The Energy Transition and Climate Change

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Economics of Energy, Climate Change, and Sustainability Program

This module

- We will discuss what are **desirable attributes** of climate policies.
- You will learn the specifics about major climate policies in the US and Europe.

Today

- Achieving climate goals
- Climate policy goals and attributes
- Fit-for-55 (time-permitting)

Note on group project

- **Idea**: Evaluate a climate policy in the light of the trade-offs that we will discuss today.
    - Describe the policy in detail: **specific policy proposal or enacted law**.
    - Show ways in which way policies have been modified to deal with trade-offs.
    - Suggest other ways in which they could be modified, things that might be underestimated: **critical discussion**.
    - Present supporting evidence when possible: studies, reports, or newspaper articles that show **trade-offs** with policies.
    - Note: cite all the work you use, no problem in citing a lot but needs to be cited!

- **“Deliverables”**:
    - In-class presentation (last day of class).
    - 4-page write-up.

Achieving climate goals

How does this play out in practice?

- **Strategies** for reducing emissions:
  - Substitution towards cleaner technologies
  - Innovation in cleaner technologies
  - Reduction or substitution in consumption
  - Capture/sequestering of emissions
- **Policies** for reducing emissions:
  - Tax/require permits for emitting sources
  - Subsidize non-emitting sources
  - Ban/phase-out emitting sources
  - Set standards
  - Etc.

Remember from last week

$$max_{e,a} \sum_t [V(e_t, a_t) - C(E_t)]e^{-rt}$$

- In an ideal environment, consider the value (V) from different activities that require emissions, accounting for the technologies used in the production process (a).
- If there are several sectors, value of emissions across sectors would equalize due to the common damage (also intertemporally).
- Cap-and-trade market or carbon tax would send the right signal to achieve desired level of emissions.
- Imagine **two sectors**, value of emissions equalizes:

$$V_1'(e) = V_2'(e)$$

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Example with two technologies

- Consider electricity generation with two technologies: **renewable** (emissions are zero) and **fossil fuels** (e>0).
- A carbon tax or a subsidy introduces **a wedge between the two technologies**.
- The two types of technologies maximize their profit:
    - $\Pi_r = (p + s_r)q_r - C_r(q_r)$
    - $\Pi_f = \left(p + s_f - t\, e\right)q_f - C_f(q_f)$

- In the first-order condition:
    - $p = c_r - s_r$
    - $p = c_f + t\, e - s_f$

How do the policies perform?

	Tax	Subsidy
Substitution towards cleaner technologies		
Innovation in cleaner technologies		
Reductions in consumption		

A tax is superior to a subsidy!

- A subsidy to renewable energy without a proper tax to carbon emissions is a **subsidy to energy consumption**.
- While it makes the energy mix cleaner, it also incentivizes the use of fossil fuels (or it fails to disincentivize properly).
- Yet… we see renewable energy subsidies in many countries, and indeed, they tend to be much more popular than carbon taxes/cap-and-trade markets.

While renewable energy subsidies have positive dynamic effects, it is hard to economically (or morally) argue that carbon should not be taxed.

But why?

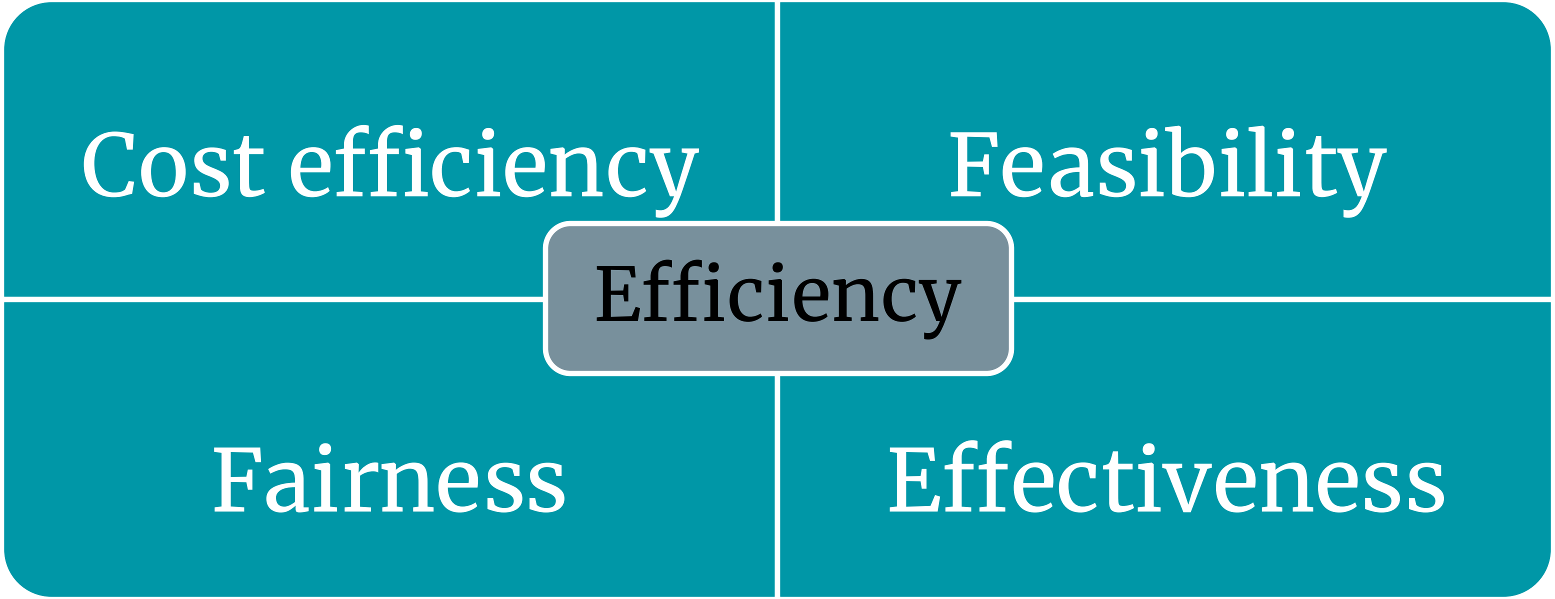
Why aren't we properly pricing carbon?

