NATIONAL ECONOMIC EDUCATION DELEGATION

Climate Change Economics

Sarah Jacobson, Ph.D.
Williams College

Bainbridge Island Oatmeal Club

August 31, 2023

1

Credits and Disclaimer

- **This slide deck was authored by:**
  - Shana McDermott, Trinity University
  - Sarah Jacobson, Williams College
  - Sharon Shewmake, Western Washington University
- **This slide deck was reviewed by:**
  - Jason Shogren, University of Wyoming
  - Walter Thurman, North Carolina State University
- **Disclaimer**
  - NEED presentations are designed to be nonpartisan.
  - It is, however, inevitable that the presenter will be asked for and will provide their own views.
  - Such views are those of the presenter and not necessarily those of the National Economic Education Delegation (NEED).

2

Outline

- Economic Building Blocks
- Climate Change
- Impacts of Climate Change
- Reducing Emissions
- Climate Change Policy
- Policy in Action

NATIONAL ECONOMIC EDUCATION DELEGATION

3

Economic Building Blocks

NATIONAL ECONOMIC EDUCATION DELEGATION

4

How Can Economists Help Fight Climate Change?

- By measuring climate change damages and estimating the costs of fighting climate change.
- By assessing behavioral reactions to climate change.
- By designing smart policies that minimize costs to society.

5

Econ 101: When Everything Is Simple, No Regulation Is Needed for Efficiency

- Simple transactions: buyer and seller feel all costs and benefits of sales
- They choose based on the costs & benefits they feel
- → Efficient number of transactions! (Maximizes social benefits)

6

When Our Decisions Affect Others, We Need Regulation

- **Pollution causes an EXTERNALITY: a side effect (here, a cost) that affects someone else**
  - Polluting things have an "unfair cost advantage" because part of cost is offloaded on others
  - → Too much pollution is generated
  - Regulation limiting pollution has net benefits
- ***The "efficient" amount of pollution balances costs & benefits of pollution***

NATIONAL ECONOMIC EDUCATION DELEGATION

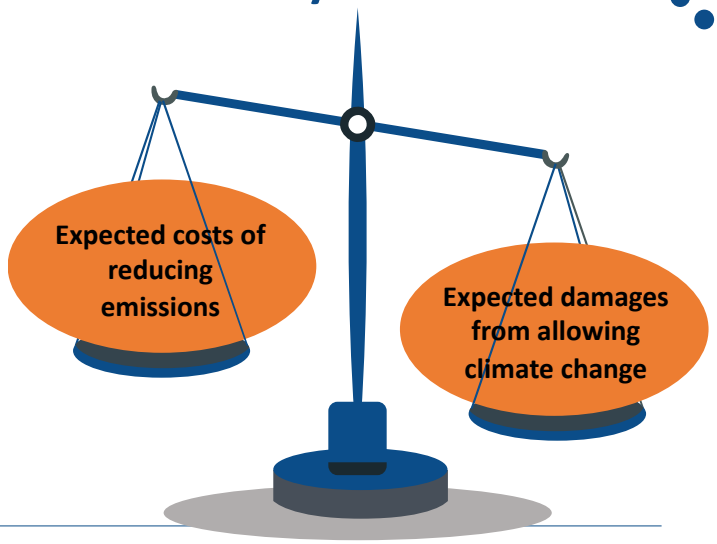
7

How Economists Decide How Much to Fight Climate Change: Cost Benefit Analysis

Abating greenhouse gas emissions is costly…

… but without action, climate change damages are even more costly.

Goal is not zero emissions, but efficient level that achieves a balance.



NATIONAL ECONOMIC EDUCATION DELEGATION

8

Cost-Benefit Analysis of Fighting Climate Change

- **Most economic models suggest the costs of keeping warming below 2°C are relatively small, amounting to 1-4% of GDP by 2030.**
- **Costs of acting to keep warming below 2°C are almost certainly less than future economic damages they would avoid.**
  - Damages estimated to be between: **7-20% of worldwide GDP.**

