External cost assessment of future electricity supply systems

Wolfram Krewitt
DLR
Institute of Technical Thermodynamics
Systems Analysis and Technology Assessment
Stuttgart

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key questions

- Uncertainties related to the quantification of external costs are large. Is information on external costs robust enough to steer decision processes?
- Does external cost information sufficiently represent long term dynamics of potential development pathways to support long term strategy development?

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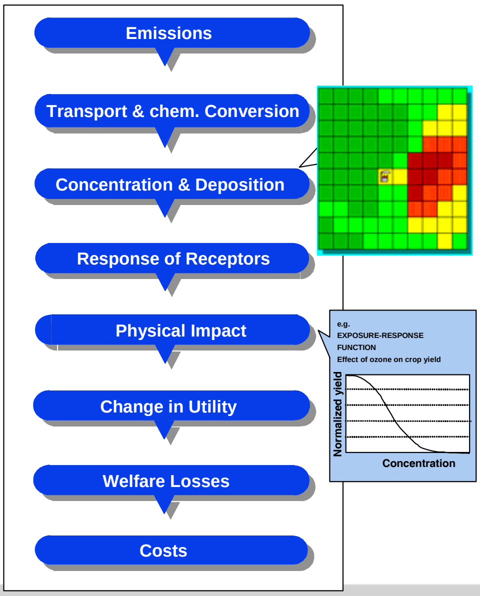
the ExternE Impact Pathway



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consensus areas

Damage to building materials, change in agricultural yield

- Dose-response modelling based on experiments
- Monetary valuation based on market prices

- relatively accurate quantification of external costs
- very low external costs (external costs <<< private costs)

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consensus areas with significant uncertainties

Effects from air pollution on human health

- Dose-response modelling based on epidemiologic studies
  - statistical relationship rather than causal relationship
- Monetary valuation based on contingent valuation methods (willingness-to-pay; willingness-to-accept)

→ significant external costs, in particular due to impacts from fine particles

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Climate change impacts in a risk-matrix (Watkiss et al. 2005)

Uncertainty in Valuation →

↓ Uncertainty in Predicting Climate Change

	Market	Non Market	Socially Contingent
Projection	Coastal protection Loss of dryland Energy (heating/cooling)	Heat stress Loss of wetland	Regional costs Investment
Bounded Risk	Agriculture Water Variability (drought, flood, storms)	Ecosystem change Biodiversity Loss of life Secondary social effects	Comparative advantage and market structures
System change and surprise	Above, plus Significant loss of land and resources Non-marginal effects	Higher order social effects Regional collapse Irreversible losses	Regional collapse

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why so many different numbers?

"Implicitly or explicitly any marginal damage estimate of climate change is based on some preference ordering that a potential decision maker is assumed to hold.

There is no consensus on what the 'right' or correct preference order should be, and indeed it is commonly assumed that this question is one that cannot be answered by simple scientific investigation."

(David Anthoff, 2007, NEEDS)

the role of 'equity weighting'

Equity weighting takes into account the attitude towards inequality in average per capita income between different world regions.

Recommendations from NEEDS (Anthoff 2007)

- The use of equity weights is not suggested for a regional decisionmaker.
- Equity weights might serve as a helpful reminder of what a truly benevolent global decisionmaker would do.

Climate change damage costs from NEEDS

without equity weighting: 7 $€_{2005}$ per ton of CO_2 [a)]

with equity weighting: 98 $€_{2005}$ per ton of CO_2 [a) b)]

[a)] Year of emission: 2005
[b)] Normalised to European average per capita consumption

Source: NEEDS, Anthoff 2007

other potential sources of external costs

- Nuclear beyond design accidents
- Proliferation
- Impacts from nuclear waste treatment
- Security of supply
- Changes in land use patterns due to biomass use
- …

↳ satisfying methodological approaches for quantifying related external costs are not available

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conceptual limits in quantifying environmental externalities

- constant preferences over time (hundreds or thousands of years)?
- Arrow (1963): it is impossible to aggregate individual preferences in a plural society in a fashion that is both democratic and consistent.
- *develop a better understanding about which externalities can be reasonably quantified and used for supporting decision making!*

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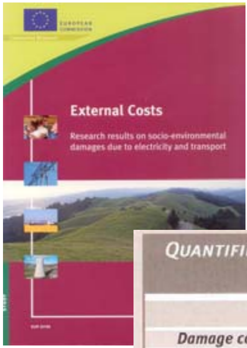

European Commission's brochure on ExternE results (2003, EUR 20198)

QUANTIFIED MARGINAL EXTERNAL COSTS OF ELECTRICITY PRODUCTION IN GERMANY[2] (IN € CENT PER KWH)