- Concerns about the price of energy/inflation impacts
- Concerns about political backlash (e.g., subsidies to gasoline)
- Concerns about fossil fuel jobs or rents
- Lobbying efforts to maintain status quo
- General aversion to taxation
- Etc.

Economic efficiency alone does not explain the climate policies we see in practice.

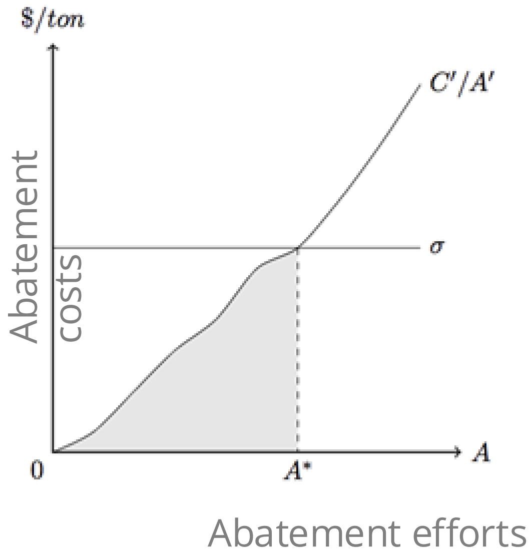
Climate goals and attributes

A broader definition of efficiency



Source: Fabra and Reguant (2022)

Cost efficiency



Defining the optimal abatement

- Choose those policies (x) that balance the benefits (B) and costs (C) from reducing emissions

$$\max_{\mathbf{x}} B(\mathbf{x}) - C(\mathbf{x}).$$

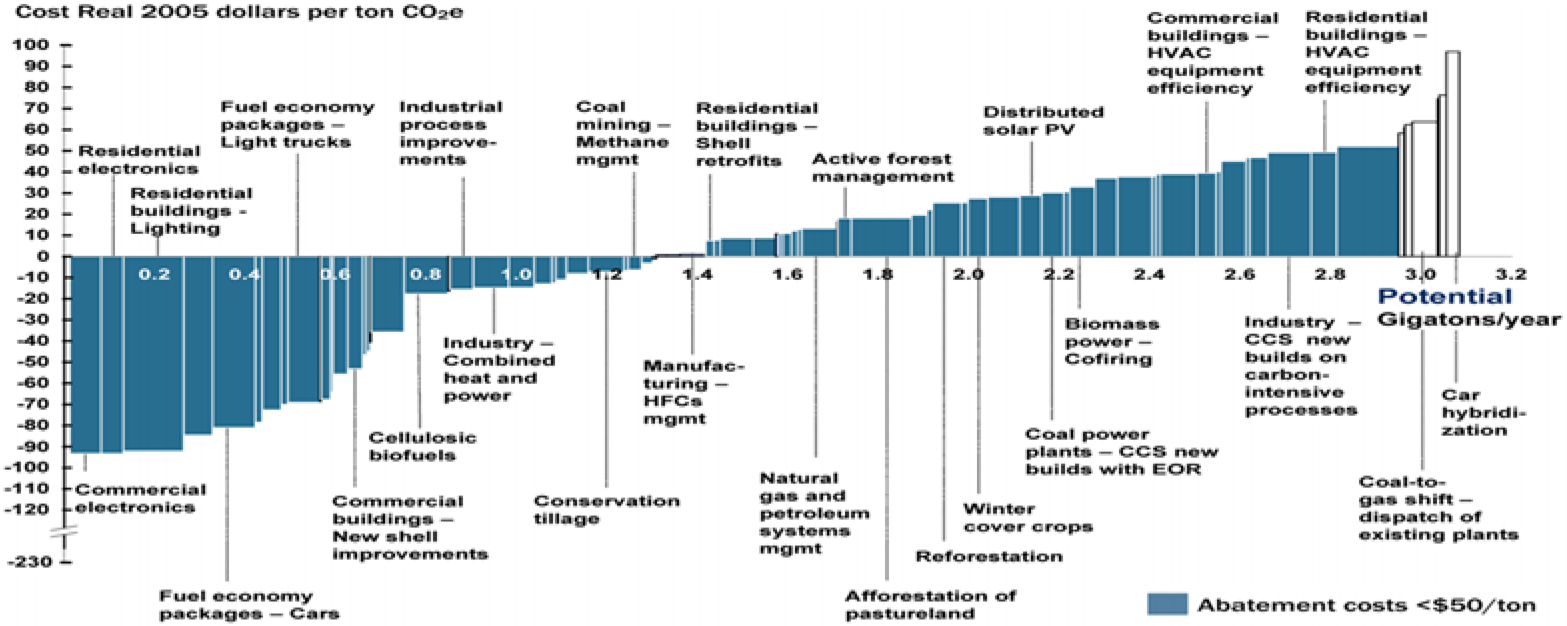
- Benefits: damages avoided due to abatement (A)
- Costs: costs of the policy

