

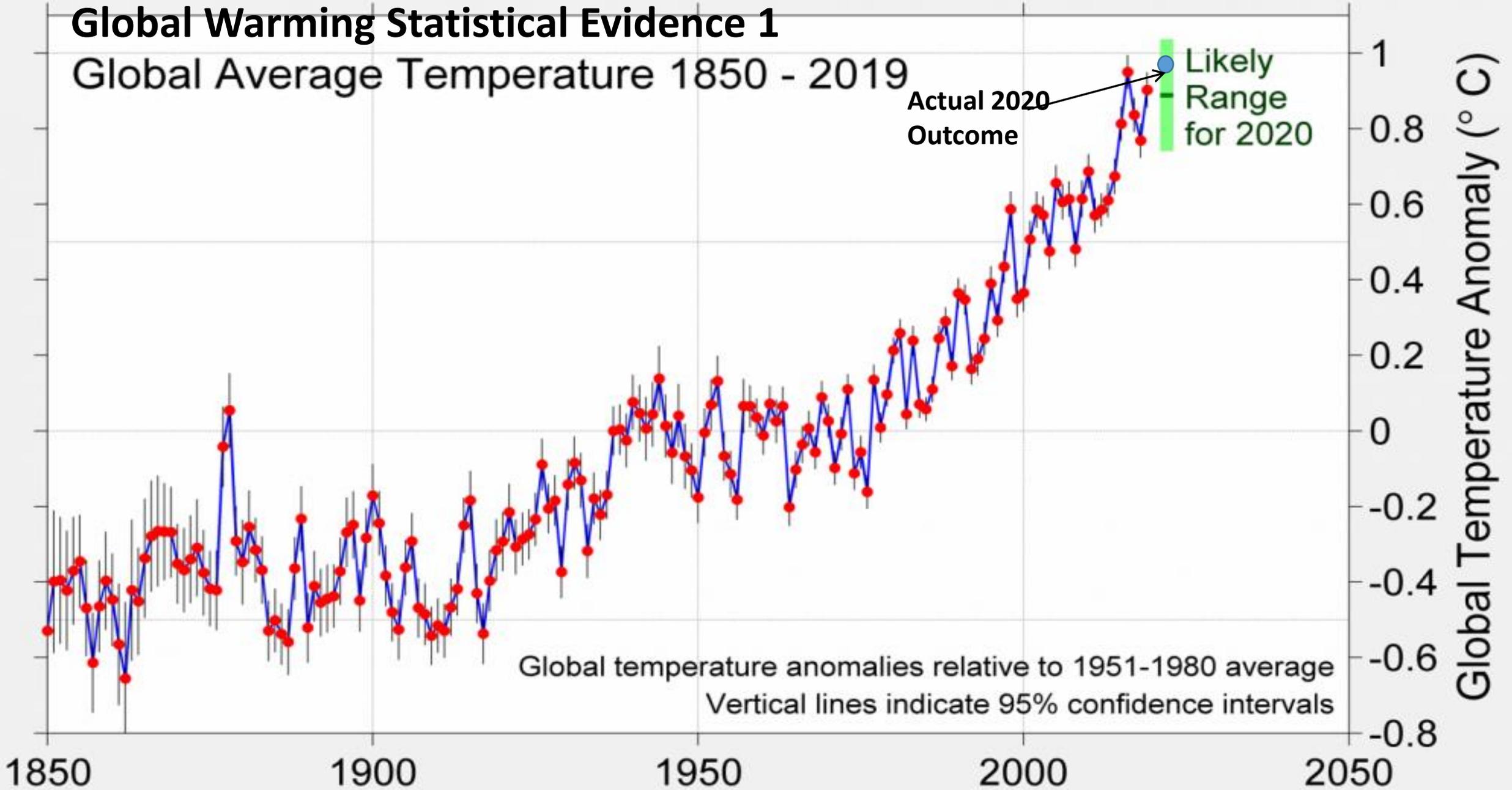
# Climate Change and Economics of Addressing It

# The Context

- Climate change, or global warming, can be described as steady warming of earth's average temperature.
- Many believe human/industrial/economic activities are contributing factors, through following processes.
  - # CO2 and other greenhouse gas emissions from human activity increase stock of CO2 and other emissions in atmosphere (the CO2 stock reached a new record last year)
  - # Which in turns creates a greenhouse effect
  - # Which in turn raises average earth temperature
- This group also generally believes that global warming is creating / will create severe problems, and that immediate steps need to be taken to address it.
- On the other hand, others believe some combination of: global warming is part of cycles of warming and cooling the earth naturally goes through, the impacts will not be that severe, and the costs of steps to stop it outweigh the benefits of doing so.

