Economics of Climate Change

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Climate Change Questions for Economists

- How sharply should countries reduce GHG emissions?
- What should be the time profile for emissions reductions?
- How should the reductions be distributed across sectors, industries and countries?
- What policies will be most efficient to reduce emissions?
- Who should pay? How should costs be distributed between rich and poor households or nations?

Aravena, 2015

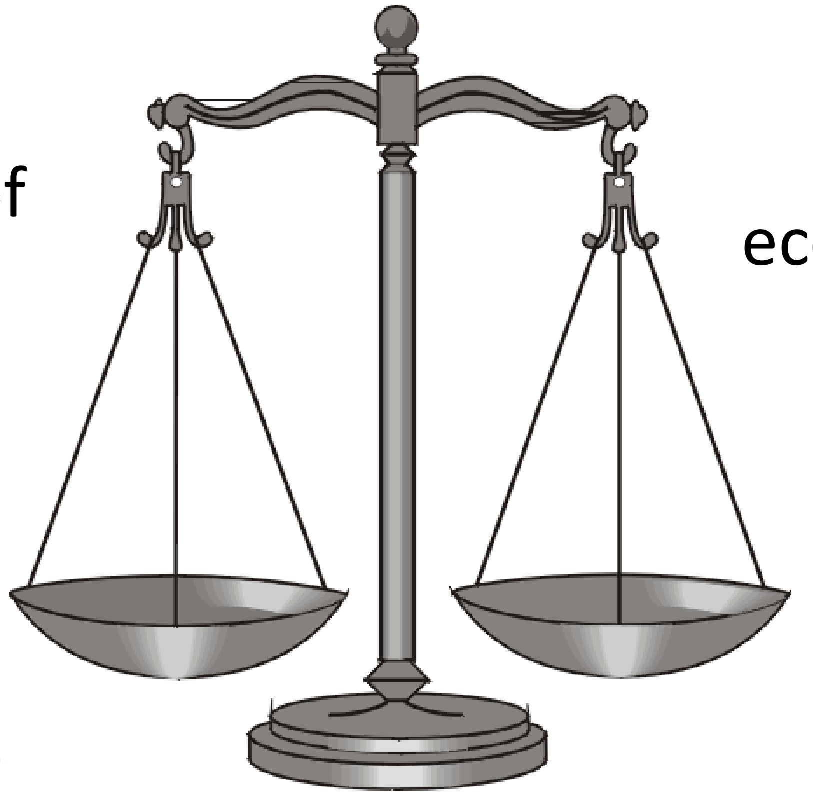
Overview

- Using economics in Climate Policy analysis:
  - Cost-benefit analysis
  - Costs
  - Benefits
- Mitigation Policy
  - Justification: market failures
- Categories of policy :
  - Command and control
  - Information
  - Economic Instruments
- Irish policy situation
- Resources

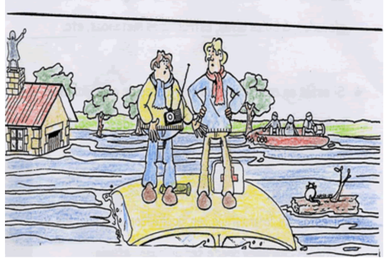
Economic Analysis of Climate Change

How much emissions should we mitigate? Which policy measure?

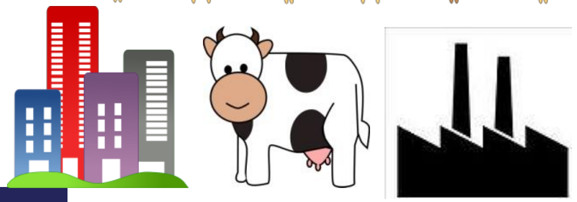
Compare economic cost of climate change mitigation….



…with future ecological benefits



Reduction of GHG emissions



Aravena, 2015

Choosing Emissions Targets

- "The choice of a stabilization target shapes much of the rest of policy analysis and discussion, because it carries strong implications for the permissible flow of emissions, and thus for emissions reductions targets."
- "The reduction targets, in turn, shape the pricing and technology policies."
- Targets can be set in terms of stabilisation concentration or GHG emissions – latter more common

Stern (2008) The Economics of Climate Change, AER P&P.

Optimal GHG Emissions Reduction: Benefit-cost analysis (1)

- Societal Benefit-Cost analysis needed to establish optimal emissions reduction
- Based on concept of social welfare (W)
- In estimating welfare, we maximise net societal gain G(E) as proxy for welfare
- Max G(E) = B(E) - C(E)
  - B(E) = Benefit of emissions reduction = Avoided damage costs + ancillary benefits
  - C(E) = Cost of emissions reduction

$$\frac{\delta G}{\delta E} = 0 \Leftrightarrow \frac{\delta B}{\delta E} - \frac{\delta C}{\delta E} = 0 \Rightarrow \frac{\delta B}{\delta E} = \frac{\delta C}{\delta E} = \frac{\delta D}{\delta E}$$

or MC=MB

Over time: Benefit-cost analysis (2)

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- Climate change is a dynamic intertemporal problem
- Maximise the value of the gains over time
- Assume the benefits are instantaneous -> benefits at time t depend only on emissions at time t.
- Optimisation equation becomes:

$$\max \sum_t \frac{G}{(1+r)^t} = \sum_t \frac{D_t(E_t, E_{t-1}, \ldots E_t) - C_t(E_t)}{(1+r)^t} \qquad = NPV_t$$

Where r = discount rate

- If NPV > 0 => policy is welfare enhancing
- In policy comparison, if $NPV_1 > NPV_2$, then Policy 1 is more welfare enhancing

Class example

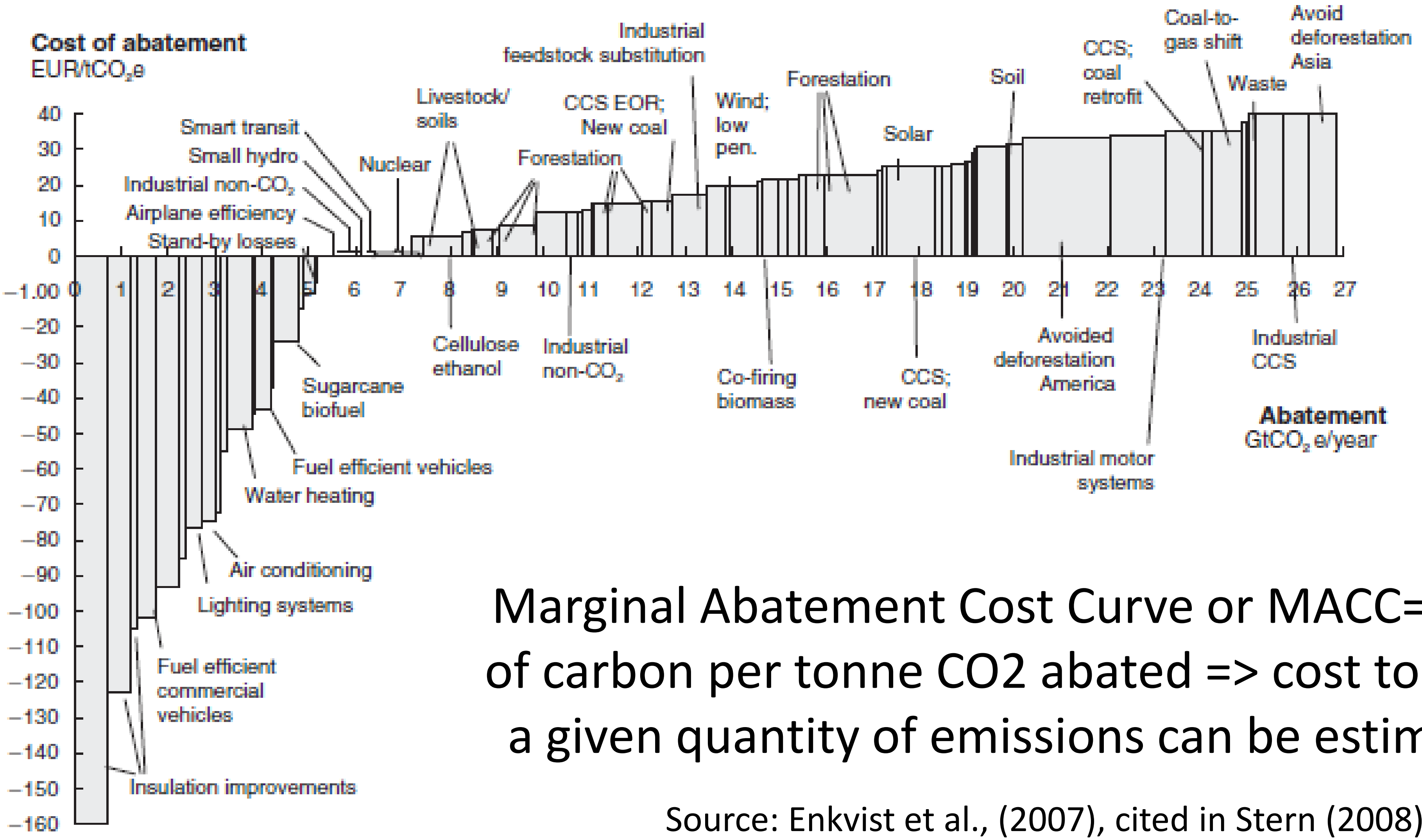
- Consider two policies and a discount rate of 5%
- Estimate NPV of A and B:
- Which policy should you choose?

