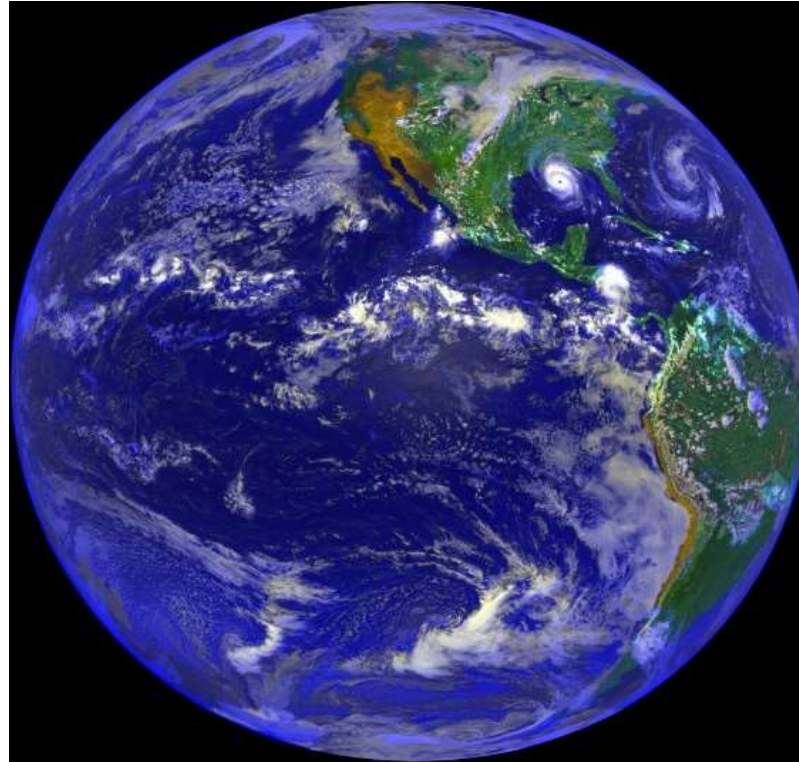


Geopolitics of Energy and Climate Change



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Great Decision Series—February 9, 2017

Why do 99.9% of Climate Scientists Believe CO₂ is Warming the Planet?

1. Theory predicts that increasing atmospheric CO₂ should warm the planet.
2. Geologic evidence links CO₂ and temperature in the past.
3. Recent CO₂ concentrations and warming are unprecedented (dwarfing natural variability).
4. Climate models show that rising CO₂ is necessary to simulate 20th century temperature trends (solar and volcanic ash are minor players).

Source: Adapted from
Kim Cobb (2016)

The “Enhanced” Greenhouse Effect

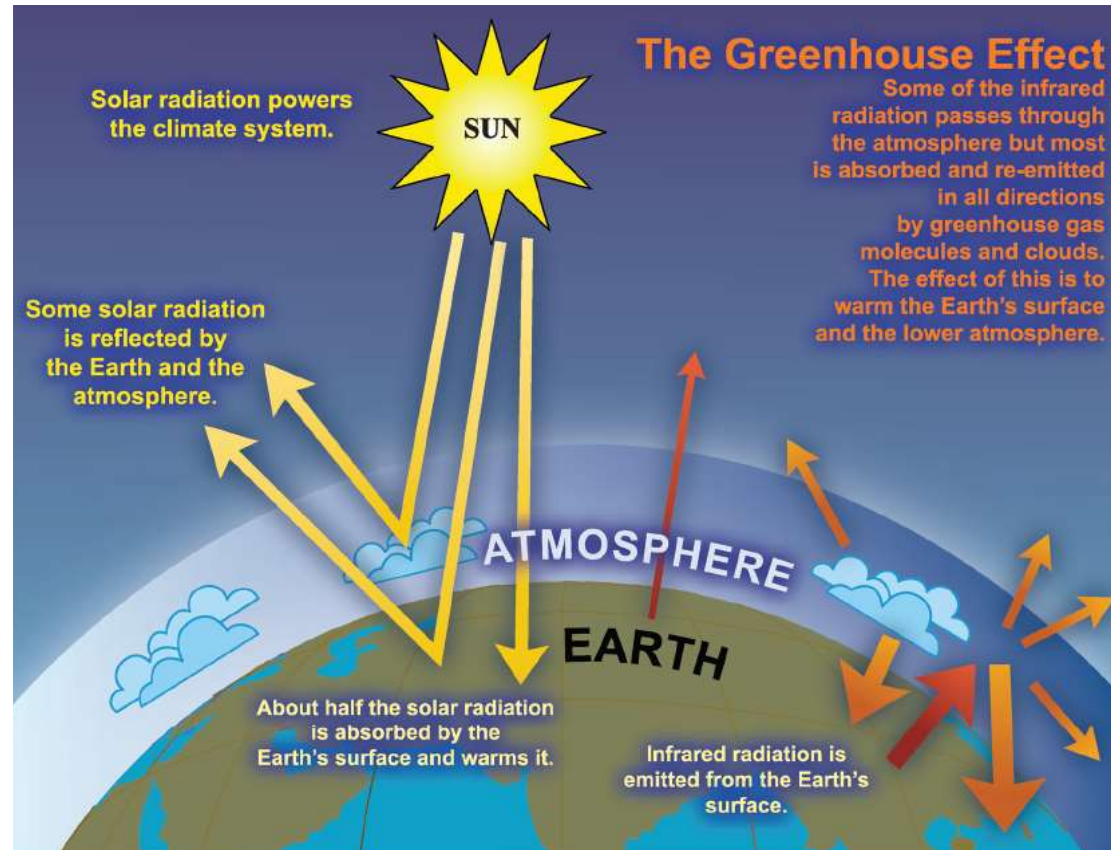
Greenhouse gases allow solar radiation to pass through the atmosphere.

But when the sunlight is re-radiated back toward space, GHGs absorb and then re-emit the infrared radiation, trapping heat.

The most abundant GHGs are naturally occurring:

- water vapor (H_2O)
- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)....

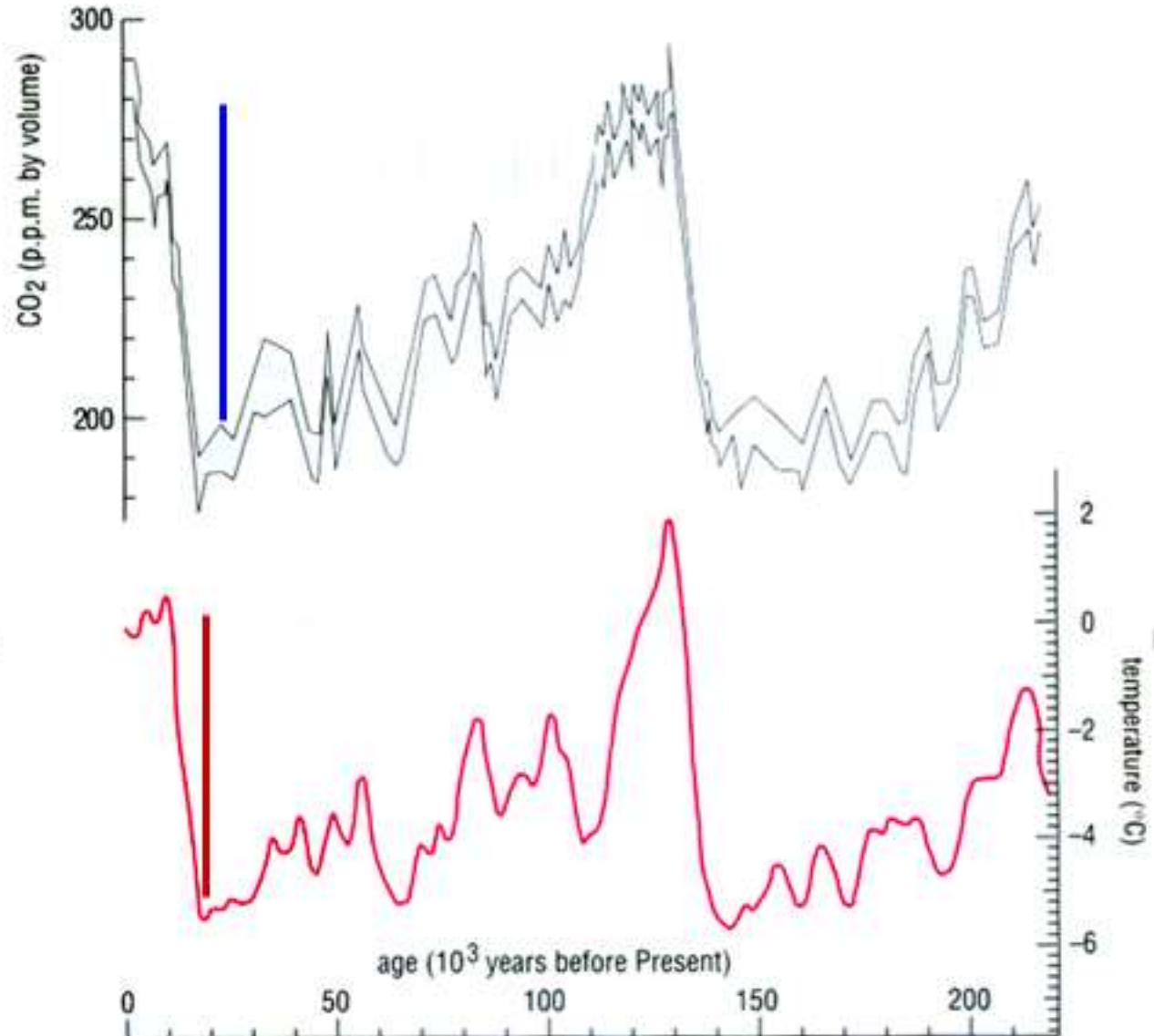
Human actions are “enhancing” this natural greenhouse effect--primarily from the burning of fossil fuels.



