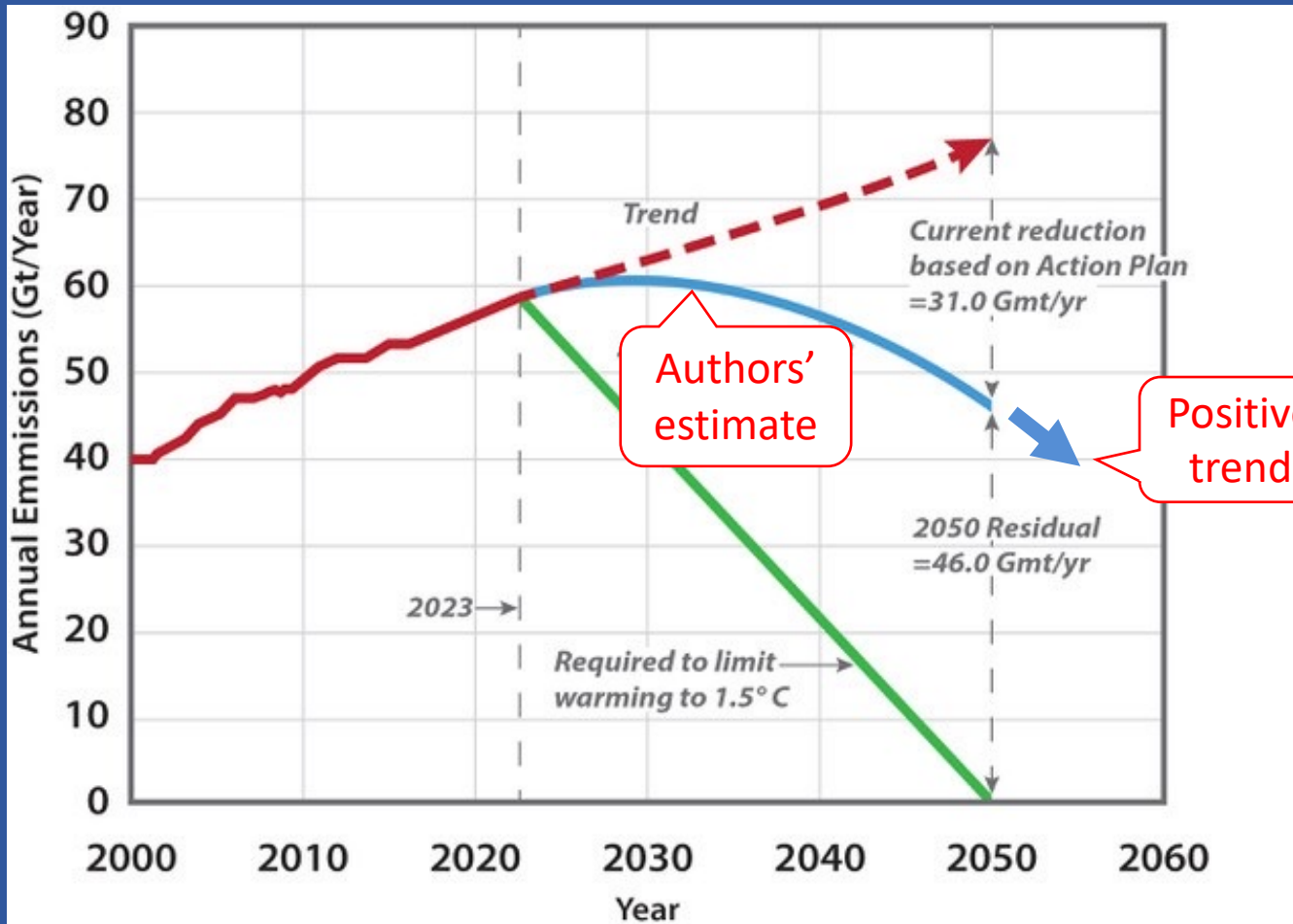


GREENHOUSE GAS EMISSIONS STILL INCREASING

- **54 BILLION METRIC TONS/YEAR** in 2023
- On track to set new emissions record in 2024
- Follows a temporary decline due to the virus pandemic
- CO₂ emissions of about 40 billion metric tons/year



IT'S TOO LATE TO LIMIT GLOBAL WARMING TO $< 2.0^{\circ}\text{C}$



HOW DO WE KNOW GLOBAL WARMING IS REAL?

Bill Fletcher

IS GLOBAL WARMING REAL?

