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# Climate Change Economics

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Osher Lifelong Learning Institute
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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
    - Furman (D), Rosen (R), Bernanke (R), Yellen (D), Tyson (D), Goolsbee (D)
  - 3 Nobel Prize Winners
    - Akerlof, Smith, Maskin
- **Delegates: 590+ 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: 45 Ph.D. Economists**
  - Aid in slide deck development

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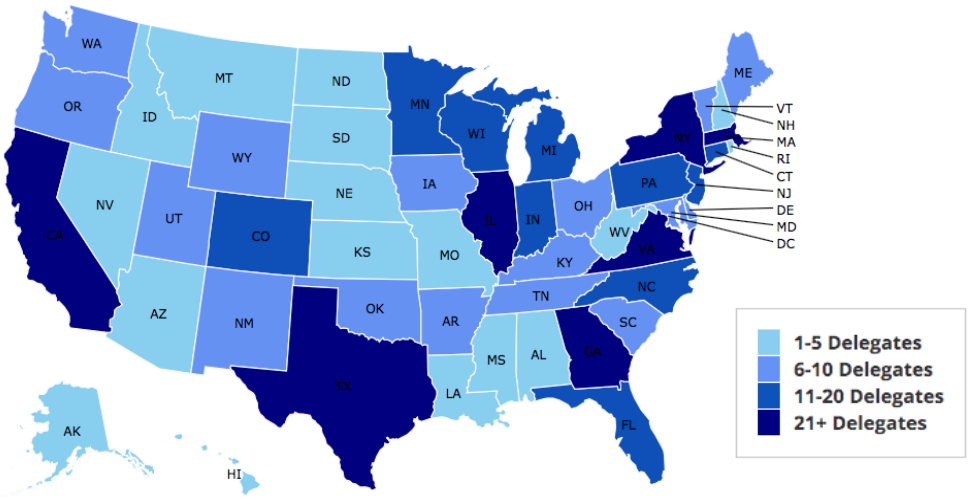
# Where Are We?

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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 and 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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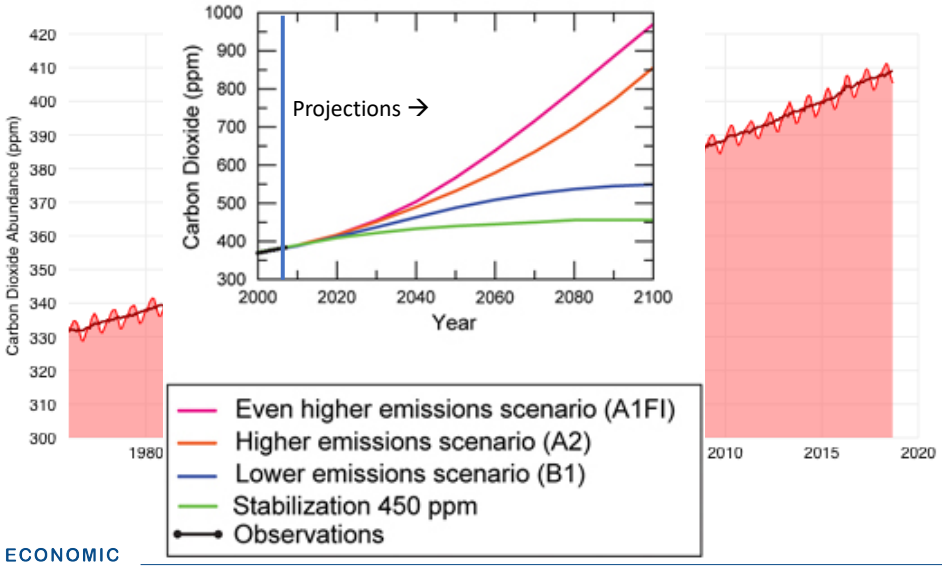
# Atmospheric $CO_2$ Concentrations

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Source: IPCC data distribution center and climate.gov