# Global Warming Statistical Evidence 1

## Global Average Temperature 1850 - 2019

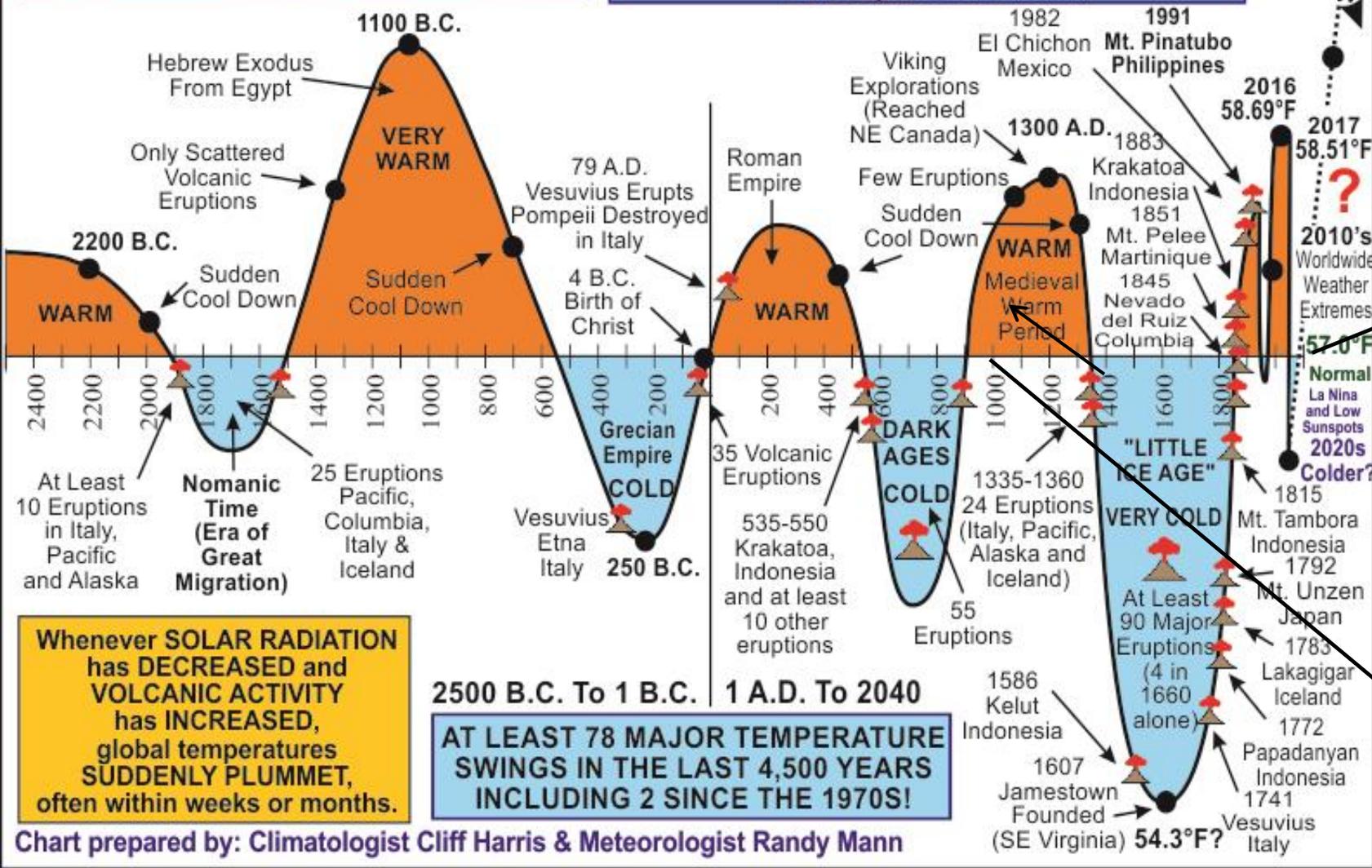


# Global Warming Statistical Evidence 2

## GLOBAL TEMPERATURES (2500 B.C. TO 2040 A.D.)

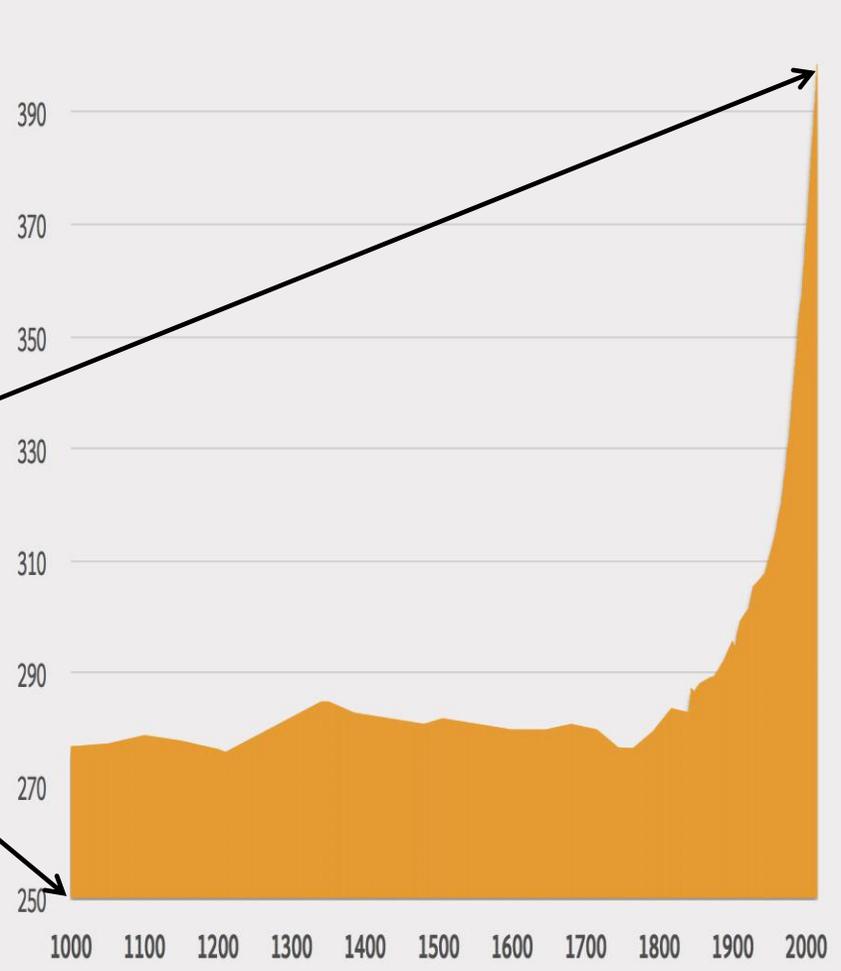
**MAJOR GLOBAL COOLING FROM 2007 TO 2009**  
A 0.9 Degree Fahrenheit drop in global temperatures occurred from October 2007 to February 2009.

**MOUNT PINATUBO ERUPTION (Philippines)**  
1.1 Degree F. Rapid Cool Down (June 1991 to March 1992)  
Global Temperature Went From 0.6 Degrees Above Normal To 0.5 Degrees Below Normal.



## Atmospheric CO2 Concentration (1000-2014)

Concentration (Parts Per Million by Volume)



# Current Tangible Impacts / Other Indicators of Global Warming

Warming Ocean

Shrinking Ice Sheets

Glacial Retreat

Decreased Snow Cover

Sea Level Rise

Declining Arctic Sea Ice

More Extreme Weather Events

Ocean Acidification

Changed Bird Migration Patterns

Earlier Blooming Plants

Later Fall Colors

# Differential Impacts of Global Warming

- Before moving into the causes and economics of global warming, it is worth noting global warming has differential impacts across the planet.
- In general the greatest negative impacts occur:
  - Where it is already hot (Australia)
  - In coastal areas; this puts low island nations / areas especially at risk (Kirabati / Key West)
  - In poorer countries that do not have resources to deal with the impacts (Haiti)
- Areas that are cooler might actually benefit as the higher temperatures lower heating costs and make agriculture more possible (Canada, Russia, Scandanavia)

# Country “Causers” of Global Warming 1, at least of CO2 Emissions

Total Emissions (billion tons of CO2 per year)

China 9.8  
United States 5.0  
Europe 4.1  
India 2.5  
Russia 1.5  
Japan 1.1

Emissions Per Capita (tons of CO2 per person per year)

United States 15  
Russia 11  
Japan 9  
Europe 8  
China 7  
India 2

Emissions Per Dollar of GDP (tons of CO2 per \$million of GDP)

India 919  
Russia 902  
China 682  
United States 232  
Japan 220  
Europe 179

# Fossil CO<sub>2</sub> Emissions and 2018 Projections

16 Gt  
CO<sub>2</sub>

Projected global emissions growth: +2.0% (+1.1% to +3.4%)  
Updated: 5 March 2019