A Paleo Perspective: Glacial-interglacial Cycles

CO₂

range = 200 to 280ppm

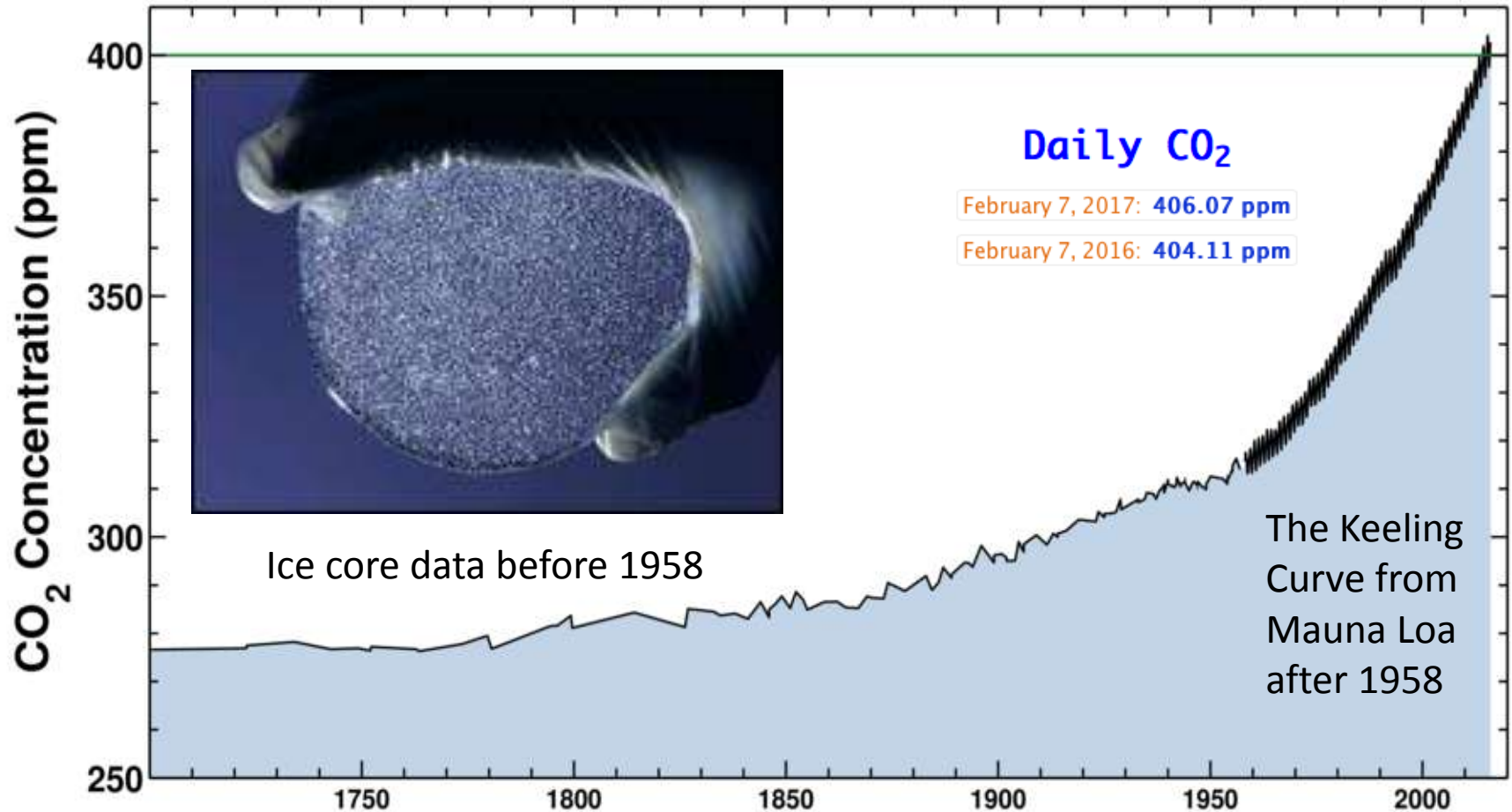


Temperature

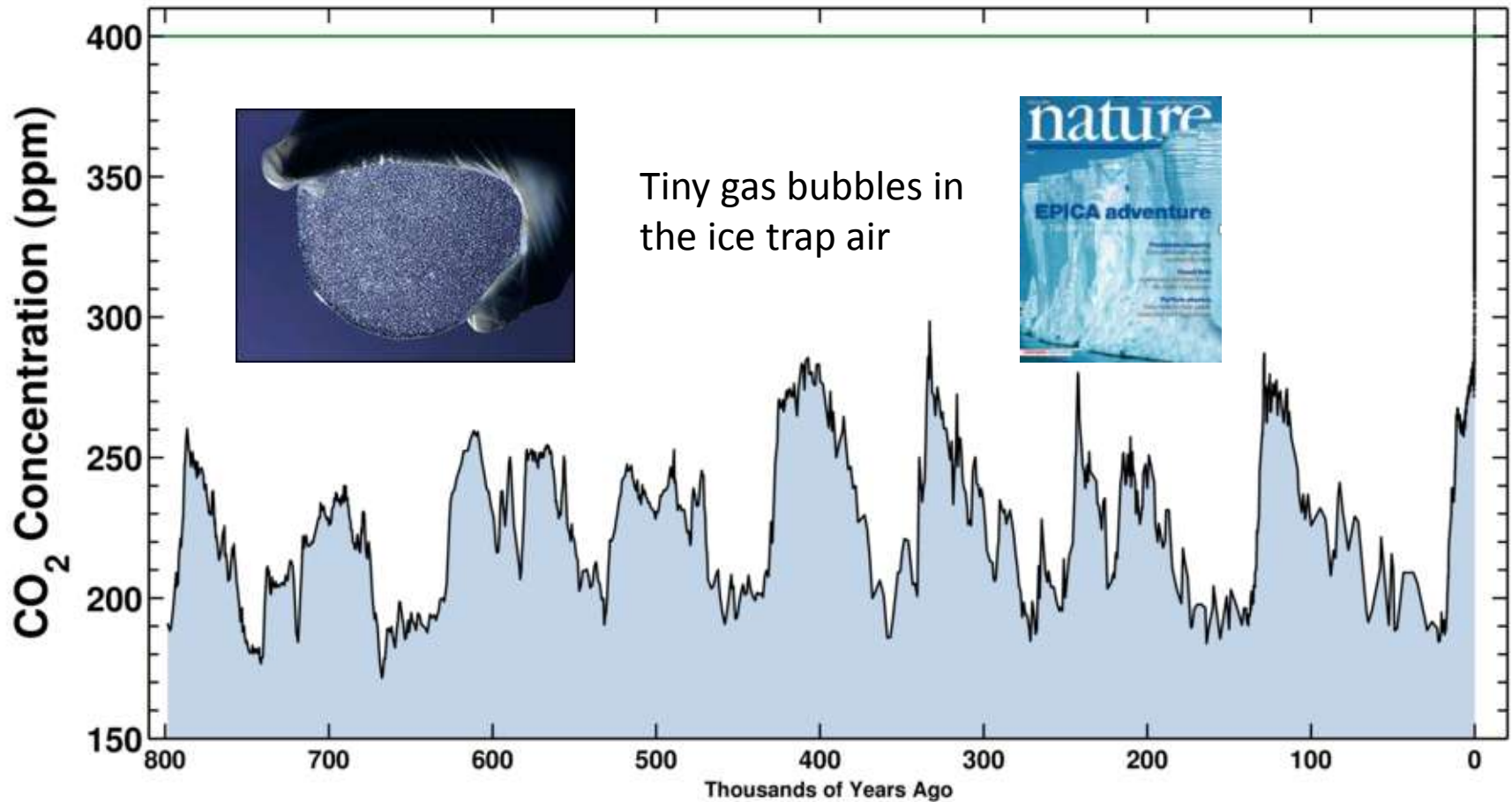
range = 5°C

Source: Adapted from
Kim Cobb (2016)

