Introduction to Economics and Policy of Climate Change

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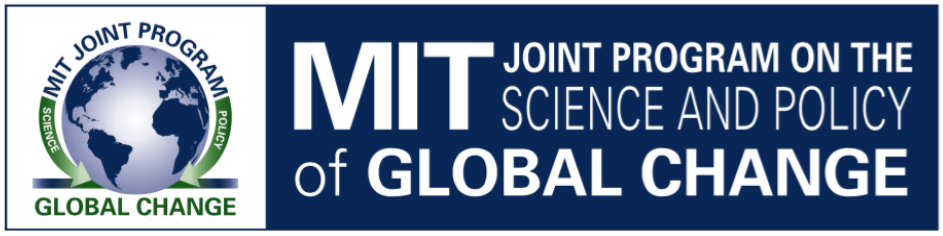


MIT Joint Program on the Science & Policy of Global Change

Ground Rules

Acronym Soup

- Interrupt us if we use a jargon and do not explain what it means

Other Questions

- Quick clarifying questions welcome. For generalities & hypotheticals, please save for the break

Not Spokespeople

- ……for the Joint Program, MIT, or any sponsors of either. Our editorial remarks & opinions are entirely personal

Not Experts

Thanks to previous contributors: Paul Kishimoto, Michael Davidson and Sam Houston

Outline

- Why we need environmental policies? What's special about environmental/climate policies?
- What are the available policy options dealing with climate change?
- How do we tell if a climate policy is good or not?

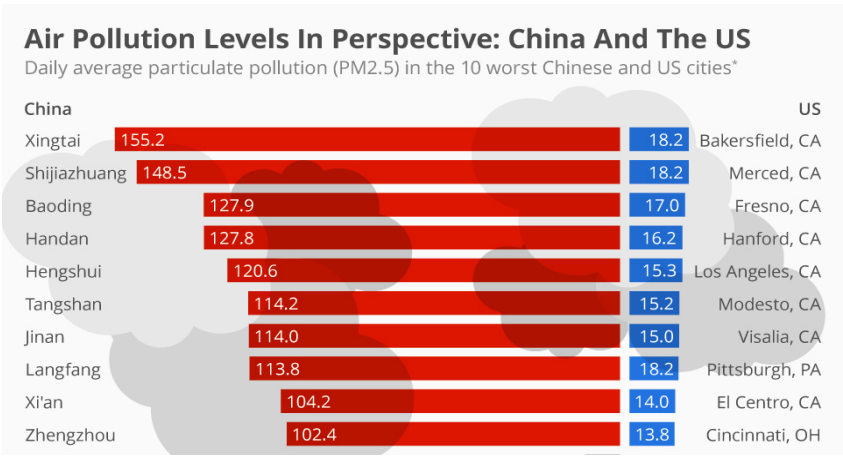
Why we need an environmental policy?

We need a policy when (a group of) people cannot get to the "optimal solution" by themselves alone (without any rules)

--it happens when there are lots of people but resource is limited

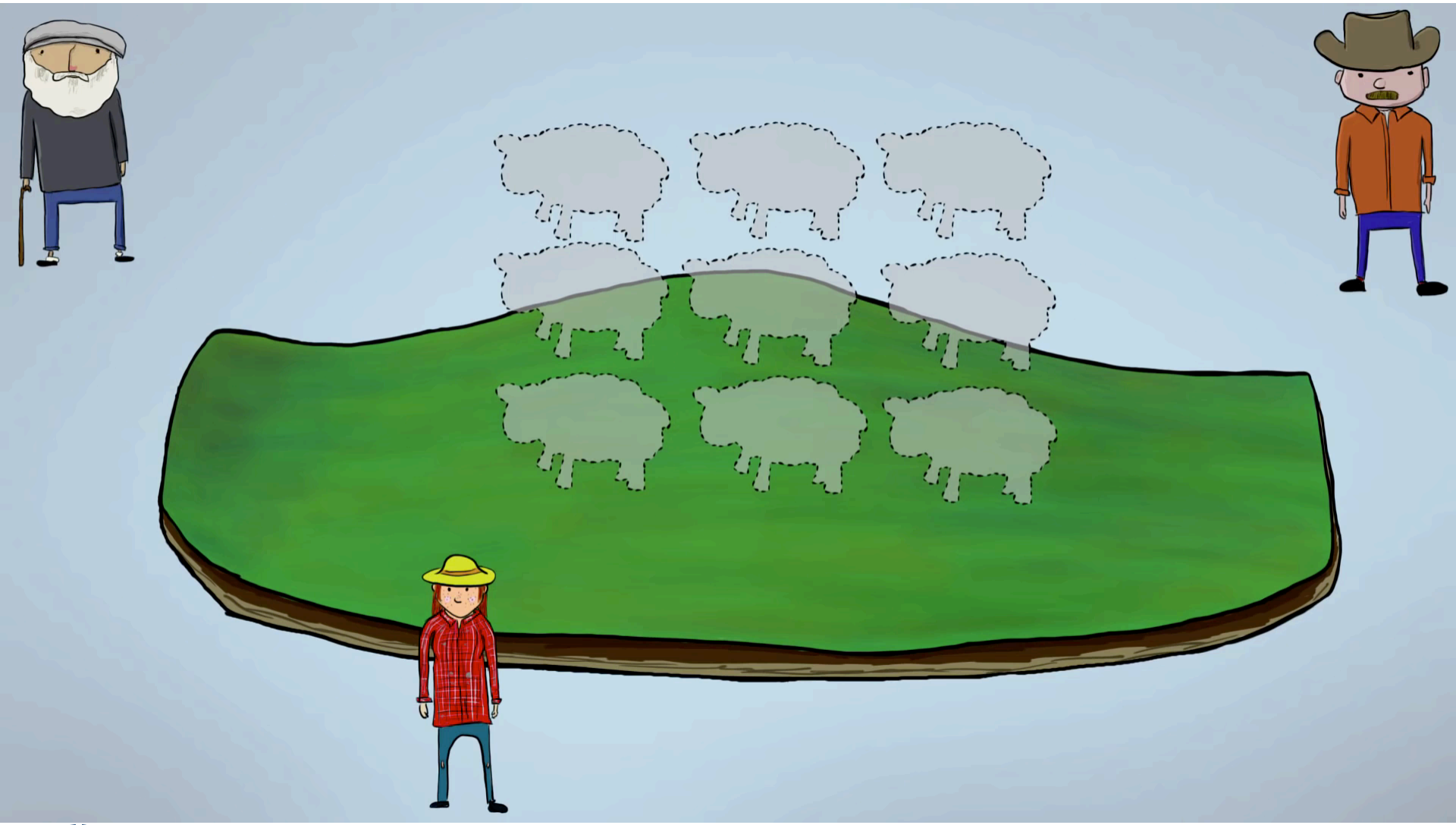
Policy is especially important in environmental domain:

