


Climate Change Economics

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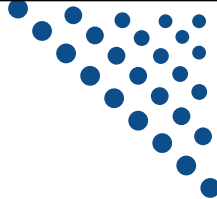
Bay Area Transportation Working Group
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Outline

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



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Economic Building Blocks



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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.



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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)



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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



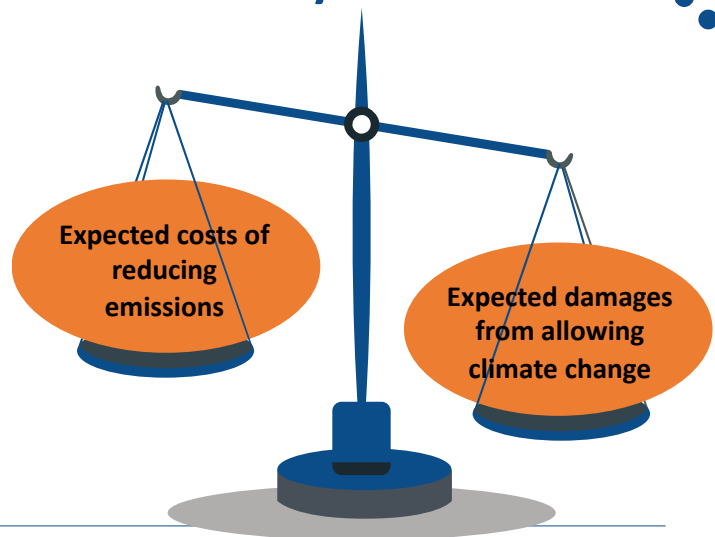
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How Economists Decide How Much to Fight Climate Change: Cost Benefit Analysis

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.



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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.**



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Climate Change



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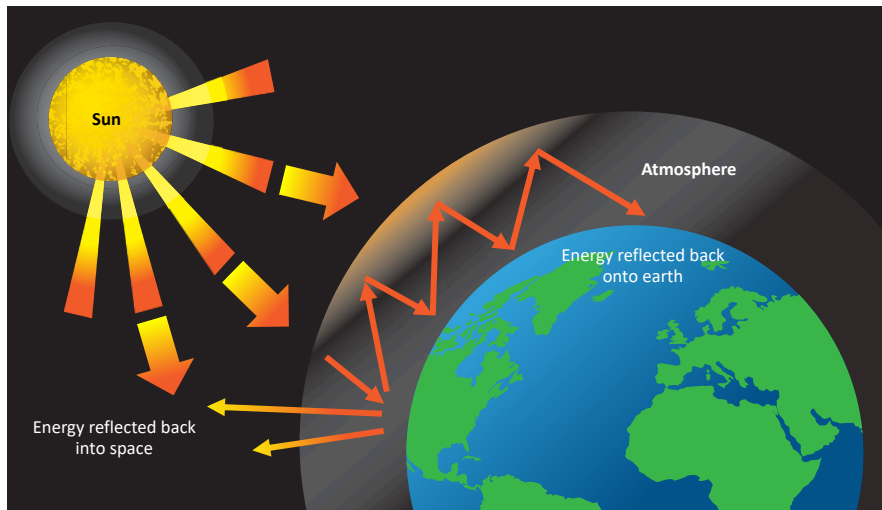
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A Climate Change Ladder

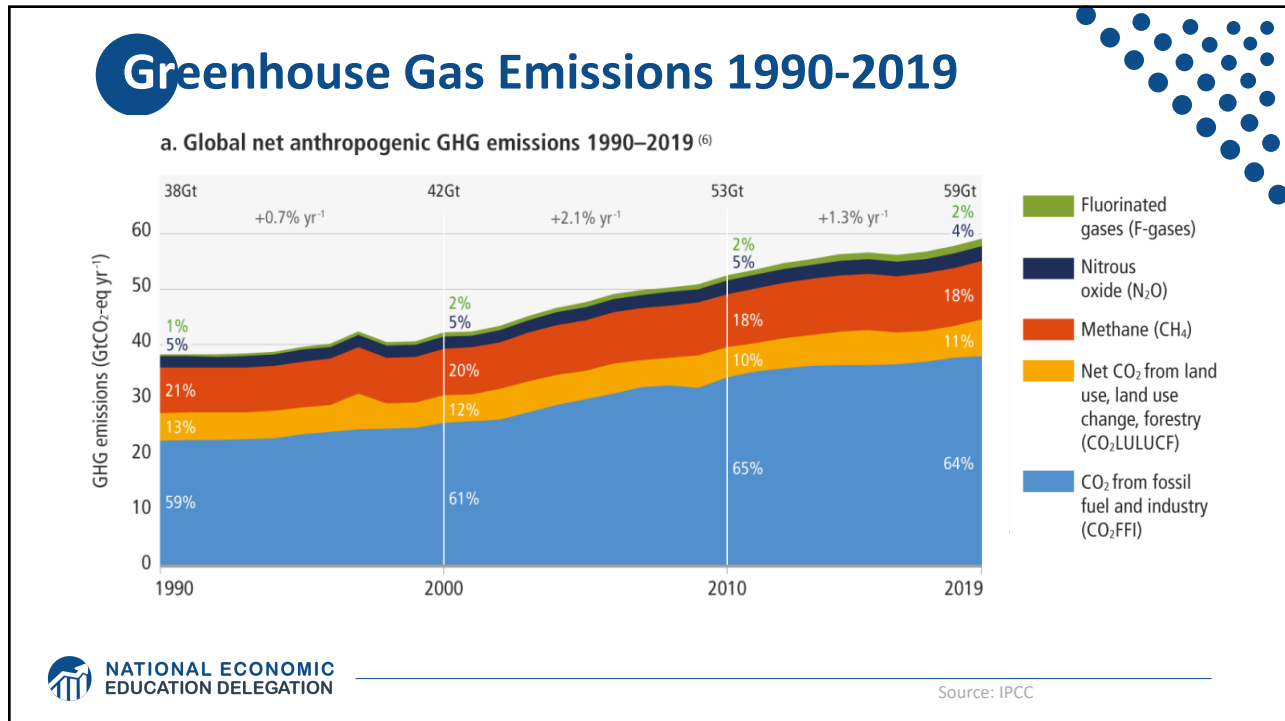
- Emissions
- Mitigation (a.k.a. Abatement)
- Adaptation
- Damages

