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The effect of the modelling framework on the assessment of emission control measures

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Introduction 1

- Current technologies will not adequately and economically constrain emissions with uncontrolled energy demand growth
  - Limits to technologies in sight – EOP, biofuels, hydrogen cars, etc,

- So measures controlling energy service demand and associated emissions are important policy options
  - e.g. car downsizing (reduction potential 10% of total UK CO_2), restraining aviation growth, increased building efficiency

- How is the full range of measures handled in Integrated Assessment Modelling?

Introduction 2

- The choice of integrated assessment model, such as whether it includes welfare costs, may substantially change the net cost of a measure
  - effect on the assessment of measures and subsequent policy choices
  - e.g. car downsizing net cost might change from negative to positive

- IA modelling handles measures and costs in various ways
  - leads to problems comparing results from different models, and using them together

- Terminology used differently

Terminology: measures and instruments

We propose that:

- A ***measure*** is a physical change to the system, including behaviour
  - e.g. lower speed, insulation, a wind turbine or a catalytic converter
- An ***instrument*** is a policy device used to implement a measure
  - e.g. regulation, tax, or information

Different (or combinations of) instruments can be used to implement a given measure.

- e.g. emission limits, taxes or information to downsize cars

Conversely, single instruments often have multiple effects, i.e. they implement several measures.

- e.g. LEZ may induce use of smaller cars, modal change, modernisation of vehicle park, …

Assessing non-market costs

Market costs have a public tradeable market value, non-market do not

Willingness-to-pay studies, shadow prices, elasticity estimates may give indications on non-market costs … but these can probably not be generalized

- **costs may differ across individuals** (e.g. value attached to large cars depends on individual preferences)
- **costs depend on a specific situation** (e.g. value attached to large cars and right to speed vary between countries)
- **costs may change over time** (e.g. due to information campaigns against large cars)

Modelling different actors/consumers

Do models account for these? Should they?

- **benefits and disbenefits may be unevenly distributed across individuals** (e.g. possibly more travel time but less accidents for speed reduction; building insulation and renting)

- **different interest rates may apply to different actors** (e.g. for governments and individuals for building investment)

Examples of measures chosen for illustration

- Behavioural change
  - downsizing cars (less powerful, lighter cars)
  - reduced (motorway) speeds
- Demand management
  - building energy efficiency (insulation, ventilation control, efficient lights)

Passenger transport: some non-market issues

- Downsizing cars has a negative market cost, but an imputed positive welfares cost.
  - Private utility, e.g. of large car can change because of consumer preference, advertising etc. etc. E.g. value of 4x4 was negligible in 1975, then became large, and may become small again because of information campaigns, or change in preference because of environmental guilt!
  - Welfare cost may not be used in other sectors – e.g. the value of having a house at a certain temperature, so how to compare?

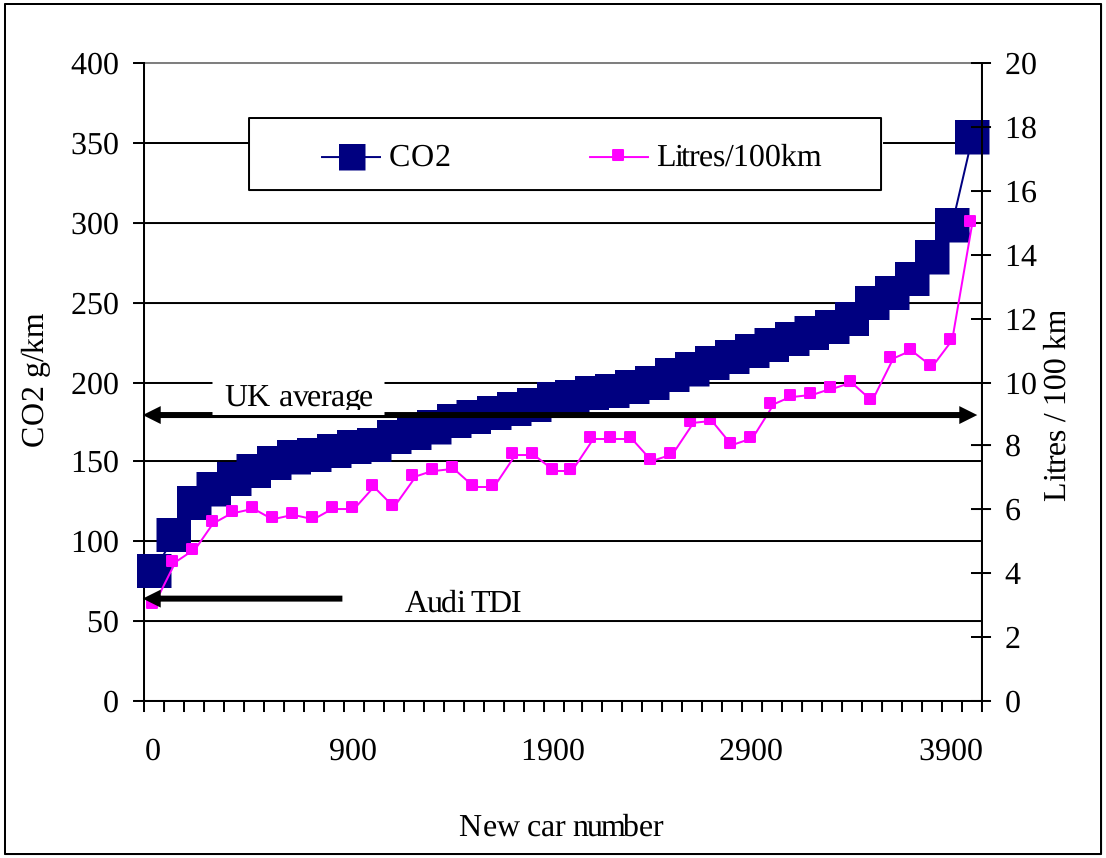
- Welfare value of having a large car may be included, but what is the welfare cost of:
  - being endangered and exposed to air and noise pollution when walking or cycling
  - having to walk longer distances to cross road
  - being put at risk if you drive a small car and are hit by a large car
  - of car congestion

