Environmental external costs and international experience with the internalisation

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Expert mission on the internalisation of external environmental costs into energy sector planning for the Mexican electricity sector

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Outline

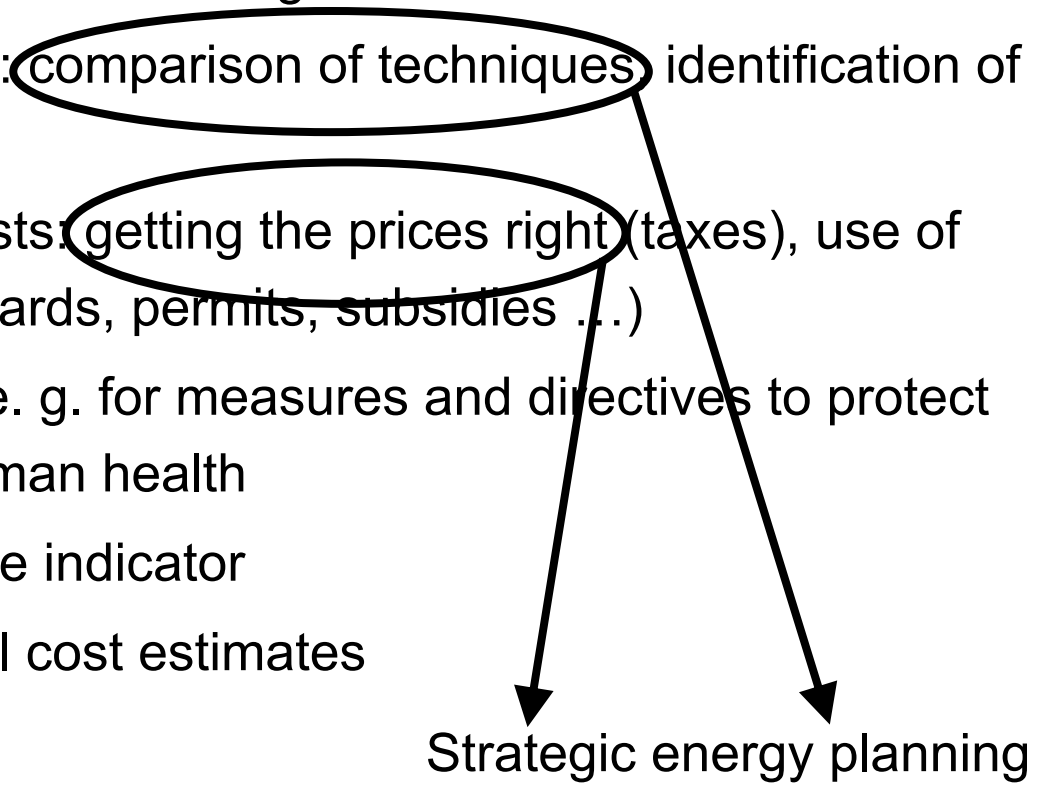
- Background
- The ExternE Project Series
- The ExternE Methodology
- Illustrating Results
- Application of ExternE Methodology or Results

For what purpose are estimates of external costs needed?

To consider external effects, when taking decisions

- Technology assessment: comparison of techniques, identification of weak points
- Internalising external costs: getting the prices right (taxes), use of other instruments (standards, permits, subsidies …)
- Cost-Benefit-Analyses, e. g. for measures and directives to protect the environment and human health
- Sustainability and welfare indicator

→ Different types of external cost estimates



The ExternE Project Series

The ExternE Project Series I

ExternE = **Extern**alities of **E**nergy

- Launched in 1991, financed by the European Commission, DG Research (close to 15 M€)
- Cooperation with US DoE until 1995
- Scope: development of a framework for estimating environmental external costs of power plants
- Multidisciplinary research consortium from all over Europe (more than 50 research teams in over 20 countries)

The ExternE Project Series II

- Follow-up projects until today
  i. improving and extending the methodology, incorporating new knowledge
  ii. extending country coverage and the field of applications: heat production, transport, industrial activities, agriculture, waste treatment, …

- Methodology, available tools and results at

  www.externe.info

The ExternE Methodology

Basic Principles

- Assessment of effects/damages (e.g. health risk), not of pressures (e.g. emissions of pollutants or other results of the inventory analysis of an LCA)

