


***Osher Lifelong Learning Institute, Spring 2022***  
**Climate Change Economics**

California State University – East Bay  
March 30 and April 6, 2022

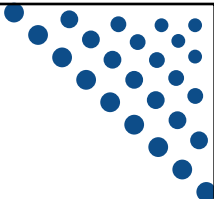
Jon Haveman, Ph.D.  
National Economic Education Delegation

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**National Economic Education Delegation**

- **Vision**
  - One day, the public discussion of policy issues will be grounded in an accurate perception of the underlying economic principles and data.
- **Mission**
  - NEED unites the skills and knowledge of a vast network of professional economists to promote understanding of the economics of policy issues in the United States.
- **NEED Presentations**
  - Are nonpartisan and intended to reflect the consensus of the economics profession.

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## Who Are We?

- **Honorary Board: 54 members**

- 2 Fed Chairs: Janet Yellen, Ben Bernanke
- 6 Chairs Council of Economic Advisers
  - o Furman (D), Rosen (R), Bernanke (R), Yellen (D), Tyson (D), Goolsbee (D)
- 3 Nobel Prize Winners
  - o Akerlof, Smith, Maskin

- **Delegates: 651+ members**

- At all levels of academia and some in government service
- All have a Ph.D. in economics
- Crowdsource slide decks
- Give presentations

- **Global Partners: 49 Ph.D. Economists**

- Aid in slide deck development

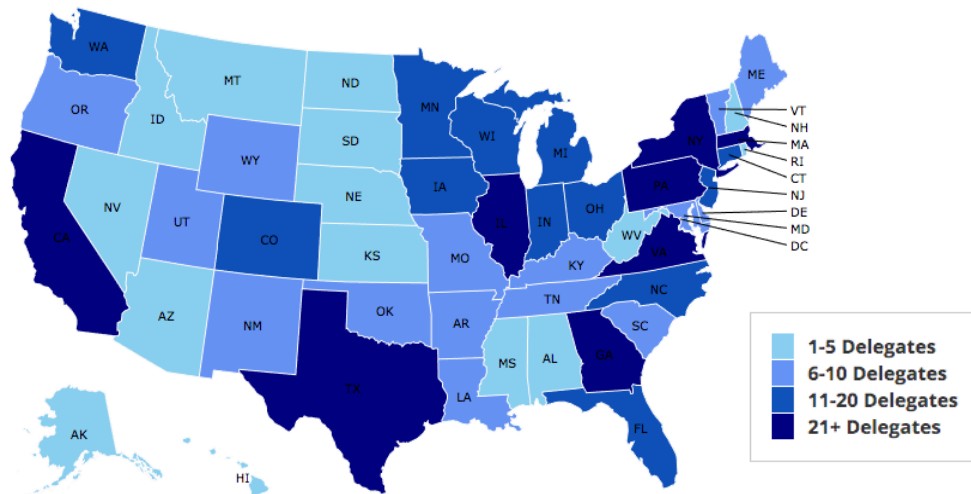


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## Where Are We?



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## Available NEED Topics Include:

- Coronavirus Economics
- US Economy
- Climate Change
- Economic Inequality
- Economic Mobility
- Trade and Globalization
- Minimum Wages
- Immigration Economics
- Housing Policy
- Federal Budgets
- Federal Debt
- Black-White Wealth Gap
- Autonomous Vehicles
- US Social Policy



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## Credits and Disclaimer

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- **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).



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## Outline

- Climate change science
- Impacts of climate change
- Economics of responding to climate change
- Addressing the sources of our emissions
- Climate change policy
- Policy in action



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## Economics Informs Almost Everything

- Prices
- Incentives
- Externalities
- Cost-Benefit Analysis
- Growth
- Inflation
- Interest Rates
- Climate Change
- International Trade
- Immigration
- Housing
- Education
- Health Care
- Gun Control



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## How Can Economists Contribute to Thinking about Climate Change?

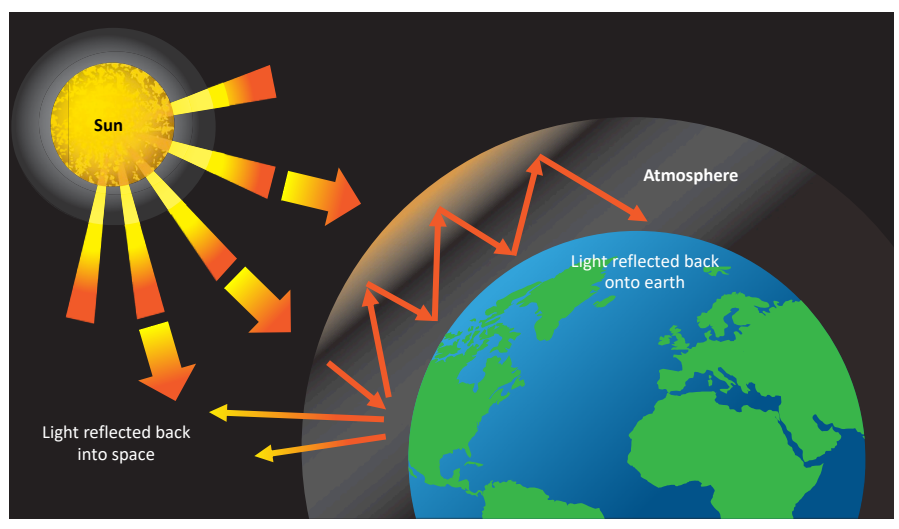
- By assessing behavioral reactions to climate change.
- By measuring the damage and estimating the economic costs of fighting climate change.
- By designing smart policies that minimize costs.
  - Balance economic growth with GHG emission mitigation.



## Climate Change: A Little Science



# The Atmospheric Greenhouse Effect



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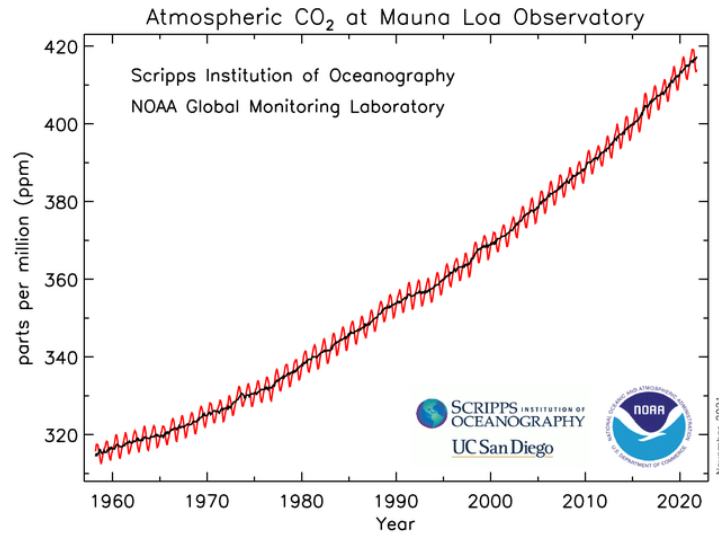
# Uncertainty



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## Atmospheric CO<sub>2</sub> Concentrations Up To Now

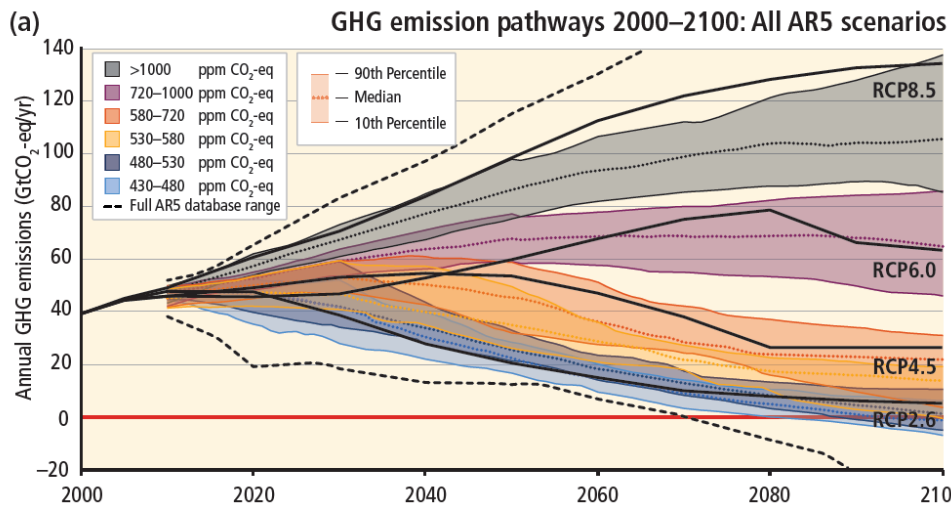


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Source: NOAA

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## Emissions Trajectories into the Future



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Source: IPCC Assessment Report 5

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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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# Icebergs Are Significant Contributors

“If the West Antarctic Ice Sheet collapsed, the most widely cited estimate of the resulting global mean sea-level rise that would result is 3.2 meters,” said Powell.

**EARTH**

The Reason Antarctica Is Melting: Shifting Winds, Driven by Global Warming

Annie Sneed

**CLIMATE CHANGE**

Antarctica's Ice Shelves Have Lost Millions of Metric Tons of Ice

Chelsea Harvey and E&E News

**EARTH**

World's Largest Iceberg Breaks Off of Antarctica

Ben Turner and LiveScience

**EARTH**

Antarctica's Ice Shelves May Be at Growing Risk of Collapse

Chelsea Harvey and E&E News

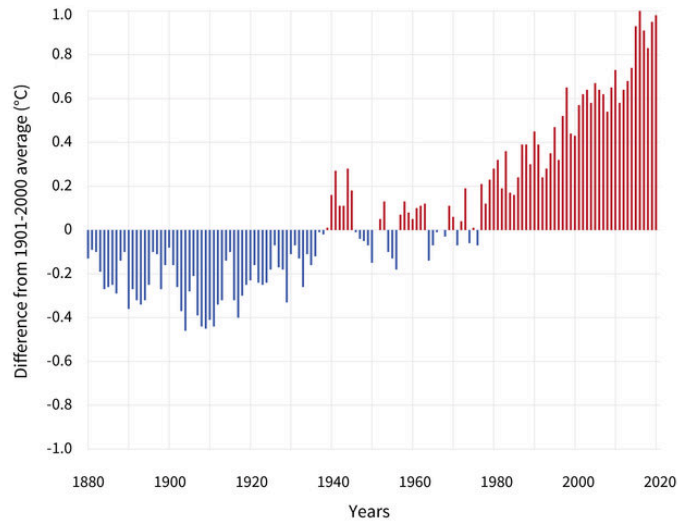
There is still some uncertainty about the full volume of glaciers and ice caps on Earth, but if all of them were to melt, global sea level would rise approximately **70 meters (approximately 230 feet)** flooding every coastal city on the planet.

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# The Earth is Clearly Warming

Global Average Surface Temperature



Yearly surface temperature compared to the 20<sup>th</sup>-century average from 1880–2020. Blue bars indicate cooler-than-average years; red bars show warmer-than-average years. NOAA Climate.gov graph, based on [data](#) from the National Centers for Environmental Information.

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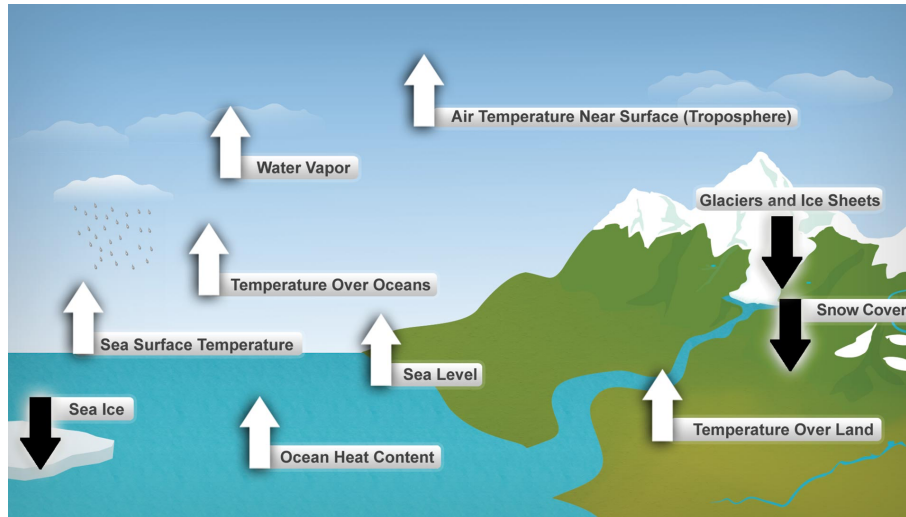
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# Impacts of Climate Change



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## Global Warming Indicators

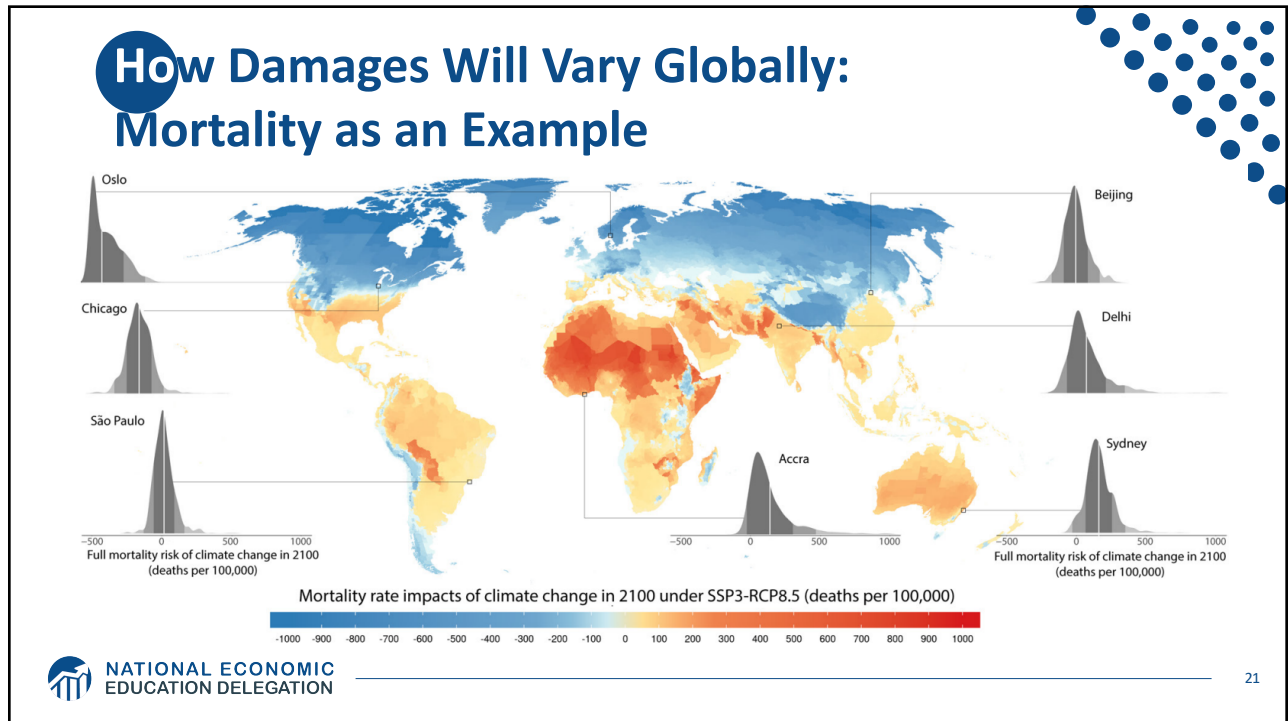


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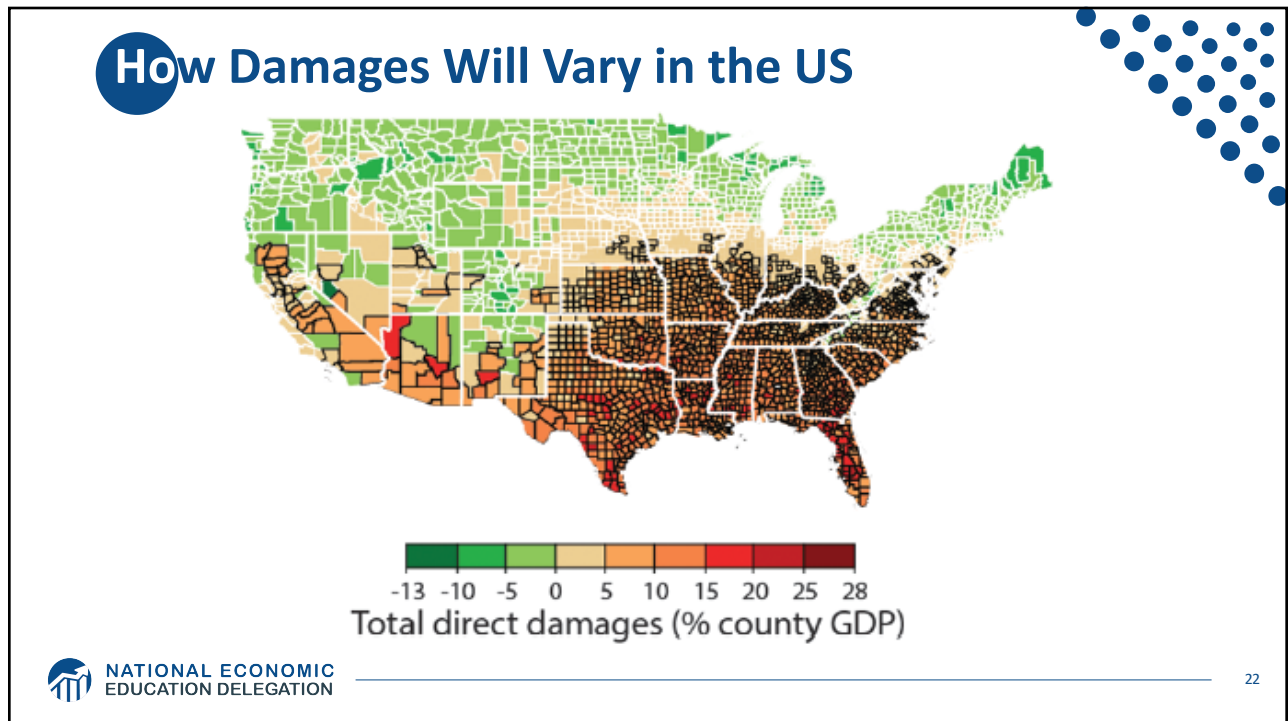
## How These Impacts Affect Humans