## Country "Causers" of Global Warming / CO<sub>2</sub> Emissions 2

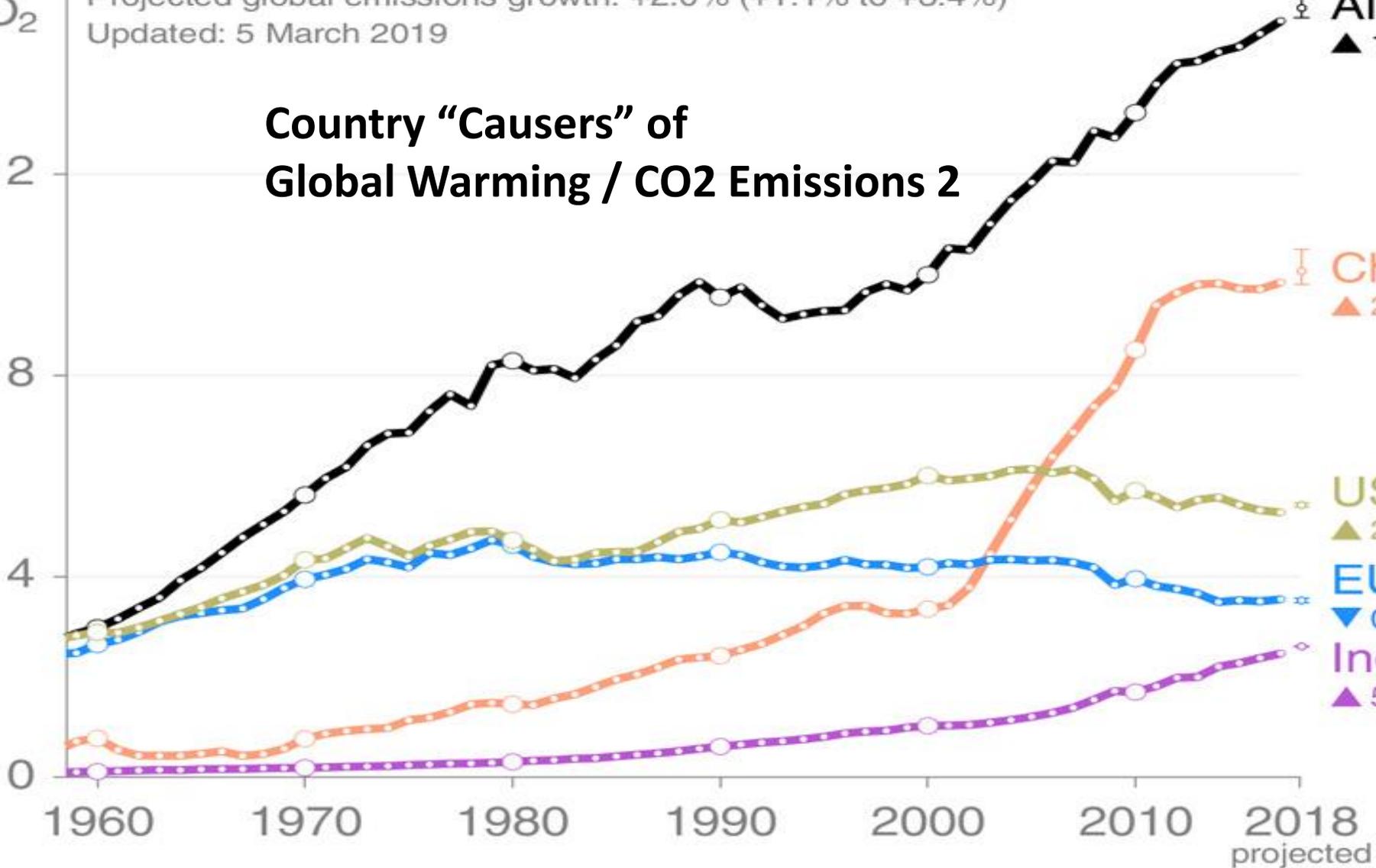
Projected Gt CO<sub>2</sub> in 2018  
**All others 15.3**  
▲ 1.7% (+0.4% to +3.0%)

**China 10.1**  
▲ 2.3% (-0.4% to +6.7%)

**USA 5.4**  
▲ 2.8% (+2.1% to +3.5%)

**EU28 3.5**  
▼ 0.7% (-2.0% to +0.6%)

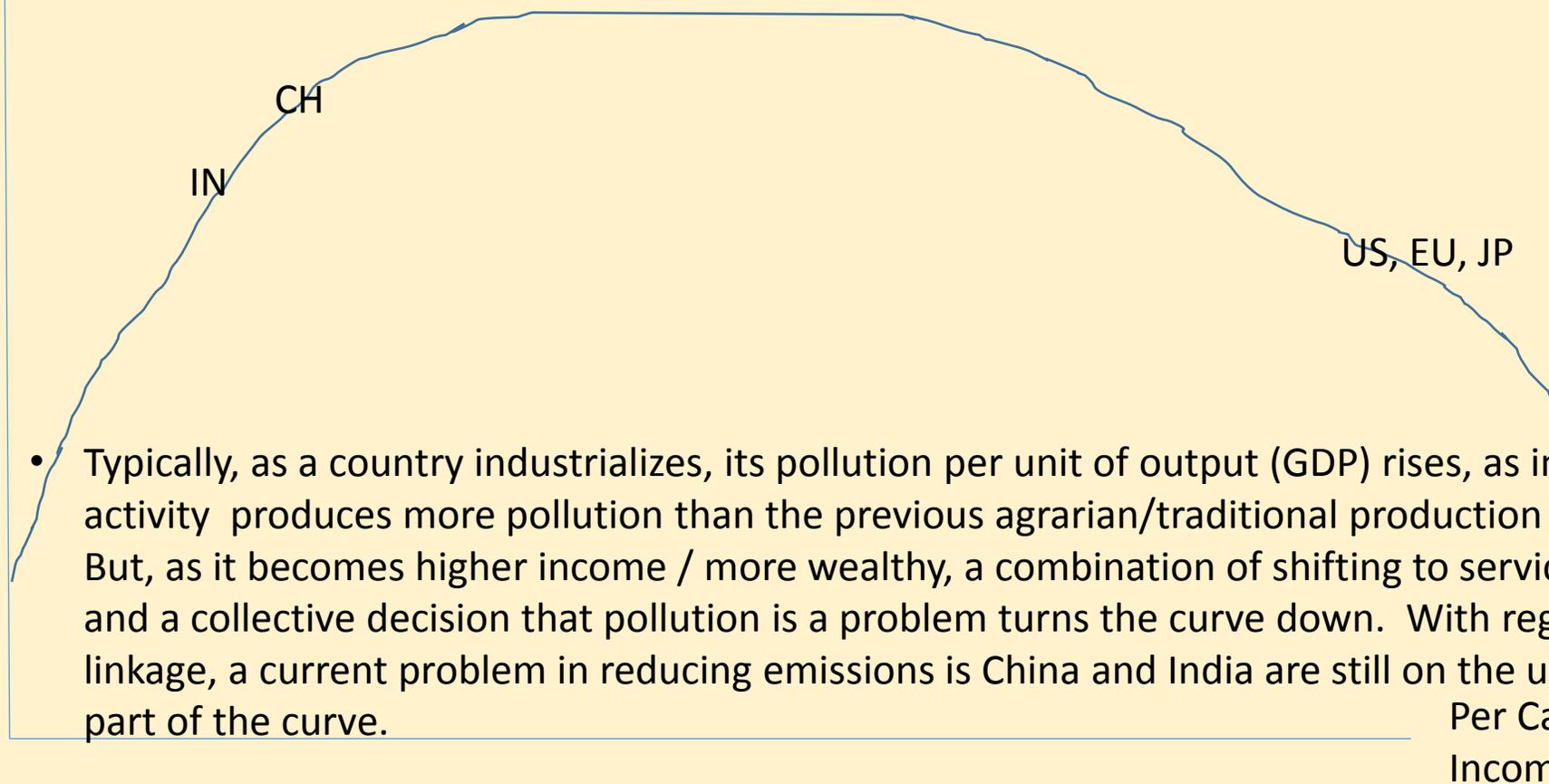
**India 2.6**  
▲ 5.7% (+5.4% to +6.1%)