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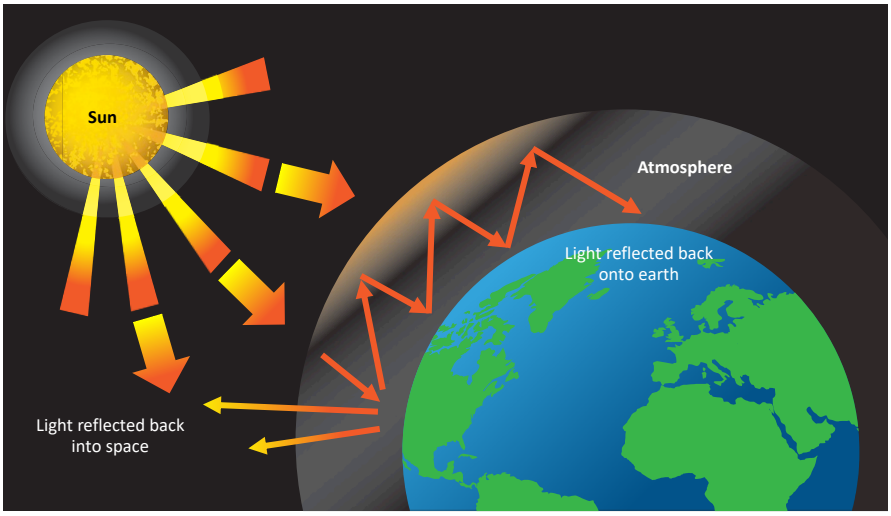
# The Atmospheric Greenhouse Effect

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## Uncertainty


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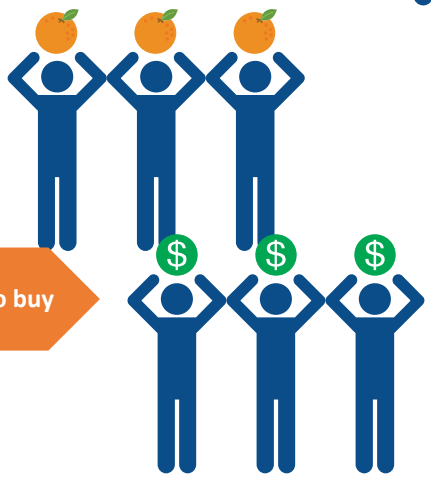
## How Much Pollution Does Society Want?

### 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***).
- <u>Prices</u> 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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# 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.

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# Reflection:

- **Take a moment to write into the chat box a situation in which some market activity creates either benefits or costs to someone outside of the market**
  - Example 1: in the market for electricity, the cost of carbon emissions is borne by everyone, even people who do not use electricity
  - Example 2: in the market for beautiful front yard gardens, the joy of beautiful flowers is enjoyed by everyone who walks by, not just the owner of the garden

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# Impacts of Climate Change

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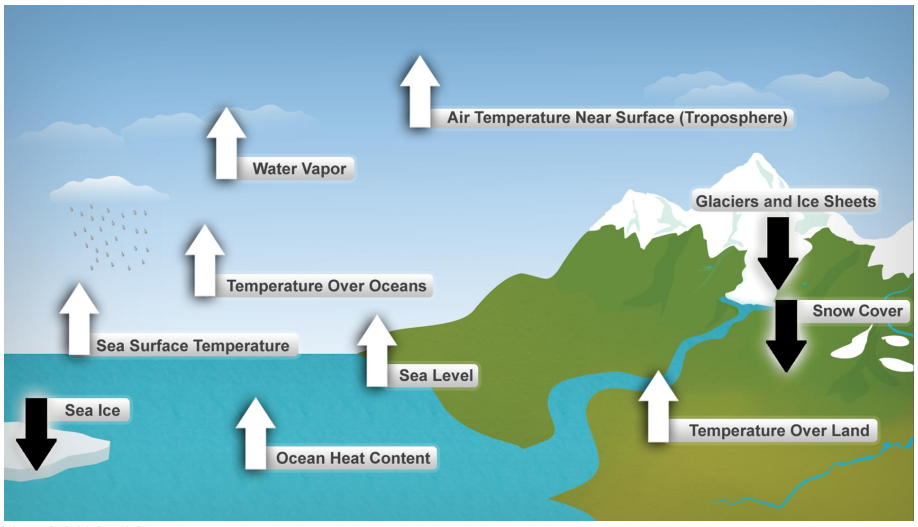
## Global Warming Indicators