NATIONAL ECONOMIC EDUCATION DELEGATION

9

Climate Change

NATIONAL ECONOMIC EDUCATION DELEGATION

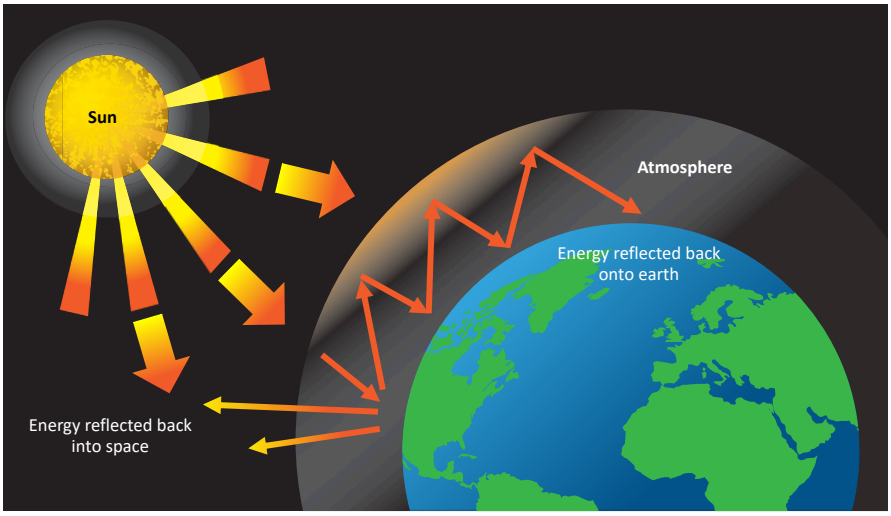
10

A Climate Change Ladder

- Emissions
- Mitigation (a.k.a. Abatement)
- Adaptation
- Damages

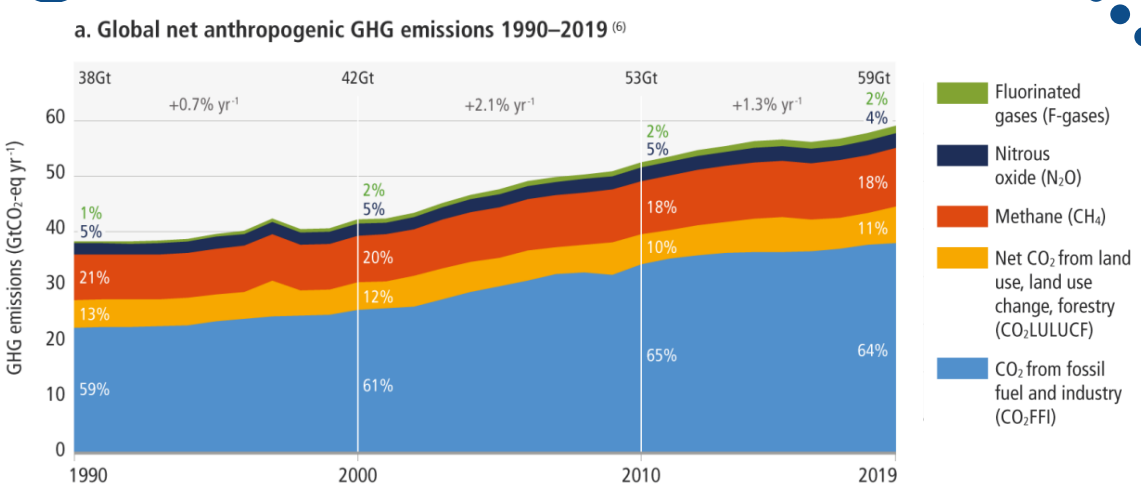
11

The Atmospheric Greenhouse Effect



12

Greenhouse Gas Emissions 1990-2019

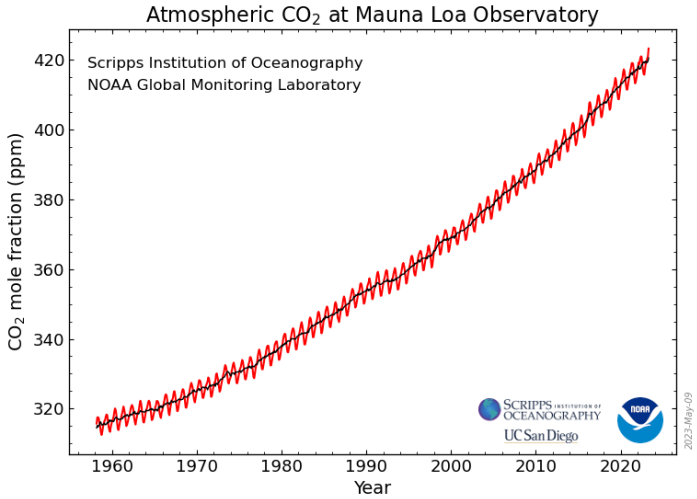


NATIONAL ECONOMIC EDUCATION DELEGATION

Source: IPCC

13

Atmospheric CO_2 Concentrations Up To Now

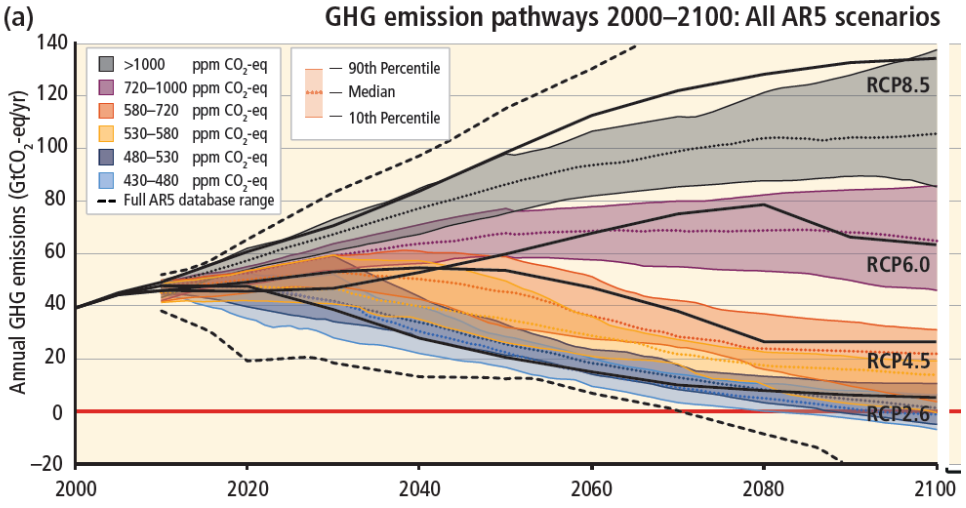


NATIONAL ECONOMIC EDUCATION DELEGATION

Source: NOAA

14

Emissions Trajectories into the Future



NATIONAL ECONOMIC EDUCATION DELEGATION

Source: IPCC Assessment Report 5

15

What Do Greenhouse Gas Emissions Do to the Planet?