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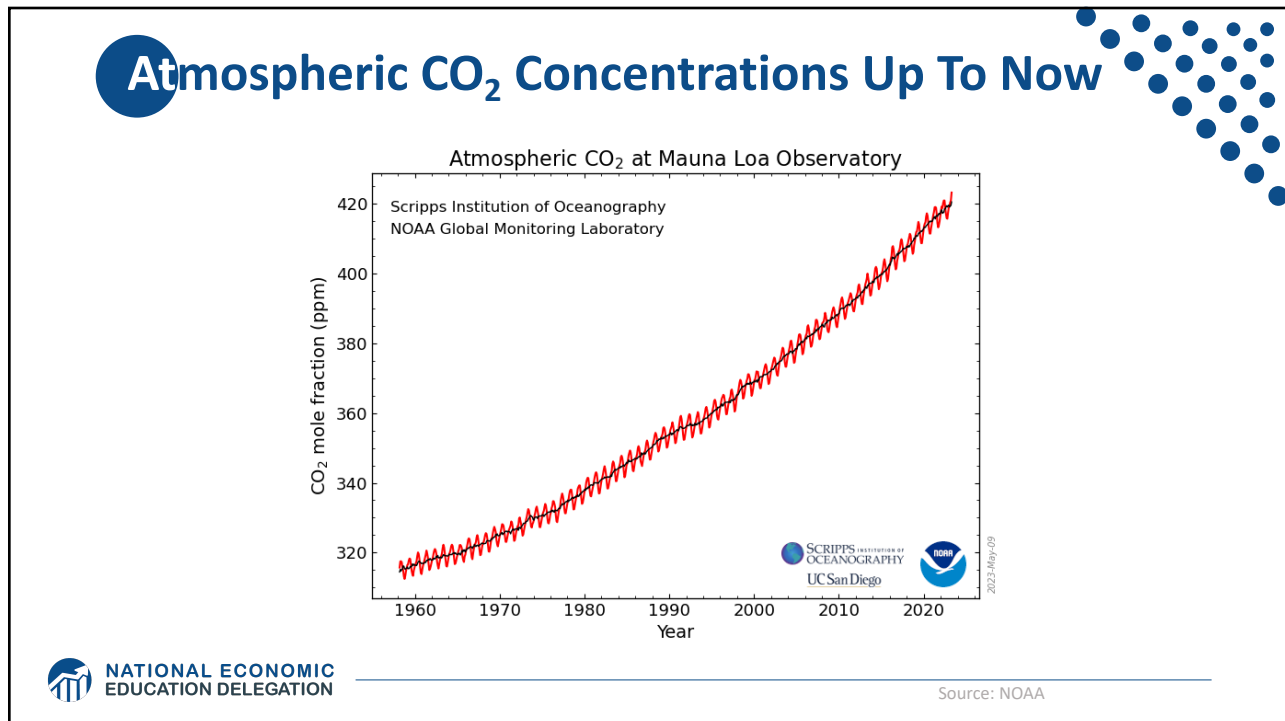
The Atmospheric Greenhouse Effect



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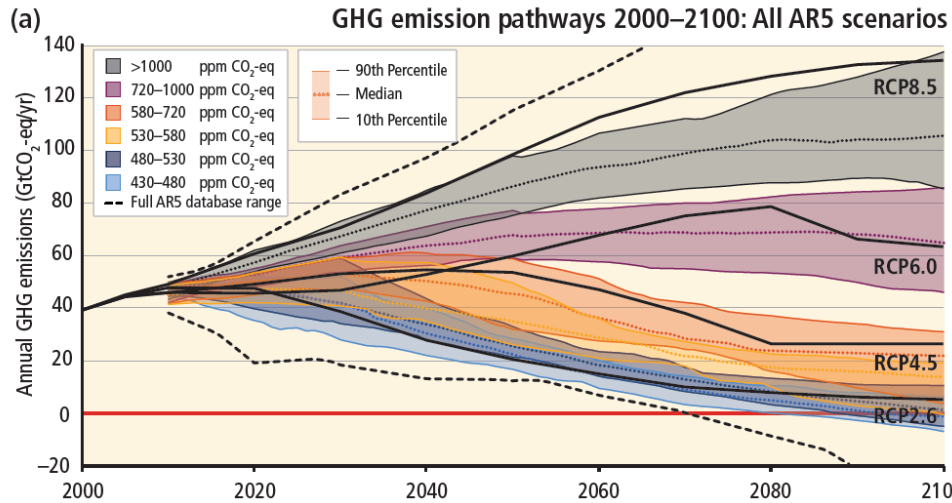


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Emissions Trajectories into the Future



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What Do Greenhouse Gas Emissions Do to the Planet?

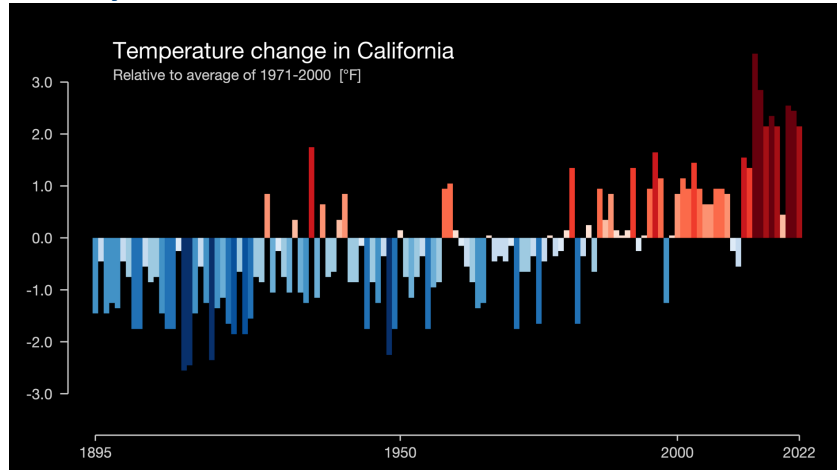
- **Increased temperatures**
 - Sea level rise
 - Storm surges
- **Altered precipitation patterns**
- **More variable weather**
- **More / more powerful storms**
- **Carbon dissolves in ocean**

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These Changes Are Already Underway

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

Here's California!

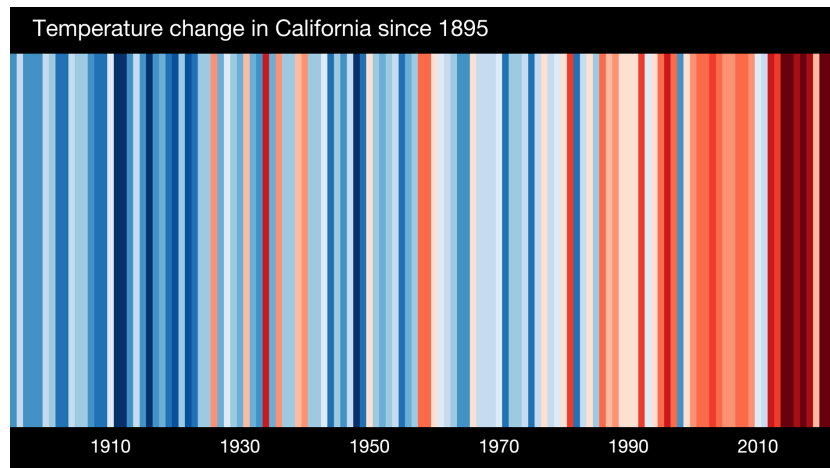


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These Changes Are Already Underway

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

Here's California!