  What about social equity? Poor/old/young suffer from impact of cars, but can't drive them.

- Is all of this included in models? If not, how would cost-effectiveness and CBA of measures change if they were?

- Does the modelling analytic framework favour options such as cars?

Passenger transport: car fuel consumption and carbon emission

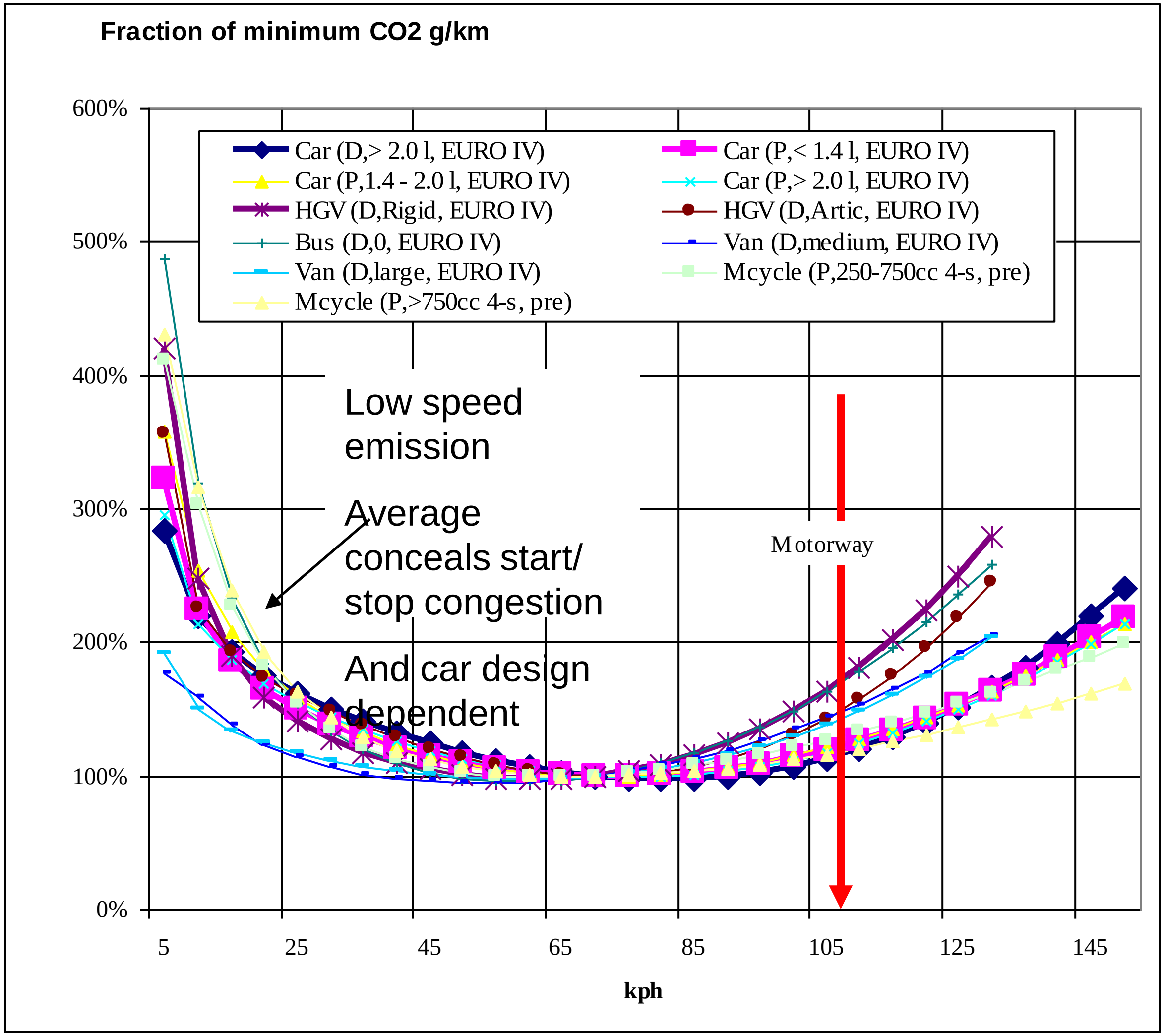


Switching to 5 seat, 95 mph, 3 cylinder Audi Tdi with ~95 mpg combined drive cycle consumption would reduce car stock energy and CO2 by about 60%. This Audi isn't made any more. A switch to small cars would reduce total UK emissions by 5-10% in 15 years.