- **Increased temperatures**
  - Sea level rise
  - Storm surges
- **Altered precipitation patterns**
- **More variable weather**
- **More / more powerful storms**
- **Carbon dissolves in ocean**

NATIONAL ECONOMIC EDUCATION DELEGATION

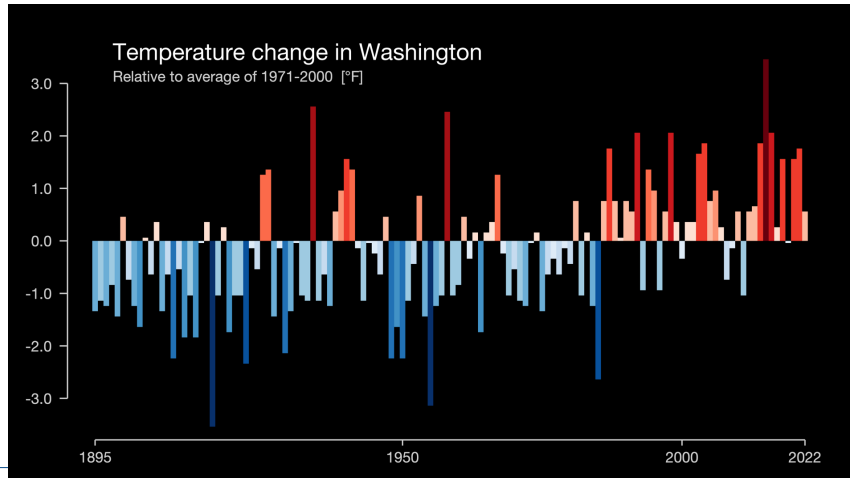
16

16

These Changes Are Already Underway

Use https://showyourstripes.info/ to see the temperature history of an area!

Here's WA!



NATIONAL ECONOMIC EDUCATION DELEGATION

17

Impacts of Climate Change

NATIONAL ECONOMIC EDUCATION DELEGATION

18

How Climate Change Affects Humans

- Agriculture
- Fisheries
- Coastal damages
- Direct health effects, including sickness and death (temperature & drought; also pollution)
- Indirect health effects (vector-borne disease)
- Reduced fresh water availability
- Wildfires
- Shifting zones for important ecosystems, and desertification
- Reduced worker productivity
- Increased violence
- Some of these may cause human migration and/or conflict

NATIONAL ECONOMIC EDUCATION DELEGATION

19

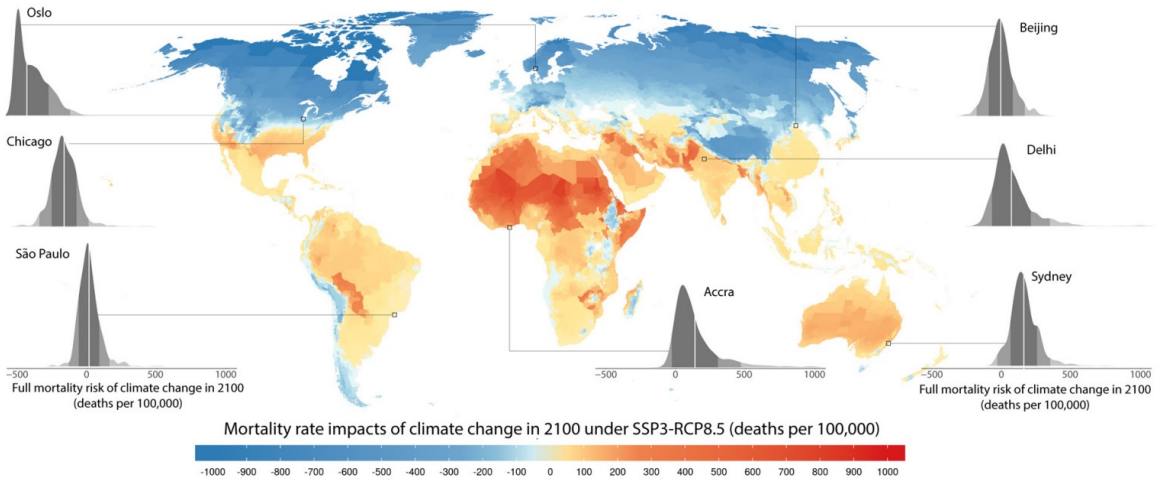
Social Cost of Carbon

- The expected cost of damages from each unit of greenhouse gas emissions.
- Current EPA estimate: ~$51 per metric ton of CO_2
  - About $157/car per year for an avg driver.
- But in 2022 they put forward a proposal to raise it to $190!
- Cost will increase over time.

NATIONAL ECONOMIC EDUCATION DELEGATION

20

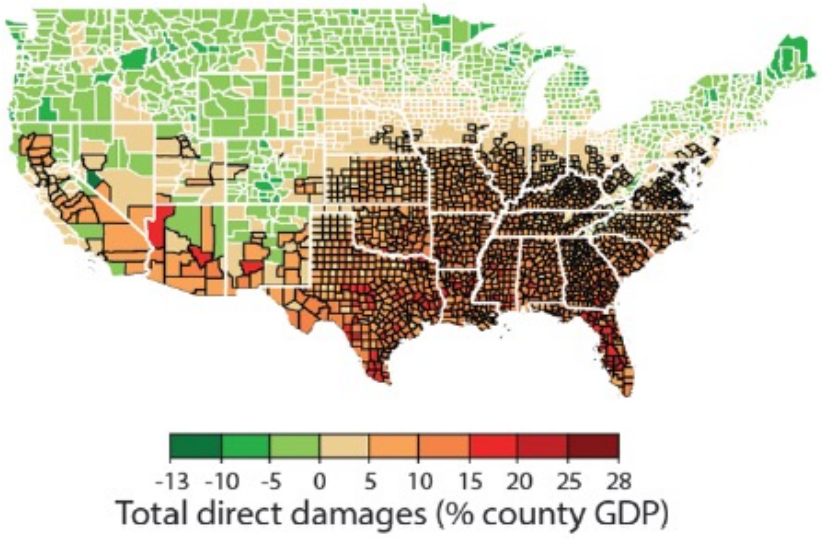
How Damages Will Vary Globally: Mortality as an Example



NATIONAL ECONOMIC EDUCATION DELEGATION

21

How Damages Will Vary in the US



NATIONAL ECONOMIC EDUCATION DELEGATION

22

Adaptation Reduces Damages

- *Adaptation*: costly action that reduce damages from climate change.
- The net damage cost to society is the cost of adaptation plus the cost of remaining damages.
- People and firms will take some actions on their own, up to the point where they find it worthwhile.
- Some adaptation requires government involvement.