- people's understanding of "good environments" are different
- natural(environmental) resource is limited



- Even people have same value judgment on environments, there are still problems:

Tragedy of the commons (TOC)

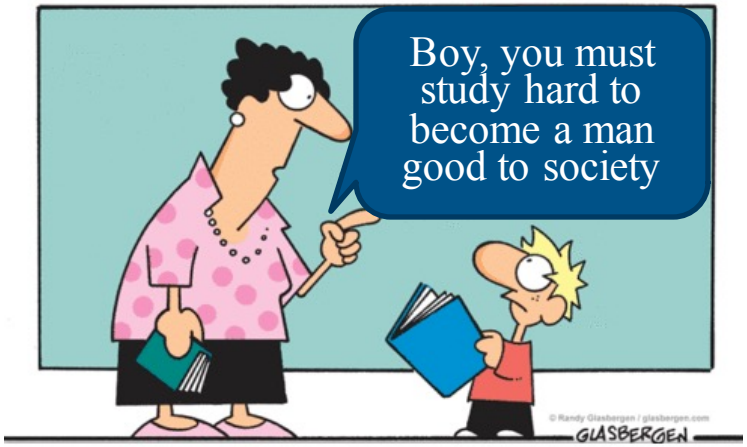


https://www.youtube.com/watch?v=WYA1y405JW0

What's behind the "tragedy of the commons"

Externality---why TOC happens

An externality is present whenever the well-being of a consumer/firm is directly affected by another agent in the economy.



Positive Externalities

Negative Externalities

Public Goods---why TOC is hard to solve

A good that individuals cannot be effectively excluded from use and where use by one individual does not reduce availability to others

e.g. environment protection, national security, cleaning common kitchen

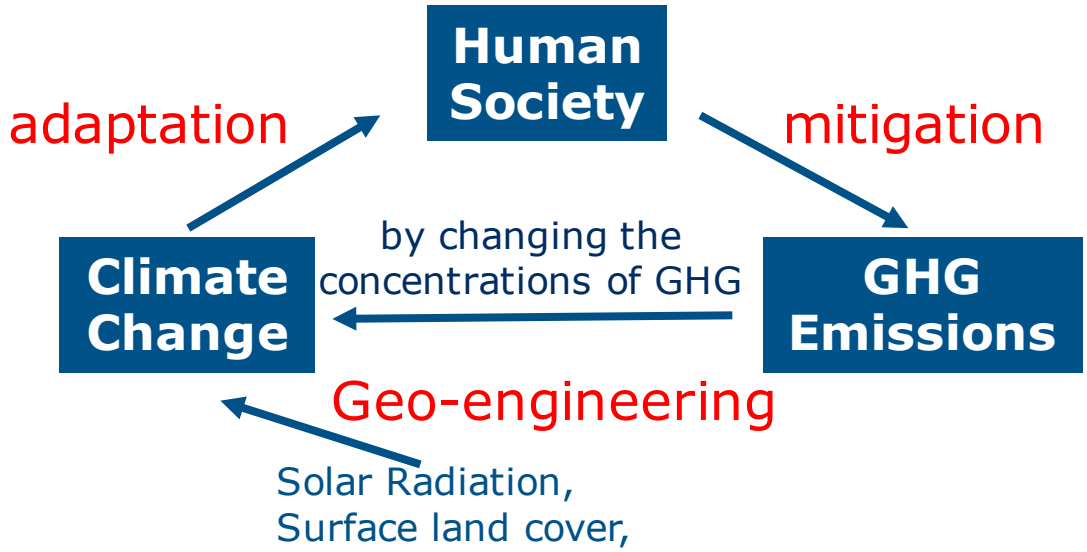
Climate change is a TOC!

- A "commons" problem: GHG-emitting activities give immediate tangible benefits, but the negative impacts (costs to society and environment) are distributed over time and over populations (negative externality).
- The removals of CO2 emissions are public goods (can't exclude any country from sharing the atmosphere)…

What makes climate change more complex:

- 1) uncertainty
- 2) difficulty of negotiations
- 3) difficulty of "reducing numbers of sheep"

What are our options?