CO₂ Concentration Since 1700

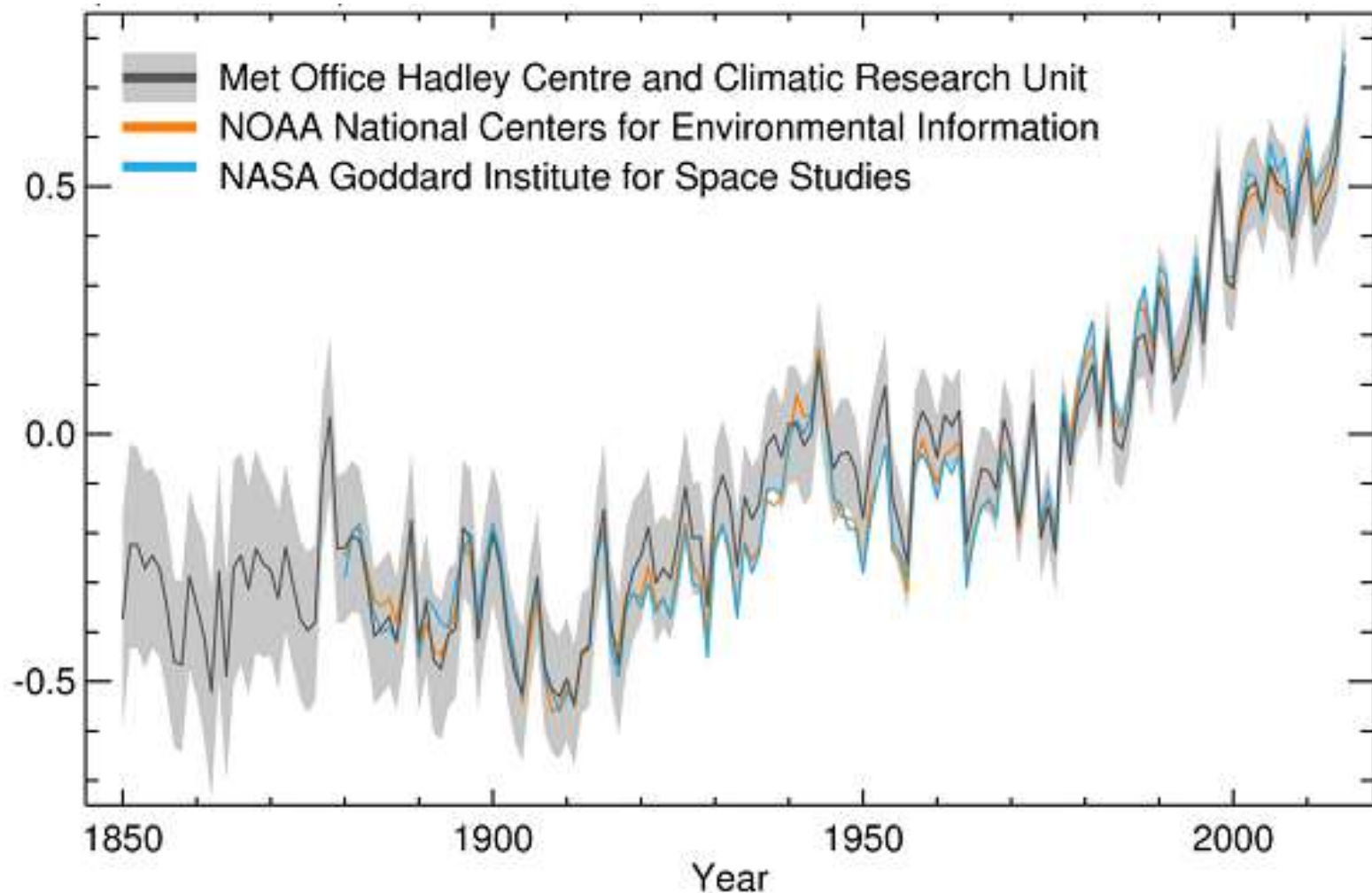


CO₂ Concentration Over the Last 800,000 Years



A $\sim 1^{\circ}\text{C}$ warming over the last century with a New Record in 2016

Global Average Temperature Differences from 1961-1990 ($^{\circ}\text{C}$)



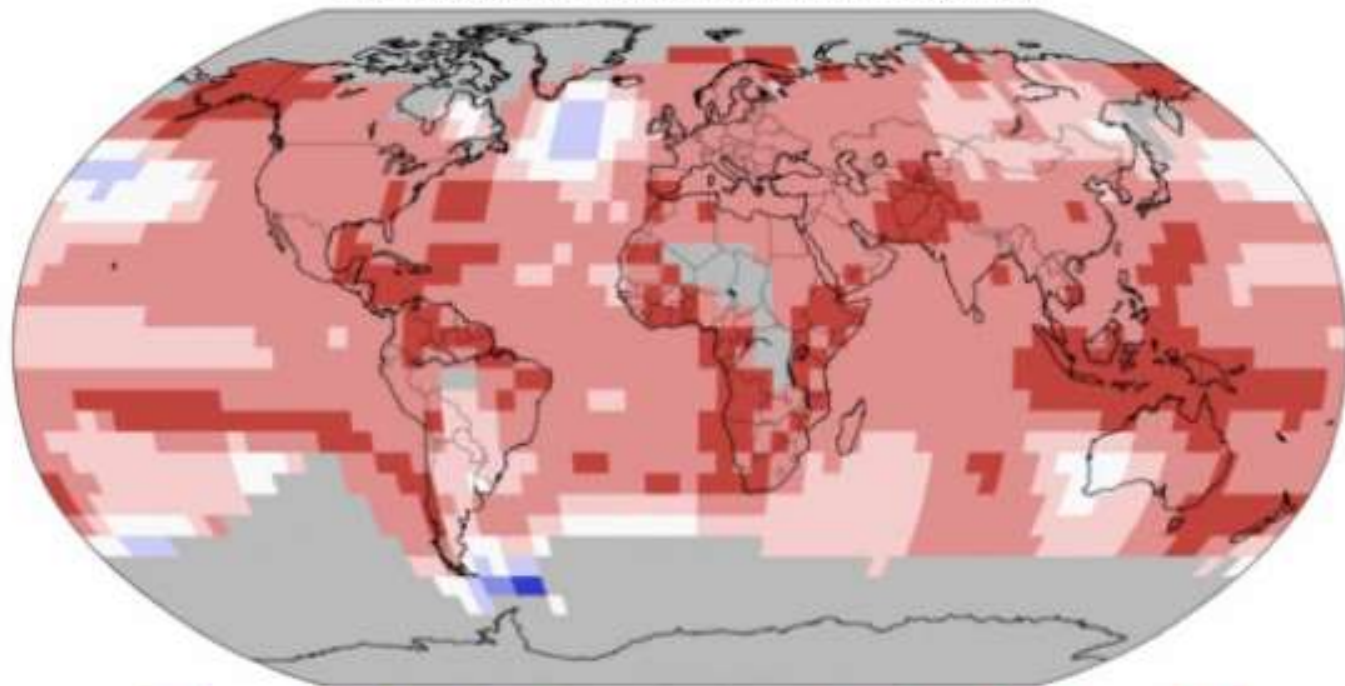
Source: Hadley Center, UK Met Office

2016: Hottest Year on Global Record (Third in a Row)

