CLIMATE CHANGE PT. 2: POLICY

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PARIS 2015
UN CLIMATE CHANGE CONFERENCE

LESSON OBJECTIVES

01

Analyze International Climate Policy

02

Analyze Domestic Climate Policy

03

Analyze Policy Interactions

THE COOPERATION PROBLEM

Greenhouse gases are uniform mixing pollutants

- Emitting a ton of GHGs in Boston would be the same as emitting a ton in Beijing
- They equally contribute to atmospheric GHG levels and thus the impacts of climate change

Thus, the climate can be treated as a **global public good**.

Do people pay to use the climate?

- No!

Will the use of climate be efficient?

- No!

PROBLEM

Market will overuse the climate because it is a global public good.

SOLUTION

Many economic agents, so private solutions probably won't work.

Since the climate is a global public good, what about international climate policy?

01

INTERNATIONAL CLIMATE POLICY

COOPERATION IN INTERNATIONAL CLIMATE POLICY

Let's start by trying to get countries to work together

- Ignore the specific policy for now.

In 1993, Economist Scott Barrett argued that international cooperation in an international environmental agreement (IEA) will only be rational if it is a *self-enforcing agreement.*

- Self-enforcing means that every member of the agreement has incentive to stay a member

Barrett then pointed out a problem with these self-enforcing agreements: the free-rider problem.

FREE-RIDER PROBLEM

In a *self-enforcing agreement* each actor acts independently in their own self-interest

- Try to maximize their own net benefits

<u>The problem:</u>
Climate is a global public good

- Individual countries bear the cost of their emissions reductions
- But **everyone** shares in the benefits!
- Countries cannot exclude others from reaping the benefits and do not internalize the spillovers.

Cooperation problem with two outcomes for IEAs:

- Small but deep
- Broad but shallow

ATTENDANCE ACTIVITY

Consider the following game:

Players: China and the US

Assumptions: RCP6.0/SSP2, 3% dr

USA:

- $MC_{USA}(Q) = 1.56 \times 10^{-7} Q$
- $CSCC_{USA}(Q) = \$43/\text{ton}$

China:

- $MC_{China}(Q) = 3.38 \times 10\text{-}8Q$
- $CSCC_{China}(Q) = \$81/\text{ton}$

Market:

- $MC_{Market}(Q) = 2.78 \times 10^{-8} Q$
- $GSCC\,(Q) = \$124/\text{ton}$

(Sources: POLES EnerData and Ricke et al., 2018)

1. What is the efficient quantity of abatement? What is the net benefit for each country?
2. How much abatement each country will do independently?
3. If each country cooperated (set their MC=GSCC), do they have incentive to deviate (cheat on opponent and set MC=SCC)?

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(Sources: POLES EnerData and Ricke et al., 2018)

1. What is the efficient quantity of abatement? What is the net benefit for each country?

MC_{Market}=GSCC

-> $Q_{Tot} = 4.46x10^9$ tons of CO_2

$Q_{China} = 3.67x10^9$ tons of CO_2

$Q_{USA} = 7.95x10^8$ tons of CO_2

$NB_{China} = 4.46x10^9x81 - 1/2x124x3.67x10^9$
$= \$1.34x10^{11}$

$NB_{USA} = 4.46x10^9x43 - 1/2x124x7.95x10^8$
$= \$1.42x10^{11}$

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(Sources: POLES EnerData and Ricke et al., 2018)

2. How much abatement each country will do independently?

$MC_{China}=CSCC_{China}$

-> $Q = 2.40x10^9$ tons of CO_2

$MC_{USA}=CSCC_{USA}$

-> $Q = 2.76x10^8$ tons of CO_2

$Q_{Tot} = 2.67x10^9$ tons of CO_2

ATTENDANCE ACTIVITY

Consider the following game:

Players: China and the US

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(Sources: POLES EnerData and Ricke et al., 2018)

1. If each country cooperated (set their MC=GSCC), do they have incentive to deviate (cheat on opponent and set MC=SCC)?

USA cooperates and China shirks

$NB_{China} = 81\text{x}3.19\text{x}10^{9} - 1/2\text{x}81\text{x}2.40\text{x}10^{9}$
$= \$1.61\text{x}10^{11} > \$1.34\text{x}10^{11}$

China cooperates and USA shirks

$NB_{USA} = 43\text{x}3.94\text{x}10^{9} - 1/2\text{x}43\text{x}2.76\text{x}10^{8}$
$= \$1.63\text{x}10^{11} > \$1.42\text{x}10^{11}$

Both countries have incentive to shirk

Cooperation will fail!

ATTENDANCE ACTIVITY

Net payoffs:
$276>$228 so better off cooperating

US		China: Cooperate	China: Don't Cooperate
	Cooperate	• China gets $134 Billion • US gets $142 Billion	• China gets $161 Billion • US gets $88 Billion
	Don't Cooperate	• China gets $92 Billion • US gets $163 Billion	• China gets $119 Billion • US gets $109 Billion

COOPERATION PROBLEM

We have not even picked the policy, and we already can't reach the efficient outcome!

This free-riding problem is thought to be one of the main barriers to effective international climate policy.

There has been research to understand what can increase the incentive to cooperate

- Transfers (think Kaldor-Hicks)
- Uncertainty
- Tipping points

But still stands as a barrier

INTERNATIONAL CLIMATE AGREEMENTS

A **very** brief look at a few highlights in international climate policy

United Nations Framework Conventions on Climate change (UNFCC)

- Began with Earth Summit in Rio de Janeiro 1992

Kyoto Protocol (1997)

- Strict binding emissions caps
- Primarily developed countries
- Set a very ambitious goal
- US did not ratify and Canada denounced in 2012
- Small but deep

Paris Agreement (2015)

- Nationally Determined Contributions (NDCs)
- Signed by 196 countries
- Set a very (very weak unambitious goal)
- Broad but shallow
- US has since announced intention to withdraw

MONTREAL PROTOCOL

PROBLEM

Free-riding stands as a barrier to international cooperation.

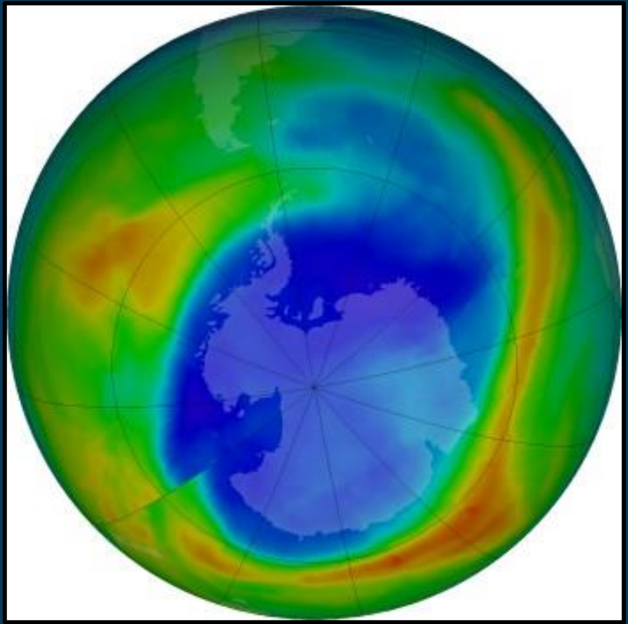
Attempts at a climate agreement show signs consistent with the free-rider problem.