	Net Benefits (in $)			
Year	0	1	2	3
Policy A	-30	20	20	20
Policy B	-30	10	10	10

A=$24.46
B=-$2.77

Estimating the costs and benefits

Costs of mitigation – the famous MACC!



Marginal Abatement Cost Curve or MACC= Price of carbon per tonne CO2 abated => cost to abate a given quantity of emissions can be estimated

Source: Enkvist et al., (2007), cited in Stern (2008)

Estimates of the Benefits of Climate Change mitigation

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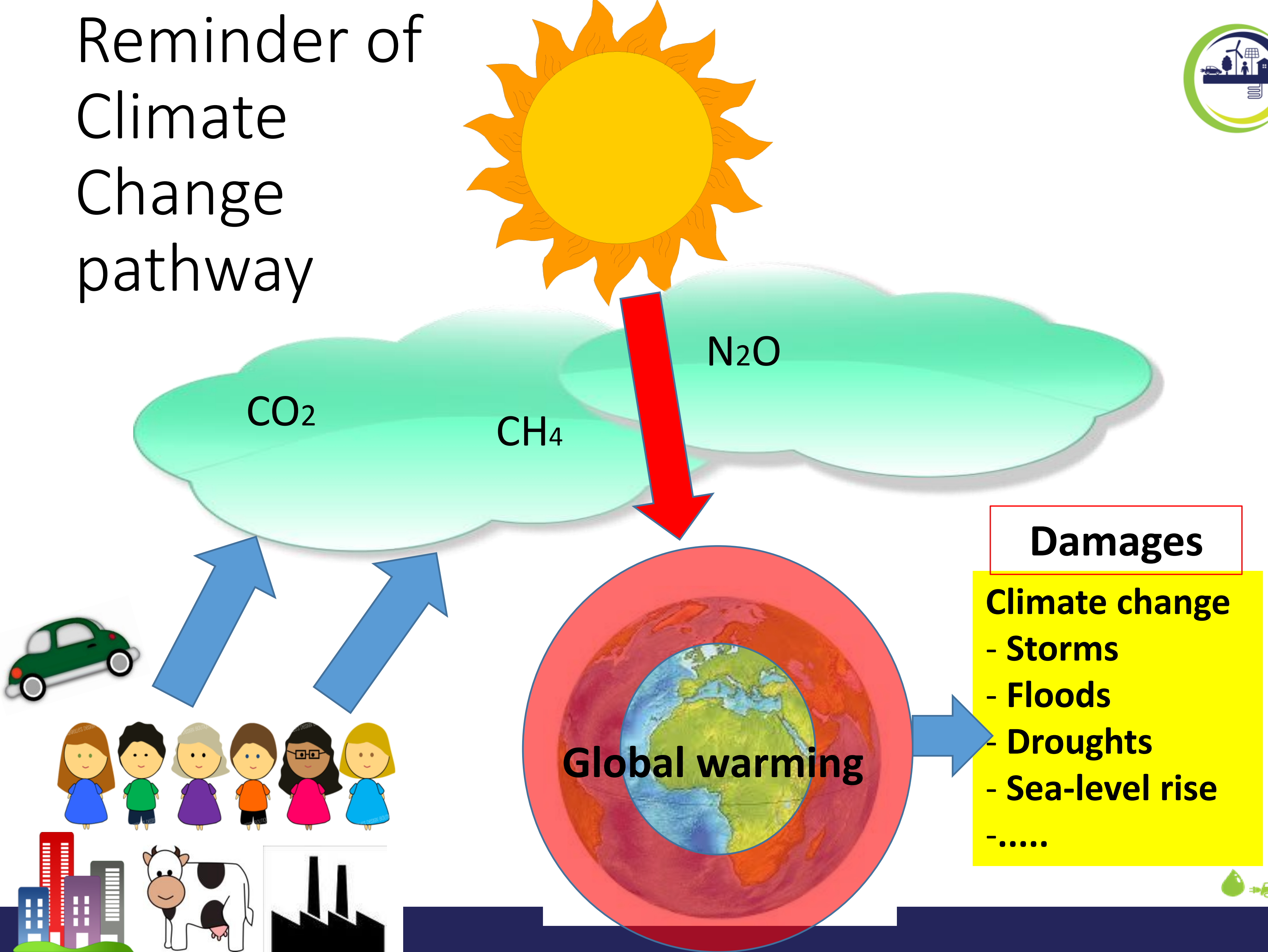
- If we want to measure the benefits of climate change policy we need to estimate the avoided damages of climate change.
- They are difficult to calculate.
- **Why?**