Land & Ocean Temperature Percentiles Jan–Dec 2016

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



Record
Coldest

Much
Cooler than
Average

Cooler than
Average

Near
Average

Warmer than
Average

Much
Warmer than
Average

Record
Warmest

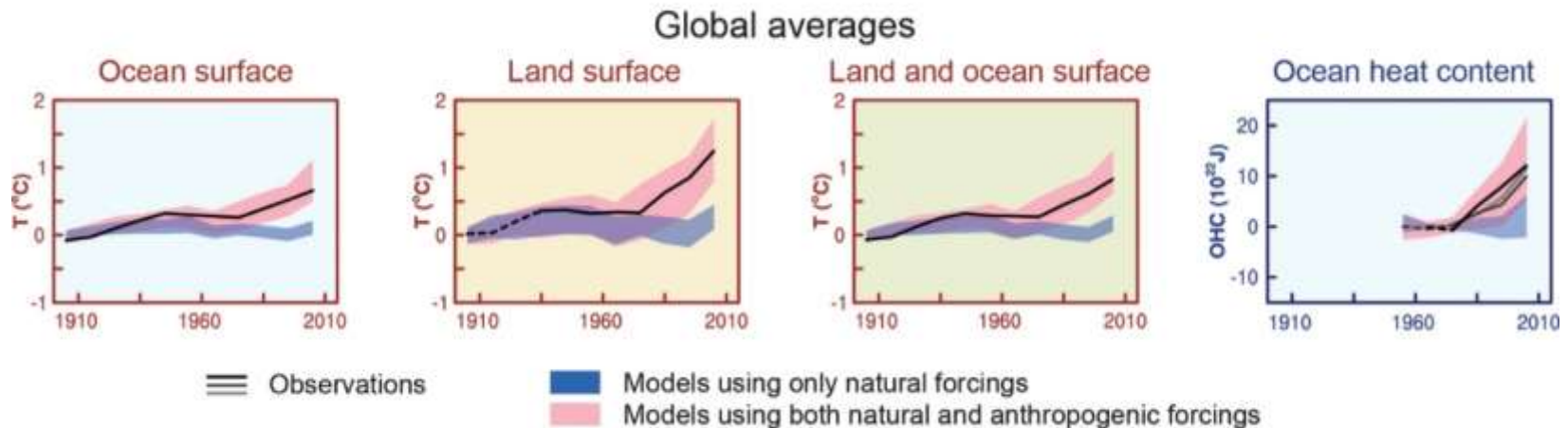


Wed Jan 11 07:07:38 EST 2017

2016 temperatures compared to normal around the globe. (NOAA)

The Southeast is no longer an "anomaly".

Anthropogenic Forcings are Needed to Match Climate Models to Observations



Intergovernmental Panel on Climate Change

- “Human influence has been detected:
in warming of the atmosphere and ocean,
in changes in the global water cycle,
In reductions in snow and ice,
In global mean sea level rise, and
In changes in some climate extremes.”
- “It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.”

Source: IPCC *Summary for Policy Makers*. 2014

CARBON DIOXIDE IS UP TO
400 PARTS PER MILLION.



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THAT MEANS FLOODS, DROUGHT
AND RISING SEA LEVELS.



www.bostonglobe.com/wasserman

WHY ARE YOU PEOPLE
ALWAYS SO NEGATIVE?



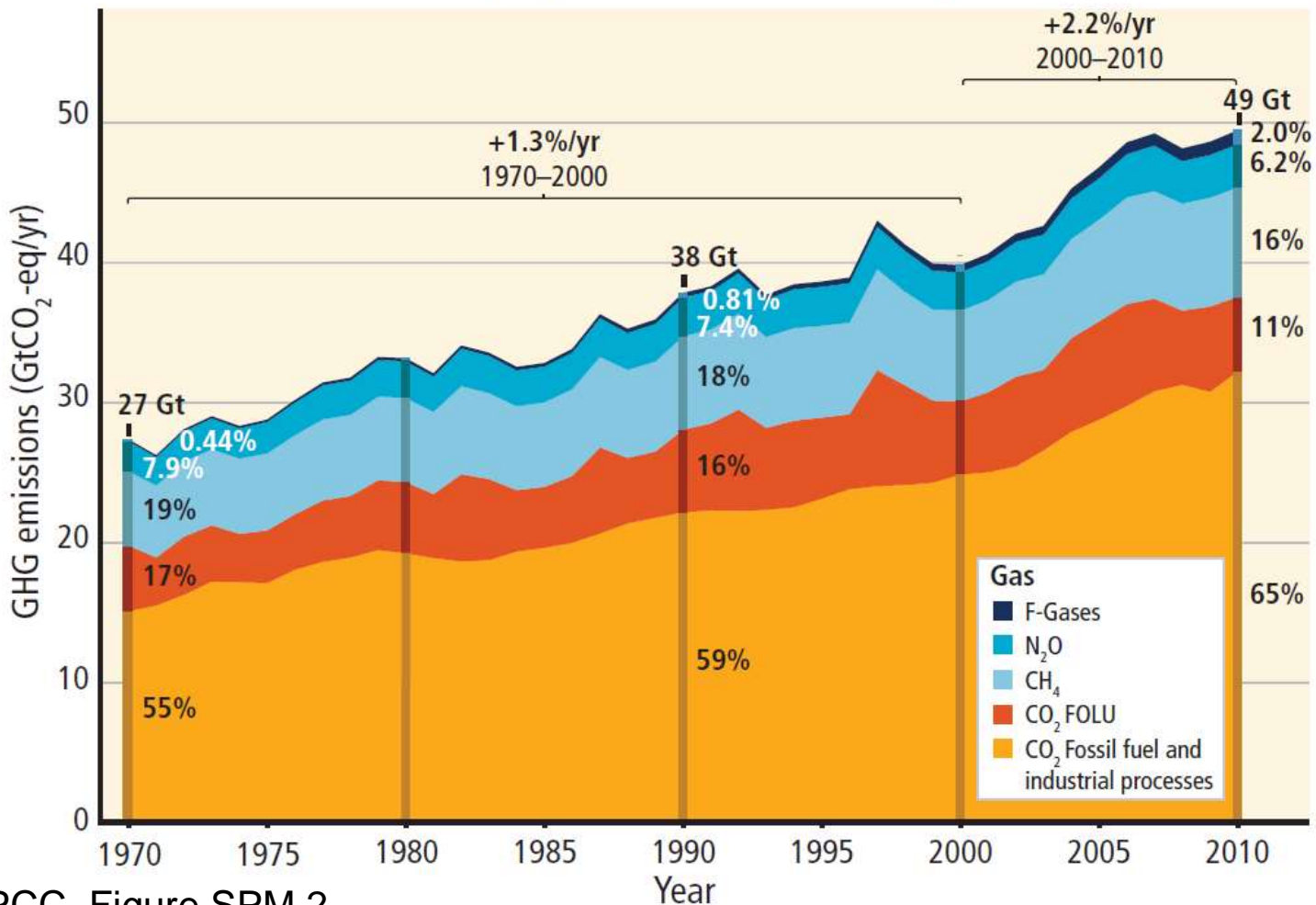
WASSERMAN © 5.13 THE BOSTON GLOBE

YOU NEVER TALK ABOUT THE
OTHER 999,600 PARTS!



CO₂ is the Most Important Greenhouse Gas

Total Annual Anthropogenic GHG Emissions by Gases



Global Climate Policy is Moving Forward

The Paris Agreement:



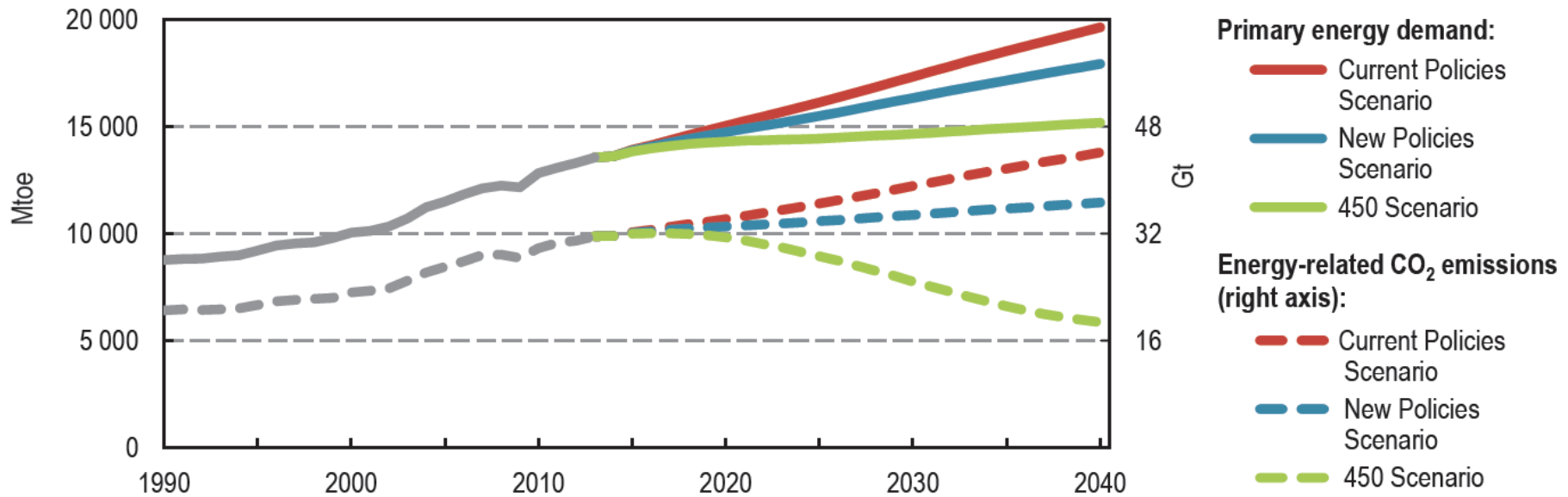
- “strengthen the global response to the threat of climate change by
 - a) Holding the increase in the global average temperature to **well below 2°C above pre-industrial levels** and to pursue efforts to limit the temperature to 1.5°C above pre-industrial levels,
 - b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience
 - c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development.”
- “Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.”