- 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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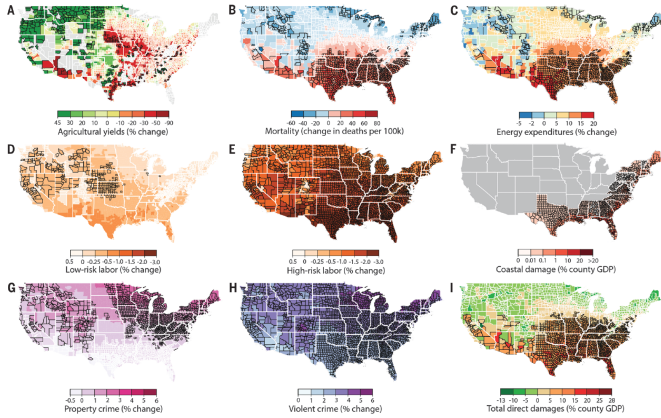


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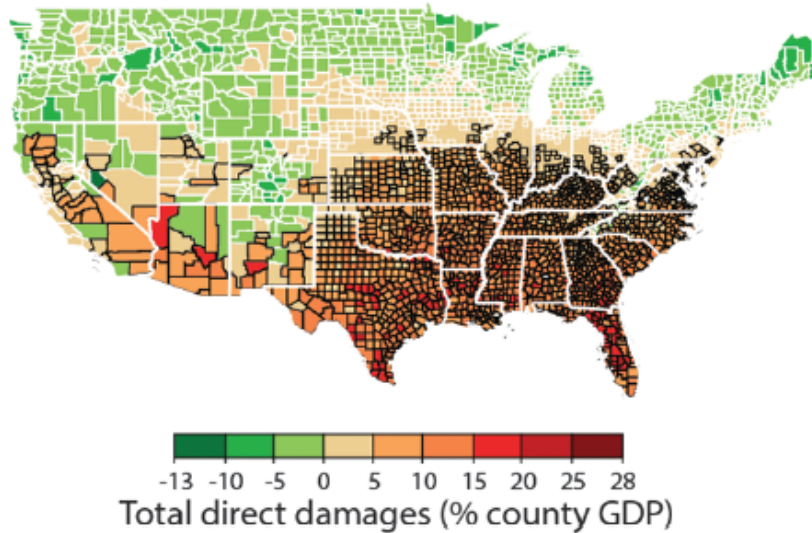
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# Projected Effects Vary Across the U.S. but Are Estimated at 1.2% of GDP per 1C Increase



**Fig. 2. Spatial distributions of projected damages.** County-level median values for average 2080 to 2099 RCP8.5 impacts. Impacts are changes relative to counterfactual "no additional climate change" trajectories. Color indicates magnitude of impact in median projection; outline color indicates level of agreement across projections (thin white outline, inner 66% of projections disagree in sign; no outline, ≥83% of projections agree in sign; black outline, ≥95% agree in sign; thick white outline, state borders; maps without outlines shown in fig. S2). Negative damages indicate economic gains. **(A)** Percent change in yields, area-weighted average for maize, wheat, soybeans, and cotton. **(B)** Change in all-cause mortality rates, across all age groups. **(C)** Change in electricity demand. **(D)** Change in labor supply of full-time-equivalent workers for low-risk jobs where workers are minimally exposed to outdoor temperature. **(E)** Same as (D), except for high-risk jobs where workers are heavily exposed to outdoor temperatures. **(F)** Change in damages from coastal storms. **(G)** Change in property-crime rates. **(H)** Change in violent-crime rates. **(I)** Median total direct economic damage across all sectors [(A) to (H)].

# How Damages Will Vary in the US



# Most Vulnerable People and Places

- Tropical areas
- Low-lying coastal areas
- Low-income people

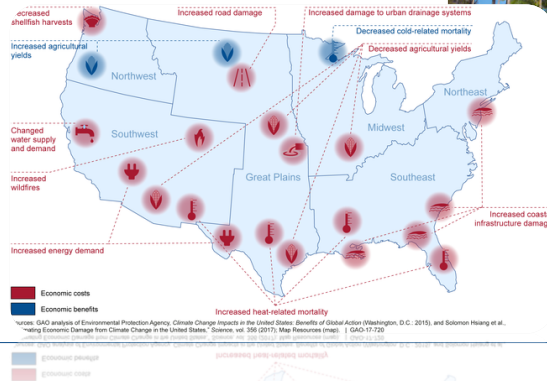
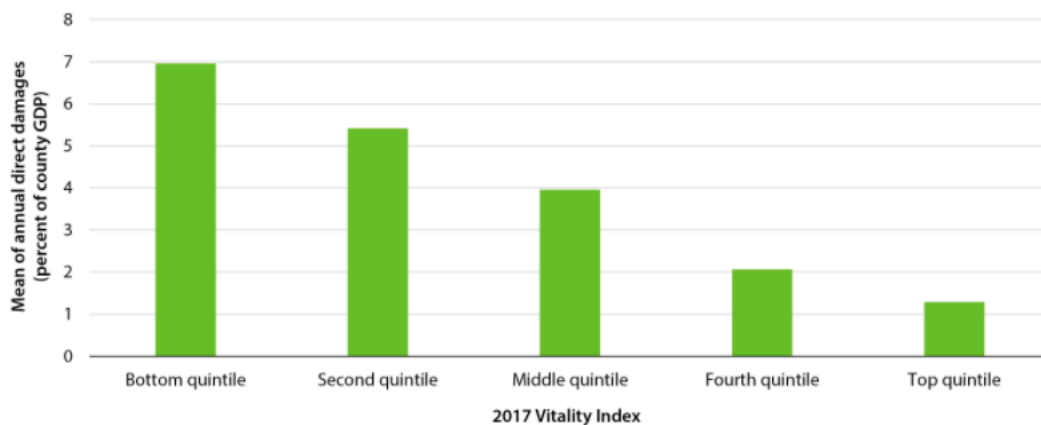
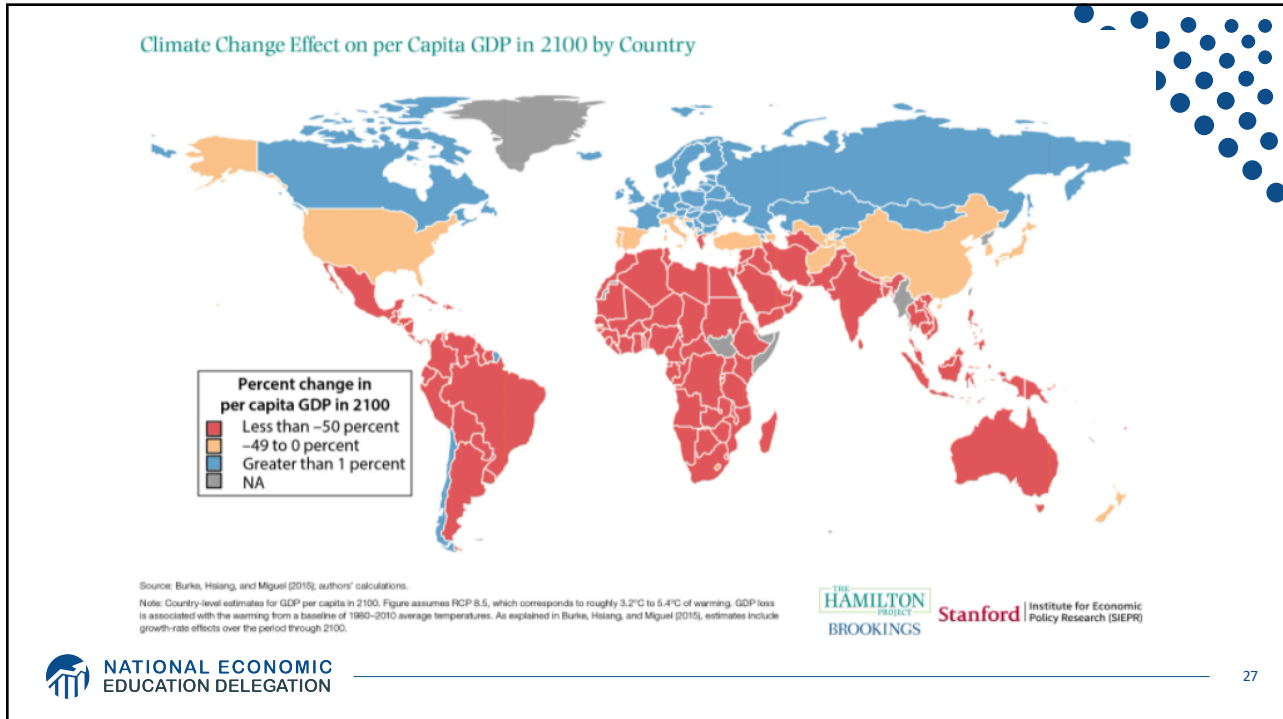


FIGURE 2. Economic Damages to U.S. Counties from Climate Change in 2080–99 by Quintile of Economic Vitality Index



Source: Hsiang et al. 2017; Nunn, Parsons, and Shambaugh 2018; authors' calculations.  
 Note: Vitality quintiles are population-weighted. Figure assumes the mean estimate for average annual GDP loss during 2080–99 under RCP 8.5, which corresponds to roughly 3.2°C to 5.4°C of warming relative to preindustrial levels.





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# Economics & Climate Change

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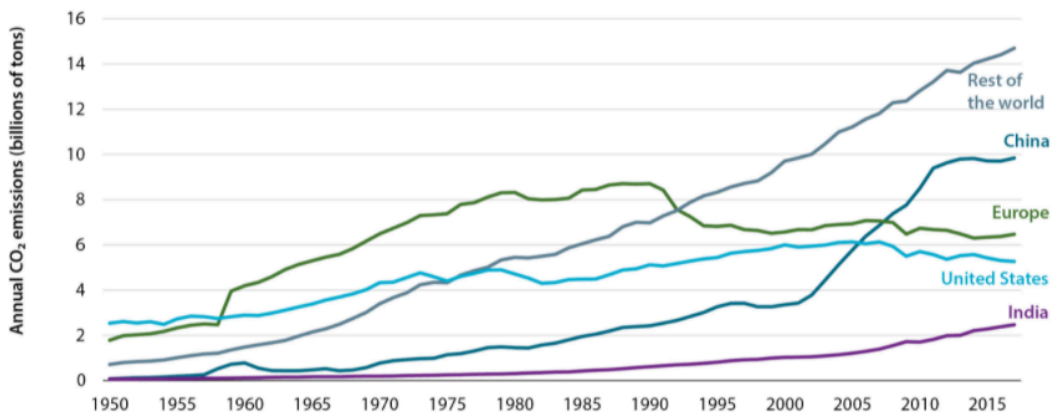
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# A Climate Change Ladder

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

# Sources of the Global Flow of Emissions

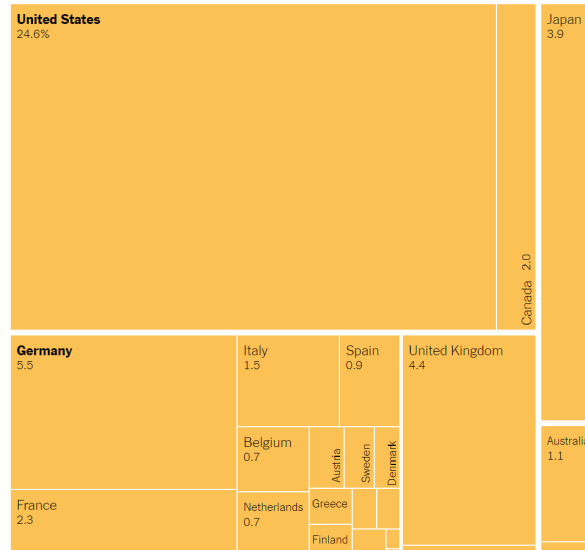
FIGURE D.  
Annual CO<sub>2</sub> Emissions by Geographic Region, 1950–2017



Source: Fritsch and Roser 2017; authors' calculations.  
Note: "Europe" includes all 50 member countries as determined by the United Nations. "Rest of the world" includes all countries not in another group.

# Sources of the Global Stock of Emissions

23 rich, developed countries are responsible for half of all historical CO<sub>2</sub> emissions.



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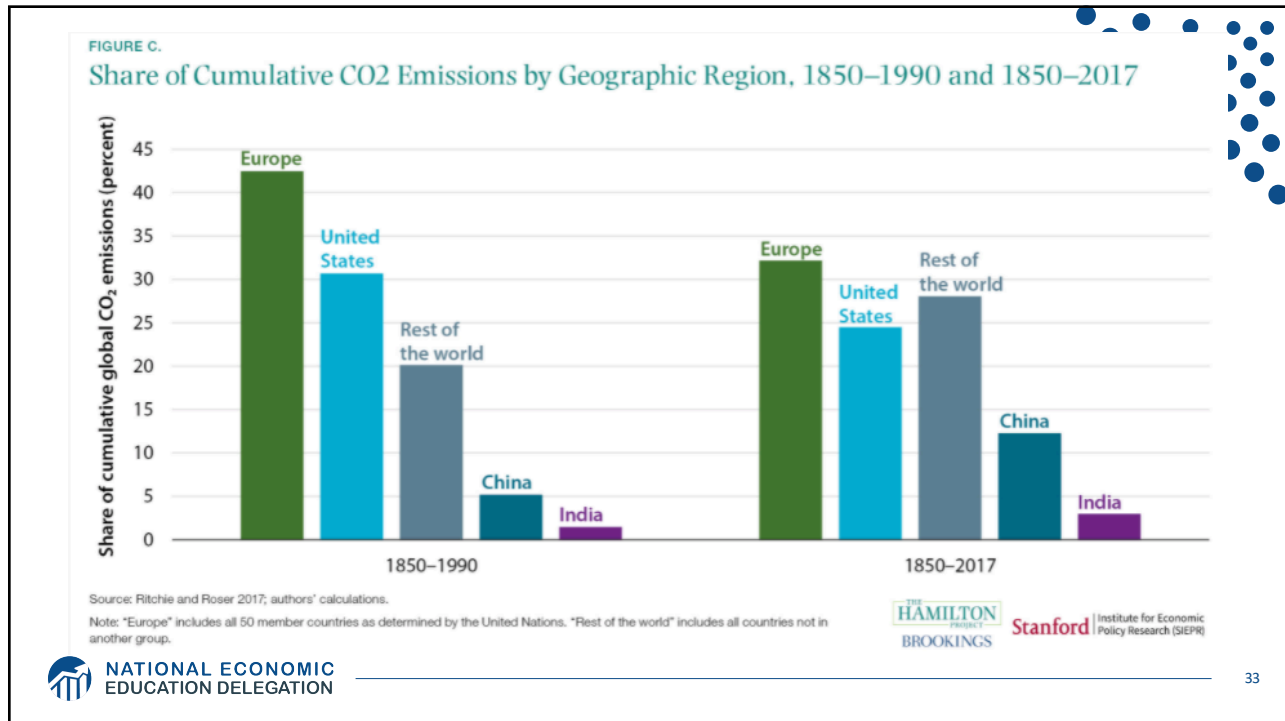
# Sources of the Global Stock of Emissions

More than 150 countries are responsible for the other half.