ARE GREENHOUSE GAS CONCENTRATIONS INCREASING? YES

IS THE EARTH'S TEMPERATURE RISING? YES

IS THE OCEAN'S TEMPERATURE RISING? YES

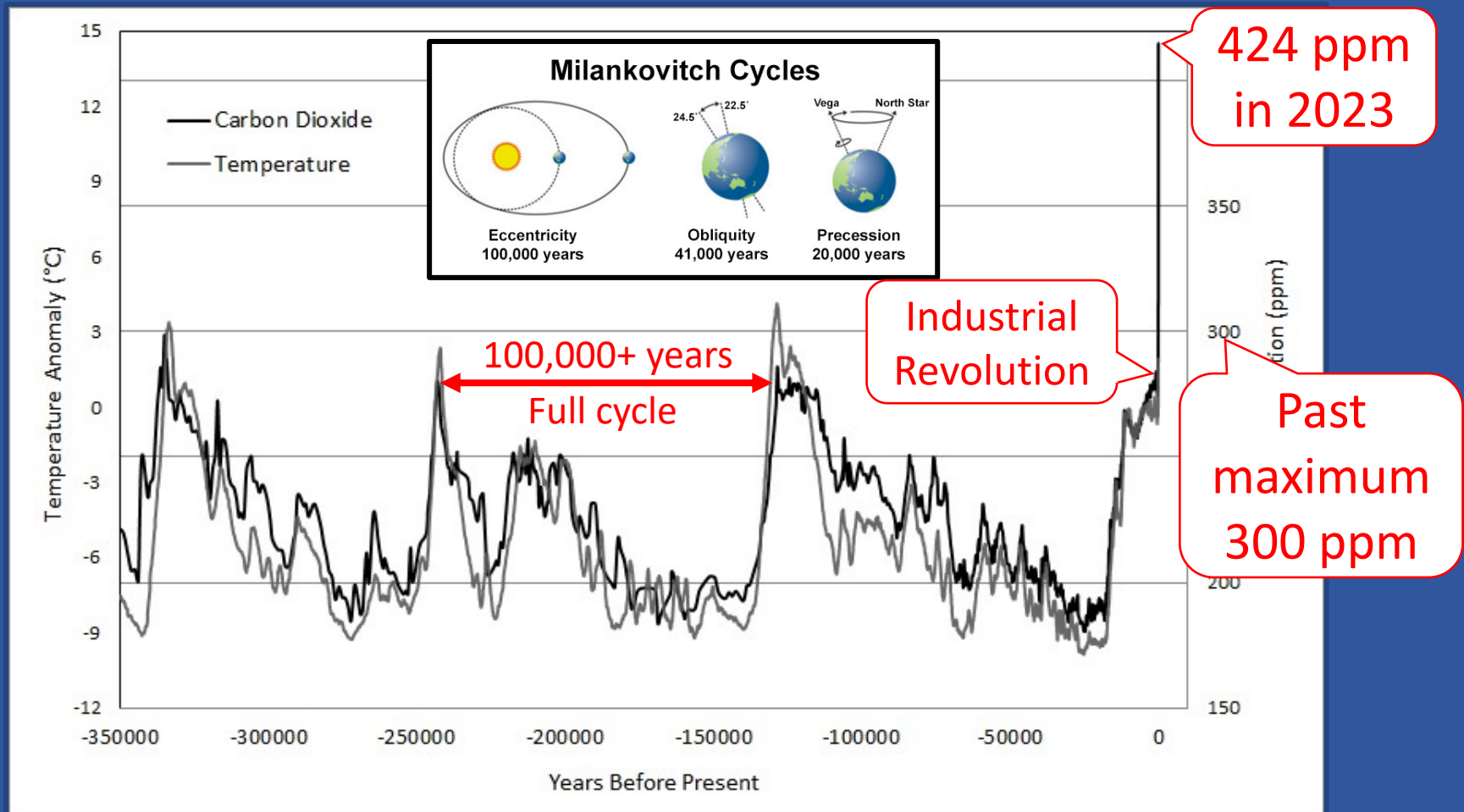
ARE SEA LEVELS RISING? YES

ARE GLACIERS MELTING EVERYWHERE? YES

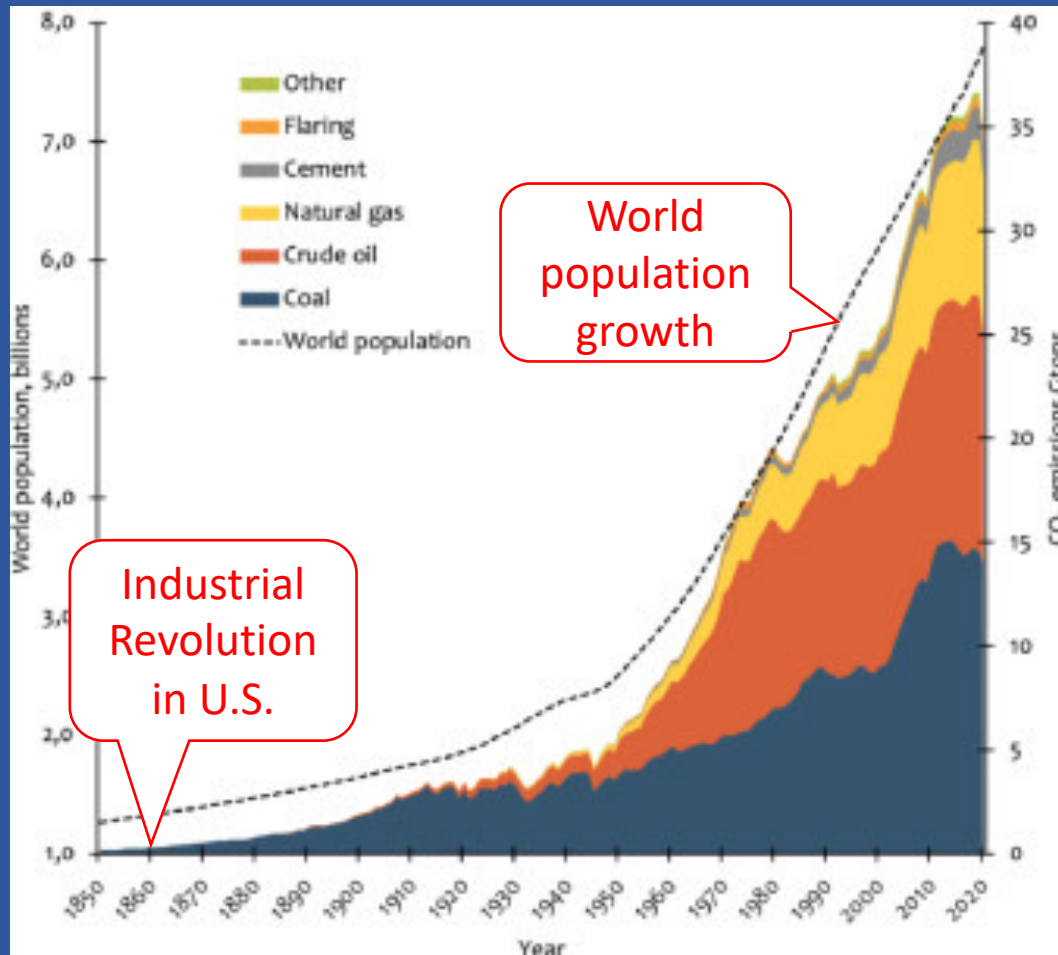
IS ARCTIC AND ANTARCTIC SEA ICE RETREATING? YES

IS THE GREENLAND AND ANTARCTIC ICE CAPS MELTING? YES

NATURAL CHANGES TAKE 100,000 YEARS



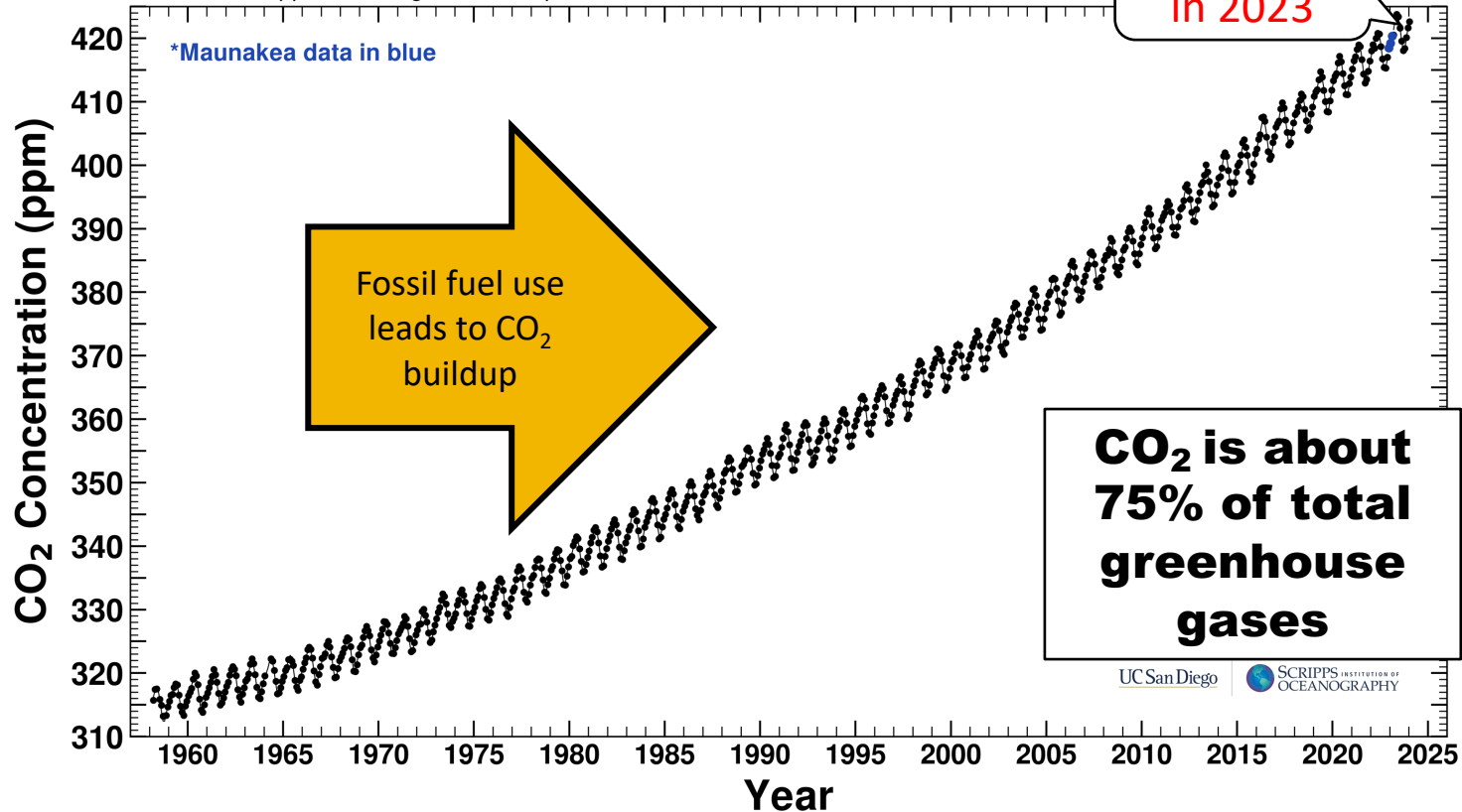
CO₂ INCREASING DUE TO HUMAN FOSSIL FUEL USE