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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?**
  - Write what you do differently in the chat
  - 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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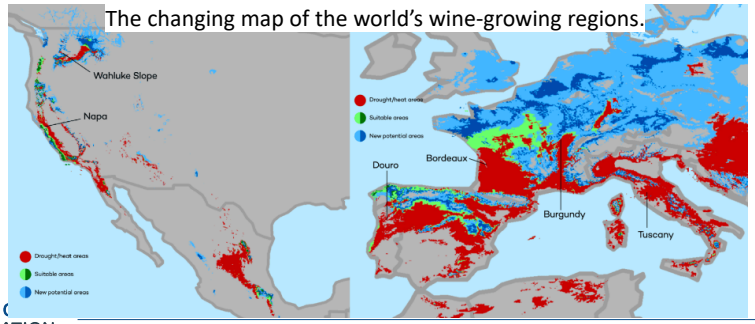
# Market Based Adaptation

- **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.

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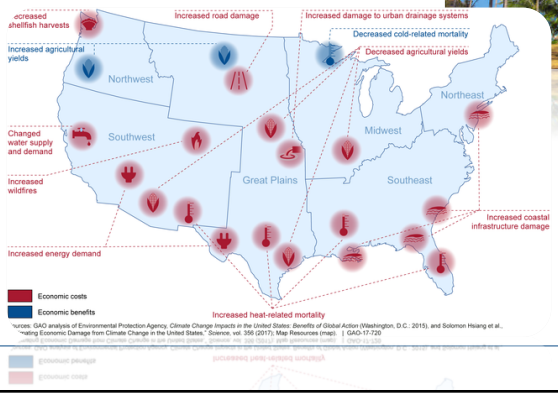
# Most Vulnerable People and Places

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

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

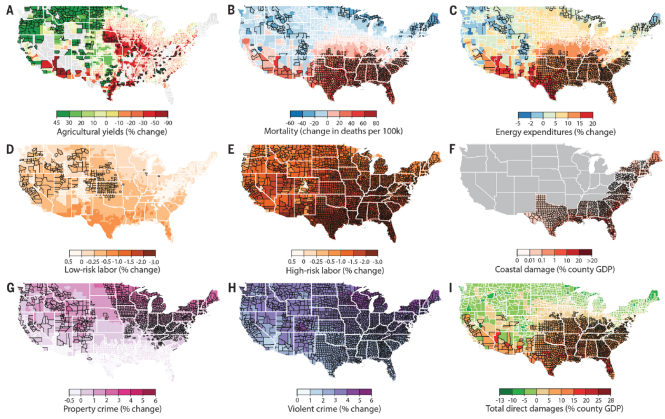


**Fig. 2. Spatial distributions of projected damages.** County-level median values for average 2080 to 2099 RCP8.5 impacts. Impacts are changes relative to counterfactual "no additional climate change" trajectories. Color indicates magnitude of impact in median projection; outline color indicates level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

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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: ~$51 per metric ton of $CO_2$.**
  - About $32 Billion for all vehicles in the US.
- **Social cost of carbon will increase over time.**


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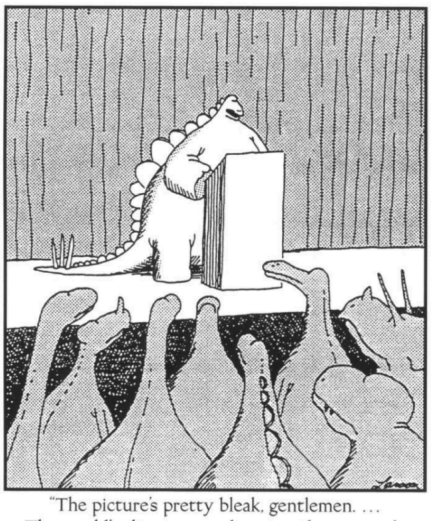

"The picture's pretty bleak, gentlemen. … The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