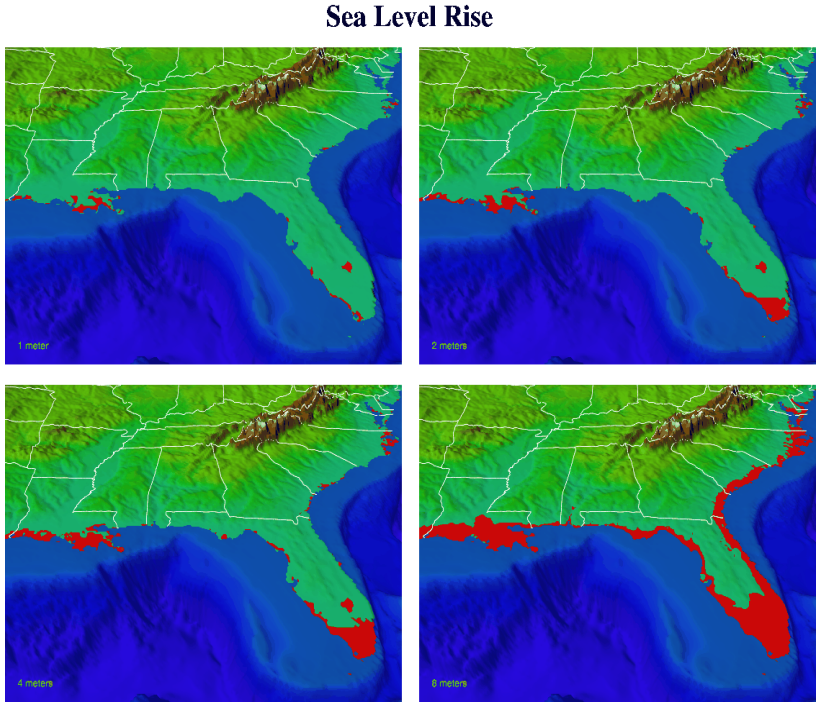
Consider the entire possible range of responses to climate change:

- Mitigation/Abatement (reduce GHG Emissions)
- Geoengineering (modify climate without reducing GHG emissions)
- Adaptation (limiting the impacts of climate change)
- Suffering (…)

Suffering

Accepting the effects of climate on humans and ecosystems

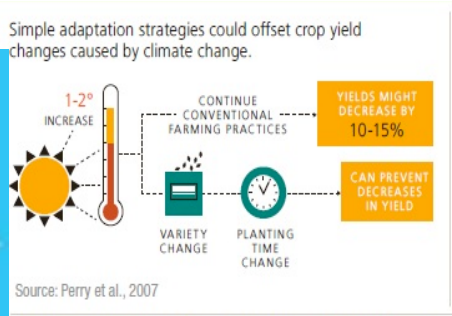
- "Business as usual" scenario is likely to be a mix of adaptation and suffering
- Bottom line for policy evaluation

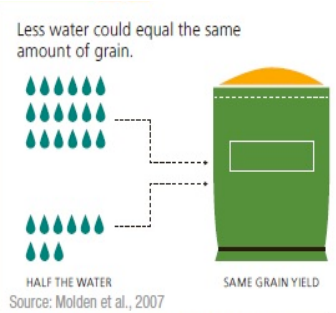


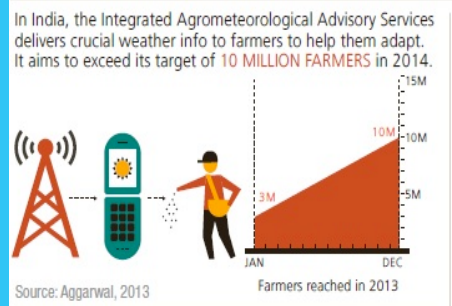
Adaptation

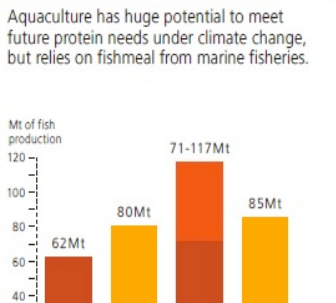
Limiting the impacts of climate change on humans and society

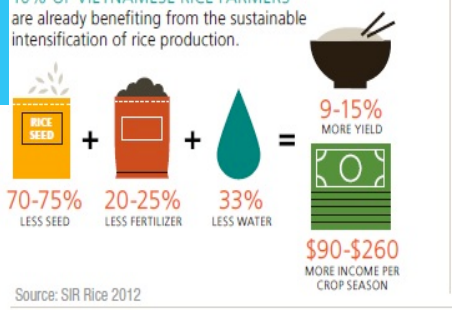
- Adaptation is place- and context- specific
- Most adaptation is carried out at local scale (might be great!), it is not necessarily expensive, but requires time!