This seems like a bad sign!

Are there any international efforts around environmental problems that have been successful?

Yes!

MONTREAL PROTOCOL (1987)



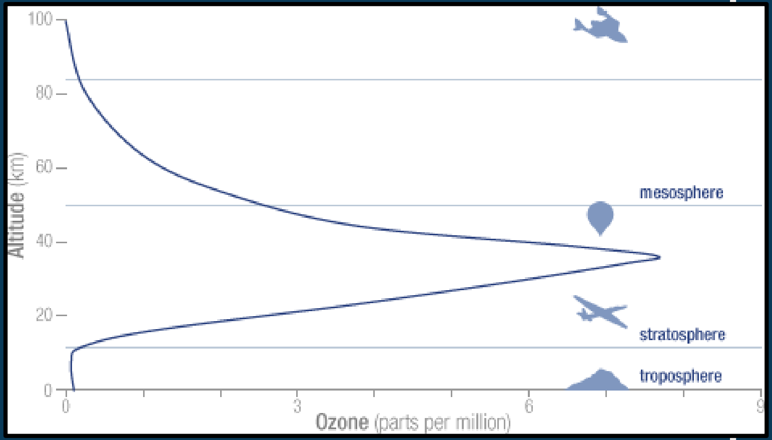
A brief history:
Issue: depletion of Ozone (O3) in the stratosphere

- The ozone hole has been at least 8 million square miles in size every year since 1990 (>2x size of U.S.)

1973 - Basic science discovering the problem
1987 – First international treaty (with goal of full implementation in 1989)

Montreal Protocol is an international agreement to limit the release of Chlorofluorocarbons – primarily implemented through bans on production/use.

MONTREAL PROTOCOL (1987)



Damages:
Without ozone, the Sun's UV radiation would sterilize Earth's surface.

In troposphere: natural concentration of ozone is 10 parts per billion (0.000001%).

- EPA: exposure to ozone levels > 70 ppb for > 8 hours or longer is unhealthy.

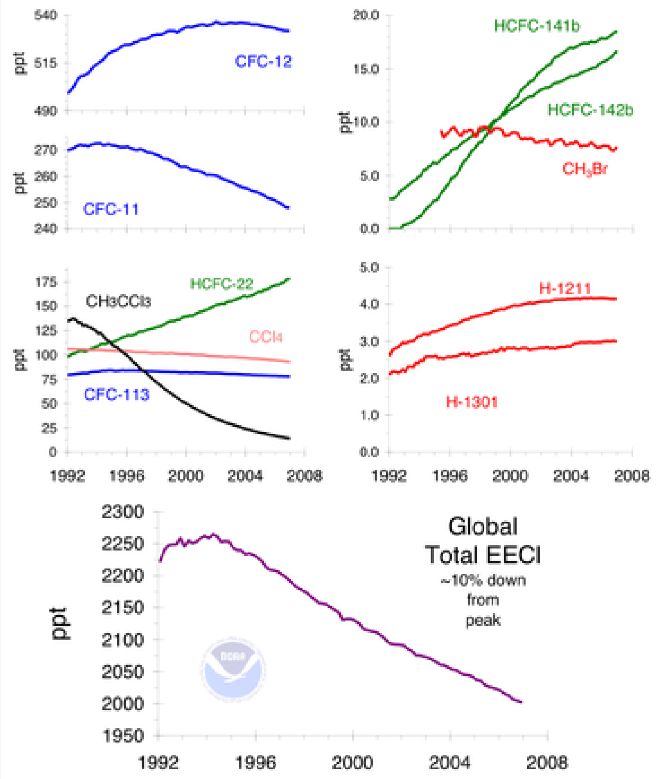
Relative to 1970s, UV exposure is estimated to be up to:

- 7% more in Northern Hemisphere mid-latitudes during the winter and spring (4% in summer and autumn)
- 6% at Southern Hemisphere mid-latitudes on a year-round basis

US EPA estimates that a 2% increase in UV-B radiation could result in a 2 to 6% increase in non-melanoma skin cancer (e.g., 2m excess cancers if 100m are at risk)

- Australia? Risk is as high as 3 in 4 to get some form of cancer

MONTREAL PROTOCOL (1987)



Response:

NASA estimates:

- Hole has stabilized
- "… we can say with confidence that ozone holes will be consistently smaller than 8 million square miles by 2040,"
- Could be completely gone by 2100

WHAT MADE THE MONTREAL PROTOCOL SUCCESSFUL?

It is often held up as an example of successful international agreement & a successful command-and-control policy.

- Clearly the Montreal Protocol did not fall trap to the free-rider problem.

<u>What contributed to this?</u>

- The problem clearly defined & easy to measure
- Transfers through the Multilateral Fund established to assist developing countries in complying
- Evidence that the benefits were substantial enough to make a ban the self-interested decision for different parties. Largely due to availability of substitutes
- Scientific lobbying alliance played key role in convincing Federal Govt & Industry (particularly, DuPont) of science of problem <u>and solution</u>

THE COORDINATION PROBLEM

PROBLEM

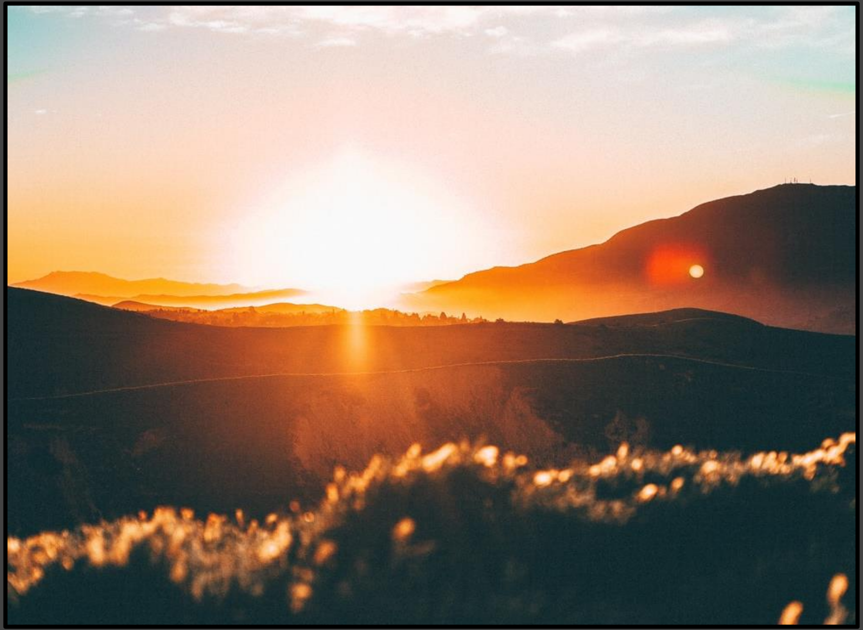
International policy around mitigation presented a coordination problem

But, mitigation was just one of our options!

Let’s look at another important international option.

What about solar geoengineering?

SOLAR GEOENGINEERING



Solar geoengineering allowed for the manipulation of the climate.

Specifically, it could be used to influence global temperatures and precipitation.

It has three important characteristics:

- Quick
- Cheap
- Imperfect

So what happens to international agreements around solar geoengineering?

THE COORDINATION PROBLEM

For mitigation, high costs and small benefit shares made cooperation difficult.

But solar geoengineering has low costs!

