Osher Lifelong Learning Institute, Winter 2020

What Economists Know About Important Policy Issues

Lecture 3: Climate Change Economics

February 5, 2020

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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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Course Outline

- **What Economists Know About Important Policy Issues**
  - Week 1 (1/22): US Economic Update
  - Week 2 (1/29): Government Budgets
  - **Week 3 (2/5): Climate Change**

No class next week

  - Week 4 (2/19): Trade and Globalization
  - Week 5 (2/26): Income Inequality

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Climate Change Economics

Lecture 3

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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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How Can Economists Contribute to Thinking about Climate Change?

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

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Climate Change Science

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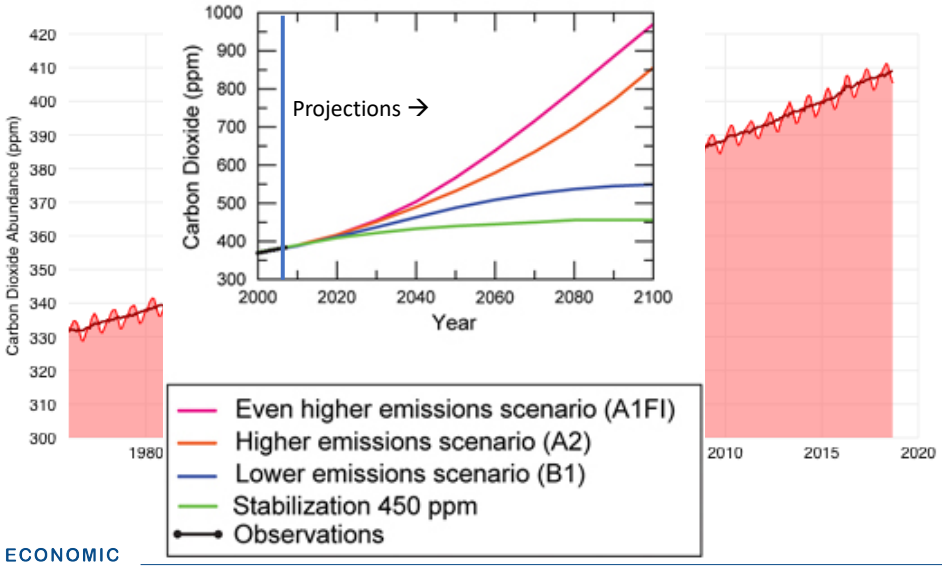
Atmospheric CO_2 Concentrations



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Source: IPCC data distribution center and climate.gov

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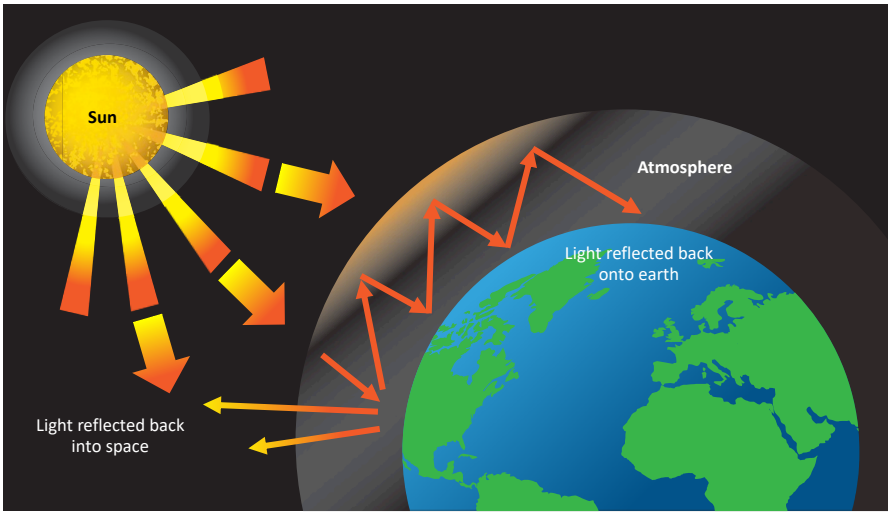
The Atmospheric Greenhouse Effect



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Uncertainty

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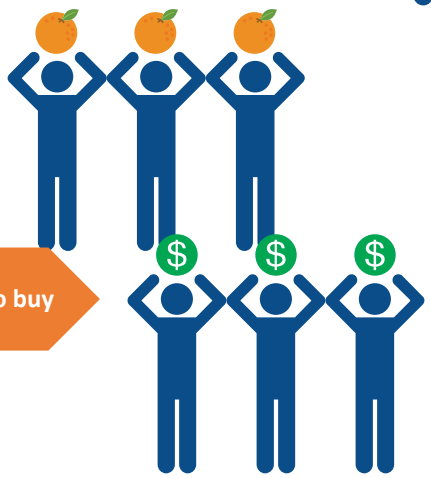
How Much Pollution Does Society Want?

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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Pollution Is Different From Oranges

- **Human activity creates 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. The balance is wrong.
  - There is too much pollution.