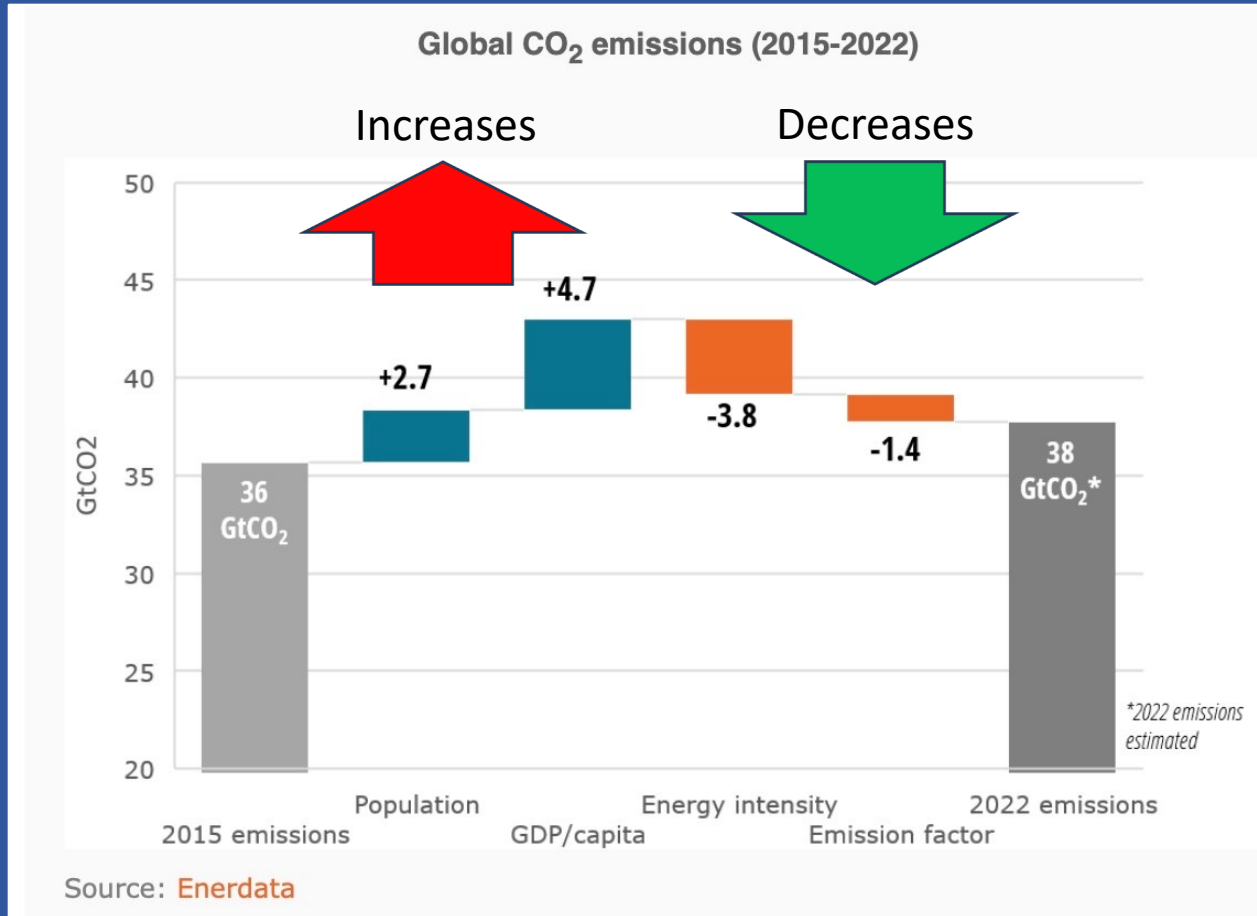
CO₂ INCREASING DUE TO HUMAN FOSSIL FUEL USE