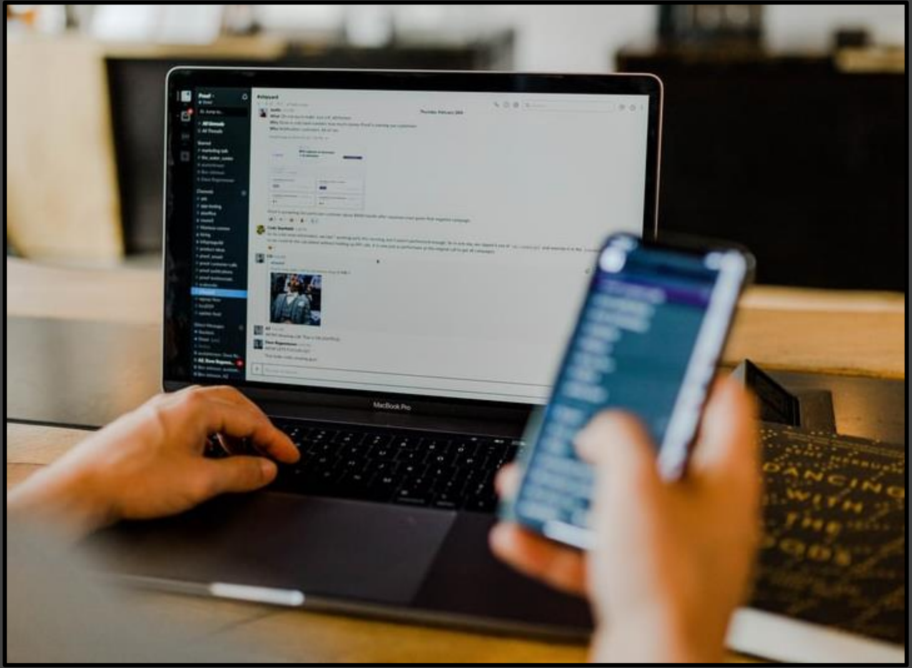
Unfortunately, this can create a new problem.

If solar geoengineering is sufficiently inexpensive, anyone could do it to “turn the thermostat” to whatever they like.

The free-rider problem becomes a *free-driver problem*.

- Could use it to the detriment of others

This has lead to concern and calls for an international governance structure to manage its use.



02

National and Subnational Climate Policy

CARBON TAX

CARBON TAX

What would be the optimal policy response to the climate change problem?

- We have an externality problem, where individuals do not face the *true cost* of their actions
- What if we put a price on carbon?
- Setting a Pigouvian tax equal to the social cost of carbon would result in the market providing the efficient level of environmental quality

Other benefits of a tax:

- Provide the best incentive for innovation (pushes energy efficiency)
- Provides tax revenues that could be used to offset distortionary taxes

Problems with a tax:

- Firms don't like them
- Can be regressive
- Politically difficult

CARBON TAXES EXAMPLES

Most aggressive carbon tax to date:
Canadian province of British Columbia

- $10 (Canadian) per metric ton (tonne) of CO_2 in 2008, rising annually by $5/tonne until $30 in 2012.
- Credited with reducing fuel use by 19%
    - BC's fuel went down 16% while rest of Canada increased 3% over same period of time

BC CARBON TAX

Overall, the tax has been considered to be successful

BC's minister of environment:

> "We were told it would destroy the economy and we'd never get elected again, but we've won two elections since [our carbon tax] was enacted five years ago. It's the revenue neutrality that really makes it work. We collected C$1.2 billion last year and a little bit more was returned."

Tax is designed to be "Revenue Neutral".

- Revenue neutral policies pair increases in revenues from one source with reductions in taxes from another source to keep government's total the same.
- Revenue from carbon tax is used to reduce personal and business income taxes as well as financing a low-income tax credit.

BC CARBON TAX

Although some argue the tax is still not enough.

The Economist, July 2011

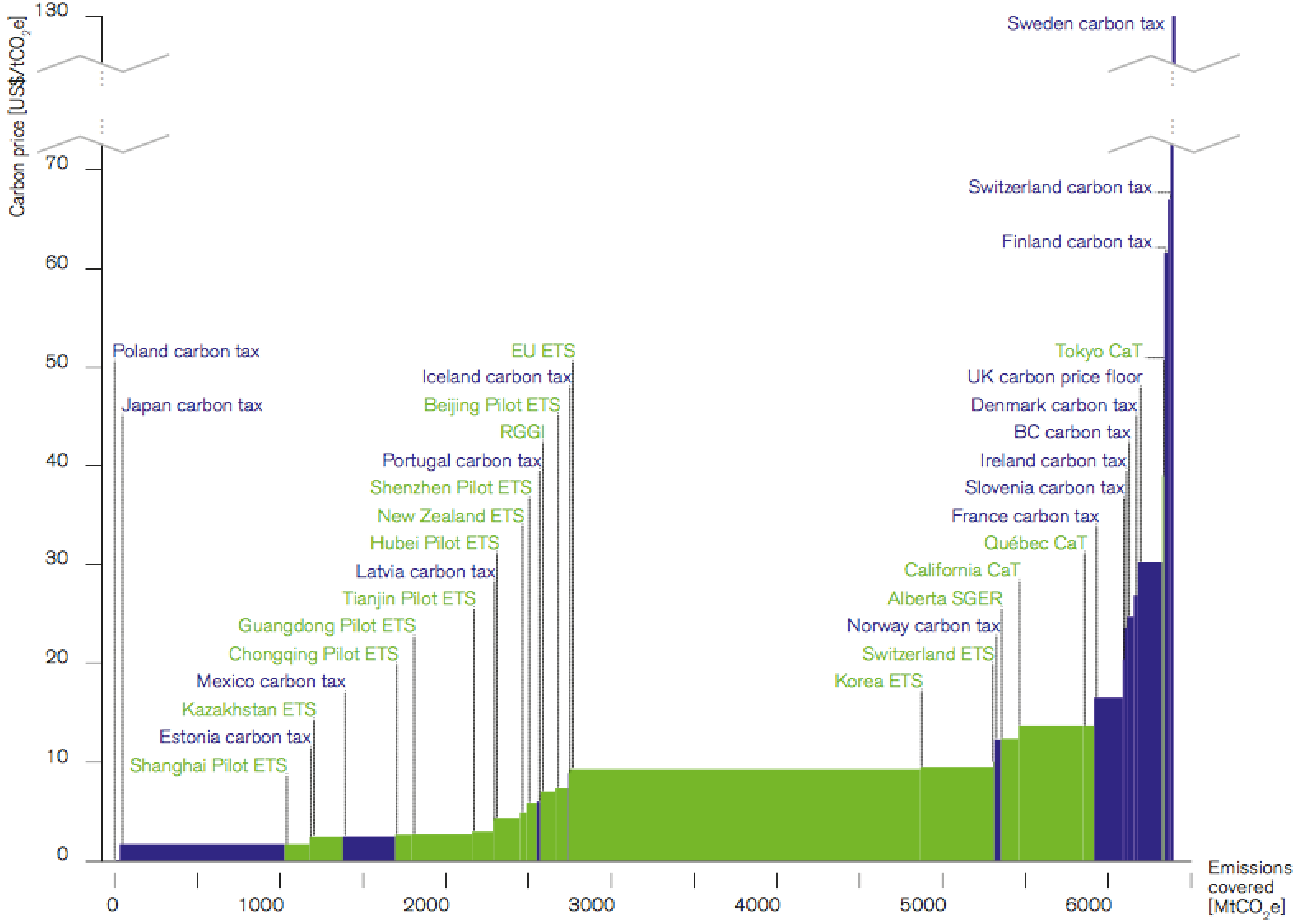
"At C$25 per tonne, British Columbia's tax already exceeds the price of carbon in Europe's emissions-trading scheme. But it is still too low to prompt radical changes in behaviour: it adds just five cents to the price of a litre of petrol. Getting the most energy-intensive industries to make big cuts might take a tax four times as high. Even so, British Columbia has shown the rest of Canada, a country with high carbon emissions per head, that a carbon tax can achieve multiple benefits at minimal cost."