- Relation between pressure and effect is in general non-linear and
- Effects depend on time and location of activity

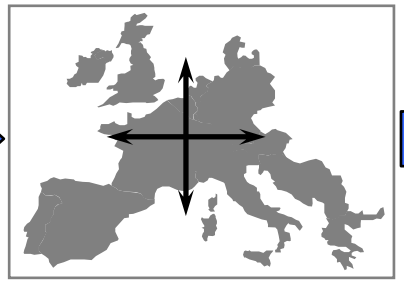
→ Bottom-up approach needed for the complex pathways: the 'impact pathway approach'

- Valuation of damages is based on the (measured) preferences of the affected well-informed population

The Impact Pathway Approach

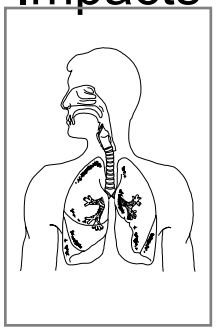
Additional Pressure

Transport and Chemical Transformation; Noise Propagation



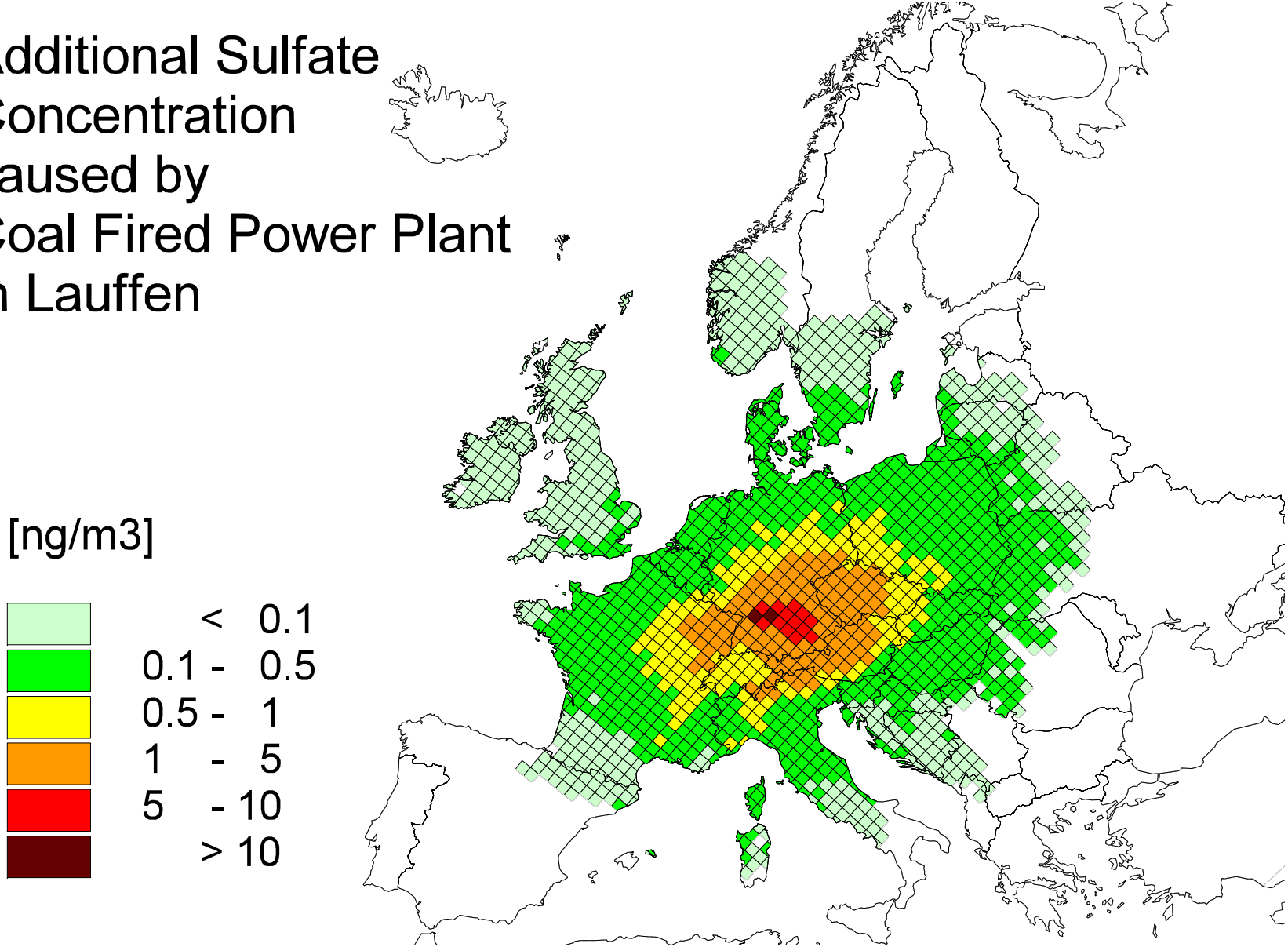
2 Calculations:
with **and** without „project“