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Impacts of Climate Change



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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



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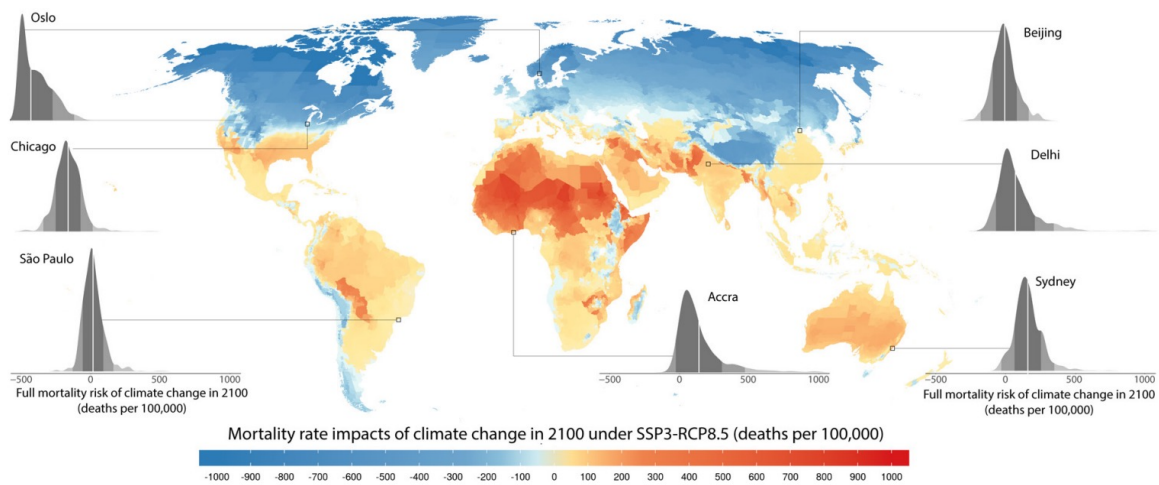
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Social Cost of Carbon

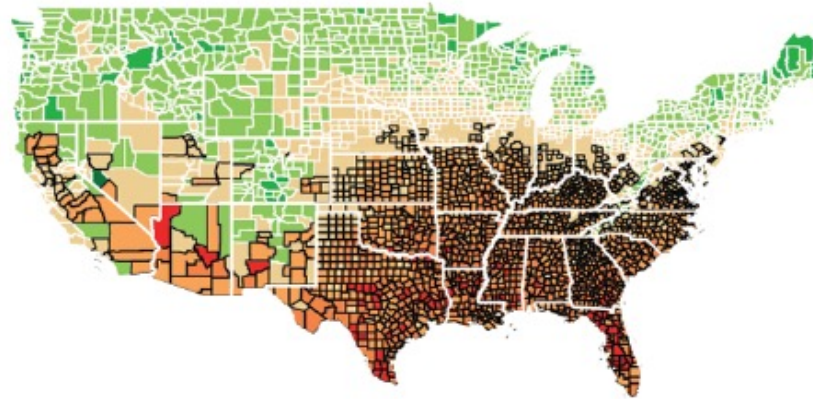
- The expected cost of damages from each unit of greenhouse gas emissions.
- Current EPA estimate: ~\$51 per metric ton of CO₂
 - About \$157/car per year for an avg driver.
- But in 2022 they put forward a proposal to raise it to \$190!
- Cost will increase over time.



How Damages Will Vary Globally: Mortality as an Example



How Damages Will Vary in the US



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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.



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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.



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)**



Reducing Emissions



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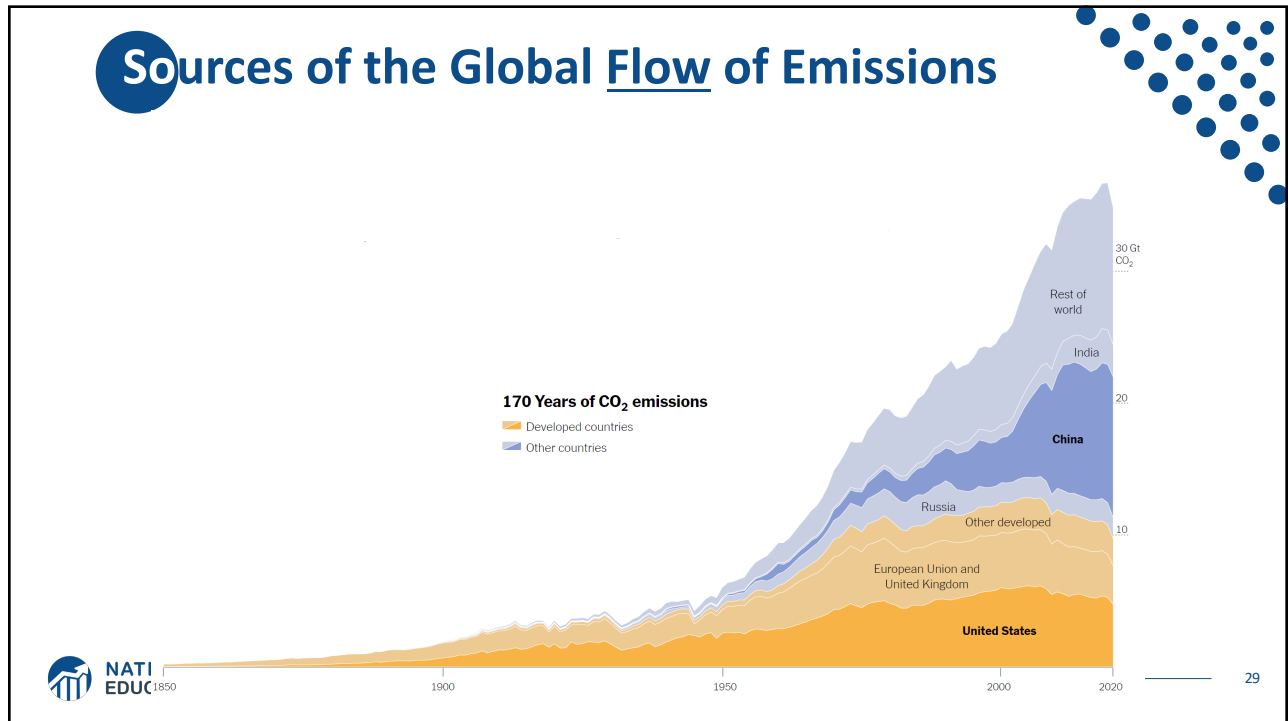
Global Net Emissions Are What We Care About