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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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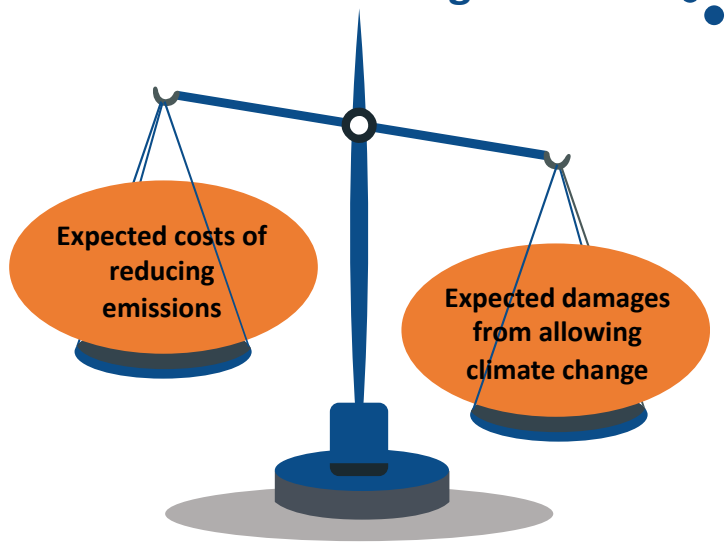
# How Economists Decide How Much to Fight Climate Change

- **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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## 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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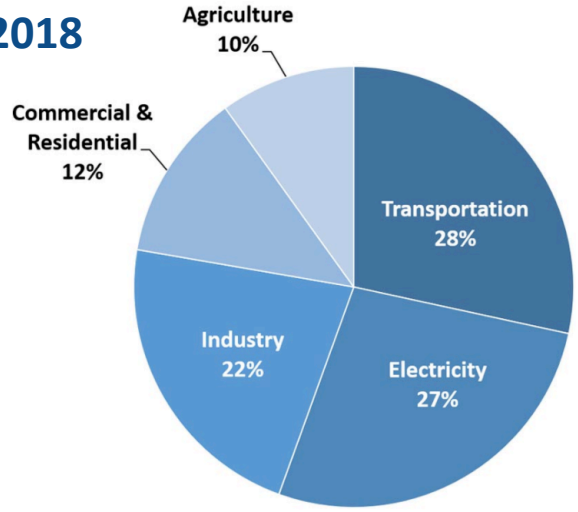
## Total U.S. Greenhouse Gas Emissions by Economic Sector in 2018




U.S. Environmental Protection Agency (2020). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018

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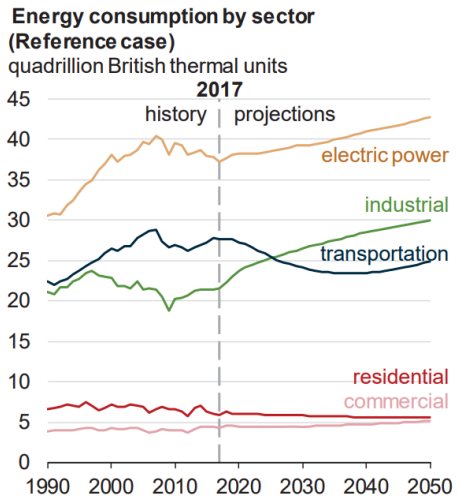
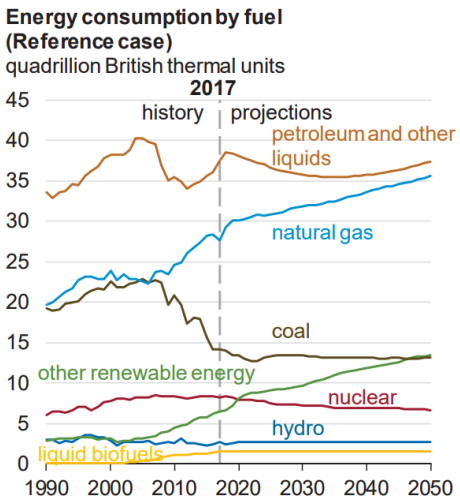
## Fossil Fuels Dominate U.S. Energy Production