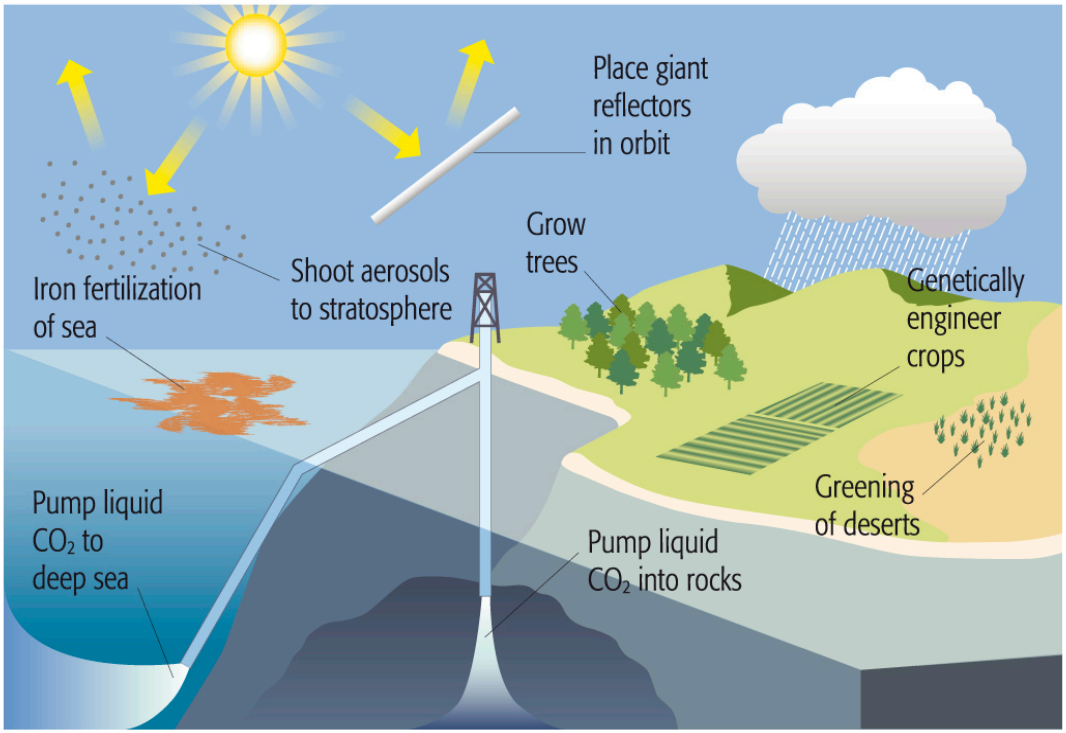






Geoengineering

Modify GHG concentrations or other factors in climate system



Solar Radiation Management:
(1) Stratospheric aerosols
(2) Space mirrors
(3) White roof

Removal of GHG:
(1) Carbon Capture and Storage
(2) Ocean fertilization
(3) Grow trees

- (In)expensive, dangerous, unknown or limited efficacy, unknown side effects
- Governance challenges (for large scale experiment)

What is the right climate?

Mitigation/Abatement

Reducing GHG emissions

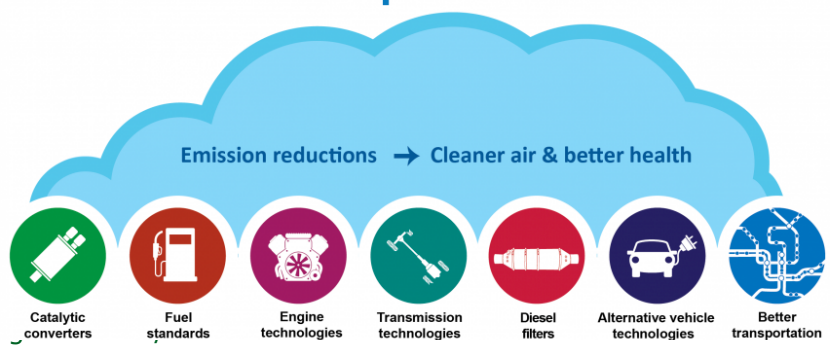
Methods:

- Reduce activities which emit greenhouse gases (conservation)

- Do the same activities differently i.e. with technology:
  - Increase the efficiency → fewer GHGs per unit of activity
  - Do them very differently → far fewer GHGs per unit of activity

Policy instruments:

1. Command & control
2. Carbon tax
3. Cap and trade



Mitigation: Command & Control Policy

Regulate emissions by mandating specific quantities or performance levels

Major part of Environmental policy

Examples
Corporate Average Fuel Economy, Renewable Portfolio Standard, Renewable Fuels Standard, Clean Power plants plan

Advantages
Prompts investment in new technology

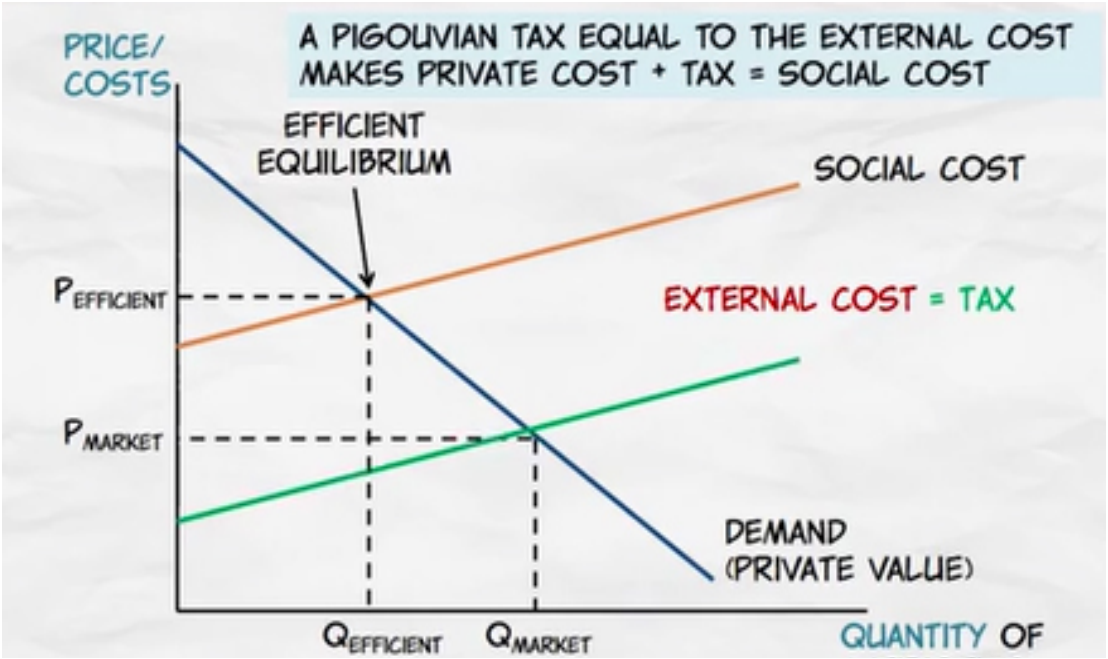
Drawbacks
- Inefficiency
- Burden unequal for different producers
- Requires viable enforcement mechanisms