Transport: road speed and CO2 emission

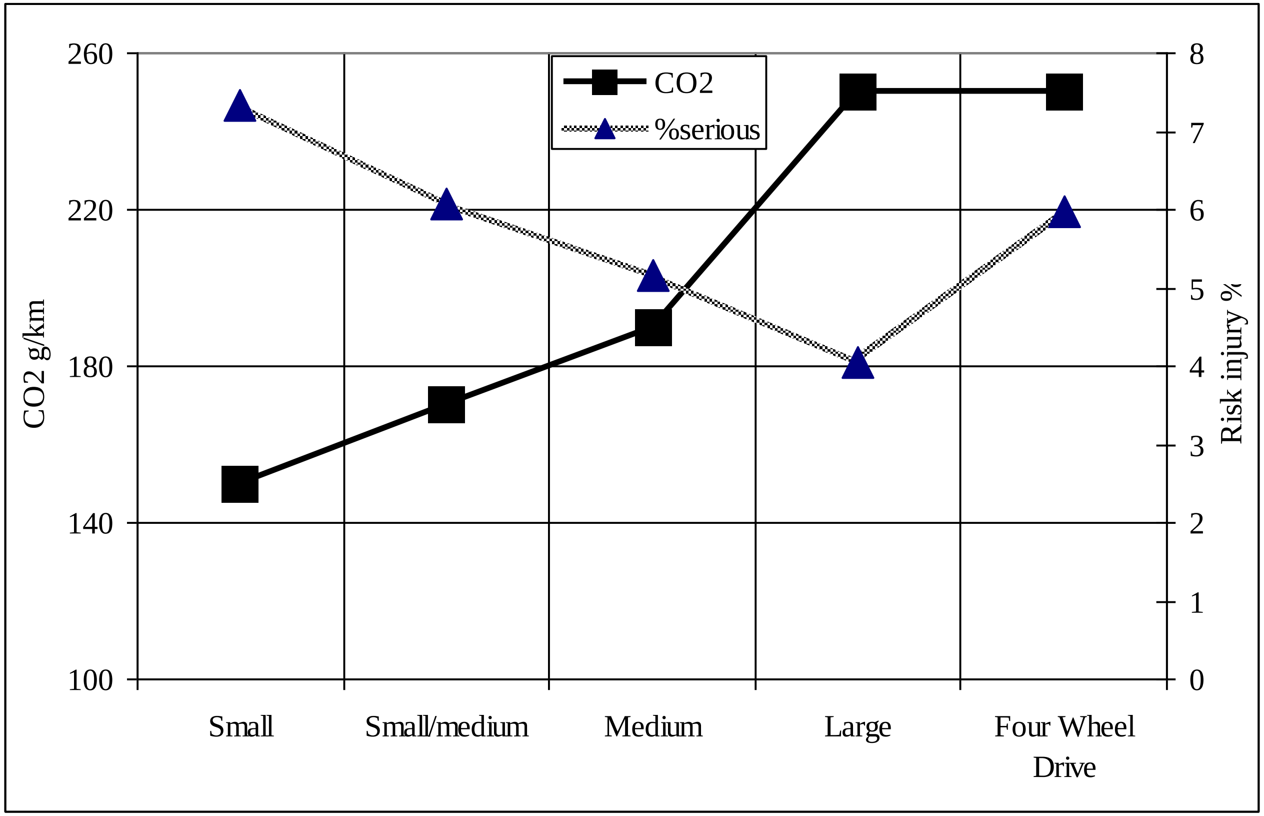
Energy use and carbon emissions increase strongly with speed. Curves for other pollutants generally similar, because emission strongly related to fuel consumption.

These curves are only applicable to current internal combustion vehicles. Characteristics of future vehicles (e.g. urban internal combustion and electric powered) would be different. Minimum emission would probably be at a lower speed, and the fuel consumption and emissions at low speeds would not show the same increase.