- **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

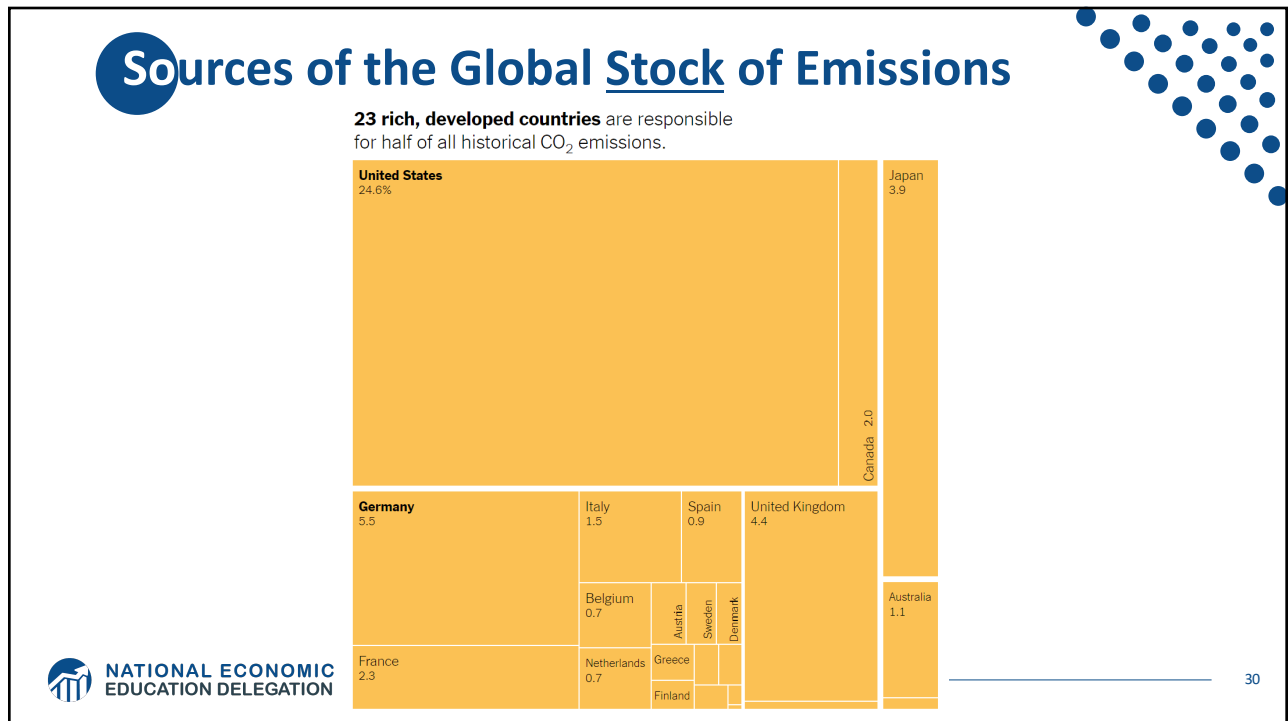


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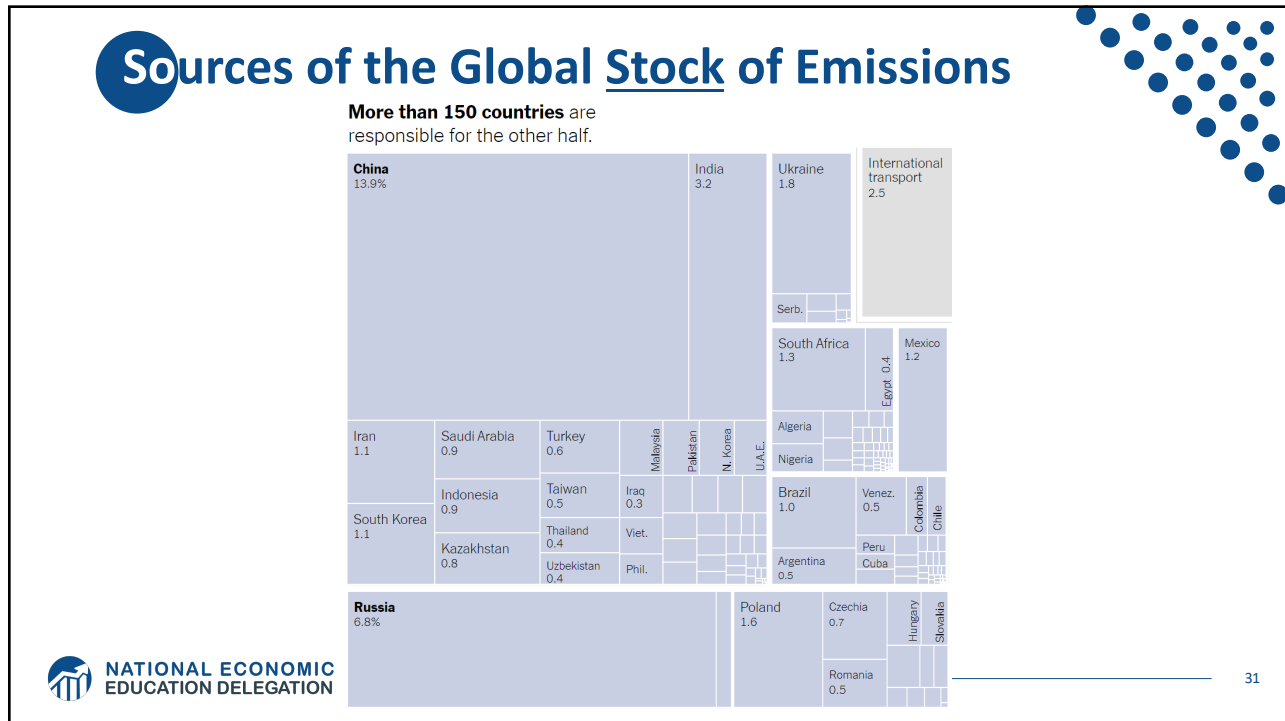