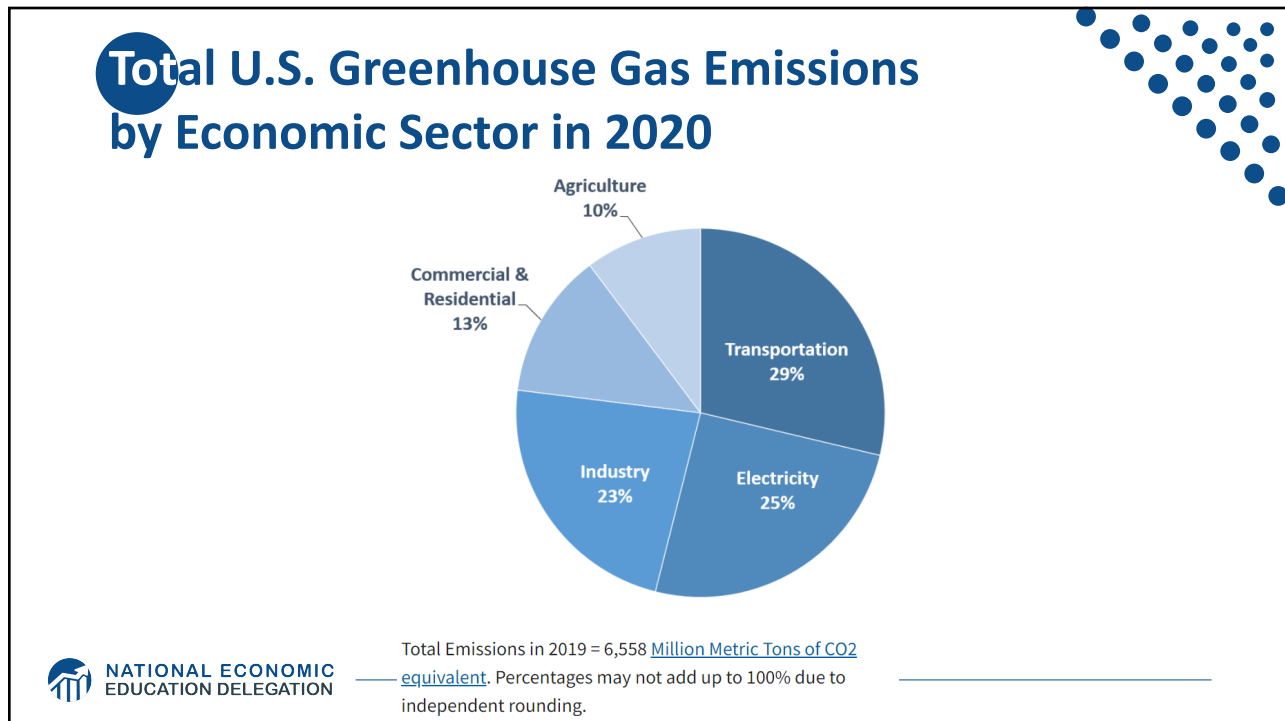


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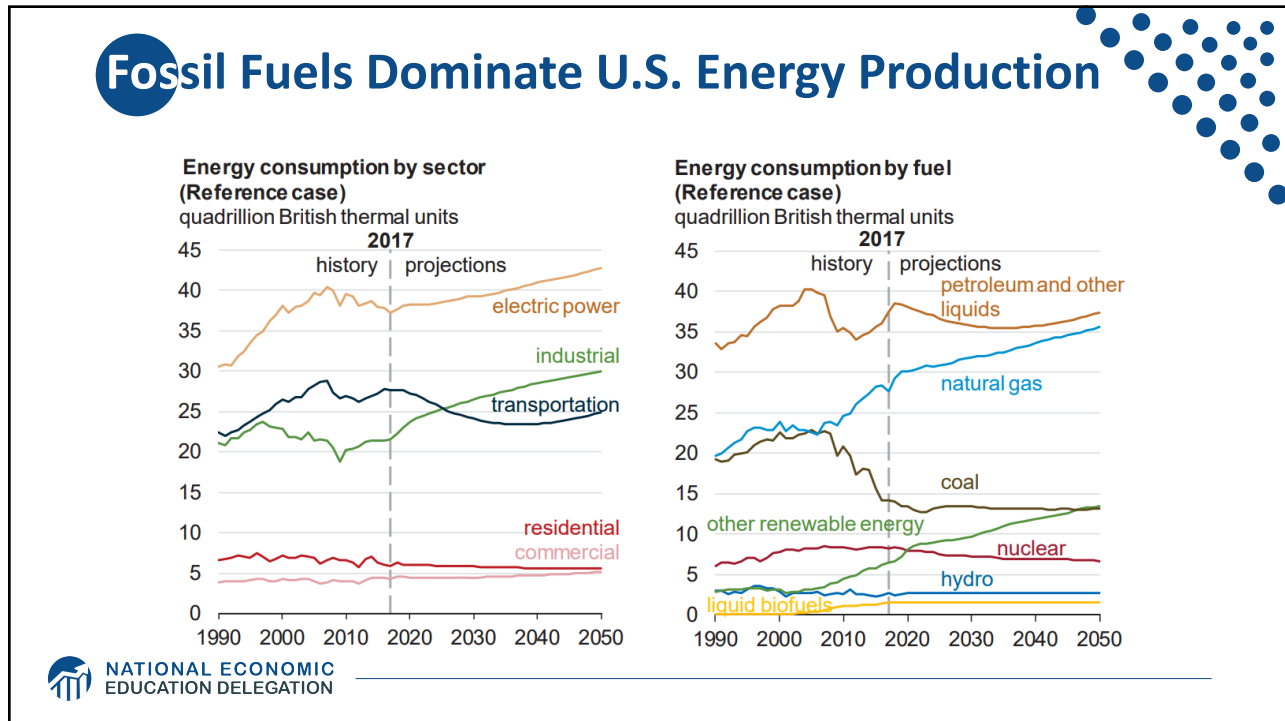




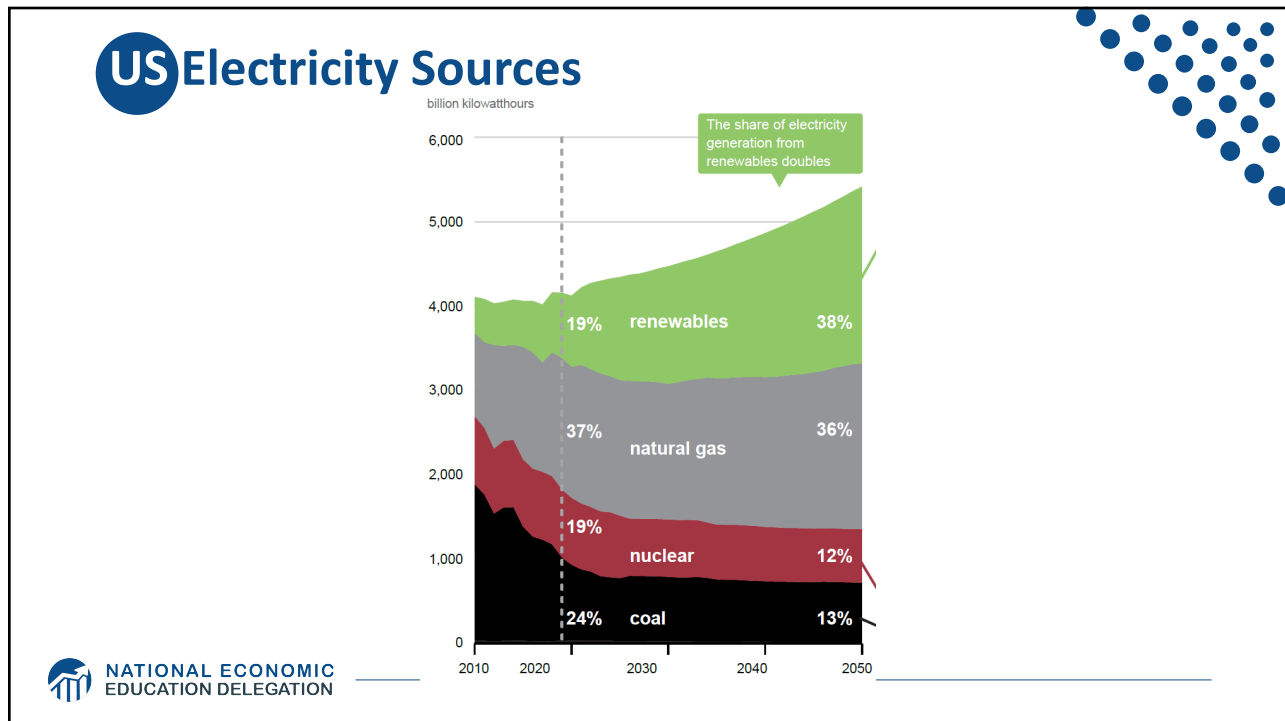
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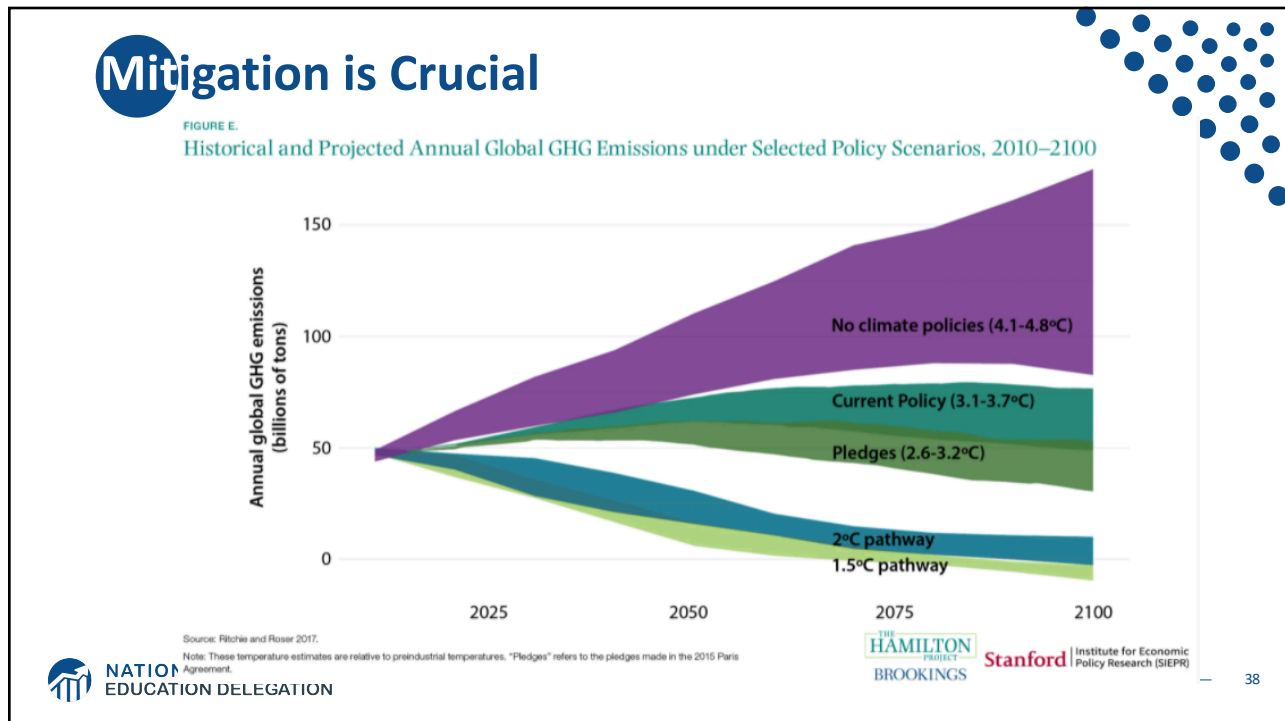
# A Climate Change Ladder

- Emissions
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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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## How Much Pollution Does Society Want? Analogy: How Many Oranges Does Society Want?

- People grow and sell oranges for a price that at least covers costs (*supply*).
- People will not pay more for them than what they consider to be their value (*demand*).
- Prices let *supply* and *demand* balance out. The price settles where:

# of oranges people want to sell = # of oranges people want to buy

- This is the “right” number of oranges for society.
- Prices reflect scarcity and the social value of the resource.



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## The First Theorem of Welfare Economics

...is that private markets are perfectly efficient on their own, with no interference from government, provided certain conditions are met.

**Economic Efficiency:** When the sum of the profits of buyers and the profits of sellers is maximized.

\*You can't make anyone better off without making someone worse off.



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## What are "certain conditions"?

No public goods

No information problems

No externalities

No transaction costs

No taxes

No common property

No monopoly buyers or sellers

No increasing returns to scale

No other 'distortions' between the costs paid by buyers and the benefits received by sellers.



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## Characteristics of Goods

**Excludable:** Goods that you can exclude people from using.

**Rival:** One person's use of the good diminishes other's ability to use the good.

**Public Goods (Not Rival or Excludable):** Benefits additional users at no cost to society.

**Common Resources (Rival, but not Excludable):** Common property, or open access resources, where anyone can extract or harvest the resource freely and no one recognizes the full cost of using the resource.



## Characteristics of Goods & Environmental Economics

**Externalities:** some costs or benefits of producing, consuming, or disposing of a good or service are *external to the market*.

**Missing Markets Problem:** some goods (or inputs) into production are not sold on a market. Firms and individuals then sometimes value the good at what they pay for it, \$0, instead of what it is worth.



## Examples of Externalities

### • Negative Externalities:

- Heating your house
- Smoking
- Getting a dog
- Pig farming

### • Positive Externalities

- Education
- Growing apples
- Getting a vaccination
- Basic scientific research



## Pigouvian Taxes

### • Internalize negative externalities.

- Make the buyers of the good that produces an externality pay for the externality.
  - o Creates a market of sorts for the externality.
    - Government is the caretaker of clean air, for example.
    - Cigarette's pollute the air, so smokers pay the government for the right to pollute the air.

### • It does this by equalizing “marginal social cost (MSC)” with “marginal social benefit (MSB)”.

- With no externality:  $MSB = MSC$
- With a negative externality:  $MSB < MSC$ 
  - o My actions cost society more than I am paying to undertake them.



## Marginal Social Cost and Social Benefit?

- **Marginal:** refers to the costs and benefits of the last unit sold.
- **Marginal Cost (MC):** refers to the cost of making the last unit sold.
- **Marginal Benefit (MB):** refers to the value the consumer puts on buying the last unit.
- **Social cost:** the impact, in dollar terms, of consuming the last unit sold.
- With a negative externality:
  - $MSB = MB$
  - $MSC = MC + \text{Social cost}$

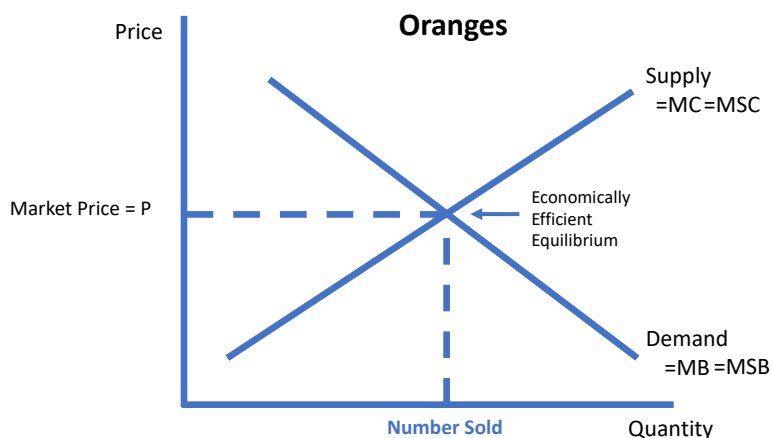


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## How Does A Pigouvian Tax Work?



A market with  
no externalities.

$MSC = MC$   
 $MSB = MB$   
 $MSB = MSC$

**No Pigouvian  
tax is necessary.**

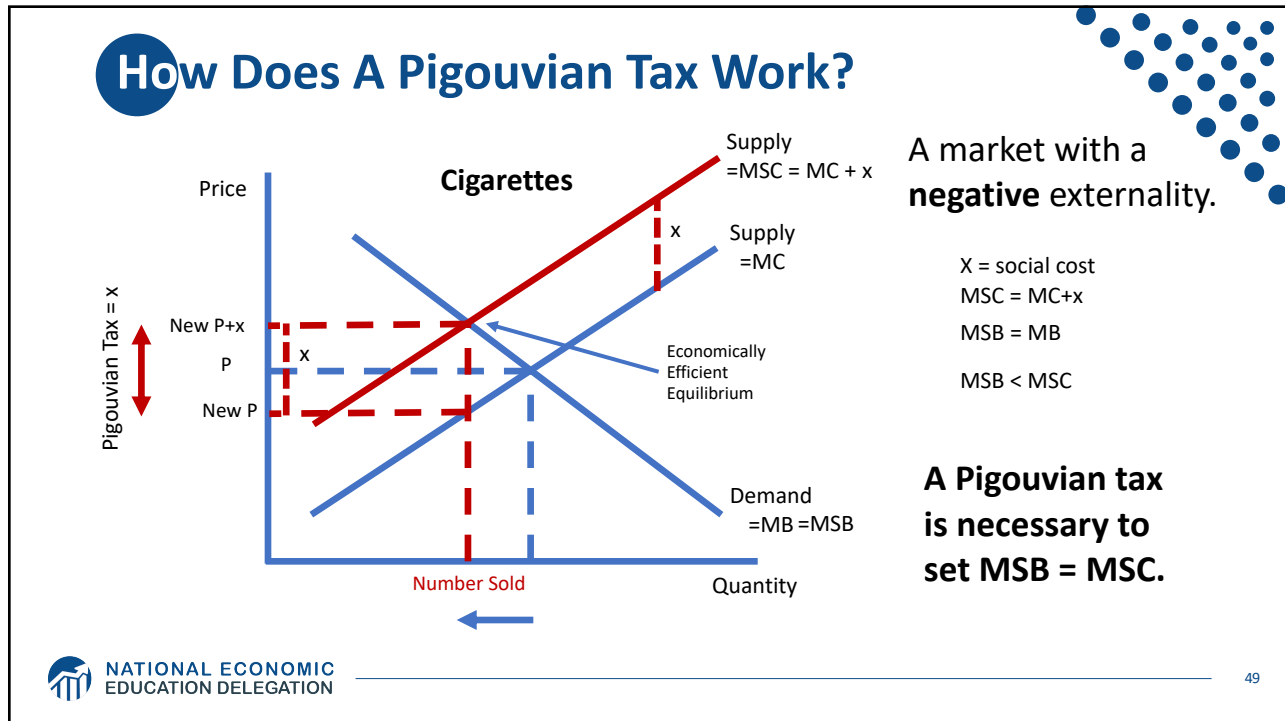


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## How Does A Pigouvian Tax Work?

- 1) A Pigouvian tax raises the cost of buying the item.
- 2) The higher cost results in less of the item being purchased.
- 3) With lower consumption, comes less of the externality.

**Key:** Consumer is now paying for all of the costs associated with the good.

**Note:** the tax **REDUCES** the amount of the externality. It does not eliminate it.

How much of a cost should we bear to get rid of a \$5 externality?


**Answer: \$5**

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# Electricity Is Different From Oranges

- Many sources of electricity generate pollution.
- Pollution is an **EXTERNALITY**:
  - a side effect (cost or benefit) that affects someone else when something is bought or sold.
  - This is a *market failure*.
- The price of electricity does not reflect all of the costs.
  - Electricity is too cheap.
  - There is too much pollution.

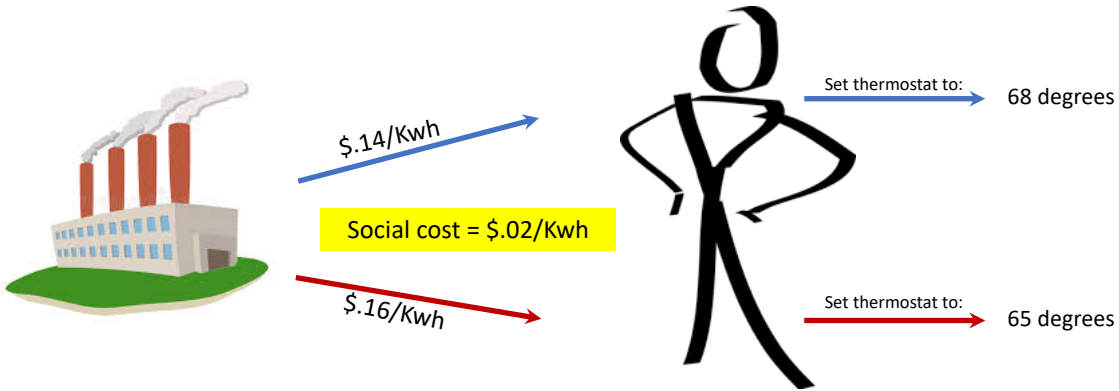


The illustration shows a power plant on the left with a large plume of black smoke rising from its chimney. This smoke drifts to the right, where it is shown as a dark cloud over a house. Two lightning bolts strike the house, symbolizing the negative impact of pollution on the environment and human health.