What Might a 2°C Scenario Look Like?

Red ~ Current Policies Scenario

Blue ~ 2015 Paris Accord (New Policies Scenario)

Green ~ 2°C global temperature increase above pre-industrial revolution



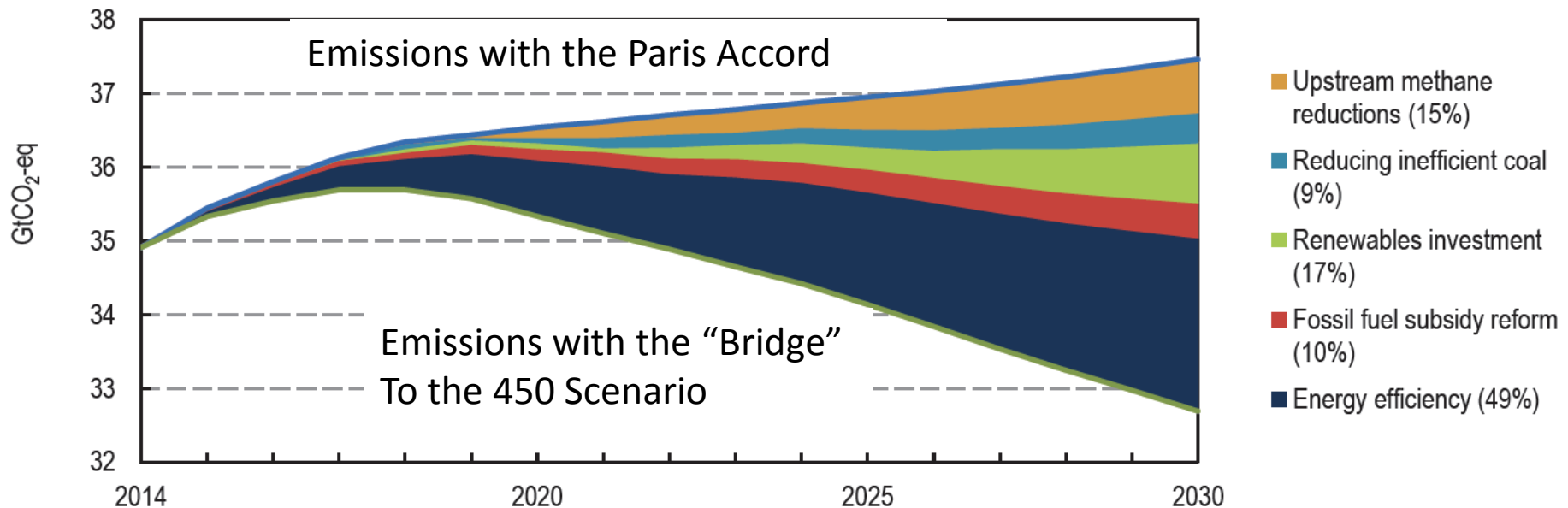
The Paris Accord will not achieve the 2°C goal.

Source: IEA. 2015. *WEO*

Energy Efficiency Mitigates Climate Change and Can Save \$

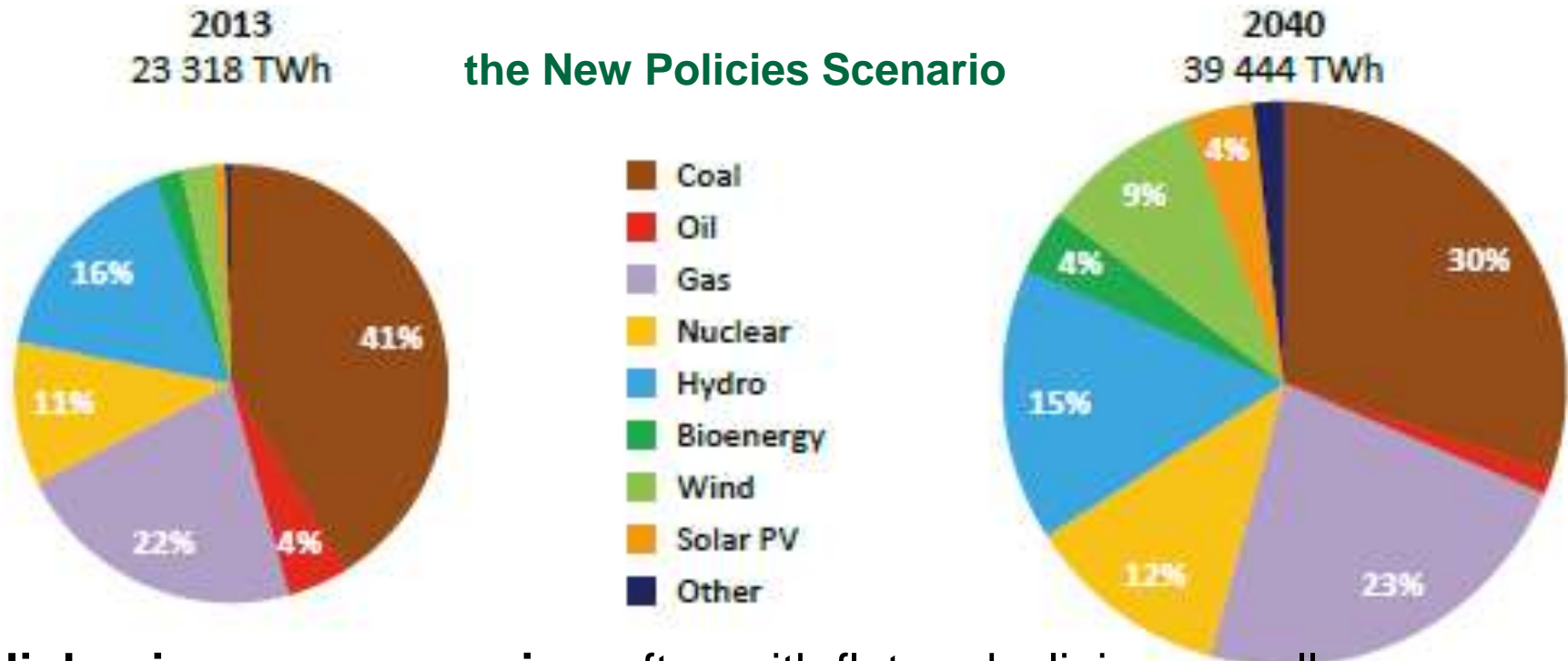
- The “Bridge” to the 450 ppm Scenario is 50% energy efficiency. It is seen as one of the most cost-effective actions.

Share of Emissions Savings by Measure by 2030



Source: IEA. 2015. Energy and Climate Change: A Special Report

The Power Sector Leads the Way Towards Decarbonized Energy



Higher income economies, often with flat or declining overall energy needs, make large strides in displacing coal.

India and countries in Southeast Asia, cannot afford to neglect a low-cost source of energy.