NATIONAL ECONOMIC EDUCATION DELEGATION

23

Individual-Level Adaptation

- **Perhaps you…**
  - Stay inside more.
  - Turn on the air conditioning.
- **Farmers may:**
  - Plant at different times.
  - Plant new crops.
- **Businesses may:**
  - Give outdoor workers water / shade breaks.
- **Everyone might:**
  - Think about moving to a safer place.

NATIONAL ECONOMIC EDUCATION DELEGATION

24

Public Adaptation

- **Governments can help:**
  - When collective action is less costly than everyone acting alone.
  - When individual action is not possible or likely.
  - When some people can't protect themselves.
- **Sea walls**
- **Ecosystems that provide protection**
- **Policies that protect workers or low-income and vulnerable populations**
- **Planned retreat (moving a community)**

NATIONAL ECONOMIC EDUCATION DELEGATION

25

Reducing Emissions

NATIONAL ECONOMIC EDUCATION DELEGATION

26

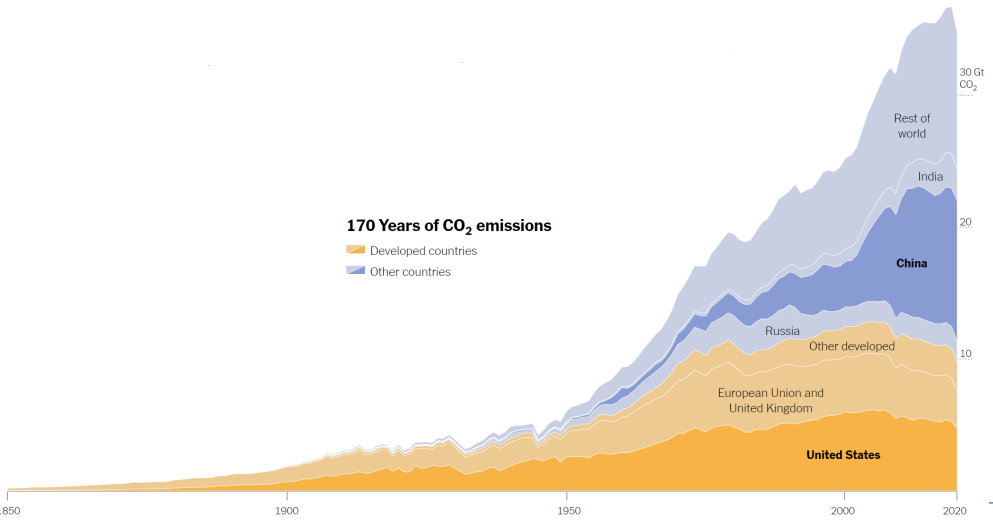
Global Net Emissions Are What We Care About

- **For climate impacts, we don't care where they are emitted, only how much**
  - There may be other local impacts
- **Gross emissions (greenhouse gas sources): how much greenhouse gases (including CO2) we put out**
- **Greenhouse gas sinks: ways to pull CO2 out of the air**
  - Existing: oceans, forests
  - Increase sinkage by planting trees, or other measures

NATIONAL ECONOMIC EDUCATION DELEGATION

27

Sources of the Global Flow of Emissions



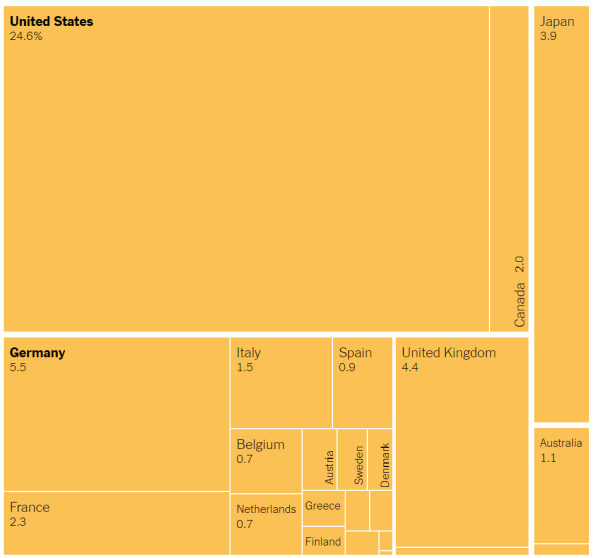
NATI EDUC

28

28

Sources of the Global Stock of Emissions

23 rich, developed countries are responsible for half of all historical CO_2 emissions.



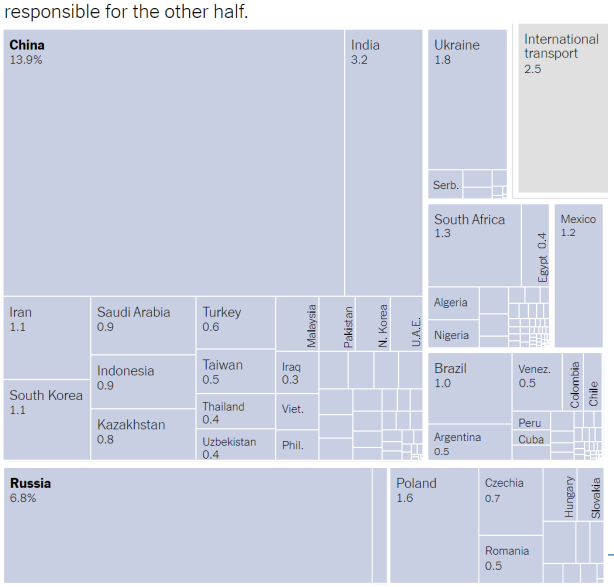
NATIONAL ECONOMIC EDUCATION DELEGATION

29

29

Sources of the Global Stock of Emissions

More than 150 countries are responsible for the other half.

