

# Climate Change and Energy Policy

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# Overview I

- Climate change of increasing interest and importance. Also widely misunderstood and politicized.
- There is no real **scientific** debate about the **existence of anthropogenic climate change**; human causes are chiefly release of **greenhouse gases from burning fossil fuels and also removal of forest cover**. However, **there is debate** over some of the science, modeling techniques, and esp. policy choices.
- The scientific, social, economic, political, and ethical aspects all merit serious attention and debate, and often do not get it.
- The climate denial movement is real, but a weak argument to which many people nonetheless are receptive.

# Overview II

- Climate change is real and poses serious risks to the U.S. and the world. Hence discuss **what to do about it**.
- Three strategies: prevention, mitigation, and adaptation.
- Too late for prevention in short term, even if much can be done for longer-term future. Most strategies focus on how best to **mitigate** likely impacts and **adapt** to a warmer world, e.g., through infrastructure improvements.
- Climate change as a long-term challenge. Reduce fossil fuel use and substitute sustainable or renewable energy sources. Also foster energy conservation and efficiency.
- Transition should be fairly rapid to have much chance of keeping us below target of 2 degrees C or 3.6 degrees F increase over pre-industrial averages.

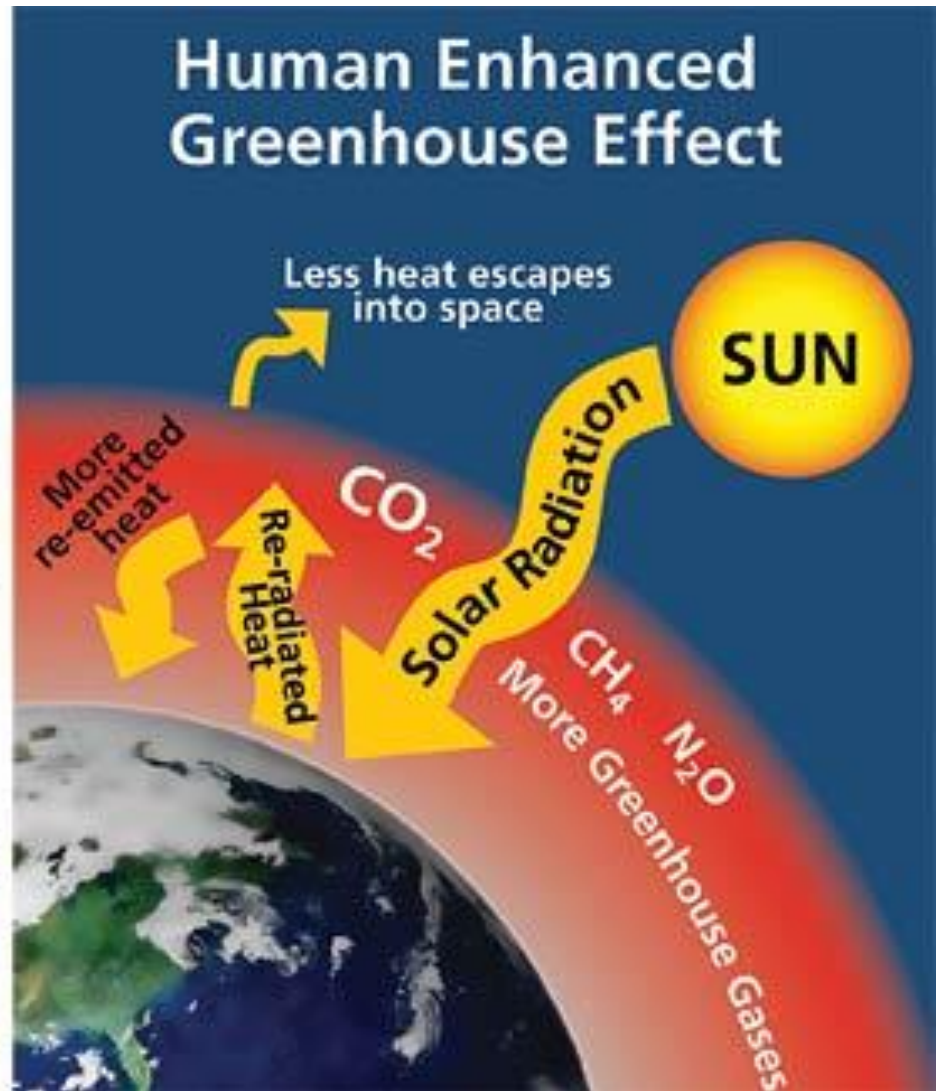
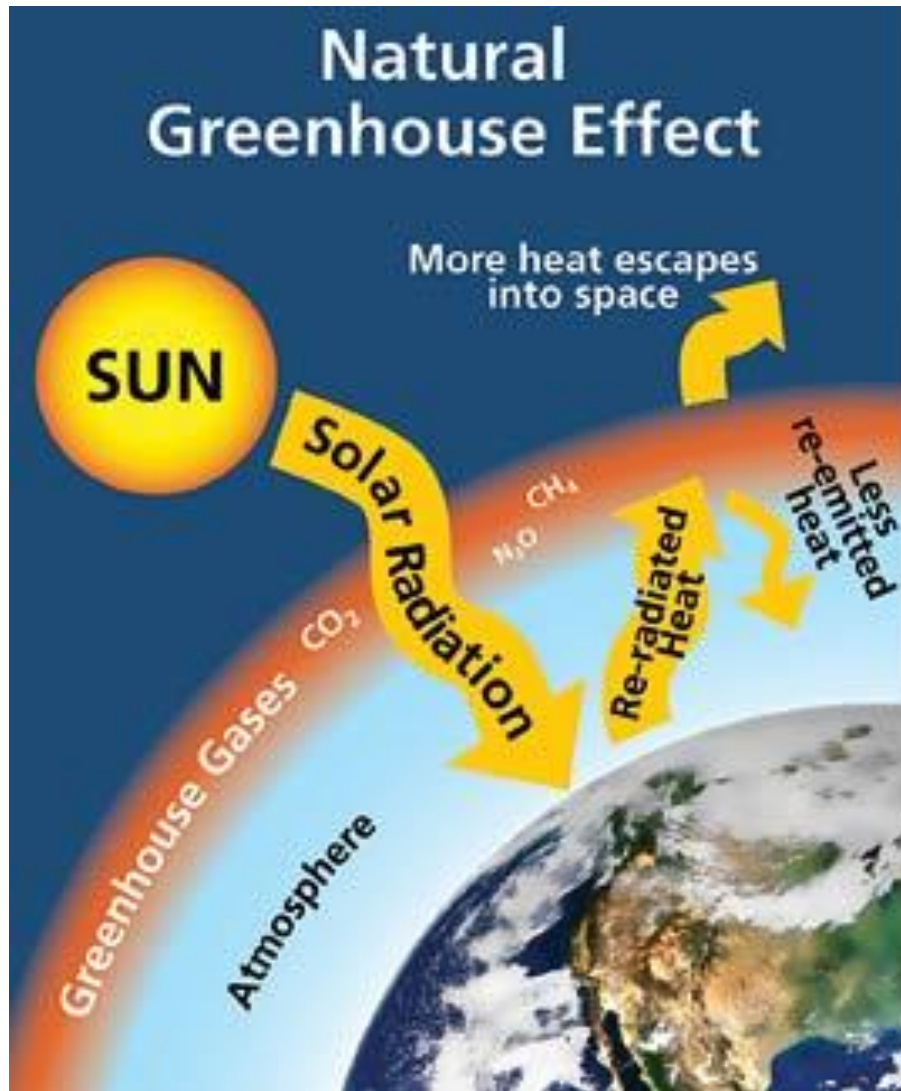
# Overview III

- Given central role of energy and its use, I will review U.S. and global energy resources on which we depend, and recent changes in energy use.
- The serious policy and political debates are about the **pace of change** that is needed, and **which policy options** are most defensible in terms of effectiveness, cost, and public acceptability.
- Will review current energy use and policies, proposals for changing both, and conflicts that arise over such actions.
- **Ask questions throughout** as well as at the end. Otherwise this becomes a very long lecture.

# What Is Climate Change I

- Climate change refers to **new climate patterns** linked by scientists to rising levels of greenhouse gases (GHGs) in Earth's atmosphere, primarily from burning carbon-based fuels: coal, oil, and natural gas (esp. **carbon dioxide or CO<sub>2</sub>**).
- There are other greenhouse gases: methane, nitrous oxide, ozone, and water vapor. Fracking can release methane, as can melting of tundra/permafrost. Other causes are deforestation from human activities.
- We call this **anthropogenic**, or human-caused, changes.
- CO<sub>2</sub> levels up sharply since industrial revolution, around **1750**; up from around **280 parts per million** to **over 400**, or about 42%. Rising in all of the past five years.
- So we see greenhouse effect. CO<sub>2</sub> leads to buildup of heat. Not that much so far, but much more in the future.

# Greenhouse Effect

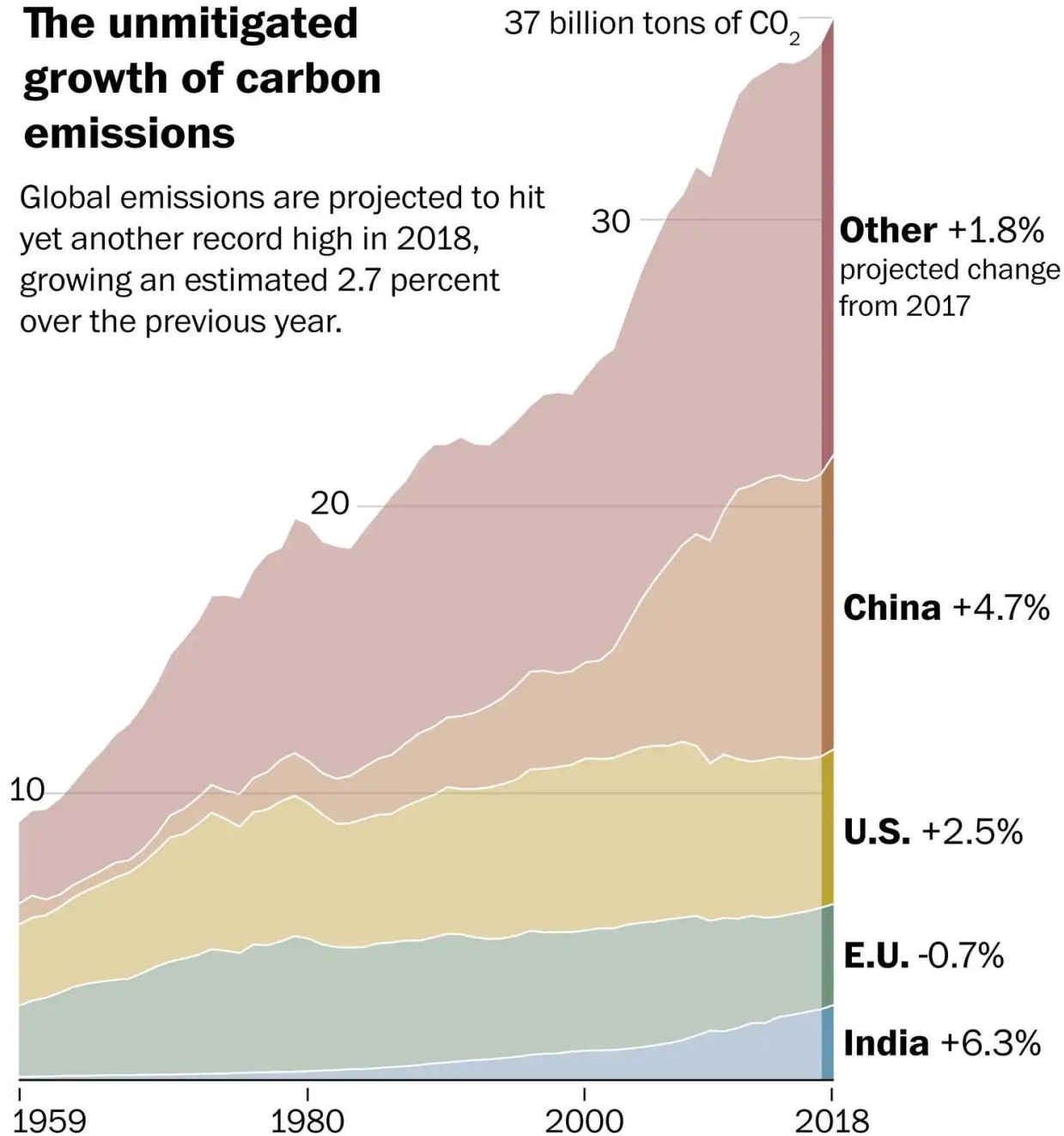


# What Is Climate Change II

- 2016 was the warmest year on record globally, as was 2015, as was 2014. 18 of the 19 hottest years on record occurred since 2001. 2017 was just below record of 2016; second hottest ever even without the El Niño effect. That made 2016 the warmest. 2018 the fourth warmest year on record.
- 88 percent of cities in AccuWeather database higher than normal.
- Climate scientists use computer models to simulate past climate and forecast the future. Models are complex and varied, but much agreement.
- Models indicate that average temperature will **rise over the next 100 years, likely for far longer**. CO<sub>2</sub> lasts a long time in atmosphere, unlike methane, which dissipates in decades.
- **CO<sub>2</sub> emissions** rate was stable until recently (due to increased use of renewables and reduced use of coal), but now rising again (rise of 2.7% globally in 2018 and est. 2.5 to 3.4% in U.S., most in 8 years). CO<sub>2</sub> **concentration** in atmosphere also rise to record levels.
- Variations from year to year in temperatures, and, yes, we still get record cold waves in January 2019/polar vortex. But the warming trend is expected to continue, though not even around world.

# The unmitigated growth of carbon emissions

Global emissions are projected to hit yet another record high in 2018, growing an estimated 2.7 percent over the previous year.



Figures show emissions from fossil fuels and industry, which includes cement manufacturing but not deforestation

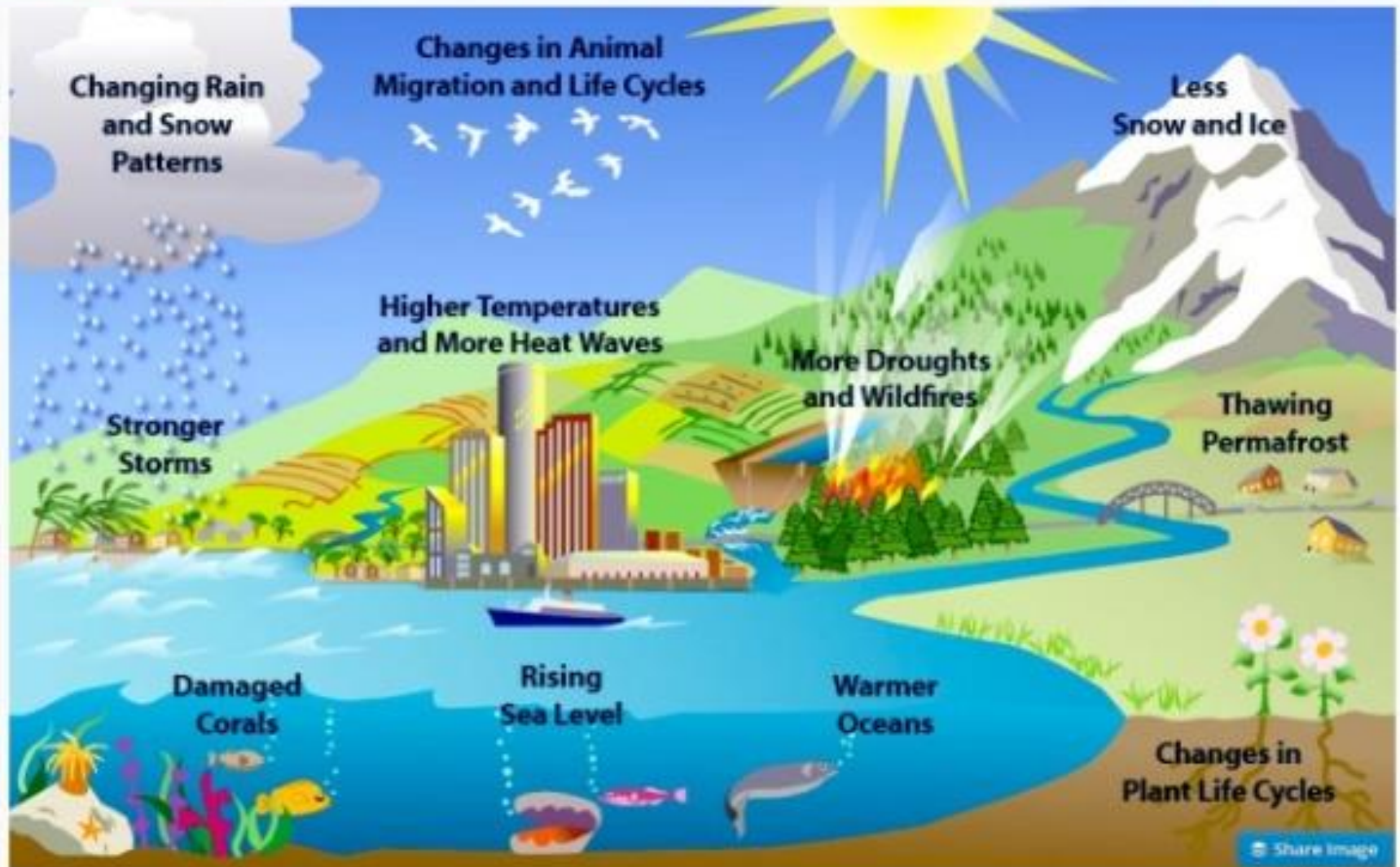


# What Is Climate Change III

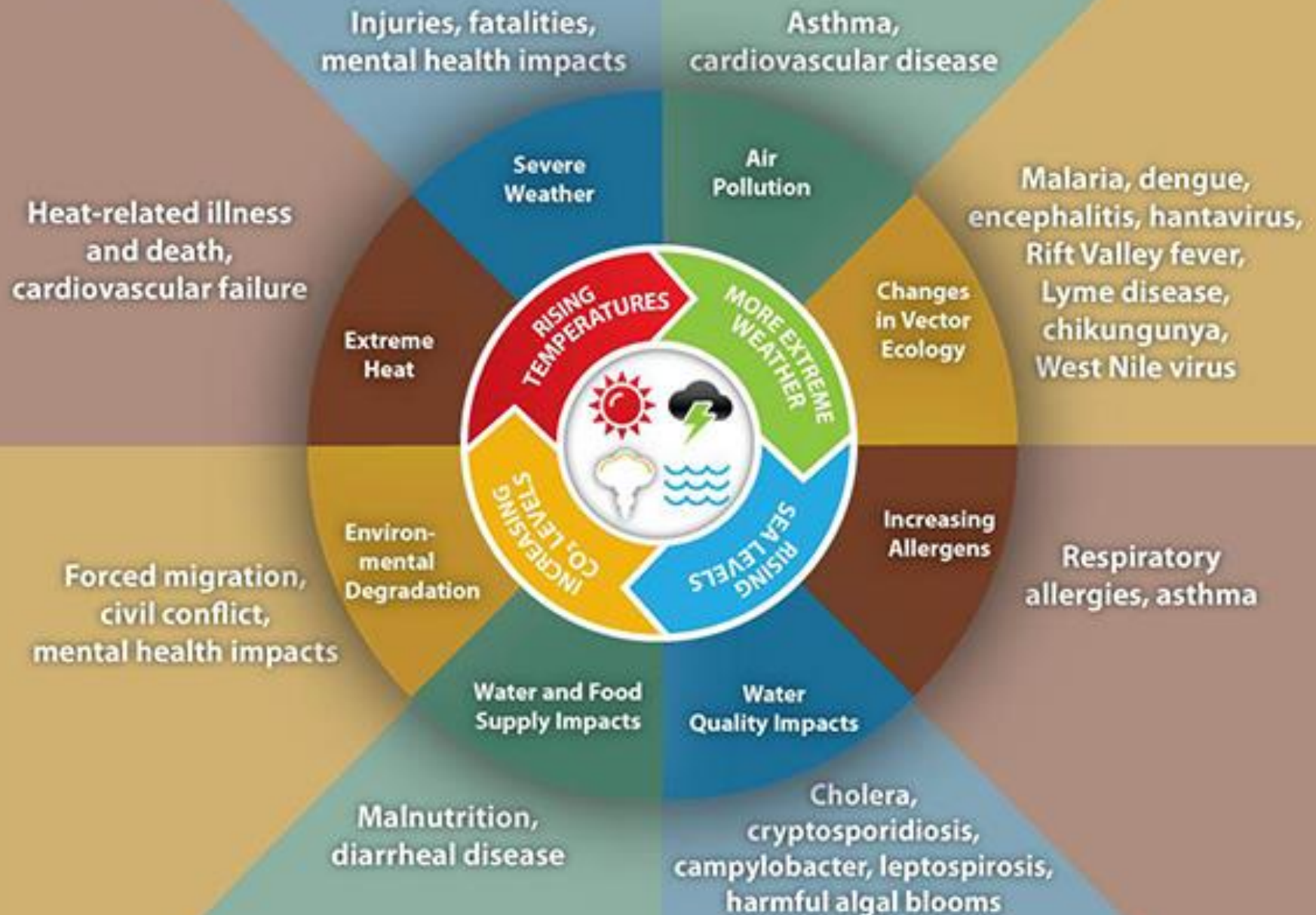
- Not just warming. Rising **sea levels** from melting of Arctic and Antarctic ice, greater moisture in the atmosphere from **warmer seas**, and thus more severe **storms and floods** in some areas (e.g., Florence in NC), but also prolonged **drought** in others and changes in **rainfall patterns**. Drought also affects **wildfires** as trees and brush dry up (CA 2018).
- Generally less snow and more rain at higher elevations over time, loss of glaciers, and thus impact on water supply that is dependent on snow pack of winter, as in Calif.
- Also rising **oceanic acidity** from absorption of CO<sub>2</sub>.
- **Possible impacts** include water scarcity, agricultural and food supply risks, biodiversity losses, and **human health** risks. Plus world population is rising to 9.8 billion by 2050.
- Also major **social and economic impacts**. Economic costs could be high given likely damage to coastal cities' infrastructure from rising seas and severe storms. Plus refugees fleeing droughts and food scarcity, esp. Africa.