Passenger transport: Risk of injury to car drivers involved in accidents between two cars

Cars that are big CO2 emitters are most dangerous because of their weight, and because they are usually driven faster. In a collision between a small and a large car, the occupants of the small car are much more likely to be injured or killed. The most benign road users (small cars, cyclists, pedestrians) are penalised by the least benign.



Passenger transport: Risk of injury by mode

Let your child walk to school, or take them in the car?

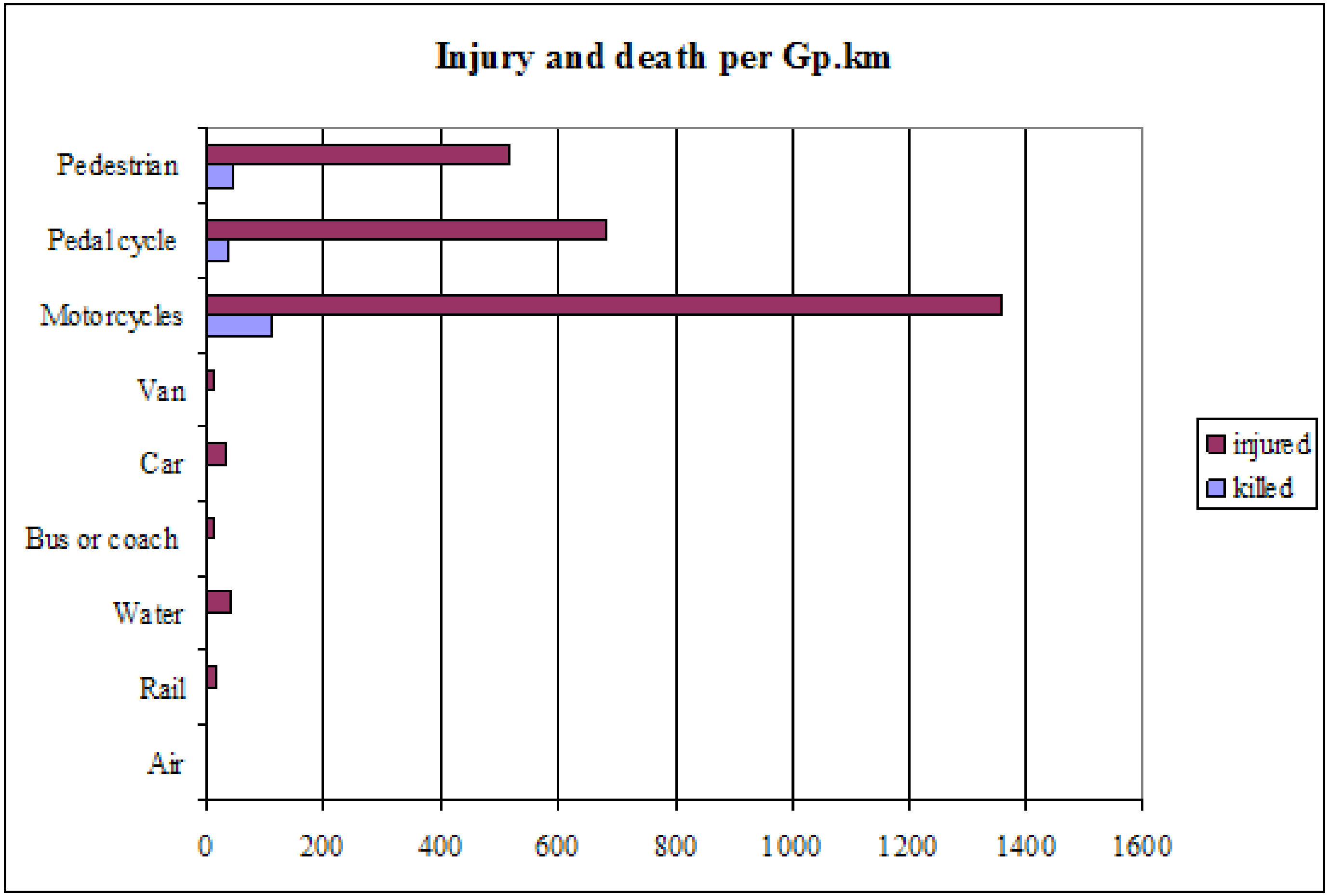
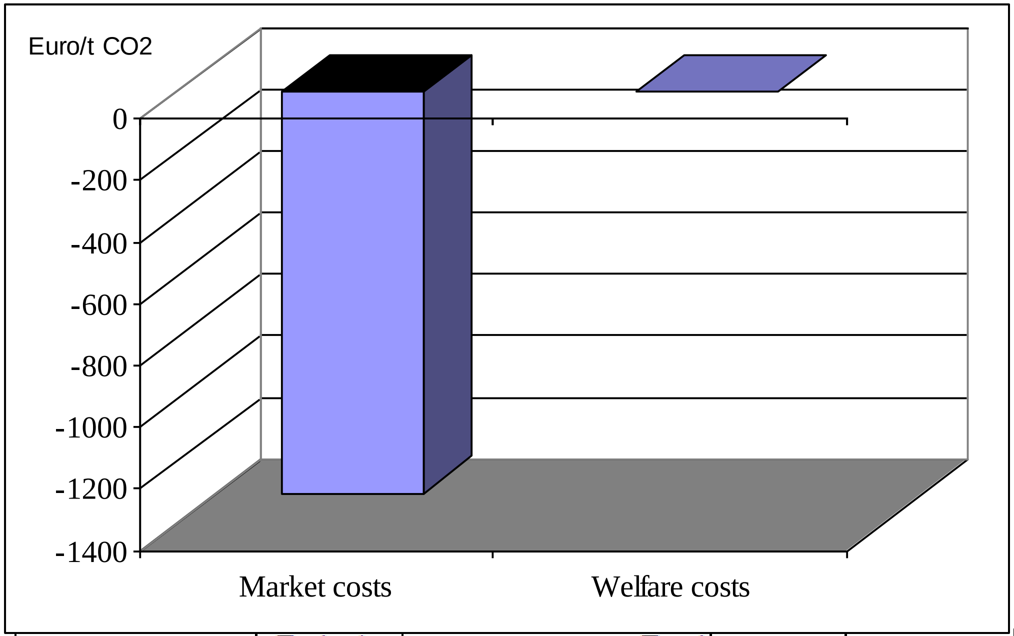