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Externalities

- **An externality occurs when market activity affects people outside of a market.**
  - Market activity SPILLS OVER onto others.
  - A **negative externality** occurs when a ***cost*** spills over.
  - A **positive externality** occurs when a ***benefit*** spills over.

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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

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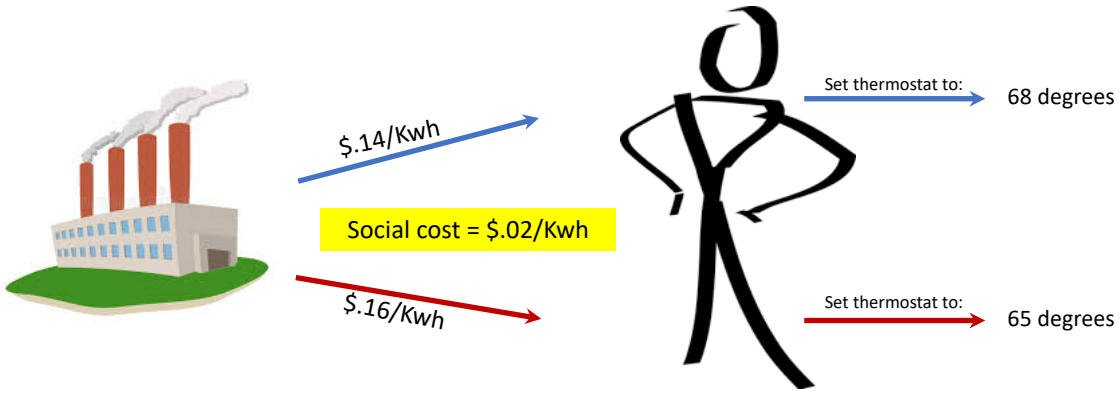
Addressing a Negative Externality



The social cost of $.02/Kwh has been INTERNALIZED.

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Impacts of Climate Change

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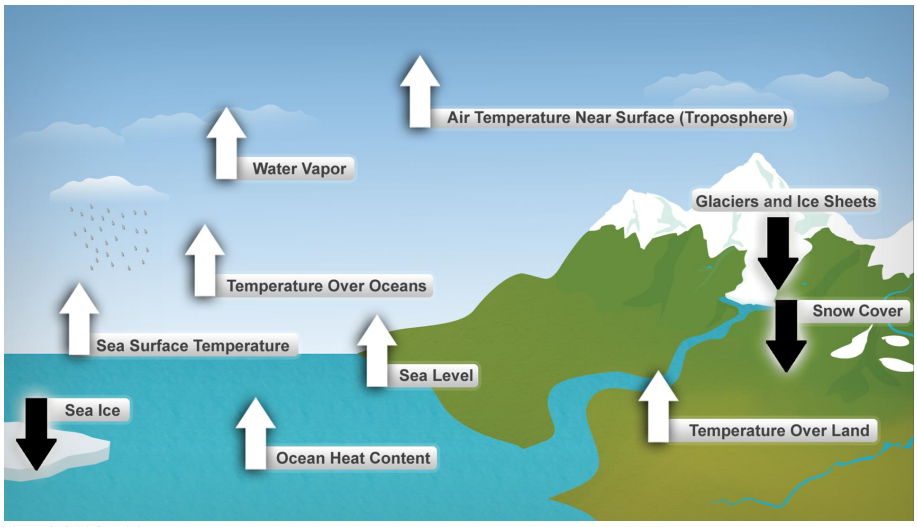
Global Warming Indicators



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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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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 Examples

- **Do you behave differently on a hot day?**
  - Staying inside more.
  - Turn on the air conditioning.
  - Plant at different times.
  - Plant new crops.
  - Think about moving.

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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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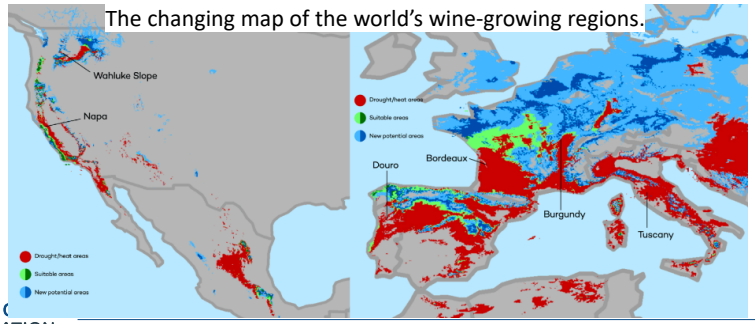
Market Based Adaptation

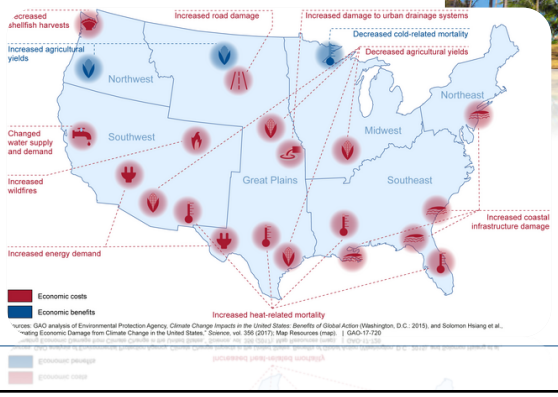
- **Prices and costs influence behavior.**
  - Where to live.
  - Where/when/what to plant.
- **Avoid barriers to market adjustment.**
  - Trade barriers, immigration restrictions, federal flood insurance, agricultural subsidies, and zoning regulations.