# Impacts of Global Warming

<http://planetsave.com/2015/06/02/global-warming-or-climate-change-whats-the-difference/>



# Impact of Climate Change on Human Health



# Climate Change Scientific Reports: The Sources of Data and Forecasts

- Intergovernmental Panel on Climate Change (IPCC), every three to five years. New one released in 2018.
- What IPCC is and how to take their periodic reports on state of climate science. Thousands of scientists.
- National Climate Assessment. Second volume released in late November 2018. Nearly 1,700 pages on economic, community, and health impacts of climate change in each region of the U.S. Section on Midwest covers Wisconsin.
- *Risky Business* and continuing studies. Business and economic case for climate change.
- National Academy of Sciences reports, plus NOAA and NASA—both issued 2016 warming reports in early 2017.
- Pentagon, CIA, NSA. Concern over **national security** implications of climate change, esp. **refugee movement** as result of droughts and food scarcity.



# Where to Find Scientific Summaries:

## Note: Government Pages May Change

- IPCC [www.ipcc.ch/](http://www.ipcc.ch/)
- National Climate Assessment for 2017/2018 (Volumes 1 and 2):  
<http://www.globalchange.gov/>
- NOAA [www.noaa.gov/climate](http://www.noaa.gov/climate)
- NASA <http://climate.nasa.gov/>
- EPA [www.epa.gov/climatechange](http://www.epa.gov/climatechange): removed by Trump EPA, but archived at:  
<https://19january2017snapshot.epa.gov/climatechange.html>
- EPA Climate Change Indicators Report: Still there:  
<https://www.epa.gov/climate-indicators>
- National Academy of Sciences <https://nas-sites.org/americasclimatechoices/>
- Risky Business Project <https://riskybusiness.org/>
- Climate Science and Policy Watch [www.climate science watch.org/](http://www.climate science watch.org/)
- Inside Climate News <https://insideclimatenews.org/>
- Union of Concerned Scientists [www.ucsusa.org/](http://www.ucsusa.org/)
- Climate Wire [www.eenews.net/cw](http://www.eenews.net/cw)
- Pentagon [www.defense.gov/News/Article/Article/612710](http://www.defense.gov/News/Article/Article/612710)

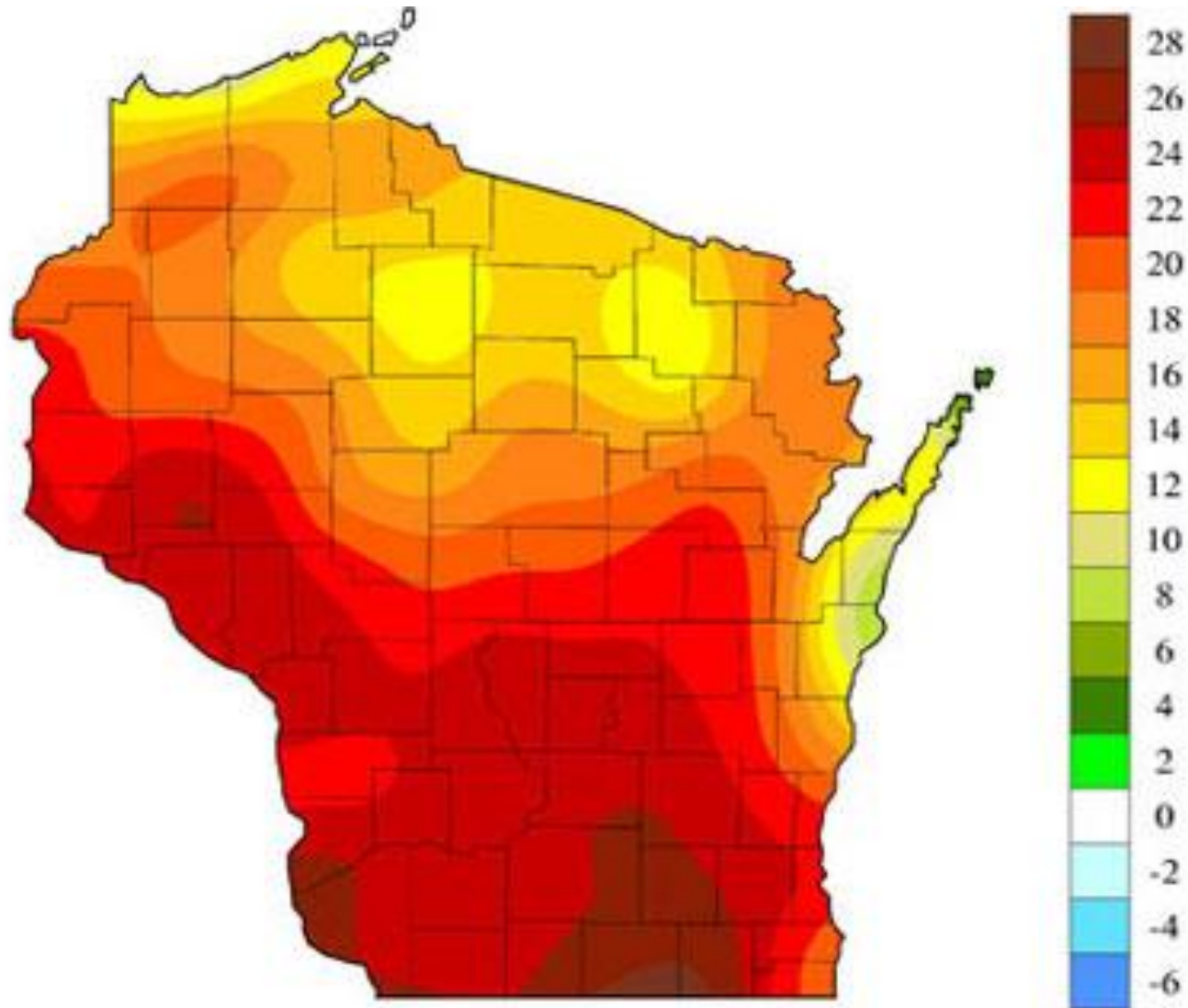
# Leading Climate Denial Websites

- CFACT [www.cfact.org/issues/climate-change/](http://www.cfact.org/issues/climate-change/)
- Climate Depot [www.climatedepot.com/](http://www.climatedepot.com/)
- Conservative Think Tanks: CATO, Heritage, Heartland, Competitive Enterprise Institute, Institute for Energy Research.
- Their argument: the science is not that solid, scientific consensus doesn't exist, and the risks are highly exaggerated.
- Many say there is no warming at all, and nothing needs to be done because climate changes are natural.
- Some allege that scientists are faking the data or “cooking the books,” using inappropriate models, and are climate alarmists. Esp. directed at NOAA and the so-called “pause” in warming.
- Others dispute estimates of high economic costs of climate impacts. Much depends on assumptions made in economic forecasting and how the “social cost of carbon” is calculated.
- All of this is rejected by vast majority of reputable climate scientists and economists.

# Wisconsin's Climate Future as Example

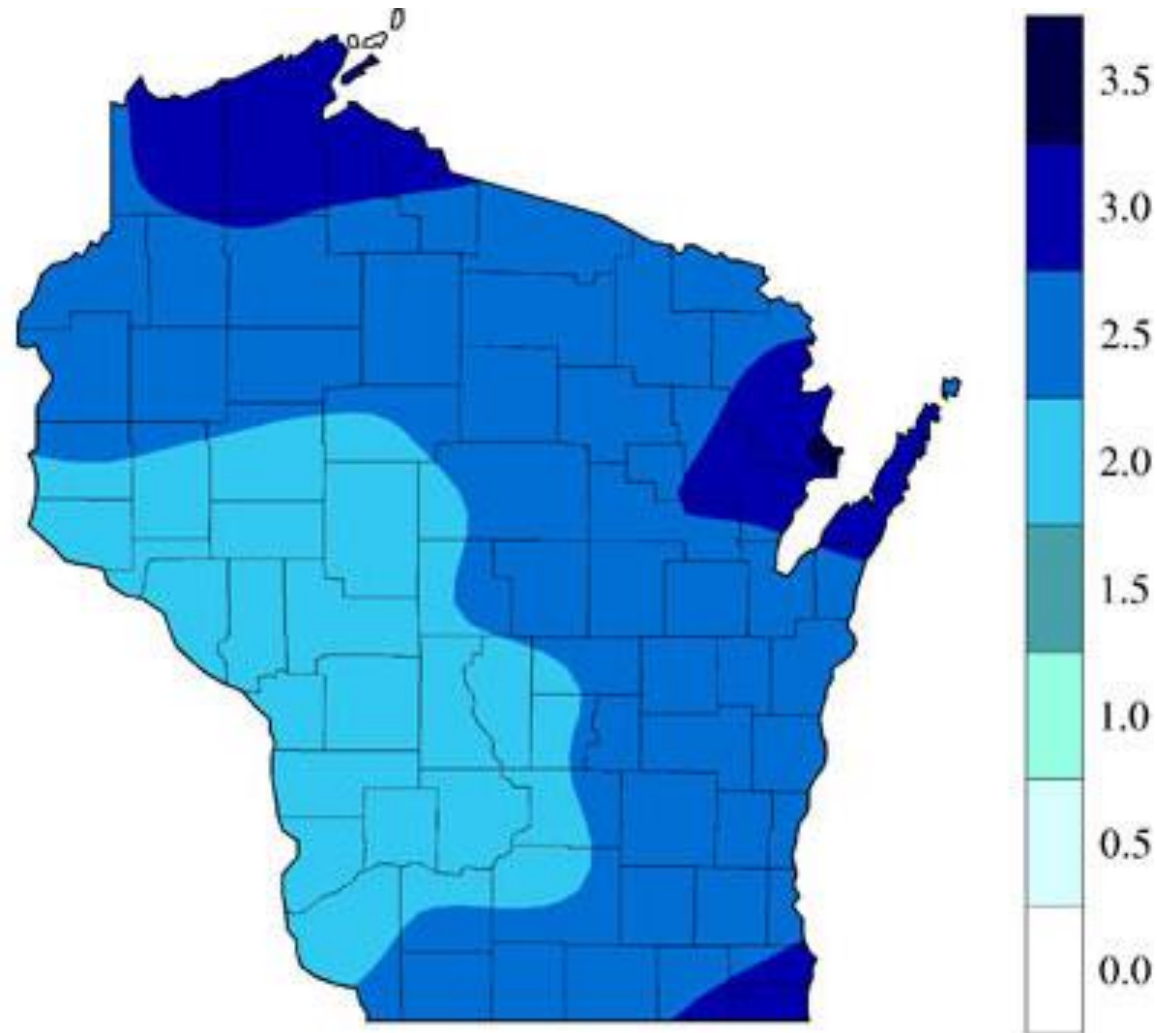
- The state's DNR pulled climate change information from agency website in late December 2016. Will likely change back under Gov. Evers. Under Walker, said causes of climate change are matters of scientific debate. National news.
- WI Public Service Commission did the same in 2016, deleting links to Gov. Doyle's task force report on climate change.
- Justified or not, effect may be that Wisconsin will be less likely to deal with climate change and plan for it. Yet, insurance companies and many businesses already do so, as do planning agencies, farmers, and businesses.
- Wisconsin Initiative on Climate Change Impacts from UW's Nelson Institute are still there. Can access from website: <https://nelson.wisc.edu/ccr/index.php>. Two examples follow.

# WICC V: Projected Change in No. of 90 Degree Days/Year, 1980-2055





# WICC VI: Change in Precipitation Events of 2 Inches+, 1980-2055 (Days per Decade), 25% Increase



# The Role of Politics and Public Opinion

- Shift now from the **science** of climate change and its impacts to the role of **politics, political parties, and public opinion**.
- Why this focus?
- The most important societal decisions about climate change occur in governmental settings, from U.S. national government to the states to United Nations—Paris Agreement.
- Important to understand differences of opinion, continuing **partisan divide** over climate change, and what it will take to build consensus.

# Political Parties and Climate Change

- Party Platforms 2016: Democrats say they recognize climate change as a major challenge and favor strong action.
- Republicans say they doubt the severity of climate change and want to reverse Pres. Obama rules, esp. EPA's Clean Power Plan and vehicle fuel efficiency standards, and favored withdrawal from Paris Agreement.
- The difference evident in the Trump administration compared to Obama. Trump initial appointment as EPA administrator, Scott Pruitt, a climate change skeptic. So too his replacement, Andrew Wheeler.
- See full political party platforms at: [www.presidency.ucsb.edu/platforms.php](http://www.presidency.ucsb.edu/platforms.php). Summaries follow.

# Public Opinion on Climate Change

- Why public opinion matters in a democracy, and the pattern of the last decade.
- Pattern over time: public recognition and support, then growing doubts and low saliency, and recently a rising level of concern and greater support for policy action.
- However, public's knowledge generally is poor, as is the case with most policy issues—health care, immigration.
- Public has been influenced by the climate denial movement, energy companies' statements, and opponents of taking action.
- Mostly, people just don't think about it all that much. Was and still is a low salience issue most of the time.

# Yale/George Mason Study 12/2018

- Seven in ten Americans (73%) think global warming is happening, an increase of ten percentage points since March 2015. Only about one in seven Americans (14%) think global warming is not happening.
- About six in ten Americans (62%) understand that global warming is mostly human-caused.
- More than half of Americans (57%) understand that most scientists agree that global warming is happening, the highest level since 2008.
- Even more think global warming will harm people in the U.S. (65%), the world's poor (67%), people in developing countries (68%), plant and animal species (74%), and/or future generations of people (75%).

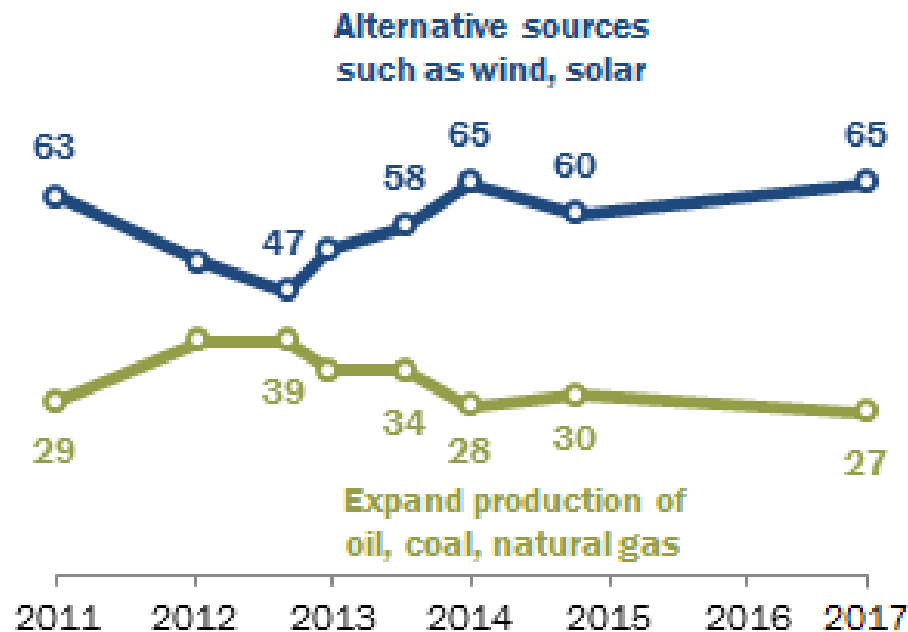
# Yale/George Mason Survey II

- About seven in ten Americans (72%) say the issue of global warming is either "extremely," "very," or "somewhat" important to them personally. Three in ten (28%) say it is either "not too" or "not at all" personally important.
- About two in three Americans (65%) think global warming is affecting weather in the United States, and three in ten think weather is being affected "a lot" (32%).
- About half think global warming made the 2018 wildfires in the Western U.S. (50%) and/or hurricanes Florence and Michael (49%) worse.
- A majority of Americans are worried about harm from extreme events in their local area including extreme heat (61%), flooding (61%), droughts (58%), and/or water shortages (51%).