Difference in Physical Impacts



Monetary Valuation

Additional Sulfate Concentration caused by Coal Fired Power Plant in Lauffen



Quantification of Impacts and Costs

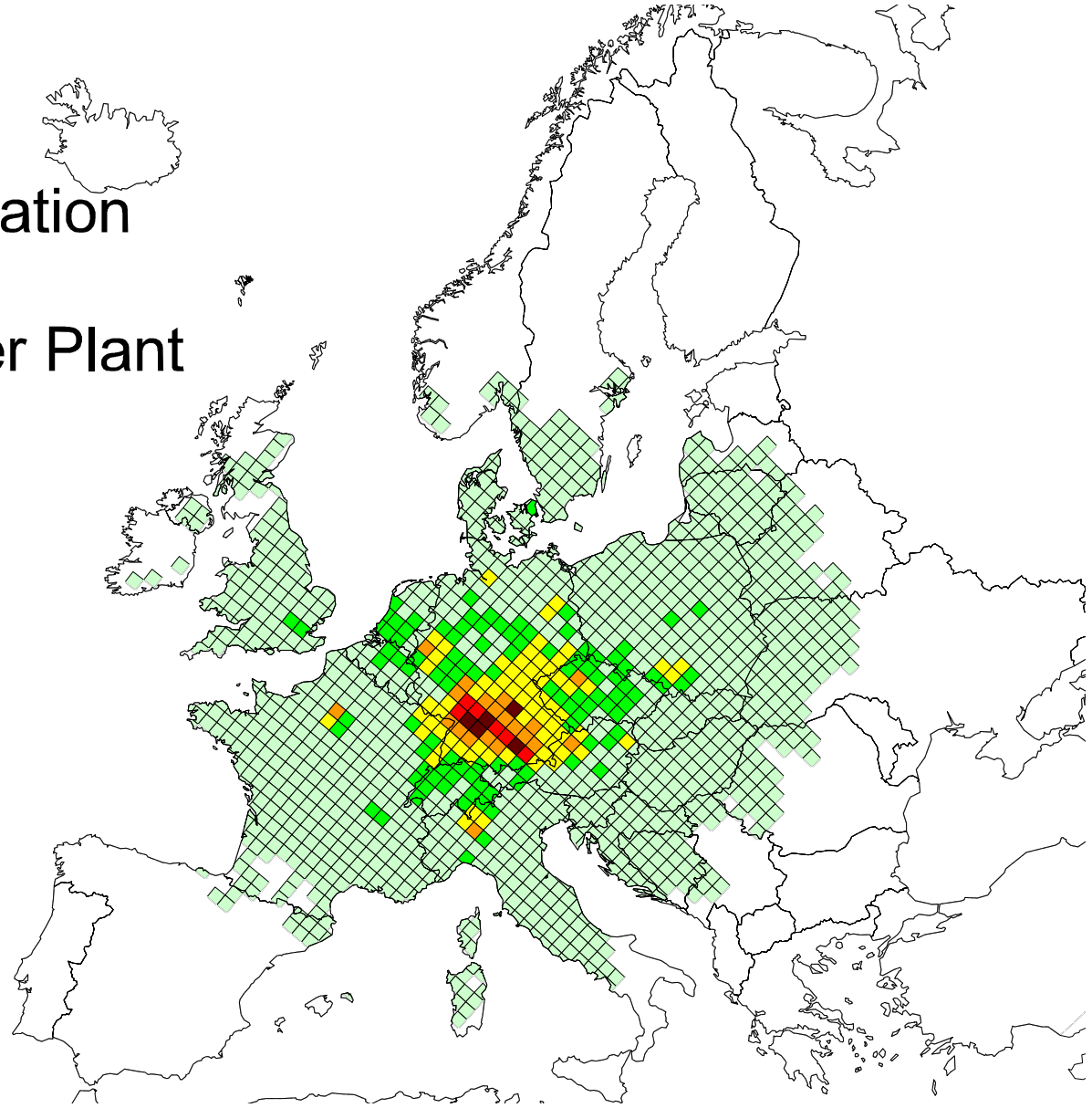
Concentration-Response-Function:

Additional Years of Life Lost

$$= 3.9 \cdot 10^{-4} \cdot \Delta\text{Concentration}_{\text{Sulfate}} \cdot \text{Population}$$

Resulting number of additional Years of Life Lost due to one year operation: 103

Life Time Lost caused by Sulfate concentration due to Coal Fired Power Plant in Lauffen



Impacts considered I

Impact Cat.	Pollutant / Burden	Effects
Human Health mortality	PM_{10}, SO_2, O_3	Reduced life expectancy due to short and long time exposure
	Benzene, BaP, Diesel part., dioxins, heavy metals, radiation, other canc. subst.	
	Noise	Reduced life expectancy due to long time exposure
	Accidents	Fatality risk from traffic and workplace accidents
Human Health morbidity	PM_{10}, O_3, SO_2	Respiratory hospital admissions
	PM_{10}, O_3	Restricted activity days
	PM_{10}, CO	Congestive heart failure
	Benzene, BaP, 1,3-butad., Diesel part., dioxins, HM, o.canc.	Cancer risk (non-fatal)
	PM_{10}	Cerebrovascular hospital admissions, cases of chronic bronchitis, cases of chronic cough in children, cough in asthmatics, lower respiratory symptoms
	O_3	Asthma attacks, symptom days
	Noise	Myocardial infarction, angina pectoris, hypertension, sleep disturbance

Impacts considered II

Impact Cat.	Pollutant / Burden	Effects
Human health	Accidents	Risk of injuries from accidents
Humans	Mercury, lead	IQ loss in children
Building Material	SO_2, Acid deposition	Ageing of galvanised steel, limestone, mortar, sand-stone, paint, rendering, and zinc for utilitarian buildings
	Combustion particles	Soiling of buildings
Crops	SO_2	Yield change for wheat, barley, rye, oats, potato, sugar beet
	O_3	Yield change for wheat, barley, rye, oats, potato, rice, tobacco, sunflower seed
	Acid deposition	Increased need for liming
	N, S	Fertilising effects
Global Warming	CO_2, CH_4, N_2O	World-wide effects on mortality, morbidity, coastal impacts, agriculture, energy demand, and economic impacts due to temperature change and sea level rise
Amenity losses	Noise	Amenity losses due to noise exposure
Ecosystems	SO_2, NO_x, NH_3	Biodiversity reduction due to eutrophication, acidification, land use change

New approach for biodiversity changes

Potentially Disappeared Fraction (PDF) + Restoration costs

- Land use changes
  Example: „Coniferous forest“ → „Built-up land“ = 2.66 Euro / m^2

- Emissions of SO_2, NO_x, NH_3 (acidification & eutrophication)
  Example: Deposition of SO_2 in EU25 = 0.15 Euro / kg

According to expert judgment the impact pathways described are the most relevant for assessing the environmental and health impacts of energy conversion processes.

Effects that are not (yet) included:

- Visual intrusion
- Biodiversity loss (local, however included in Environmental Impact Study)
- Risk of nuclear proliferation and terrorism
- Risk aversion and treatment of Damocles risks
- Security of energy supply

The Impact Pathway Approach

Additional Pressure

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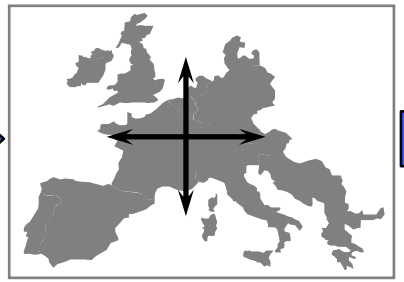

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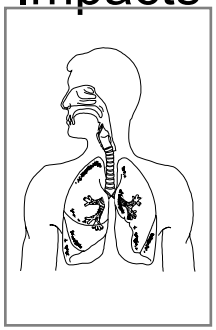