CARBON TAX EXAMPLES

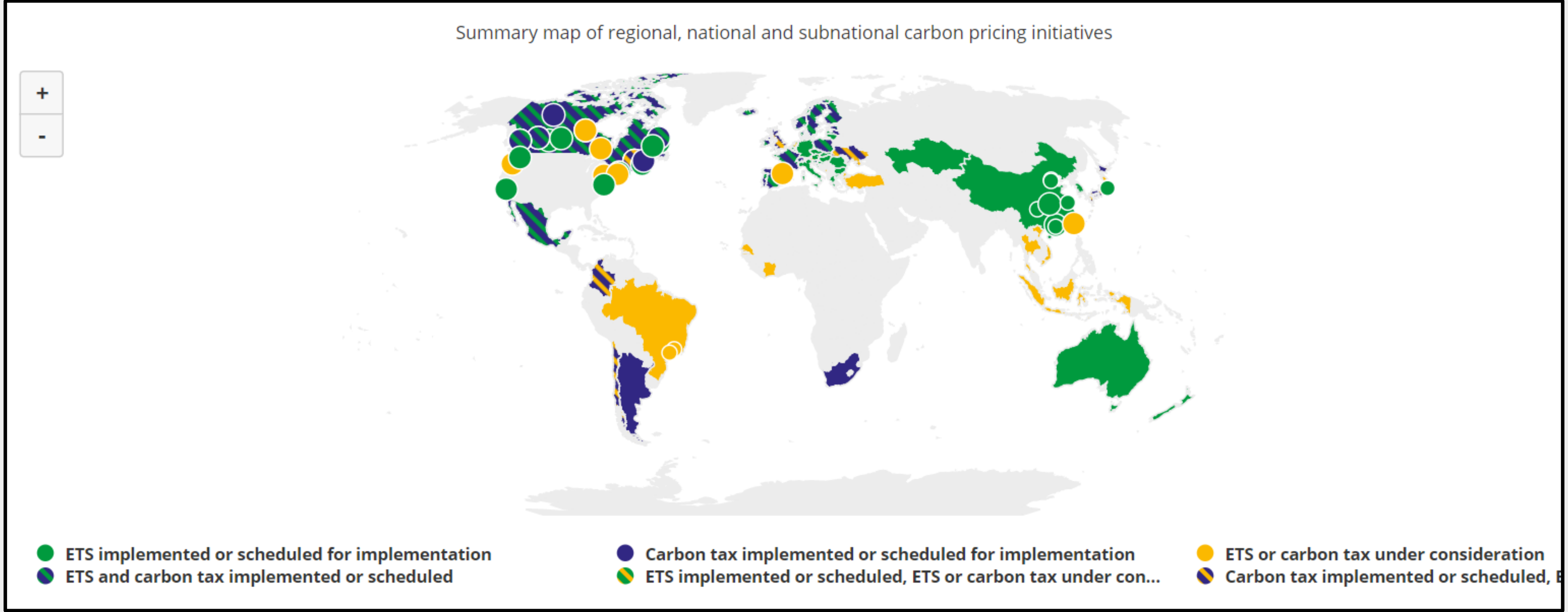
A variety of other countries and states have applied a carbon tax policy.

A few examples:

- Ireland:
  - Started in 2010, now EU$20/ton
- Australia:
  - Started in 2012 at $20/ton, now repealed
- Chile:
  - Started in 2018 at $5/ton
- Sweden:
  - Started in 1991, now $150/ton



Note: The carbon tax rate applied in Mexico, Finland, and Norway varies with the fossil fuel type and use. The graph shows the average carbon tax rate weighted by the amount of emissions covered at the different tax rates in those jurisdictions.


Summary map of regional, national and subnational carbon pricing initiatives
+
-
ETS implemented or scheduled for implementation
Carbon tax implemented or scheduled for implementation
ETS or carbon tax under consideration
ETS and carbon tax implemented or scheduled
ETS implemented or scheduled, ETS or carbon tax under con...
Carbon tax implemented or scheduled,

CAP-AND-TRADE

CAP-AND-TRADE

Tradeable permits was another policy that placed a price on pollution

Through trade of permits, it could achieve an emissions reduction goal at least cost

Compared to taxes:

- Equally efficient except under uncertain costs
- Less incentive to adopt new technologies, but more than standards
- Can avoid tax bill if permits freely distributed

Cap-and-trade programs have become a more prevalent approach to climate change policy

EU EMISSIONS TRADING SCHEME (ETS)

Started in 2005 with market between 15 countries

- Now covers 31 countries
- Covers emissions from power stations, factories, as well as aviation
- Covers almost half of EU's CO_2 emissions

The policy has been split into three phases

- Each phase has a tightening cap
- Allows for adjustments in process (eg. Changes in banking, regional caps, etc.)
- Currently in its third phase, which ends this year

EU ETS

The EU ETS has been successful in meeting its goal

- Emissions were reduced by 22% between 1990 and 2015
- Most reductions occurred in the electricity generation sector
- The policy is shown to increase innovation

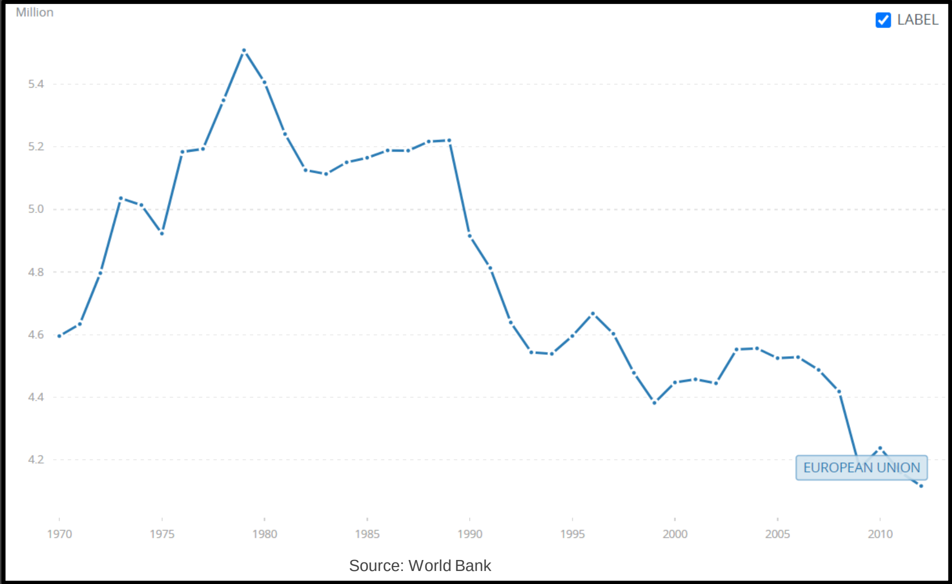
<u>Sources of concern:</u>

Variation in allowance price

- Phase 1: prices dropped rapidly from €30/ton to €15/ton
  - Due to over-allocation
- Phase 2: volatility was reduced, but prices have continued to decline
  - Due to recession, offset availability
- Low prices have led to low abatement

Process of distributing allowances

- Initially were freely distributed, generating profits for recipients
- Now auctioned expect for those with concerns around “carbon leakage”



California Carbon Cap-and-Trade

In 2012, California instituted a permit market on carbon.