# Pew Research Center Jan. 2017

## Most in U.S. give priority to developing alternative energy over fossil fuels

*% of U.S. adults who say \_\_\_\_ should be the more important priority for addressing America's energy supply*



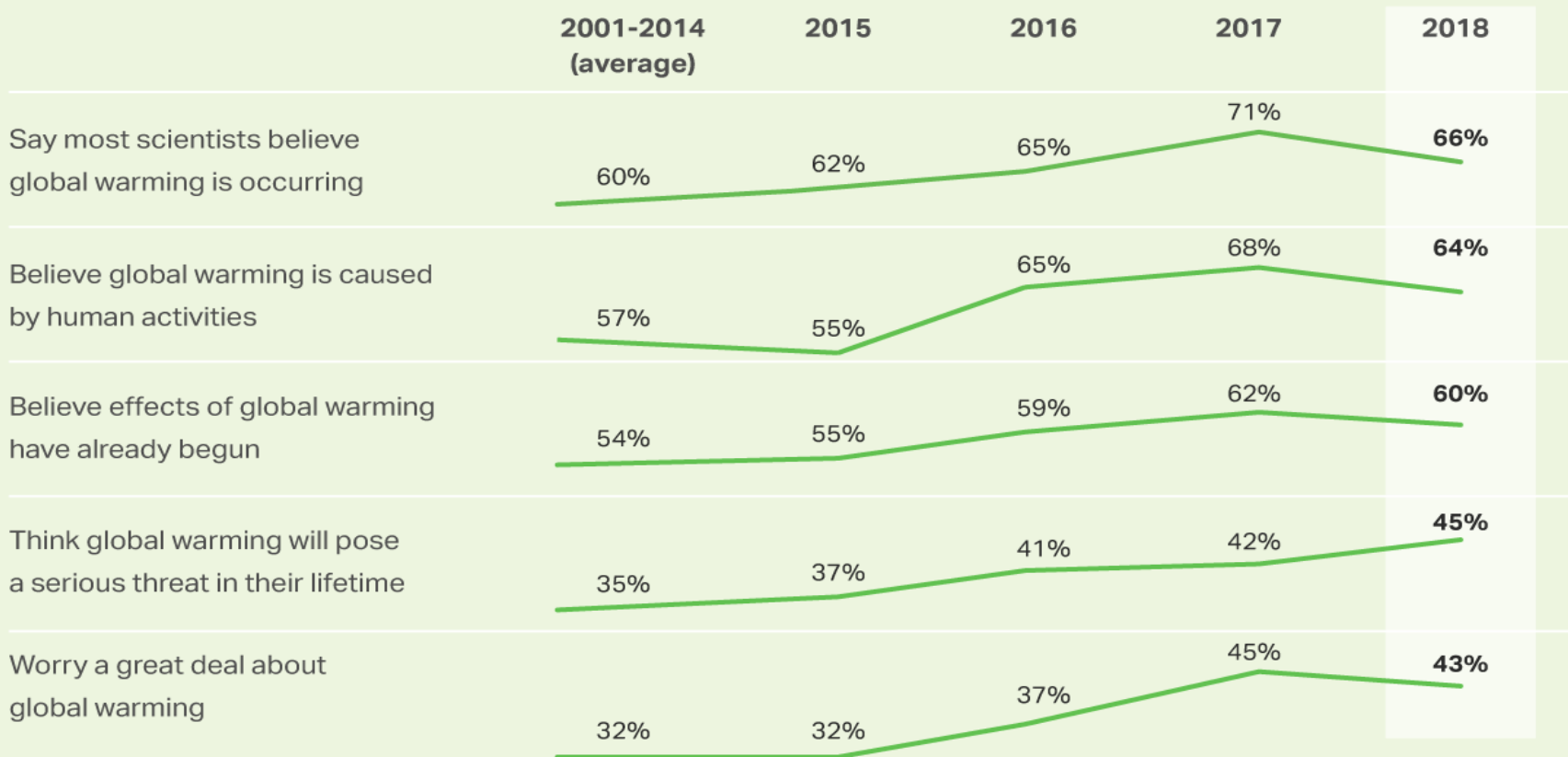
Note: Both/Don't know responses not shown.

Source: Survey conducted Jan. 4-9, 2017.

PEW RESEARCH CENTER

# Public Concern At 30-Year High in 2017, But Pulled Back in 2018: Gallup Poll. Also Not a Salient Issue for Most People. Not Basis of Vote

## Summary of Americans' Views on Global Warming

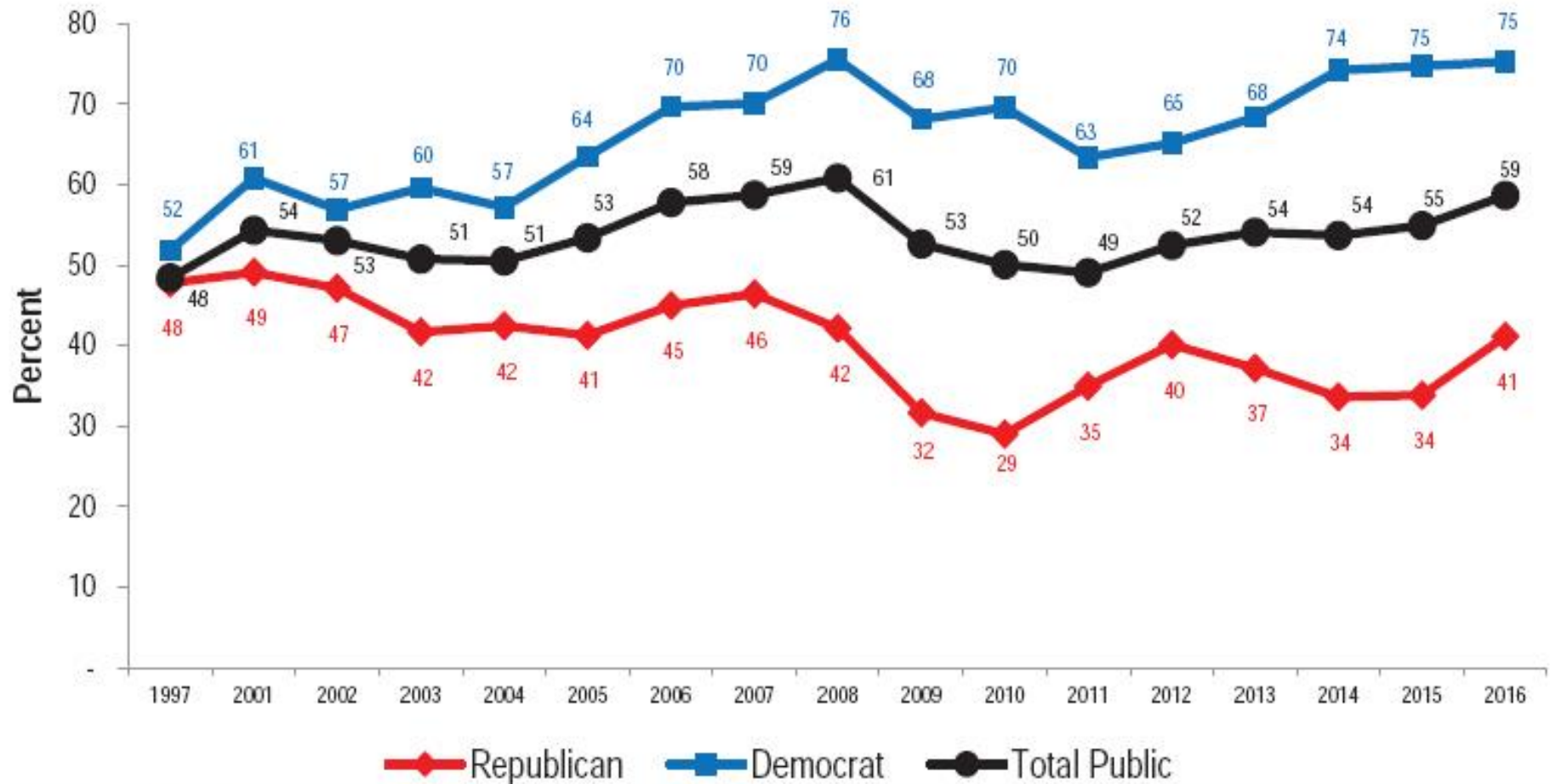


All polls conducted in March

GALLUP



# Effects of Global Warming Have Already Begun, by Party

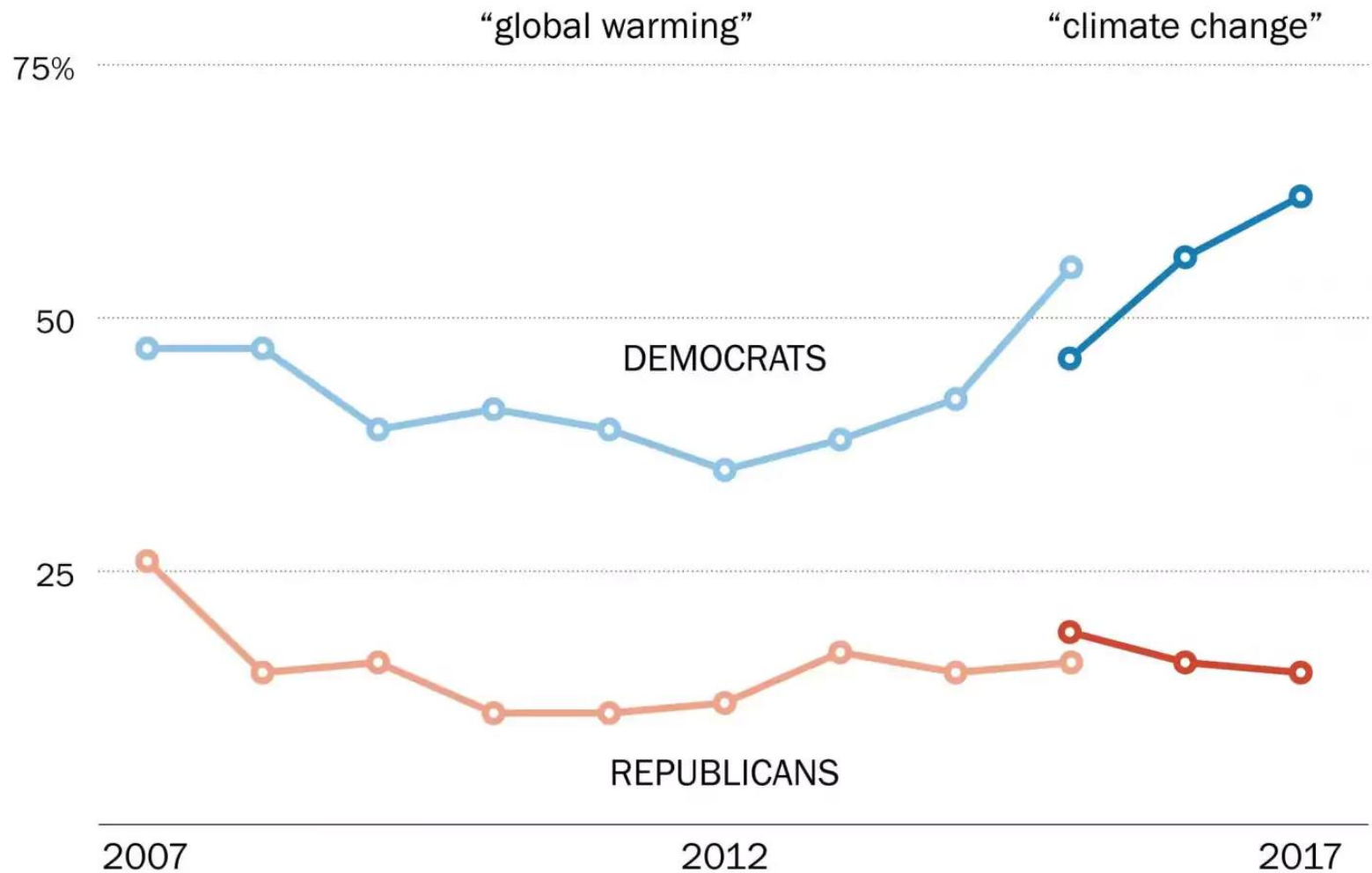


Source: The Gallup Organization

# Pew on Partisan Differences: Jan. 2017

## Partisans describing climate change as a top priority

Percent labeling the issue a top priority for Congress. Data from Pew Research, Jan. 2017.



# Why These Large Partisan Differences?

- So why do these partisan differences occur and persist, and even increase?
- What does this imply for developing climate change/energy policies that can win broad support?
- If you are a Democrat, what would you say to a Republican on the subject?
- If you are a Republican, what would you say to a Democrat on the subject?
- Can the two parties come together with an acceptable policy?

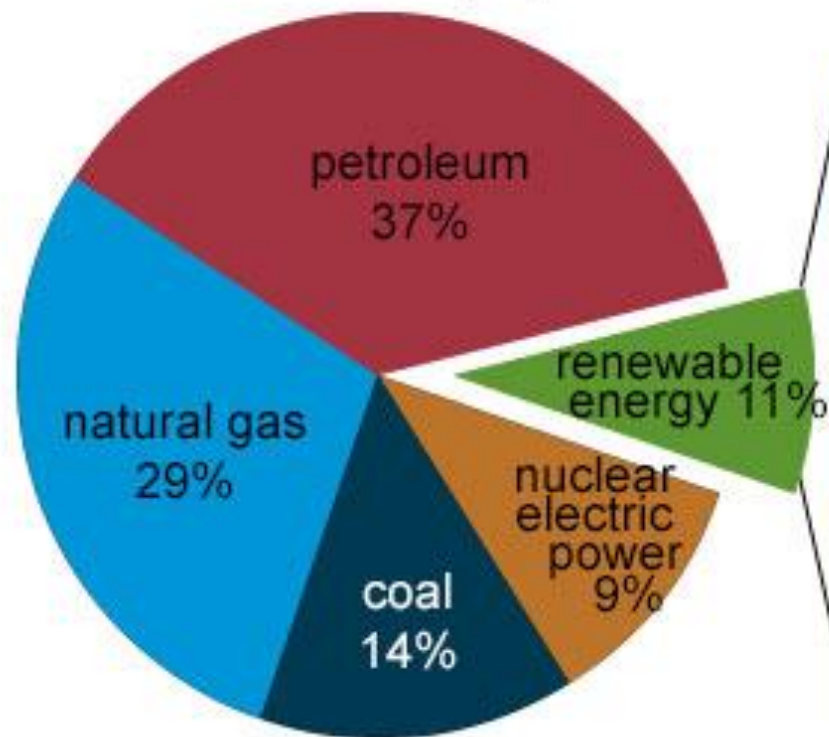
# Anthropogenic Climate Change: Energy Use

- We are about **80% dependent** on fossil fuels, which release carbon dioxide when burned. Coal, oil, natural gas.
- Thus a need to cut back on fossil fuels, move to renewable sources. **How much and how fast is open to debate.** E.g., Green New Deal.
- A role for **nuclear power**, but expensive and presents waste issue. Five plants closed since 2013; six more likely by 2025. Four plants under construction in S.C. and GA, but **construction halted on the two S.C. plants.** Huge cost overruns on GA plant as well, but, GA agreed to continue construction for now. Extend life of existing reactors?
- Core argument: move toward sustainable energy use, including conservation and efficiency. Both are feasible and addresses causes of climate change.
- Public and private investment in **energy research/technologies.**
- Does not harm the economy. Latest studies (Brookings): reducing carbon emissions does not harm the economy and creates jobs.

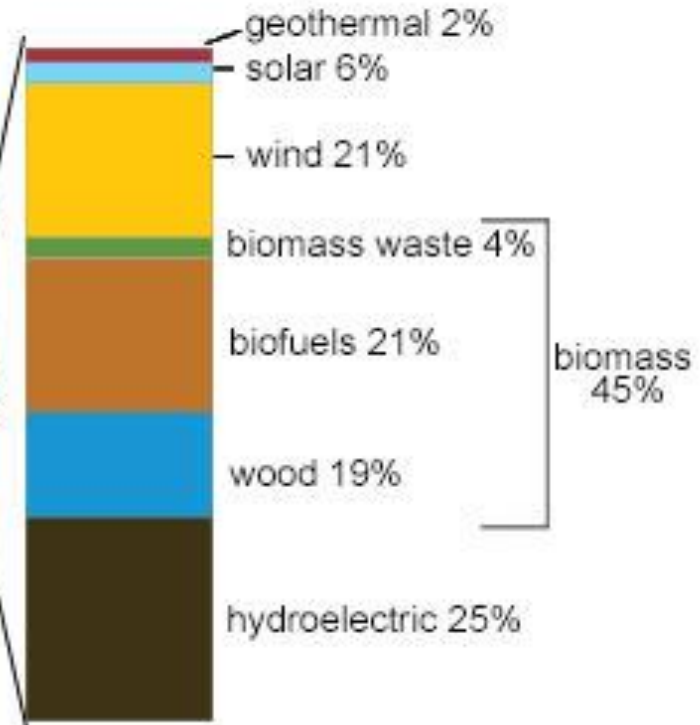
# U.S. Energy Consumption: 80% Fossil Fuels

## U.S. energy consumption by energy source, 2017

Total = 97.7 quadrillion  
British thermal units (Btu)



Total = 11.0 quadrillion Btu



Note: Sum of components may not equal 100% because of independent rounding.  
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2018, preliminary data.

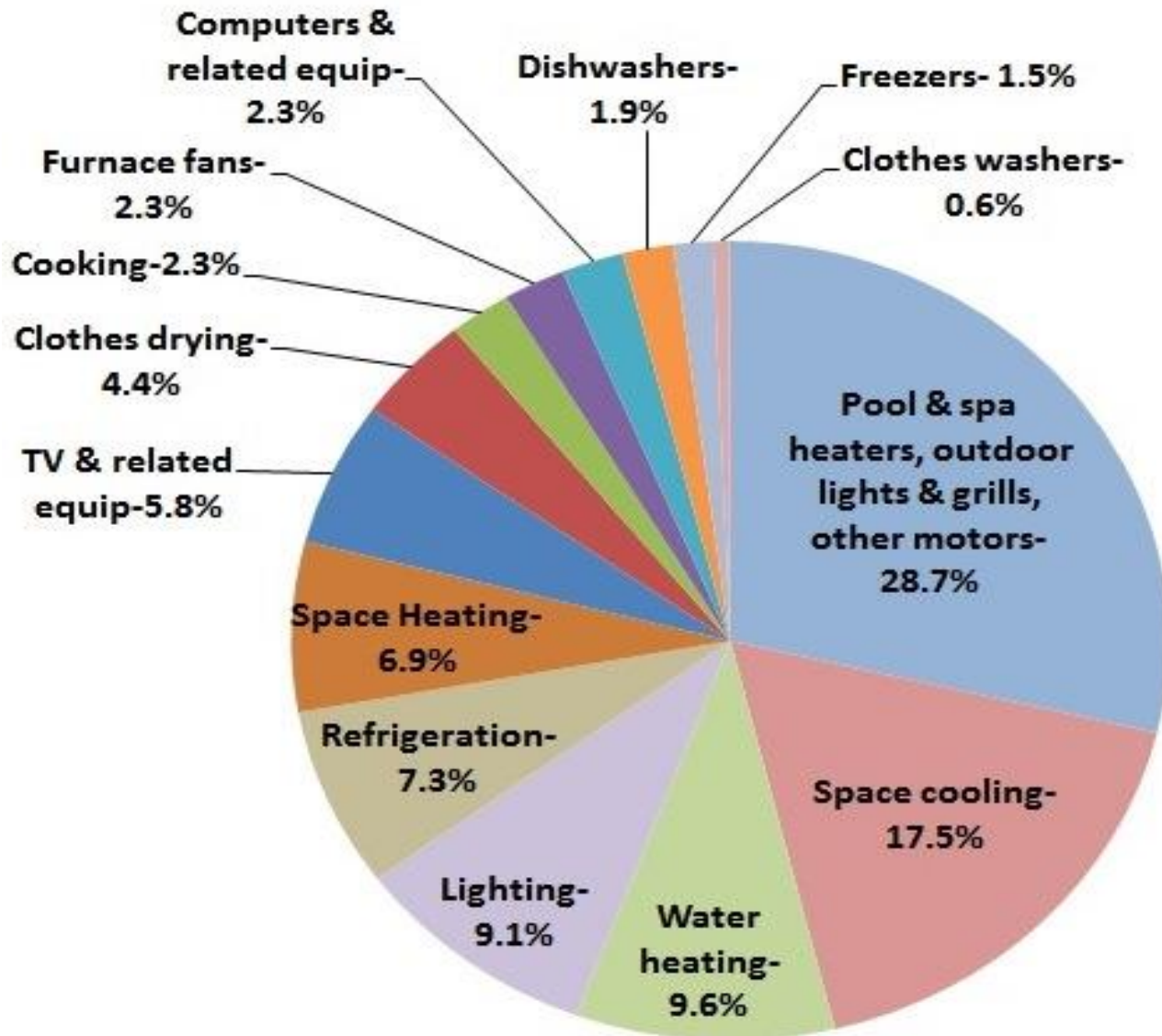
# Electricity Generation by U.S. Utilities 2017

- **Natural gas = 31.7%**
- **Coal = 30.1%**
- **Nuclear = 20.0%**
- **Renewables (total) = 17.1% [a big increase in recent years]**
- Hydropower = 7.5%
- Wind = 6.3%
- Biomass = 1.6%
- Solar = 1.3%
- Geothermal = 0.4%
- Petroleum = 0.5%
- Other gases = 0.4%
- Other nonrenewable sources = 0.3%

# Wisconsin Energy Use 2017

- Wisconsin relies for its **electricity** on:
- **Coal**: 52% (well above average)
- **Oil**: 0%
- **Nuclear**: 11% (below average)
- **natural gas**: 29% (below average)
- **Renewables: hydroelectric, wind, biomass**: 8% (well below average)
- Little progress in reducing GHGs compared to other states.
- WI Renewable Energy Portfolio is 10% by 2015, one of the lowest in the nation. Now slightly exceed that amount.
- Contrast: CA and NY: 50% by 2030; MN 25% by 2025. Wisconsin lagging. **See coming slide**
- WI uses far less wind power than Iowa, Illinois, Minn., and Indiana. Some controversies in Brown County on health effects of wind turbines; not confirmed by studies.
- Build wind farms, promote biomass, such as farm waste.