Monetary Valuation

Monetary valuation

Health end-point	Recommended central unit values in € price year 2000
Value of a prevented Fatality	1,000,000
Year of Life Lost	50,000 / year lost
Hospital admissions	2,000 / admission
Emergency Room Visit for respiratory illness	670 / visit
General Practicioner visits:	
Asthma	53 / consultation
Lower respiratory symptoms	75 / consultation
Respiratory symptoms in asthmatics:	
Adults	130 / event
Children	280 / event
Respiratory medication use – adults and children	1 / day
Restricted activity days	130 / day
Cough day	38 / day
Symptom day	38 / day
Work loss day	82 / day
Minor restricted activity day	38 / day
Chronic bronchitis	190,000 / case

Quantification of Impacts and Costs

Concentration Response Function:

Additional Years of Life Lost

$$= 3.9 \cdot 10^{-4} \cdot \Delta\text{Concentration}_{\text{Sulfate}} \cdot \text{Population}$$

Resulting number of additional Years of Life Lost due to one year operation: 103

Monetary value

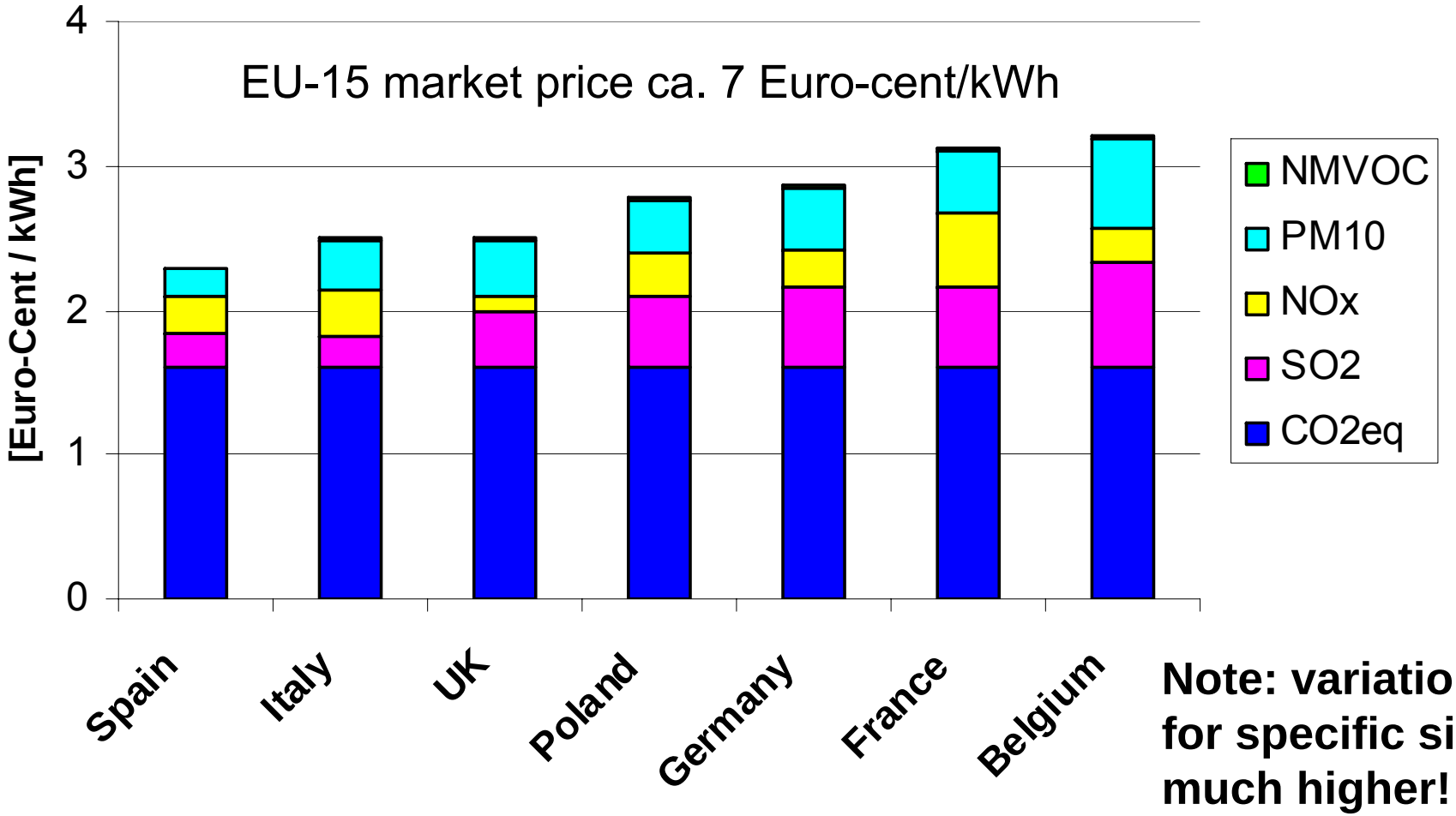
50,000 Euro_{2000} per Year of Life Lost