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



Most Vulnerable People and Places

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



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

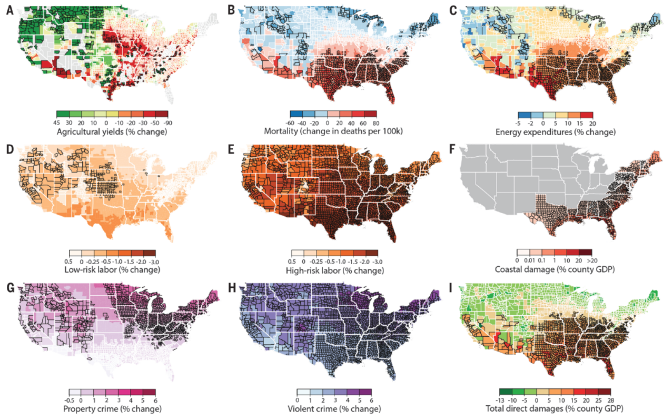


Fig. 2. Spatial distributions of projected damages. County-level median values for average 2080 to 2099 RCP8.5 impacts. Impacts are changes relative to counterfactual "no additional climate change" trajectories. Color indicates magnitude of impact in median projection; outline color indicates level of 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)].

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Social Cost of Carbon

- **Cost above price paid.**
- **The expected cost of damages from each unit of greenhouse gas emissions.**
- **Current EPA estimate: ~$40 per metric ton of CO_2.**
  - About $123/car per year.
  - $26 Billion for all vehicles in the US.
- **Social cost of carbon will increase over time.**

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Economics of Responding to Climate Change

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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

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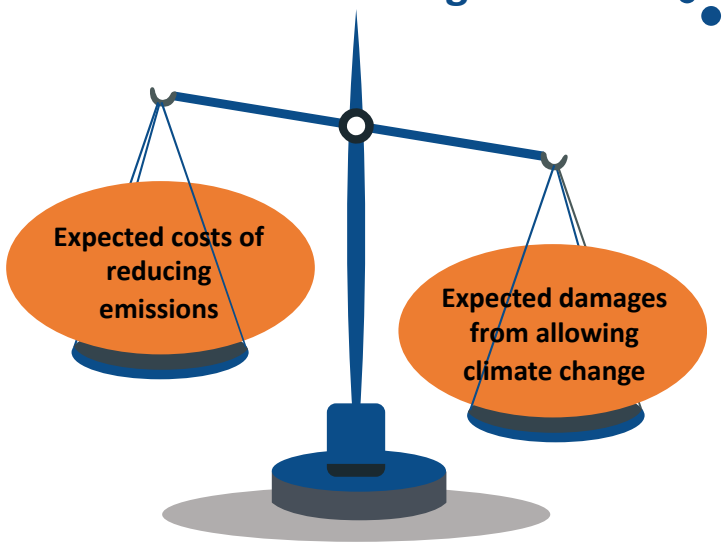
How Economists Decide How Much to Fight Climate Change

- **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 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

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This is What Precisely Wrong Looks Like

Facebook's office may be fully underwater by 2100, based on worst-case scenario sea level rise projections. Shayanne Gal/ Business Insider

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This is What Precisely Wrong Looks Like

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This is What Precisely Wrong Looks Like

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This is What Precisely Wrong Looks Like

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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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Addressing the Sources of Our Emissions

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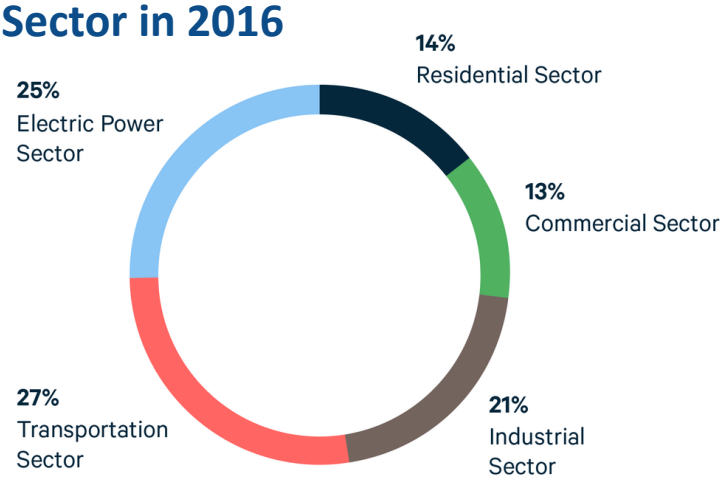
Total U.S. Greenhouse Gas Emissions by Economic Sector in 2016

RFF



Source: Data source: US Energy Information Administration, May 2019 Monthly Energy Review