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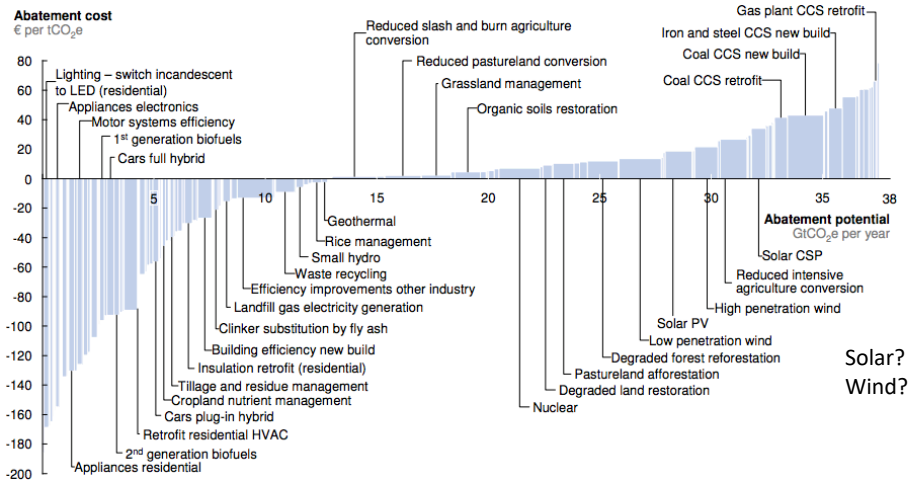
# Global GHG Abatement Cost Curve




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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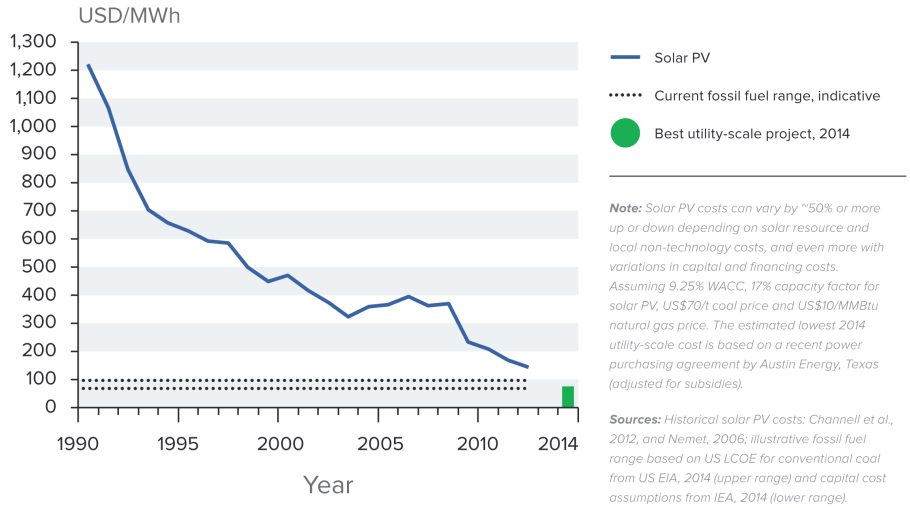
# Indicative Solar Costs Over Time




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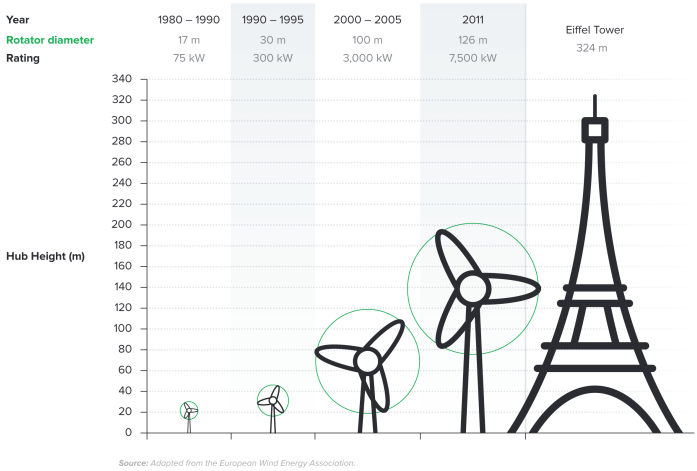
# Wind Turbines Have 100 Times More Power Generation Capabilities Than 30 Years Ago




*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.

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## 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.