© Global Carbon Project • Data: CDIAC/GCP/UNFCCC/BP/USGS

Pollution  
Per \$GDP

## Pollution:GDP Curve\*



- Typically, as a country industrializes, its pollution per unit of output (GDP) rises, as industrial activity produces more pollution than the previous agrarian/traditional production activities. But, as it becomes higher income / more wealthy, a combination of shifting to service activities and a collective decision that pollution is a problem turns the curve down. With regard to this linkage, a current problem in reducing emissions is China and India are still on the upward sloping part of the curve.

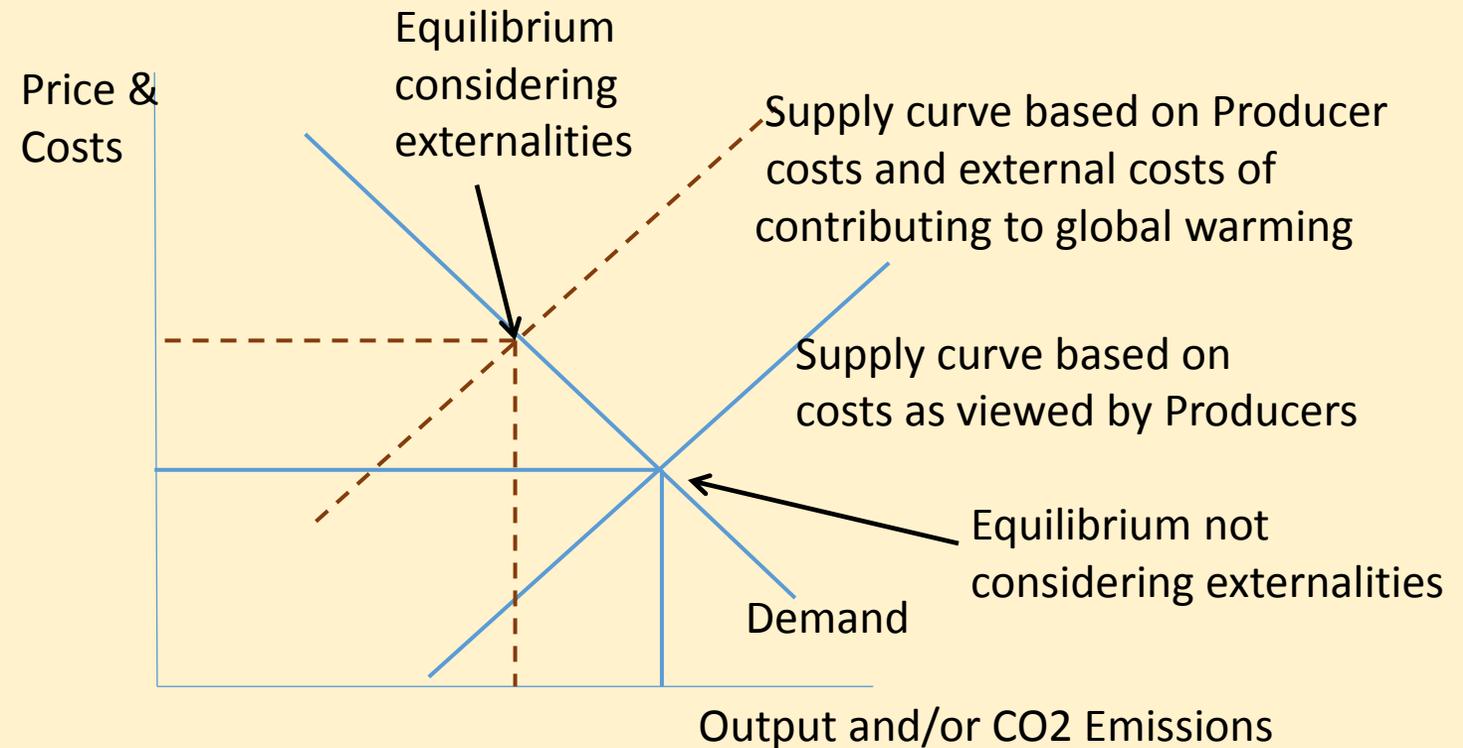
# An Economic Theory Digression: If CO2 Emissions Are “Bad”, Why Do They Happen..... The Economic Theory of Externalities

- Economic principles which explain the human causes of global warming are called economics of externalities, where an externality is a by-product of a production process that has an impact on third parties, in global warming case a negative one, that producer does not incorporate in its costs.

Some specific examples include:

- Pollution into Cleveland’s river
- Downwind impacts of PA steel mills
- Auto exhaust pollution in congested areas

In the graph at right, the solid blue curves shows the market equilibrium where Producers do not consider the external impacts of their production; it results in production levels that are higher than they should be if these external costs were considered.



# The Conceptual Steps To Deal With Warming

- Experts have placed actions to deal with global warming in 3 conceptual categories.
- First category is **Mitigation**, essentially taking steps to stop / reduce amount of CO<sub>2</sub> and other emissions at their source, which in turn will reduce / reverse growth in stock of CO<sub>2</sub> in atmosphere, and in turn reduce/reverse temperature rise and in turn prevent consequences. Mitigation involves either reducing CO<sub>2</sub>/ emissions creating activities, or reducing amount of CO<sub>2</sub>/emissions they create. Mandating low energy use light bulbs, carbon taxes, and pollution markets are examples. *This approach most places costs of dealing with global warming on users and producers of products which create it.*
- A second category might be called **Capture**, essentially accepting that CO<sub>2</sub> and other emissions are going to occur, but developing/applying technologies that stop their global warming effects. Some actions are complicated, such as “Carbon capture”, “atmosphere seeding”; other actions are simpler, such as “tree planting”, and “preservation of forests”. Iceland evidently has a fairly large carbon capture pilot project up and running. *This approach probably places more costs of dealing with global warming on governments / taxpayers to fund the research and policies to develop and implement the actions*