Illustration: Downsizing the car

- assume market cost differences (capital +running) = consumer private utility?

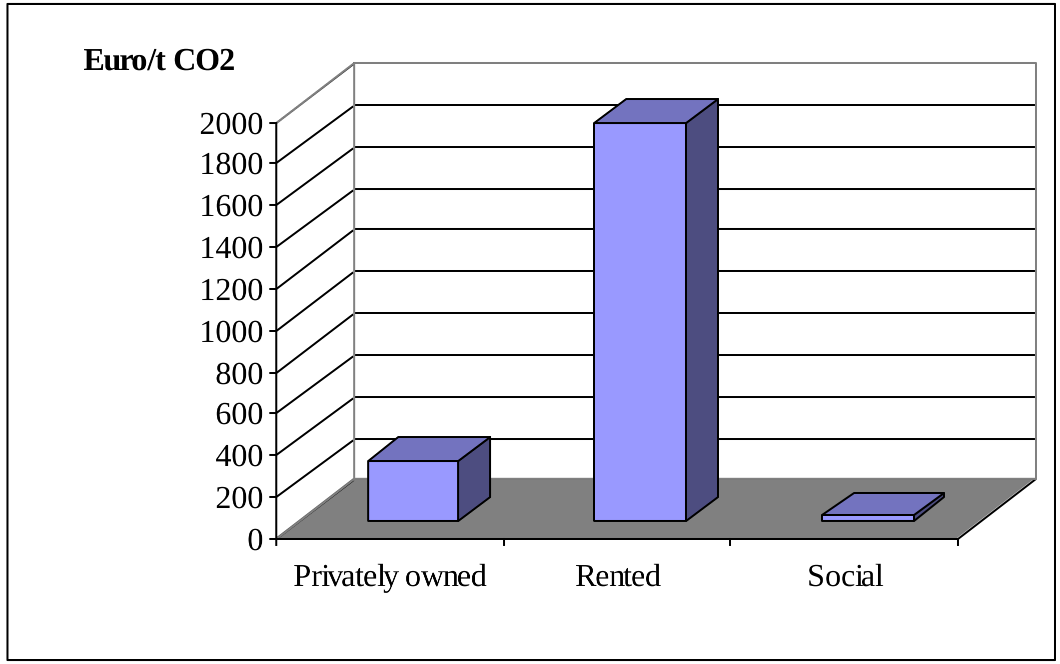
- CO_2 abatement cost
  - zero including welfare
  - -1300 euro/t market costing.



Measure	Case	Extra Capital Euro	Project Life yrs	Interest rate %	Annual Energy Saving GJ/a	Extra Running Euro/a	Emission per Energy kg/GJ CO2	Annuitised Capital Euro/a capital	Total Annual cost Euro/a	Emission reduction t/a CO2	**Abatement cost Euro/t CO2**
Car downsizing	Market costs	-10000	12	7%	35	-2025	72	-1,259	-3,284	2.52	-1303
	Welfare costs	0	12	7%	35	0	72	0	0	2.52	0

Illustration: Insulating the house

- who invests, who benefits?
- time periods and interest rates depend on agent and changes
- CO_2 abatement cost varies by a factor of about 100