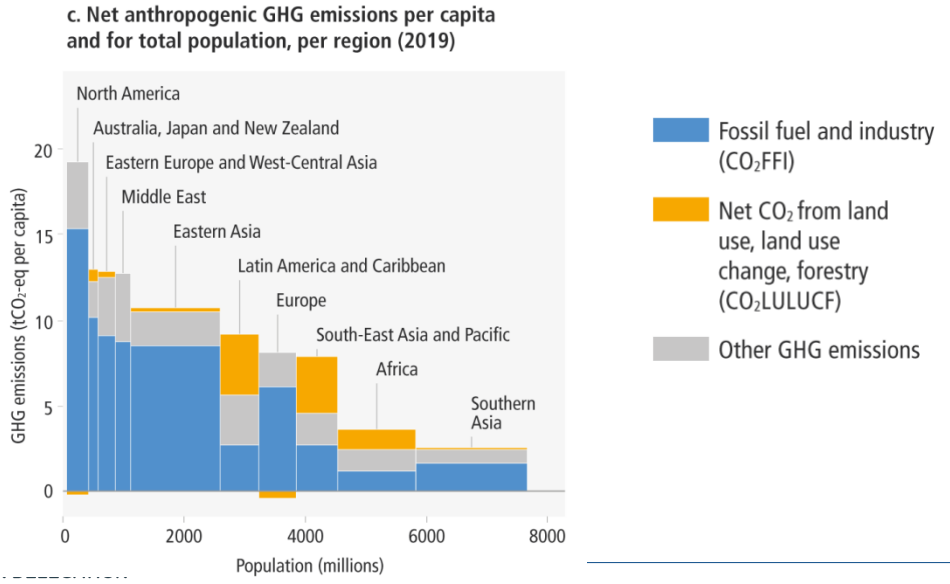


NATIONAL ECONOMIC EDUCATION DELEGATION

30

30

How Does This Look Per Capita (Per Person)?

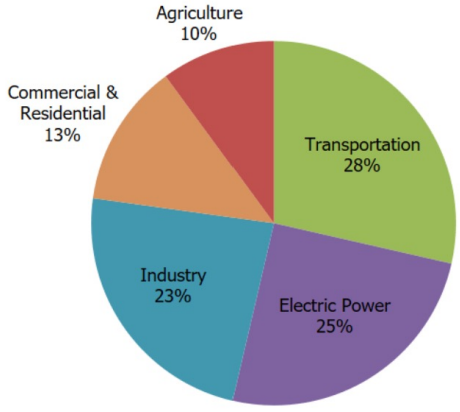


NATIONAL EDUCATION DELEGATION

31

31

Total US Greenhouse Gas Emissions by Economic Sector in 2021



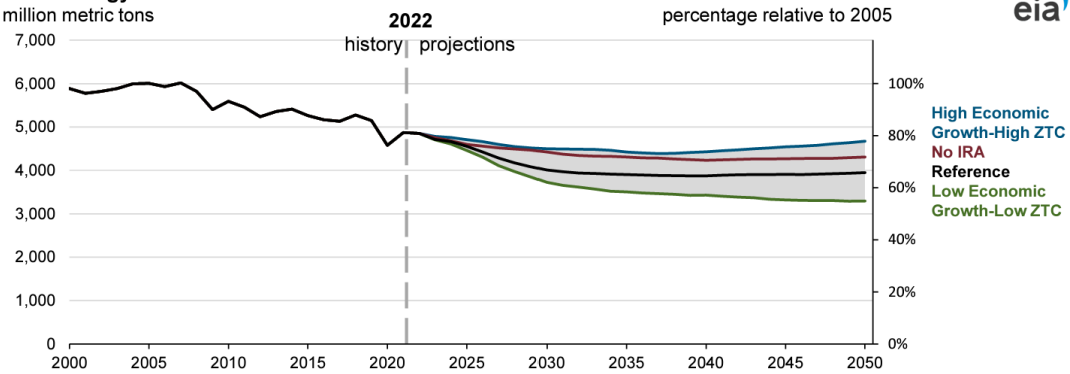
NATIONAL ECONOMIC EDUCATION DELEGATION

Total Emissions in 2021 are 6,340 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100%

32

Energy Related Emissions Are Falling (though They Still Need to Fall Further)

Total energy-related carbon dioxide emissions



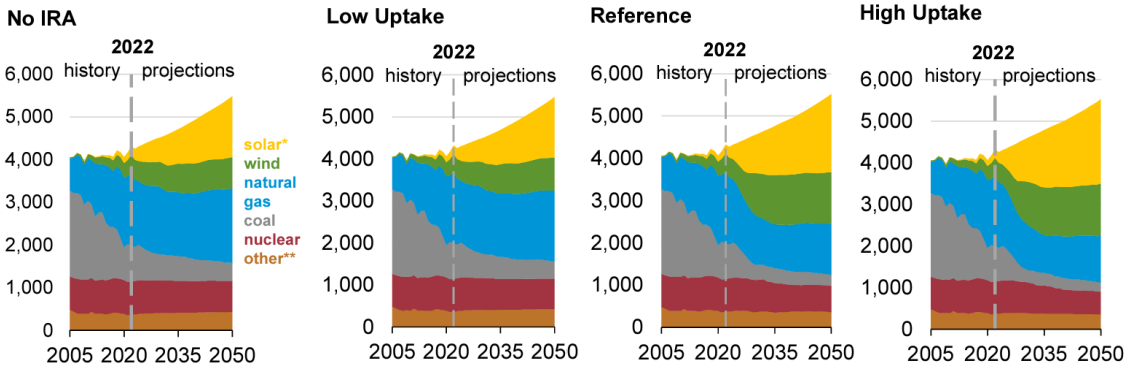
Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases. ZTC=Zero-Carbon Technology Cost; IRA=Inflation Reduction Act.