Reminder of Climate Change pathway



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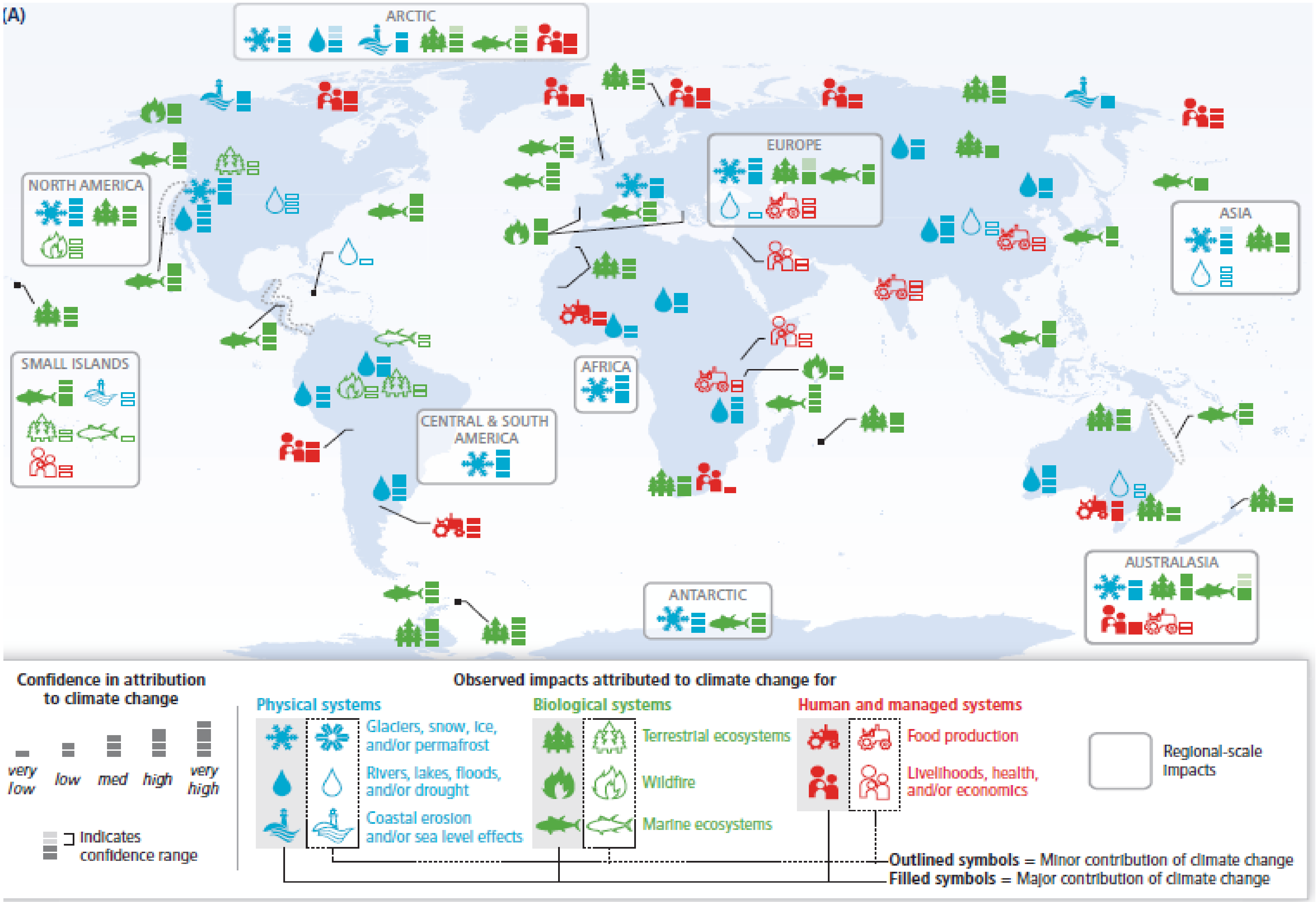
Observed climate change impacts

- Physical systems
  - Glaciers, snow ice and permafrost
  - Rivers, lakes, floods, and drought
  - Coastal erosion and sea level effects
- Biological systems
  - Terrestrial ecosystems
  - Wildlife
  - Marine ecosystems
- Human and managed systems
  - Food protection
  - Livelihoods, health, and/or economics

Climate Change impacts

- **Developed countries**
  - Small predicted impacts – sometimes positives.

- **Developing countries**
  - More vulnerable
  - Likely to suffer more adverse impacts.



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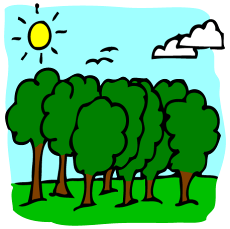
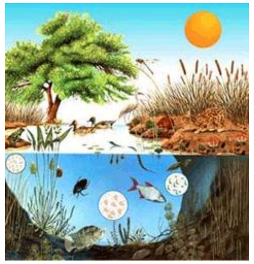
Estimates of the Damage Costs of Climate Change

- Effects considered by Tol, 2002:
  - Agriculture
  - Forestry
  - Sea level
  - Human health
  - Natural ecosystem
  - Water resources
  - Energy consumption





Aravena, 2015

Attributes of Climate Change

- Uncertainty

- Ethics and distribution effects

Aravena, 2015

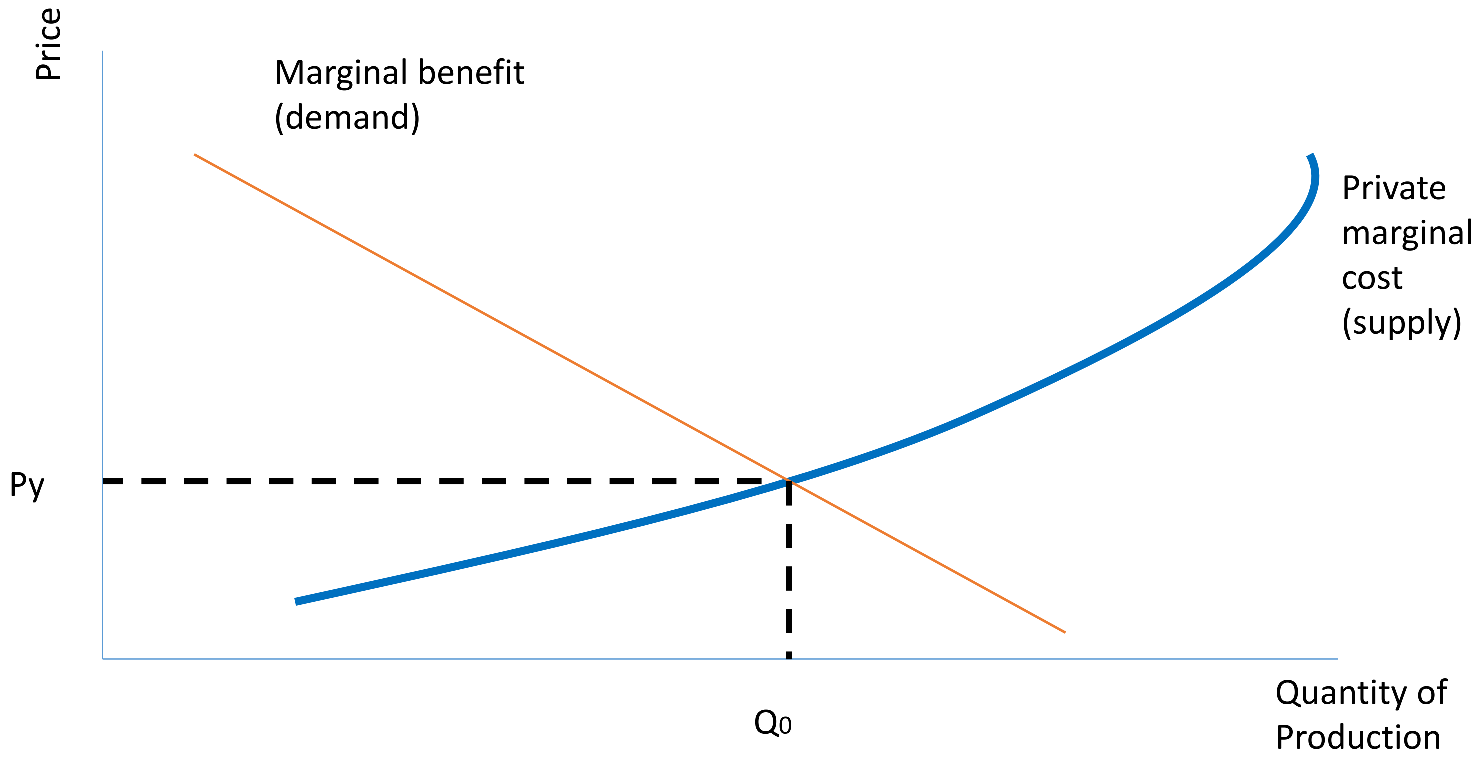
Discounting

- Describes the valuation of future outcomes (V) (damages, costs, benefits, utility values) in present day terms
- Discount factor D: Gives the value of one unit in the future (generally in one year) in present value terms
- Discount rate r: Gives the rate at which future value is discounted
- It holds $D = \frac{1}{1+r}$ and
- PV = V * D^n (n= number of years)
- Stern report recommended r close to zero, disputed

Climate policy: do we need it?