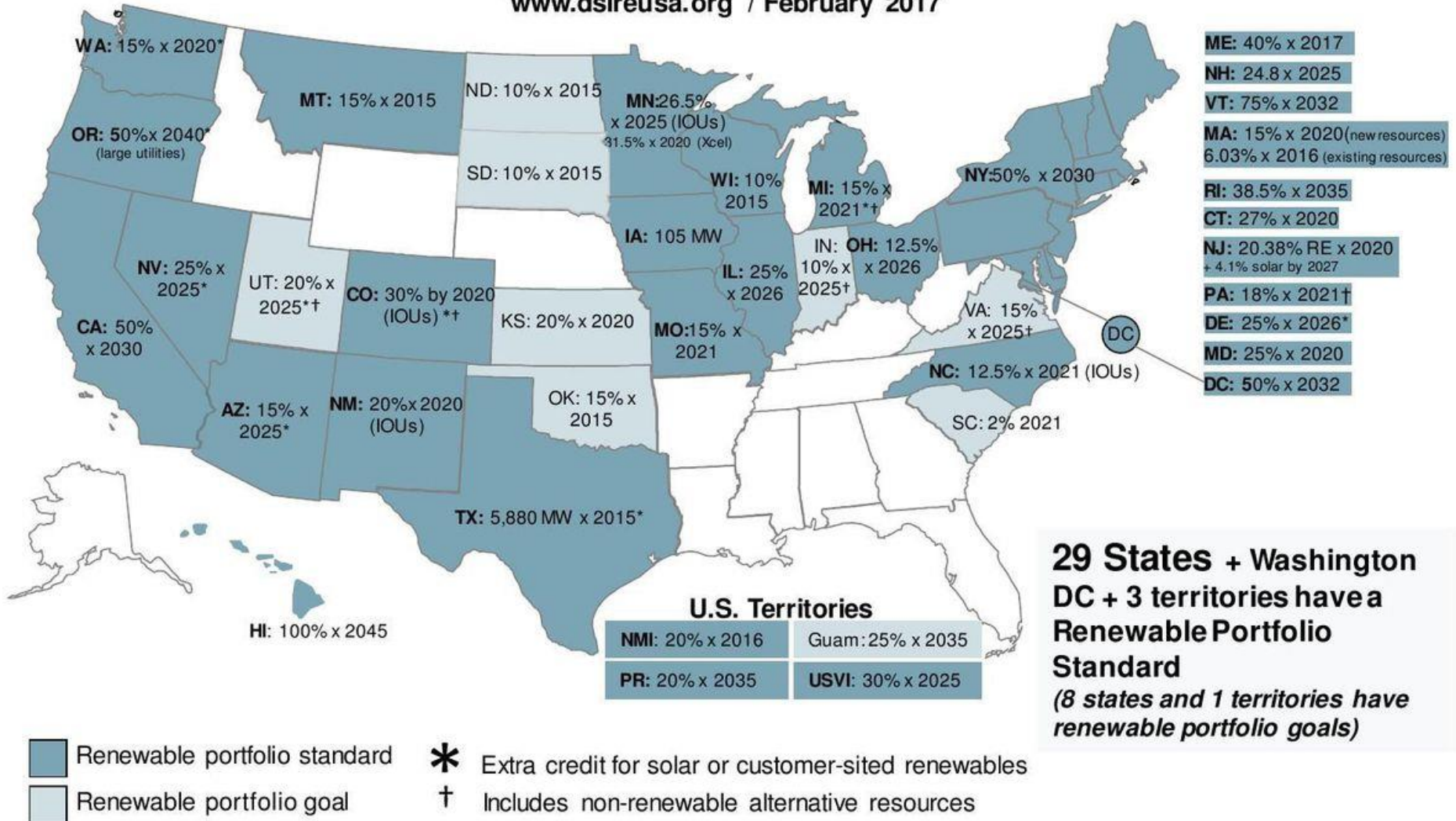
# Where U.S. Uses Energy: Potential for Conservation and Improved Efficiency





# Renewable Portfolio Standard Policies

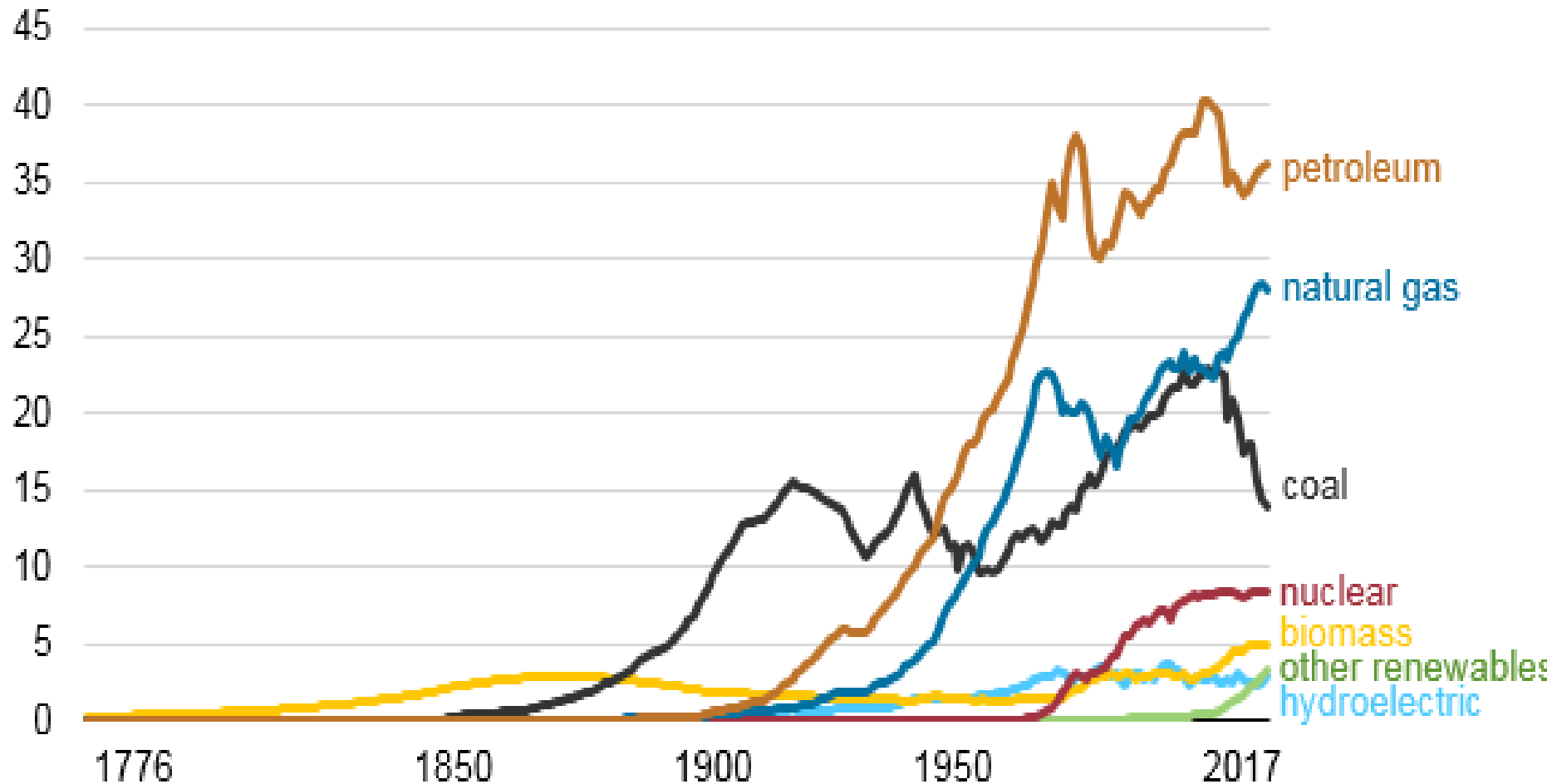
www.dsireusa.org / February 2017



# U.S. Energy Use Historically: To 2017

Energy consumption in the United States (1776-2017)

quadrillion British thermal units



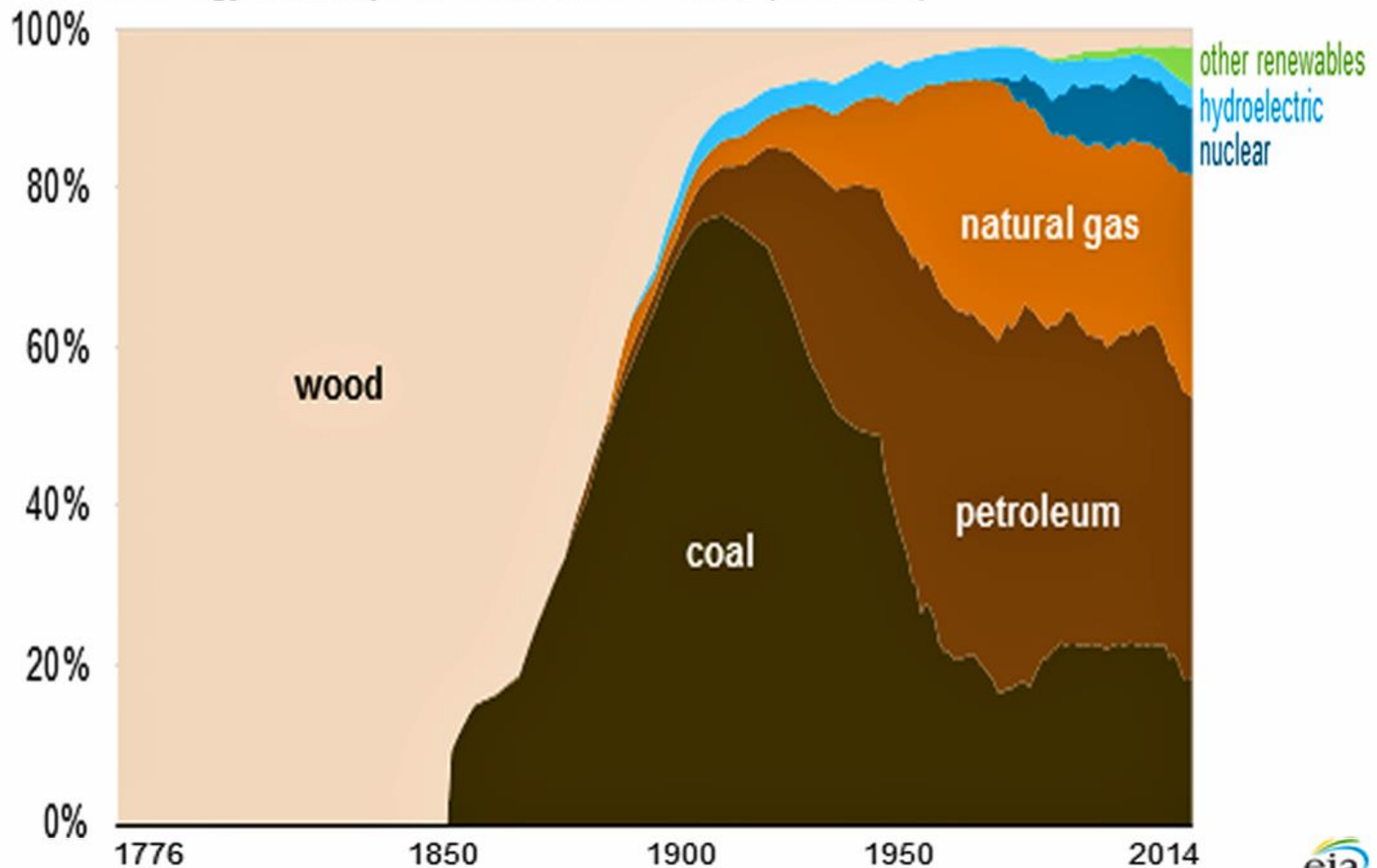
# Recent Changes Are Striking

- NY Times, 2018: “Coal generation dropped precipitously over the past two decades, and nuclear power plateaued... while natural gas and renewable energy, like wind and solar, are on the rise.”
- Even so, **in 2017**, after three years of being flat, the world emitted the most greenhouse gases in a single year ever, due to rising economies in Asia. **In 2018, emissions rose by est. 2.7 percent, largest in last eight years.** Why? Economic growth rose sharply, thus more emissions from factories, planes, trucks, even with a big drop in coal use.
- Despite gains in renewables, 70% of global energy demand growth met by oil, natural gas and coal.

# Same Changes, but as Percentages of Use

Markets  Chart of the Day

Share of energy consumption in the United States (1776-2014)



# Another View of Current Energy Use



# The Path Forward

- Calls for reducing use of fossil fuels and moving toward renewables: From NAS and other scientific reports to Pope Francis's encyclical on the subject.
- The **Paris Agreement** (slide coming), and initially all nations but Syria and Nicaragua approved. Took effect in November 2016. **U.S. now alone in opposing agreement; others might.**
- What all this means in terms of energy that we will need.
- Recent investments in renewables and the outlook
- Also whether carbon sequestration can work economically.
- Estimates by various groups as to the feasibility of a rapid transition to renewables.
- The challenge of measuring social costs of carbon or costs of climate change.



# The Path Forward II

- By early 2017, coal industry sees need to change.
- *New York Times*, Feb. 27: “coal producers are voicing greater concern about greenhouse gas emissions. Their goal is to **frame a new image for coal** as a contributor, not an obstacle, to a clean-energy future.”
- Executives of leading companies aligning with environmental groups to press Congress for **expansion of government subsidies to reduce environmental impacts of coal**.
- They want further incentives to develop and use **carbon capture and storage or sequestration technologies**, which are expensive and so far not very effective.
- Symbolic: Harlan County, Kentucky **coal mining museum** in April 2017 switched to solar power to save money on heating.

# Paris Agreement of 2015

- Aims to keep increase in average temperature to **well below 2°C (3.6° Fahrenheit)** above **pre-industrial levels**.
- Need for **global emissions to peak as soon as possible**, recognizing that this will take longer for developing countries.
- Undertake **rapid reductions** after that peak in accordance with the best available science.
- Nations develop voluntary **national climate action plans** to guide their efforts, and strengthen them over time.
- Agreement will not keep warming below 2°C.
- So governments **meet every 5 years to set more ambitious targets as required by science** and to report progress. Are to do so with transparency and accountability.
- How likely we will do enough and do it in time?



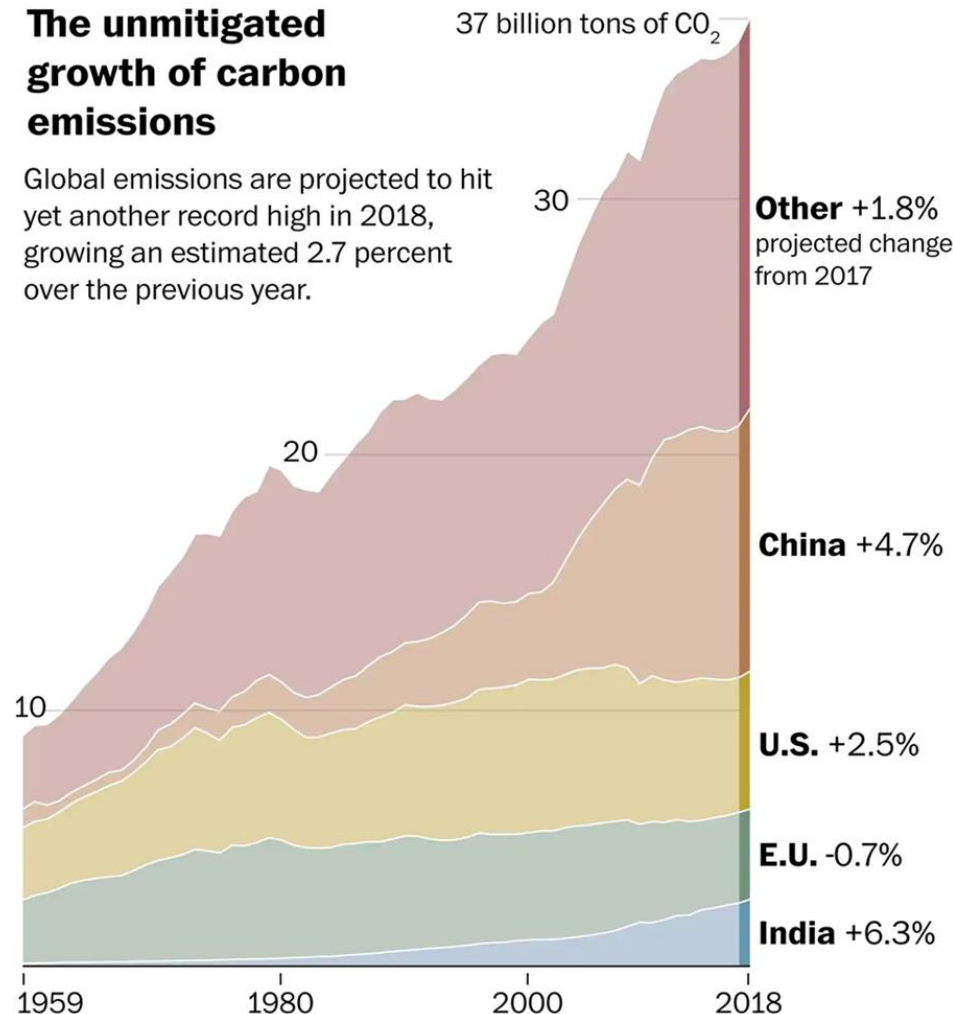
# June 2017: Trump Announces U.S. Withdrawal from Paris Agreement



# Yet Other Nations Also Are Not Doing Enough; Same Slide As Shown Earlier

## The unmitigated growth of carbon emissions

Global emissions are projected to hit yet another record high in 2018, growing an estimated 2.7 percent over the previous year.