$$x_j^* = \arg\max_{x_j} \sigma A_j(x_j) - C_j(x_j).$$

- It is efficient to implement those policies whose marginal cost per additional abated ton is below or equal to the cost of climate damages

Source: Fabra and Reguant (2022)

Cost efficiency



Marginal Abatement Cost Curve

Traditional Marginal Abatement Cost (MAC) curves typically show the total annual emissions that could be abated (or reduced) by each measure or technology (width of bars along the x-axis), ordered by the increasing marginal cost that it would take for each measure to reduce a ton of emissions (height of bars along the y-axis)

Source: Environmental Defense Fund

Cost efficiency…also a dynamic concept

- Efficiency also depends on other factors beyond static marginal costs:
  - **How policies influence one another** (complementarities)
    - e.g., more renewable generation, increases the abatement of EVs
    - e.g., developing charging infrastructure facilitates adoption of EVs through network externalities
  - **How long it takes to implement those policies**
    - e.g., nuclear plants are zero-carbon but their construction is lengthy
  - **Whether today's policies affect future costs**
    - e.g., deploying renewables reduces future costs through learning by doing (e.g., Gerarden, 2021) but requires investment in back-up/storage

$$\max_{\mathbf{x_t}} \; [B(\mathbf{x_t}) - C(\mathbf{x_t})] + \beta[B(\mathbf{x_{t+1}}) - C(\mathbf{x_t}, \mathbf{x_{t+1}})]$$

Cost efficiency…also a dynamic concept

- Gerarden (2021) shows that subsidies that were initially set above the level justified by the static environmental benefits boosted the adoption of solar panels and triggered significant cost reductions

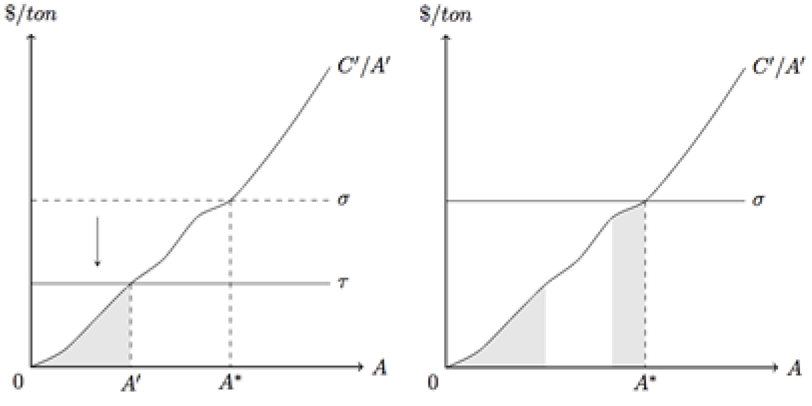
Graphical evidence that subsidies increase demand

In Japan, quantities were low in 2010-2011, but increased after a feed-in tariff was introduced. Quantities fell as the feed-in tariff was lowered in 2015, despite prices slowly but steadily declining. Quantities also fell in Germany after 2012Q2 as the feed-in tariff was lowered, even though prices were falling through early 2013 and remained fairly stable thereafter.

Feasibility

- Policies need to have **sufficient societal support** to be adopted
  - However, carbon pricing and cost-effective investments in renewable energy or transmission capacity often face local opposition

$$\max_{\mathbf{x}} B(\mathbf{x}) - C(\mathbf{x})$$
$$\text{s.t.} \quad F(\mathbf{x}) \leq \overline{F}.$$