Damage costs per year:

5.1 Million Euro_{2000}

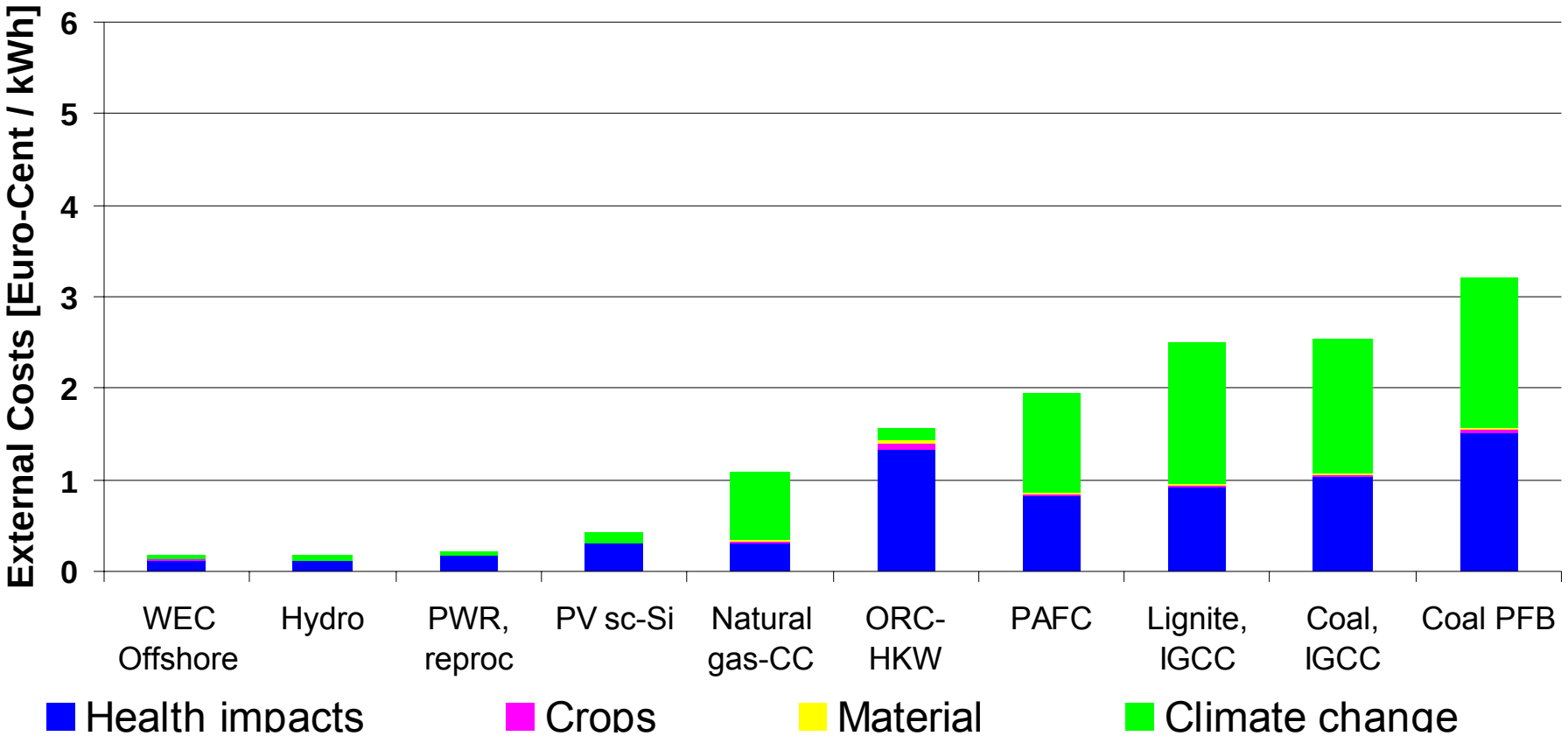
Illustrating Results

Variation of external costs with location: hypothetical coal fired power plant (steam turbine)



Note: variation for specific sites much higher!