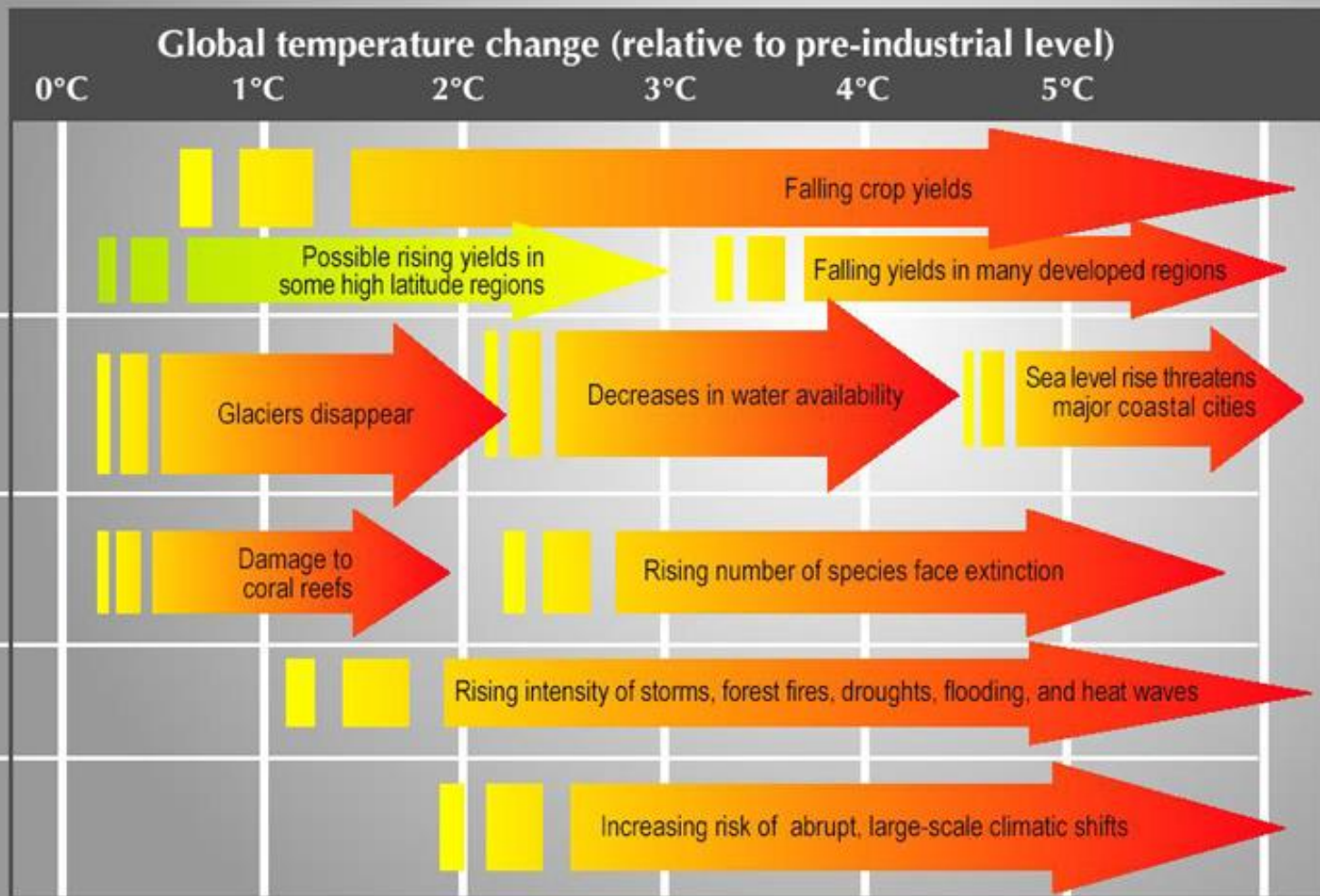
Figures show emissions from fossil fuels and industry, which includes cement manufacturing but not deforestation.

# Revisions to Paris Agreement in Climate Change Meeting in Poland Late 2018

- Diplomats from 200 nations agreed to keep the agreement alive
- Adopted detailed rules for implementation
- Requires every nation in the world to follow similar rules/standards for measuring emissions and tracking their policies.
- Calls on nations to step up plans to cut emissions before next meeting in 2020
- Calls on richer nations to be clear how they will assist poorer nations install more clean energy and build resilience against effects.



# Projected Impacts of Climate Change



C = Celsius; CO<sub>2</sub> = Carbon Dioxide

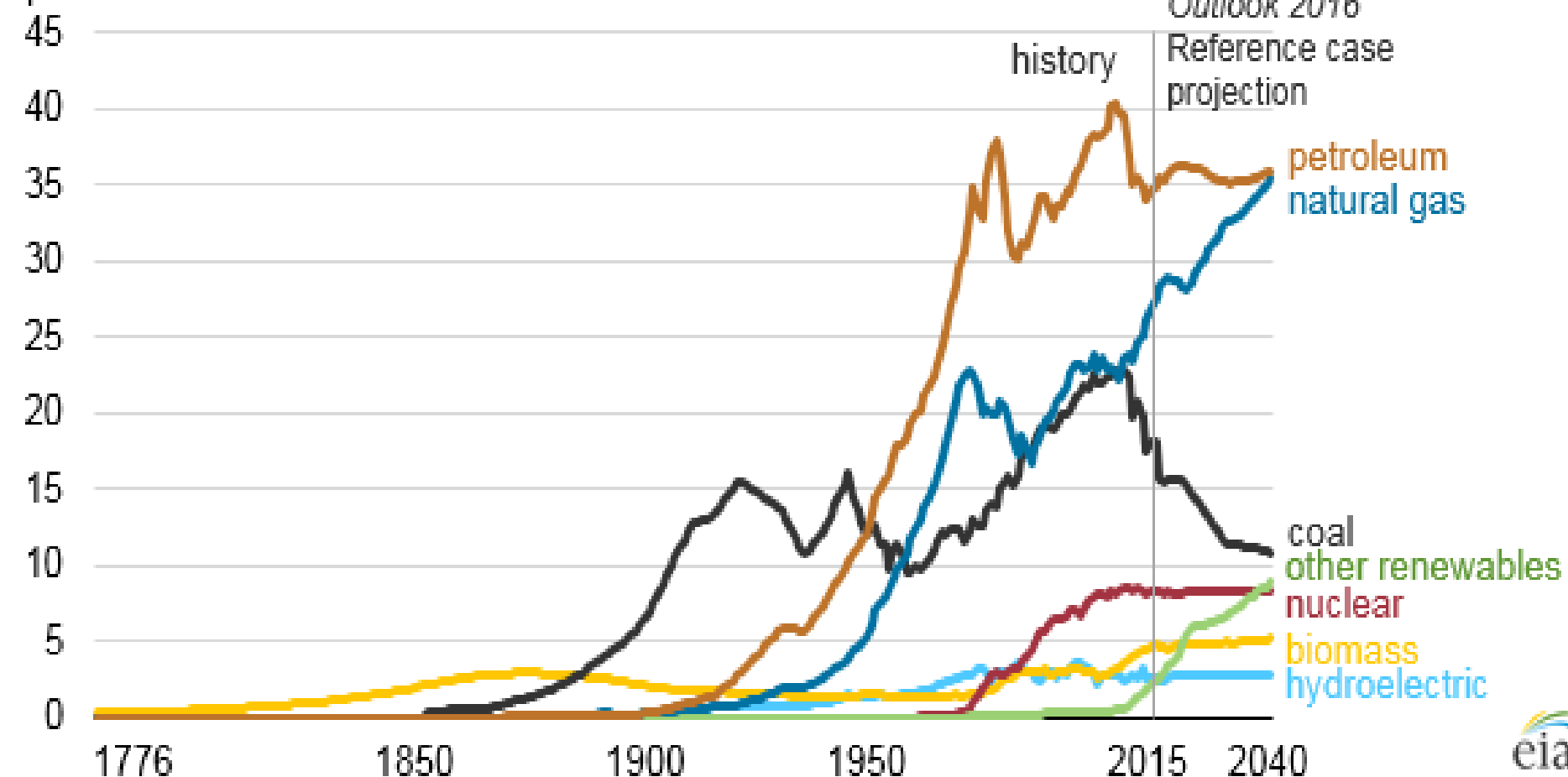
Source: Adapted from the *Stern Review on the Economics of Climate Change*.

# Projected Energy Use

- Few analysts forecast a major resurgence of nuclear power in the United States. Too expensive.
- According to DOE's Energy Information Administration (EIA), percentage contributions of **nuclear power and fossil fuels are unlikely to change much** over the next two decades.
- Coal declining, natural gas rising, oil about the same.
- The following projections from 2016 and 2017 DOE reports.
- Then some recent changes in energy production.
- **DOE's Annual Energy Outlook 2019**, with projections to 2050. The key resource if you want details. Lots of information and graphs. Both PDF and PPT.

# Energy consumption in the United States (1776-2040)

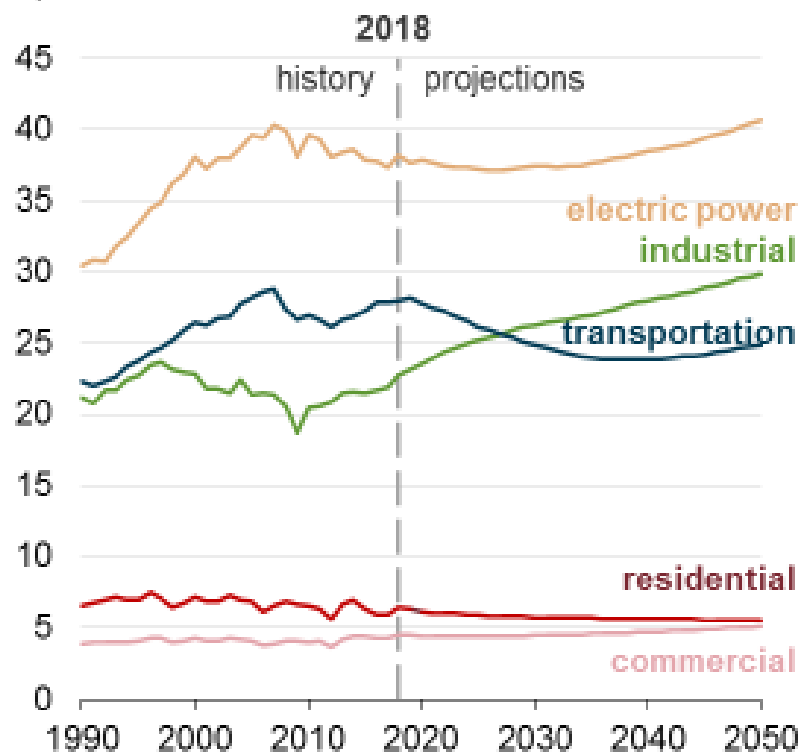
quadrillion Btu



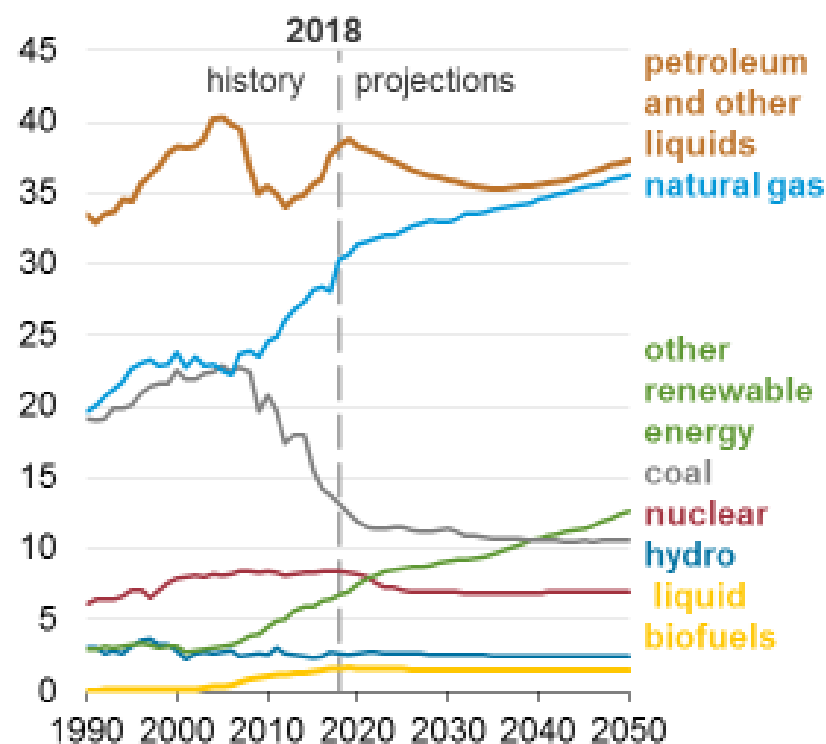


## Policy, technology, and economics affect the mix of U.S. fuel consumption—

Energy consumption by sector (Reference case)  
quadrillion British thermal units



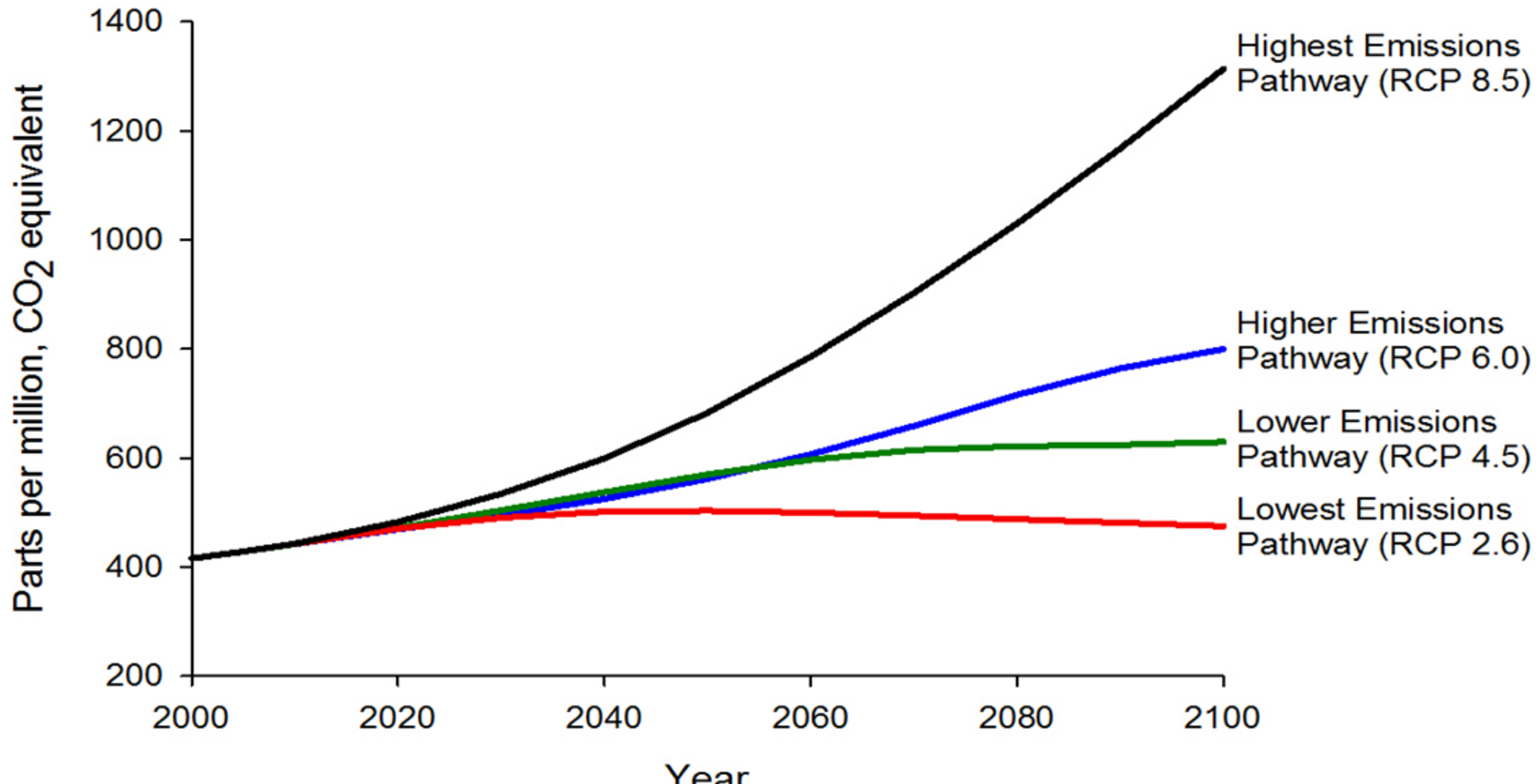
Energy consumption by fuel (Reference case)  
quadrillion British thermal units



# Scenarios for Energy Future

By 2100, the average U.S. temperature is projected to increase by about 3°F to 12°F, depending on emissions scenario and climate mode.

## Projected Atmospheric Greenhouse Gas Concentrations

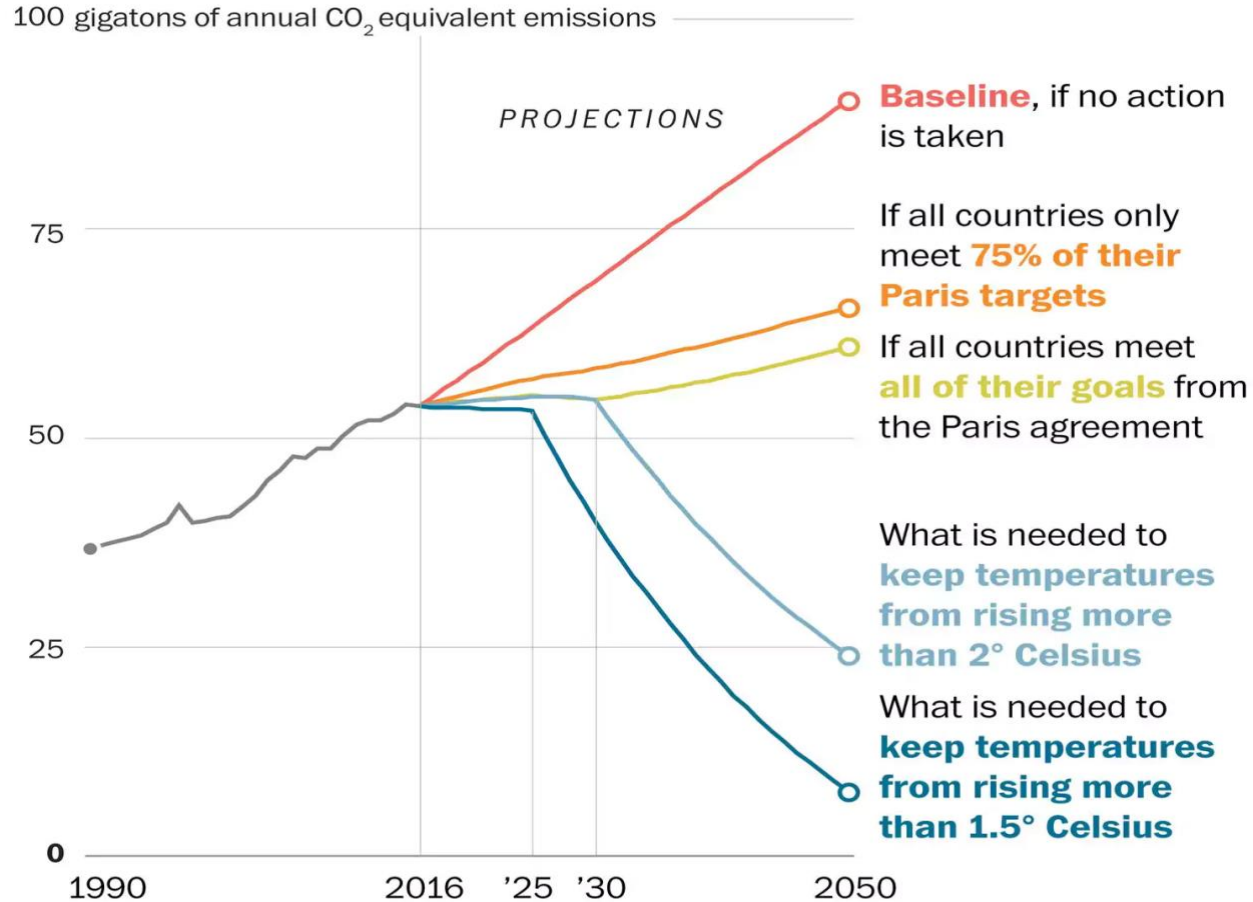




# Emissions Scenarios

## Emissions targets to cool a warming planet

Even if all countries hit their targets under the Paris agreement, global carbon dioxide emissions will still far exceed what is needed to keep temperatures from rising above 1.5 or 2 degrees Celsius.