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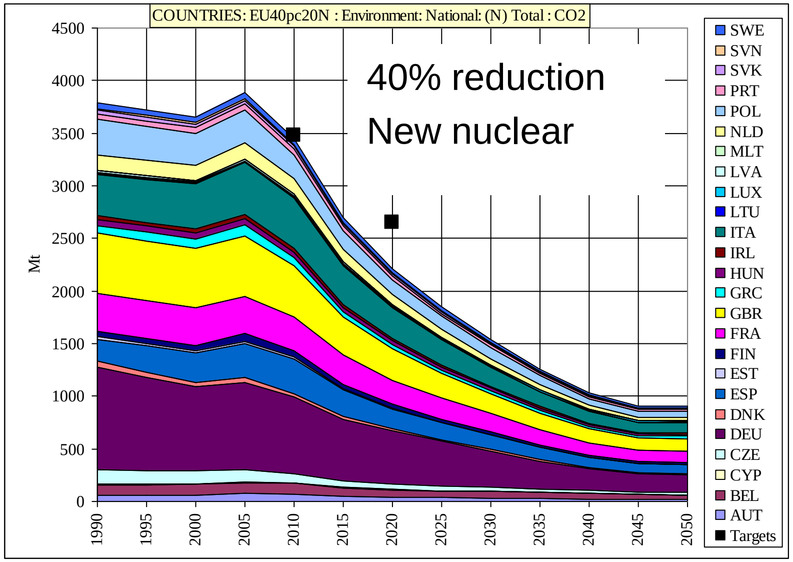
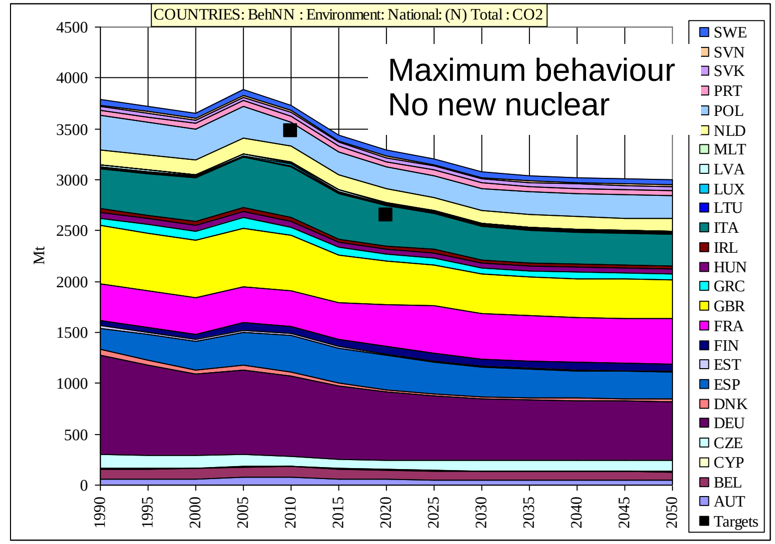
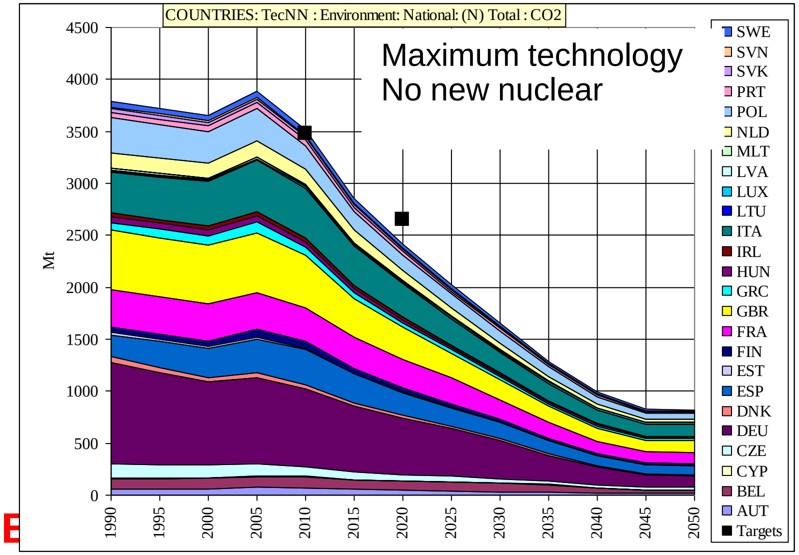
Insulation	Privately owned	3000	7	8%	10	-100	167	576	476	1.67	**285**
of electrically	Rented	3000	1	10%	10	-100	167	3,300	3,200	1.67	**1916**
heated house	Social	3000	50	4%	10	-100	167	140	40	1.67	**24**