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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 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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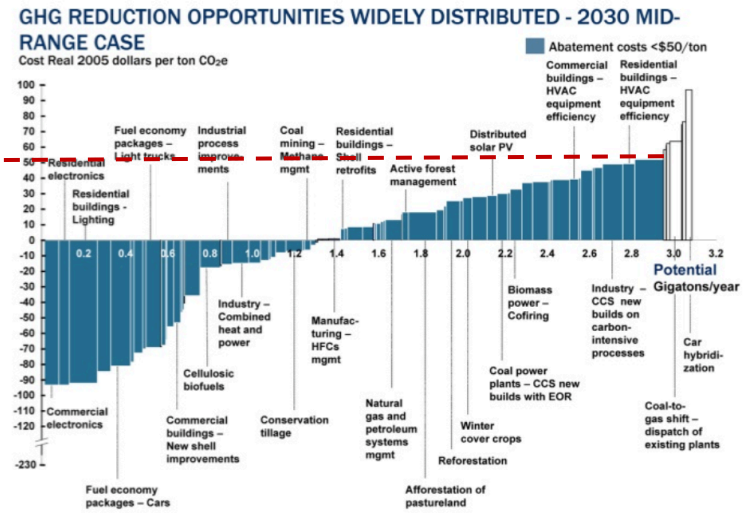
# How Does a Carbon Tax Work?

- **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



# 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
    - Costs may weigh more heavily on low-income households.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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<br>2) May require legislation to change<br>3) Predictability | 1) Susceptible to lobbying.<br>2) Only generates revenue if government sells permits.<br>3) Cap can be changed by regulator.<br>4) Less certainty over future.<br>5) Regulations reduce efficacy of Cap & Trade |

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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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## 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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# Climate Change Policy in Action

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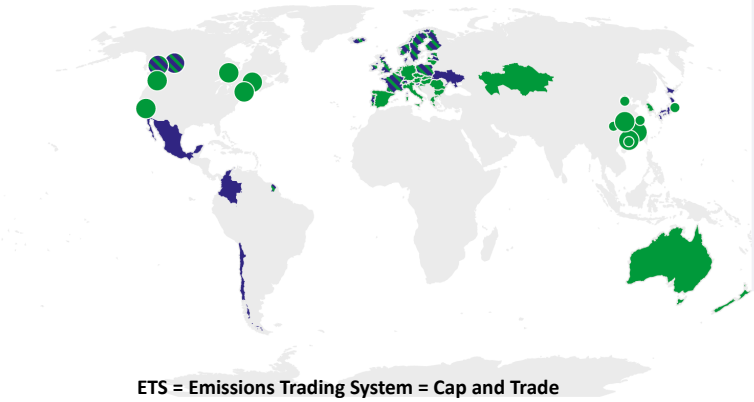
# Carbon Policies Across the World

Data last updated December, 01 2017

Summary map of regional, national and subnational carbon pricing initiatives



**STATUS**
- [x] Implemented
- [ ] Scheduled
- [ ] Under consideration

**TYPE OF INSTRUMENT**
- [x] Carbon tax
- [x] ETS
- [ ] Undecided

**TYPE OF JURISDICTION**
- [x] National
- [x] Regional
- [x] Subnational

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

- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS and carbon tax implemented or scheduled

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Source: World Bank Carbon - Pricing Dashboard

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# Cap and Trade


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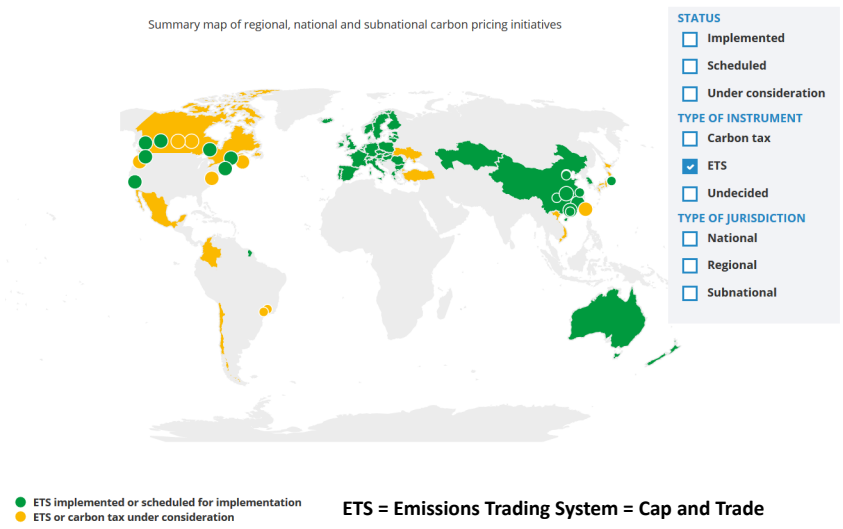
# Cap and Trade Policies Around the World