Data is based on scenarios from Climate Interactive.

Source: Climate Interactive

THE WASHINGTON POST

# Higher v. Lower Emissions Scenarios: Top Graphs are Higher Emissions

Higher Emissions Scenario - Projected Temperature Change (°F)  
From 1961-1979 Baseline

Mid-Century (2040-2059 average)



End-of-Century (2080-2099 average)



Lower Emissions Scenario - Projected Temperature Change (°F)  
From 1961-1979 Baseline

Mid-Century (2040-2059 average)

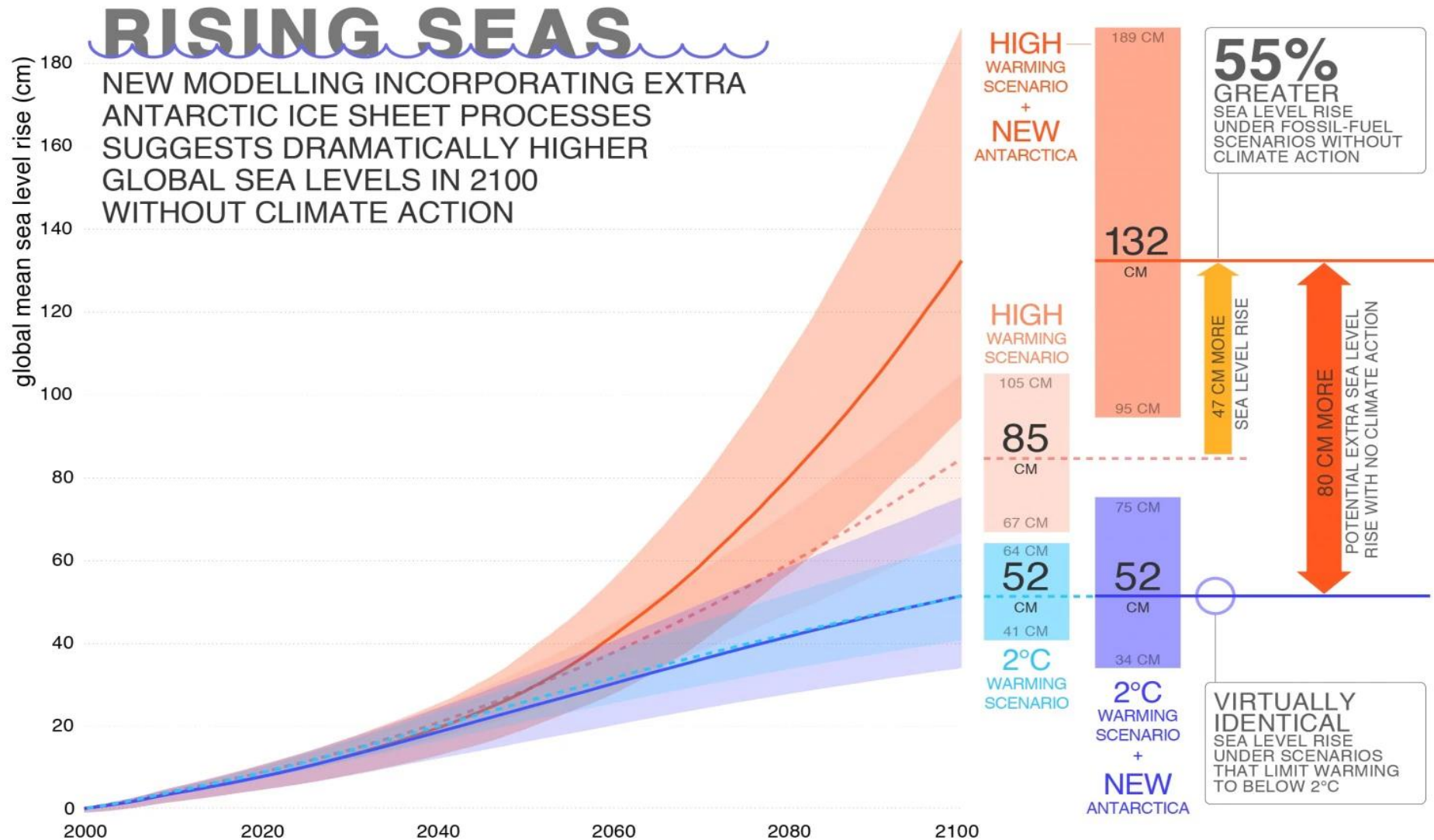


End-of-Century (2080-2099 average)

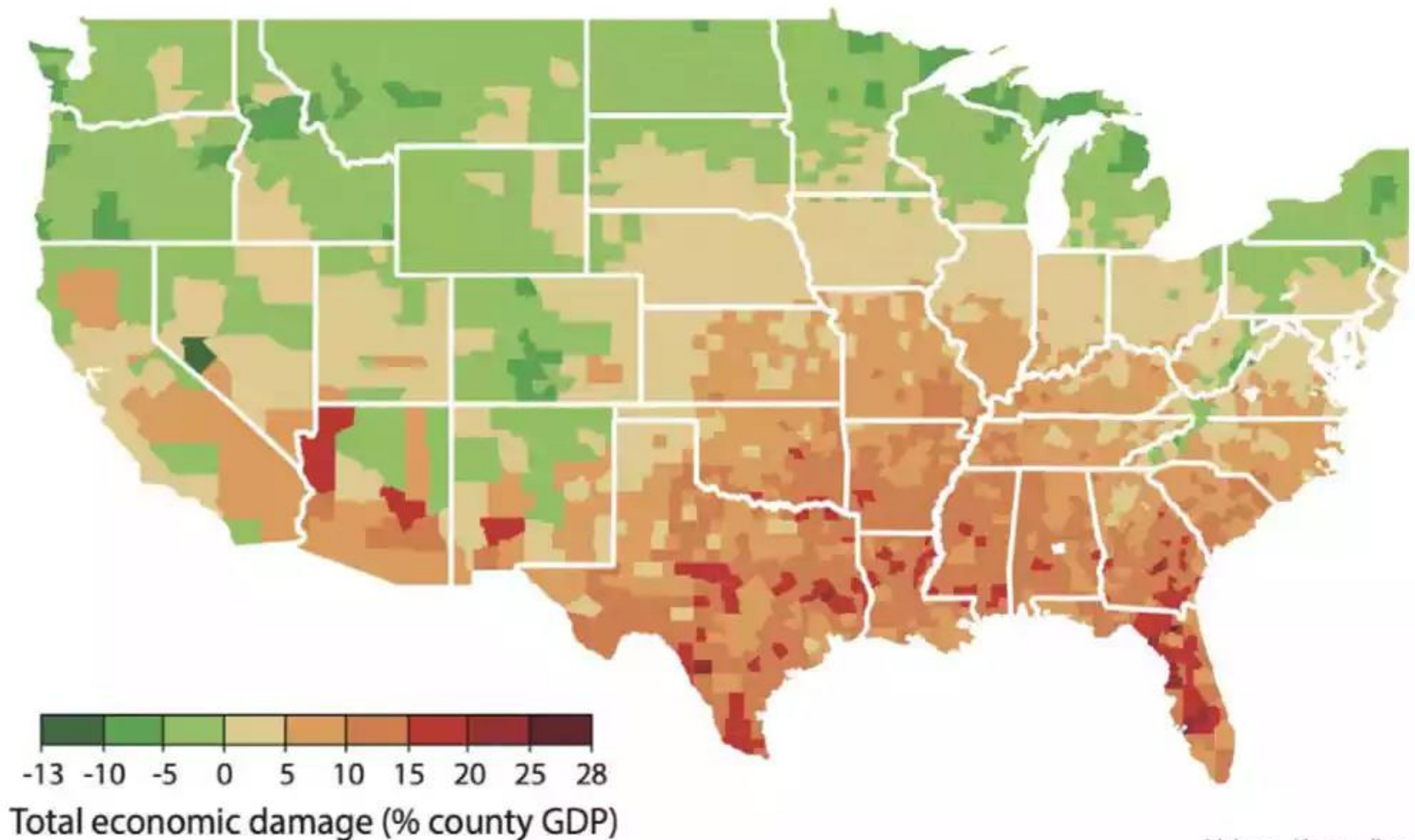


All Maps  
Source: NOAA

# Sea Level Rise for High Emissions Scenario: Three More Feet



Economic Impacts of Climate Change:  
2080-2099, *Science*, 6/30/17. Hurricane  
Harvey 2017, est. \$125 billion in damages.



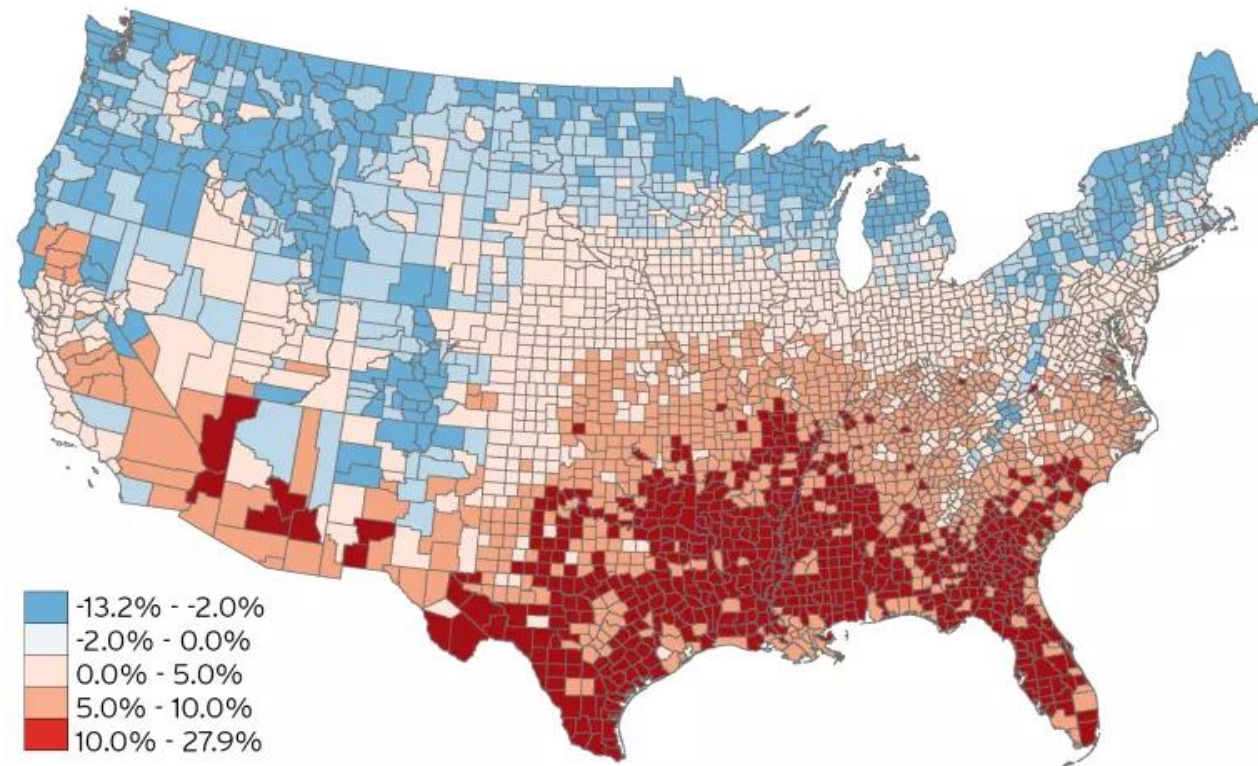


# Other View of Economic Impacts on Counties: Brookings Jan. 2019

MAP 2

## Climate-related costs by 2080-2099

Share of 2012 county income

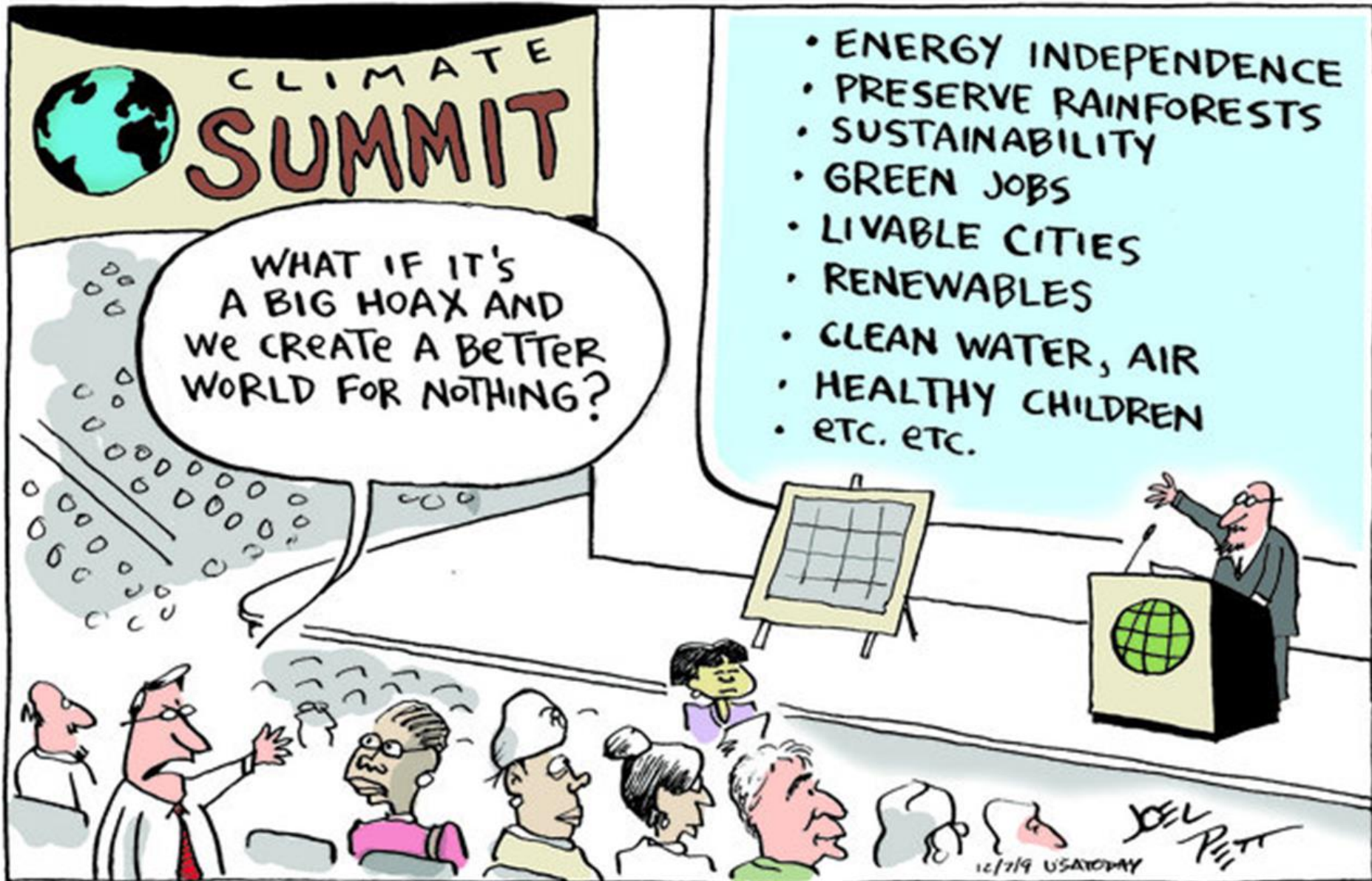


Note: Emissions projections are based on a "business-as-usual" scenario (RCP8.5), which reflects the current global trajectory

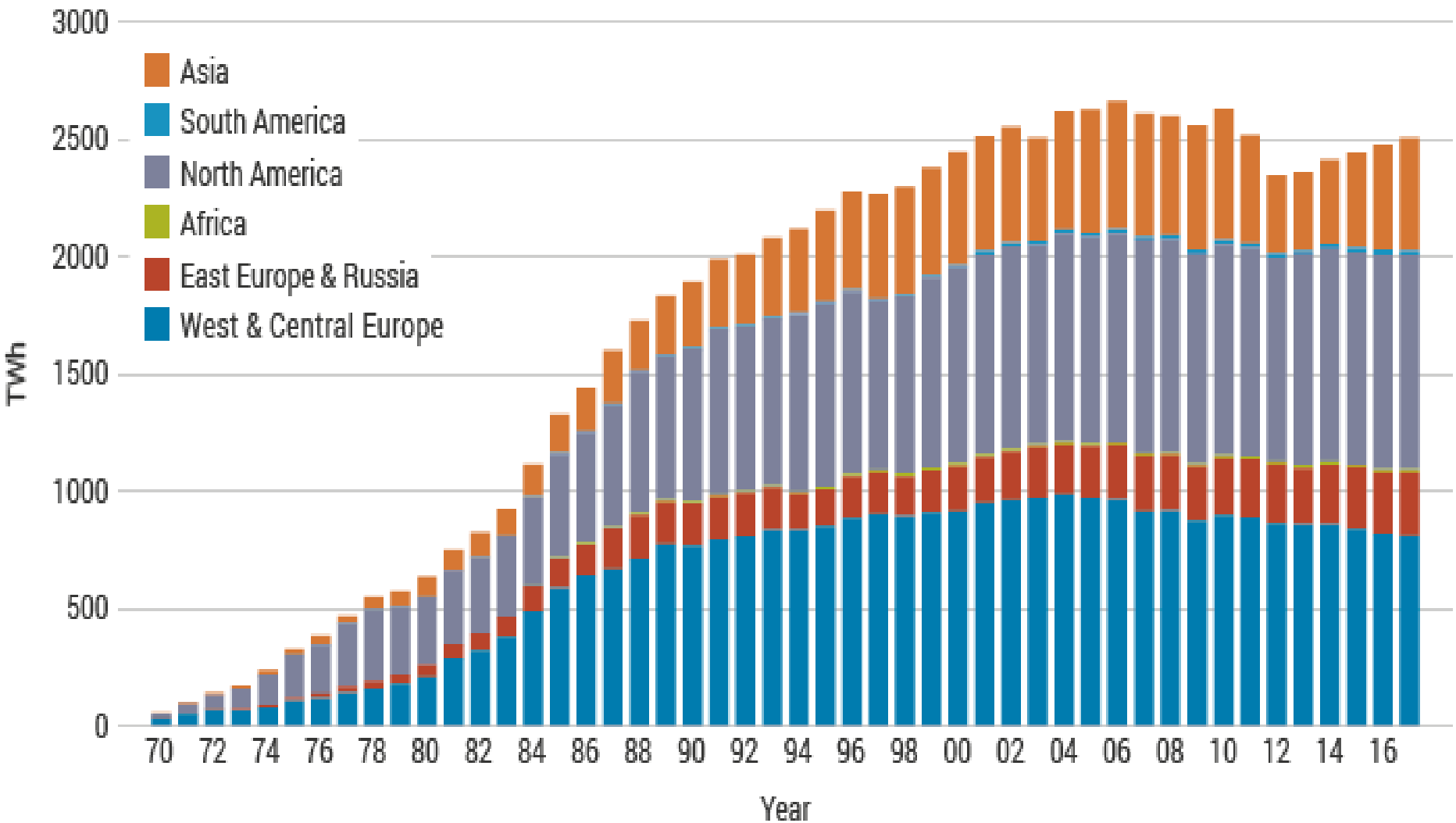
# Best to Select Precautionary Actions

- Energy projections useful, esp. for growth in renewables and away from coal and oil. Also need to reduce natural gas use.
- There is a **path to reduced emissions**, and we are already on it with movement to wind, solar, biomass, and possibly different form of nuclear power. Clean Power Plan and fuel economy.
- Many new technologies are in development.
- Present action should emphasis precaution/“no regrets”.
- **Jobs not the issue many think:** More solar jobs in U.S. now than in the oil, gas and coal extraction industries combined.
- January 2017: DOE reported that “solar technologies, both photovoltaic and concentrated, employ almost **374,000 workers**, or 43 percent of the electric power generation work force.” In comparison, **coal accounts for about 86,000 workers**.