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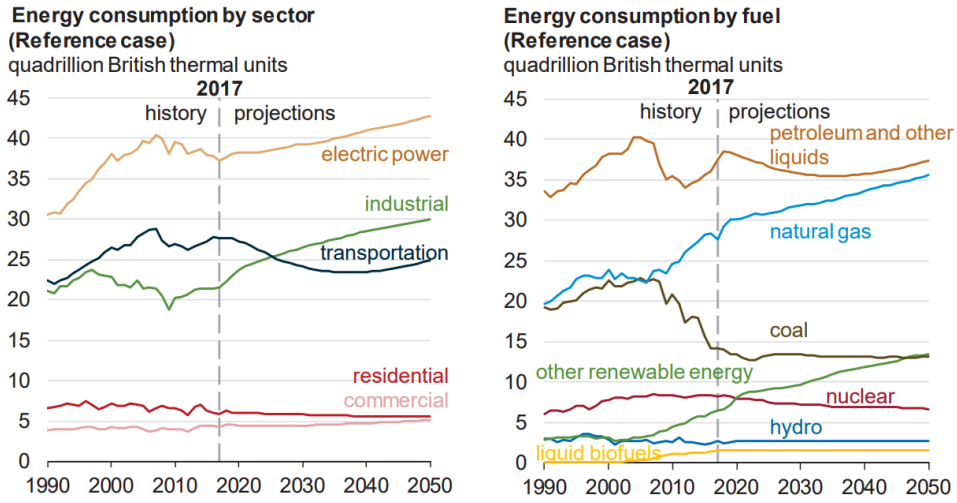
Fossil Fuels Dominate U.S. Energy Production



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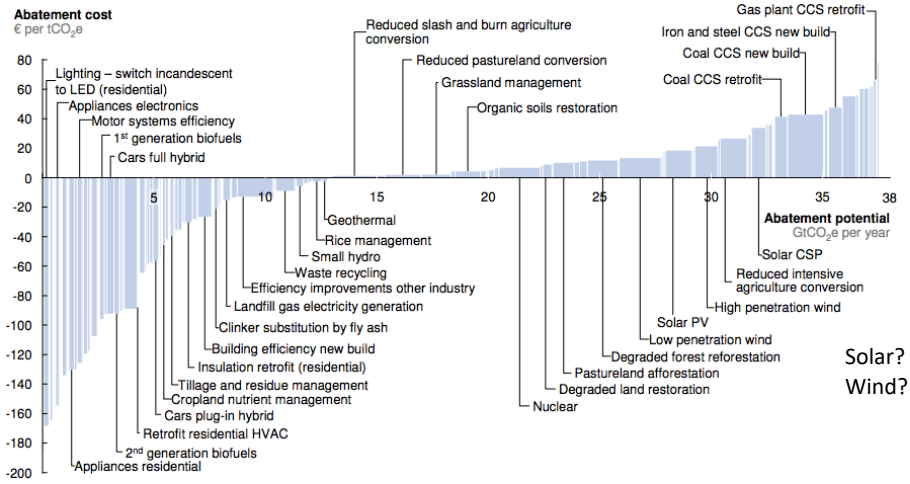
Global GHG Abatement Cost Curve

Lighting
Appliances
Hybrid cars



Solar?
Wind?

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

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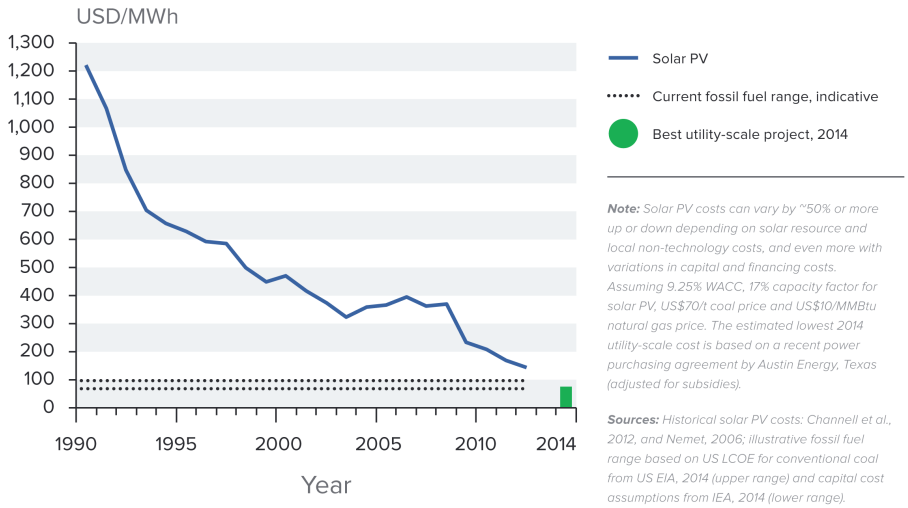
Indicative Solar Costs Over Time



Note: *Solar PV costs can vary by ~50% or more up or down depending on solar resource and local non-technology costs, and even more with variations in capital and financing costs. Assuming 9.25% WACC, 17% capacity factor for solar PV, US$70/t coal price and US$10/MMBtu natural gas price. The estimated lowest 2014 utility-scale cost is based on a recent power purchasing agreement by Austin Energy, Texas (adjusted for subsidies).*