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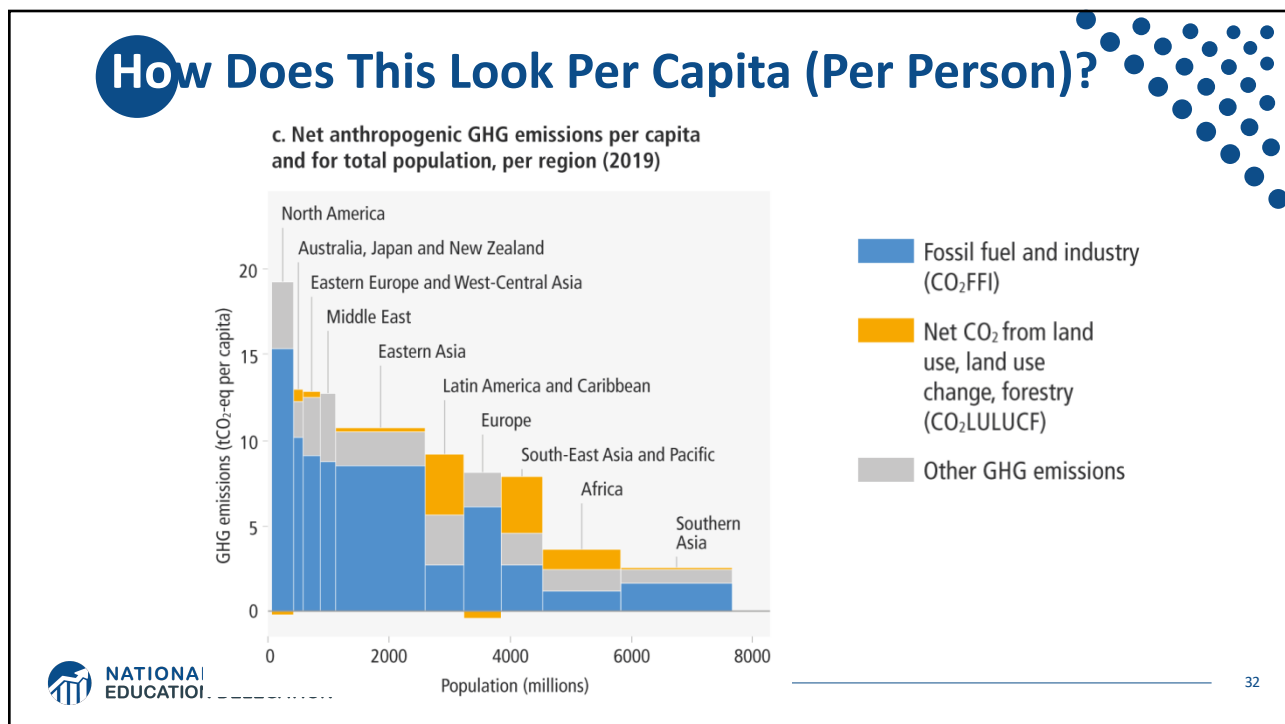
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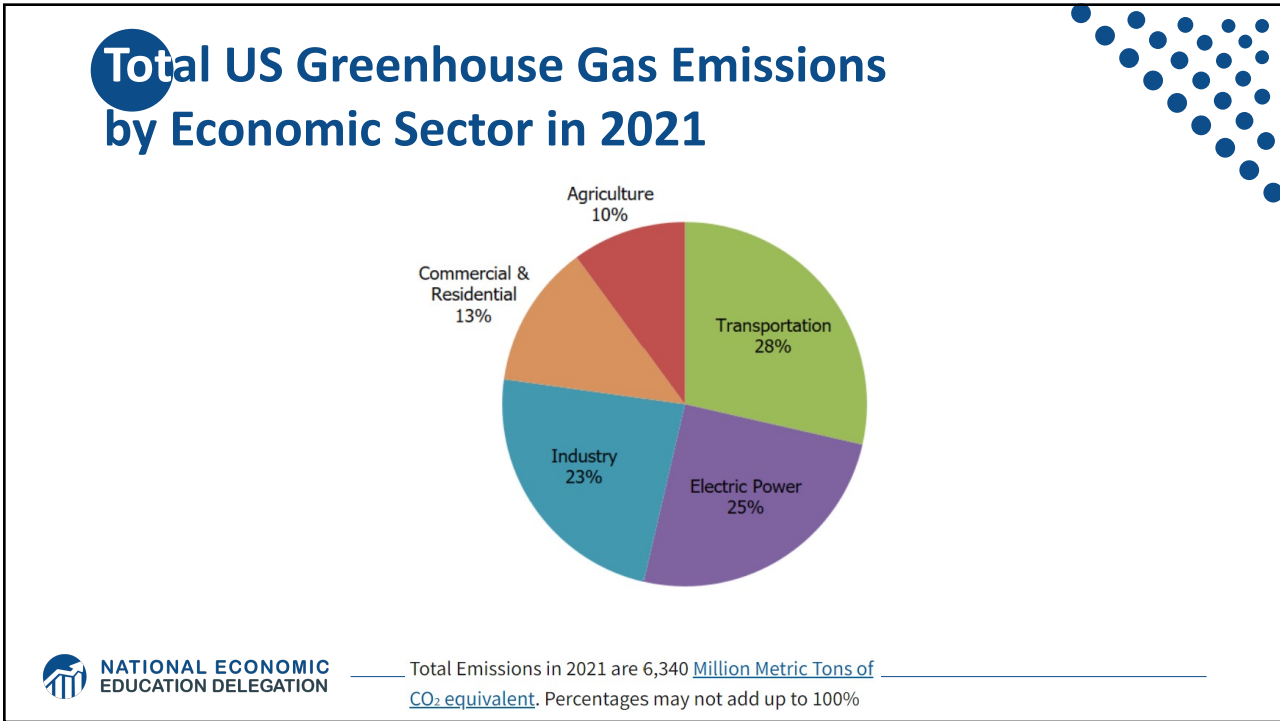
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