Internalizing carbon externality: carbon tax

Mechanism

- Price (cost) of GHG incorporated into price of goods and services

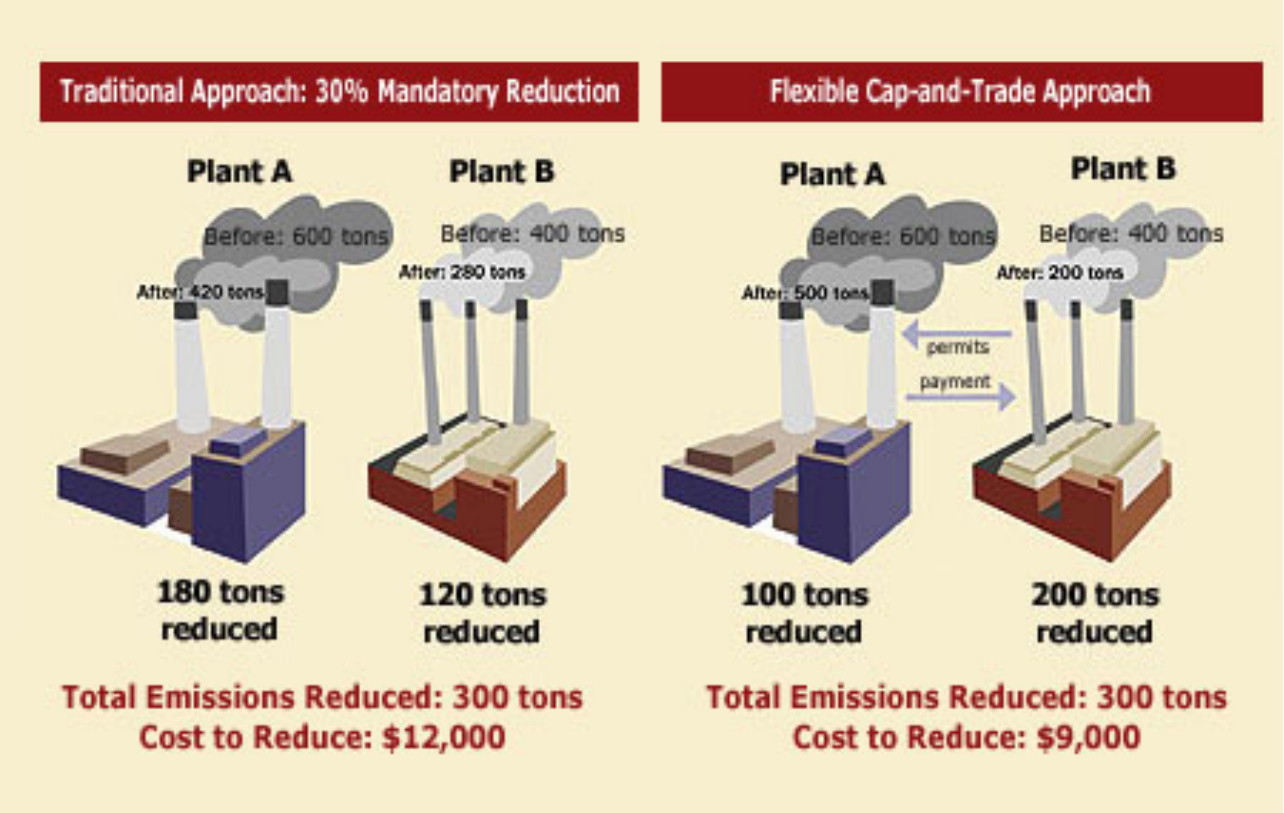
For every unit of GHG, emitter pays for the social cost of GHG



How is the tax-rate determined? ---- Social Cost!

Cap & Trade

Set maximum emissions; allocate or auction permits to producers; allow them to trade in a market, which determines the carbon price (by itself)



Cap & Trade

e.g. California Cap-and-Trade program:

(1) Cap: -2%(2013), -2%(2014), -3% annually (2015-2020)

(2) Permit Auction/Allocation

Auction Name	Total Current Vintage Allowances Offered	Total Current Vintage Allowances Sold	Current Auction Settlement Price	Total Future Vintage Allowances Offered	Total Future Vintage Allowances Sold	Advance Auction Settlement Price
August 2014 Auction #8	22,473,043	22,473,043	$11.50	9,260,000	6,470,000	$11.34
May 2014 Auction #7	16,947,080	16,947,080	$11.50	9,260,000	4,036,000	$11.34
February 2014 Auction #6	19,538,695	19,538,695	$11.48	9,260,000	9,260,000	$11.38