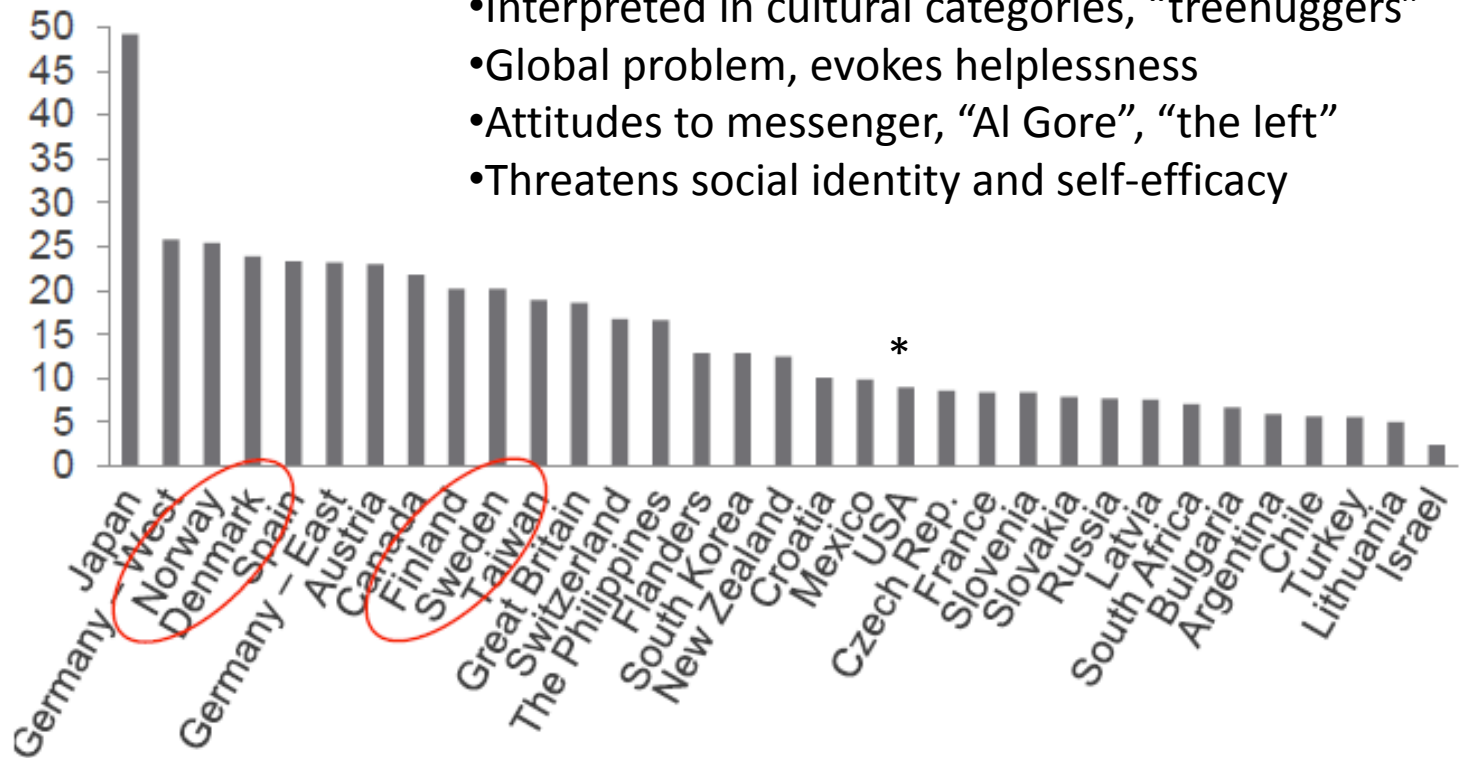
China is the process of moving from the latter group to the former.

Source: IEA, WEO 2015

Different Parts of the World have Different Views...

Why don't information campaigns work for climate?

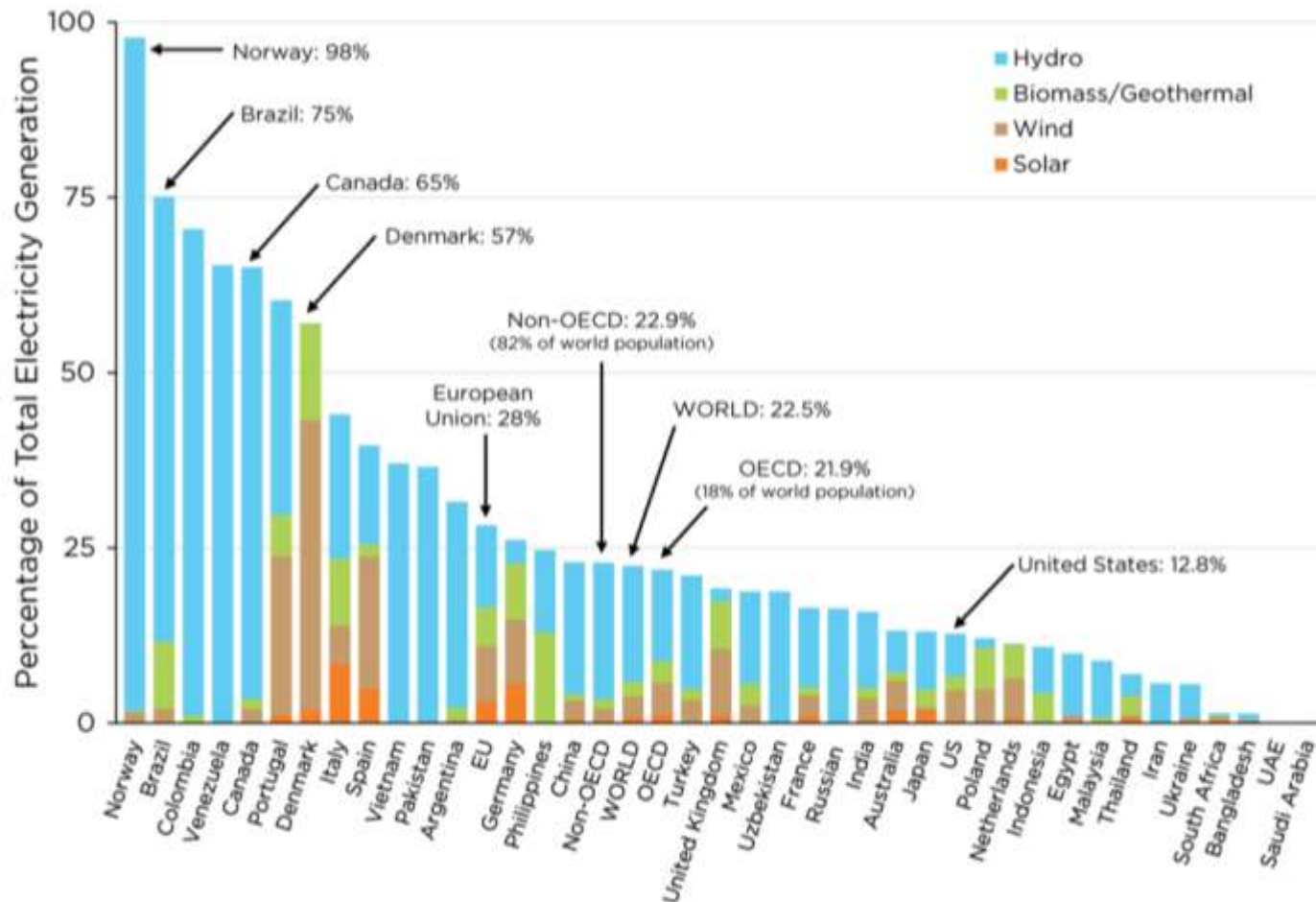
% selecting climate change as most important environmental problem



- Fear and doom fatigue; “hell doesn’t sell”
- Interpreted in cultural categories, “treehuggers”
- Global problem, evokes helplessness
- Attitudes to messenger, “Al Gore”, “the left”
- Threatens social identity and self-efficacy

Source: Sovacool from “Public Attitudes towards Climate Change and Other Global Environmental Issues”

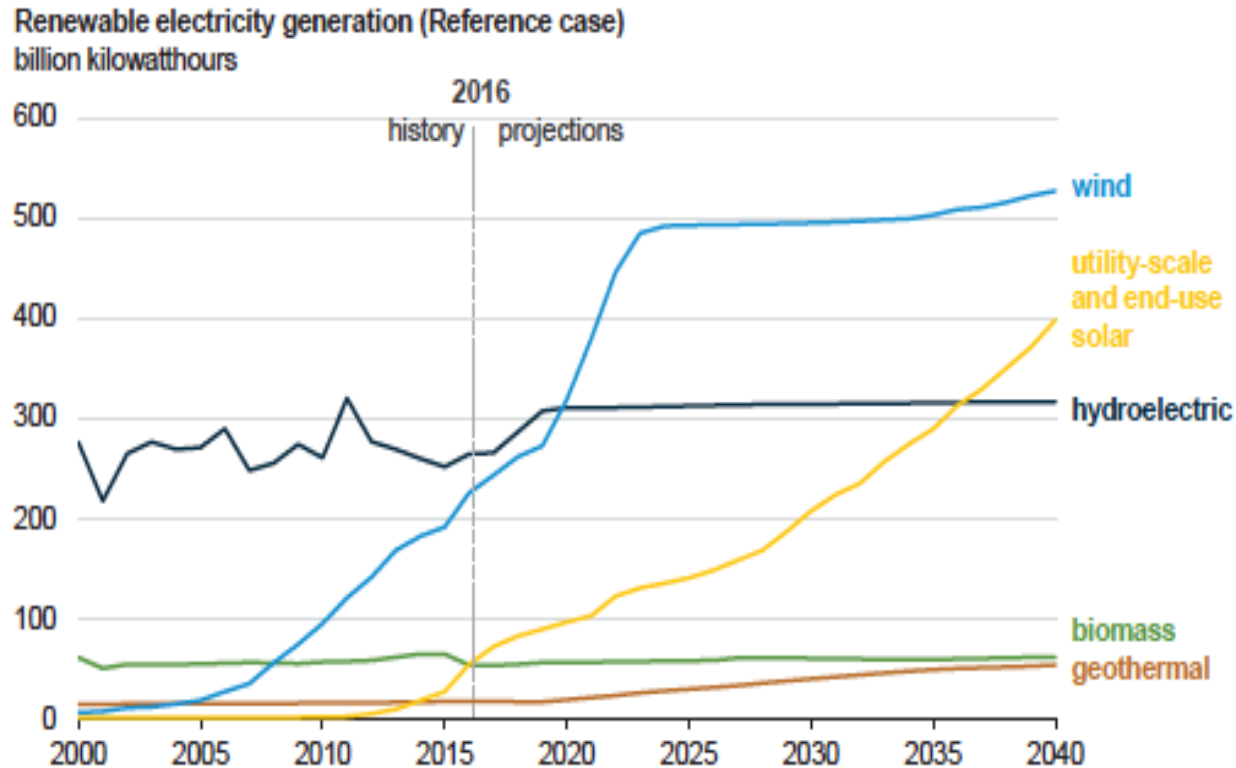
Views about Climate Change Influences the Prospects for Renewables



Percentage of electricity generated by renewables in selected countries, 2014.