Variation of costs with future (year 2010) power plants (hypothetical "average" site in Germany)



Average values for power plant emissions in €/tonne

Pollutant emitted	NO_x	NMVOC	SO_2	$PM_{2.5}$	
Effective pollutant	O_3, Nitrates, Crops	O_3	Sulphates, Acid deposition, Crops	Primary $PM_{2.5}$	
Local environment				urban	outside built-up areas
Austria	4,300	600	4,200	15,000	12,000
Belgium	2,700	1,100	5,700	17,000	14,000
Cyprus**	500	1,100	400	3,000	2,000
Czech Republic	2,900	1,100	4,200	9,000	8,000
Denmark	1,900	800	2,100	9,000	5,000
Estonia	1,400	500	1,200	3,000	2,000
Finland	900	200	800	6,000	3,000
France	4,800	800	4,400	14,000	11,000
Germany	2,800	1,100	4,300	12,000	9,000
Greece	2,300	600	1,200	4,000	3,000
Hungary	5,100	800	4,300	8,000	7,000
Ireland	1,800	400	1,600	8,000	4,000
Italy	3,000	1,600	1,700	9,000	7,000
Latvia	1,800	500	1,500	3,000	2,000
Lithuania	2,600	500	1,900	3,000	3,000
Luxemburg	4,700	1,400	5,200	17,000	12,000
Malta (O_3 estimated)	500	1,100	400	3,000	1,000
Netherlands	2,600	1,000	5,500	18,000	14,000
Poland	3,000	800	3,800	9,000	8,000
Portugal	2,500	1,000	1,700	6,000	5,000
Slovakia	4,600	1,100	4,000	7,000	6,000
Slovenia	4,400	700	4,200	7,000	6,000
Spain	2,400	500	1,900	6,000	4,000
Sweden	1,100	300	1,000	7,000	3,000
Switzerland	4,600	600	4,200	18,000	13,000
United Kingdom	1,400	700	3,000	13,000	10,000

Human Health Effects due to Electricity Production in the EU25 Countries

Substance	Years of Life Lost	Damage Costs (Million Euro$_{2000}$)
PM10 (primary and secondary)	474 000	35 300
O3 and SO2	11 000	430
Total (rounded)	**480 000**	**36 000**

Application of Methodology or Results

Application of ExternE Approach or Results I

Internalisation

- Energy: justification for promoting and subsidising renewable energy; recommended cap on subsidies for renewables
- Transport: planned to levy tolls according to infrastructure and external costs

Impact assessment of policy initiatives

- CBA of Clean Air for Europe Programme (CAFE)
- CBA for all recently implemented directives for Air Pollution Control: e.g. Non-Hazardeous Waste Incineration Directive, Large Combustion Plant Directive, National Emissions Ceilings Directive, Daughter Directives to Air Quality Directive: ozone, CO and benzene
- CBA for the UN/ECE multi-pollutant multi-effect protocol

Application of ExternE Approach or Results II

Energy System Models

- MARKAL: energy optimisation model
- GEM-E3: general equilibrium model for the EU countries
- …

Project assessment

- Transport: CBA mandatory for all major infrastructure projects

Numerous national applications: UK, Netherlands, Finland, Belgium, France, Ireland, Greece, Spain ..., e.g. in Germany: external costs of biomass; subsidies for renewable energies; Scandinavia: transport fuel quality; …

Application in other parts of the world: Russia, China, Brazil, Ukraine, Japan, …

→ Adaptation of EcoSense software

Summary

- ExternE Accounting Framework represents broadly accepted state-of-the-art methodology for assessing environmental external costs
- It has been widely used for decision support in the fields of energy conversion, transport and environmental protection
- Gaps and uncertainties exist, however these will be more and more reduced due to ongoing research (e.g. on pathways involving further toxic substances, heavy metals, biodiversity, water and soil contamination…)