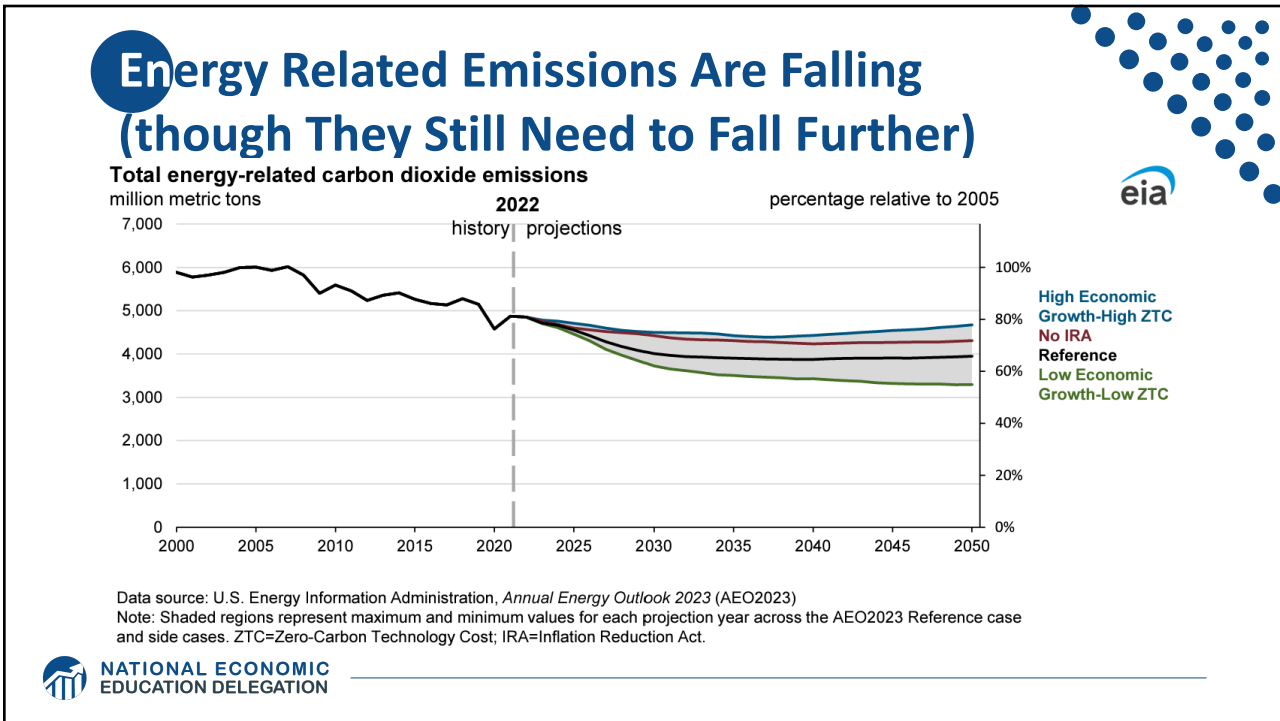
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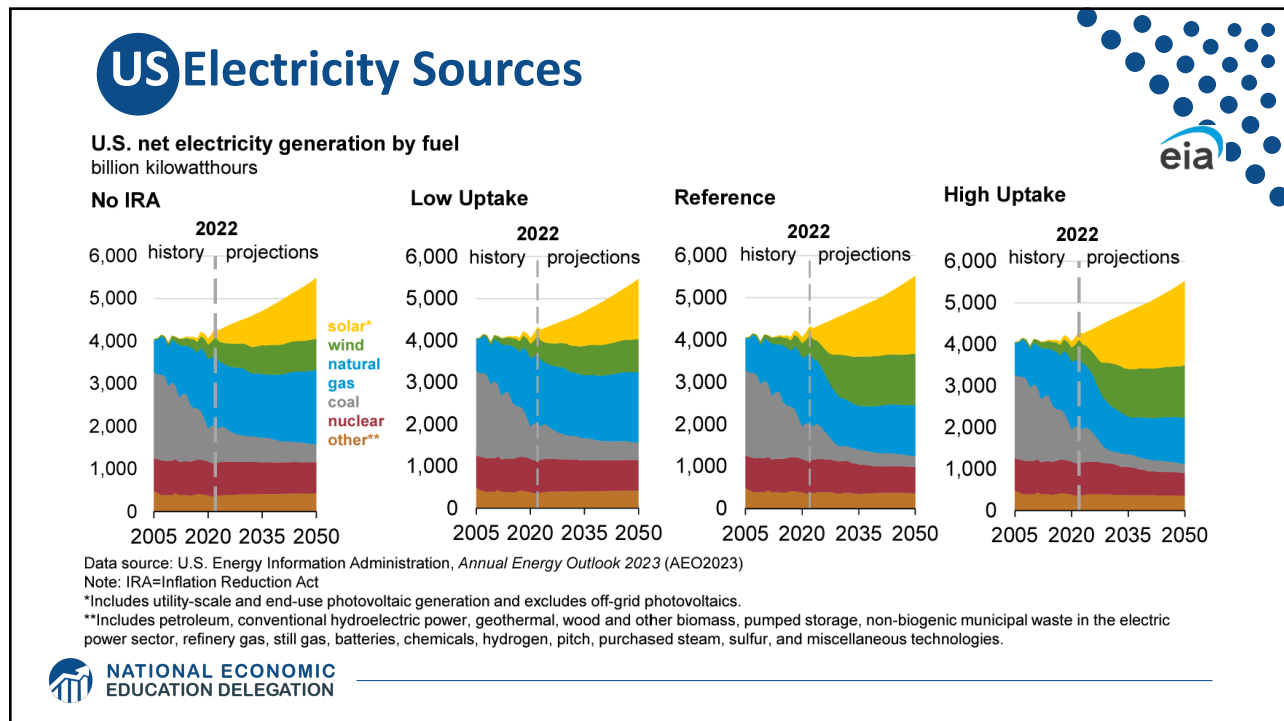
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Which Emissions Should We Cut?