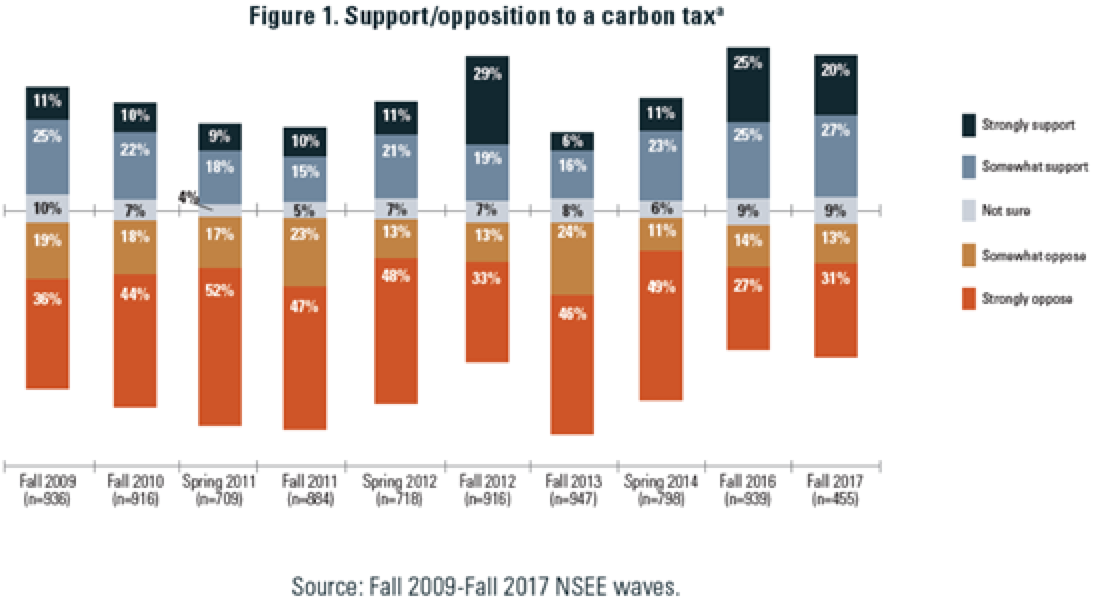


(a) Reducing ambition for a feasible policy (b) Implementing the optimal feasible set

Optimal abatement within the feasible set

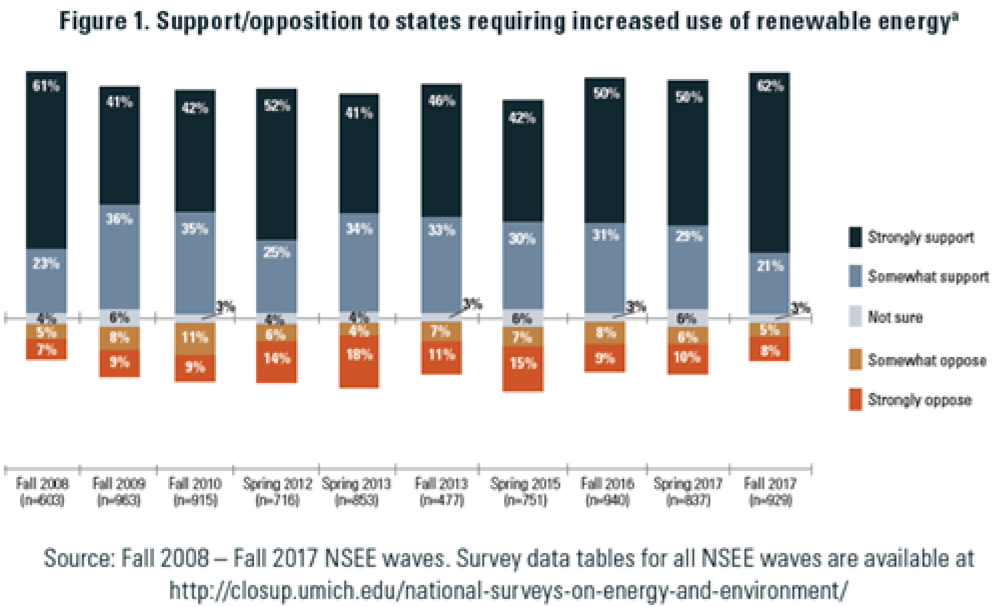
Policies must be in a feasible set:
- Some cheaper but unfeasible policies might have to be dropped in favour of feasible ones
- Preferable to implement any feasible and cost effective policy, rather than to reduce the level of ambition (total A)
- Countervailing policies might be needed to make policies feasible

Support/opposition to a carbon tax



Source: National Survey on Energy and the Environment

Support/opposition to renewable energy mandates



Source: National Survey on Energy and the Environment

Feasibility

Some examples:

- Carbon policy, leakage and compensation schemes
  - US: feasibility concerns have led to very low carbon prices, or even none
  - Europe: a carbon market has been in place since 2005; compensation schemes for industries under risk of leakage were introduced to avoid social and political opposition (Reguant, Petersen and Fowlie, 2021)
- Grid-scale renewables versus smaller projects
  - Grid-scale renewables are more economically efficiently than smaller distributed generation projects
  - However, smaller projects are more socially acceptable and are able to raise social support for the energy transition

Fairness

The **effects of climate policies are not evenly distributed** across the population:

- Costs tend to be concentrated; benefits are distributed widely
  - e.g. coal miners; rural areas; unskilled workers…
- Carbon taxes affect the poor disproportionately more (in relative terms)

Fairness is critical to ensuring public support, which is key for implementation

Countervailing policies:

- Carbon dividend (recycle carbon tax revenues)
- Just Transition Fund
- Social Climate Fund (25% of the expected revenues of emissions trading for building and road transport fuels)
- Programs to re-skill workers