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# Addressing a Negative Externality



The diagram illustrates the internalization of a negative externality. On the left, a factory icon is shown. A blue arrow points from the factory to a person icon, labeled "\$.14/kwh". A red arrow points from the factory to the person, labeled "\$.16/kwh". A yellow box in the center contains the text "Social cost = \$.02/kwh". On the right, the person icon has two arrows pointing to thermostat settings: a blue arrow labeled "Set thermostat to: 68 degrees" and a red arrow labeled "Set thermostat to: 65 degrees".

The social cost of \$.02/kwh has been INTERNALIZED.

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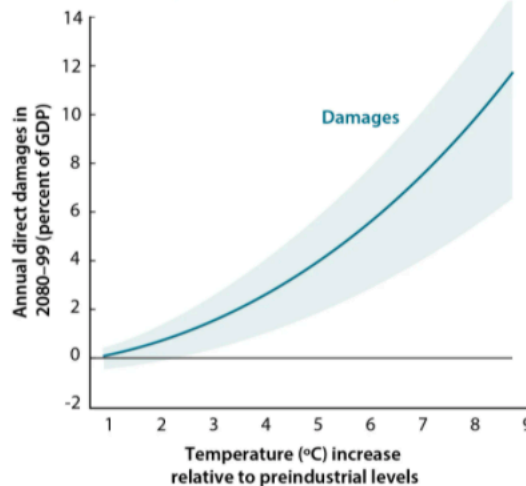
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# Social Cost of Carbon

- The expected cost of damages from each unit of greenhouse gas emissions.
- Current EPA estimate: ~\$51 per metric ton of CO<sub>2</sub> (but estimates vary a lot!)
  - About \$157/car per year.
  - \$32 Billion for all vehicles in the US.
- Reduce emissions until the cost of reducing emissions is greater than \$51 per metric ton.
- Price of emissions rises with level of emissions in the atmosphere.



FIGURE 1.  
U.S. Economic Damages from Climate Change in 2080–99 by Temperature Increase



Source: Hsiang et al. 2017.  
Note: The shaded area represents a 90 percent confidence interval around the central estimate for a given temperature increase. Costs associated with mitigation are excluded.

## Pros and Cons of A Pigouvian Tax

### • Pros:

- **Fosters market efficiency:**
  - Pigouvian taxes promote market efficiency by incorporating the additional costs imposed by negative externalities.
- **Discourages harmful activities:**
  - In certain cases, Pigouvian taxes may effectively discourage the activities that lead to negative externalities. For example, the introduction of a carbon tax may place a significant burden on a company that produces substantial emission gases. Therefore, a company may decide to transfer to operations that produce fewer emission gases.
- **Generates additional government revenue:**
  - Pigouvian taxes generate additional revenues for the government. The additional funds may be used to subsidize initiatives and programs that will further challenge negative externalities.



## Pros and Cons of A Pigouvian Tax

### • Cons:

- **Hard to measure:**
  - In theory, Pigouvian taxes must be equal to the costs generated by the negative externality. However, in the real world, the precise measurement of such costs is not always possible. Thus, in practice, the taxes are less effective than in theory.
- **Political issues:**
  - The imposition of Pigouvian taxes is frequently associated with political problems. Government attempts to introduce such taxes generally face resistance from lobbyists who support parties that can be affected by the taxes (e.g., tobacco producers). Therefore, such taxes are not always an optimal solution from a political perspective.



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### **Available** NEED Topics Include:

- Coronavirus Economics
- US Economy
- Climate Change
- Economic Inequality
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# Outline

- Climate change science
- Impacts of climate change
- Economics of responding to climate change
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- Policy in action

# Climate Change: Week 2

## A Climate Change Ladder

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



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## Adaptation Reduces Damages

- Human *adaptations* are costly actions that can reduce damages from climate change.
- The **net cost to society** is the **cost of adaptation** plus the **cost of the remaining damages**.
- People will take some actions on their own, up to the point where they find it worthwhile.
- Some responses require government involvement: large-scale actions or actions with shared benefits.
- Adaptation is already underway.



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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.



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## 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**
- **Supporting low-income and vulnerable populations**
- **Moving residents of a town**



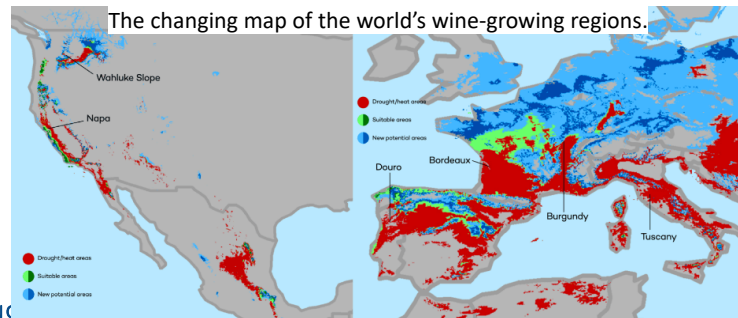
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## Market Based Adaptation

- **Prices and costs influence behavior.**
  - Where to live.
  - Where/when/what to plant.
- **Avoid barriers to market adjustment.**
  - Trade barriers, immigration restrictions, federal flood insurance, agricultural subsidies, and zoning regulations.



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## A Climate Change Ladder

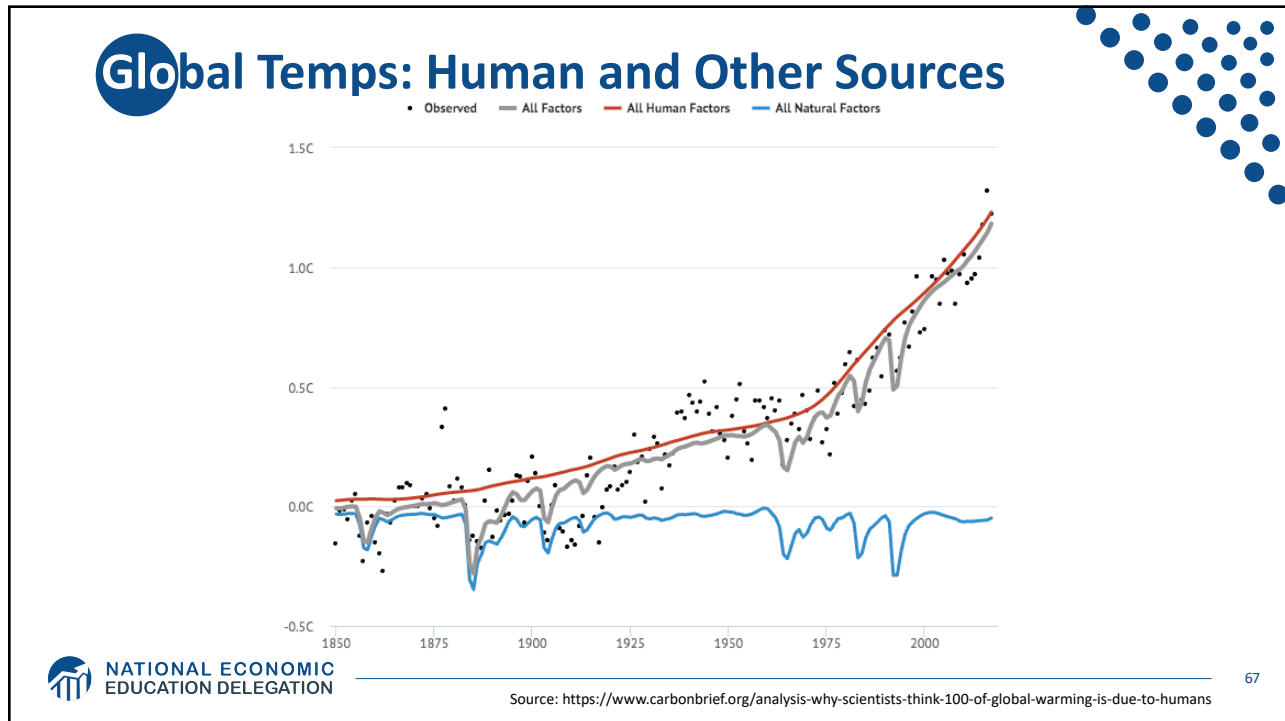
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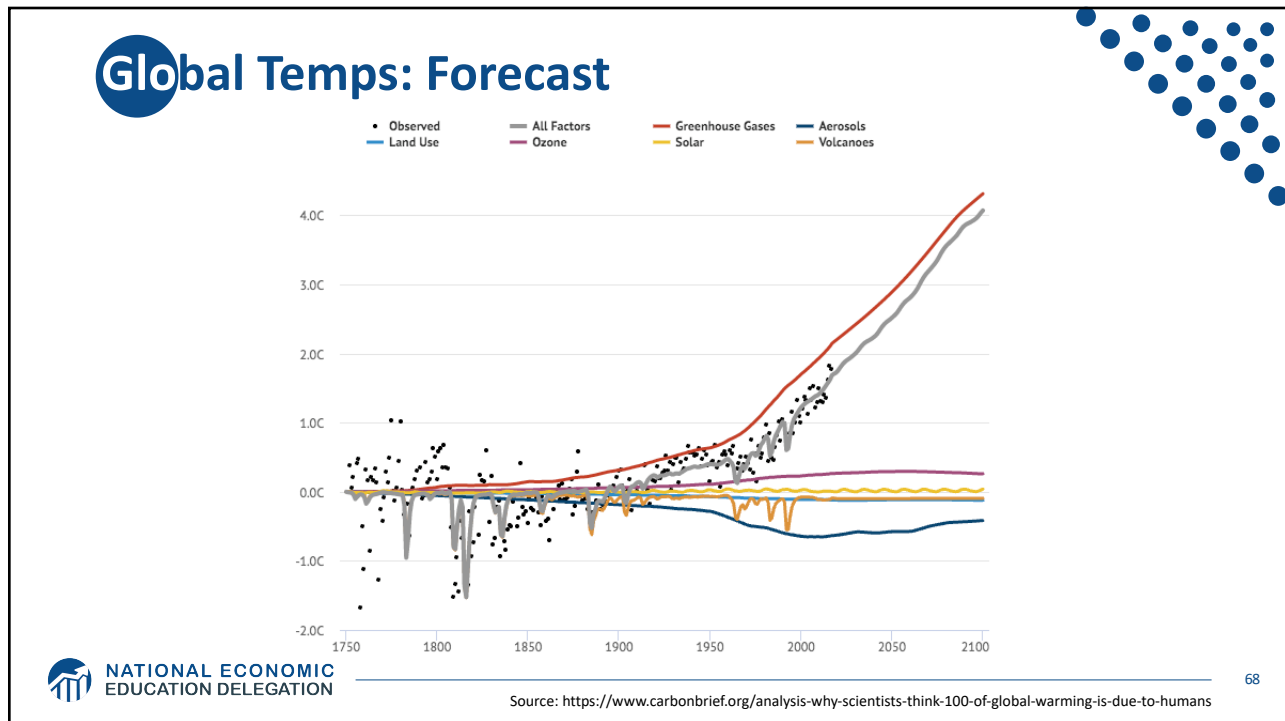
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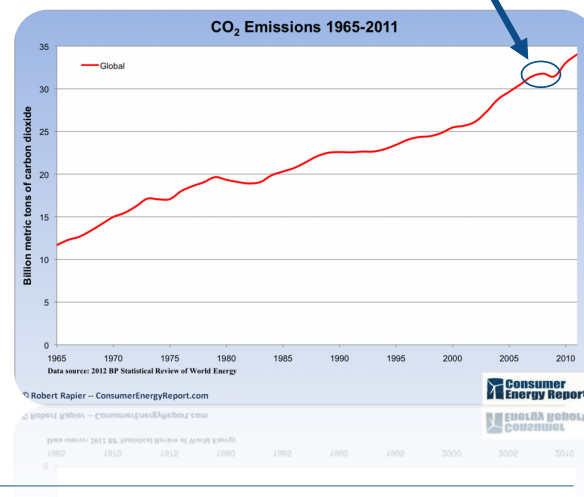
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## International Climate Policy Goals

- **Intergovernmental Panel on Climate Change (IPCC)**
  - Global effort to fight climate change
  - Reports on consensus of climate science, including economics
- **IPCC report in 2007:**
  - Recommended goal: < 2 degrees C (3.6 degrees F)
  - Industrialized countries should reduce GHG emissions between 25% and 40% below 1990 levels by 2020.
- **2016 Paris Agreement:**
  - Basic goal of 2 degrees C: requires 40-70% GHG reduction 2010 → 2050
  - Reach goal of 1.5 degrees C: requires 70-95% GHG reduction 2010 → 2050
- **IPCC report in 2018:**
  - Temperature has already increased by 1.0 degrees C - Recommended: < 1.5 C

## Recent Progress on Climate Goals

- **IPCC's Fifth Assessment Report (2014)**
  - Goals from previous report (2007) were met!
  - ... but mainly because of the Great Recession...
  - ... which is not the preferred method of reducing emissions.



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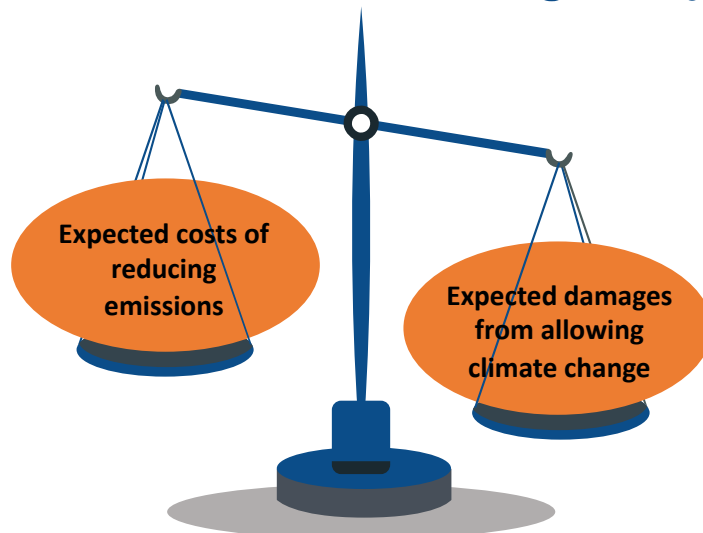


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## How Economists Decide How Much to Fight Climate Change

- Cost Benefit Analysis
- Weigh:



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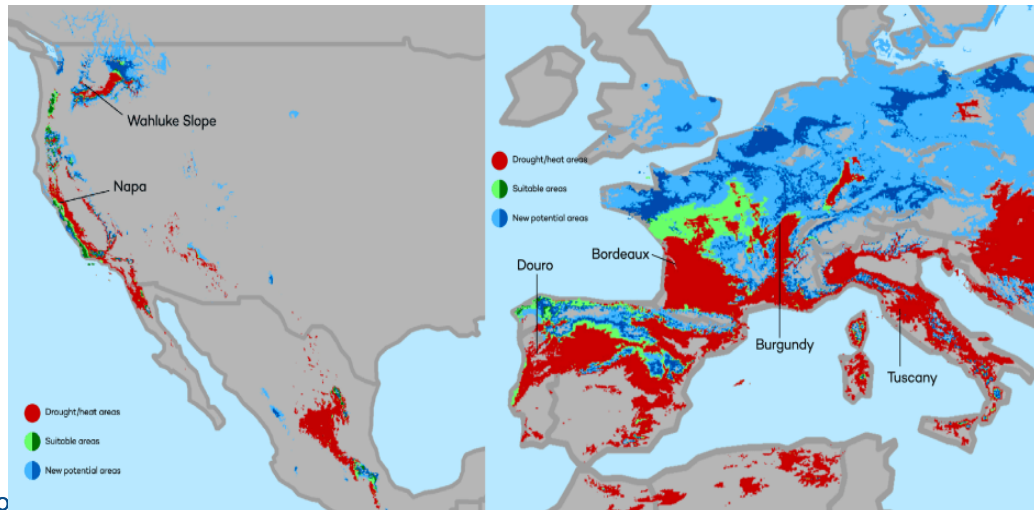
## Cost-Benefit Analysis of Fighting Climate Change

- Most economic models suggest the costs of keeping warming below 2°C are relatively small.
  - Costs amount to **1 - 4% of global 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.**
- **Caveats:**
  - Putting a monetary value on priceless things
  - Inequality
  - Uncertainty and risk



## This is What Precisely Wrong Looks Like

The changing map of the world's wine-growing regions.



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## Air Travel

- **Warmer weather makes air travel more difficult and more costly.**

- Warmer weather means that:
  - o Planes need to be lighter.
  - o Runways need to be longer.
  - o Schedules may need to be adjusted to earlier and later in the day.
- Specific events:
  - o June 2021 – Heat Dome – Seattle/Portland
    - Flights cancelled and delayed, ramp employees can't work.
  - o 2018 – London – many flights cancelled.
  - o 2017 – Phoenix – many flights cancelled.
- It's not just the Middle East anymore.
- Spillover effects onto the rest of the economy.
  - o Business travel as well as shipping of goods.