- 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!

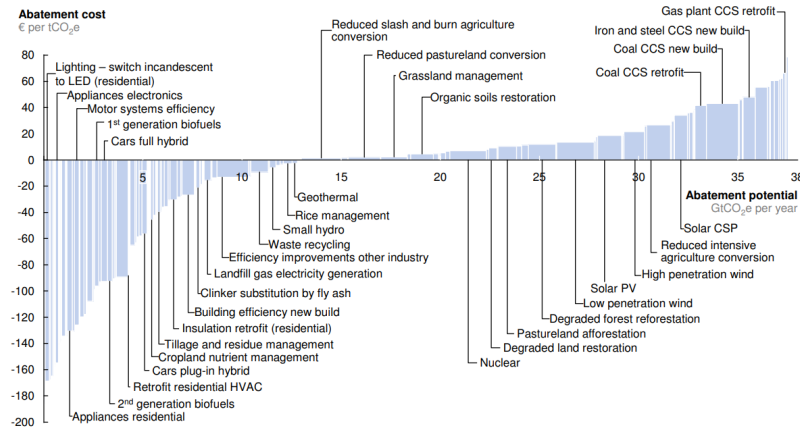
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Example Abatement Cost Curve

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

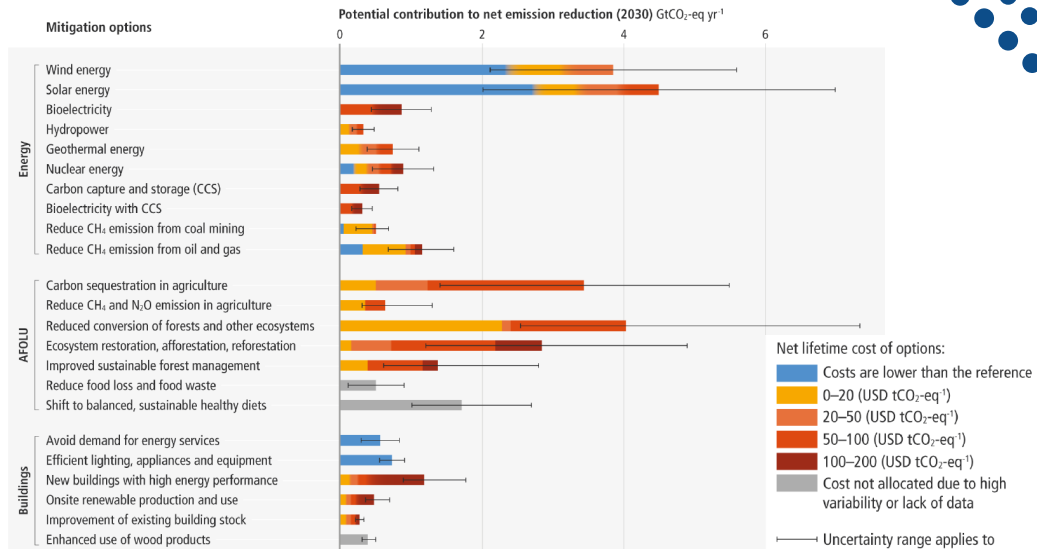
V2.1 Global GHG abatement cost curve beyond BAU – 2030



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO₂e 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

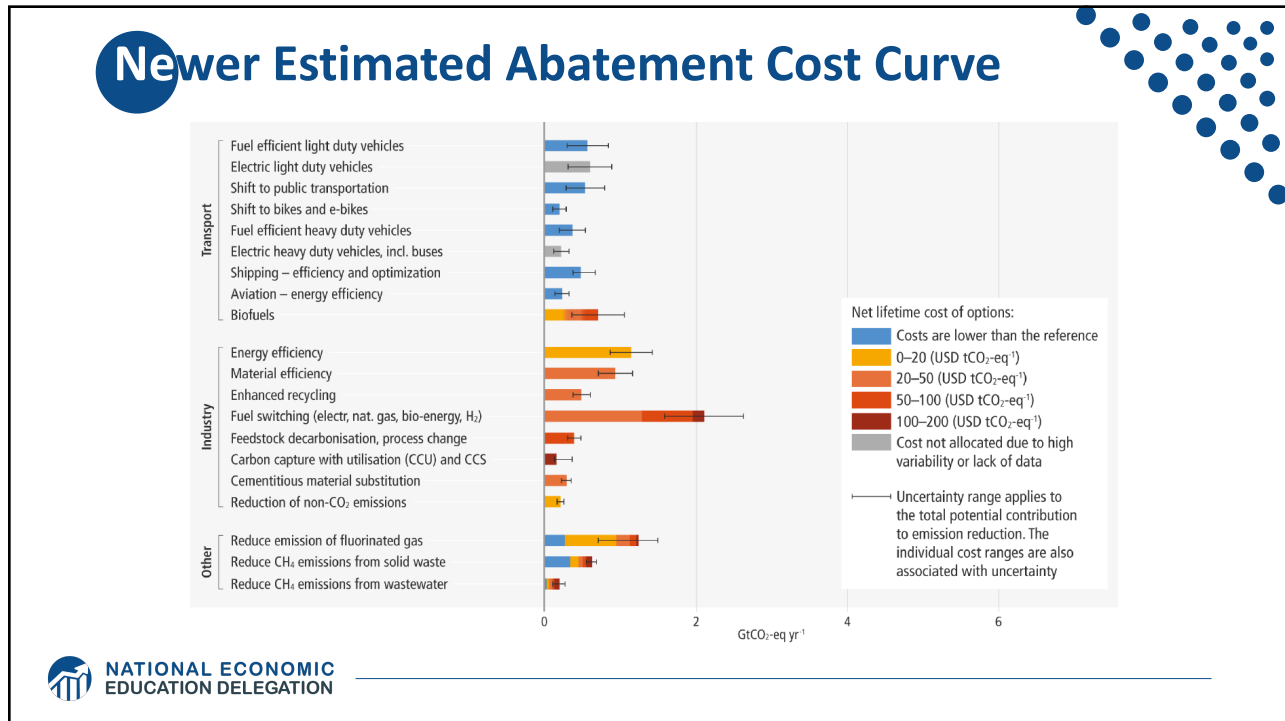
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Newer Estimated Abatement Cost Curve



Net lifetime cost of options:
 Blue: Costs are lower than the reference
 Yellow: 0–20 (USD tCO₂-eq⁻¹)
 Orange: 20–50 (USD tCO₂-eq⁻¹)
 Red: 50–100 (USD tCO₂-eq⁻¹)
 Dark red: 100–200 (USD tCO₂-eq⁻¹)
 Grey: Cost not allocated due to high variability or lack of data
 Horizontal line: Uncertainty range applies to the total potential contribution to emission reduction. The individual cost ranges are also associated with uncertainty

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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

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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



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Climate Change Policy



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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)



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.



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**



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**



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



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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**



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Leakage and Regulatory Interconnections

- **If some areas are more tightly regulated than others, polluters may move from the high-regulation to the low-regulation areas**
 - This is called leakage
 - It may cause overall pollution to not decline
 - So far, there's little evidence that firms relocate because of enviro rules
- **Rationale for old “broad, then deep” approach**
- **Climate economists have been surprised by profusion of local & regional climate regulations**
- **Now some may get stitched together – “deep, then broad”?**



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Border Carbon Adjustments

- **To avoid leakage & stay competitive, high-regulation places can impose border carbon adjustments**
- **Tweak prices up on imports from low-regulation places to reflect “correct” regulated price because of embodied pollution**



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Climate Change Policy in Action

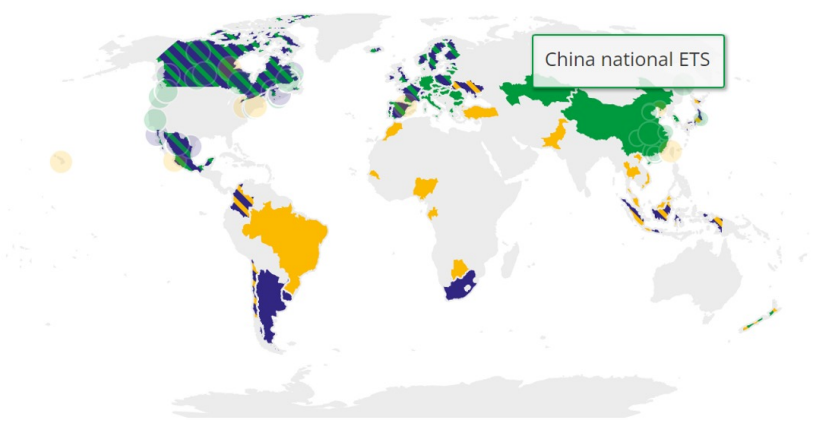


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Incentive-Based Climate Policies Right Now


Summary map of regional, national and subnational carbon pricing initiatives



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- 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...