Mauna Loa Observatory, Hawaii* Monthly Average Carbon Dioxide Concentration

Data from Scripps CO₂ Program Last updated March 2024



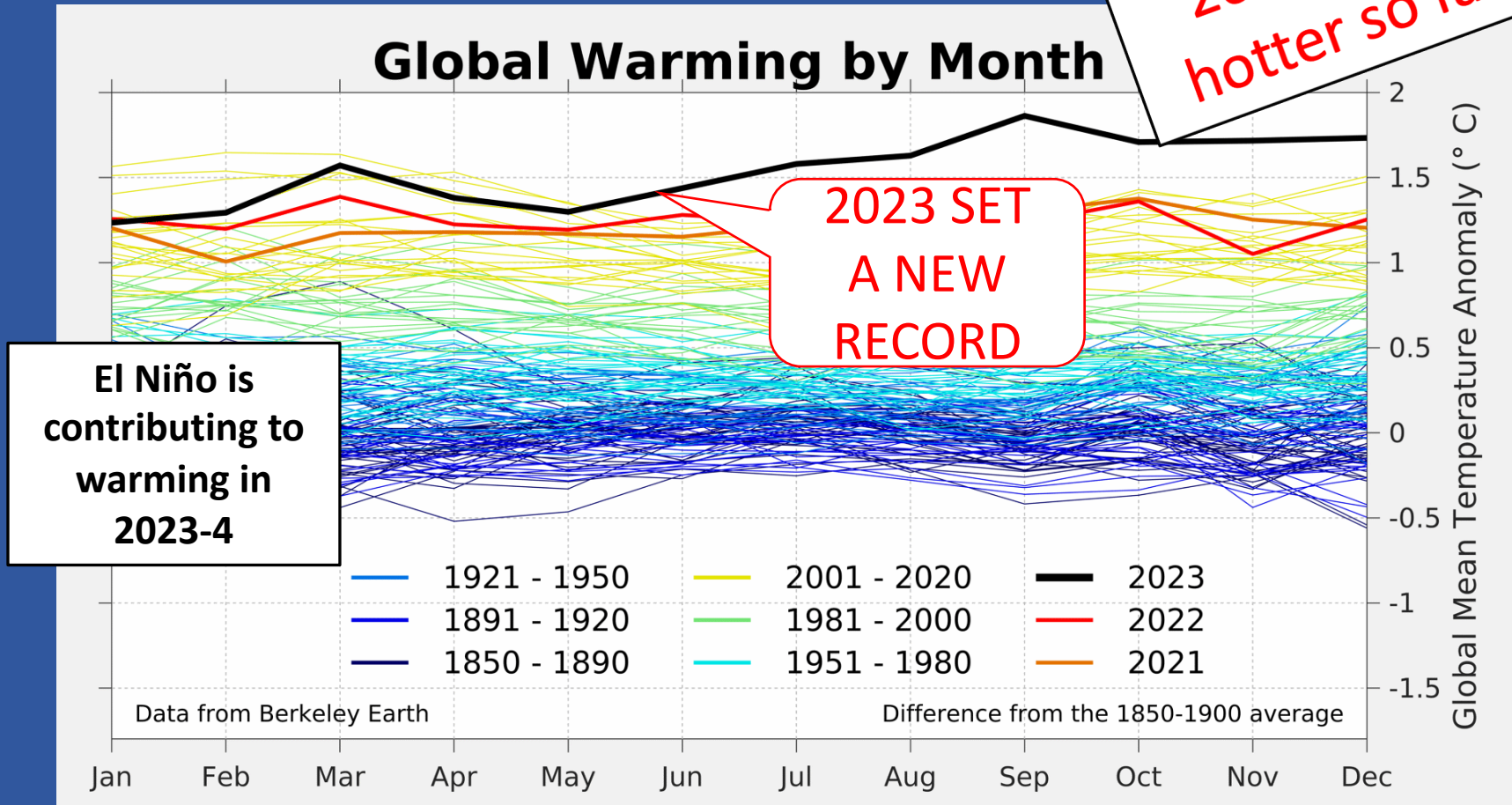
NO REDUCTIONS SO FAR



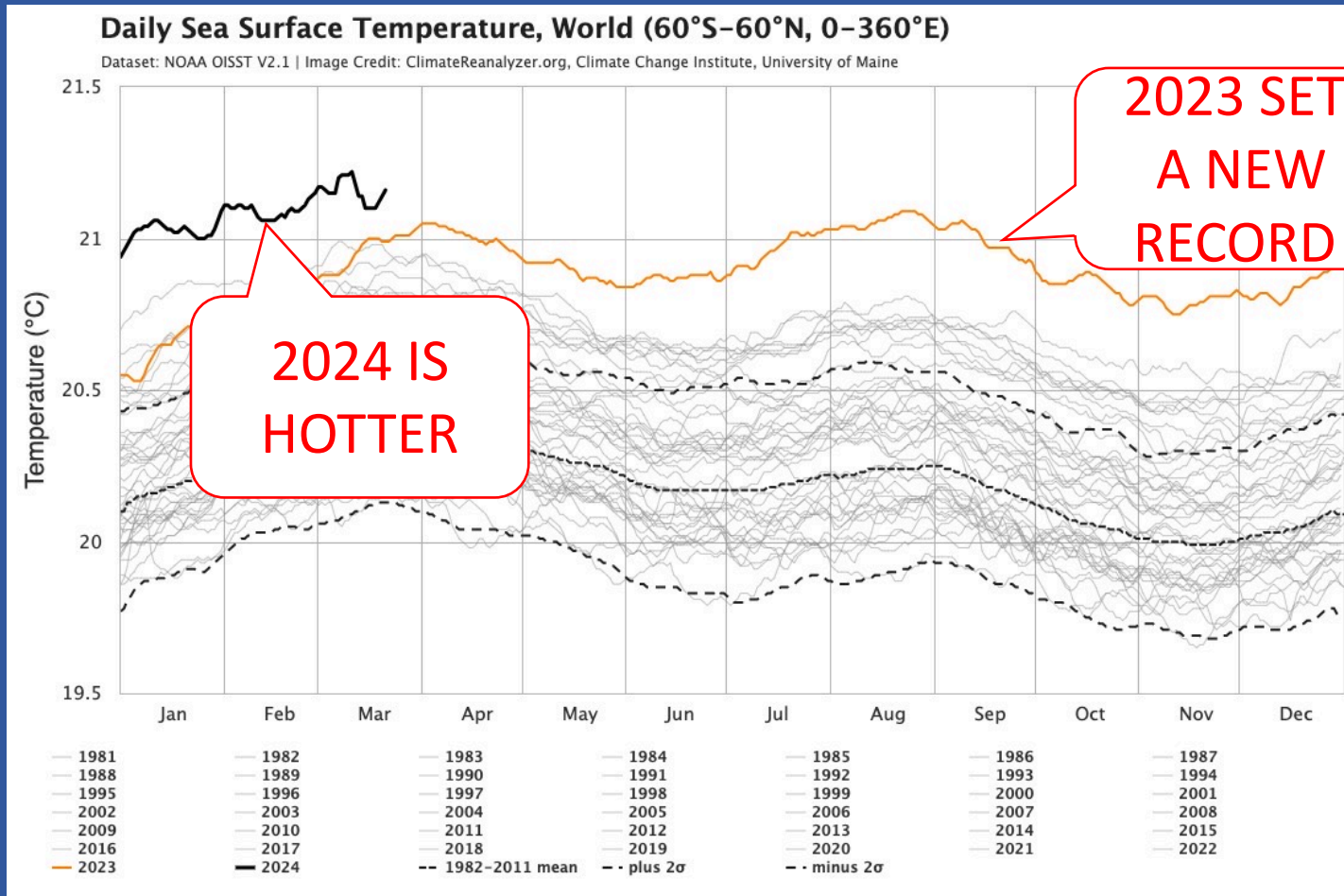
PAST 10 YEARS HOTTEST ON RECORD

2024 even hotter so far

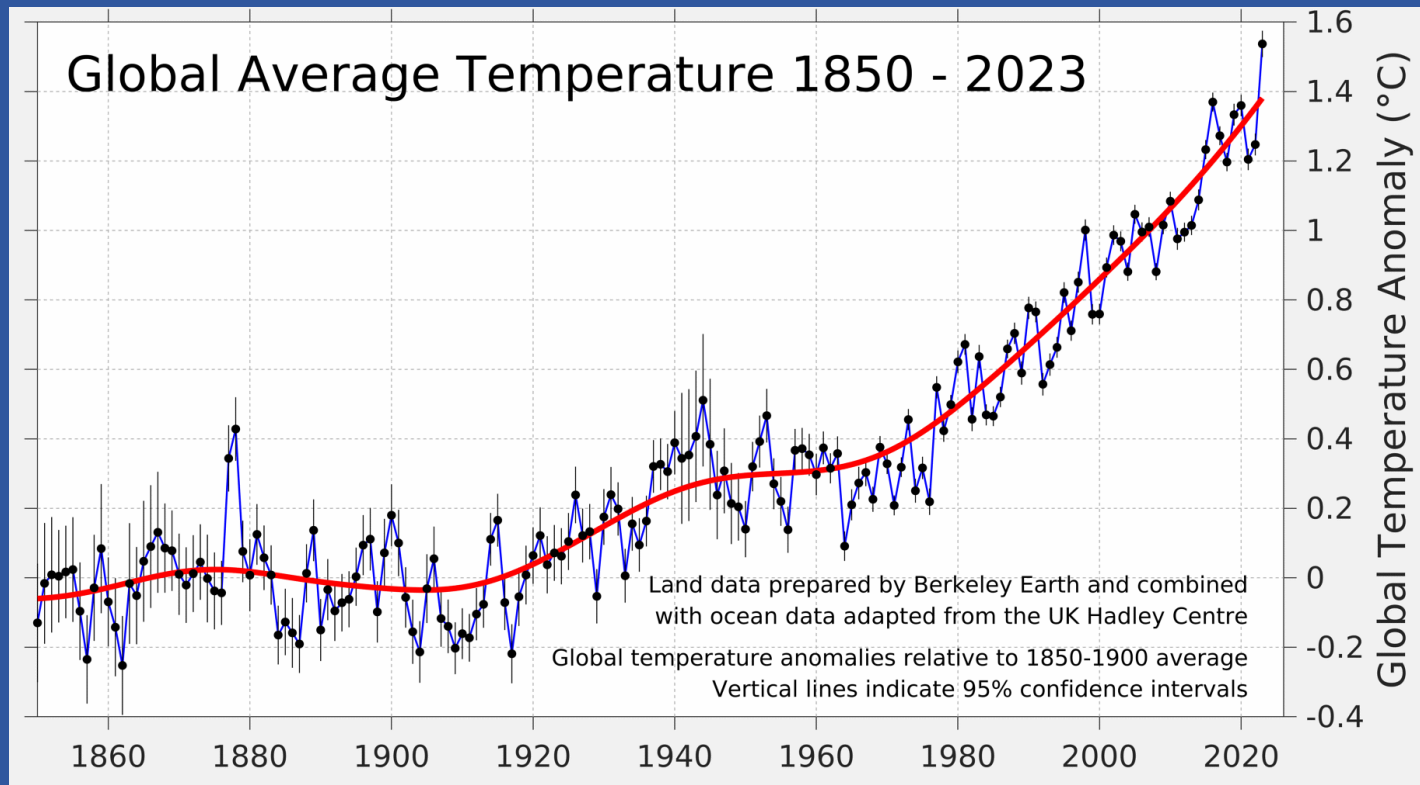
Global Warming by Month



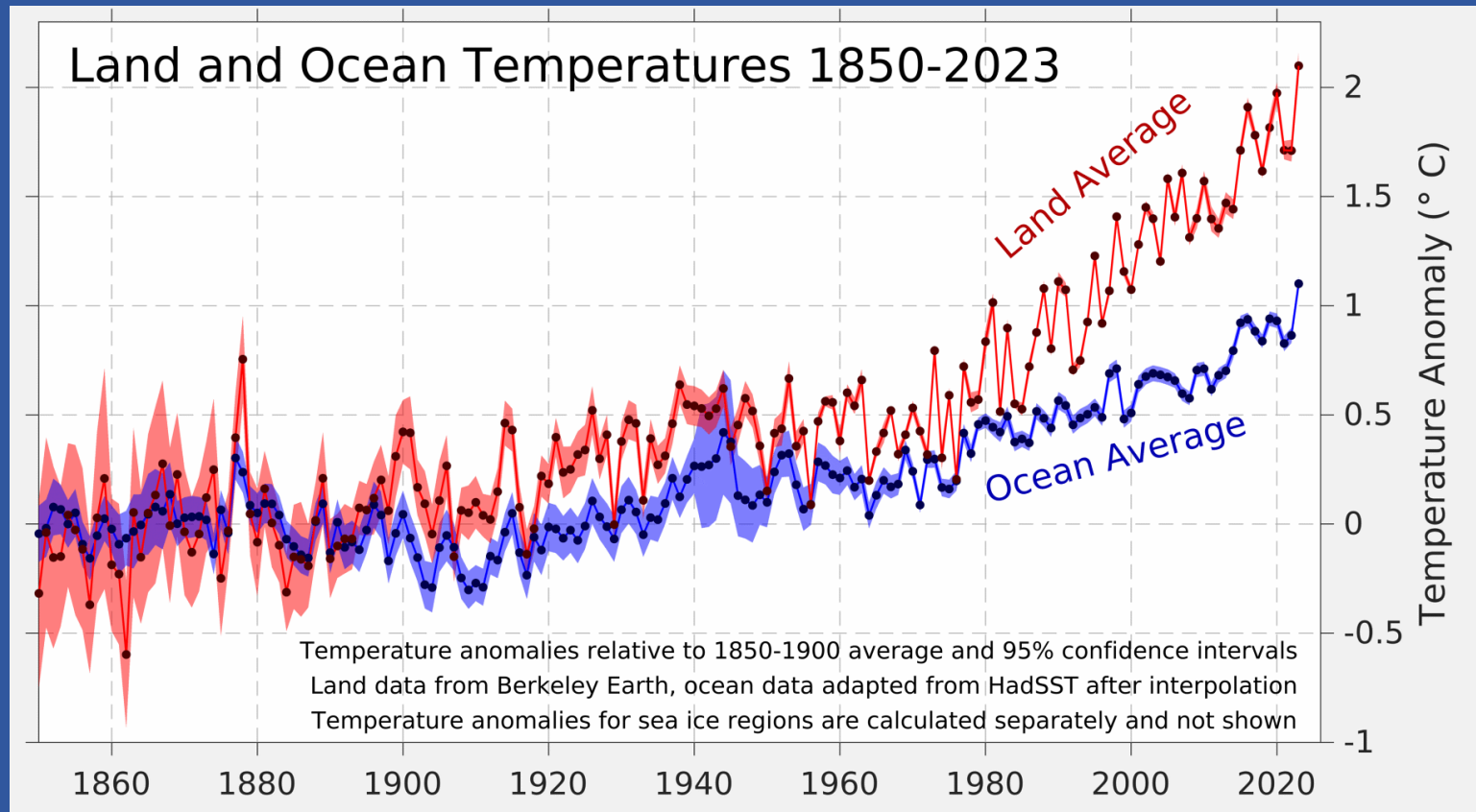