76

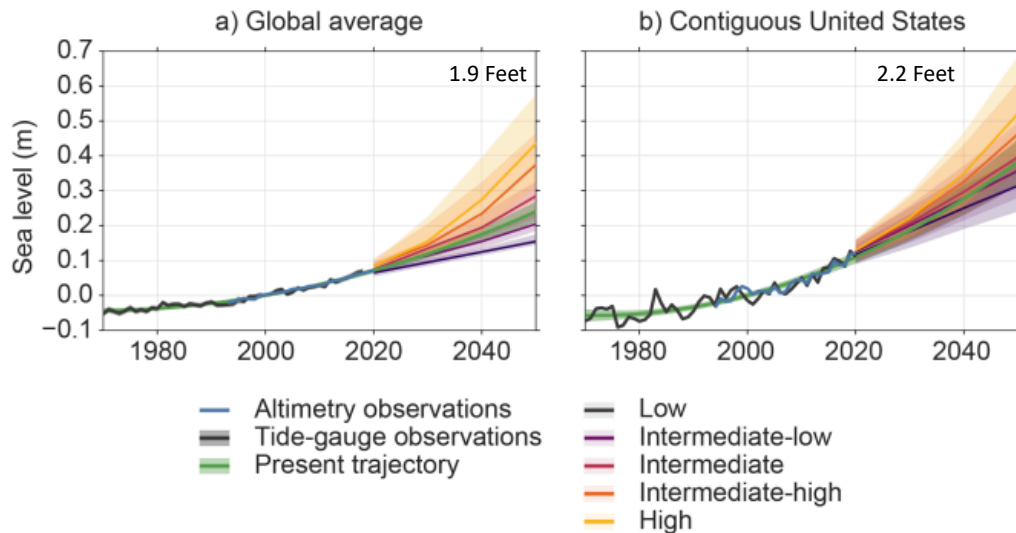
# Extreme Heat Events

1960s	2010s
Average 2/year	Averaged 6/year
	- On average one day longer than in the 1960s.
	- Season for heat waves more than 47 days longer.

And more intense heat waves are on the way.

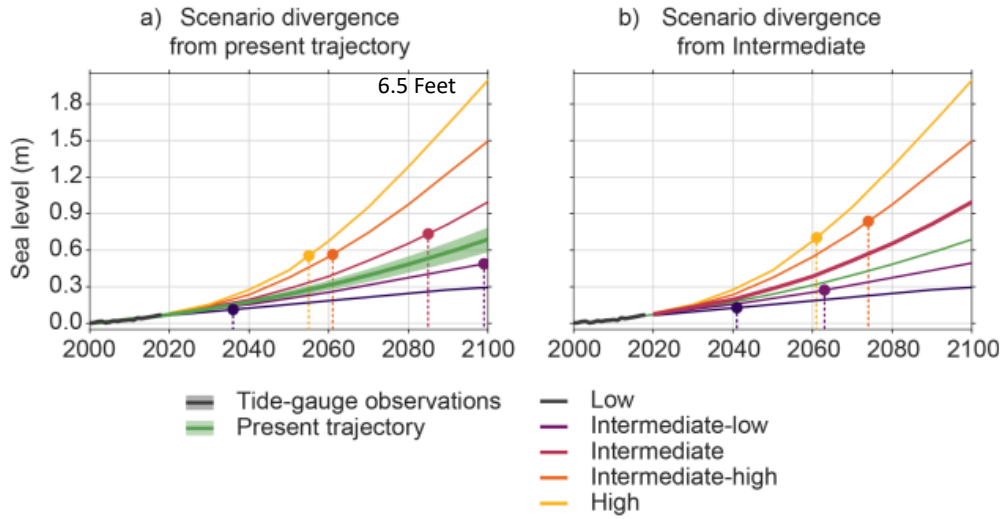
77

# Sea Level Rise – to 2050



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# Sea Level Rise – to 2100



# Silicon Valley is Vulnerable





# Silicon Valley: Facebook's Vulnerability



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# Silicon Valley: In Just A Couple of Decades



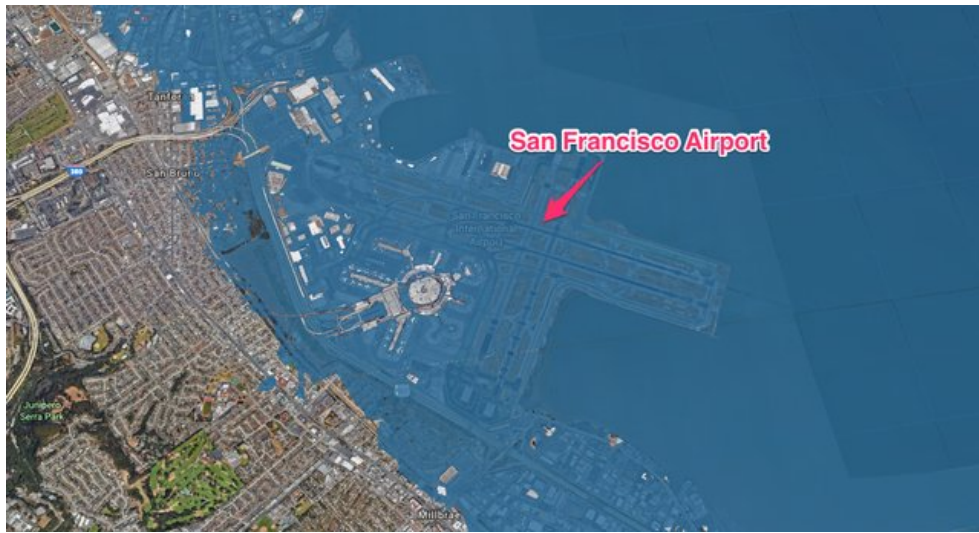
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## Silicon Valley: End of the Century



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## Lots of Infrastructure is Vulnerable



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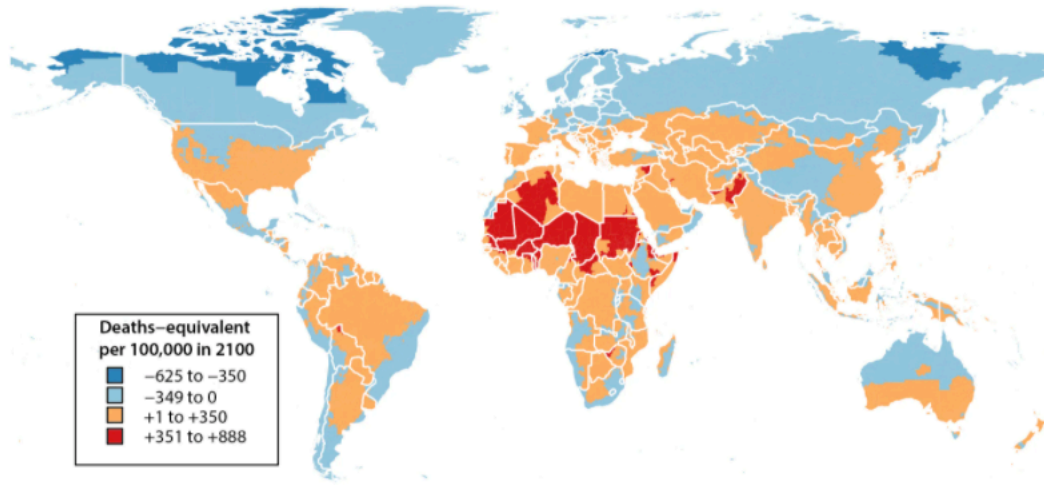
## Downhill Skiing: Sierra Nevadas

- **By the end of the century:**
  - Temperatures will likely rise 6-9 degrees F.
  - Rain-to-snow transition will rise by 1,500 to 3,000 feet.
    - o No snowpack below 6,000 feet.
  - 60% reduction of the snowpack.
  
- **Implications not only for the ski industry, but for water in the Bay Area.**
  - The Sierras are (as of now) a massive water reservoir.

## Food Insecurity

Climate change	Impacts
Increase in average temperature	<ul style="list-style-type: none"> <li>Reduced quantity and reliability of agricultural yield</li> <li>Increased heat stress in livestock</li> <li>Destruction of crops or lowering crop productivity</li> <li>Decline in certain fish stocks due to increased sea temperature</li> </ul>
Change in amount of rainfall	<ul style="list-style-type: none"> <li>Reduced water availability for crop and livestock</li> <li>Heavy reliance on irrigation</li> <li>Poor quality of crops due to deteriorating water quality</li> </ul>
Increased severity of drought	<ul style="list-style-type: none"> <li>Decreased crop yield</li> <li>Increased probability of fire</li> </ul>
Increased intensity of extreme events	<ul style="list-style-type: none"> <li>Soil erosion</li> <li>Increased land degradation and desertification</li> <li>Inability to cultivate land</li> <li>Damage to crops and food stores</li> </ul>

FIGURE 4.  
Mortality Impacts from Climate Change in 2100 by Region



Source: Carleton et al. 2018; authors' calculations.

Note: The map shows impact-region estimates for mortality rates in 2100. Figure assumes the mean estimate under RCP 8.5, which corresponds to roughly 3.2°C to 5.4°C of warming. Negative values refer to lives saved from climate change (e.g., fewer deaths as a result of fewer dangerously cold days).

THE HAMILTON PROJECT  
BROOKINGS | Stanford | Institute for Economic Policy Research (SIEPR)



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<https://www.brookings.edu/research/ten-facts-about-the-economics-of-climate-change-and-climate-policy/>

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## One Estimate of Costs and Benefits



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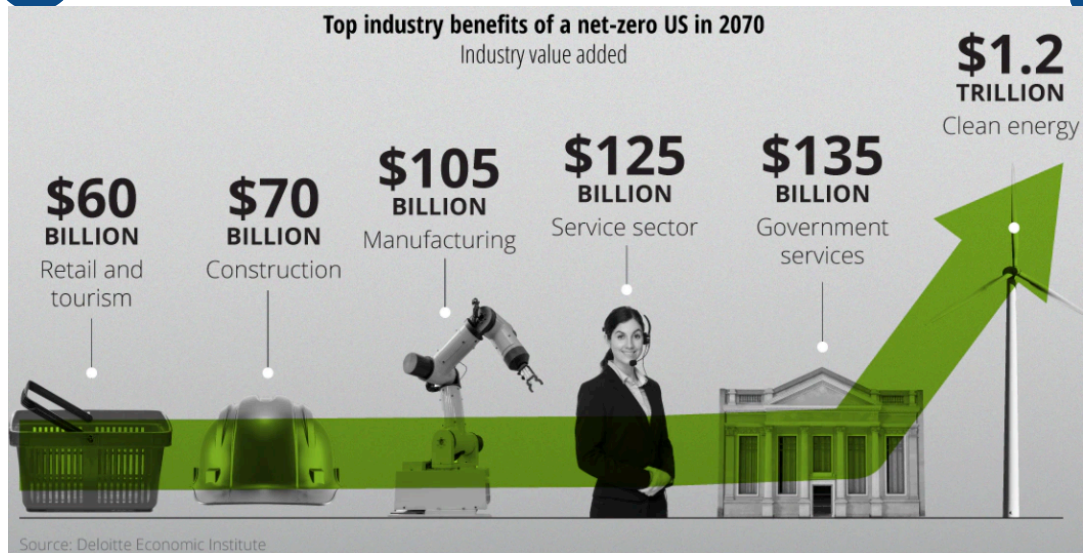
\*Present value of GDP over 50 years

Source: Deloitte Economic Institute

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## Where do the Benefits Accrue?



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## Economic Growth and Climate Change Action Are Compatible

- Abating greenhouse gas emissions is costly...  
... but climate change damages are even more costly.
- Economic growth comes with consequences that we have to deal with, including climate consequences.
- Economies with environmental regulations can still be dynamic.
- Goal: design policies that reach climate goals at the least possible cost.



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# Reducing Emissions: Policy Focused on Mitigation

## **Global Net Emissions** Are What We Care About

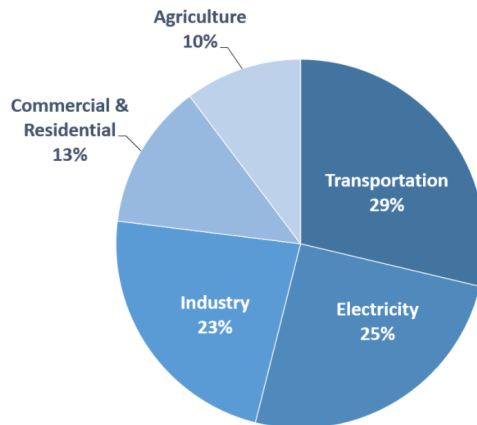
- **For climate impacts, we don't care where they are emitted, only how much**
  - There may be other local impacts
- **Gross emissions (greenhouse gas sources): how much greenhouse gases (including CO<sub>2</sub>) we put out**
- **Greenhouse gas sinks: ways to pull CO<sub>2</sub> out of the air**
  - Existing: oceans, forests
  - Increase sinkage by planting trees, or other measures

## Electricity Is Different From Oranges

- Many sources of electricity generate pollution.
- Pollution is an **EXTERNALITY**:
  - a side effect (cost or benefit) that affects someone else when something is bought or sold.
  - This is a *market failure*.
- The price of electricity does not reflect all of the costs.
  - Electricity is too cheap.
  - There is too much pollution.



## Total U.S. Greenhouse Gas Emissions by Economic Sector in 2020



Total Emissions in 2019 = 6,558 Million Metric Tons of CO<sub>2</sub> equivalent. Percentages may not add up to 100% due to independent rounding.

# 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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## Average Abatement Costs for Selected Policy Options

\$/Ton of Emissions Reduction

		Low estimate	High estimate
<b>Agriculture</b>	Reforestation	1	10
	Agricultural emissions policies	51	67
	Livestock management policies	73	73
<b>Clean energy</b>	Renewable portfolio standards	0	195
	Wind energy subsidies	2	266
	Clean Power Plan	11	11
	Renewable fuel subsidies	102	102
	Low carbon fuel standard	102	2971
	Solar photovoltaics subsidies	143	2151
<b>Energy efficiency</b>	Behavioral energy efficiency	-195	-195
	CAFE Standards	-110	318
	Cash for Clunkers	277	430
	Weatherization assistance program	359	359
<b>Fossil fuel</b>	Methane flaring regulation	20	20
	Reducing federal coal leasing	34	70

Source: Gillingham and Stock 2018; authors' calculations.  
 Note: The values were updated to 2018 dollars using the CPI-U-RS. This table applies a different categorization of selected policy approaches than was used in Gillingham and Stock (2018).

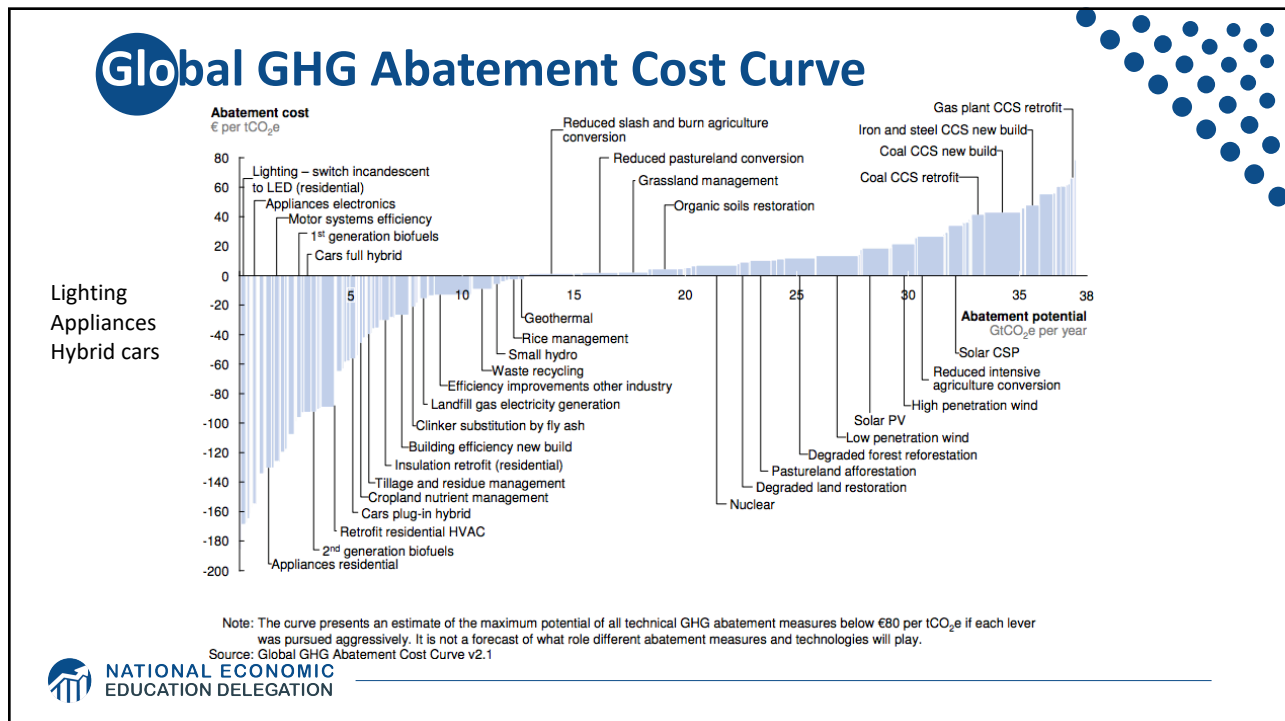


<https://www.brookings.edu/research/ten-facts-about-the-economics-of-climate-change-and-climate-policy/>

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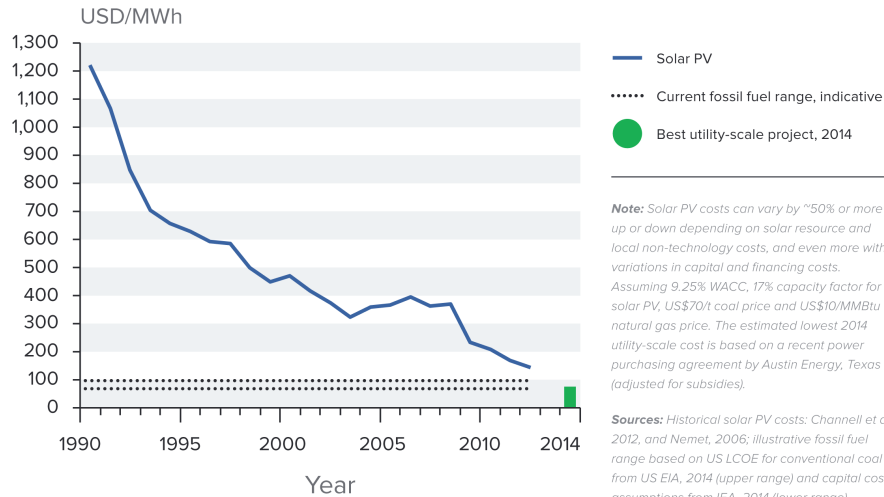
## But Are Costs So Easy to Assess?