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Source: World Bank Carbon - Pricing Dashboard

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California's Cap and Trade System Since 2012



0.7%

of global
greenhouse gas
emissions



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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

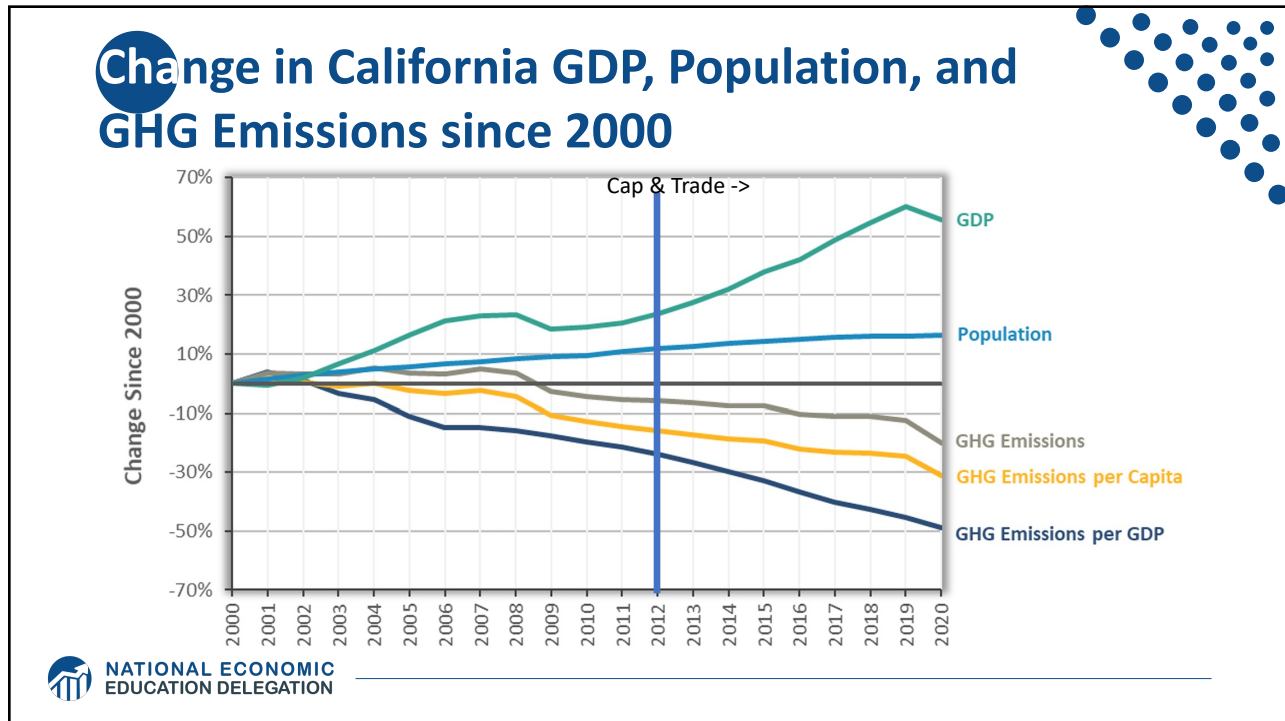
- **California's Tools:**

- Cap and Trade
- Renewable Portfolio Standard
- Clean Cars Program
- Low Carbon Fuel Standard

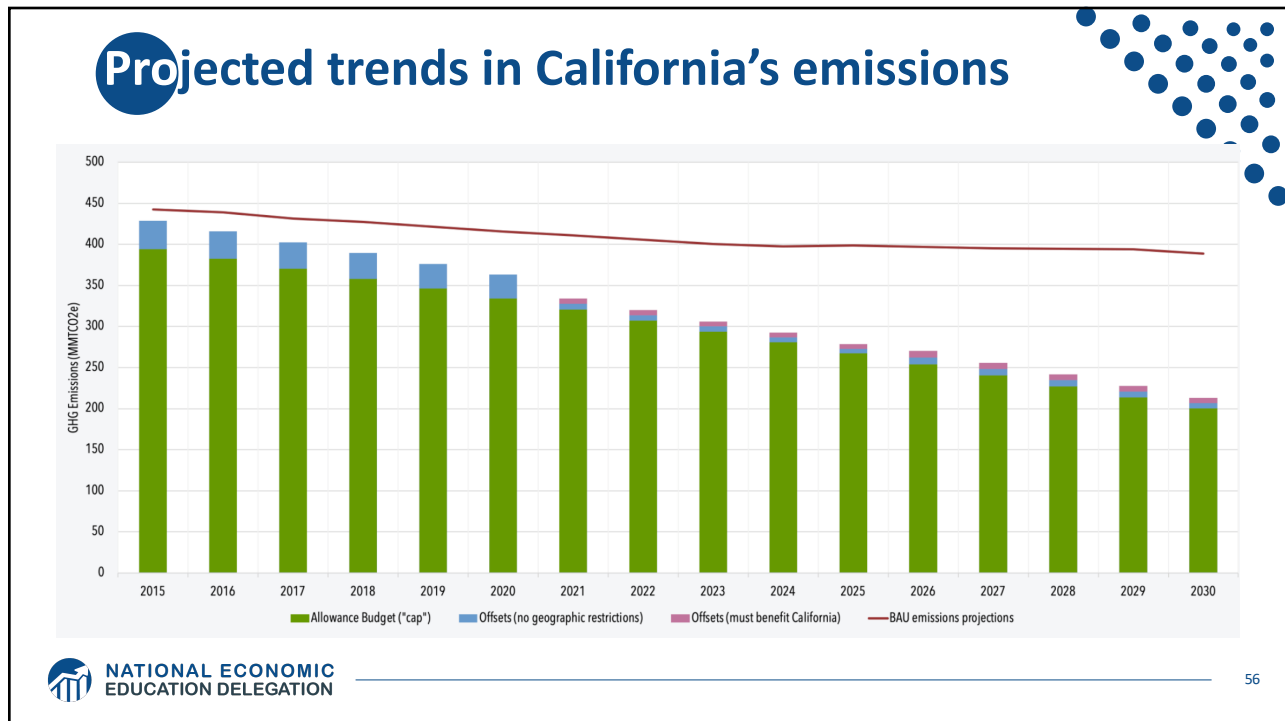


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Summary

- **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.**



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Thank you!

Any Questions?

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