**ETS = 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
  - 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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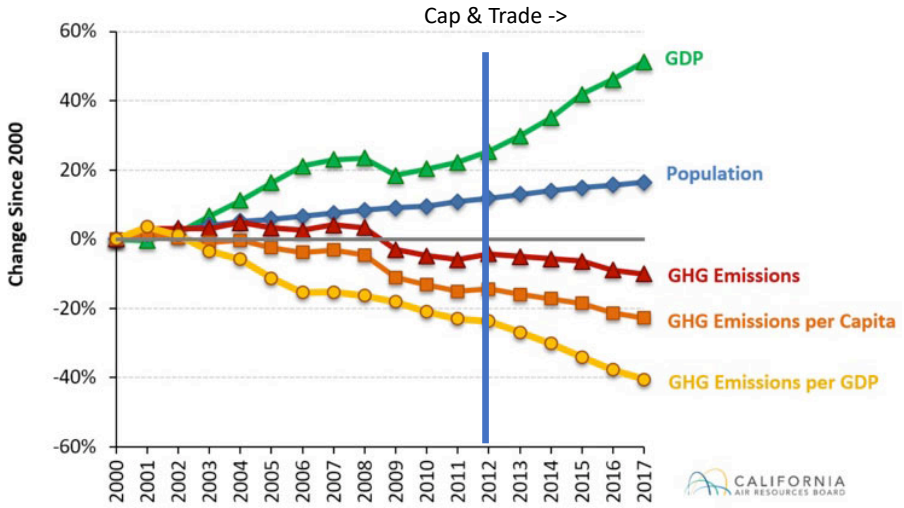
# Change in California GDP, Population, and GHG Emissions since 2000

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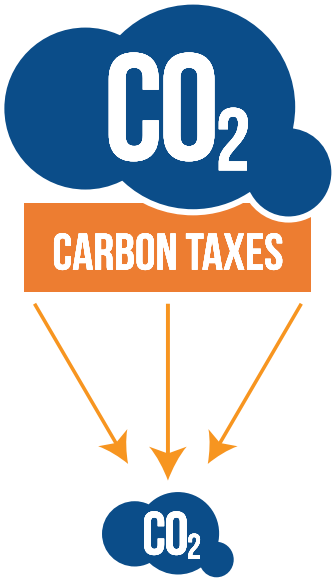
## Carbon Tax

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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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## 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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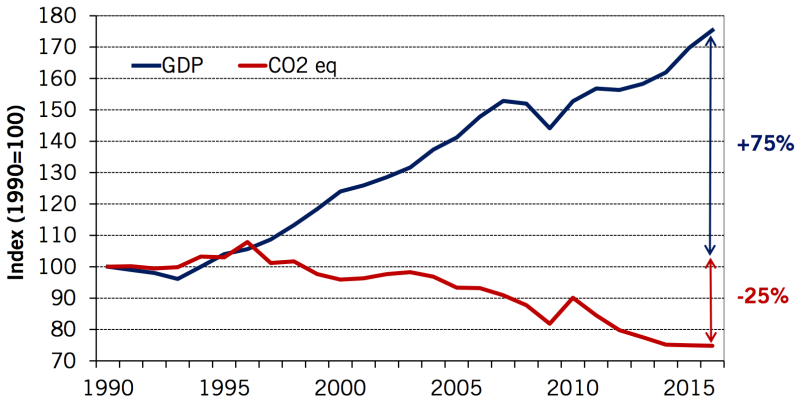
## Real GDP and Domestic $CO_2$eq Emissions[1] In Sweden, 1990-2016




[1] In accordance with Sweden's National Inventory Report, submitted under the UNFCC and the Kyoto Protocol. $CO_2$ = approx. 80 % of total $CO_2$eq emissions. Preliminary data for 2016.

***Sources***: Swedish Environmental Protection Agency, Statistics Sweden

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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?

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