# Is There a Downside to Precaution?



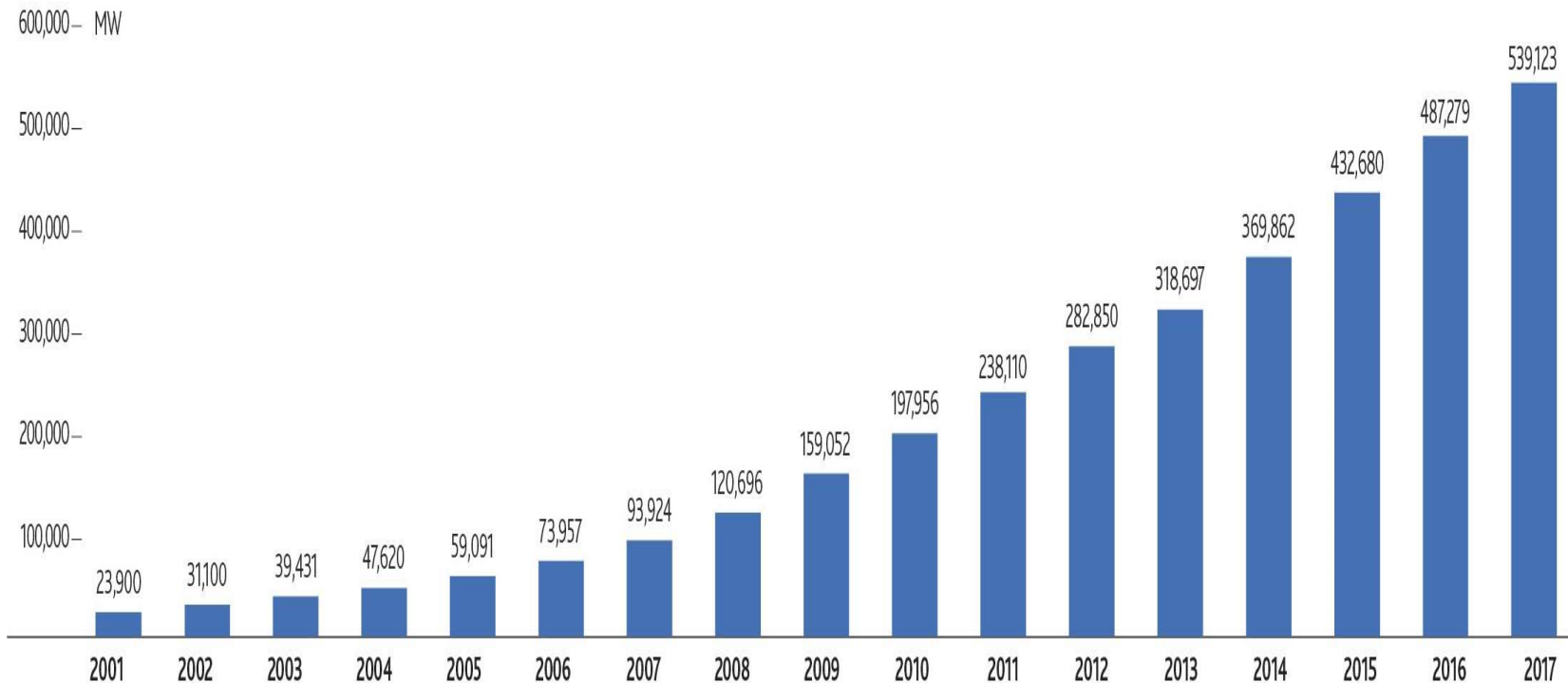
# Energy Trends: Global Nuclear Power As Slow Growth or Leveling Off in 2017





# But Wind and Solar Increasing: Wind Capacity Grows as Costs Decline

GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 2001-2017



Source: GWEC

# Offshore Wind Increasingly Used: Photo Is Off Britain's Coast with 600-Foot High Turbines; Wing Span of 270 Feet.



# Wind Turbines in Fond du Lac County: 262 Feet Tall and Power 36,000 Homes

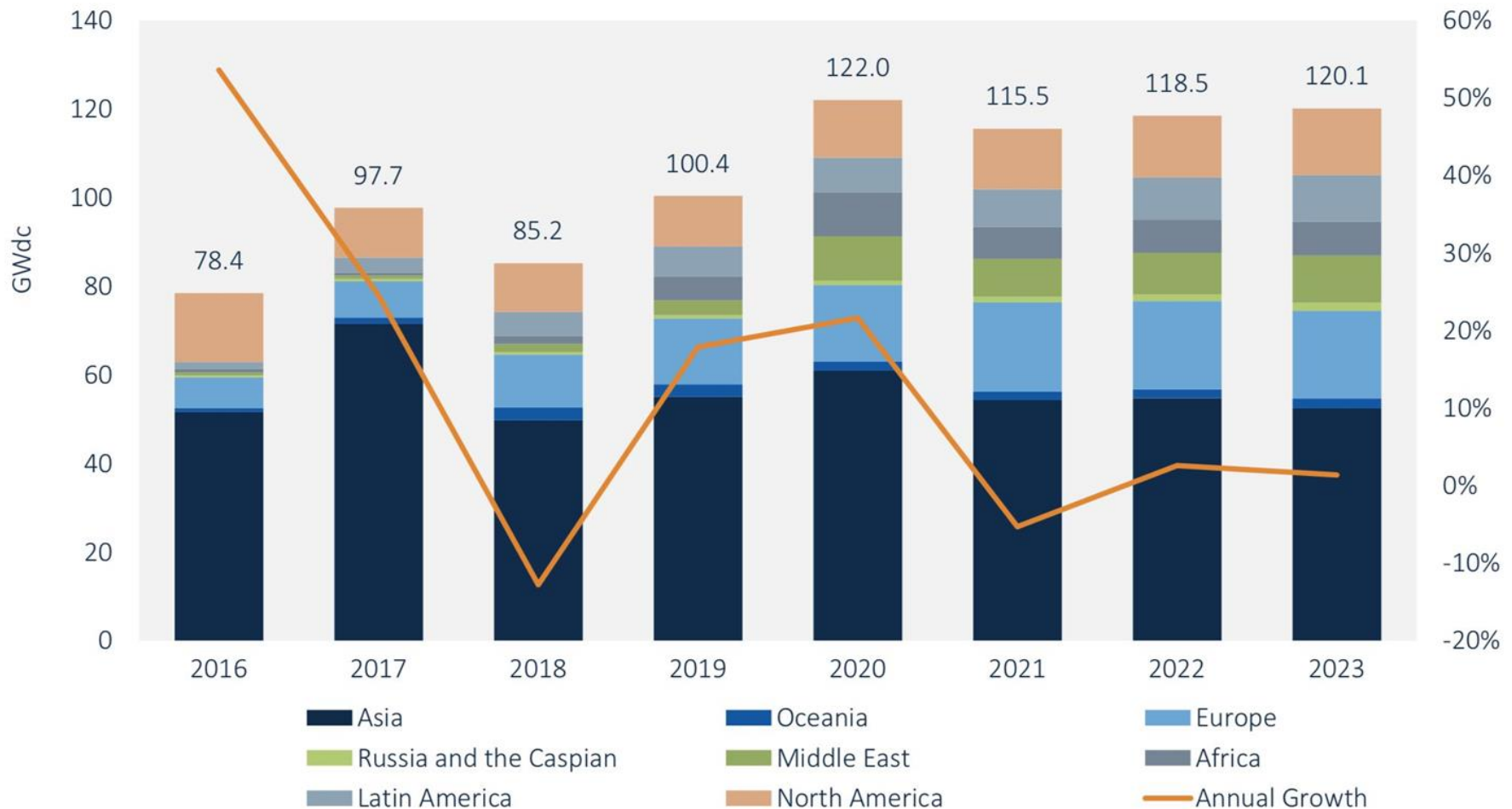


# Wind Power in China

- More than 92,000 wind turbines have been built across the country, capable of generating 145 gigawatts of electricity, nearly double the capacity of wind farms in the United States.
- **One out of every three turbines in the world is now in China**, and the government is adding them at a rate of more than **one per hour**.
- China's government vows to continue investing heavily in renewable energy.
- Will spend at least \$360 billion through 2020 on developing renewable energy sources.

# Solar PV Capacity: Trends and Projections for 2023

Global PV Demand by Region, 2016-2023E



# DOE's EIA on Recent Changes

- E and E News, January 12, 2017: **“More than half of the roughly 24,000 megawatts of electricity generation capacity added to the U.S. grid in 2016 came from renewable resources.”** In 2017, U.S. solar output rose 47 percent for the first three quarters of year. **By 2018, nearly all of the new U.S. capacity was from natural gas and renewables!**
- Global picture even more striking: **Two-thirds of generation capacity added in 2016 came from renewable sources.**
- “In contrast to the growth in renewable energy, EIA also reported that **U.S. coal is expected to fall to its lowest level in nearly 40 years**, at 743 million short tons. That vast majority of U.S. coal is burned to generate electricity.”
- **“In 2016, natural-gas-fired power generation surpassed coal-fired generation for the first time**, accounting for an estimated 34 percent of total electricity generation, compared with coal's 30 percent share.”

# A Clean Energy Revolution

- New York Times reports: “experts predicted in 2000 that wind generated power worldwide would reach 30 gigawatts; by 2010, it was 200 gigawatts, and by last year it reached nearly 370, or more than 12 times higher.”
- Similarly, predictions in 2002 suggested that “installations of solar power would add one new gigawatt per year by 2010.” Yet it was 17 times that by 2010 and 48 times that amount in 2014.
- **Why? Rapid gains in technology improve efficiency and lower costs.**
- One indication: offshore wind power around the world, and now in the U.S. as well.
- In 2016, wind power generation in the U.S. was greater than hydroelectric power for the first time.



# Clean Energy and Lower Costs I

- From Thomas Friedman, Nov. 16, 2016:
- Hal Harvey has long advised major companies on climate and energy policy.
- He notes that thanks to technological advances, “the cost of solar energy has dropped more than 80 percent since 2008, wind costs dropped more than 50 percent since 2008, battery costs dropped more than 70 percent since 2008, and LED lighting costs dropped more than 90 percent since 2008. As a result, **a clean future now costs less than a dirty one.**”
- For graphics and discussion of these critical trends, see New York Times of Oct. 16, 2017:  
<https://www.nytimes.com/interactive/2017/10/15/opinion/editorials/donald-trump-epa-truths.html?action=click&pgtype=Homepage&clickSource=story-heading&module=opinion-c-col-left-region&region=opinion-c-col-left-region&WT.nav=opinion-c-col-left-region>



# Clean Energy Technology II

- Prices dropping rapidly on solar and wind around the world to as low as **3 cents a kilowatt hour**. Harvey: “That compares to about 6 cents for a new natural gas power plant, and double that for new coal.”
- Researchers at Univ. of Texas in early 2017 announced a low-cost, **all-solid-state battery** that is noncombustible and will be **safer, faster charging, hold more power, and keep a charge longer than current lithium ion batteries**.
- Bloomberg New Energy Finance in July 2017: electric cars likely to become cheaper than conventional cars (even if no government subsidies) sometime between 2025 and 2030.
- Tesla, GM, Ford, Mercedes-Benz, and Volvo, among others, planning new electric/plug-in hybrids that will be more affordable and practical. All see a bright future for electric vehicles.
- Major impact on carbon emissions. Transportation accounts for 14 percent of global GHG emissions; 27 percent in the U.S.

# Even Fossil Fuel Companies Agree

- Exxon Mobil, the world's largest publicly traded international oil and gas company, operates in many countries that seek to reduce carbon emissions.
- Exxon Mobil issued a **public statement in support of the Paris climate agreement** on Nov. 4, 2016, the day it took effect. Shell and BP also support the Paris Agreement and in April 2017 urged President Trump to stick with it. He didn't.
- Shutting down coal use in favor of natural gas, which is cleaner and emits about half of the carbon, is something that Exxon Mobil and other oil companies see as a business opportunity.
- Yet big oil companies continue to oppose state carbon tax proposals, as they did in Washington State in 2018.

# Clean Energy Technology III

- New York Times: Dec. 26, 2016:
- “Cheap natural gas, which has increasingly replaced coal as a fuel source, has had a lot to do with this progress, but so has the **drop in the cost of wind and solar power.**”
- “The cost of **batteries** has dropped by almost three-fourths.”
- In Iowa, Illinois, Kansas, Nebraska and parts of Texas—“new wind turbines can generate electricity at a lower cost, **without subsidies**, than any other technology.”
- Employment in **solar sector** increased by 25 percent in 2016. Calif. led the way with **25,000 new jobs**.
- Overall, the industry grew at 17 times the pace of rest of economy, adding 51,000 jobs nationwide. The sector accounted for 2 percent of all new U.S. employment.
- Limits on future growth? Electrical utilities fighting back against rooftop solar and net metering policies. Backed by ALEC and fossil fuel interests at state level.

# State and Local Energy Commitments

- States in the top ten for electricity derived from renewables: Iowa, South Dakota, Kansas, Oklahoma, California, North Dakota, Vermont, Colorado, Minnesota, and Nevada.
- Cities that already rely on **renewables for 100% of their electricity**: Burlington, Vermont, but also conservative Georgetown, Texas.
- Mayor of Georgetown: “We’re doing this because it is good for our citizens. Cheaper electricity is better. Clean energy is better than fossil fuels.”
- Many other cities, large and small, pledging to reach the same goal, including Orlando, Florida; St. Louis, Missouri; Denver, Colorado (and nine other Colorado cities); San Francisco, California; and Portland, Oregon.
- In 2018, Denver was the 73rd city in the U.S. to adopt such a goal, and hopes to get there sooner than most.

# The Energy Policy Debate I

- So if we are to reduce fossil fuel use and do so fairly quickly, **what policies might help?** Federal, state, local, private sector, and an array of choices. The **two parties differ on this.**
- **Regulation**, e.g., Obama Clean Power Plan and fuel efficiency standards. The heart of his energy policy because Congress refused to act. Republican opposition still intense. Trump and Congress are determined to reverse both; courts will decide.
- **Carbon tax or other incentives.** Pros and cons.
- **Subsidies**—wind, solar, **electric and hybrid vehicles** initially. Arguments for and against. Big changes under Obama.
- **Research** on new energy sources from DOE and private sector. Very promising, and a big change under Obama. Including research on **geoengineering** (e.g., CO<sub>2</sub> removal)
- **State renewable energy portfolios.**

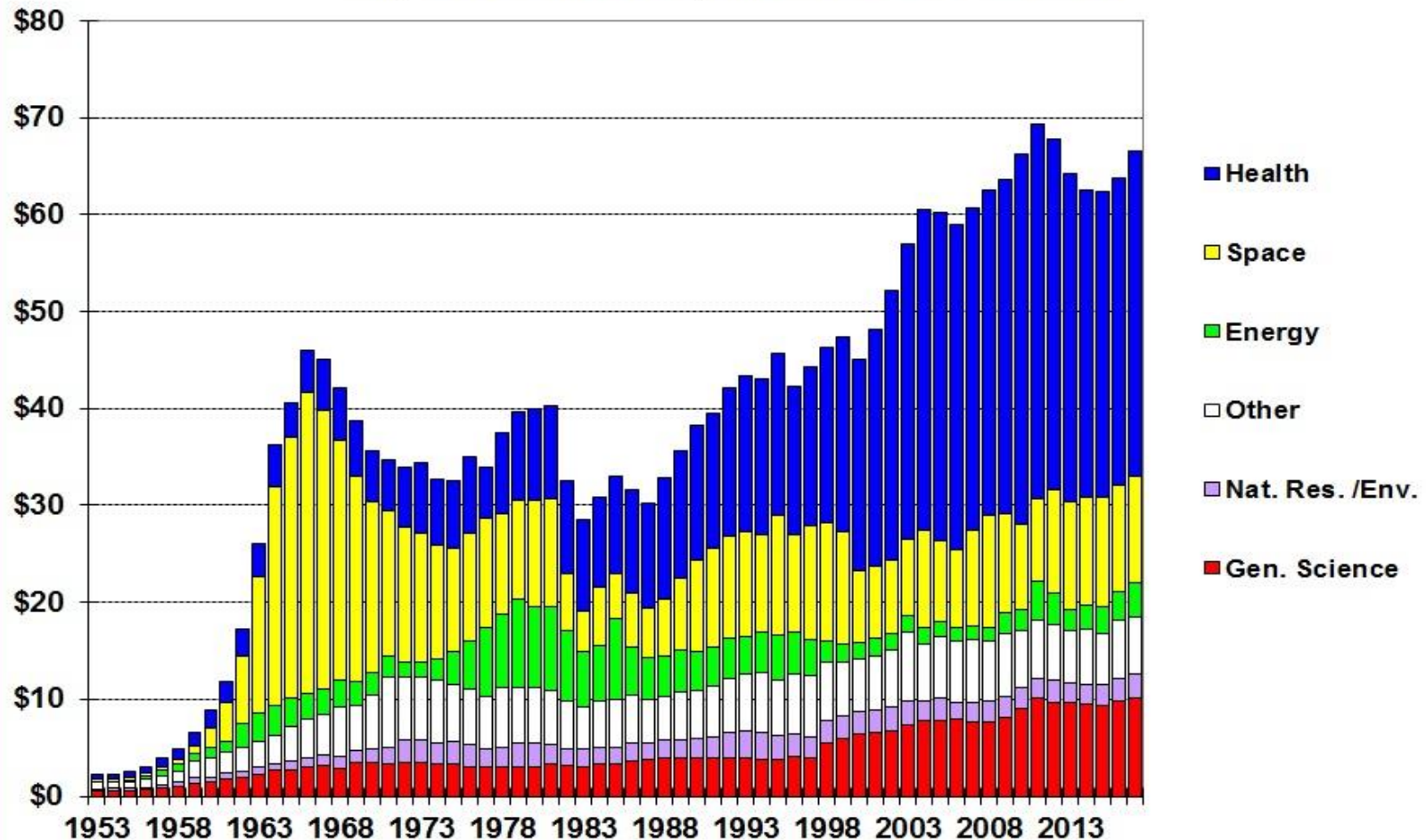
# Energy Policy Debate II

- **Politics** as barrier or as facilitator?
- **Ethics**, including intergenerational ethical issues. What is fair to future generations?
- What is fair to **developing countries**? Will rich nations object, or not contribute financially?
- **Economics**. What does climate change policy cost? What is the cost of doing nothing?
- **Plenty of options**, many of which are politically feasible, economically beneficial, and ethical if only we look at the facts and analysis of options fairly. Can we do that in a fact-challenged world?
- Also, can begin with a “no regrets” and modest policy and change it over time as evidence and support increase.