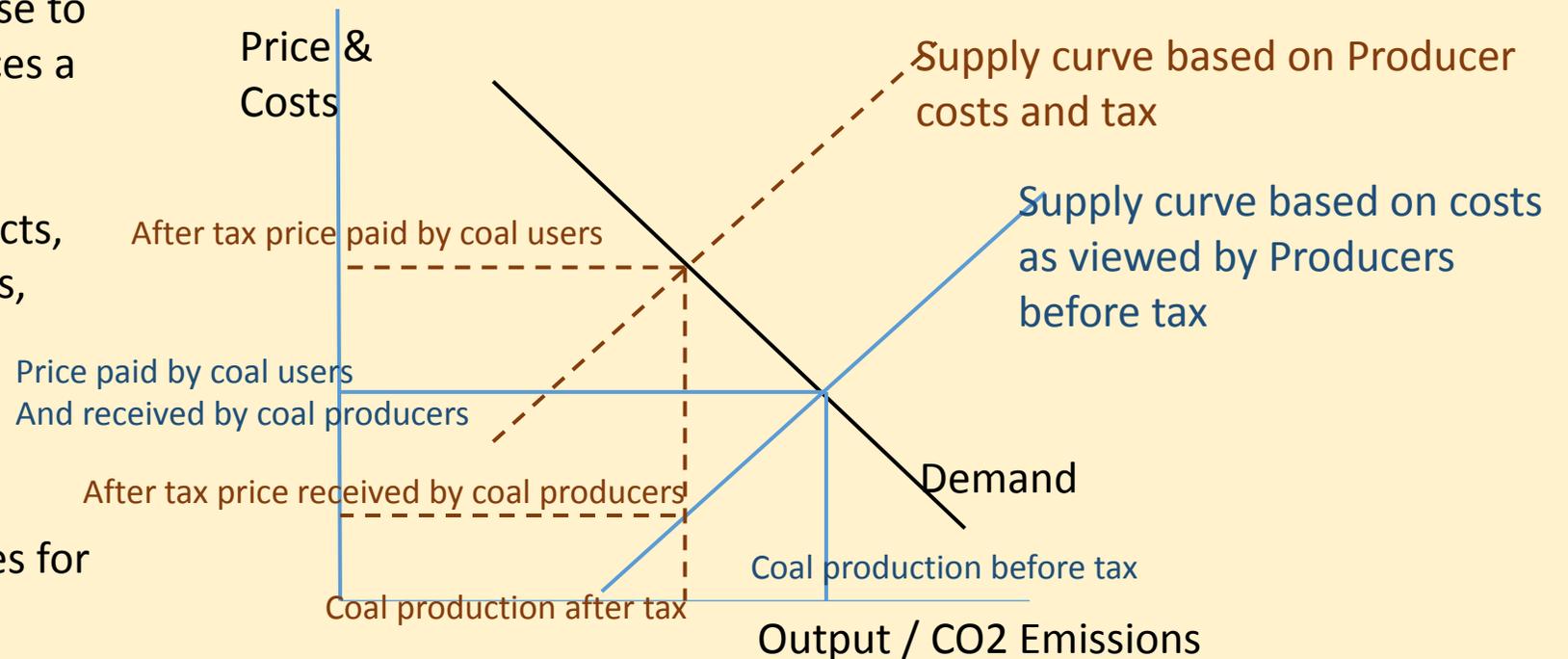
# Steps to Deal with Warming

- A third category is called **Adaptation**, essentially accepting that earth may continue to warm and produce undesirable consequences, and taking/planning steps to adapt to consequences. An extreme example is island nation of Kiribati negotiating with Australia to take its entire population if necessary. Another example is changed coastal building codes. *This approach most places costs of dealing with global warming on the third parties affected by it; for example, coastal locations having to build bigger seawalls*
- As a quick summary of above choices.....doing something about global warming has unavoidable costs. One of the considerations is who bears the costs. If Mitigation is used, the producers and users of CO2 emissions (petrochemical industry) likely bear more of the costs (next slide summarizes the economics of this); if Capture is used, governments and taxpayers likely bear more of the costs; if Adaptation is used, third parties adversely affected (coastal areas) likely bear more of costs (slide after next illustrates the economics of these).
- And, there is the alternative of taking **No Action**, if one believes that global warming is a purely natural cyclical phenomena that is not driven by human activity that will at some point reverse itself, or that the effects are not serious enough to react to, or that the actions will not have enough of desired effect on warming

# Graphical Analysis Of The Impacts Of Dealing With Global Warming Through Mitigation Actions

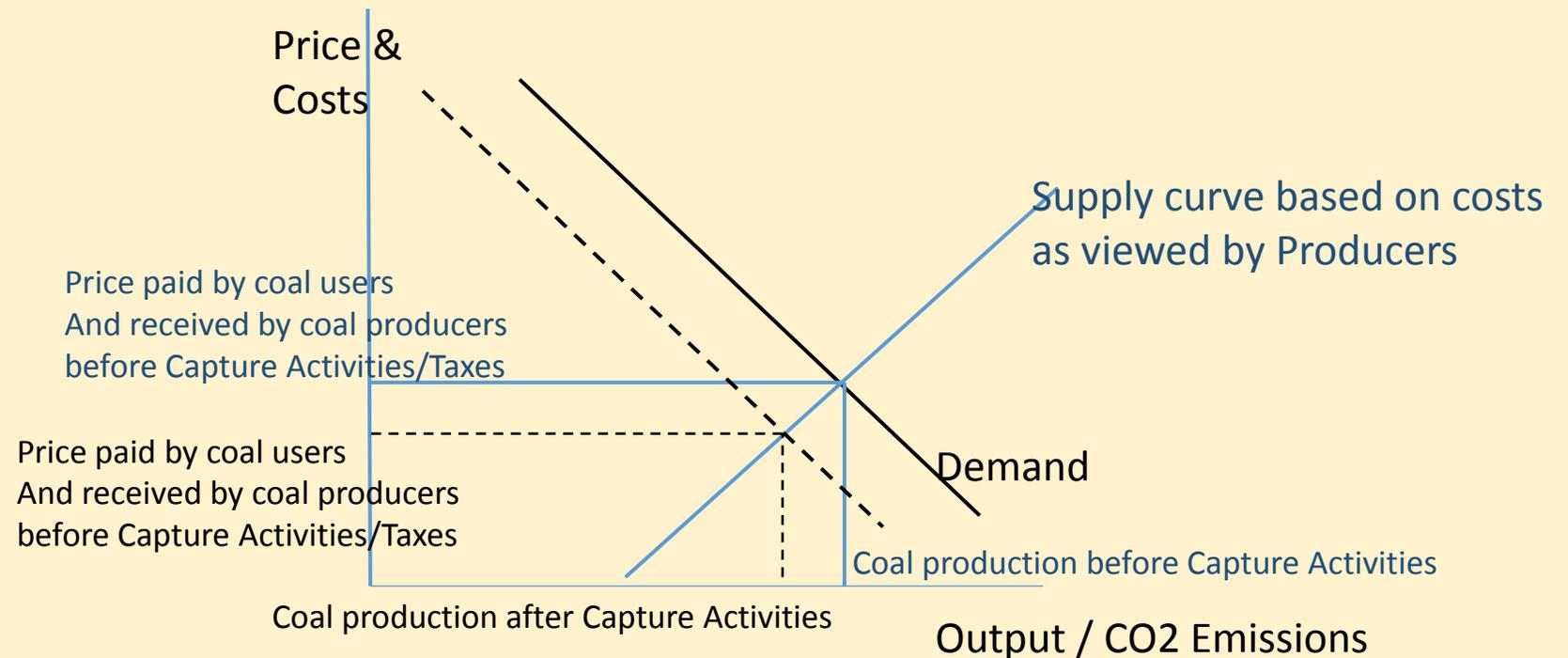
As an example, suppose this is a graph of the coal-producing/using sector. From solid blue supply line, the government places a tax on every ton of coal produced....a mitigation action. This tax would cause the cost of supplying coal to rise to the dashed orange supply line. This produces a new equilibrium that results in:

- # higher user prices for coal and coal products,
- # lower prices and profits for coal producers,
- # lower coal production,
- # lower employment in coal sector
- # coal tax revenues for government
- # lower CO2 emissions.
- # competitive advantages for any substitutes for coal that are not also taxed.