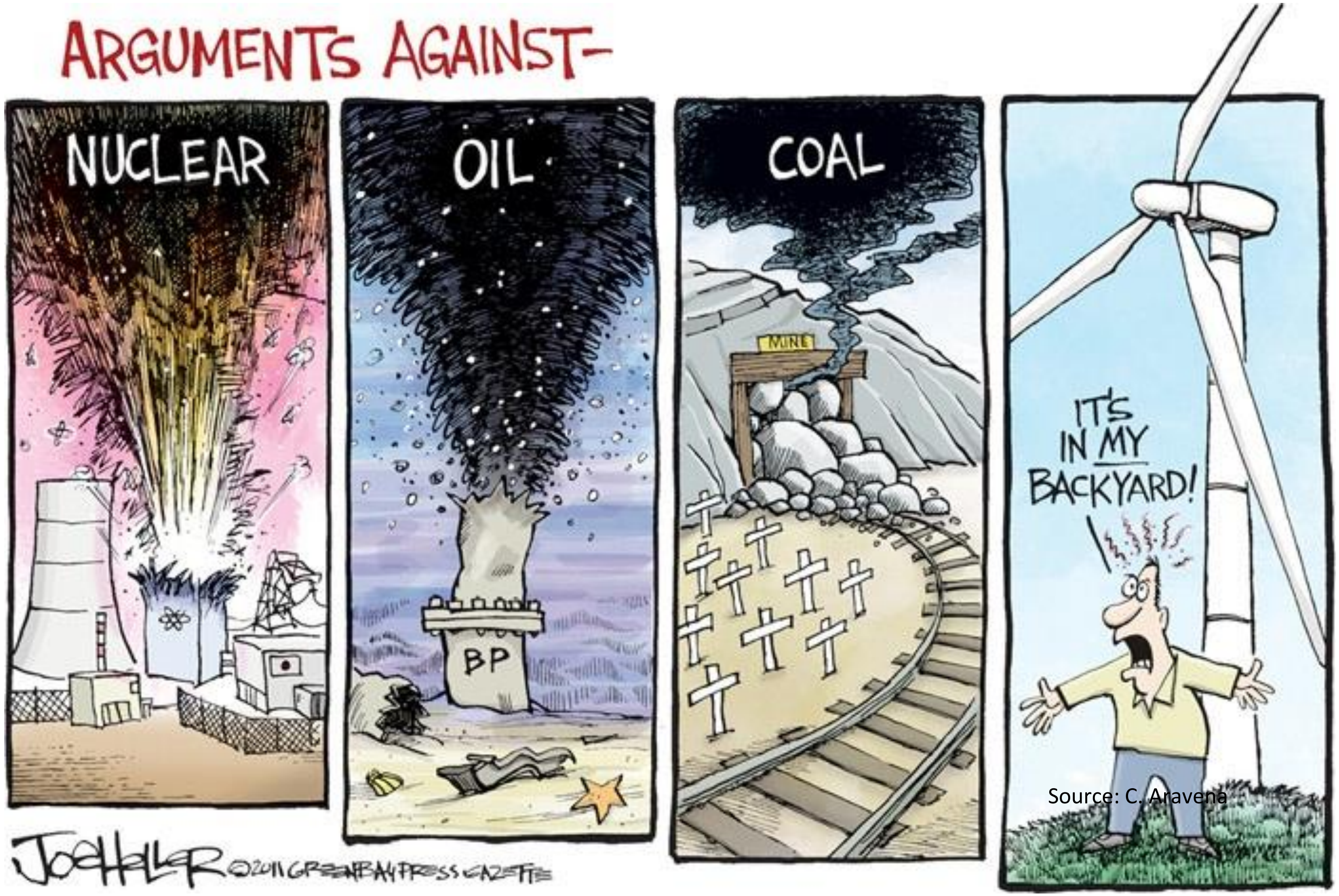
Can the market deliver the emissions reduction?

- Market demand and supply curves for emissions considering firm costs only
- Optimal level of production when MC = MB



The competitive equilibrium is P_y and Q_0:
At MPC = MPB

Externalities in the Energy Sector



Source: C. Aravena

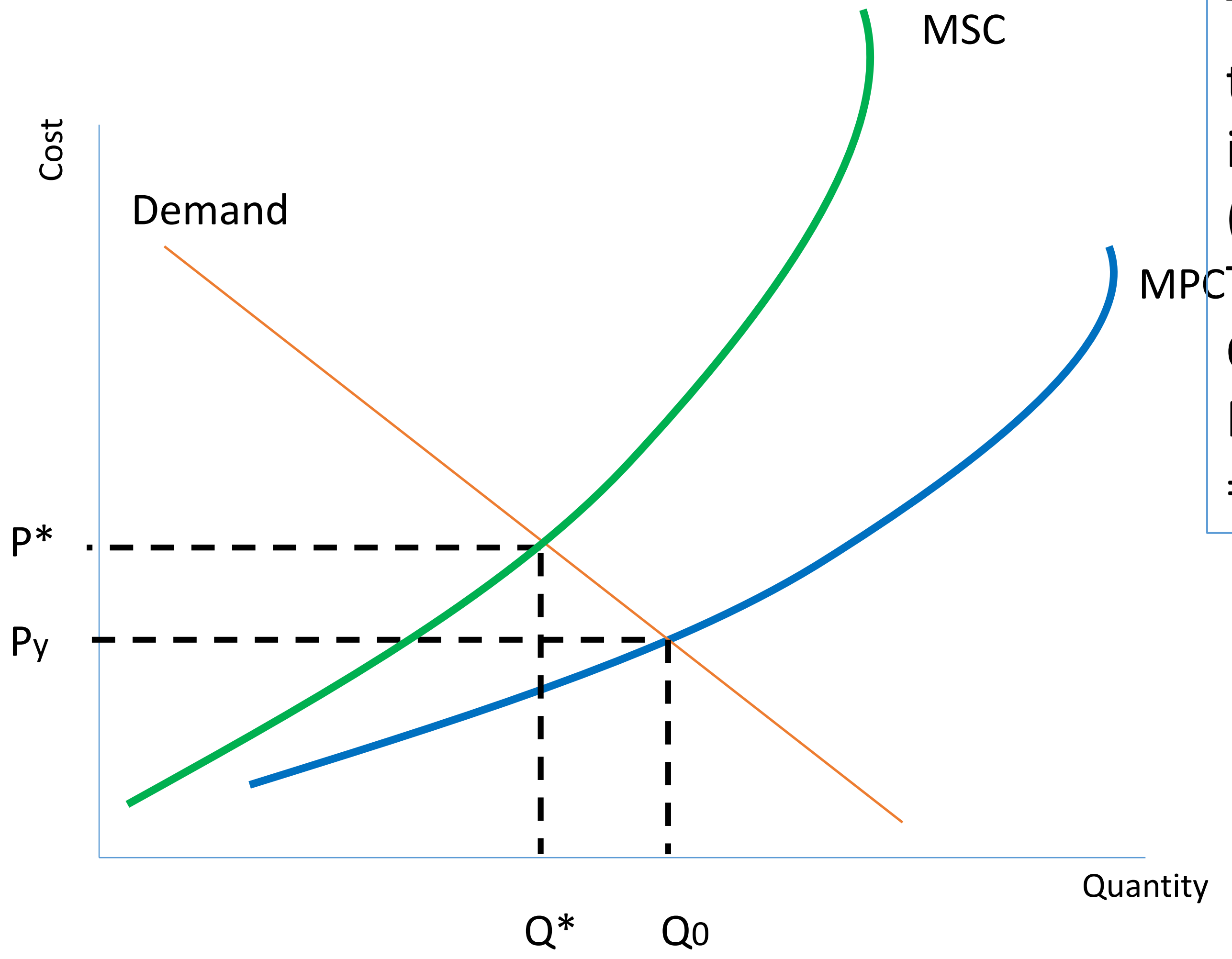
Negative environmental externality

- Negative externalities create a divergence between private and social costs equal to the ***external cost***.
- Problem: suppliers (ex: airlines) have no incentive to consider the external cost.
- Market forces generate an equilibrium production level and price associated with private costs rather than social costs.