Sources: *Historical solar PV costs: Channell et al., 2012, and Nemet, 2006; illustrative fossil fuel range based on US LCOE for conventional coal from US EIA, 2014 (upper range) and capital cost assumptions from IEA, 2014 (lower range).*

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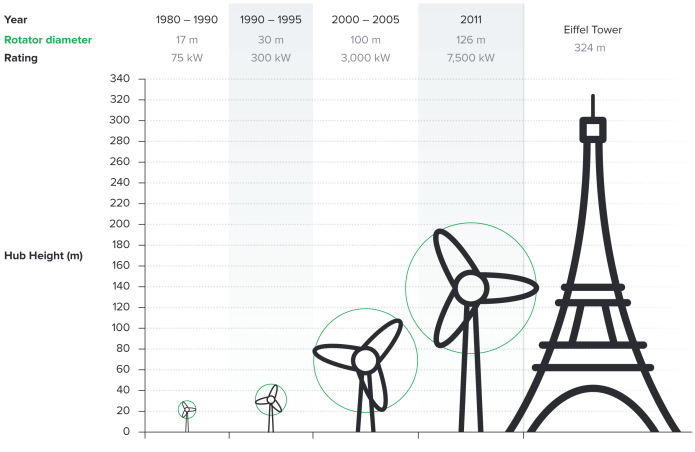
Wind Turbines Have 100 Times More Power Generation Capabilities Than 30 Years Ago



Source: Adapted from the European Wind Energy Association.

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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.

Infrastructure and Climate Change

- **$90 trillion in investment will be needed for U.S. infrastructure, 2015-2030.**
- **Add $4 trillion (< 5%) to make it low-carbon infrastructure.**
  - This would also reduce climate damage to infrastructure.
  - Railway, urban transport, renewables.
- **The electrical grid is particularly troublesome.**
  - It is outdated and not suited for renewable energy storage.
  - Those with solar panels use the grid but contribute little to its upkeep.

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 Cap and Trade Work?

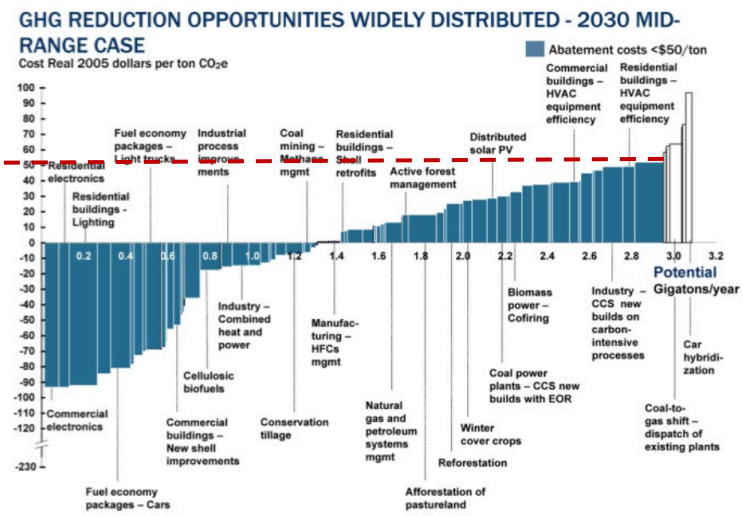
- **Activities to be covered are determined.**
- **Acceptable emissions levels are indicated.**
- **"Permits" that allow acceptable emissions levels are issued.**
  - How?
    - According to historical emissions?
    - Evenly across emitters?
    - Sold at some price?
- **A "market" is developed.**
- **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.**

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?**

Putting a Price on Carbon

Suppose a Social Cost Of Carbon of $50



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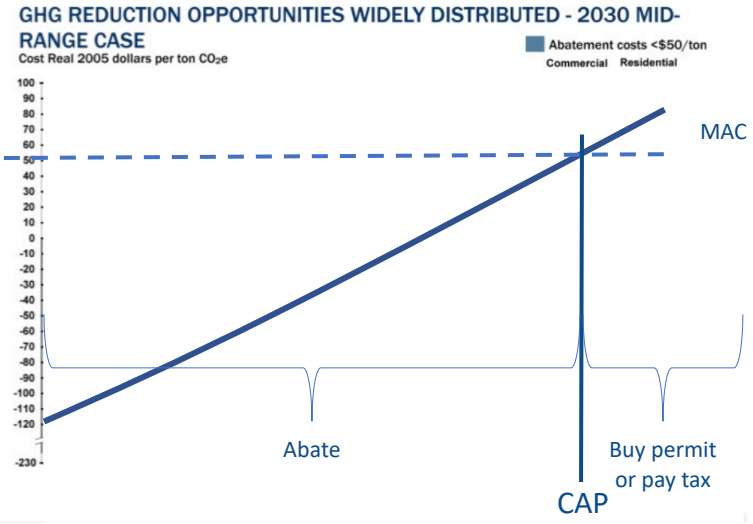
Putting a Price on Carbon