NATIONAL ECONOMIC EDUCATION DELEGATION

33

US Electricity Sources

U.S. net electricity generation by fuel
billion kilowatthours



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: IRA=Inflation Reduction Act
*Includes utility-scale and end-use photovoltaic generation and excludes off-grid photovoltaics.
**Includes petroleum, conventional hydroelectric power, geothermal, wood and other biomass, pumped storage, non-biogenic municipal waste in the electric power sector, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

NATIONAL ECONOMIC EDUCATION DELEGATION

34

Which Emissions Should We Cut?

- List all possible ways to reduce emissions
- Figure out how much each can reduce in total
- Figure out how much each costs per unit of emissions reduced
- Line them up in order: cheapest to costliest ("marginal abatement cost curve")
  - → Tackle first the cheapest ones!

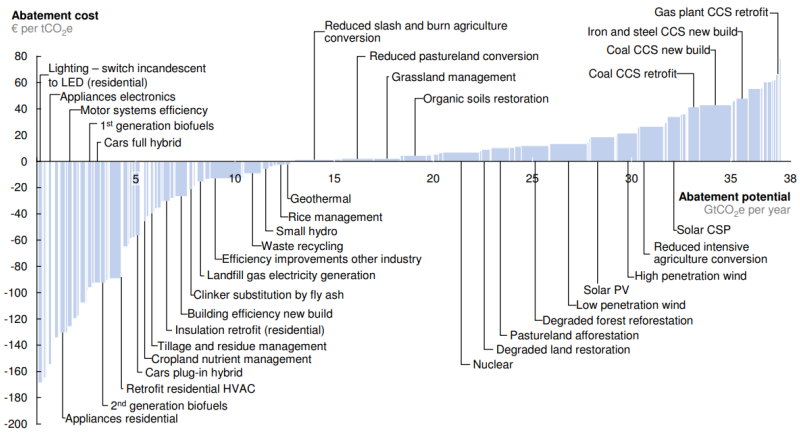
NATIONAL ECONOMIC EDUCATION DELEGATION

35

Example Abatement Cost Curve

(Don't trust these numbers, this is just to show the idea)