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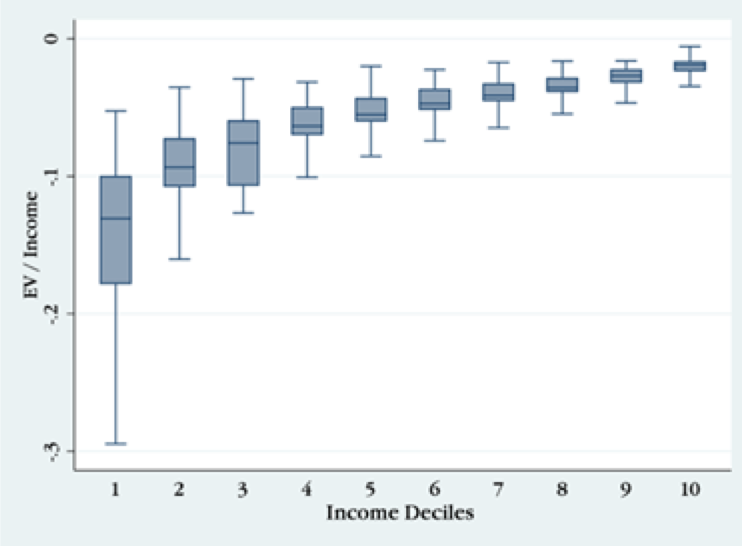
Fairness

Paoli and van der Ploeg (2021)



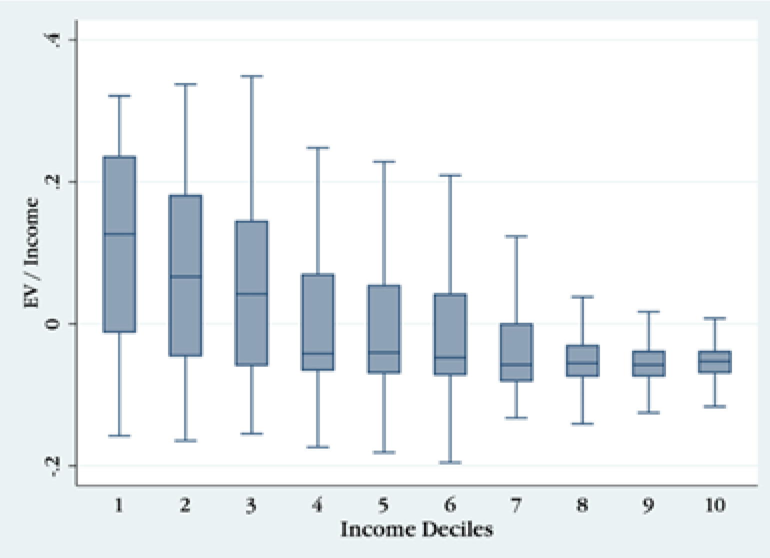
Distributional implications of a carbon tax without recycling

- Microsimulations of household behaviour from UK data to investigate the equity impacts of carbon taxes and different ways of recycling the carbon tax revenue
- Without recycling, carbon pricing is regressive, with carbon taxes representing almost 8% of weekly expenditures for the lowest income decile and around 5% for the richest households

* Equivalent variations (EVs): how much households are willing to pay to avoid a policy change

Fairness

Paoli and van der Ploeg (2021)



Distributional implications of recycling revenues by expanding social security benefits

Recycling revenues via:

1. Introducing per-capita transfers
2. Expanding social security benefits
3. Lowering income tax rates

Policies 1-2 are progressive:

- Lower income deciles experience welfare gains, especially when recycling is via targeted transfers
- Higher income deciles, experience small welfare costs

Policy 3 is regressive:

- Higher income deciles gain more than lower deciles (although there is large within-income heterogeneity)

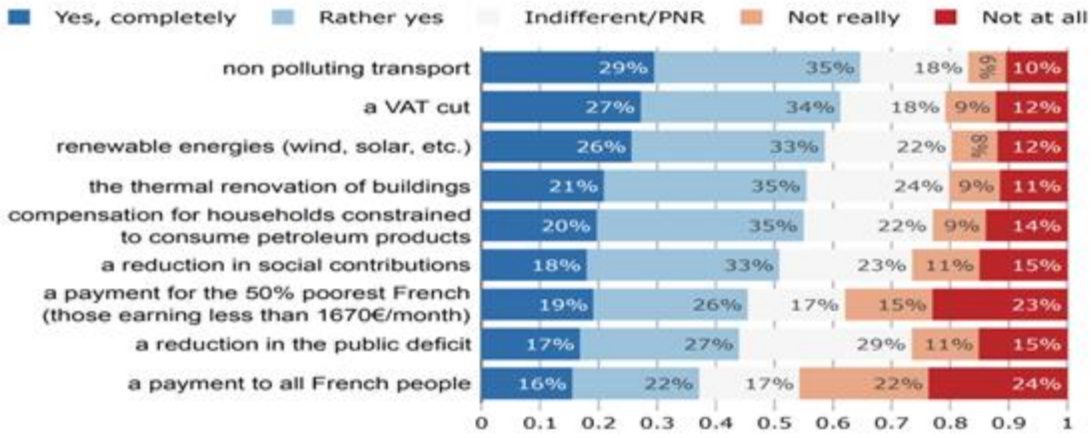
Still, people reject a carbon tax with dividend

Douenne T. and A. Fabre (2022)

- **Survey** among 3,000 French households during the yellow vest revolt
- **Proposal**: budget-neutral €50/tCO2 carbon tax and dividend policy (+€0.11 per litre of gasoline and a €110/year per household transfer)

Only 10% of the survey respondents approve, while 70% do not accept the proposal

Figure 3 "Would you approve of an increase of the carbon tax if the revenues were used to...?"