(3) Permit Transfer

Allowance Transfers	Priced Transfers			Unpriced Transfers		Total	
	# of Transfers	Quantity	Weighted Average Price	# of Transfers	Quantity	# of Transfers	Quantity
2013	228	12,983,910	$12.23	110	8,083,869	338	21,067,779
2014	338	33,587,549	$11.98	87	3,501,244	425	37,088,793

https://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

Differences and Connections between Cap-and-trade with carbon tax

- **Carbon Tax**

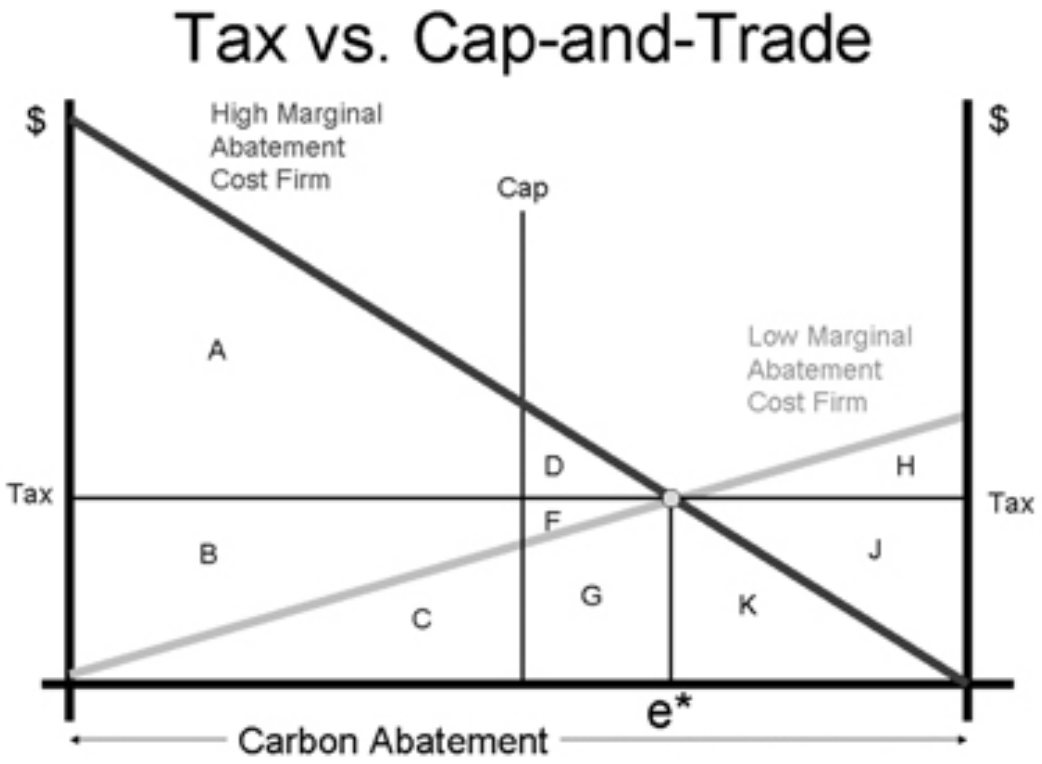
-- fixed cost per unit

-- uncertainty in emissions

- **Cap-and-trade**

-- fixed emissions

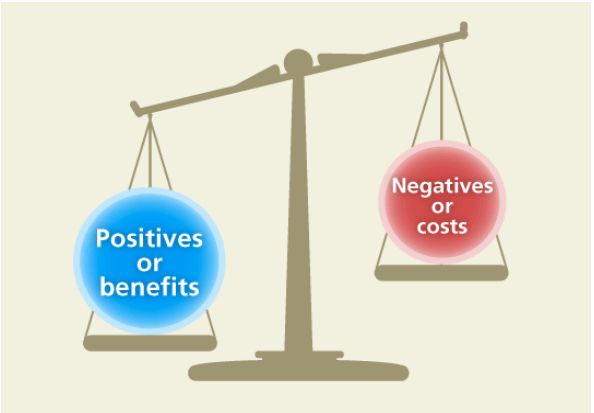
-- uncertainty in cost



- Can be same if the tax rate is associated with the emission cap

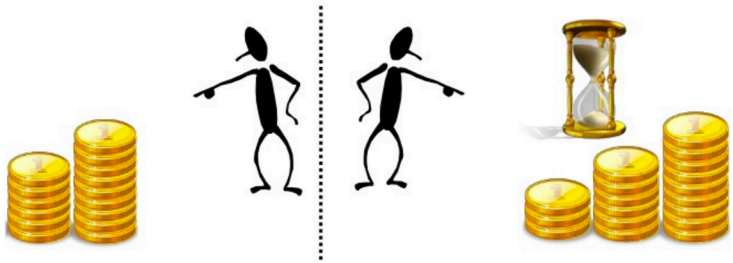
- All Market policies--Markets are complex societal constructs that theoretically accomplish human activities at minimum cost (economic efficiency)

How can we evaluate a policy?



Framework: Cost-Benefit Analysis (CBA)

- expressed in monetary terms
- adjusted for the time value of money, expressed on a common basis in terms of their net present value
- comparative framework that evaluate a list of possible alternatives



- List all the alternatives and stakeholders
- Select the measures of cost/benefit
- Predict cost/benefit over different time periods
- Determine the discount rate
- Calculate the Net Present Value

How to calculate the benefits?

Where are the benefits come from?

- **mitigation policy:** we gain benefits from cutting down CO2 emissions, how is the decrease of CO2 emissions transformed into monetary unit?
- **Adaptation policy:** more like conventional policy(?), benefits from food production, energy conservation, human health

Mitigation benefits:

- How much CO2 emissions can a policy cut down?
- How much value is a unit of CO2 abatement?

- **Social cost of carbon:** economic cost of an additional ton of CO2 emissions (in terms of discounted utility value of consumption)
- In real, to calculate the social cost is very difficult.