SEA TEMPERATURES RISING



GLOBAL AVERAGE TEMPERATURE UP AT LEAST 1.2°C (2.2F)



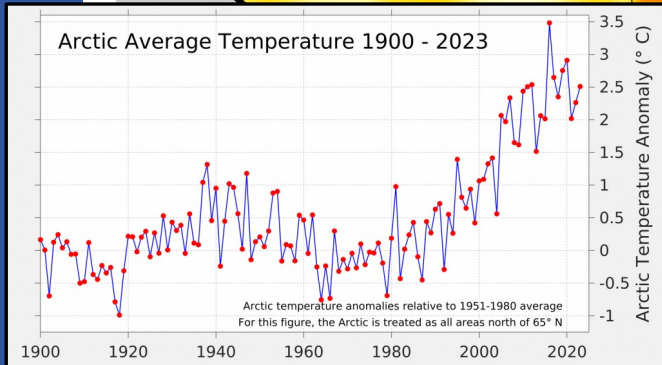
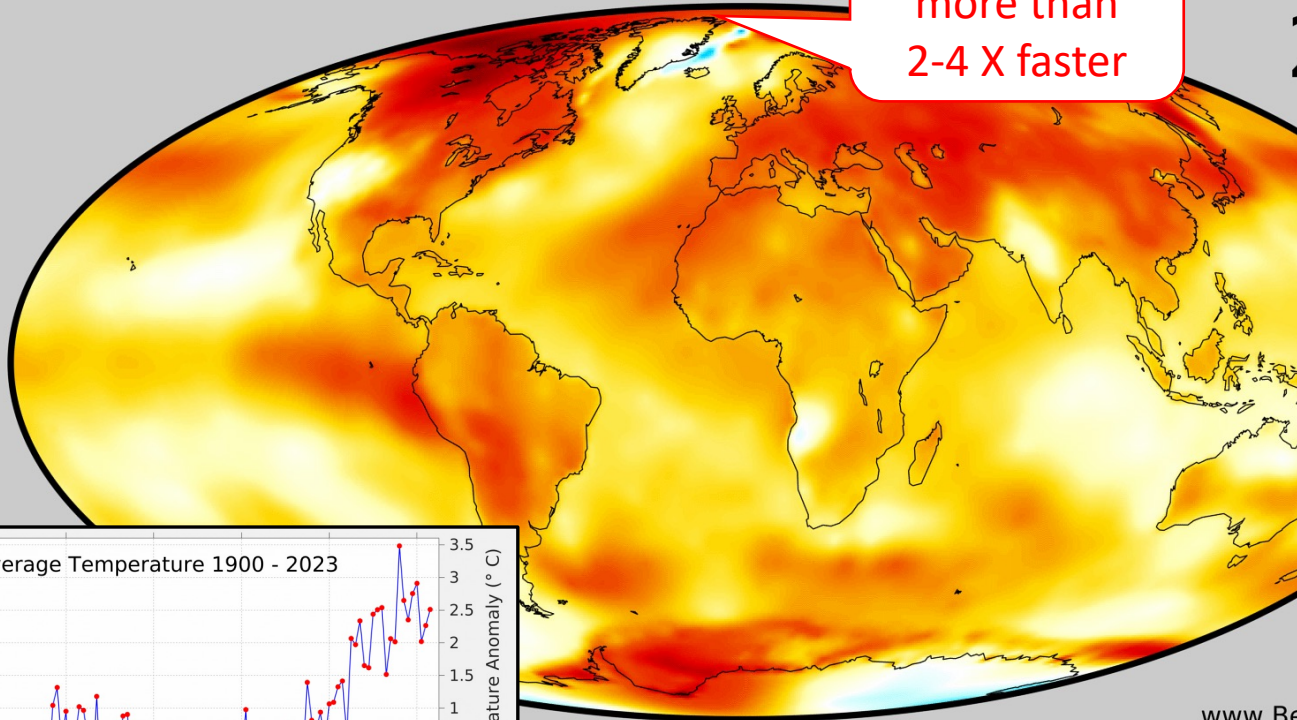
LAND IS HEATING FASTER THAN THE OCEANS



ARCTIC HEATING MUCH FASTER

Arctic heating
more than
2-4 X faster

2023

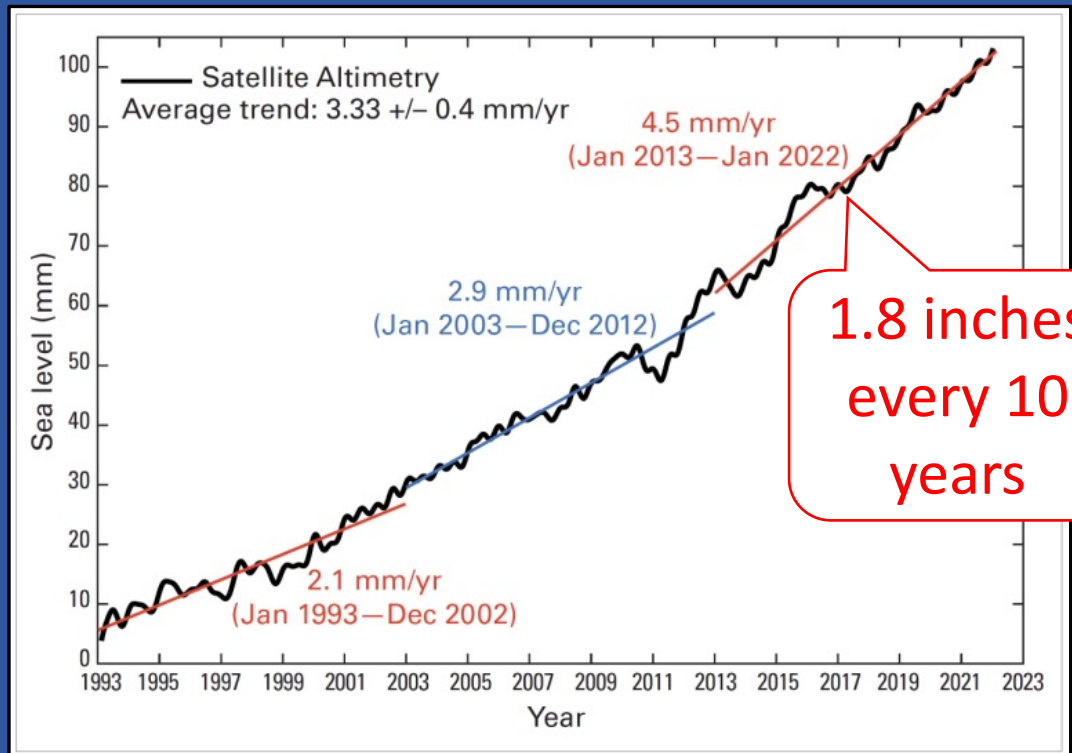


www.BerkeleyEarth.org

Temperature
Anomaly (° C)