- Goal: return to 1990 levels of CO_2 by 2020 (15% reduction as compared to do nothing by 2020).

Permits cover sources responsible for 85% of CA emissions

- About 450 entities – electricity generators, large manufacturing/industry, distributors of natural gas & transit fuels

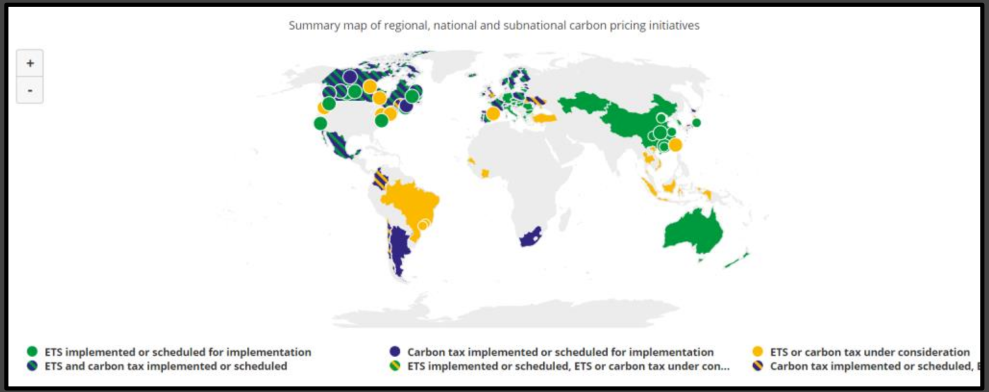
Permit market started in 2013 with 2% reduction, followed by another 2% tightening of cap in 2014, and 3% tightening each year thereafter until 2020

- Permits are auctioned off (generating revenue for the state).
- State is reinvesting revenues in related activities including high-speed rail, electric vehicle infrastructure

Market clearing price was $12.73 in February 2016.

- Recent estimates suggest program raised price of gas in CA by 11-13 cents (assuming all cost of permit program are passed through to the consumer).

PRICING CARBON

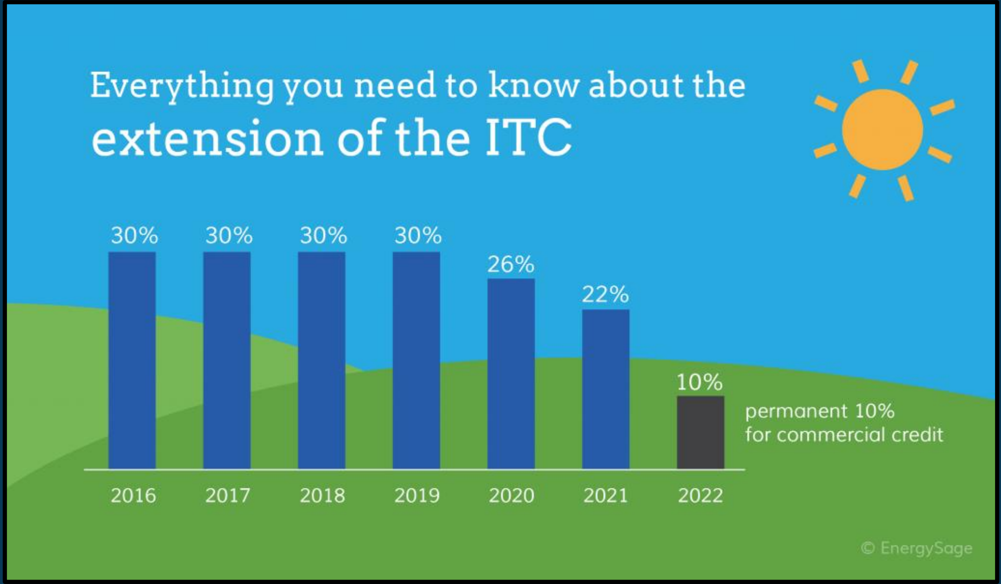


Globally around 40 countries and more than 20 cities, states, and provinces use some carbon pricing scheme

Covers around 13% of annual GHG emissions

STANDARDS AND SUBSIDIES

RENEWABLE ENERGY SUBSIDIES



In the 1970s the US federal government began push for solar energy

- US energy crisis
- Tax credits for residential solar
- Later cut back until more recently.

State and local governments have also subsidized solar adoption

- Eg. California, New Hampshire, Louisiana, New Jersey

Other countries have subsidized solar adoption

- In particular, Japan and Germany have had long term efforts
- More recently, China

SUBSIDIES

Instead of pricing GHGs, many have opted to *subsidize* substitutes and technological innovation.

Eg. Renewable energy subsidies and research grants

What do these subsidies do?

<u>Benefits:</u>

- Availability of substitutes and technological progress is important
- Incentivizes substitution from "dirty" energy sources

<u>Problems:</u>

- Tax performs better than a subsidy because firms have to face *true cost*
  - We will see this when we talk about energy transitions

STANDARDS

In addition to subsidies, many federal, state, and local governments have used *standards* as a policy approach.

These standards (like the subsidies) have been used to push improvements in energy efficiency and use of cleaner energy sources.

Examples:

- RPS
- Cafe

We know from theory, that these standards will only outperform market-based policies in select scenarios.

Studies have found that market-based policies could achieve the same reduction at lower cost or more reduction at the same cost

RENEWABLE PORTFOLIO STANDARDS

Many US states have implemented *renewable portfolio standards (RPS).*

These standard require that a specific share of electricity must come from a renewable source.

- Wind, solar, biomass, etc.