V2.1 Global GHG abatement cost curve beyond BAU – 2030

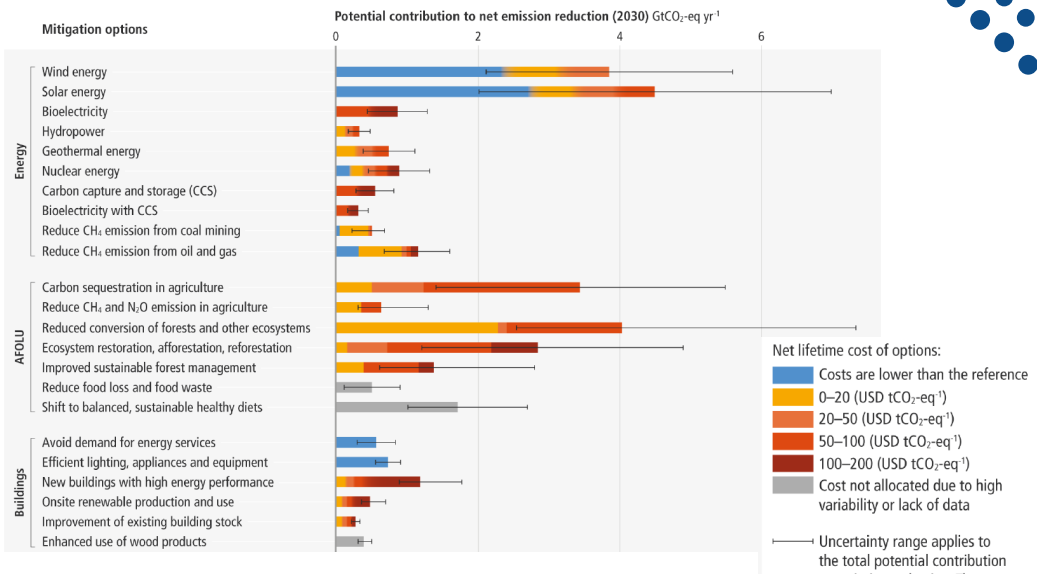


NATIONAL EC EDUCATION DEL

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.1

36

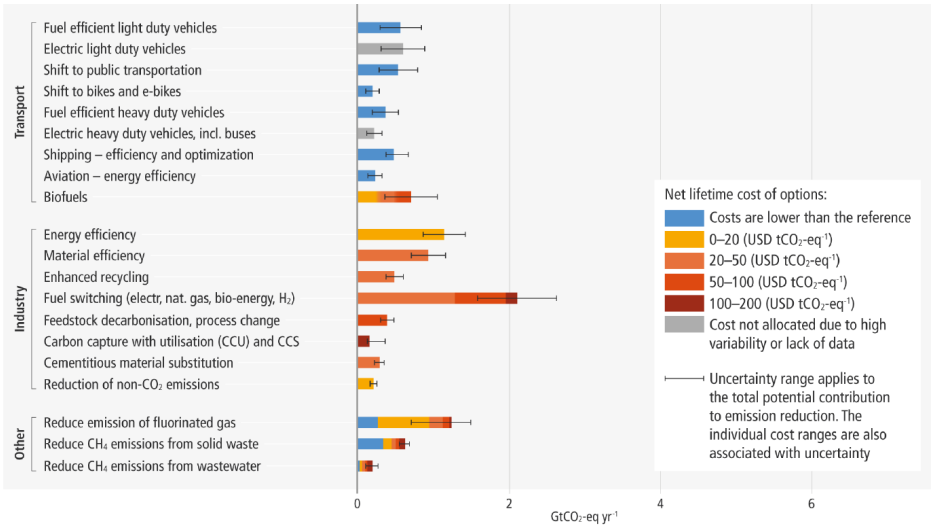
Newer Estimated Abatement Cost Curve



NATIONAL ECONOMIC EDUCATION DELEGATION

37

Newer Estimated Abatement Cost Curve



NATIONAL ECONOMIC EDUCATION DELEGATION

38

Costs and Barriers Can Be Difficult to Assess

- **Difficult to project future costs for new technology**
  - Costs of renewables have been dropping fast
- **Investments in research and development and infrastructure (e.g., EV charging) can lower future costs**
- **Barrier to expanding renewable energy: intermittency**
  - Battery technology under development

NATIONAL ECONOMIC EDUCATION DELEGATION

39

Geoengineering and Carbon Capture

- **Technical pathways to reduce climate change without reducing emissions**
- **Carbon capture: captures CO2 emissions and stores them or "utilizes" them (for energy, pressure, etc.)**
  - Not yet proven at scale
- **Solar geoengineering: make the atmosphere reflect more light to regain earlier thermal balance**
  - Totally theoretical
  - Potentially risky

NATIONAL ECONOMIC EDUCATION DELEGATION

40

Climate Change Policy

NATIONAL ECONOMIC EDUCATION DELEGATION

41

Policies That Reduce Emissions Directly

- **Command and control regulation**
  - Emissions standards or limits (e.g., Clean Water Act discharge limits)
  - Tech standards (e.g., require scrubbers on power plants)

- **Incentive-based policies**
  - Putting a price on emissions – leveling the playing field!
    - Tax or cap & trade
    - Subsidizing green energy (*e.g.*, feed-in tariffs)

NATIONAL ECONOMIC EDUCATION DELEGATION

42

42

Command and Control vs. Incentive-Based Regulation

- **Efficiency**
  - Both can achieve the same amount of emissions reduction.
  - Incentive-based policies can achieve emissions reduction at much lower cost.
- **Equity**
  - Both have may regressive impacts (low-income families bear costs that are a larger percent of their incomes vs hi-income families)
    - However, new evidence increasingly questions this.
  - Cap and trade and carbon tax can generate revenues that can be used to offset the regressivity.
    - E.g.: "carbon dividend"
  - Command and control regulations do not.

43

How Does a Carbon Tax Work?

- **Choose activities to be covered (e.g., electricity sector, all emitters, etc.).**
- **Set tax level.**
  - Optimally, it represents the social cost of polluting.
- **Polluters must pay a tax for every unit emitted.**
  - Polluters with **low** abatement costs will **abate** to avoid the tax
  - Polluters with **high** abatement costs will pollute and **pay the tax**

44

How Does Cap and Trade Work?

- **Choose activities to be covered (e.g., electricity sector, all emitters, etc.).**
- **Set maximum emissions level ("cap").**
- **That many pollution permits are issued.**
  - Can be auctioned off or given to polluters
- **Every polluter in a covered sector must have a permit for every unit of pollution.**
- **Polluters buy and sell ("trade") permits on a market as they wish.**
  - Polluters with **low** abatement costs will make / save money by **abating** and selling / not buying permits
  - Polluters with **high** abatement costs will buy permits and **pollute**

45

Examples of Other Policies that Reduce Emissions

- **Research and development subsidies**
- **Renewable energy mandates (e.g., renewable portfolio standards)**
- **Energy efficiency mandates and subsidies (e.g. CAFE fuel economy standards)**
- **Grid / infrastructure improvements**
- **Public transportation**
- **Land use / zoning policies**

46

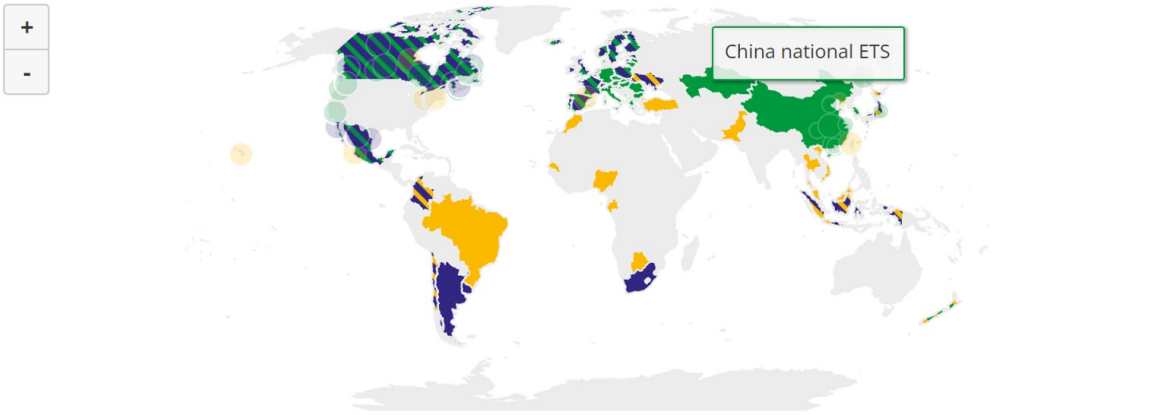
Offsets and "Net Zero"

- **Carbon offsets are assets that can be purchased that correspond (theoretically) to reductions in emissions elsewhere**
  - Either reduction / prevention of a carbon source or generation / prevention of loss of a carbon sink
  - Examples: capping landfills for methane leaks; forest protection
- **This lets global net emissions decline more than direct emissions do**
  - Net zero emissions goal means new offsets must equal new emissions
- **Can fit into any regulatory scheme to "count against" direct emissions (if the regulation allows them)**
- **Concerns: verifiability, additionality, ethics / justice**

Climate Change Policy in Action

Incentive-Based Climate Policies Right Now

Summary map of regional, national and subnational carbon pricing initiatives



- ETS implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS implemented or scheduled, ETS or carbon tax under c...
- Carbon tax implemented or scheduled for implementation
- ETS and carbon tax implemented or scheduled
- Carbon tax implemented or scheduled, ETS under consider...