"Even when people are expected to benefit from carbon taxation, **pessimistic beliefs about the effect of the policy** could lead them to oppose it"

People favour measures whose **costs are less salient**

- prefer norms or subsidies to taxes
- strongly support public investments

Effectiveness/Long-term considerations

Factors that might reduce the effectiveness of climate policies:

- **Carbon leakage**
  - Countervailing: Carbon Border Adjustment Mechanism (CBAM)
- Firms' and households' **weak response to price signals**
- **Coordination failures** (across sectors; across countries)
  - e.g., green hydrogen (need to coordinate supply +demand+network)
  - e.g., electric vehicles (need to coordinate supply+ charging infrastructure and need to enforce compatibility of charging stations, Li 2022)
- Weak ability to **monitor compliance (e.g. offsets, clean development mechanisms)**
- Lack of **credibility** of the policy
- Behavioural biases

Many dimensions to balance

- Allocative efficiency
- Cost efficiency
- Dynamic efficiency
- Effectiveness
- Asymmetric information (and uncertainty)
- Government revenues and their proper use
- Accountability (monitoring and sanctioning)
- Lobbying incentives
- Distribution and fairness
- Political feasibility

Assessing climate policies in practice

Policy instrument		Assessment criteria: Short-term minimisation of abatement costs	Long-term minimisation of abatement costs	Administrative costs	Ability to deal with uncertainty	Reallocation and distributional concerns	Political economy and public acceptability	Fiscal impact: revenues and expenditures
Emission-pricing instruments	Greenhouse gases tax	Highest	High	Moderate to high	High	Moderate	Low	Rev. raising
	Emission trading schemes (ETS)	Highest	High	High	Moderate	Moderate	Low to moderate	Rev. raising (when auctioning permits)
	Non-tradable performance standards	Moderate	Moderate	Low	Low	Low	High	Neutral
Standards and regulations	Subsidies to abatement	High	Moderate	High	High	moderate to High	High	Expenditure
	Feebates (e.g. feebates on vehicles)	Fairly high (often higher than non-tradable performance standards)	Moderate	Low to moderate	High	Low to moderate	Fairly high (higher than performance standards)	Neutral (can be revenue or expenditure)
	Technology standards	Low	Low	Low	Low	High	High	Neutral

The cell colours indicate how favourable the assessment criteria are for a given policy instrument (green: highly favourable; orange: medium favourable or mixed outcome; red: unfavourable; white: not applicable)

Source: Pisu et al. (2022)

An application to *un-ideal* carbon pricing

Ideal features of carbon pricing

Ideal features under a notion of perfect *economic efficiency*

1. **Universal coverage**: sectoral, geographic, temporal.
2. **Adequate price levels** that properly reflect externalities (or that are consistent with goals).
3. **Polluter-pays** principle.

‼ Political feasibility and imperfections (e.g., in monitoring) make design of non-trivial, while limiting their effectiveness.

How does carbon pricing fare under broader framework?

Universal sectoral coverage comes with dangers (internal leaks)

- In theory, **all sectors** covered in one unified scheme.
- **Challenges**:
  - Limits political feasibility, can lead to generous rebates / very low prices / protests.[2]
  - Opens the door to false emissions reductions (e.g., shady offsets or non-additional negative emissions), which contaminate price in a quantity scheme.
  - Complicates accounting with other gases and land use, difficult to verify, easy way out to claim visible targets.

- While not first best, might need to focus reductions where they are **verifiable ("effective") and feasible**.

Geographic coverage has proven challenging (external leaks)

- Not all countries or states participate in carbon markets leading to **leakage**.
- Most effective economic solutions (carbon border adjustment mechanisms, taxing consumption, taxing fossil fuels for their CO_2 and methane embedded content at the source) generally *not politically feasible or hard to quantify, which opens the door to litigation.*

- More **aggressive policies might be available/easier on *specific sectors***, rather than trying to fix it for all.
- **Consumption taxes** of embedded footprint may level playing field by making it easier to treat all products equally, even if less taylored.

Temporal commitments are subject to high levels of uncertainty

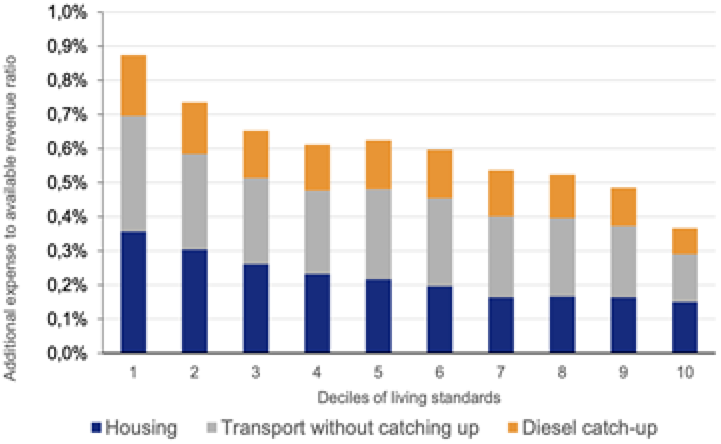
- Credibility of climate policy is **inexistent or extremely limited**.
- Carbon prices and agreements often a function of the economic *business cycle*.
    - Example: stringency of reserve, recent changes in EU policy declaring investments in natural gas “green,” quantity pathways easily manipulated (e.g., via offsets).