In effect, renewable pants generate power and create credits

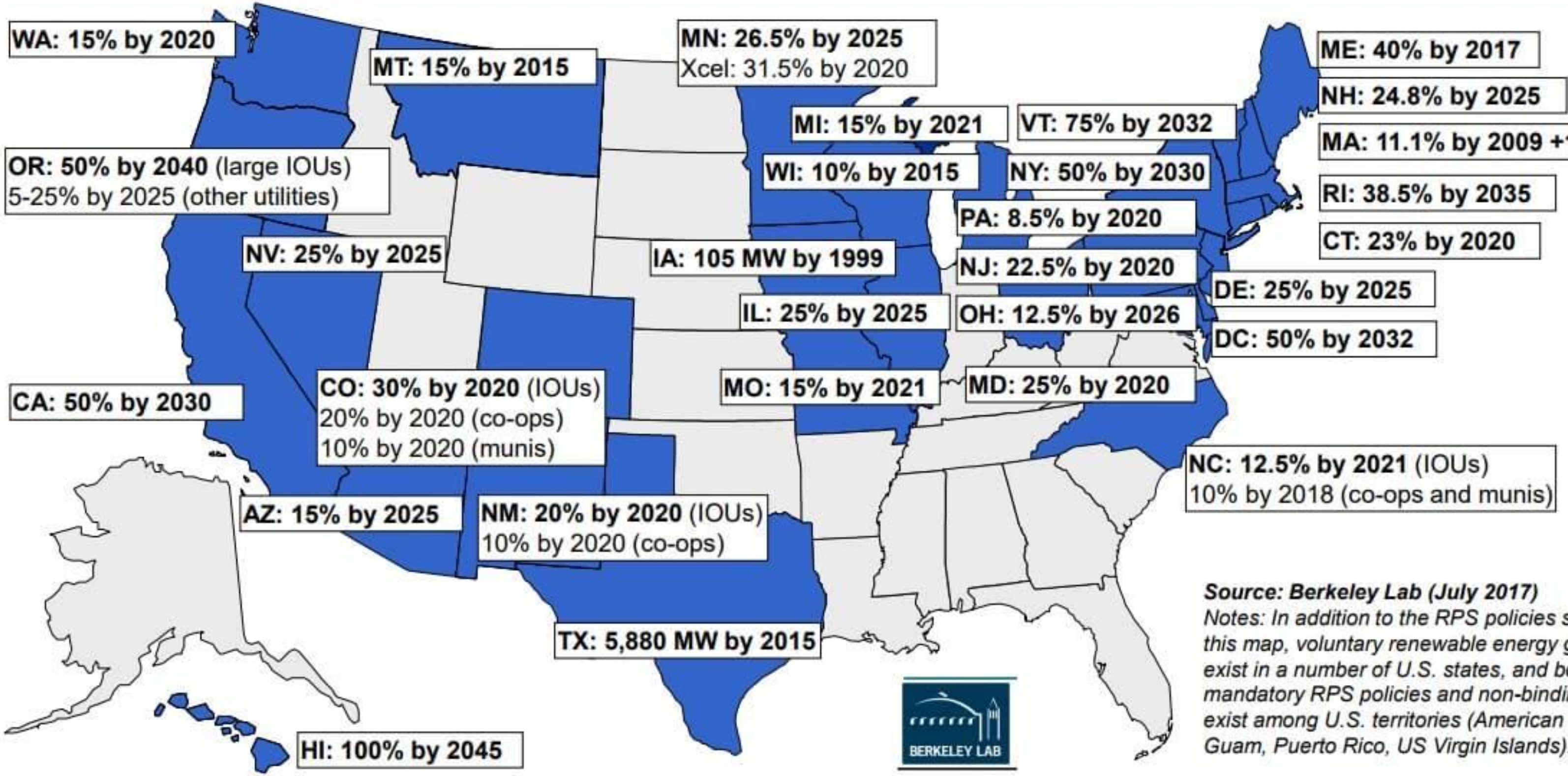
Dirty plants generate power and must get credits

Similar standards have been implemented elsewhere

- Eg. UK (Renewables Obligation), Italy, Poland, Sweden, Belgium, and Chile

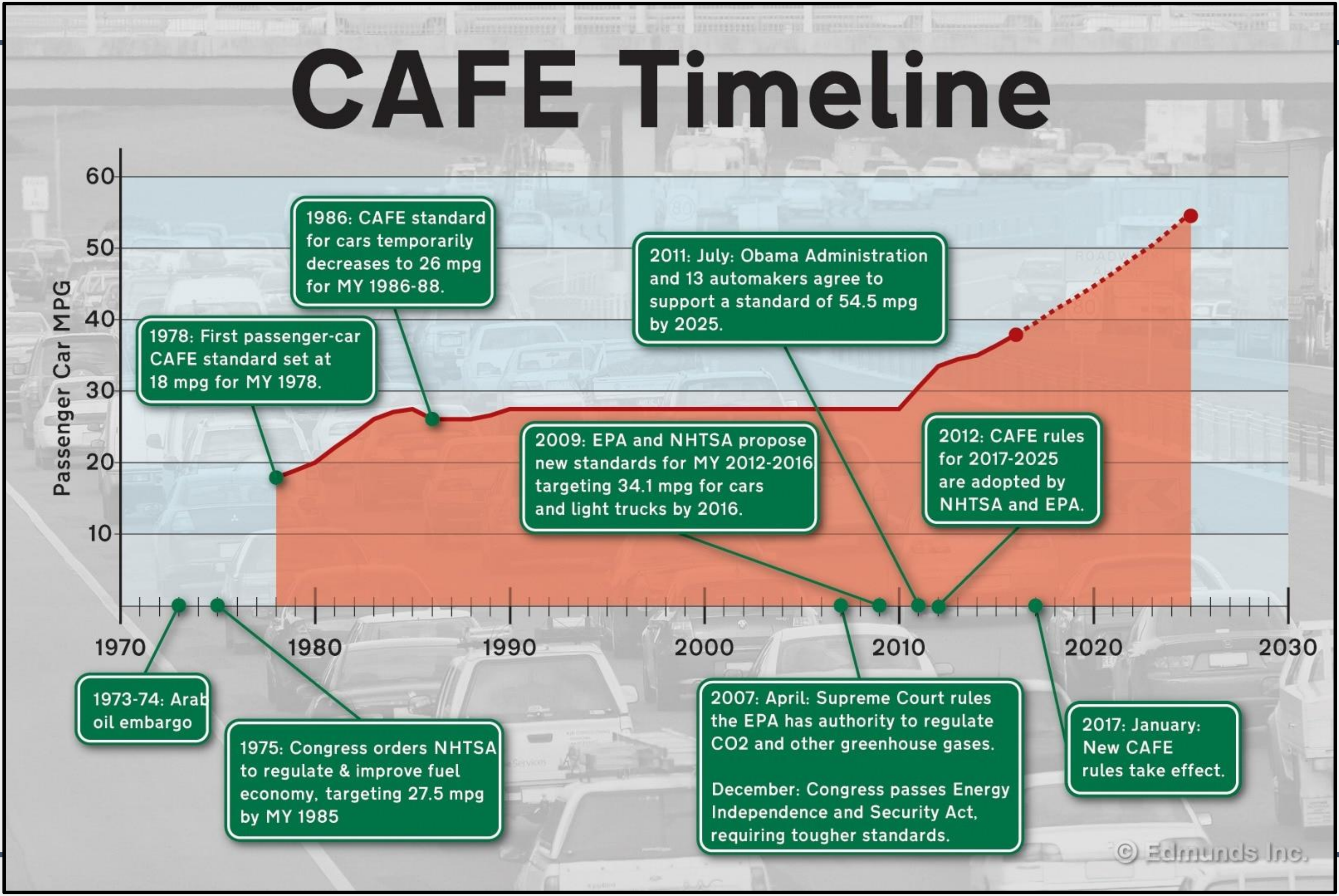
RPS Policies Exist in 29 States and DC

Apply to 56% of Total U.S. Retail Electricity Sales



Source: Berkeley Lab (July 2017)

Notes: In addition to the RPS policies shown on this map, voluntary renewable energy goals exist in a number of U.S. states, and both mandatory RPS policies and non-binding goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).