NATIONAL ECONOMIC EDUCATION DELEGATION

Source: World Bank Carbon - Pricing Dashboard

49

California's Cap and Trade System Since 2012

0.7%

of global greenhouse gas emissions

NATIONAL ECONOMIC EDUCATION DELEGATION

50

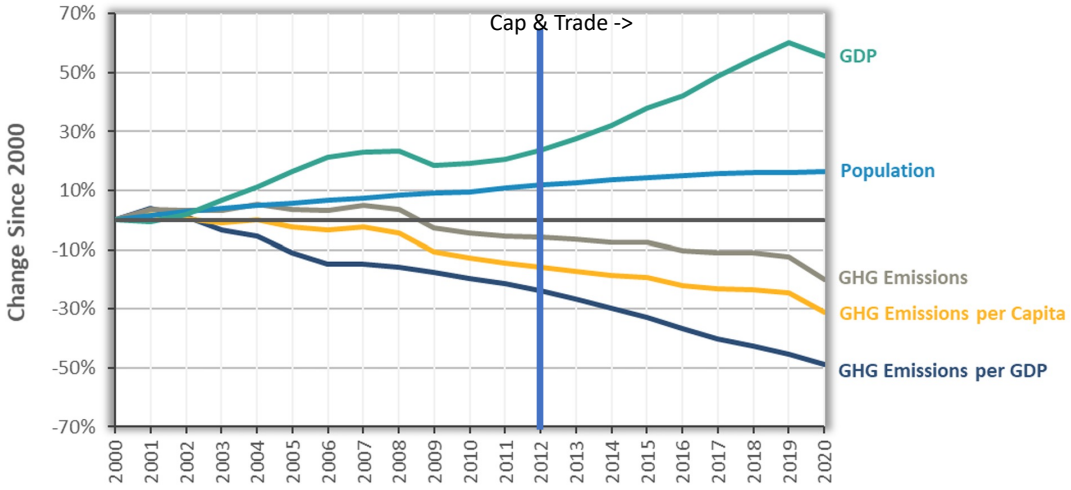
California's AB32: Global Warming Solutions

- **California's goals:**
  - Reduce emissions to 1990 levels by 2020
  - An 80% reduction in emissions from 1990 levels by 2030
- **California's Tools:**
  - Cap and Trade
  - Renewable Portfolio Standard
  - Clean Cars Program
  - Low Carbon Fuel Standard

NATIONAL ECONOMIC EDUCATION DELEGATION

51

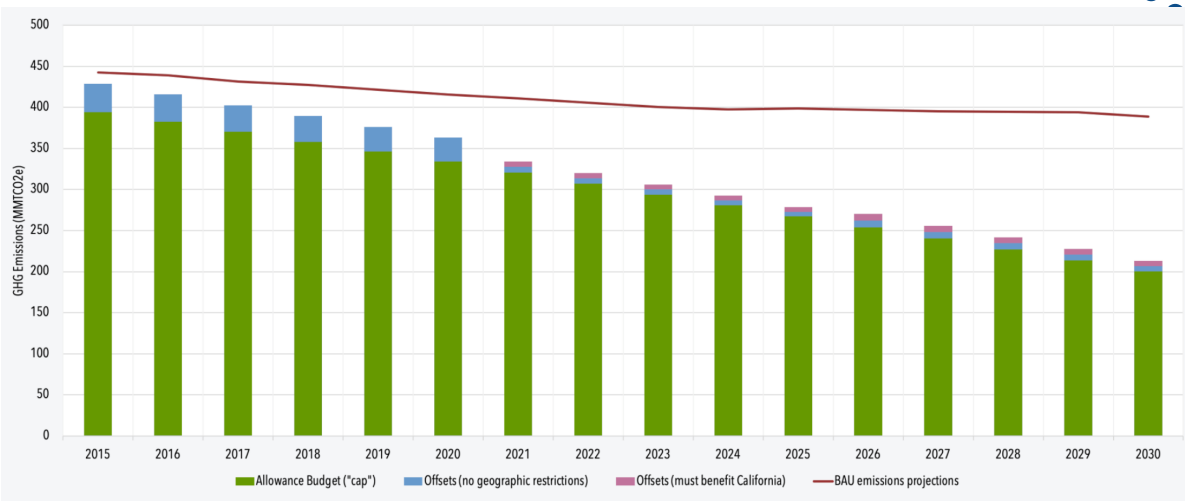
Change in California GDP, Population, and GHG Emissions since 2000



NATIONAL ECONOMIC EDUCATION DELEGATION

52

Projected trends in California's emissions



Summary

- **Climate change is real, is caused by human actions, and has impacts we're already feeling.**
- **This problem won't solve itself; we need policy intervention, and fast.**
  - Fortunately, a lot of action is happening – we need to double down!
- **Smart policy can reduce greenhouse gas emissions by the right amount and at the lowest possible cost.**
  - For example, cap and trade and emissions taxes!
- **We also need policies to help with adaptation and support those bearing the greatest damages.**

Thank you!

Any Questions?

www.NEEDEcon.org
Sarah Jacobson, Ph.D.
saj2@williams.edu

Contact NEED: info@NEEDEcon.org

Submit a testimonial: www.NEEDEcon.org/testimonials.php

Become a Friend of NEED: www.NEEDEcon.org/friend.php

55