→ **Competitive solution is inefficient**

Source: S. Haller

In the presence of market failures…



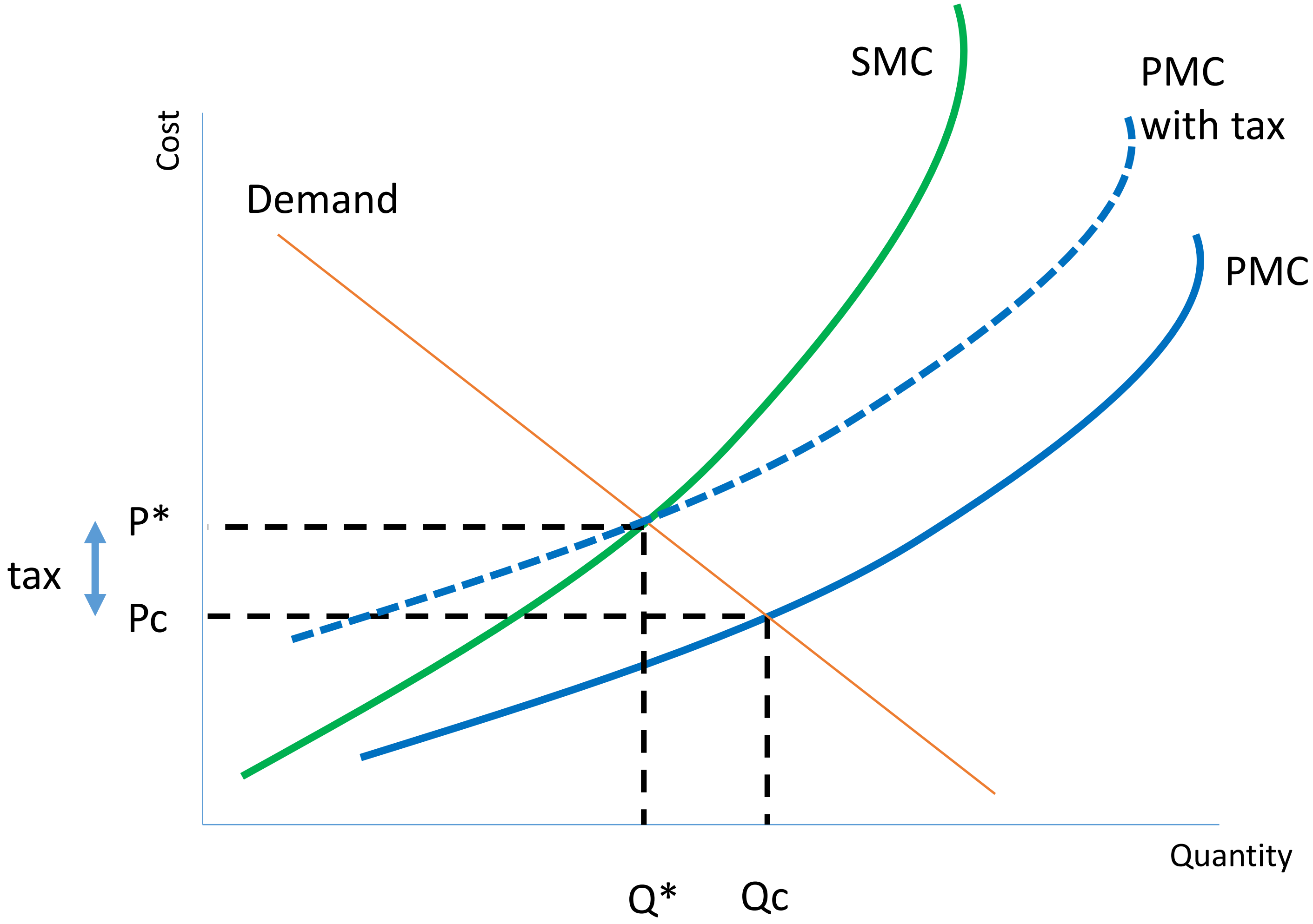
The presence of market failures means that the true cost of emissions is illustrated by the marginal social cost (MSC) of emissions.

The efficient equilibrium is at P* and Q*:

MSC = MSB

=> MPC + MEC = MPB + MEB

Correcting externalities with taxes



The cost of the externality can be added as a (carbon) tax on the firm. This shifts the marginal cost curve to the left to reflect the social marginal cost of emissions.

Dealing with Externalities

- Pigou approach:
  - When the marginal social cost is not equal to the marginal private cost => charge a (Pigovian) tax equal to the difference, ie the marginal damages or marginal external cost
  - The polluter pays and externalities are internalised

- Coase approach:
  - An efficient outcome can be achieved by granting property rights to one party and one party compensating the other;
  - Marginal analysis does not always lead to the right conclusions
  - May not be equitable

Choosing Policy Instruments

Policy Instruments: categories

- Command and control – quantity-based policies
- Information measures
- Economic instruments – price-based policies

Book by Bemelmans-Videc et al. (2003)

"This is their new big carrot and stick method."

Classwork: Name climate policy instruments

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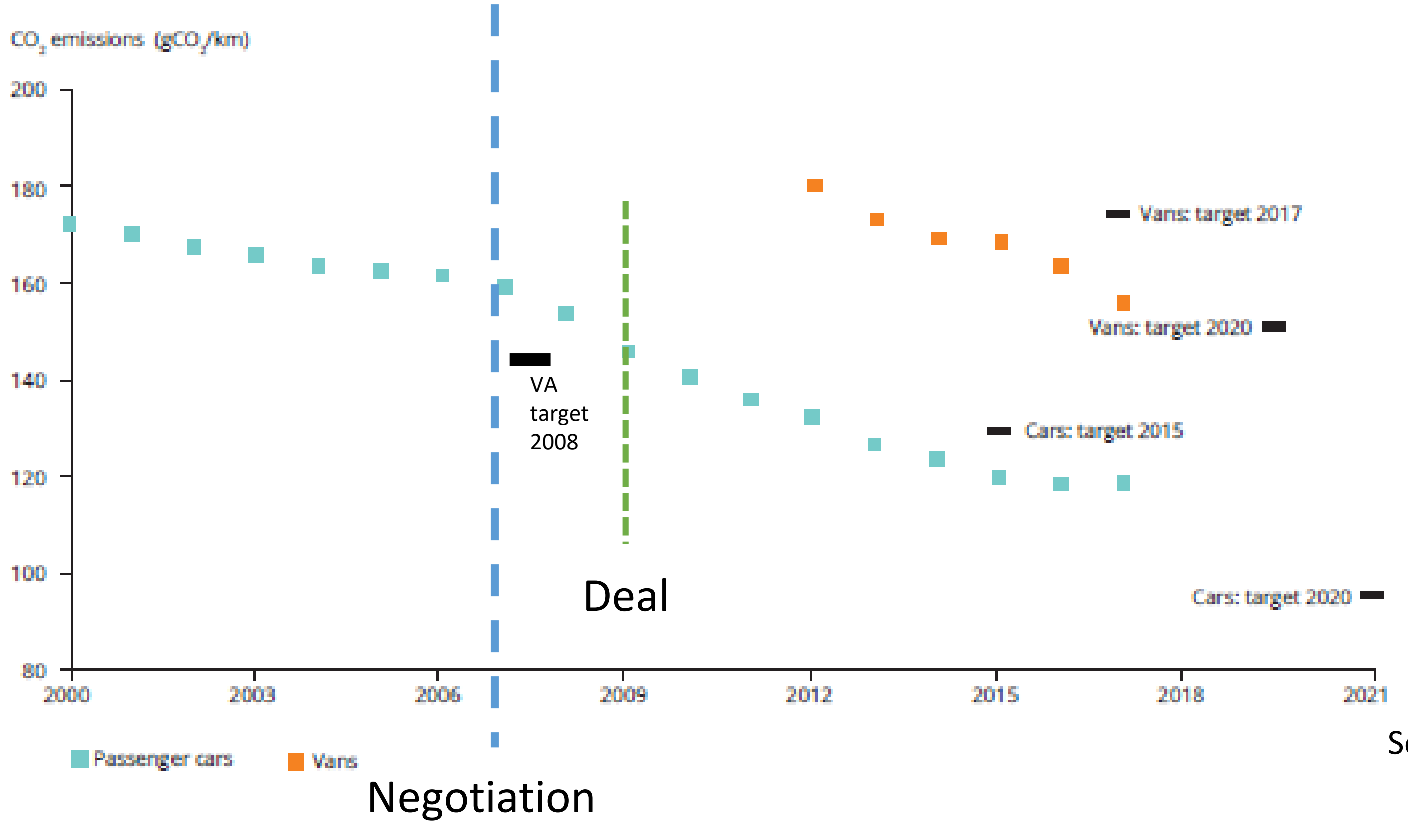
	Power	Industry	Transport	Buildings
Command and control				
Economic instruments				
Information and engagement				