- Mechanisms give the impression of credibility, but unclear that it generates necessary **long-term credibility for investors**.
- **Bans** (e.g., to public investment in fossil fuels) can be more concrete. If successfully and credibly implemented, more difficult to revert.

Carbon markets are not particularly popular, limiting ambition

- They can be **highly regressive**, as seen with the gas crisis.
- Households do not perceive proposed remedies as equalizing (even if they are).
- Some people can always afford prices, even if very high: "The 1% can pay their way out."
    - E.g., very expensive flights vs. private jets.
- Bans can be more *feasible*.

Figure 7 – Impact of increasing the carbon tax from €44.6 to €86.2/tCO_2 (plus diesel catch-up) on household disposable income



Source: Bureau, Henriet, and Schubert (2019)

“Drastic” measures like bans can be equivalent to carbon prices, which we often fail to recognize

- Net-Zero pathways imply very high prices of CO_2.
- Even with current technology, they already make many fossil fuel applications *uneconomical* (e.g., electricity, cars, heating).
- Effectively equivalent to a ban, but a ban is (maybe surprisingly) more popular.

	Boiteux (2001)	Quinet 1 (2009)	Quinet 2 (2019)
2010	32	32	
2020	43	56	69
2030	58	100	250
2050	104	250	775

Source: France Stratégie. Shadow carbon price (in 2018 euros per metric ton of CO2) in France implied by three different commissions.

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Growing consensus that we need all policies that we can pass (and ideally even more!)

- There is a confrontation between two narratives: carbon prices vs. non-price sectoral efforts.
- Sectoral efforts painted as too intrusive, but easily **compatible with suggested price paths**.
- Sectoral efforts painted as popular and easy, but they might not be as popular at the **proper scale**.
- Carbon prices painted as **evil** but removing a subsidy to fossil fuel consumption should be a no brainer!
- Important to prioritize **cost-effective policies that are within the feasible set and deliver concrete reductions.**
- **Best effort**: *Is a policy worse than nothing? Can it be marginally improved without harming feasibility? What is its least credible aspect? What are fairness concerns that could be actively addressed?*

Overview of assessment of ideal carbon pricing

Idealized features in emissions markets are not always feasible or desirable with frictions.

Universal sectoral coverage comes with dangers (**internal leaks**).

Geographic coverage has proven challenging (**external leaks**).

Temporal commitments are subject to high levels of uncertainty.

Carbon markets are not particularly popular, limiting ambition.

“Drastic” measures like bans can be equivalent to carbon prices.

Synergies between prices and more direct action need to be embraced.

Policy in practice: Fit-for-55

The European Green Deal

- Main **green growth strategy of the European Union** to deliver on the commitments under the Paris Agreement
- A package of policy initiatives which was presented by the European Commission in 2019
- The overarching goals:
  - **cutting greenhouse gas emissions** by at least 55% by 2030, compared to 1990,
  - **climate neutrality by 2050** and
  - **decouple growth from resource use**
- The Green Deals budget includes around **600 Billion € in investment,** financed from the NextGenerationEU recovery plan and the EU's 7-year budget

Fit for 55 (% emission reduction by 2030)

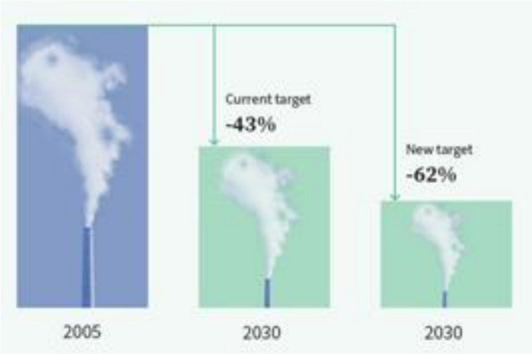
- Aims to **translate the policy packages** of the European Green Deal **into law**
- For that, it **proposes to revise and update the EU legislation** to be into line with climate goals agreed by the Council and the European Parliament
- By the European climate law, these **goals are binding for the EU and its Member states**
- Key elements:
  - Reform of the EU Emission Trading System
  - Social Climate Fund
  - Carbon Border Adjustment Mechanism
  - Effort Sharing Regulation
  - Revision of the Energy Taxation
  - Revision of the Renewable Energy Directive
  - Energy Efficiency

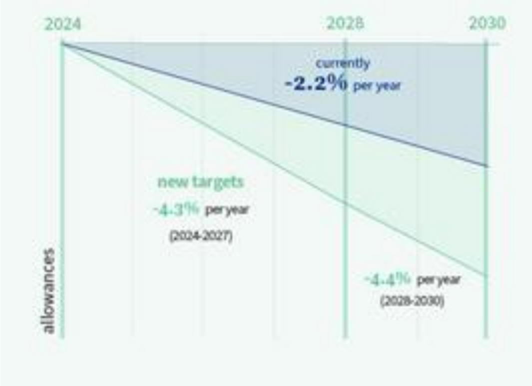
(1) Reform of the EU-ETS – Review of EU-ETS

- The EU-ETS is an example of a cap-and-trade system and a quantity-based instrument
- Entities covered by the EU ETS have to buy 'allowances' every year for their greenhouse gas emissions
- The number of allowances is limited by a cap, and the cap is degressive to create incentives for cutting emissions
- Through trade of allowances, a carbon price is set
- Some sectors exposed to carbon leakage get free allowances
- It covers around 40% of total EU emissions and approximately 10.000 companies

(2) Reform of the EU-ETS – What will change?