CAFE Timeline
Passenger Car MPG
60
50
40
30
20
10
1970
1980
1990
2000
2010
2020
2030
1986: CAFE standard for cars temporarily decreases to 26 mpg for MY 1986-88.
1978: First passenger-car CAFE standard set at 18 mpg for MY 1978.
2011: July: Obama Administration and 13 automakers agree to support a standard of 54.5 mpg by 2025.
2009: EPA and NHTSA propose new standards for MY 2012-2016 targeting 34.1 mpg for cars and light trucks by 2016.
2012: CAFE rules for 2017-2025 are adopted by NHTSA and EPA.
1973-74: Arab oil embargo
1975: Congress orders NHTSA to regulate & improve fuel economy, targeting 27.5 mpg by MY 1985
2007: April: Supreme Court rules the EPA has authority to regulate CO2 and other greenhouse gases.
December: Congress passes Energy Independence and Security Act, requiring tougher standards.
2017: January: New CAFE rules take effect.
© Edmunds Inc.

RENEWABLE ENERGY: OUTCOMES

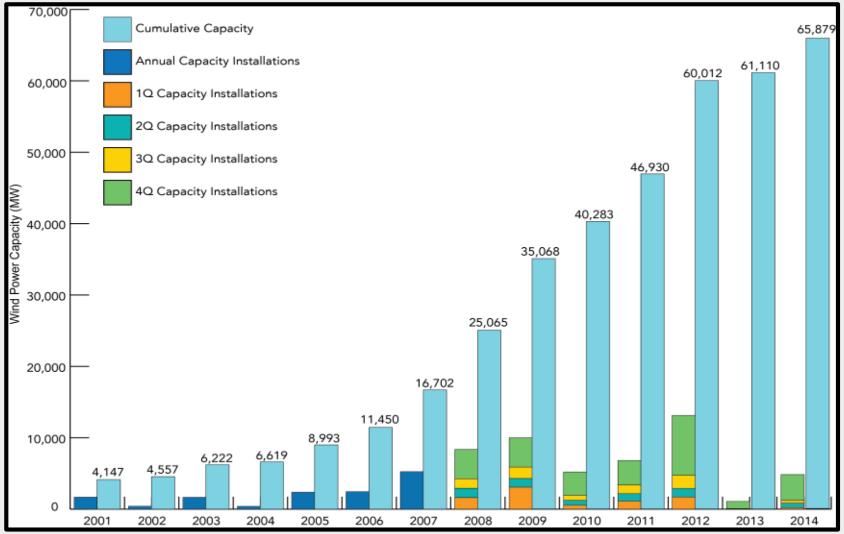
Standards have contributed to decarbonizing energy production.

Even more than expected

- 1999 US energy forecasted 0.8GW of wind power by 2020
- 2015 70 GW of energy power produced

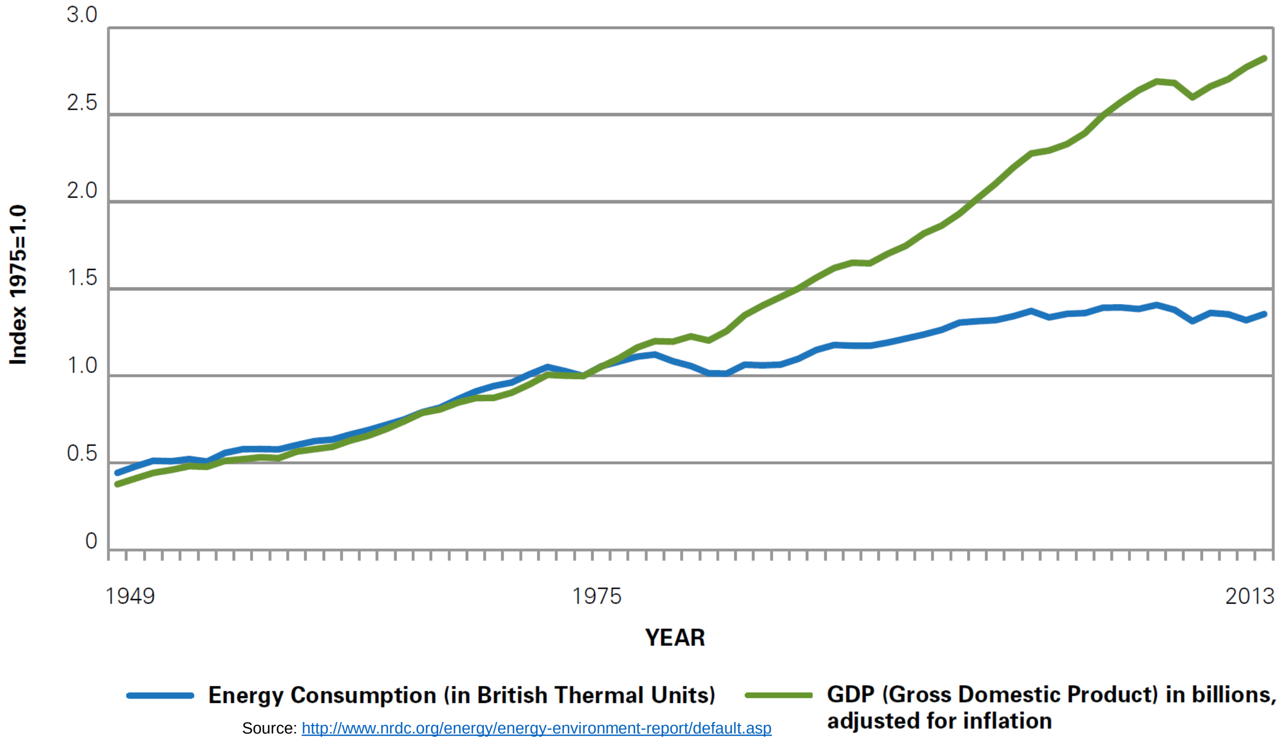
However, this is in part due to other economic factors

- Technological progress
- Availability and cost of substitutes



Source: American Wind Energy Association

ENERGY EFFICIENCY: OUTCOMES



Source: http://www.nrdc.org/energy/energy-environment-report/default.asp

STANDARDS AND SUBSIDIES

Many have opted to implement standards and subsidies as a policy response to climate change

They have been effective, but it is important to consider the alternative.

- Market-based policies can achieve the same goal at lower cost
- Market-based policies can achieve more at the same cost
- Market-based policies provide larger incentive for innovation
- Other economic factors have partially driven the gains, which could be larger under market-based policies
- Standards and subsidies can introduce new distortions

03

INTERACTION OF CLIMATE POLICIES

INTERACTION OF CLIMATE POLICIES

As we have seen, climate policy is likely to be undertaken in a *bottom-up* approach

- Bottom-up: action by individuals who can later link and form coalitions
- As opposed to *top-down* where policy begins with coalition

So, if individual actors are implementing their own climate policies, it is important to consider two consequences:

1. Strategic response
2. Overlapping policy effects

STRATEGIC RESPONSE

STRATEGIC RESPONSE

Bottom-up climate policy design will result in heterogeneity in policy stringency.

- Some places will have strong standards requirements, high carbon prices, etc.
- Other places may have no standards requirements and no carbon prices

What will happen in response?

There are two important, and related, considerations:

- Carbon leakage
- Pollution haven effect

STRATEGIC RESPONSE

Consider two countries:

- Country A has a strict climate policy with a high price on carbon
- Country B has no climate policy and no price on carbon

What is going to happen in response?

- The emissions in country A are reduced due to the policy, but what about in country B?
- The emissions may actually increase in country B!