# Graphical Analysis Of The Impacts Of Dealing With Global Warming Through Capture Actions

As an example, suppose this is a graph of the coal-producing/using sector. In the case of Capture Actions, the Coal Industry Supply Curve is not affected, but the Demand curve is by the higher taxes placed somewhere in the economy to fund the Capture Actions. As a result of the fall in Demand, Coal Industry will have some negative effects....lower price....lower output....lower employment....lower profits, but likely of smaller magnitude than mitigation. The graph of Adaptation looks much like this graph, as Adaptation and perhaps taxes to help out have no direct impact on Coal Industry, but does lower demand.



# A Digression on 2 Definitions

- Zero Emissions. At global, country, sector, or company, level, an elimination of initial emissions; a Mitigation only approach; likely will never be reached
- Net Zero Emissions. At global, country, sector, or company, level, a creation of enough actions to offset any initial emissions created; a combination of Mitigation and Capture approaches; this is what Amazon and Saudi Arabia have announced they are doing.

# US Actions to Address Global Warming

- **Clean Air Act 1963** – A federal law aiming to control air pollution on a national level. It requires the EPA to put in place regulations to protect the general public from exposure to harmful airborne contaminants. The “endangerment finding” of 2009 means the EPA is required to regulate substances according to their greenhouse effect.
- **Energy Policy Act 2005** – Provided \$4.3 billion tax breaks for nuclear power, \$2.7 billion to extend the renewable electricity production credit, and \$1.6 billion in tax incentives for investment in clean coal facilities. Loan guarantees were granted for innovative technologies such as advanced nuclear reactors and clean coal. The Bill also provided subsidies to wind energy, promoted the competitiveness of geothermal energy in relation to fossil fuels, and allocated \$50 million annually to a biomass grant programme.
- **Energy Independence and Security Act 2007** – Introduces measures to expand the production of renewable fuels, reduce US dependence on oil and increase energy security. It sets a mandatory Renewable Fuel Standard (RFS) requiring fuel producers to use at least 36 billion gallons of biofuel by 2022, and provides incentives for the development of renewable energy technologies. The act also includes provisions on lighting: phasing out the use of incandescent light bulbs by 2014 and improving lighting efficiency by more than 70% by 2020.
- **Executive Order 13423 2007** – Demands federal agencies to conduct their transportation and energy-related activities in an environmentally, economically and financially sound and integrated way.
- **Food, Conservation, and Energy Act of 2008** – Expands the Biorefinery Assistance Programme by providing loan guarantees of \$320 million for the creation of commercial-scale biorefineries as well as grants to build demonstration-scale biorefineries.
- The **2014 revision** reauthorises and provides \$880 million for energy programmes established in the 2008 Bill. The Biorefinery Assistance Programme is further expanded to include bio-based product and renewable chemical manufacturing, and expands the Bio-preferred programme to include forestry products.

# US Actions to Address Global Warming

- **American Recovery and Reinvestment Act 2009** – The Bill authorises a stimulus package that supports new and existing renewable energy and energy efficiency programmes through allocation of \$16.8 billion. In addition, the limitation on the issuance of new clean renewable energy bonds was increased by \$1.6 billion.
- **Executive Order 13514 2009** – Prioritises GHG emission management for federal agencies by establishing reporting requirements with detailed targets and deadlines. The Order focuses on transportation, overall energy use and procurement policies. All federal agencies are required to develop, implement and annually update a Strategic Sustainability Performance Plan.
- **Duncan Hunter National Defence Authorisation Act for Fiscal Year 2009** – Authorises defence spending for fiscal year 2009 and includes several provisions aimed at energy efficiency, renewable energy and use of alternative sources of energy within the armed forces. The Act also allocates \$55 million to support renewable biomass use in biorefineries instead of fossil fuels, as well as creating the Rural Energy for America Programme (REAP). Worth \$285 million, this promotes the use of hydroelectric source technologies.
- **Executive Order 13653 2013** – This E.O.'s goal is to improve the nation's preparedness and resilience for the impacts of climate change. Agencies are required to take a series of steps to make it easier for American communities to strengthen their resilience to climate change. These include strong partnerships and information sharing at all levels of government, and risk-informed decision-making. Adaptive learning is also key, where experiences serve as opportunities to inform and adjust future actions, as well as preparedness planning.
- **Executive Order 13693 2013** – Planning for federal sustainability in the next decade. This sets a new target for the federal government's GHG emissions to be reduced by 40%, and the share of renewable electricity consumed by the federal agencies to increase to 30% by 2025 (compared to 2008). This is to be achieved through a broad range of measures that aim to make the federal government's operations more sustainable, efficient and energy-secure.

# US Actions to Address Global Warming

- **Clean Power Plan 2015** – Developed under the **1963 Clean Air Act**, the plan establishes state targets for carbon emissions reductions, and offers a flexible framework under which states may achieve those targets. Options for cutting emissions include investing in renewable energy, energy efficiency, natural gas, and nuclear power, and shifting away from coal-fired power. The Plan also aims to limit shift to natural gas and promote renewables in its place.
- **Electrify Africa Act 2016** – Legislates the US initiative and goal to provide access to power for at least 50 million people in sub-Saharan Africa by 2020, and to enable the installation of an additional 20,000 megawatts of electricity capacity by 2020.
- **Methane and Waste Prevention Regulation 2016** – Aims to reduce natural gas wasted by venting, flaring, and leaks during oil and natural gas production activities on onshore Federal and Indian lands. The regulations also intend to clarify when produced natural gas lost through such activities is subject to royalties. The objective of the measures is to “help curb waste of natural gas supplies; reduce harmful air pollution, including greenhouse gases; and provide a fair return on public resources for federal taxpayers, Tribes, and States”.
- **Consolidated Appropriations Act 2016** – Renews tax credit programs for wind and solar electricity generation and incorporates a phase-out schedule for these support programs, providing partial stability for the renewable energy market.