- **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**

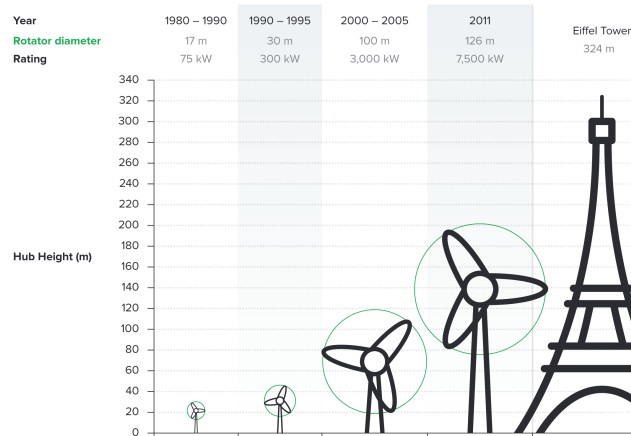
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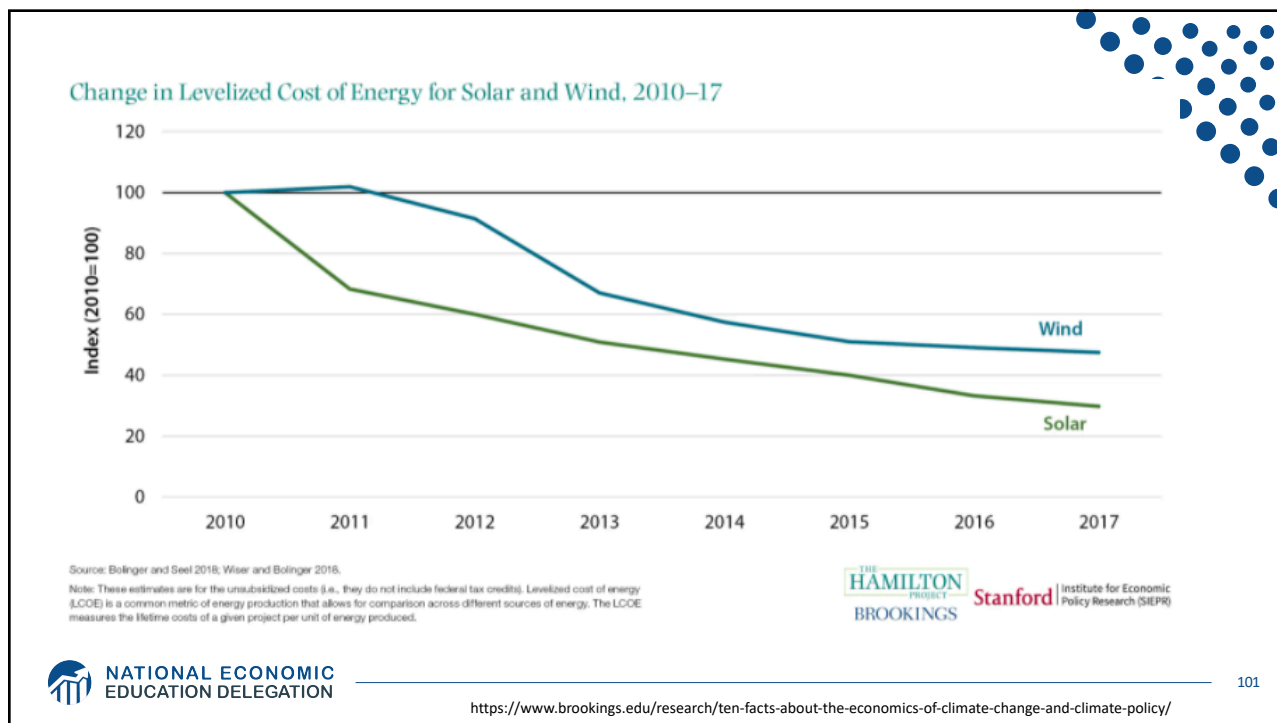
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## Indicative Solar Costs Over Time



## Wind Turbines Have 100 Times More Power Generation Capabilities Than 30 Years Ago





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## Challenges with Renewable Energy

- **It's intermittent - only produced if there is sun or wind.**
- **Energy is needed all day and night, with peak times.**
- **Limited w/o storage.**
  - Creative storage options are under development.

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# Climate Change Policy



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## Policies That Reduce Emissions: Directly

- **Regulation**

- Emissions standards or limits
  - E.g., CAFE standards

- **Market-oriented policies**

- Putting a price on emissions
  - Subsidizing green energy (*e.g.*, feed-in tariffs)
  - Tax or cap & trade



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## How Does a Carbon Tax Work?

- **Activities to be covered are determined.**
- **The price of emissions is determined.**
  - Presumably some relation to the social cost of polluting.
- **Emissions are measured.**
- **Taxes are determined.**
- **Q: What to do with the tax revenue?**



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## How Does Cap and Trade Work?

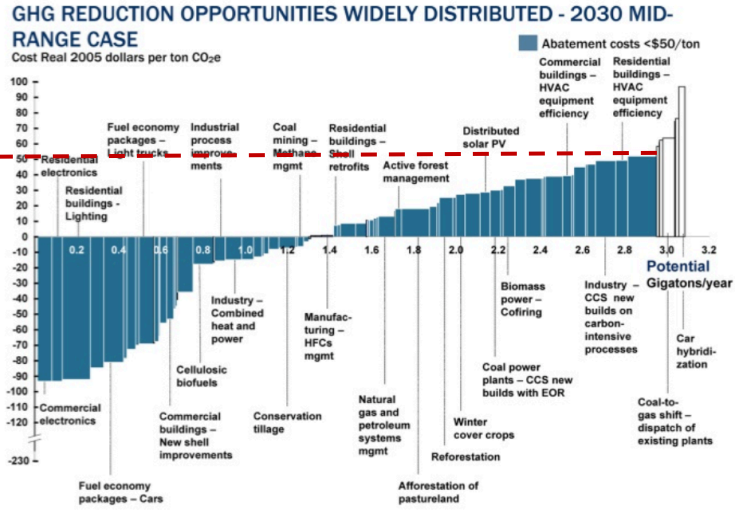
- **Activities to be covered are determined.**
- **Acceptable emissions levels are indicated.**
- **“Permits” that allow acceptable emissions levels are issued.**
  - How?
    - According to historical emissions?
    - Evenly across emitters?
    - Sold at some price?
- **A “market” is developed.**
- **Those desiring to emit will have to buy sufficient permits to accommodate their emissions.**
- **Those wishing to abate will offer their permits on the “market”.**
  - The price of a permit indicates:
    - The benefit of eliminating further emissions.
    - The cost of emitting.
- **Gov’t agency determines equality of permits in possession and emissions.**



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# Putting a Price on Carbon

Suppose a Social Cost Of Carbon of \$50



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# Carbon Prices: the Good and Bad

- **Good:**
  - Provide price signal to lower emissions.
  - They yield low-cost reductions in emissions.
  - They spur innovation in clean technologies.
- **Bad:**
  - Firms might leave to flee regulation.
  - It is necessary to monitor emissions.
  - Potentially regressive
    - o Costs may weigh more heavily on low-income households.



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## Both Policies Work Through Prices



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Full video: <https://www.youtube.com/watch?v=XHK1OBSBpwc>

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## Carbon Tax and Cap & Trade: the Differences

	Carbon Tax	Cap & Trade
--	------------	-------------

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## Carbon Tax and Cap & Trade: the Differences

	Carbon Tax	Cap & Trade
Carbon Price	Certain	Uncertain
Emissions	Uncertain	Certain
Ease of Implementation	May be easier to implement	
Additional concerns	1) Always generates revenue 2) May require legislation to change 3) Predictability	1) Susceptible to lobbying. 2) Only generates revenue if government sells permits. 3) Cap can be changed by regulator. 4) Less certainty over future. 5) Regulations reduce efficacy of Cap & Trade

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## One Other Thing: Cap and Trade vs. Carbon Tax

- **Emissions regulations and Cap and Trade can work at cross purposes.**
  - Regulations that lower emissions from big polluters...
    - Lower the demand for permits
    - Lowers the price of permits
    - Reduces incentives for other industries to cut emissions
- **Regulations can undermine the effectiveness of Cap and Trade.**
- **The same is not true of a carbon tax.**
  - Though regulations might cut tax revenue, revenue is not the goal of the carbon tax.

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## Command and Control vs. Incentive-Based Regulation

- Equity
- Efficiency



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## Command and Control vs. Incentive-Based Regulation

- **Equity**

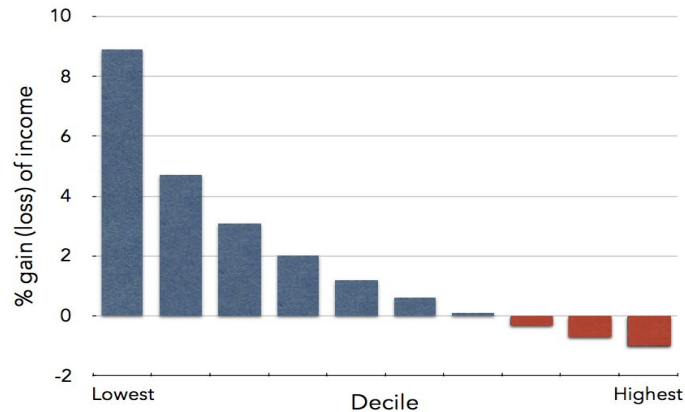
- Both may have regressive impacts (low-income families bear costs that are a larger percent of their incomes vs hi-income families)
  - Cap and trade and carbon tax can generate revenues that can be used to offset the regressivity.
    - E.g.: “carbon dividend”
  - Command and control regulations do not.



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## Revenue Dividend Eliminates Regressivity

### IMPACT OF CARBON DIVIDENDS ON U.S. FAMILY INCOMES



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Source: U.S. Treasury, 2017

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## 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.
  - o Example: CAFÉ Standards vs Carbon Tax
    - Tax is significantly more efficient.
    - Why?



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## Efficiency: CAFÉ vs Carbon Tax

- **CAFÉ = Corporate Average Fuel Efficiency**

- A fuel economy standard mandating that an auto-maker's vehicle fleet must meet minimum fuel economy standards.

- **Horse Race**

- Tax on fuel applies to ALL vehicles, not just new.
- Rebound Effect:
  - o Driving a more efficient vehicle lowers the cost per mile driven
    - leading to more miles driven.
- Slower turnover of inefficient vehicles: higher cost of new.

- **Summary**

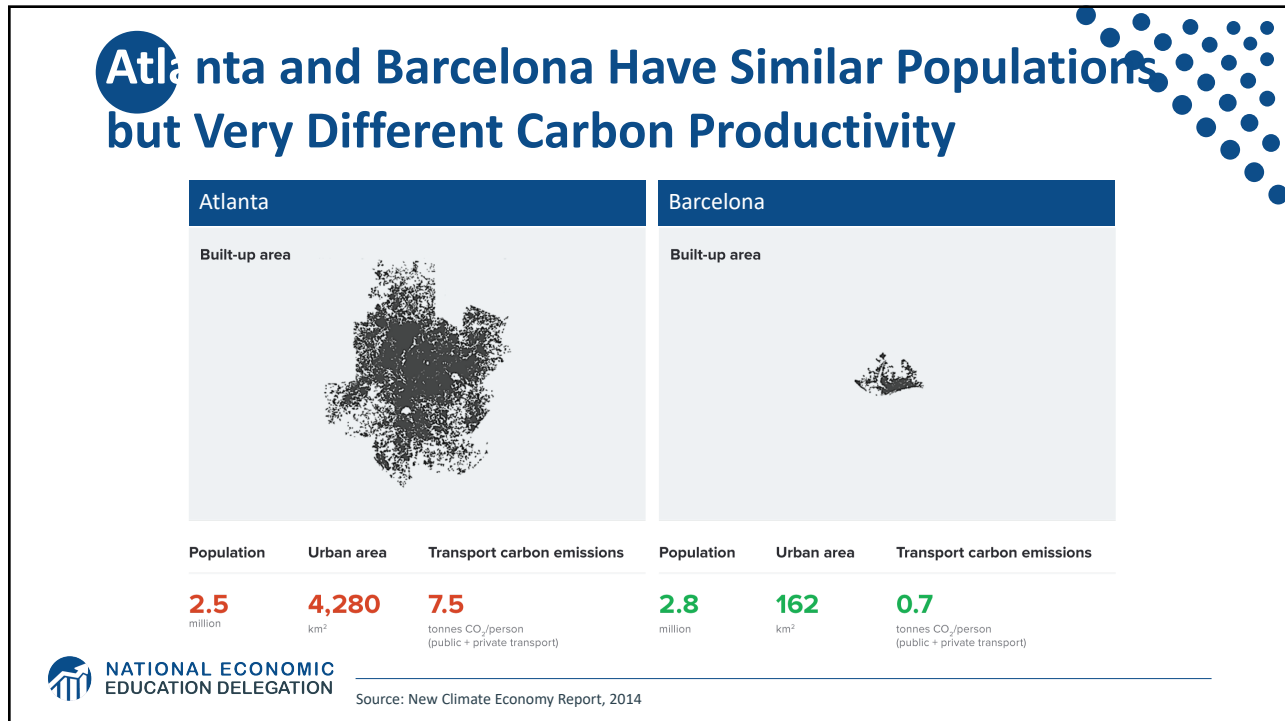
- A given level of emission reductions **costs 3-14 times more with CAFÉ** standards than under a comparable carbon tax.



## Policies That Reduce Emissions: INDIRECTLY

- **Subsidizing R&D**
- **Grid / infrastructure**
- **Energy efficiency mandates and subsidies**
- **Mandating renewable energy (e.g., renewable portfolio standards)**
- **Land use policies**





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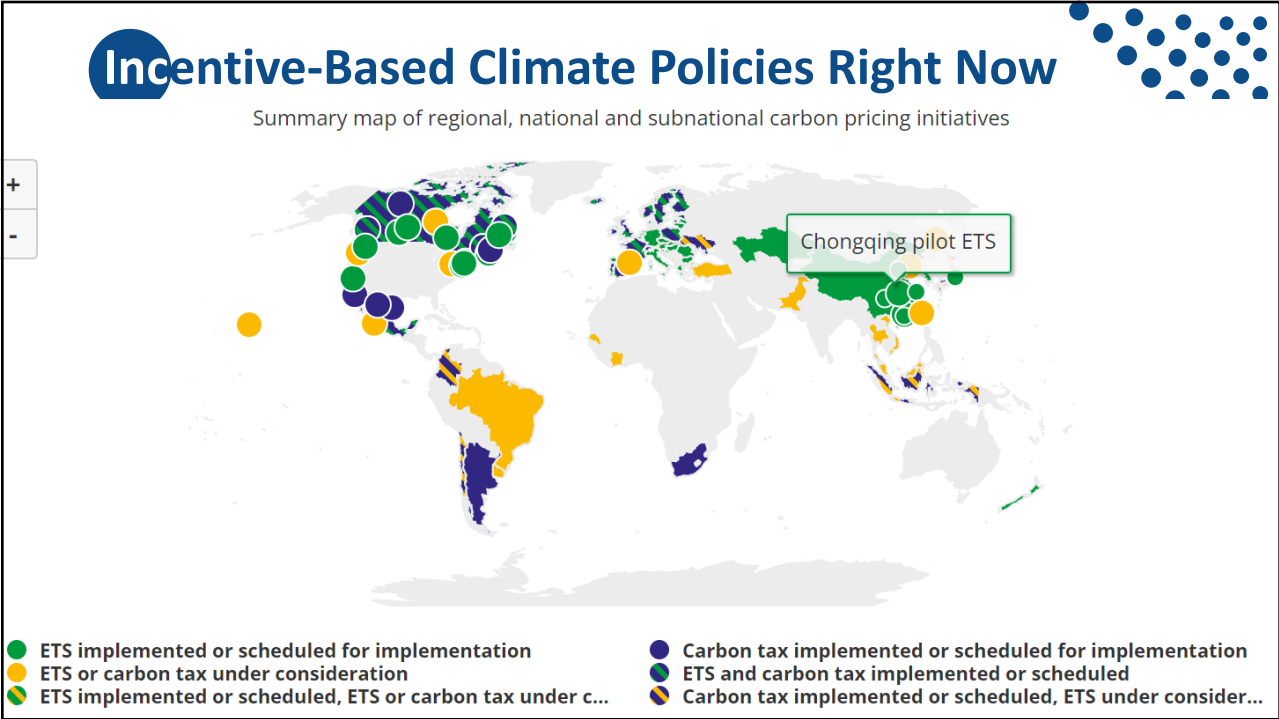


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# Climate Change Policy in Action

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# Cap and Trade

The diagram illustrates the cap and trade system. On the left, a factory with smokestacks emits CO<sub>2</sub>, which is represented by three blue circles with 'CO<sub>2</sub>' inside, connected by a vertical line. On the right, a person in a suit is shaking hands with another person, symbolizing a transaction. Behind them is a folder labeled 'Permits' and a document with 'APPROVED' stamps, representing the trading of emission permits.

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# Cap and Trade Policies Around the World

Summary map of regional, national and subnational carbon pricing initiatives

The world map shows carbon pricing initiatives. Green circles indicate ETS implemented or scheduled for implementation, while yellow circles indicate ETS or carbon tax under consideration. The legend provides details on the status, instrument type, and jurisdiction of these initiatives.