Command-and-control

- Market failure addressed: split incentives and imperfect information
- Characteristics: regulatory target set specifying environmental performance, e.g. emissions limits, technical characteristics, e.g. minimum performance standard
- Strengths: relatively easy to understand and administer, no subsidy from public budget
- Weaknesses: often inefficient, i.e. not least cost, enforcement needed, risk of regulatory capture, policymaker technical capability important.
- Examples: building codes, EU car CO2 emissions regulation, EU energy efficiency regulations on electric appliances

Example: Passenger car regulation

Average CO2 emissions: historical development and targets EU-28



Source: EEA, 2018

New car CO2 emissions in Europe

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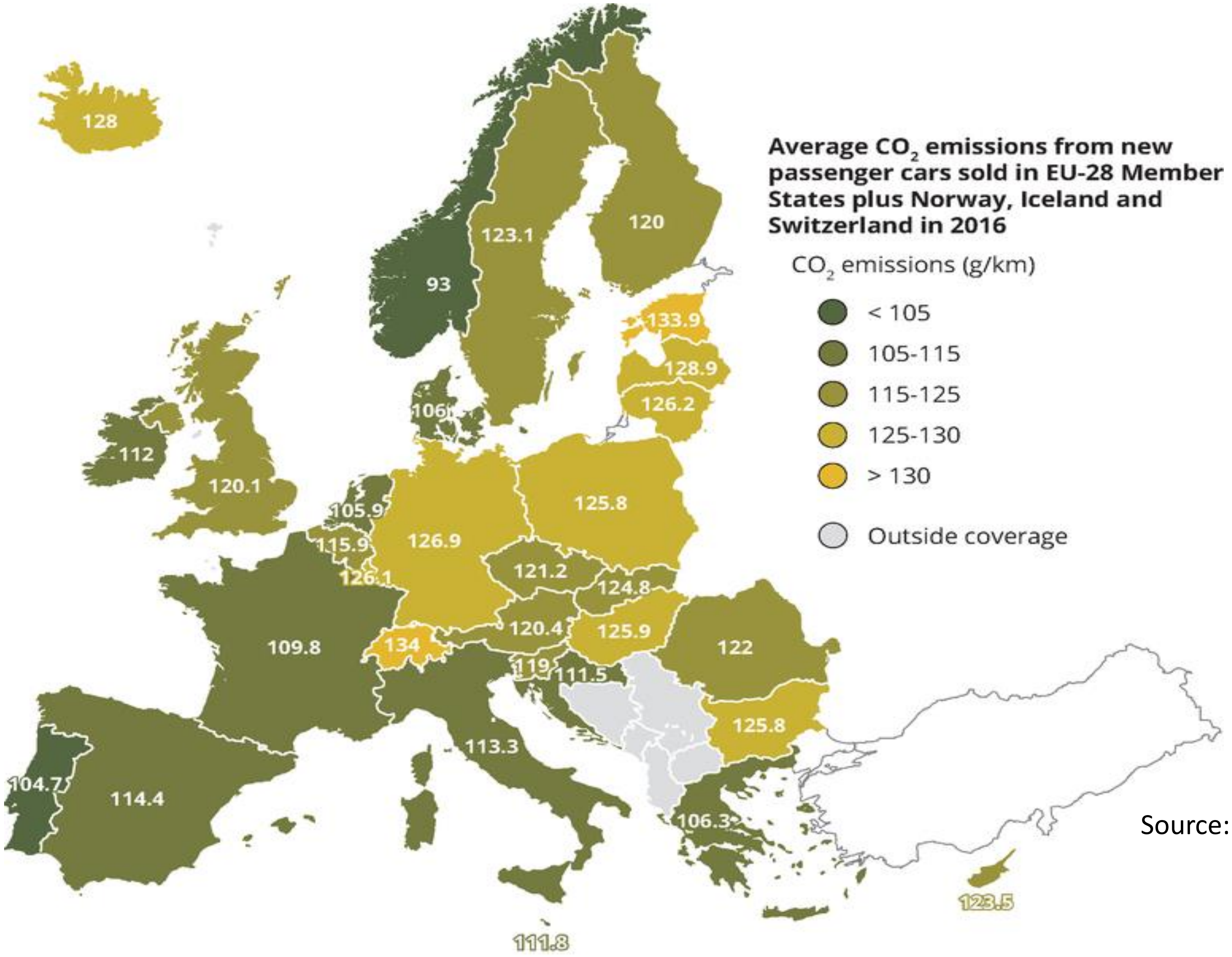