TAX
=
Permit Price
=
Carbon Price



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Carbon Prices: the Good and Bad

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

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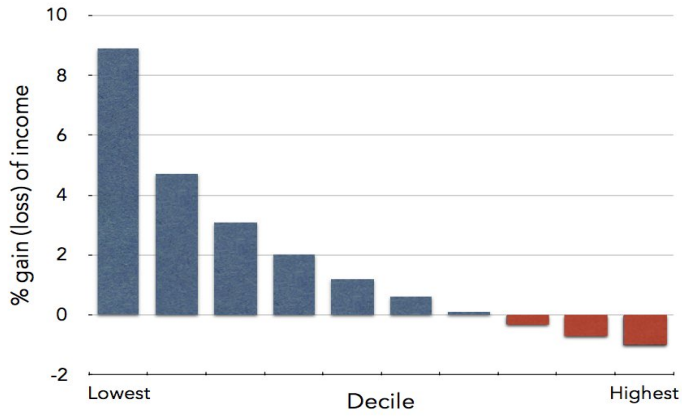
Revenue Dividend Eliminates Regressivity

IMPACT OF CARBON DIVIDENDS ON U.S. FAMILY INCOMES



Source: U.S. Treasury, 2017

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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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Thoughts on Regulation vs Market-Oriented

- **Equity.**
  - Both types of policies are regressive.
    - Cap and Trade and a Carbon Tax can offset the regressivity.
    - Regulations do not.
- **Efficiency.**
  - Market-oriented policies tend to achieve emissions reduction at much lower cost.
    - 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:
    - 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.

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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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Atlanta and Barcelona Have Similar Populations but Very Different Carbon Productivity

Atlanta			Barcelona		
Built-up area			Built-up area		
					
Population	Urban area	Transport carbon emissions	Population	Urban area	Transport carbon emissions
2.5 million	4,280 km²	7.5 tonnes CO_2/person (public + private transport)	2.8 million	162 km²	0.7 tonnes CO_2/person (public + private transport)

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Source: New Climate Economy Report, 2014

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Land Use: Restoration Is Possible

South Korea restored its forest cover from 35% to 64% of the country's total area

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Climate Change Policy in Action

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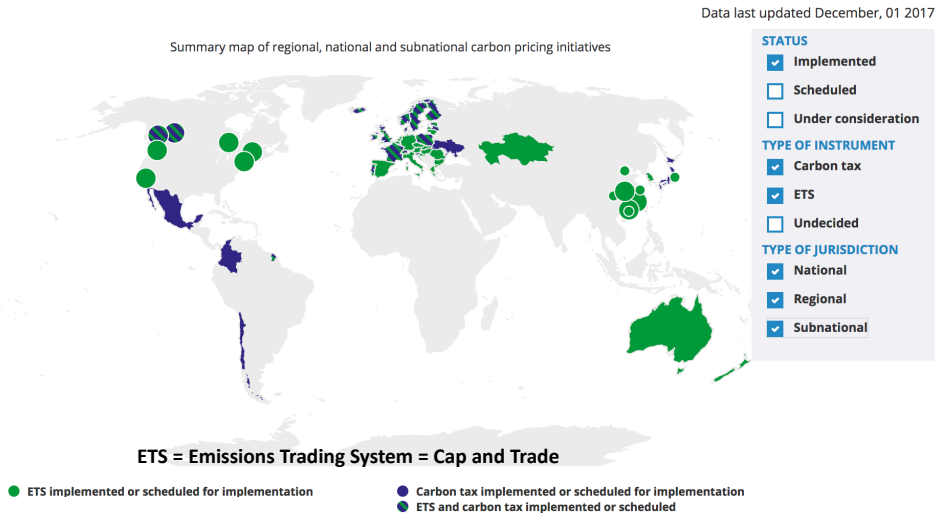
Carbon Policies Across the World



Source: World Bank Carbon - Pricing Dashboard

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Cap and Trade

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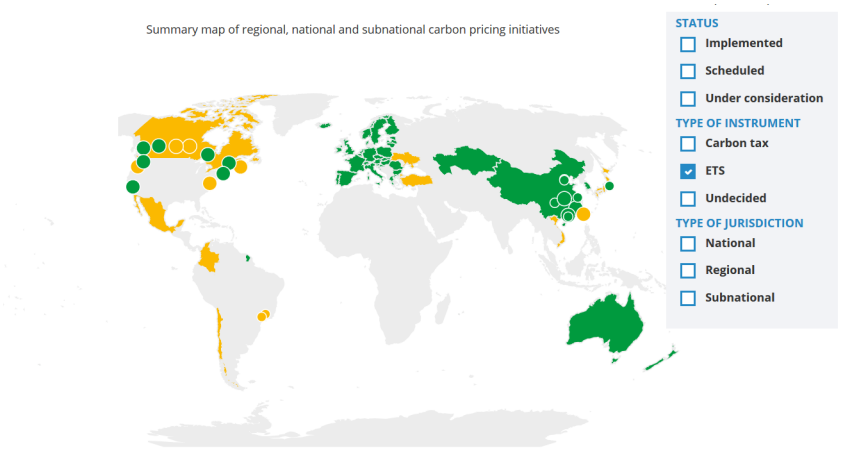
Cap and Trade Policies Around the World