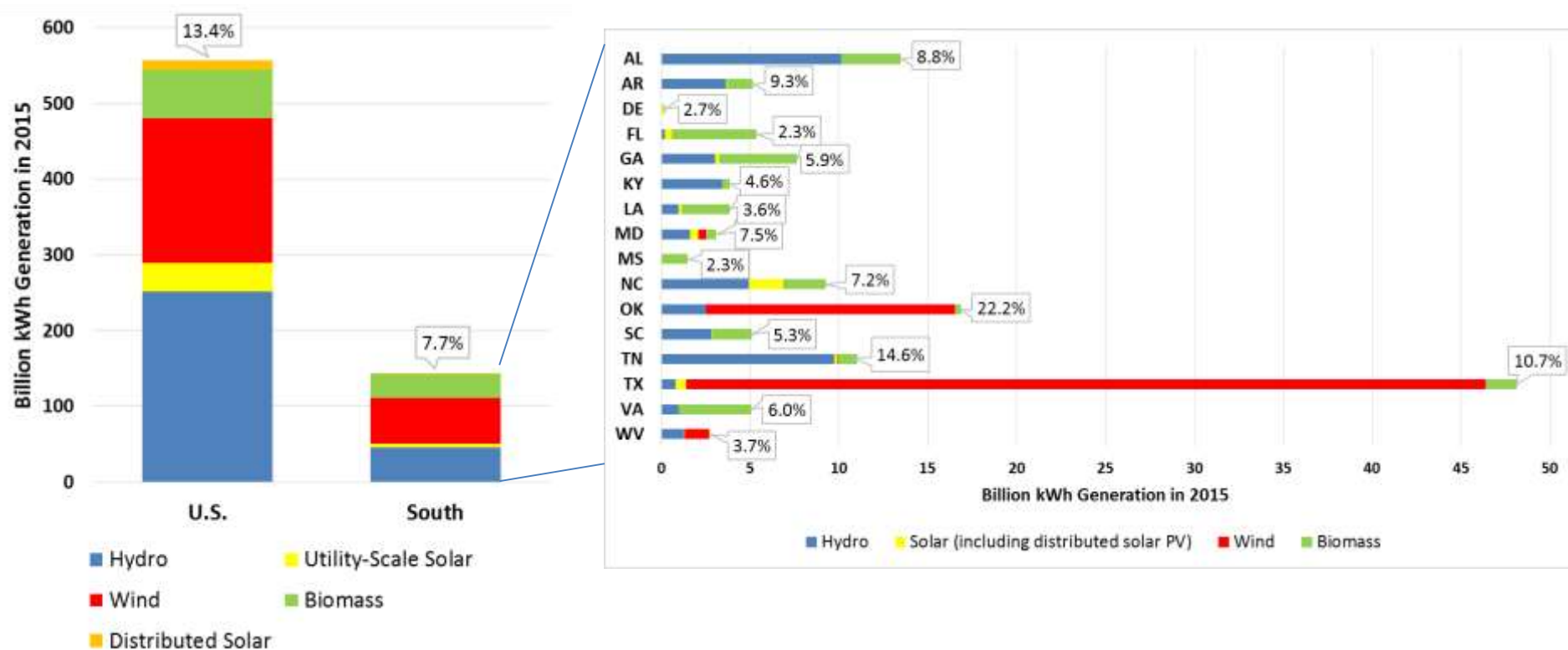
Source: J. David Hughes, Global Sustainability Research, Inc. (data from BP Statistical Review, 2015)

Wind and Solar Will Soon Dominate Renewable Electricity in the U.S.



- Substantial cost reductions, performance improvements, and a permanent 10% investment tax credit support solar generation growth.
- Wind rivals hydropower in the near-term, solar surpasses hydro by 2035 or so.

In 2015, 13% of U.S. Electricity was Fueled by Renewables (7% in the South)



Source: U.S. Energy Information Administration, [Electric Power Monthly](https://www.eia.gov/electricity/data/state/), Table 1.1A, 1.2C-E, 6.2B.

State level data is also available at <https://www.eia.gov/electricity/data/state/>

Note: Distributed generations are estimated. Utility-scale generations are based on reported generation data.

Solar Projects and Jobs in Georgia

FORT BENNING

- Location: near Columbus, GA
- Date Installed: June 2016
- Capacity: 30 MW
- Area: 240 acres
- Cost: \$75 million
- Partners: US Army, Georgia Power

HAZLEHURST II

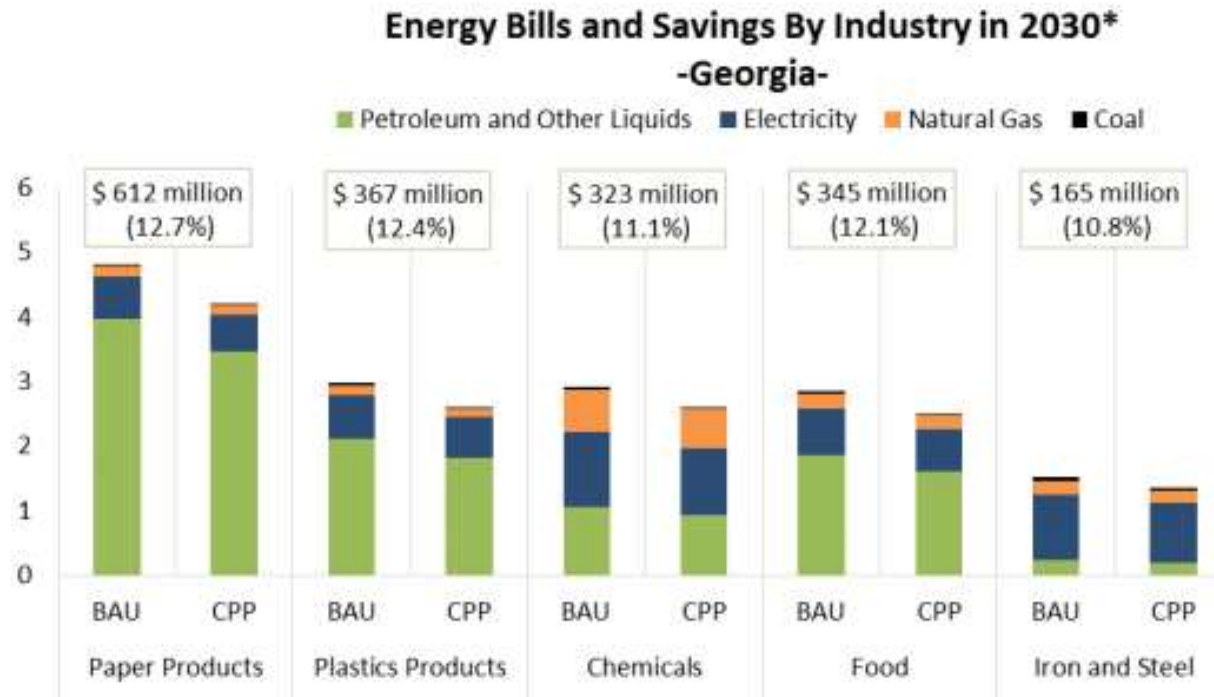
- Location: Hazlehurst, GA
- Date Complete: October 2016
- Capacity: 52 MW
- Area: 450 acres
- Partners: Silicon Ranch, Greenpower EMC

Georgia had 3,924 solar jobs in 2016, 23% more than in 2015.

https://cepl.gatech.edu/sites/default/files/attachments/CEPL_Presentation_GAsolar_Jan13.pdf



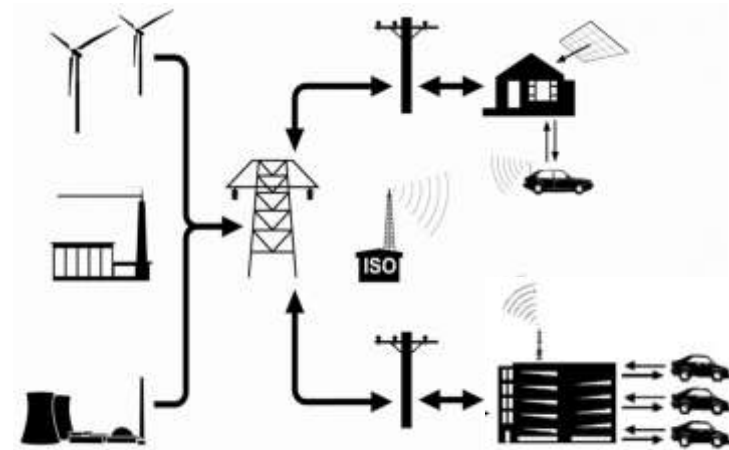
Energy Efficiency, Competitiveness, and Jobs in Georgia