STATUS	
<input type="checkbox"/>	Implemented
<input type="checkbox"/>	Scheduled
<input type="checkbox"/>	Under consideration

TYPE OF INSTRUMENT	
<input type="checkbox"/>	Carbon tax
<input checked="" type="checkbox"/>	ETS
<input type="checkbox"/>	Undecided

TYPE OF JURISDICTION	
<input type="checkbox"/>	National
<input type="checkbox"/>	Regional
<input type="checkbox"/>	Subnational

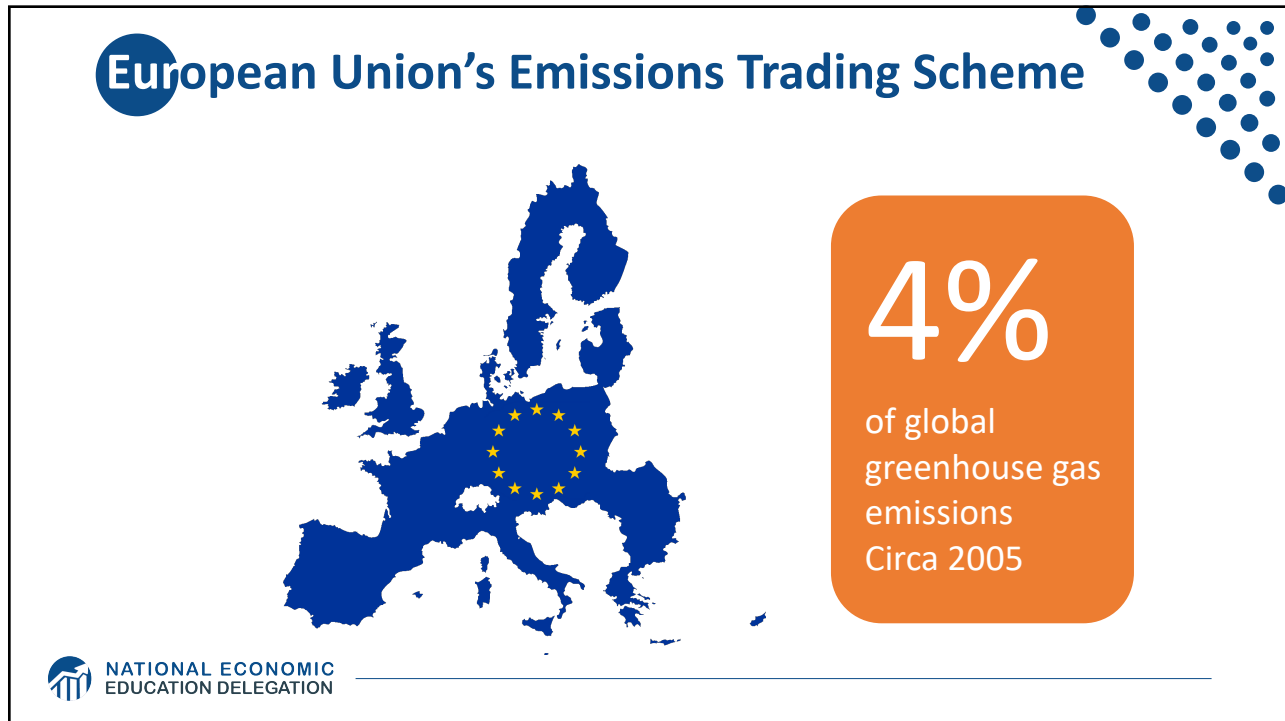
● ETS implemented or scheduled for implementation  
● ETS or carbon tax under consideration

**ETS = Emissions Trading System = Cap and Trade**

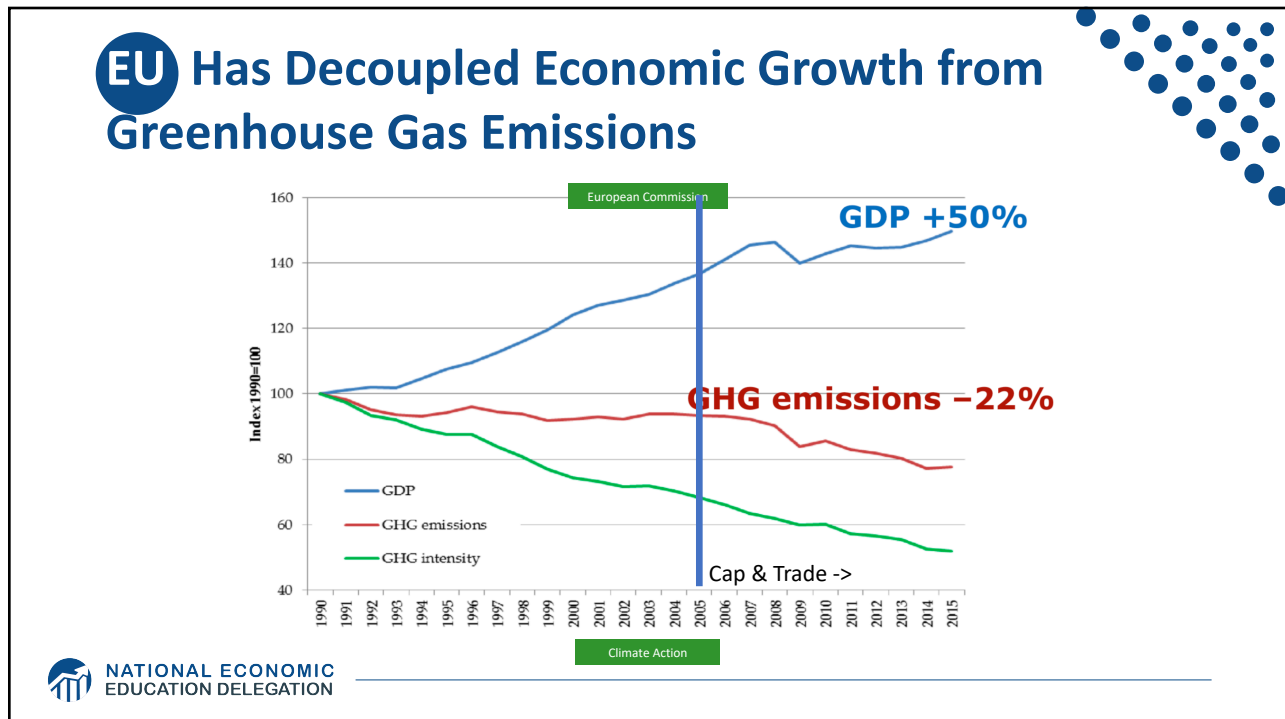
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Source: World Bank - Carbon Pricing Dashboard

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## California's Cap and Trade System: 2012+



# 0.7%

of global  
greenhouse gas  
emissions



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## California's System Is Flexible



- **California's goals:**

- Reduce emissions to 1990 levels by 2020 (2016)
- An 80% reduction in emissions from 1990 levels by 2030

- **California's Tools:**

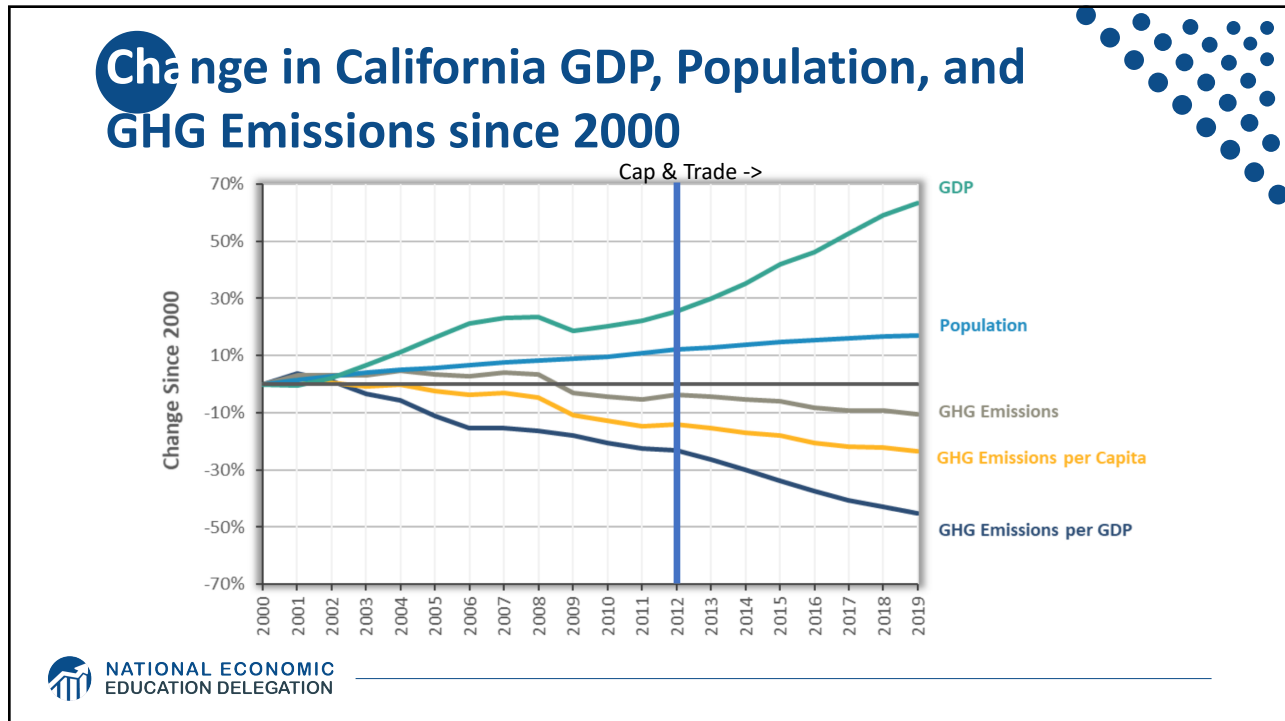
- Cap and Trade
- Renewable Portfolio Standard
- Clean Cars Program
- Low Carbon Fuel Standard



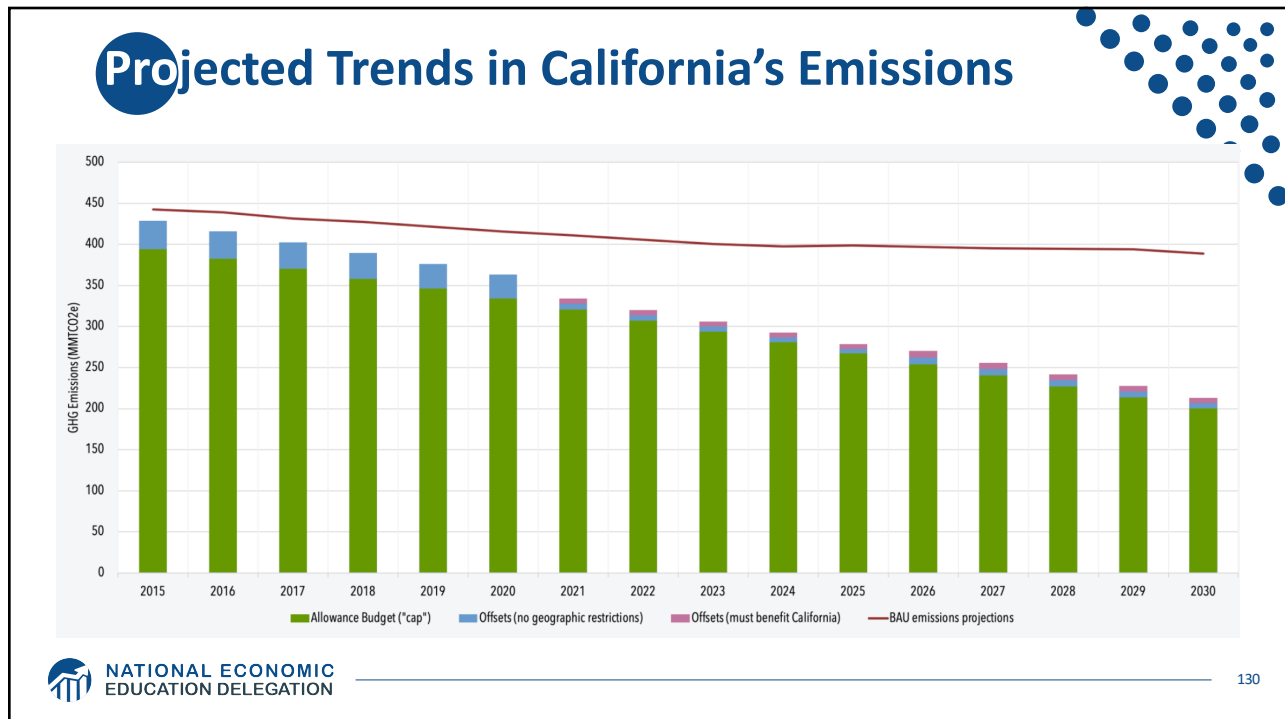
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## RGGI: the Regional Greenhouse Gas Initiative

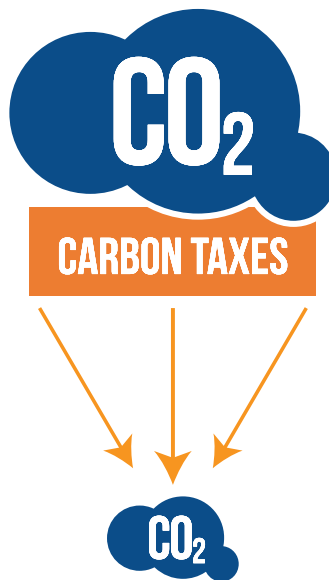
- **Participants: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont**
  - 7% of US emissions
- **Covers power plants**
- **First implemented in 2009**
- **Caused emissions reduction of 24% below what they would have been**



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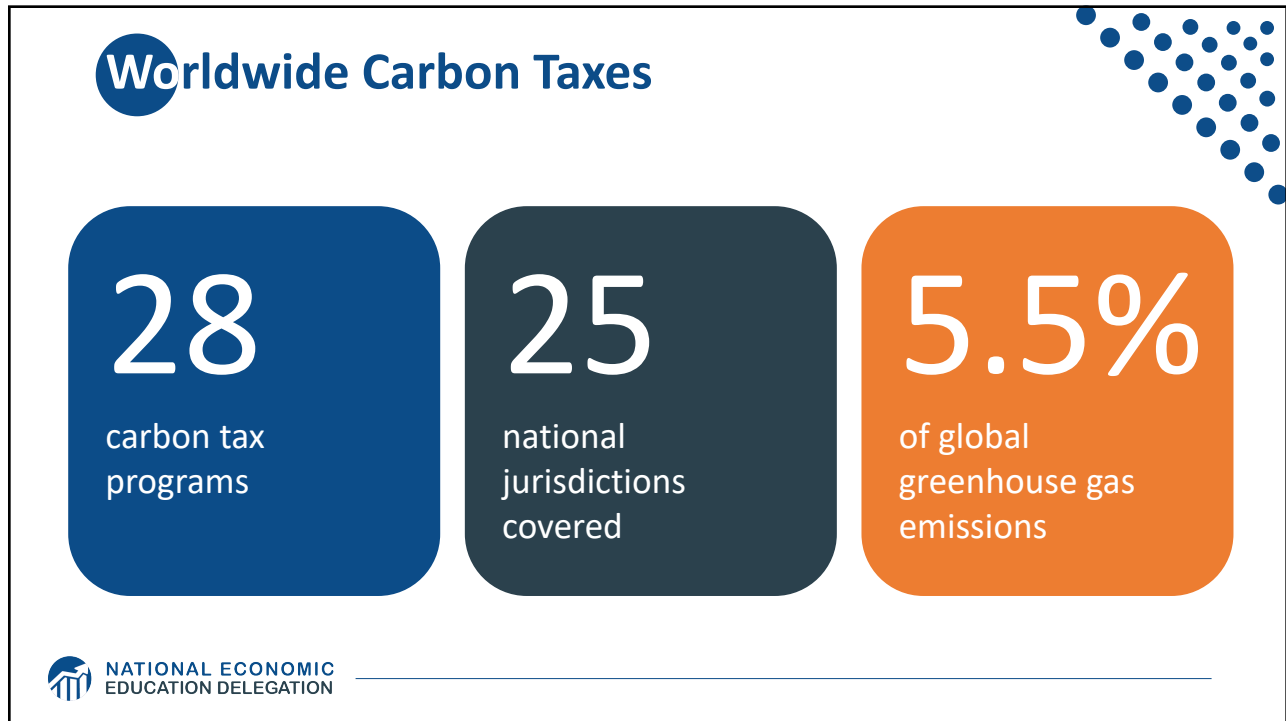
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## Carbon Tax