- More ambitious emission reduction goals
- Faster **reduction of the cap**
- Extension to maritime transport
- **Phasing out of free allowances** for certain sectors
- Increased funding for decarbonizing ETS-sectors (modernisation and innovation fund)
- **Introducing a separate new ETS** for buildings, road transport, and fuels for additional sectors (EU-ETS 2)
    - launch is set to be in 2027
    - in 2030, EU-ETS 2 achieves 42% emission reductions compared to 2005





Social climate fund

- **Revenues from the sale of EU-ETS** (and EU-ETS 2) **allowances** are partly put into the Social Climate Fund – a new financial tool
- Member states can use the assigned revenues from the fund **for those that need it the most** (vulnerable households, vulnerable micro-enterprises and vulnerable transport users)
- Used for:
  - measures and investment aimed at **boosting energy efficiency**
  - Short-term and limited **direct income support**

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Carbon Border Adjustment Mechanism (CBAM)

- The CBAM is a new regulation to **counter carbon leakage (more on this in next module)**
- Example of carbon leakage:
  - imported goods from countries outside of the EU, which do not face a carbon price, may have a price advantage
  - domestic production may move to the country with lower standards, thereby shifting CO_2 outside the country instead of reducing it
- Solution of CBAM: **importers will have to pay for CBAM certificates** which corresponds to EU-ETS allowance prices

(1) Effort Sharing Regulation (ESR)

- The ESR **sets national greenhouse gas emission targets** for each Member state
- Sectors covered by the ESR → road transport, agriculture, buildings, small industries, waste
- **targets are set according to the GDP per capita** and adjusted for above average GDP per capita countries **based on cost-effectiveness**
  - since 2023: some Member State targets are limited to prevent their targets from increasing much more than the collective target
- New ambition:
  - the existing total EU emissions **reduction target** of sectors covered by the ESR **of 29% was increased to 40% in 2030**
- for those Member States struggling to meet their national targets, they can **access additional allocations form a limited safety reserve,** as a last resort mechanism

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(2) Effort Sharing Regulation (ESR)

- the ESR also **sets annual emission limits for 2021 to 2030**
- Member States are given a number of emission allocations for each year, which decrease every year
    - emission limits per year are calculated based on the trajectory leading to the 2030 emission reduction targets
- Access allocations can be traded between countries
- Possibility of banking and borrowing from the following year
- if any Member State is not on track, they have to submit an action plan to the Commission

Revision of Energy Taxation

- Starts **taxing fuels based on their environmental impact** → products with the most pollution are taxed the highest.
- The way energy products are categorised is simplified.
  - Products covered by the directive are grouped and ranked to their environmental performance.
- Exemptions for certain products and home heating will be phased out.
- Fossil fuels can no longer be taxed below the minimum rates.

Renewable Energy Directive and the REPowerEU Plan

- The Renewable Energy Directive (RED) **sets an overall European renewable energy target.**
    - The 2030 target of at least 32% of energy consumed in the EU from renewable sources has been increased to 42.5%, aiming for 45%.
- The revision of the RED is a response to the market disruptions caused by Russia's invasion of Ukraine and part of the REPowerEU Plan.
- **REPowerEU Plan**
    - aims to **reduce dependence on Russian fossil fuels**
    - builds on the implementation of the Fit for 55 to accelerate clean energy transition, diversify energy supplies and improve energy efficiency
    - is financed mainly by unused loans from the Recovery and Resiliency Facility, the innovation fund and sale of EU ETS allowances

Recast of the Energy Efficiency Directive

- First adopted in 2012, the Commission proposed to recast the directive as part of the Fit for 55 package in 2021
- As part of the REPowerEU Plan, energy efficiency targets were further raised in 2022
- New ambitions:
  - binding target for the EU countries to **additionally reduce energy consumption by 11.7%** compared to the 2020 reference scenario
  - EU countries agreed to **set indicative national contributions**
  - putting a stronger focus on **reducing energy poverty**
  - expands **obligations of energy audits for all companies** consuming energy above a certain threshold (small and medium-sized enterprises now also have to carry out energy audits)

The Draghi report on trade-offs

"The decarbonisation of the energy system is an opportunity for the EU in reducing its dependence on fossil fuels to ensure its competitiveness, the affordability and security of supply."

"Europe faces a possible trade-off. Increasing reliance on China may offer the cheapest route to meeting the EU's climate targets. But China's state-sponsored competition represents a threat to otherwise productive industries."

"Fossil fuels will continue to play a central role in energy pricing at least for the remainder of this decade. Without a plan to transfer the benefits of decarbonisation to end-users, energy prices will continue to weigh on growth."

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