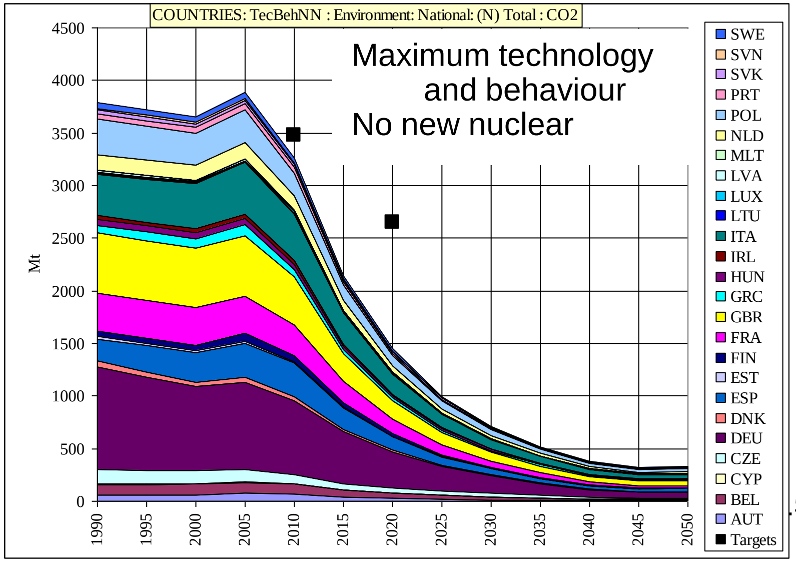
SEEScen sample: EU25 CO2 : variant scenarios

Over 2005-2050, behavioural change reduces integrated CO2 by 33% more than technology, and faster









Conclusions

- Costs of a measure may change substantially depending on
  - whether non-market costs are included (e.g. downsizing cars)
  - the investors perspective
- Concerning existing models we need to know
  - what terminology is used
  - which measures are included
  - how measures/instruments are handled
  - whether they capture the measures applied in reality or are lagging behind
- Sharing of data on assumptions about such measures used in current models may be useful
- A mapping of measures and their multiple effects may be useful
- Full presentation on the IEA web site!

The individual's and society's view

Different groupings of actors are concerned by costs and benefits of different measures

- building insulation: investment costs to owner; reduced energy bills to user
- reduced speed: more or less travel time for driver, improved traffic flow and reduced accidents also for other road users
- downsizing cars: possibly less safety for driver, but also less risk to others

A measure may be beneficial to society but not to every individual

- e.g. building insulation if the investor does not directly benefit from cost savings of reduced energy demand; on an aggregate level (society) reduced fuel import dependency
- e.g. small cars if the value of the utility attached to large cars (positive non-market cost) outweighs the price difference between large and small cars (negative market costs)

Outline

1) Examples of measures chosen for illustration
2) Terminology
3) Impact of the modelling framework on the assessment of emission reduction measures
4) Questions
5) Conclusions

A perspective on investment: domestic insulation

costs and benefits and of insulating a house

Investors

Tenant renting; time hori

Types of measures and instruments

Type of measure	Example	Instruments				
		Regulation	**Market instrument**	**Information**	**Public investment**	**…**
End-of-pipe	SCR	ELV	Emission tax			
Behavioural change	Downsizing cars	ELV on CO_2 emissions	Tax on CO_2 emissions	Advertising, labelling	Investment in public vehicle fleet	
Demand management	Building insulation	Regulation on energy efficiency standards	Economic incentives for investment	Information on electricity reduction potential	Public investment	
Improved energy conversion efficiency	Condensing gas boiler	Required in the UK				
Energy supply mix	From coal and oil to renewables	Prescription of renewable share	REFIT (Renew-able Feed in Tariff)		Renewable energy in public buildings	

Physical effects of measures

Measures can have multiple physical effects

- **FGD:**
  - reduced SO_2 emissions
  - increased energy demand and CO_2 emissions
- **Downsizing cars:**
  - reduced fuel consumption and emissions
- **Reduced (motorway) speed:**
  - typically less fuel consumption, less emissions
  - better traffic flow, more or less travel time
  - fewer accidents
- **Improved building energy efficiency:**
  - less energy, less emissions
  - ancillary benefits on an aggregate level (e.g. reduced fuel import dependency)

Costs

Market costs:

- costs which are quantified in a market of traded goods and reflected in prices
- e.g. gas, cars or catalytic converters

Non-market costs:

- costs that represent a change in utility and are not reflected in market prices
- e.g. the value people place on travel time, or speed, or pristine wilderness
- these costs are often socially determined and may, for certain measures, change rapidly due to the application of policy instruments (e.g. information campaigns)

Market and non-market costs may be positive or negative

- market costs: e.g. positive for investment in FGD; negative for downsizing cars
- non-market costs: e.g. positive for downsizing cars if value attached to larger cars; negative for reduced speed if travel time reduced owing to better traffic flow

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Importance of the model framework

- Differences in types of costs and effects covered by different models have important impact on the assessment of emission reduction measures and policy recommendations
  - extreme approaches stylised (simplified view): narrow cost-effectiveness analysis and comprehensive cost-benefit analysis
  - show impact for assessment of examples

Variables covered by CEA and CBA

Cost-effectiveness analysis (CEA)