Social cost of carbon (SCC)

Methods to calculate SCC: through integrated assessment models (IAM) e.g. DICE model by Nordhaus, Yale

Nordhaus, W. (2014). Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches. *Journal of the Association of Environmental and Resource Economists*, *1*(1/2), 273–312. https://doi.org/10.1086/676035

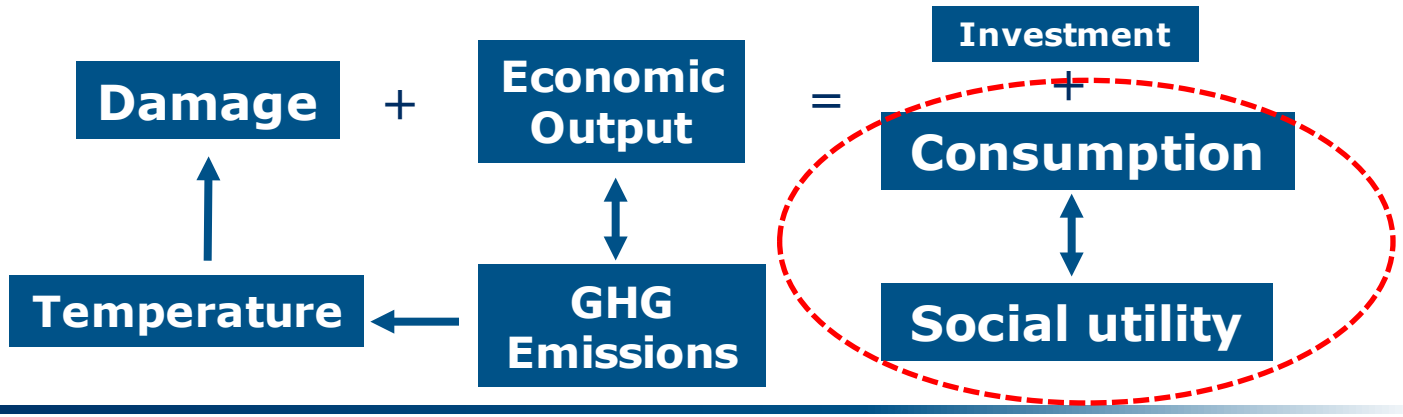
1) Defined social utility(W), depending on consumption, population, and discount factor

$$W = \sum_{t=1}^{T\max} U[c(t), L(t)]R(t).$$

2) consumption + investment = gross output – damage from climate

3) Damage is a function of temperature: $D(t) = \psi_1 T_{AT}(t) + \psi_2 [T_{AT}(t)]^2$

4) Temperature is estimated using simplified geophysical equations, as functions of emissions



Social cost of carbon (SCC)

SCC: $$\mathrm{SCC}(t) \equiv -\frac{\partial W}{\partial E(t)} \Big/ \frac{\partial W}{\partial C(t)}.$$ Unit: $/ton

e.g. If SCC=$15/ton, the damage of a ton of CO2 on the social utility can compensated by a consumption of $15.

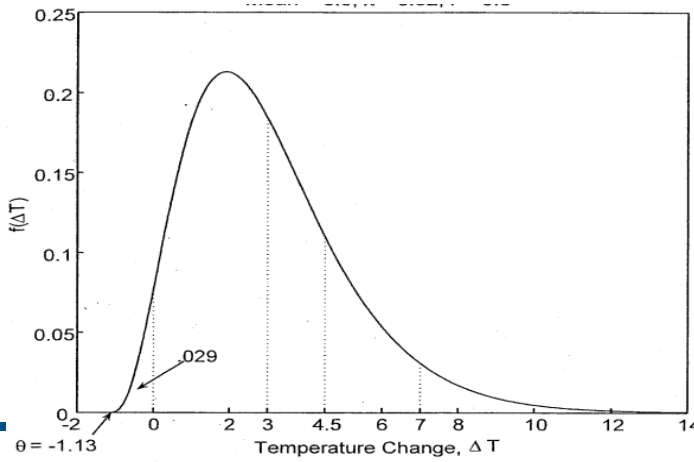
- US Interagency Working Group Estimates:

	Discount Rate and Statistic			
Year	5% Average	3% Average	2.5% Average	3% 95th percentile
2015	$11	$36	$56	$105
2020	$12	$42	$62	$123
2025	$14	$46	$68	$138
2030	$16	$50	$73	$152
2035	$18	$55	$78	$168

https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf

- Criticisms on SCC:

1) Tipping points and catastrophe
2) Not considering on technology change



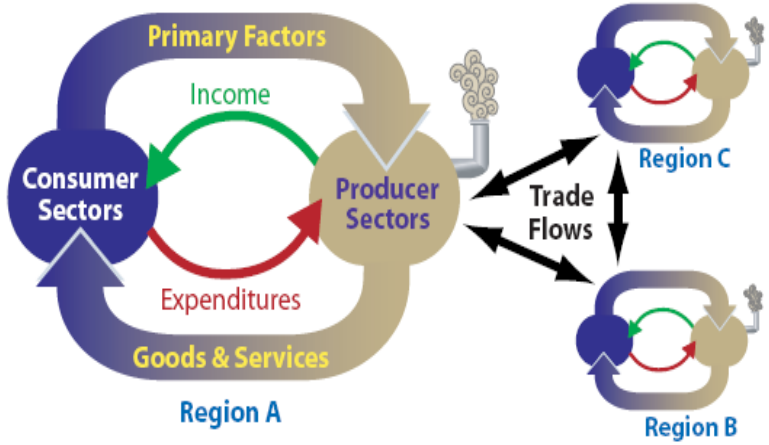
How much CO_2 can a policy cut off?