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

ETS = Emissions Trading System = Cap and Trade

Source: World Bank - Carbon Pricing Dashboard

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European Union's Emissions Trading Scheme

4%

of global greenhouse gas emissions Circa 2005

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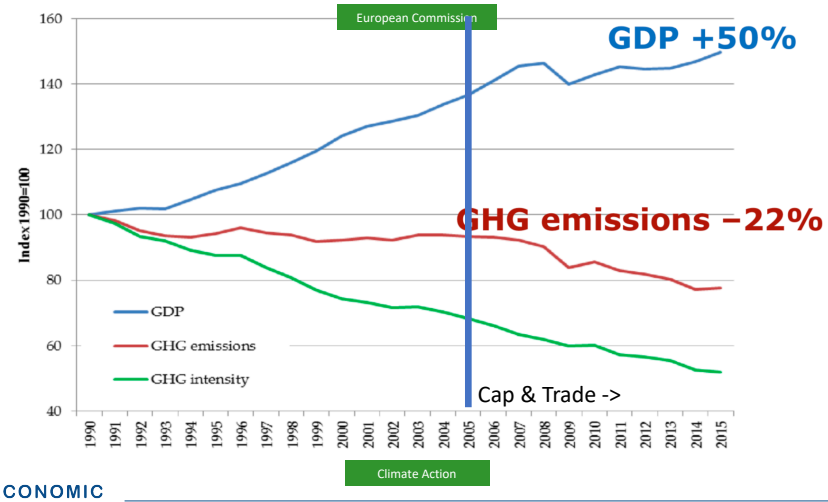
EU Has Decoupled Economic Growth from Greenhouse Gas Emissions



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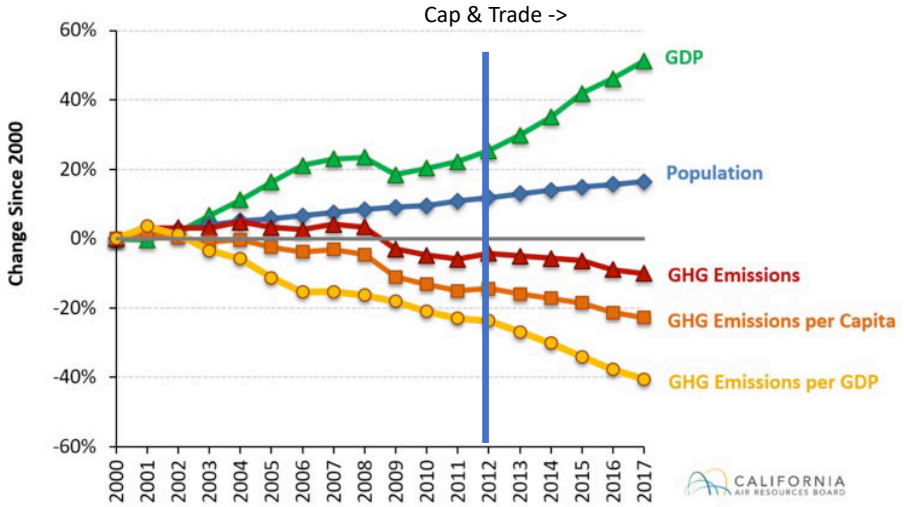
Change in California GDP, Population, and GHG Emissions since 2000



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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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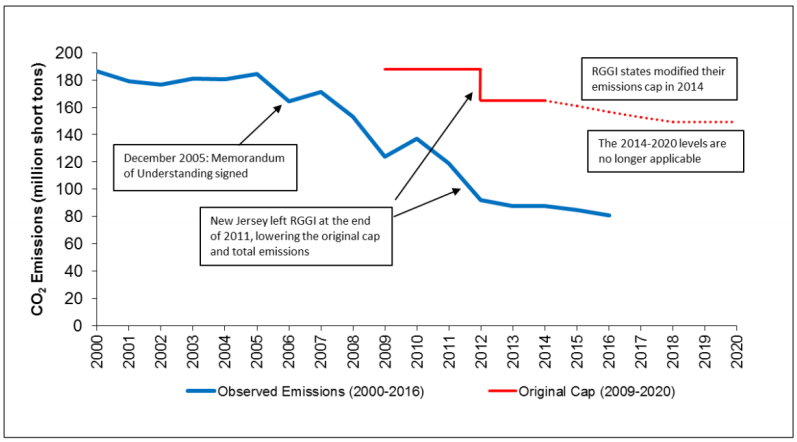
RGGI's Effect on Emissions

Figure 1. Observed Emissions Compared to the Original Emissions Cap



Source: Prepared by CRS; observed state emission data (2000-2016) provided by RGGI at http://www.rggi.org.