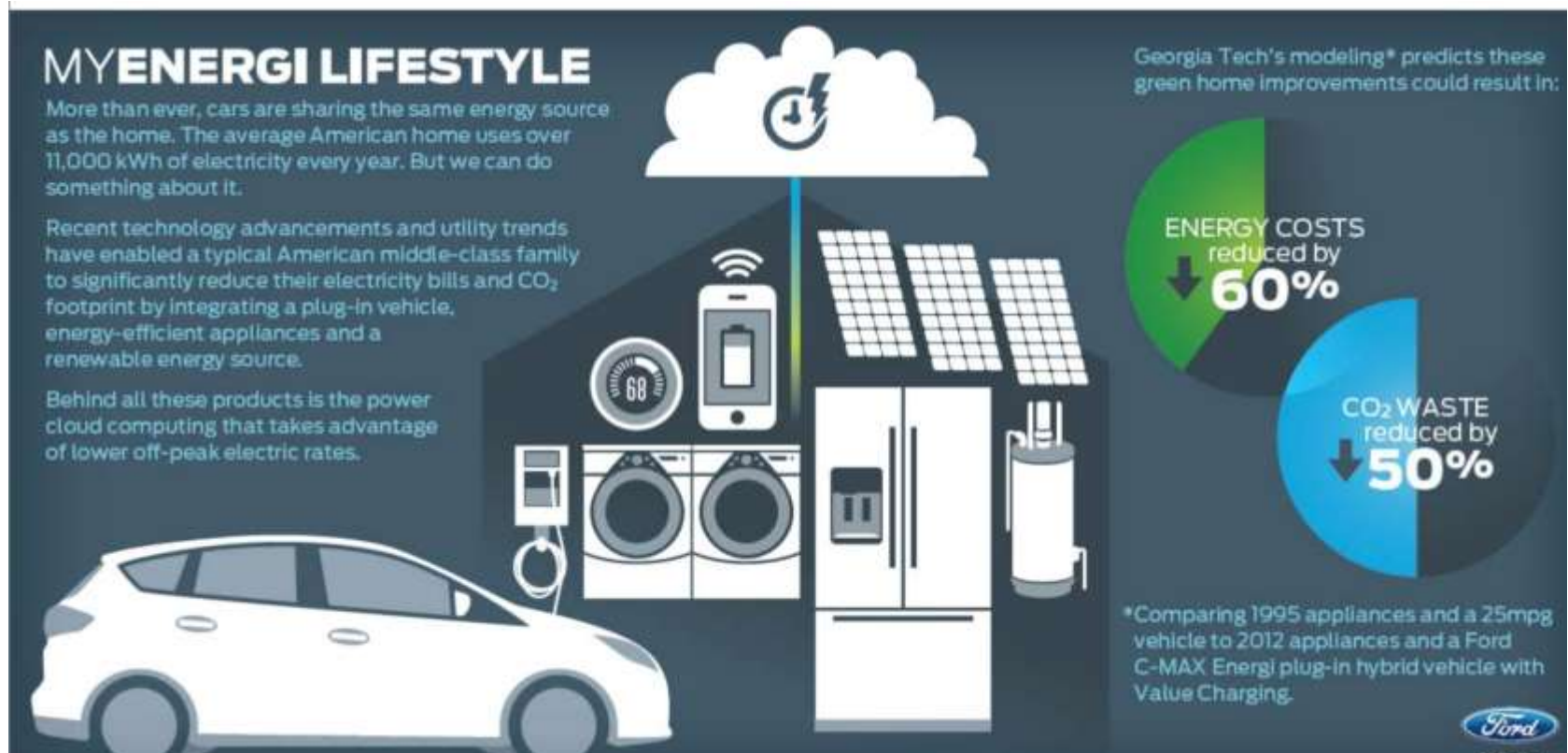
About 66,200 Georgians work in energy efficiency related businesses. The state's energy efficiency economy includes traditional HVAC, efficient lighting, and advanced materials and insulation.

Electric Vehicles Can Help to Support and Green the Grid

- Use plugged-in EVs for energy storage and frequency regulation
 - ✓ Create alternative uses when the car is parked (socializing the asset)
 - ✓ Bring payments to the EV owner & help the grid deal with intermittent resources
- Repurpose used EV batteries for energy storage
 - ✓ On the customer side of the meter (e.g., with solar homes)
 - ✓ On the utility side of the meter (e.g., TVA)



A Winning Synthesis



For Georgia consumers: Energy efficiency, solar (+storage), and electric vehicles
For Georgia utilities: All of the above with a diverse portfolio of low-carbon resources, a smart and secure grid, and a new model for pricing their services.

Source of figure: Bert Bras (2016)

http://cepl.gatech.edu/sites/default/files/attachments/BB_100Renewable_Aug4_2016.pdf

For More Information

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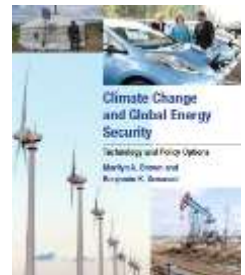
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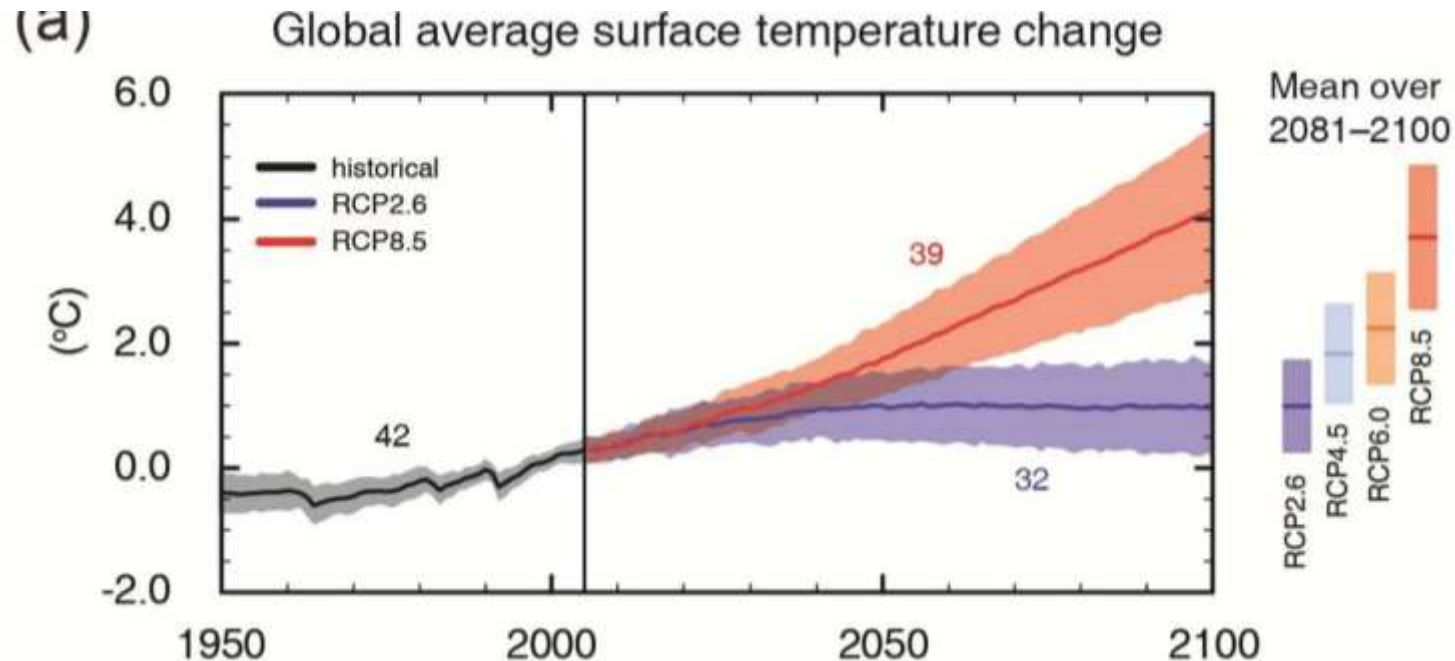
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EXTRAS

Global Surface Temperature Change

Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6.



RCP = Representative Concentration Pathway (+ total radiative forcing in 2100 relative to 1750)