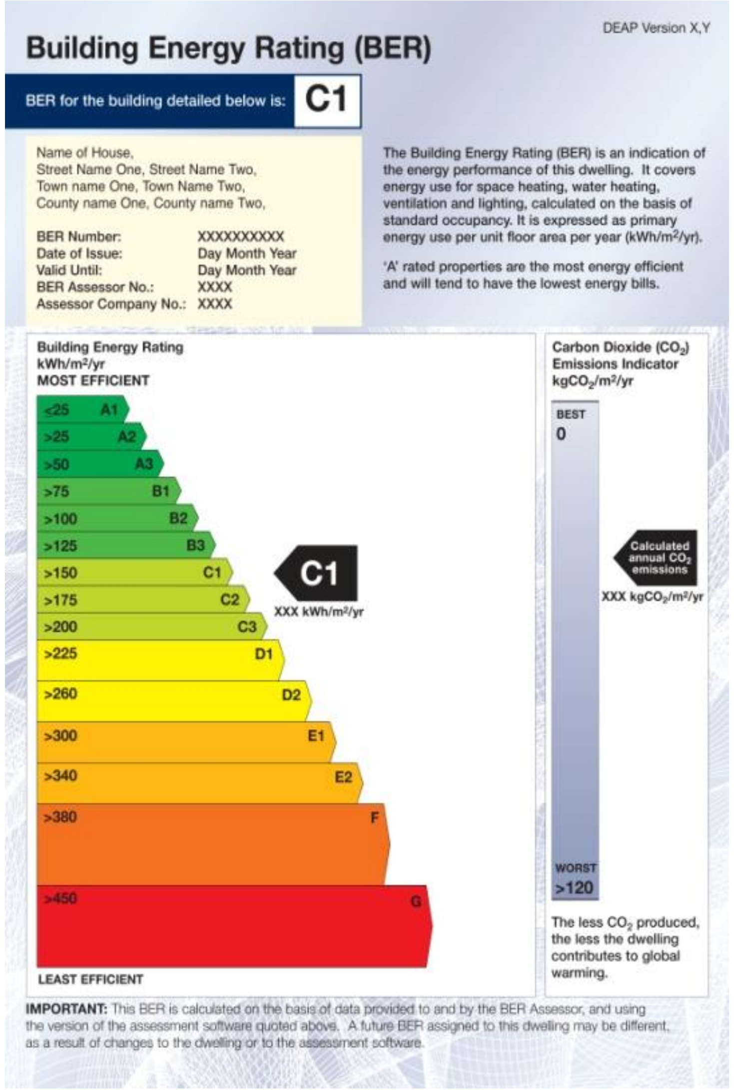
Source: EEA, 2018

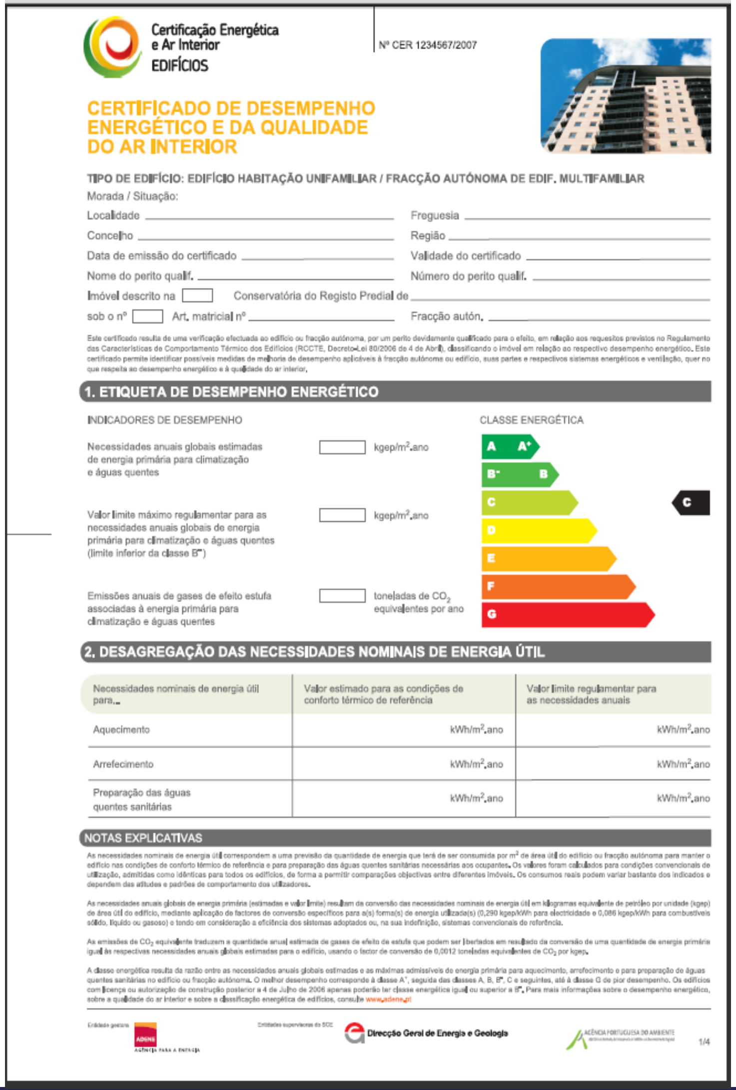
Information measures

- Overcome market failures relating to imperfect information
- Can be combined with other policy instruments such as incentives and regulation
- Need to raise awareness among public and relevant sector
- Usually provide information in the form of labels: BER in Ireland, CO_2 labels on cars, energy efficiency of white goods
- Design of labels important
- Allow sufficient time in advance of implementation to ensure trained professionals where certification is needed
- Regular checking of assessors and enforcement needed to ensure credibility

Example Information measures:

Buildings rating labelling Ireland and Portugal





Economic policy instruments (Pricing)

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- Economic instruments impose a price on goods equal to the marginal external cost of their use (marginal environmental damage cost)
- This may imply a subsidy for products that are public goods or environmental goods
- Strengths of economic instruments:
  - Cover cost of environmental damage
  - Provide incentive effects for responsible consumption
  - Raise revenue
- Weaknesses:
  - Uncertainty in damage costs and abatement costs means that prices can be difficult to set
  - Asymmetric information
  - May lead to distributional inequity

"***A sufficiently high carbon price also promotes investment in clean, low-carbon technologies***." European Commission.

Economic or market-based policy instruments

- Fiscal instruments
  - Tax relief
  - Taxes
  - User charges
- Financial measures
  - Loans
  - Grants
  - Share participation
- Market-based instruments
  - Emissions trading schemes
  - White certificate schemes
- Direct investment
  - Public procurement rules
  - Public infrastructure
  - RD&D investment

Economic instruments for clean energy in power, industry, transport and buildings

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Power sector	Industry	Transport	Buildings
• Emissions trading • Subsidies for renewables • Fuel taxes	• Tax relief • Audit support • CO_2 emissions trading • Energy management support • R&D incentives • Energy prices • Carbon taxes • 3rd party finance and ESCOs	• Vehicle tax incentives • Advanced vehicle subsidies • Fuel taxes • User charges • Infrastructure investment • CO_2 emissions trading • Carbon taxes	• Grants for EE equipment • Loans and grants for refurbishment • Direct investment in social housing • Tax relief • Energy prices • Carbon taxes • 3rd party finance and ESCOs

Carbon tax is most direct example!

Criteria for selection of Policy Instruments

- Cost-effectiveness (static efficiency)
- Long-run effects
- Dynamic efficiency
- Feasibility
- Ancillary benefits
- Equity
- Dependability
- Flexibility
- Information and uncertainty