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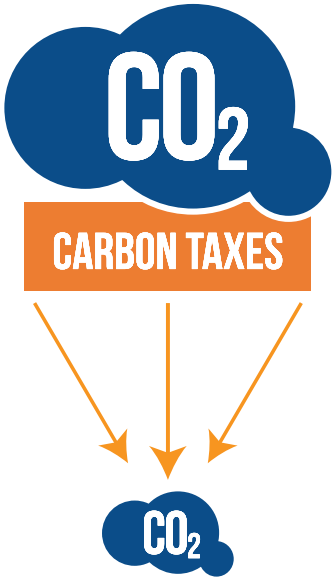
Carbon Tax



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Worldwide Carbon Taxes

28
carbon tax programs

25
national jurisdictions covered

5.5%
of global greenhouse gas emissions

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British Columbia's Carbon Tax Policy

0.1%
of global greenhouse gas emissions

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> “Tax the pollution we do not want, and return the money for what we do want — money in people’s pockets, jobs and investment.”
>
> - B.C. Government - Carbon Tax Brochure

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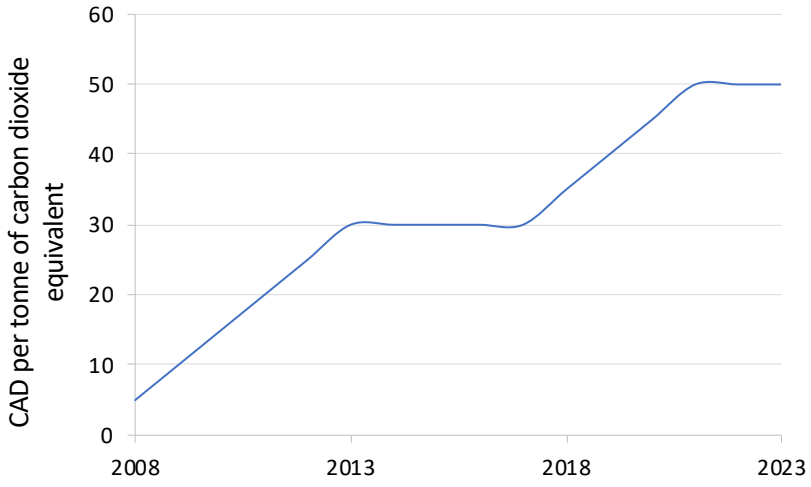
British Columbia's Tax on Carbon



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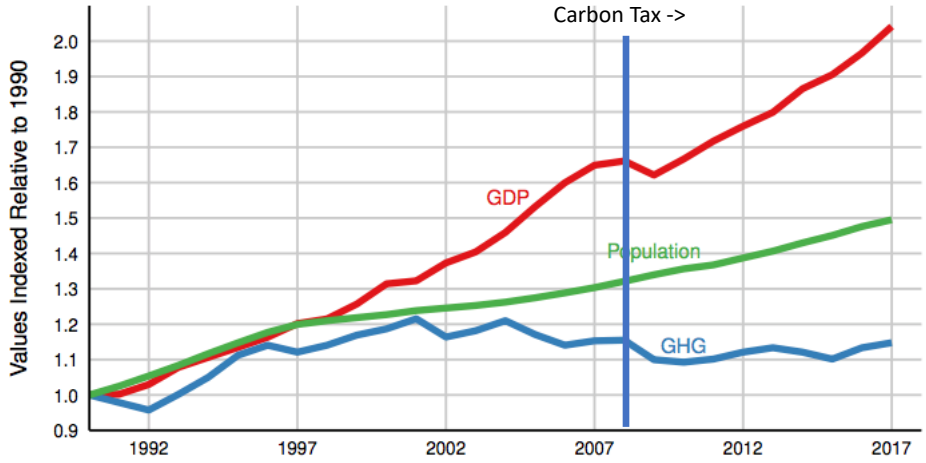
Relative Greenhouse Gas Emissions, GDP & Population Size: British Columbia



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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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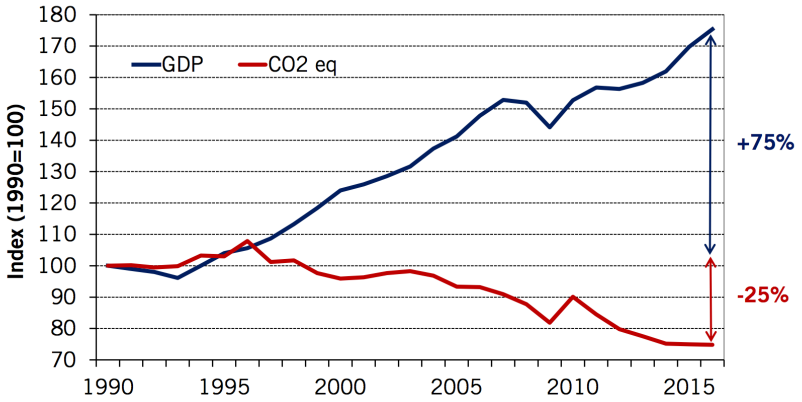
Real GDP and Domestic CO_2eq Emissions[1] In Sweden, 1990-2016



[1] In accordance with Sweden's National Inventory Report, submitted under the UNFCC and the Kyoto Protocol. CO_2 = approx. 80 % of total CO_2eq 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

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> “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 celsius.
  - *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?

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