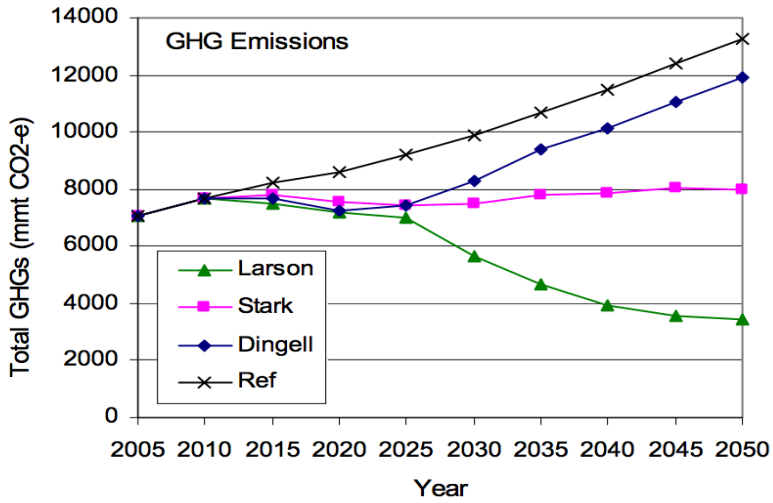
- The difficulty to estimate depends on how specific the policy is:

For policy specific focusing an industry/location:
Need to understand the CO2 emission process in that industry
e.g. thermal power sector

- More difficult: general economic policy

Q: How much CO2 can a carbon tax policy cuts down?
Methods: through integrated assessment models
(e.g. MIT Economic Projection and Policy Analysis, EPPA)
https://globalchange.mit.edu/research/research-tools/human-system-model





How to estimate the cost of a policy?

- Where might the costs of a climate policy come from?

Regulation cost, **technology cost**, economic impact (e.g. employment)...

Marginal Abatement cost

CBA on real-life cases

CBA has been a key step in evaluating a policy proposal (especially for EPA, DOE…)

Case: Light-Duty Vehicle GHG Emission and fuel economy Standards

https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006V2V.PDF?Dockey=P1006V2V.PDF

Potential Cost:
Compliance cost; impact on car sales; Accident, congestion from more use of vehicles

Potential Benefits:
Fuel saving; GHG and air pollution; Energy security; reduce of refuels

Unit: Million 2007 dollars

	2020	2030	2040	2050	NPV,3%	NPV,7%
Compliance	$15,600	$15,800	$17,400	$19,000	$345,900	$191,900
Accident, congestion	$2,300	$4,600	$6,100	$7,800	$84,800	$38,600
SCC	$900-$5,800	$2,700-$14,000	$4,600-$21,000	$7,200-$30,000	$34,500-$176,700	$34,500-$176,700
Air Pollution	NA	$1,200	$1,200	$1,200	$21,000	$14,000
Fuel Saving	$35,700	$79,800	$119,300	$171,200	$1,545,600	$672,600
Reduced Refuel	$2,400	$4,800	$6,300	$8,000	$87,900	$40,100
Energy Security	$2,200	$4,500	$6,000	$7,600	$81,900	$36,900

Co-Benefits

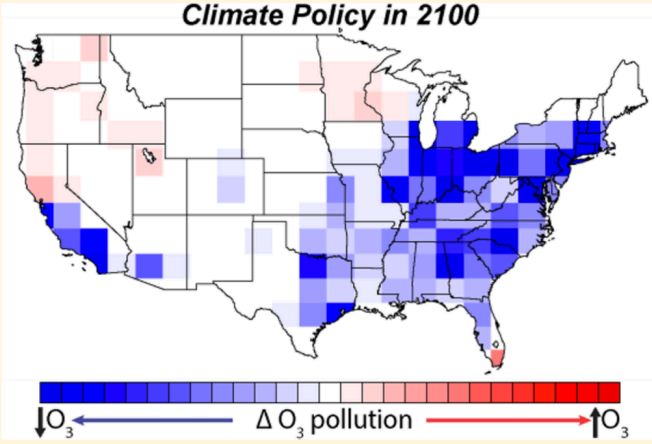
Earlier: "Climate change as a policy problem is conflicted with other issues."

- Example: Air pollution Co-Benefits of climate policy

- Coal-fired power plants produce GHGs, but also other air-pollutants: SOx, NOx (acid rain, health effects), Hg (health effects), Particulate Matters (health effects, visibility)
- These effects are better understood, or more certain, than climate.
- Policy measures may address all simultaneously, even if only aimed at one
- Even a less warm climate can help decrease the air pollution concentration

http://chicagopolicyreview.org/2014/12/05/buy-one-get-one-air-quality-co-benefits-of-us-carbon-policies/

http://www.nature.com/nclimate/journal/v4/n10/full/nclimate2342.html



Problems with cost-benefit analysis

1. Low-probability but huge-damage catastrophe event

2. How to value human's life

Six million dollars for a human's life? ----utilitarianism

3. The economic part of the model is too crude

4. Uncertainty

We might have a global temperature projection, but not rainfall, or some temperature for a specific region

5. Climate—International, Policy—Domestic

Efficiency isn't everything

Stringency and political feasibility

- How strict is the policy? How viable is the policy?

Distribution/equality

- How are the costs of mitigation/abatement/adaptation/damage distributed across & within countries?
- How does this distribution correspond to existing economic (or other) disparities?

Assignment of responsibility

- Are countries responsible in proportion as they have contributed to the current stock of GHGs or in proportion as they will emit in the future under "business as usual"?

Discounting: intergenerational equality

- What discount rate is being used?

Summary

- Why we need environmental policies? What's special about environmental/climate policies?

People are different and resources are limited

Tragedy of the commons (externality and public goods)

- What are the available policy options dealing with climate change?

Suffering, adaptation, geoengineering, mitigation

Mitigation: command & control, carbon tax, cap-and-trade

- How do we tell if a climate policy is good or not?

Cost-Benefit Analysis

The benefit of carbon tax is calculated using social cost of carbon

The technology cost can be calculated using abatement cost curve

Key tool: Integrated Assessment Model