SEA LEVEL RISING-1

- Sea level rise approximately 9 to 10 inches due to thermal expansion and melting ice

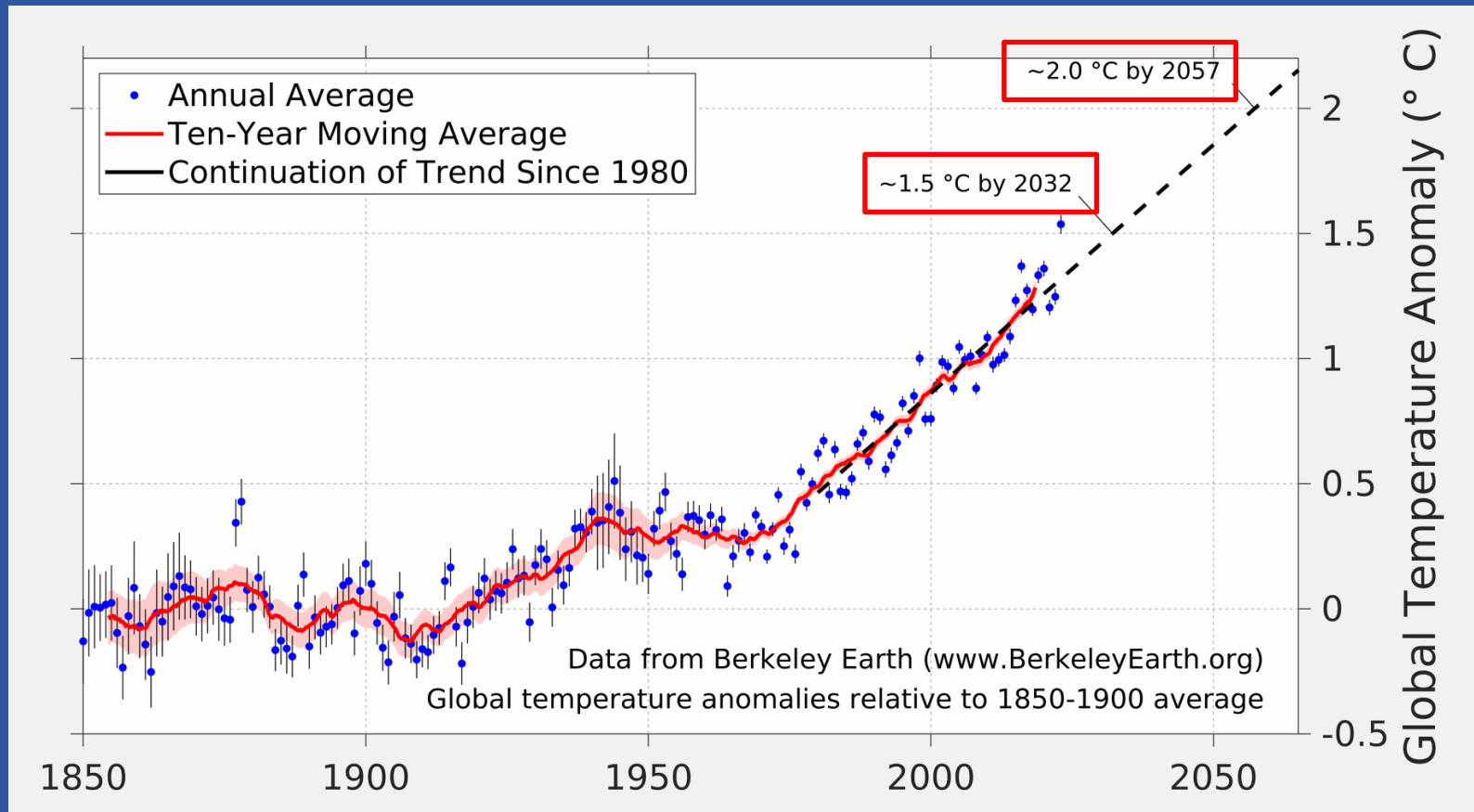


World Meteorological Organization (WMO)

WHAT ARE THE CONSEQUENCES?

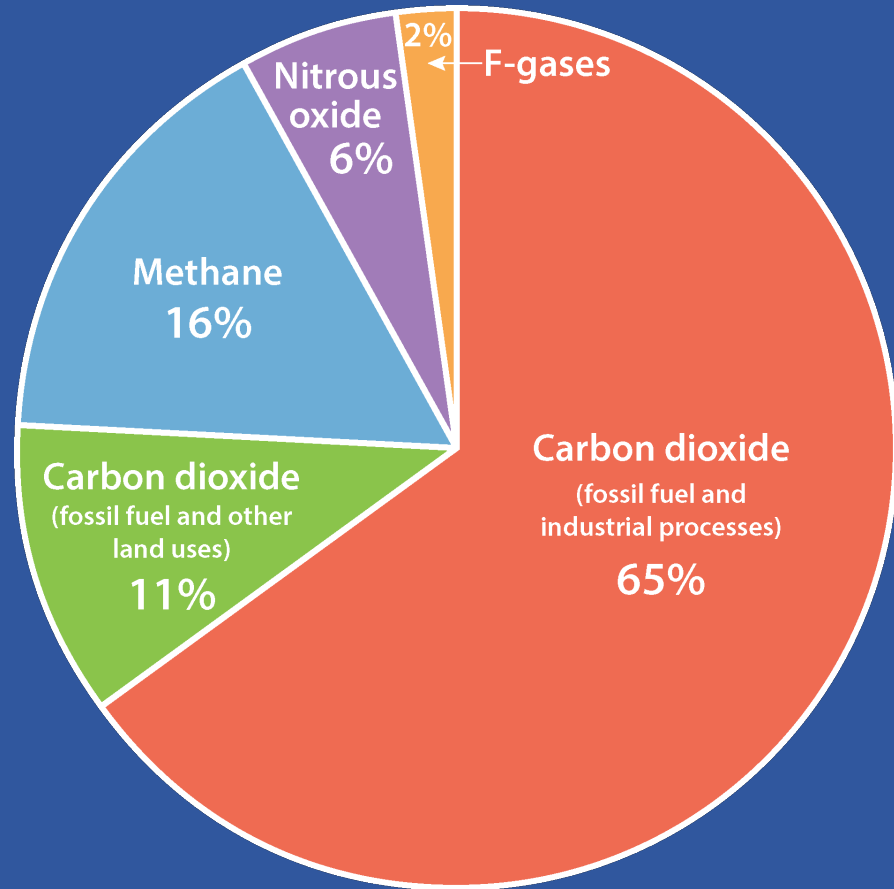
Craig Smith

WHERE ARE WE HEADED?