# International Actions to Address Global Warming

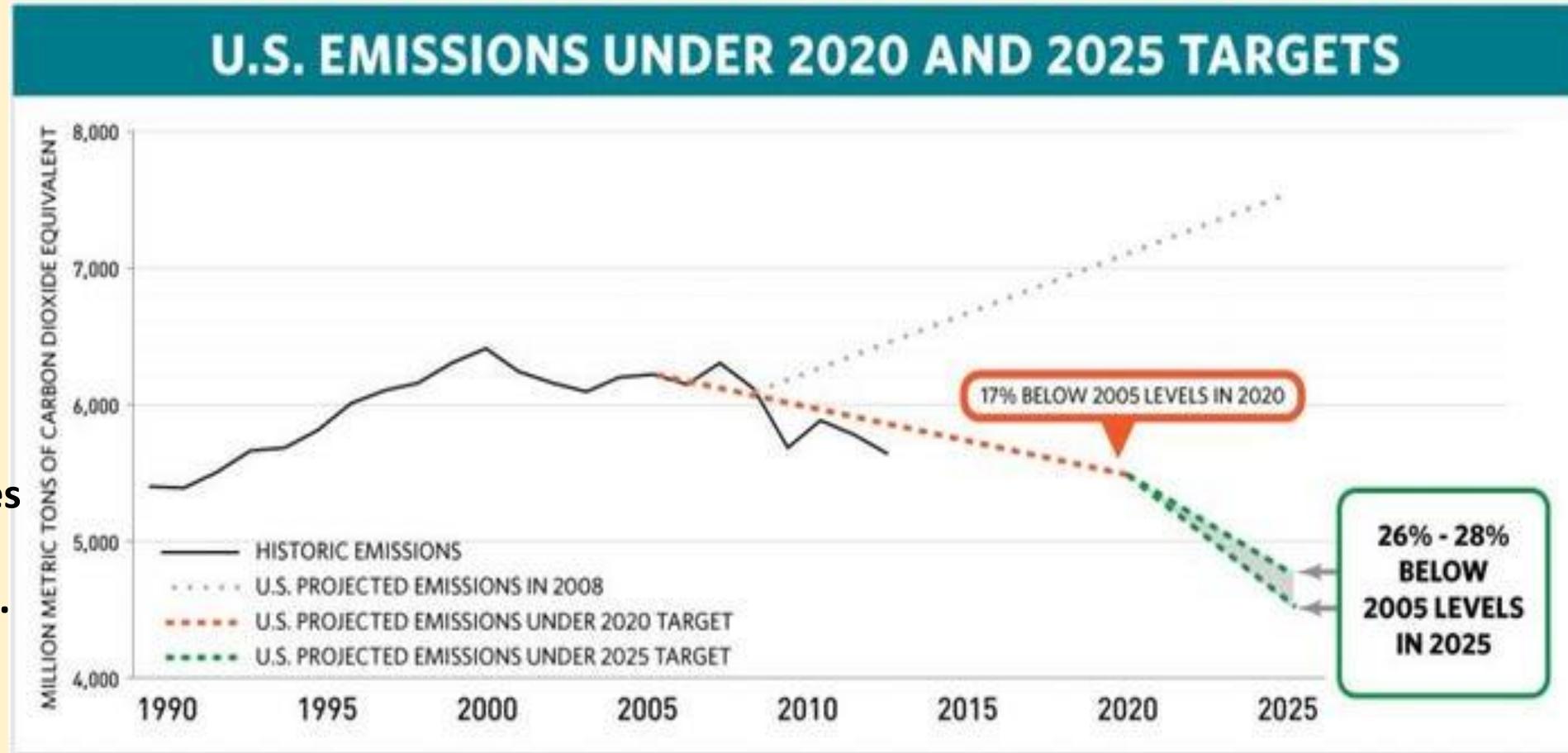
- Nearly all countries in the world are parties to the **1994 [United Nations Framework Convention on Climate Change](#)** (UNFCCC). The objective of the UNFCCC is to prevent dangerous human interference with the climate system. As stated in the convention, this requires that greenhouse gas concentrations are stabilized in the atmosphere at a level where [ecosystems](#) can adapt naturally to climate change, food production is not threatened, and [economic development](#) can be sustained. Global emissions have risen since signing of the UNFCCC, which does not actually restrict emissions but rather provides a framework for protocols that do.<sup>[73]</sup> [Its yearly conferences](#) are the stage of global negotiations.
- The **1997 [Kyoto Protocol](#)** extended the UNFCCC and included legally binding commitments for most developed countries to limit their emissions.<sup>1</sup> During Kyoto Protocol negotiations, the [G77](#) (representing [developing countries](#)) pushed for a mandate requiring [developed countries](#) to "[take] the lead" in reducing their emissions,<sup>[274]</sup> since developed countries contributed most to the [accumulation of greenhouse gases](#) in the atmosphere, and since [per-capita emissions](#) were still relatively low in developing countries and emissions of developing countries would grow to meet their development needs.
- The **2009 [Copenhagen Accord](#)** has been widely portrayed as disappointing because of its low goals, and was rejected by poorer nations including the G77. Associated parties aimed to limit the increase in global mean temperature to below 2.0 °C (3.6 °F). The Accord set the goal of sending \$100 billion per year to developing countries in assistance for mitigation and adaptation by 2020, and proposed the founding of the [Green Climate Fund](#). As of 2020, the fund has failed to reach its expected target, and risks a shrinkage in its funding.

# International Actions to Address Global Warming

- **In 2015 all UN countries negotiated the [Paris Agreement](#)**, which aims to keep global warming well below 1.5 °C (2.7 °F) and contains an aspirational goal of keeping warming under 1.5 °C. The agreement replaced the Kyoto Protocol. Unlike Kyoto, no binding emission targets were set in the Paris Agreement. Instead, the procedure of regularly setting [ever more ambitious goals](#) and reevaluating these goals every five years has been made binding. The Paris Agreement reiterated that developing countries must be financially supported. As of December 2020, 193 states and the [European Union](#) have signed the treaty and 188 states and the EU have [ratified](#) or acceded to the agreement. This is the agreement President Trump took the US out of and President Biden put US back in.
- **The 1987 [Montreal Protocol](#)**, an international agreement to stop emitting ozone-depleting gases, may have been more effective at curbing greenhouse gas emissions than the Kyoto Protocol specifically designed to do so. The 2016 [Kigali Amendment](#) to the Montreal Protocol aims to reduce the emissions of [hydrofluorocarbons](#), a group of powerful greenhouse gases which served as a replacement for banned ozone-depleting gases. This strengthened the makes the Montreal Protocol a stronger agreement against climate change.

# What Has US Committed To By Rejoining Paris Accord

1. Most significantly, to reduce emissions to well below 2005 levels, as shown in graph. How it does this is up to US, but, by definition, the steps will be mitigation actions, such as taxes on emitting activities, mandates on emitting activities, subsidies to non-emitting activities, setting up emission market.