# Federal Research: Energy a Small Part

## Trends in Nondefense R&D by Function

outlays for the conduct of R&D, billions of constant FY 2016 dollars



Source: AAAS, based on OMB Historical Tables in *Budget of the United States Government FY 2017*. Some Energy programs shifted to General Science beginning in FY 1998. © 2016 AAAS

# Federal Role in Regulation, Market Incentives, and Subsidies

- If we had congressional consensus and executive willingness to act. But that is lacking today.
- Select a combination of **regulation** (e.g., Clean Power Plan and fuel economy standards), **market incentives** (carbon tax), change in **subsidies** (end them for fossil fuels, increase them for renewables), and **research**. Can the two parties agree on this?
- Trump's general 2018 budget outline eliminates DOE's Advanced Research Projects Agency-Energy funding. Also, nearly all funding of climate change research (next page).
- Also need more **public education**, **private investment**, and provision of **corporate tax credits for energy research and development**.



# Proposed Defunding of Climate Change Research: A Good Idea or Not?

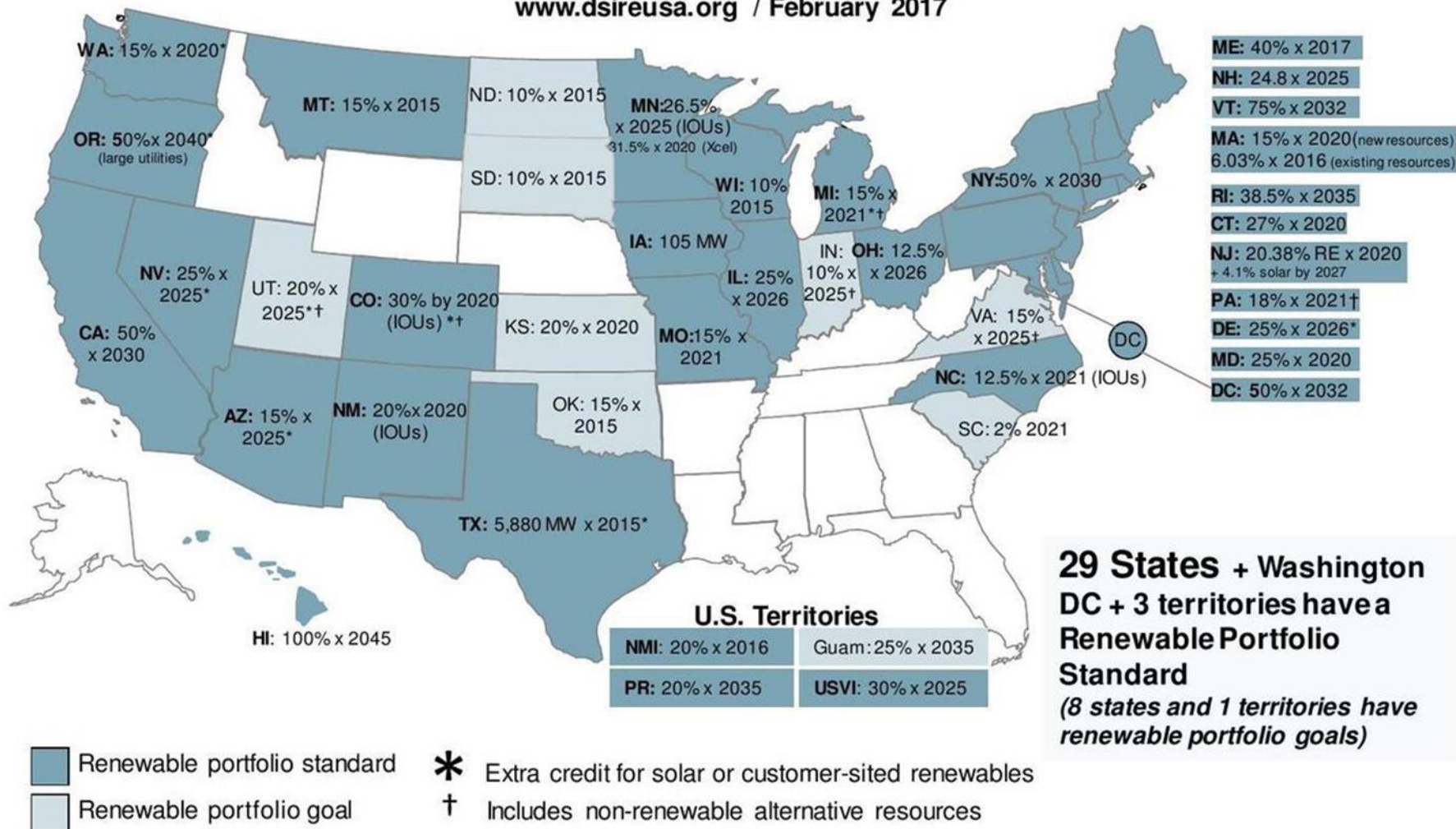
- Mick Mulvaney, OMB Director, March 2017 in unveiling President Trump's 2018 budget recommendations.
- At the EPA, the proposed budget "discontinues funding for the Clean Power Plan, international climate change programs, **climate change research and partnership programs**, and related efforts."
- This includes defunding climate research by NASA and NOAA.
- At the State Department, the budget proposal "eliminates the Global Climate Change Initiative and fulfills the President's pledge to cease payments to the United Nations' (UN) climate change programs by **eliminating U.S. funding related to the Green Climate Fund** and its two precursor Climate Investment Funds."
- Mulvaney on climate change funding: "**we're not spending money on that anymore**; we consider that to be a **waste of your money** to go out and do that. So that is a specific tie to his campaign."

# If No Federal Action, Then States Act

- States (and the private sector) could blunt much of the anticipated economic costs.
- Many states will meet the Clean Power Plan's targets by following through on planned investments and increasing energy efficiency.
- Some states have set targets that are even more ambitious than the CPP and appear to be on track to meet them. Recall **state portfolio targets**, repeated on next slide.
- California and New York plan to cut greenhouse gas emissions to **40 to 50 percent below 1990 levels by 2030**. CA will use its Clean Air Act waiver to increase vehicle fuel economy standards well above federal level. Feds may challenge; lawsuits very likely.
- Hawaii plans to get **100 percent** of its electricity from renewable sources by 2045. California adopted the same goal legislatively, signed by Gov. Brown in Sept. 2018.

# Renewable Portfolio Standard Policies

[www.dsireusa.org](http://www.dsireusa.org) / February 2017



# State Energy Policies: Much Progress

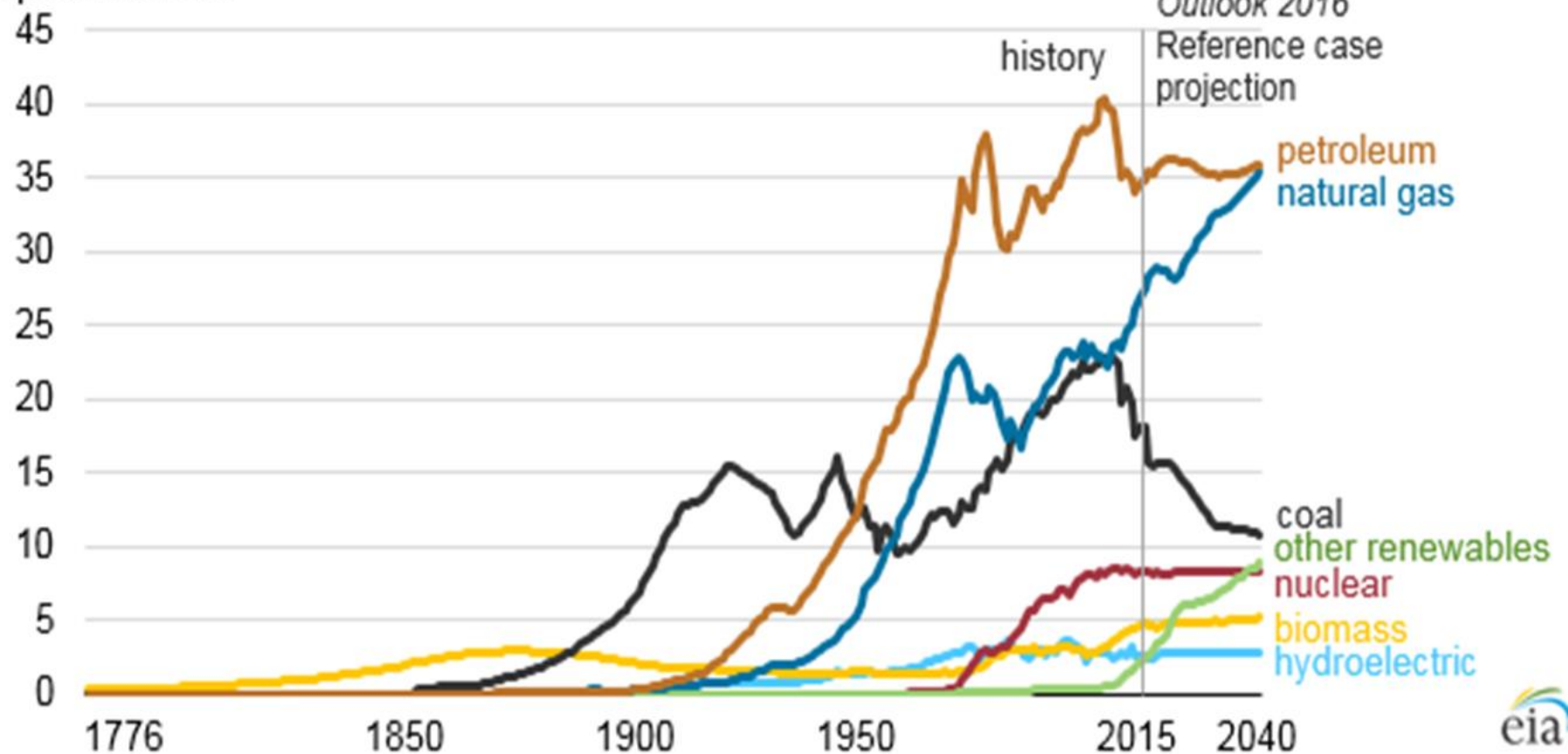
- Brookings Institution [reported in December 2016](#) that between 2000 and 2014, **33 states and the District of Columbia cut carbon emissions while expanding their economies**. That list includes red states like Alaska, Georgia, Tennessee and West Virginia.
- Cheap natural gas from fracking has much to do with this progress, but so has the drop in the cost of wind and solar power.
- As noted, in Iowa, Illinois, Kansas, Nebraska and parts of Texas, new wind turbines can generate electricity **at a lower cost, without subsidies, than any other technology**.
- States are also beginning to put a price on carbon emissions to increase the cost of older fuels and encourage cleaner sources of energy. Esp. Calif.

# Energy Forecasts and Choices

- Where are we likely heading? Next slide.
- What **choices** do we have to alter the path that current forecasts indicate? Different scenarios.
- What kinds of **leadership** needed?
- Some photos that capture the reality of climate change and perhaps inspire some willingness to change.
- And do we really have **time** to make sufficient changes to avoid catastrophe? Is it already too late?

# Energy Projections Revisited: Choices That We Can Make

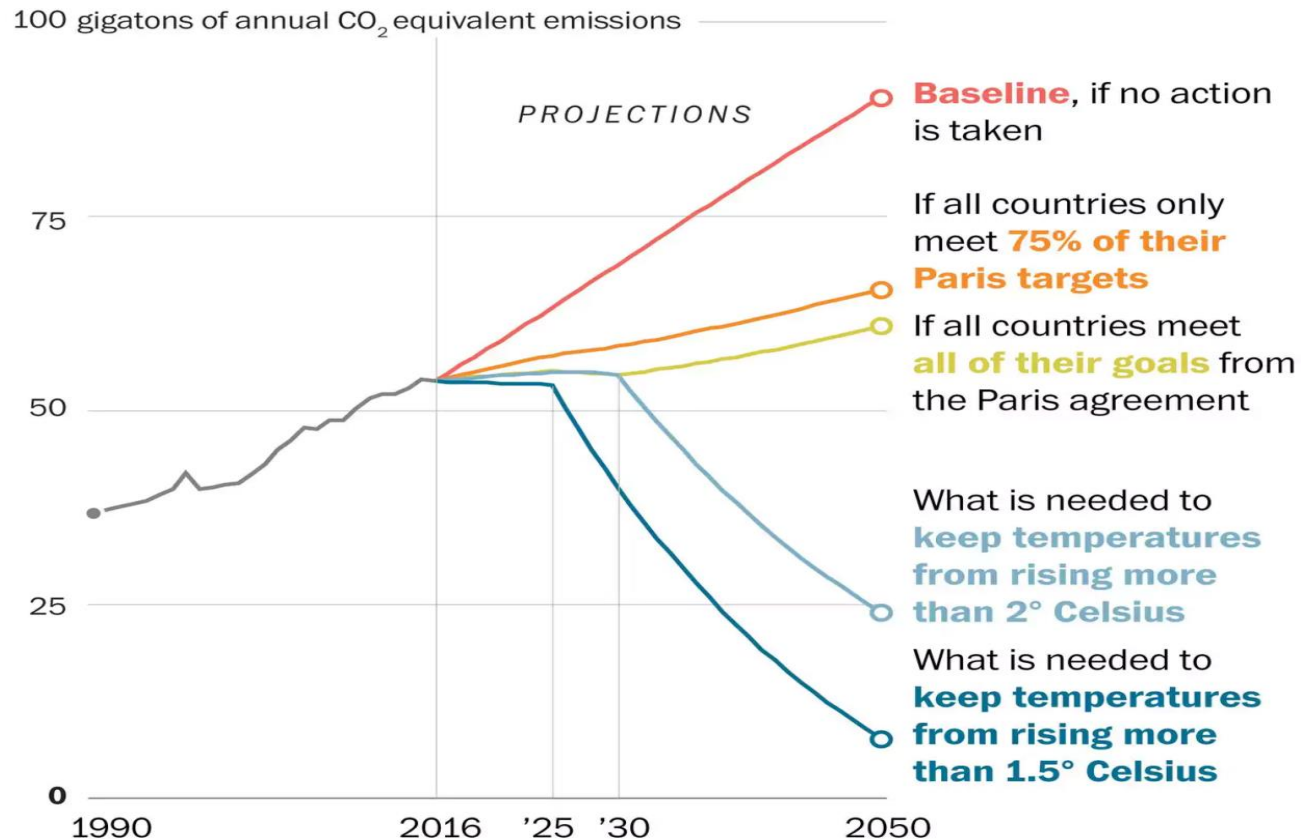
Energy consumption in the United States (1776-2040)  
quadrillion Btu



# Scenario Choices Revisited

## Emissions targets to cool a warming planet

Even if all countries hit their targets under the Paris agreement, global carbon dioxide emissions will still far exceed what is needed to keep temperatures from rising above 1.5 or 2 degrees Celsius.



Data is based on scenarios from Climate Interactive.

Source: Climate Interactive

THE WASHINGTON POST



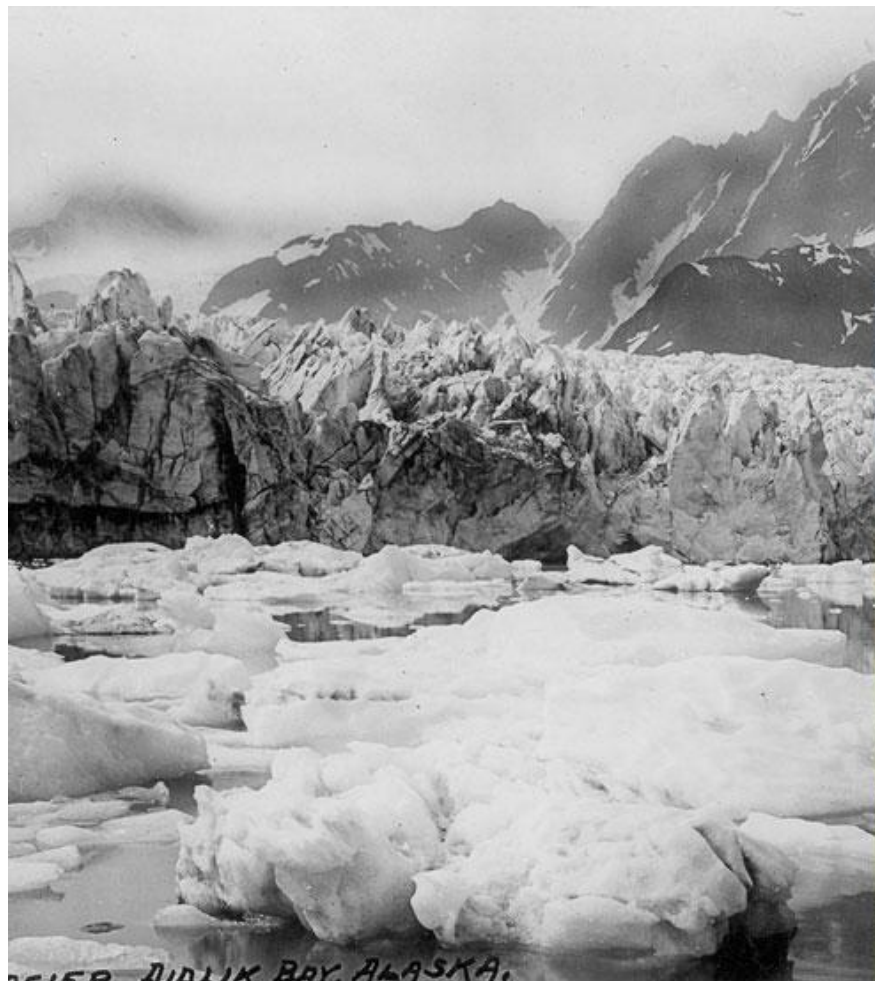
# Selected Photos of Climate Change and Impacts

- Many photos capture the impacts of climate change.
- Impacts on wildlife, cities, infrastructure/flooding, drought and fires, air quality, and more.









GLACIER, LITTLE BOY, ALASKA.



# Downtown Miami: Note Sea Level





# Cape Coral, Florida: Sea Level



# Houston Flooding 2017 from Harvey





# Hurricane Florence, Near Myrtle Beach, South Carolina 2018





# Naples, Florida 2017: Irma





# Hurricane Maria Hits Puerto Rico in 2017; nearly 3,000 Killed



# Beijing Daytime Air 2017: Changing Weather Patterns and Poor Air Quality from Fossil Fuels





# California Wildfires



We Have One Earth on Which to Live and  
Every Nation Uses the Same Atmosphere



# Conclusions

- Questions?
- Are you optimistic? Pessimistic?
- What do you think we should do?
- At the federal level.
- At the state level, say for Wisconsin, if the federal government cannot or will not do much.
- At the local level, say in building codes that encourage energy efficiency and renewables.
- Will Wisconsin become a leader or ignore the problem?



# Other Useful Websites

- Wisconsin Academy of Sciences, Arts, and Letters:  
<https://wisconsinacademy.org/initiatives/climate-future>; and  
<https://wisconsinacademy.org/climateforward>
- Climate Reality Project: [www.climateRealityproject.org/](http://www.climateRealityproject.org/)
- Citizens Climate Lobby: <http://citizensclimatelobby.org/>
- DOE's Energy Information Administration (energy facts):  
[www.eia.gov/](http://www.eia.gov/)
- National Climate Assessment 2017-2018:  
<http://www.globalchange.gov/>
- Scientific American ClimateWire (news on climate science and climate change):  
[www.climateSciencewatch.org/](http://www.climateSciencewatch.org/)
- Wisconsin Initiative on Climate Change Impacts:  
[www.wicci.wisc.edu/](http://www.wicci.wisc.edu/)