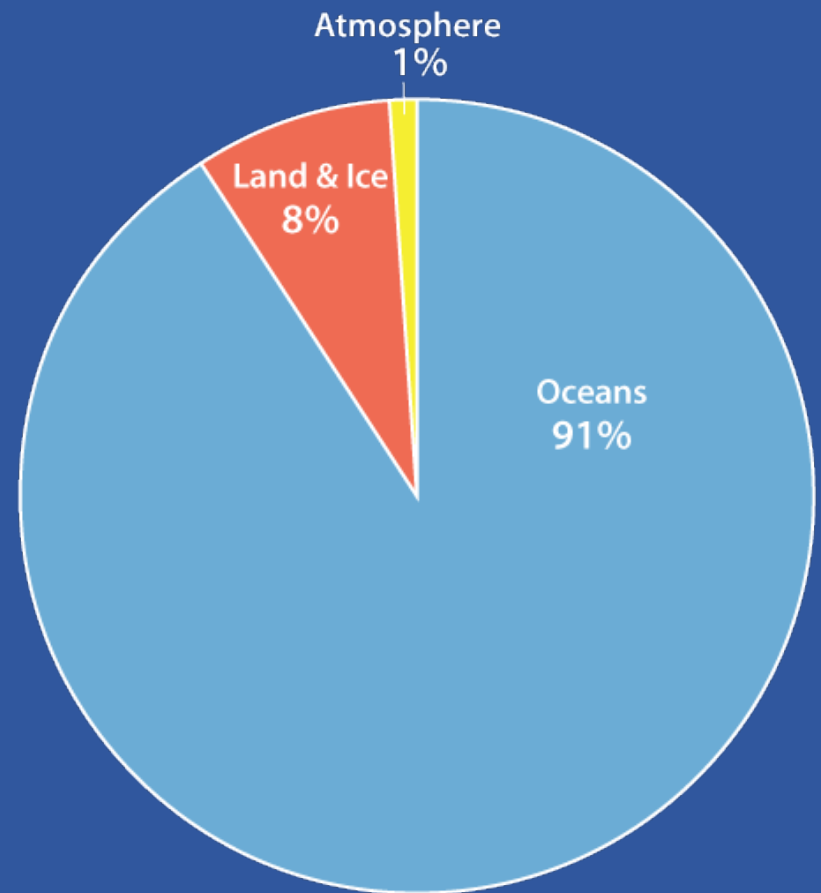
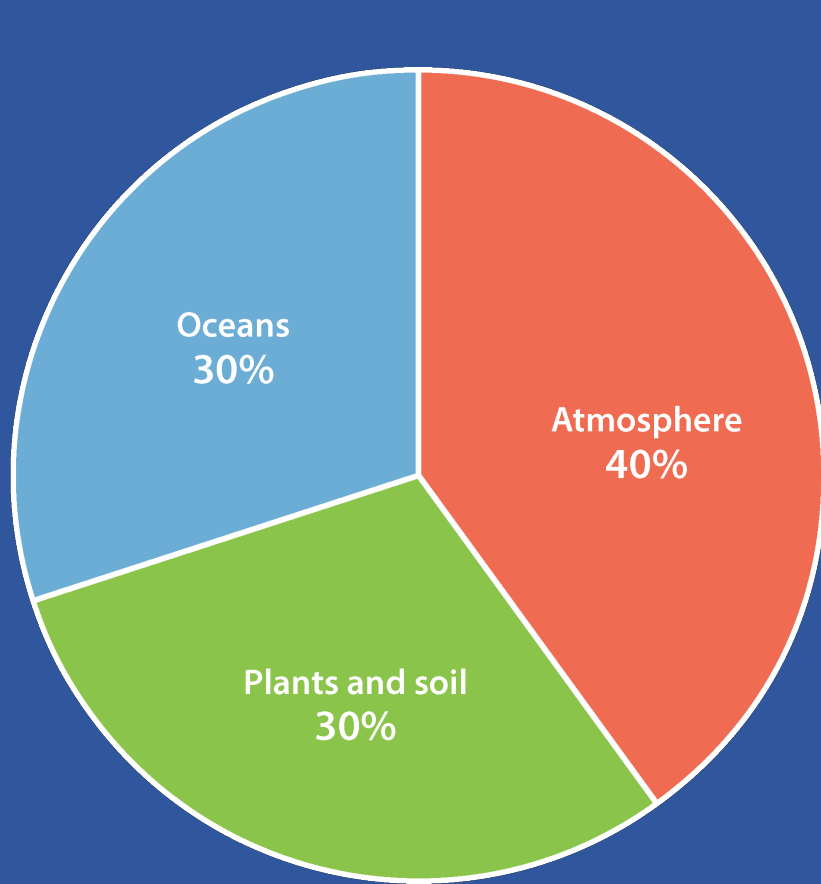


CO₂ ACCOUNTS FOR 76% OF ALL GREENHOUSE GASES

Fossil fuel use	76%
Agriculture, forestry, land use changes	24%



OCEANS ABSORB 30% OF THE CO₂ AND OVER 90% OF THE HEAT



CHINA AND THE U.S. ACCOUNT FOR 40% OF TOTAL EMISSIONS

COUNTRY	TOTAL EMISSIONS (giga metric tons)	EMISSIONS (percent)
China	15.7	29.2
U.S.	6.0	11.2
India	3.9	7.3
EU-27	3.6	6.7
Brazil	1.3	2.4
Japan	1.2	2.2
Rest of world	22.1	41.0
Total	53.8	100

PER CAPITA EMISSIONS (tons/capita)	
U.S.	17.9
China	11.0
Japan	9.4
EU-27	8.1
Brazil	6.1
India	2.8
World average	6.8

EDGAR Emissions Data Base

GLOBAL WARMING CONSEQUENCES

Global warming

- Emissions increasing
- Temperature increasing
- Sea level rising
- Oceans more acidic
- Sea ice declining
- Glaciers melting
- Weather changing

Consequences*

- Heat waves
- Forest fires
- Droughts
- Health effects
- Water scarcity
- Infrastructure damage
- Migration/displacement
- Ecosystem collapse
- Rising poverty
- Human rights injustices

*State of the Global Climate 2020, World
Meteorological Society

POSSIBLE TIPPING POINTS, NON-LINEAR EVENTS

A. Amazon rainforest

Frequent droughts

B. Arctic sea ice

Reduction in area

C. Atlantic circulation

In slowdown since 1950s

D. Boreal forest

Fires and pests changing

F. Coral reefs

Large-scale die-offs

G. Greenland ice sheet

Ice loss accelerating

H. Permafrost

Thawing

I. West Antarctic ice sheet

Ice loss accelerating

J. Wilkes Basin, East Antarctica

Ice loss accelerating

©nature

WE KNOW WHAT NEEDS TO BE DONE!

- California SB 100 Joint Energy Report, Path To 100% Clean Energy
- Wartsila, Path to 100% Renewables in California
- NREL, Los Angeles 100% Renewable Energy Study
- Cal Berkeley, 2035 report on U.S. Clean Energy Grid
- DOE, Carbon-Neutral Pathways for the U.S.
- Princeton University, Net-Zero America: Potential Pathways
- IRENA, World Energy Transitions Outlook, 1.5°C Pathway
- IEA, Net Zero by 2050, A Roadmap
- UK Government, Net Zero Strategy: Build Back Greener

WHAT MUST BE DONE?

Bill Fletcher

THE ACTION PLAN - 1

- 1 Improve efficiency and conservation**
- 2 Produce all electricity with renewables**
- 3 Use electricity for most power and heat**
- 4 Transition to electric vehicles**

THE ACTION PLAN - 2

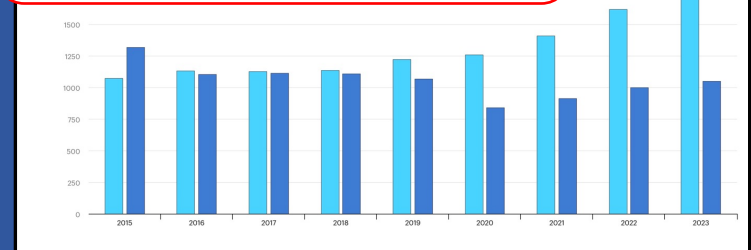
- 5 Use hydrogen and synthetic fuels where needed
- 6 Stop deforestation and plant billions of trees
- 7 Change agriculture
- 8 **Need a smooth transition from fossil fuels to reliable renewables**

WHAT SHOULD THE GOVERNMENT DO?

- Need comprehensive plans at the national and state levels
- Modernizing and expanding the electric grid is an essential up-front project
- Stop subsidizing fossil fuels and ethanol
- Land use planning is essential
- Most states will have to import renewable electricity same as fossil fuels

BUT IT WILL COST \$ TRILLIONS!!