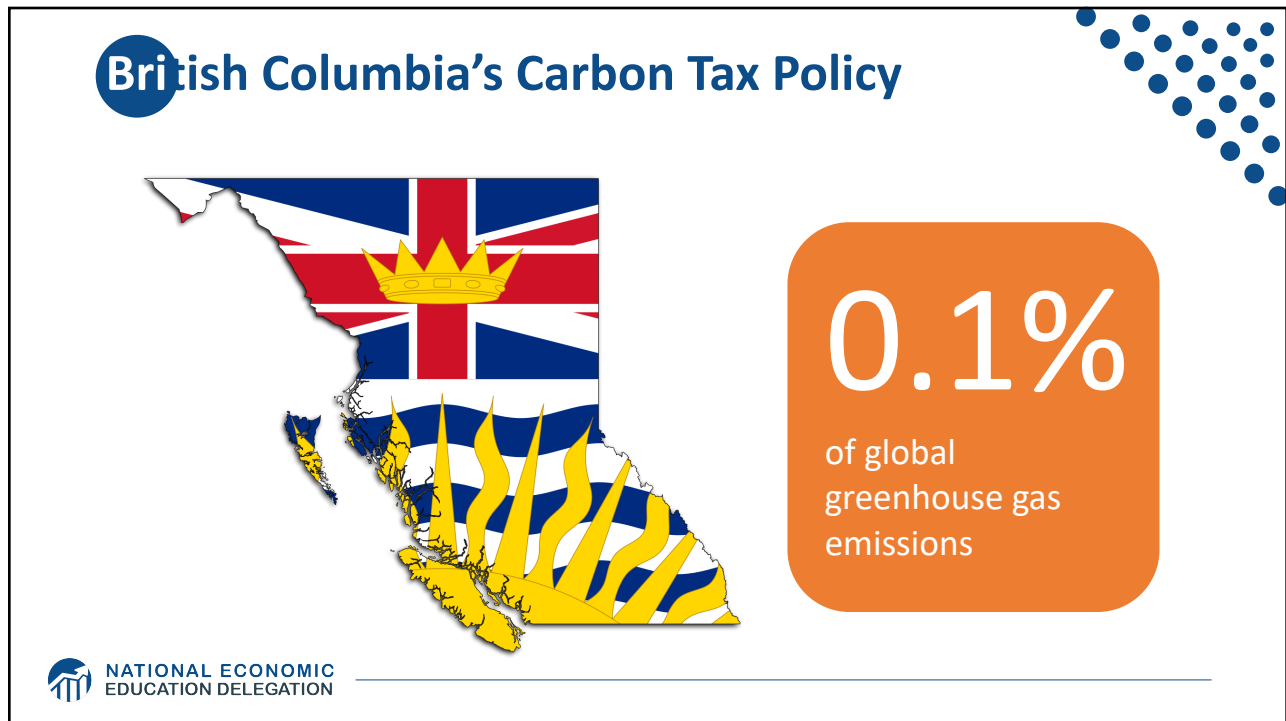


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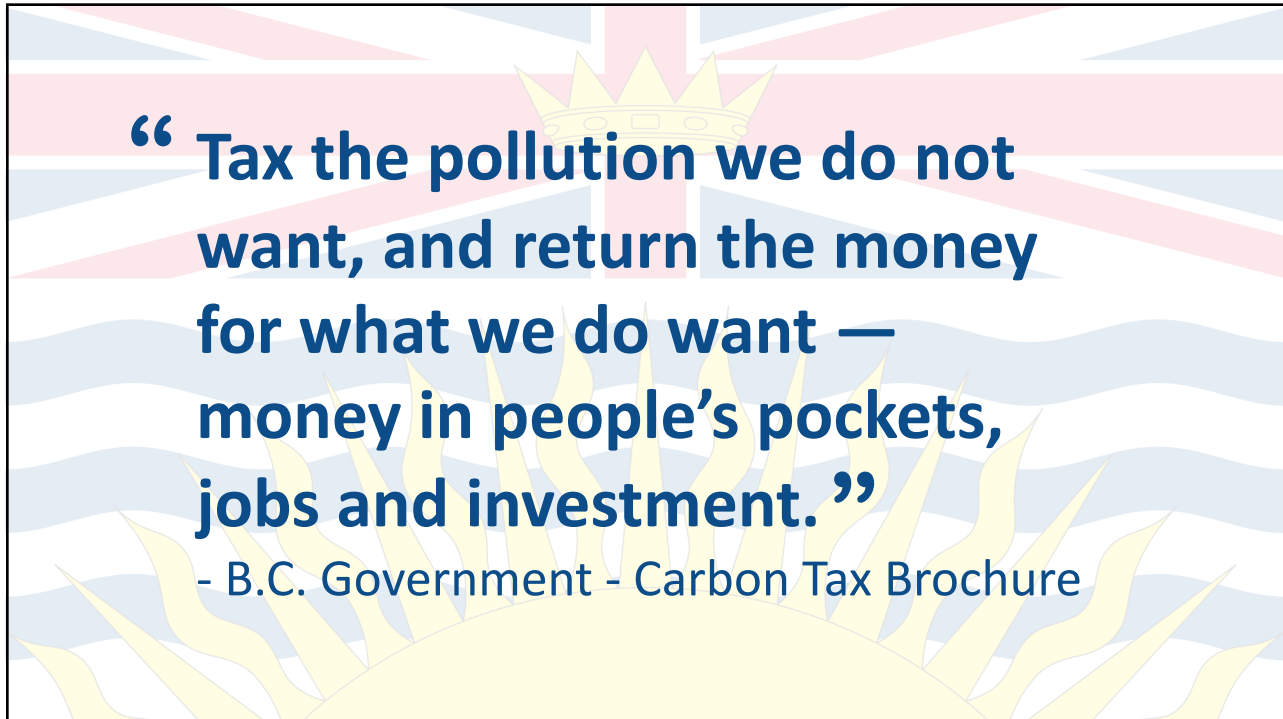
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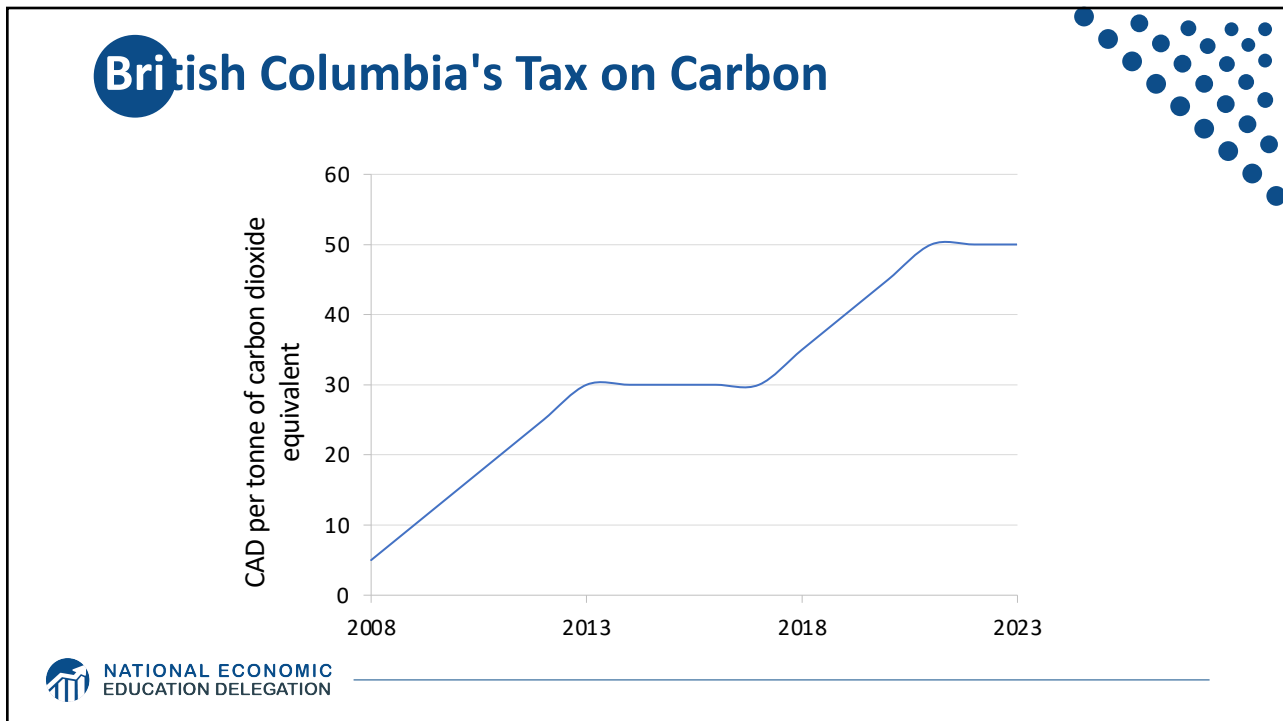
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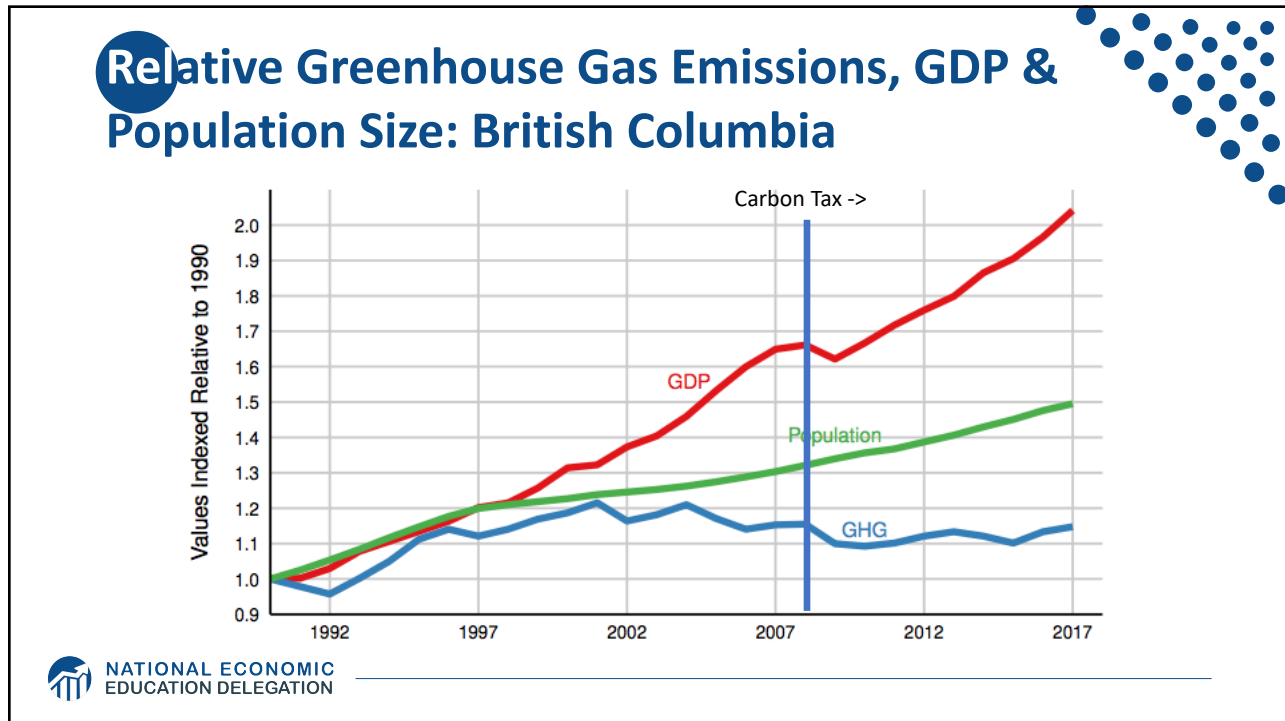
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## Sweden's Carbon Tax Policy




Oldest  
Carbon  
Tax

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## Sweden's Carbon Tax Policy



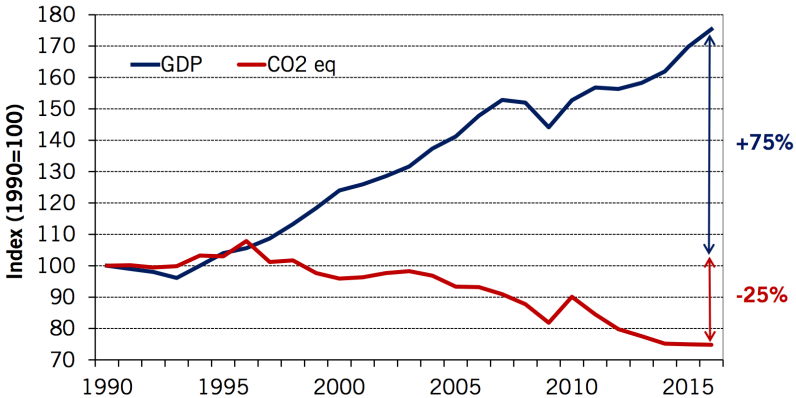
# Started in 1991

Currently at \$140/ton

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## Real GDP and Domestic CO<sub>2</sub>eq Emissions<sup>1</sup> In Sweden, 1990-2016



Year	Real GDP (Index 1990=100)	Domestic CO <sub>2</sub> eq Emissions (Index 1990=100)
1990	100	100
1995	105	100
2000	125	95
2005	145	90
2010	160	80
2016	175	75

<sup>1</sup> In accordance with Sweden's National Inventory Report, submitted under the UNFCCC and the Kyoto Protocol. CO<sub>2</sub> = approx. 80 % of total CO<sub>2</sub>eq emissions. Preliminary data for 2016.
 Sources: Swedish Environmental Protection Agency, Statistics Sweden

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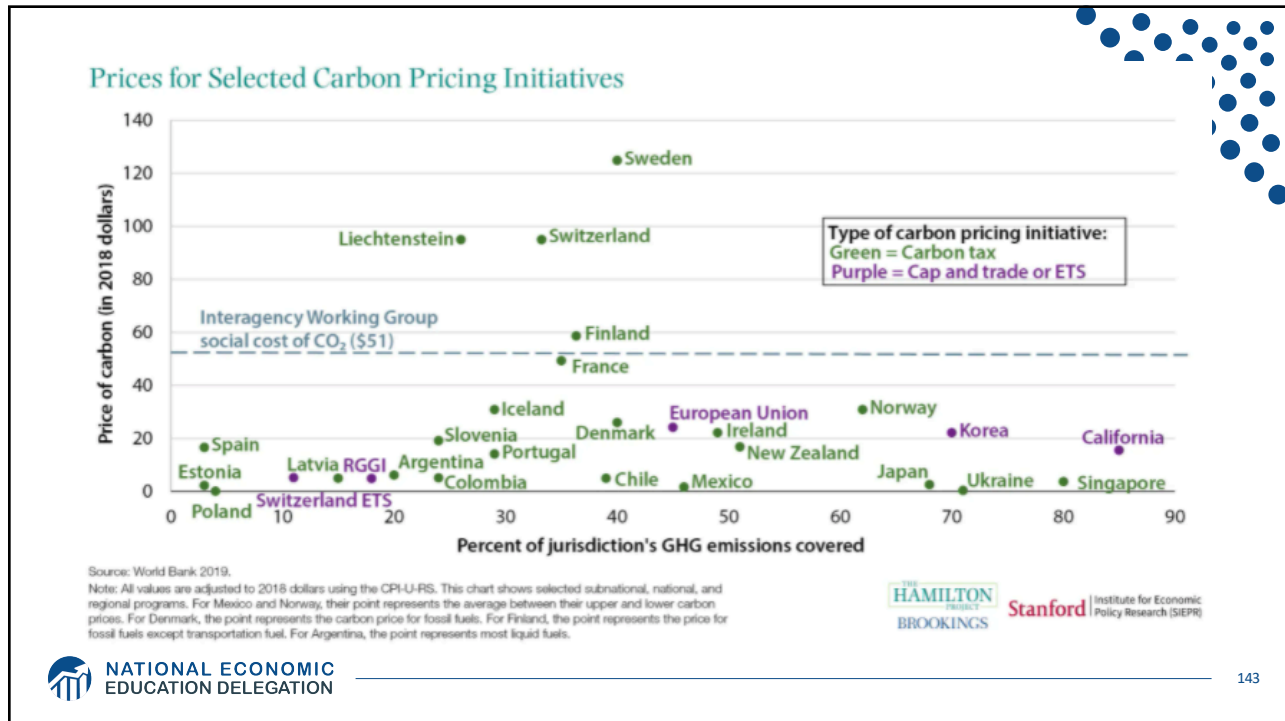
## U.S. Carbon Tax Plans

- Climate Leadership Council
- Citizens Climate Lobby
- States and municipalities:  
Washington state, Oregon,  
Washington, DC

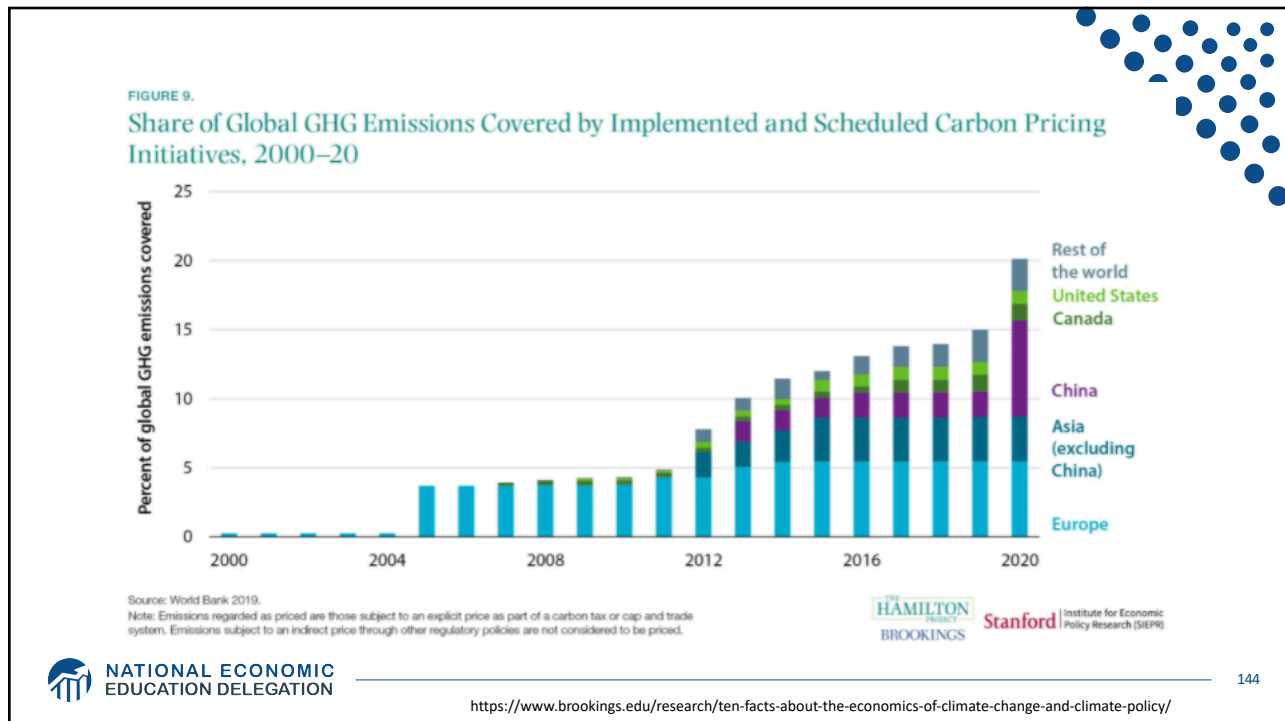


**“ Economic policies will be central to accomplishing the goals we choose.”**

- Harris and Roach (2007)



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## Summary

- Climate change is real, is caused by human actions, and has impacts we're already feeling.
- We need to reduce emissions to balance the costs of action against the costs of inaction.
- Scientists and the IPCC recommend that we work to keep warming below 1.5 degrees celcius.
  - *Economists believe that this goal is well worth the costs!*



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## Summary – continued

- There are many ways to reduce emissions.
- Economics-inspired policies can help us do this at the lowest cost.
- Taxes and cap and trade are proven effective tools to fight climate change!
- Other tools may also be necessary.



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**Thank you!**

# Any Questions?

[www.NEEDelegation.org](http://www.NEEDelegation.org)

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[Jon@NEEDelegation.org](mailto:Jon@NEEDelegation.org)

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