Ireland CO_2 emissions mitigation strategy

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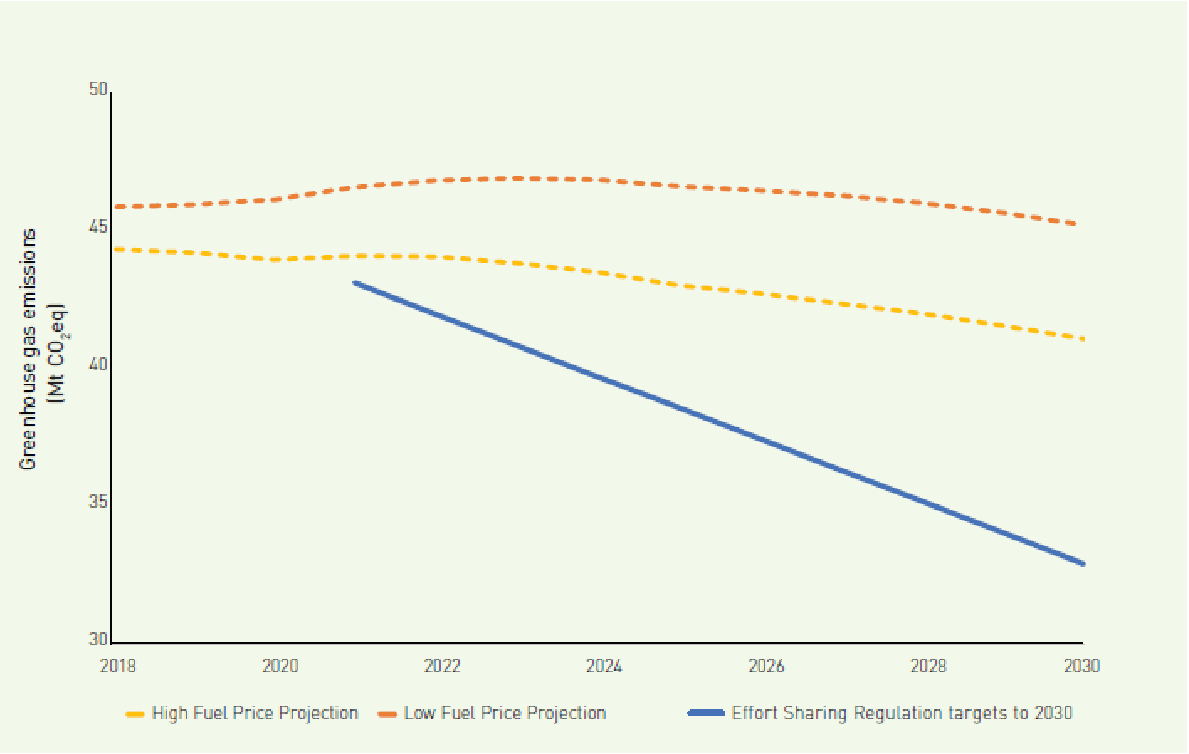
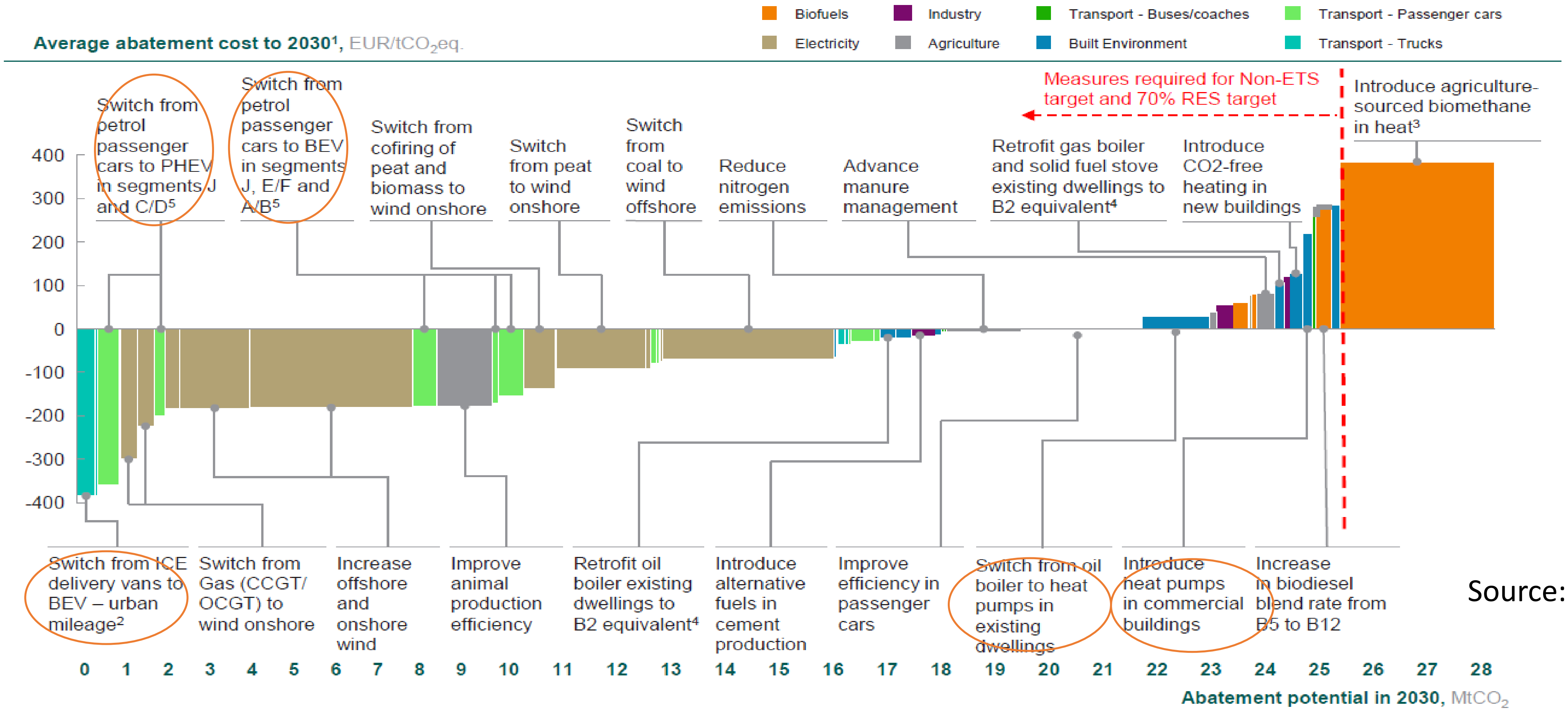
- *National Policy Position on Climate Action and Low Carbon Development*: 80% reduction in CO2 emissions by 2050 (moving to net zero carbon)
- Ireland will not meet 2020 Renewable energy or CO2 emissions targets
- Climate Action Plan launched 21st June 2019



Climate Action Plan: Marginal Abatement Cost Curve

Electrification of heat and transport, 70% RES-E key measures



Source: DCCAE (2019)

High Level strategy

Heat

Transport

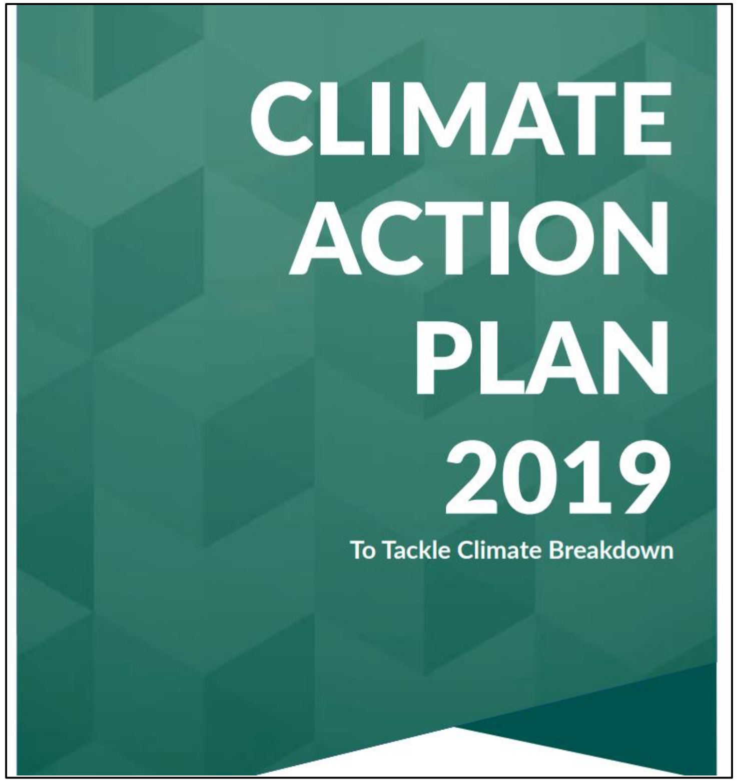
Agriculture

Electricity

Decarbonise

Electrify + Shift + Decarbonise

Focus on Consumers in Government Climate Policy



Consumers in the CAP:

- Adoption of new technologies across all sectors
  - >800,000 EVs by 2030
  - ~600,000 heat pumps by 2030
  - Retrofit 500,000 buildings to B2
  - Solar PV
- Changing energy use
  - Time of use tariffs + smart meters to facilitate VRE
  - Transport modal shift
- Financial measures
  - Carbon taxes
  - Environmental tax reform
  - Financial services
- Engaging citizens
  - Sustainable energy communities
  - Education and awareness

Conclusions

- Climate change is increasingly urgent concern
- Economics provides useful framework to consider policies, emissions levels
- Behaviour is difficult to quantify
- Policy decisions need to include consideration of societal welfare, ie social cost benefit analysis that includes externalities
- Students can use economics to understand political economy, market failures, policy instruments, fairness associated with climate change.

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