Most investment for
renewables in 2023



- Should be enough investment for renewables
- Global energy investment \$2.8 trillion in 2023
- 61% was for renewables
- Investment likely more than \$100 trillion over next 40 to 50 years
- Most investment will be to replace and obsolete fossil fuel investments

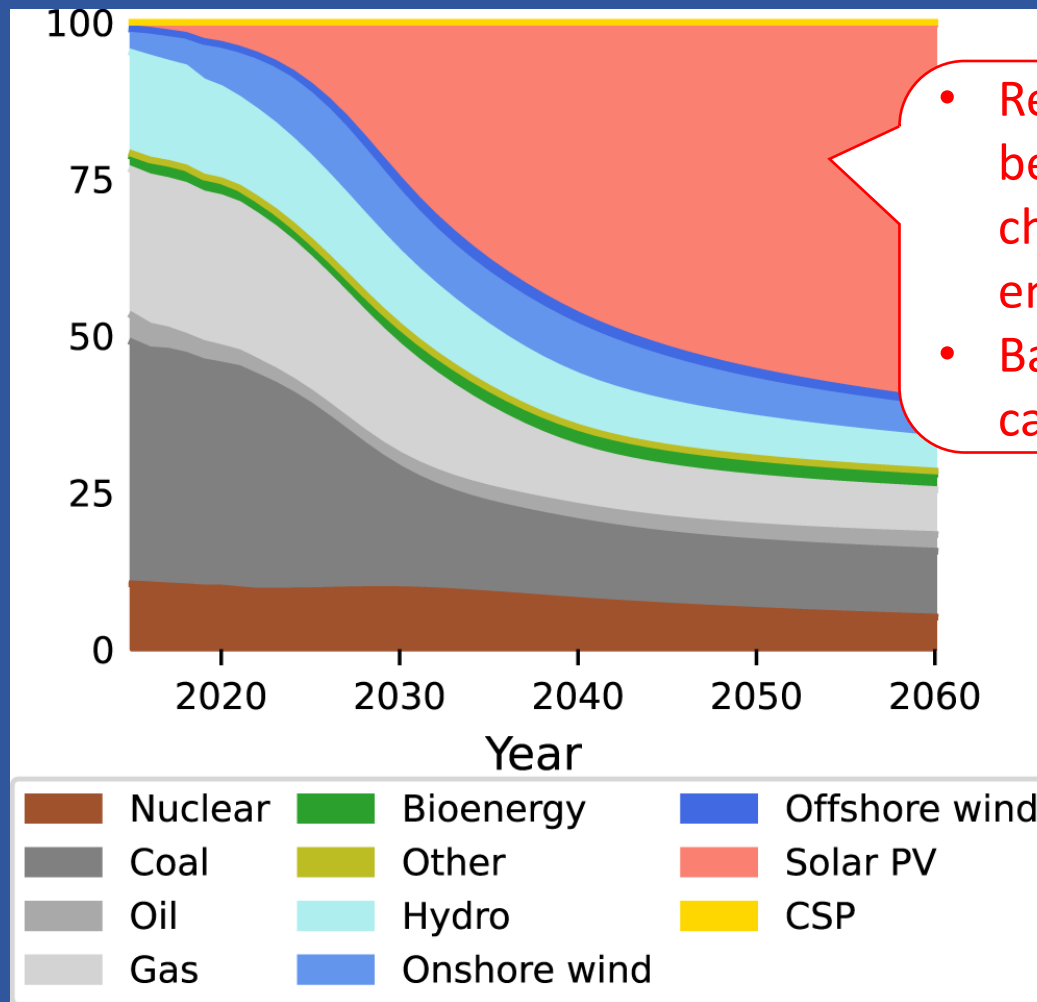
RENEWABLE ELECTRICITY SHOULD NOT COST MORE

Texas:

- Up front investment in transmission system
- Deregulated electricity market
- True competition between suppliers
- Leads to boom in renewables and low electricity prices

Metric	Texas (1)	California (2)	Texas/California
Renewable electricity (Terawatt hours)	136.8	69.5	197%
Electricity price (Cents per kilowatt)	11.36	19.90	(57%)

“THE TREND IS OUR FRIEND”



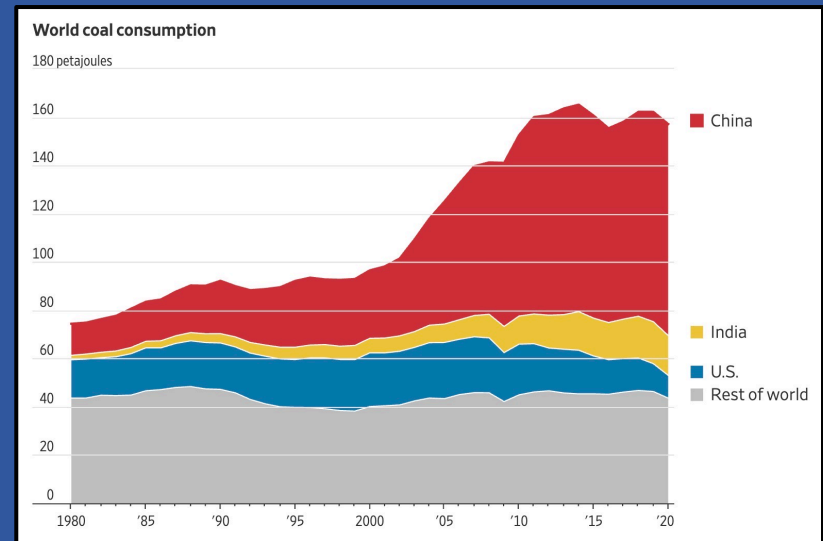
CAN NUCLEAR POWER HELP?

It will take a long time, be very expensive, and may not be successful

- Will have to replace today's old nukes (93 reactors) before we get a net benefit
- Industry was allowed to die
- Recent projects way over budget
- The public still concerned about nuclear safety
- Siting will be a problem, where will we put new nukes?
- Have to solve the spent fuel disposal problem
- New nukes have to be competitive with renewables and natural gas

THE CHINA CHALLENGE

- China committed to reach net zero by 2060
- Unfortunately, coal is China's only domestic energy source
- But, China leads in renewables with world's largest installed base of solar and wind capacity by far
- Also leads the world in production of electric vehicles, batteries, wind turbines, solar panels, high speed rail and nuclear power plants
- China is targeting renewables as a major export business opportunity



WHAT MIGHT HAPPEN? - 1

- Will not REACH NET ZERO by 2050
- 2.0 °C will be exceeded
- A carbon tax will not be politically acceptable
- Will have a rough transition to renewables
- May not attain much public support

WHAT MIGHT HAPPEN? - 2

- Adaptation and mitigation have to be a big part of our response
- Progress continues with improving technology, increasing economies of scale, successful large projects
- Renewable energy could displace most fossil fuels over time

WHAT MIGHT HAPPEN? - 3

- China may capture a large share of our green energy market
- May exceed some tipping point, a wake up call?
- May reach NET ZERO eventually
When?
- **FAILURE IS AN OPTION!!**

WHAT CAN YOU DO?

Remember, we have to get to NET ZERO!! If we don't do the big things, the commendable small things won't make much difference.

- Educate yourself
- Spread the word
- Support change
- Lobby state and federal representatives
- Take prudent actions to reduce our own greenhouse gas emissions

Q & A

Craig Smith Ph.D., is an engineer and former faculty member at UCLA. During his career he was responsible for planning large energy conservation programs for utilities, schools, corporations and the City of Los Angeles. He is the former president and chairman of the international architect/engineering company DMJM+HN. He is the author of several books on energy efficiency and management.

William Fletcher is a mechanical engineer and former senior vice president at Rockwell International. He served as an officer and engineer in the Navy working on the design and operation of nuclear-powered ships, and he was an engineer involved with the design and construction of commercial nuclear power plants. Later, he focused on automation and international operations. His international experience includes several overseas assignments including an assignment in Saudi Arabia planning the large Jubail industrial development project.

*Smith and Fletcher are coauthors of **THE GLOBAL CLIMATE CRISIS: What To Do About It** published by Elsevier in 2024*