- aim: assess the least-cost way of reaching given policy objectives
- compares usually alternatives on the basis of their costs and a single quantified (not monetised) effectiveness measure
- costs are often measured narrowly as budgetary or market costs

➢ $C_t = C_m$

➢ involves two different metrics

➢ criterion for choice e.g. marginal market costs per additional emission reduction

Cost-benefit analysis (CBA)

- aim: assess the efficiency of a programme
- ideally compares alternatives taking into account all (monetised) impacts (all social costs and benefits)
- wider view on cost and multiple effectiveness measure

➢ $C_t = C_m + C_{nm}$

➢ costs and benefits presented in a common metric

➢ criterion for choice total costs (C_t) per total monetised benefit

Effect of the model framework on the cost assessment

CEA and CBA cost assessment should be rather similar for FGD:

- ➢ Market costs positive
- ➢ *a priori* non-market costs are negligible

CEA and CBA cost assessment should differ for:

- Downsizing cars:
  - ➢ market costs negative (investment and fuel consumption)
  - ➢ non-market costs of large car presumed positive (comfort, safety, status symbol, …)
- Reduced (motorway) speed:
  - ➢ market costs generally negative (reduced fuel consumption)
  - ➢ non market costs may be positive (possibly increased travel time, perception of high speeds)
- Improved building energy efficiency:
  - ➢ total market cost depends on balance between positive investment costs and savings in use phase via reduced energy demand for heating
  - ➢ non-market costs may be positive (renting: costs and benefits spread out unevenly; possible ‘time horizon’ issue, possibly different interest rates according to investor)

=> Net cost may change from negative (CEA) to positive (CBA)

Effect of the model framework on the benefit assessment

CEA and CBA benefit assessment likely to differ in all cases

- FGD (EOP):
  - where spatial or temporal impacts are relevant
- Downsizing cars/reduced (motorway) speed:
  - owing to ancillary benefits (e.g. risk to others, fewer accidents)
- Improved building energy efficiency:
  - owing to ancillary benefits (e.g. reduced fuel import dependency)

To what extent should changes in private utility enter into policy recommendations?

Are the match between model and real world choices, and the assessment of emission control measures two different issues?

- Should non-market cost be included in modelling of cost-effectiveness of measures despite the uncertainty attached to their evaluation?
- Do consumer preferences have to be accounted for?
- Or is it sufficient to focus on such issues in policy design and enforcement to set adequate incentives for implementation?

How far are non-market costs taken into consideration in current policy choices?

- e.g. possible downsizing of cars as a result of car CO_2 ELVs

Do model framework and results capture current policies?

- Are there measures already applied that are not currently part of models or which models do not select as part of a cost-effective strategy?
  - e.g. modal change and downsizing of vehicles
  - for example as a result of the policy instrument congestion charging/LEZ

Allocation of costs to effects

The relationship between measures and effects may be one to one, many to one, one to many.

How to allocate costs over different effects (of a measure or instrument)?

For example: congestion charging might reduce:

- CO_2
- air pollution
- travel time
- accidents

How can costs be allocated, and least cost strategies for each objective?

Does this mean the only option is CBA?

Model features and integration

- How is consumer behaviour modelled?
  - which types of costs?
  - how are they accounted for?
  - where do the data come from?
- What happens if a measure is differently costed (welfare vs. market costs) in two subsequently used models?
- What if a measure is differently defined in two subsequently used models, or absent in one?

Mapping of measures, effects and possible instruments

Type	Measure	Costs		Physical impact							Ancillary dis/benefits)	transmission of effect on energy		level of services provided	Further factors relevant to costs				Instruments
		market	non market	energy	emission: CO2	SO2	NOx	PM primary	PM secondary	Emission coefficient		supply	Demand		different interest rates	Ownership	Time horizon	One's costs are others' benefits	
EOP	SCR	>0	=0	↑	↑		↓		↓										ELV, tax, tradable permit, VA, …
	FGD	>0	=0	↑	↑	↓			↓										
Behavioural	Downsizing cars	<0	>0 / <0	↓	↓	↓	↓	↓	↓		- / [+]	↘	↓					[✓]	ELV, labelling, LEZ, …
	Lower motorway speed	<0 / [>0]	>0	↓ / [↑]	↓ / ↑		↓ / ↑			↓	+		[↓]	?				[✓]	Regulation, information, …
Demand management	Building insulation	<0 / >0	<0 / >0	↓	↓	↓	↓				+	↘	↓		✓	✓	✓	[✓]	Regulation (standards), economic incentive, public investment, …
Improved energy efficiency	CHP			↓	↓	↓	↓	↓	↓										
Energy supply mix	Fuel switch from coal and oil to renewables	<0 / >0	=0?		↓					↓	- / [+]	↓ / ↑	↘ / ↗						

Thank you

- Thank you for your attention

- More information available at:

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