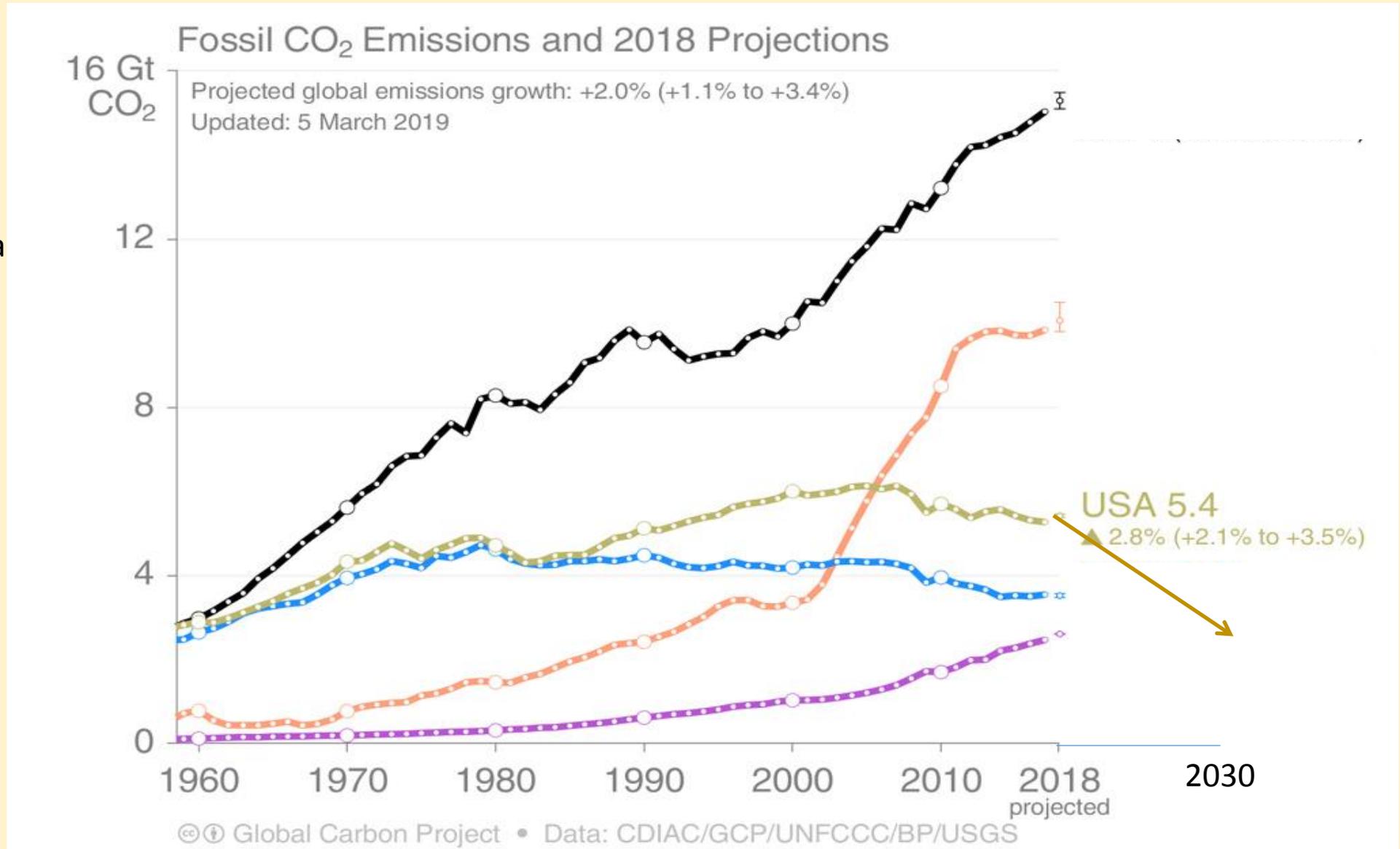
2. The US also has committed by the terms of the accord to provide financing to international efforts in the areas of Capture and Adaptation. While difficult to nail down an exact amount, it appears the amount of US funding committed to is be around \$3-4 Billion, mainly to the International Green Climate Fund.

# Climate Summit

Last April, some 40 world leaders participated in a US-initiated virtual climate summit.

Participants committed reaching reductions in emissions, including by China and Russia.

The US committed to reducing its CO<sub>2</sub> emissions to 50% below 2005 levels by 2030. This is a very ambitious goal for the US, as shown in chart, requiring about a 5% a year decline in emissions, or about an 8% a year decline in Per Dollar of GDP emissions, assuming 3% growth.



# Impacts of US Rejoining Paris Accord and Climate Summit Commitments

- Government taxes/mandates will be placed on CO2 emitting production and consumption.
- Government subsidies will be given to non-emitting production and consumption.
- Government spending will rise on research/investment in Capture technologies.
  
- Declines / Slower growth will occur in carbon based production and consumption sectors/activities.
- Faster growth will occur in non-carbon-based production and consumption sectors/activities.
- US carbon-based sectors could be disadvantaged vis a viz rest of world, but the multi-country commitments of the summit mitigates that risk.
- US non-carbon-based sectors could be advantaged vis a viz rest of world.
- *In my view, net overall impact on GDP growth is not clear, could be just as likely positive as negative*

# The Just Completed Scotland Climate Summit

- On November 12, there is to be an international climate change summit in Glasgow, Scotland.
- My plans are to fill in this slide once some results become known.

# Some Wrap Up Comments

- To me, it is not relevant whether it has been hotter in the past, and whether or not today's warming period is man-made; if one believes today's warming period is producing undesirable effects, action should be taken; even though floods are not man-made, we build levees and dams and place restrictions on building to reduce their impacts; and, in a reaction to negative effects of the ozone hole, various mandates related to CFC use were implemented and the hole is closing
- It is relevant to consider the Costs of addressing global warming along with the Benefits, and to as much as possible empirically compare those Cost and Benefits across alternative actions
  - Doing this is difficult. Estimating costs, which are near term and tangible are hard enough, but estimating benefits, which are long term and often intangible are even harder(how does one value saving plant and animal species and glaciers), as is how making things better 100 years from now is valued today
  - But it should be noted that this process occurs all the time in business world, in that a business incurs certain near-term costs, the costs of an investment, for uncertain long term gains, the returns from investment

# Some Wrap Up Comments

- If one believes today's warming period is man-made, Mitigation and Capture would seem logical approaches
- If one believes today's warming period is natural, and is producing undesirable effects, Adaptation would seem the more logical action
- If one believes today's warming period is natural, but will reverse "in time", or is too powerful to be controlled by man-made counteractions, or is producing effects that are not overly undesirable, then No Action would seem logical

# Internet Readings

- [https://en.wikipedia.org/wiki/Global\\_warming](https://en.wikipedia.org/wiki/Global_warming)
- [http://ec.europa.eu/clima/policies/international/negotiations/future/index\\_en.htm](http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm)
- <http://www.bbc.com/news/science-environment-40120770>
- <https://www.eea.europa.eu/themes/climate/policy-context>
- <https://climate.nasa.gov/>
- <https://www.scientificamerican.com/article/geoengineering-solutions/>
- <https://www.investopedia.com/terms/c/cost-benefitanalysis.asp>
- <https://www.businessinsider.com/what-did-us-agree-to-paris-climate-deal-2017-5>
- <https://www.msn.com/en-us/money/markets/biden-wants-to-slash-emissions-success-would-mean-a-very-different-america/ar-BB1fWsfX?ocid=UP97DHP&li=BBnb7Kz>