<u>What causes the increase?</u>

Pollution Haven Effect

- Firms may relocate from country A to country B

Carbon Leakage

- Change in global prices increase demand in country B

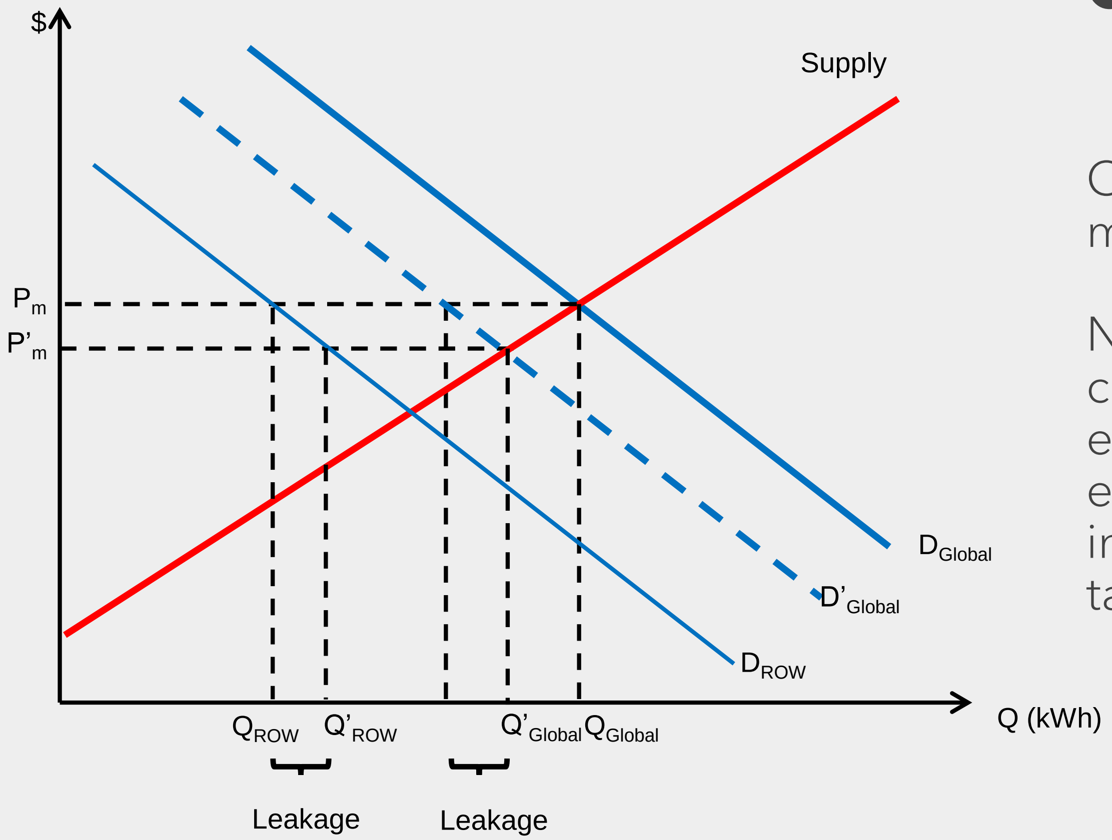
POLLUTION HAVEN EFFECT

A common argument against increasing environmental stringency is that it may push firms (jobs) to relocate to places with *lower* environmental stringency.

There has been mixed evidence for the pollution haven effect.

- Requires firms to have larger profits from relocating
- Environmental stringency is just one factor in profits
- Evidence that environmental stringency effects profits, but not significant evidence it causes relocation

CARBON LEAKAGE



Consider the global energy market.

Now say one country (or a coalition) enacts an environmental policy that effects the price of carbon in that country (eg. carbon tax).

OVERLAPPING POLICIES

A result of the bottom-up approach is that there are sometimes overlaps in policies.

- Eg. Cap-and-trade and standard

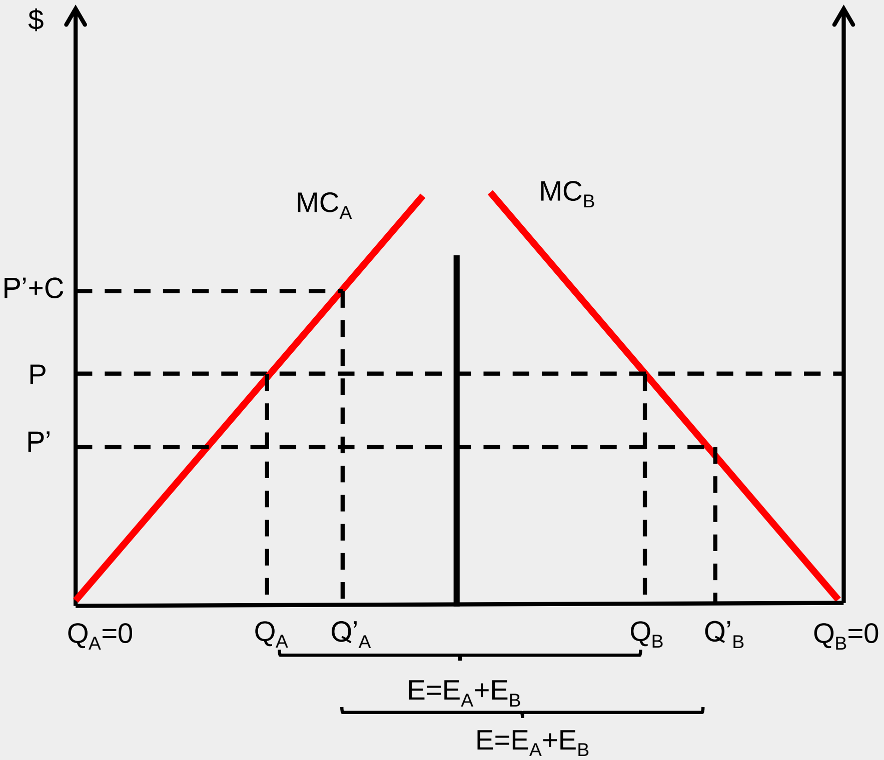
Additionally, individual policies could be expanded or linked.

- Eg. Linking EU ETS with California ETS

WHAT HAPPENS WHEN THERE ARE OVERLAPPING POLICIES?

WHAT HAPPENS WHEN POLICIES ARE LINKED?

OVERLAPPING POLICIES



Consider an ETS policy that covers two states (eg. RGGI)

What happens if one of the states implements an RPS?

- Have to buy permit *and* RPS credit
- Say the RPS is binding

RPS raises the price and increases abatement in A, but causes permit prices to decline, decreasing abatement in B.
No longer cost-effective!

LINKING POLICIES

Consider two countries with their own ETS (cap-and-trade) programs

What would happen if the markets linked to form a single ETS market

Gains from permits come from heterogeneity in costs.

If permit prices are different between markets and costs are different, can have larger gains from linking the markets

POLICY INTERACTION

It is likely that climate policy will take a bottom-up approach

It is important to be aware of strategic implications

- Pollution haven effect
- Carbon leakage

It may also be beneficial to link climate policies in the future (form coalitions)

- Larger gains from market-based policies
- Avoid some strategic implications
- Need to be aware of cooperation problem

LESSON OBJECTIVES

01

Analyze International Climate Policy

02

Analyze Domestic Climate Policy

03

Analyze Policy Interactions