	Coal	Lignite	Gas	Nuclear	PV	Wind	Hydro
Damage costs							
Noise	0	0	0	0	0	0.005	0
Health	0.73	0.99	0.34	0.17	0.45	0.072	0.051
Material	0.015	0.020	0.007	0.002	0.012	0.002	0.001
Crops	0	0	0	0.0008	0	0.0007	0.0002
Total	0.75	1.01	0.35	0.17	0.46	0.08	0.05
Avoidance costs							
Ecosystems	0.20	0.78	0.04	0.05	0.04	0.04	0.03
Global Warming	1.60	2.00	0.73	0.03	0.33	0.04	0.03

NEEDS – Research Stream 'life cycle approaches for the assessment of emerging energy technologies'

- support the representation of technology development time dynamics in long term energy scenarios
- characterisation of emerging electricity generation technologies with respect to long term future technical, economic and environmental performance

↳ 'dynamic LCA' of future energy technologies

technology futures depend on socio-economic framing conditions

- **'pessimistic scenario'**
  Socio-economic framing conditions do not stimulate market uptake and technical innovations.

- **'optimistic-realistic scenario'**
  Strong socio-economic drivers support dynamic market uptake and continuous technology development. It is very likely that the respective technology gains relevance on the global electricity market.

- **'very optimistic scenario'**
  A technological breakthrough makes the respective technology on the long term a leading global electricity supply technology.

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example: future off-shore wind technologies

	2050
'pessimistic'	- 16 MW turbine, guyed foundation - Carbon fibre tower - 75% carbon fibre + 25% natural fibre blades - Gearbox upscale
'realistic-optimistic'	- 24 MW turbine, floating foundation - Gearless turbine - Carbon fibre lattice tower - Co-existence with water turbine/wave generator; shared cables to shore
'very optimistic'	- 32 MW turbine - Hydro-windturbine - Off-shore 'energy landscape'

Source: NEEDS, DONG Energy

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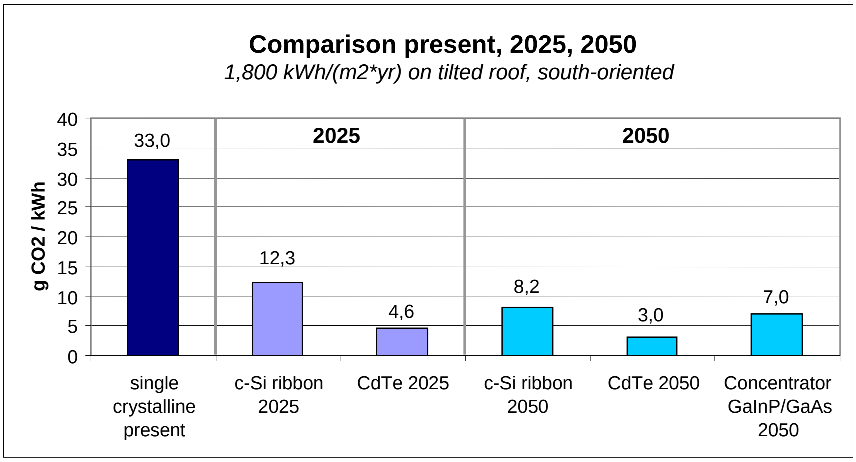
future PV life cycle CO_2-emissions



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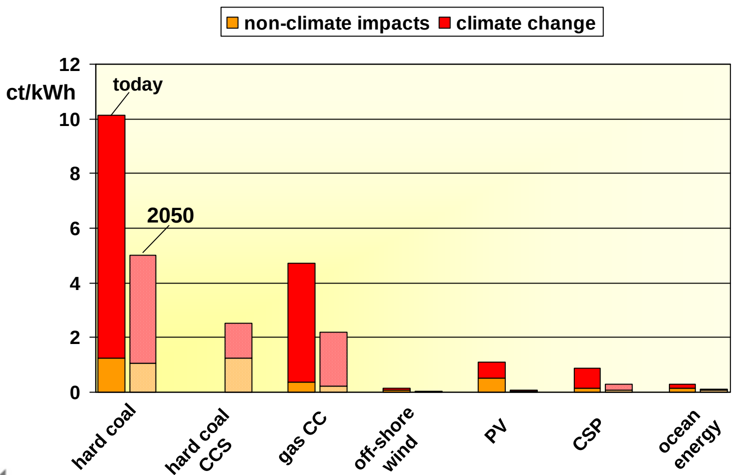
Source: NEEDS, Ambiente Italia

quantifiable external costs of future technologies

(CO_2 damage costs with equity weighting)



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Using external costs in sustainability assessment (I)

- emerging energy technologies have a significant potential to reduce costs and environmental impacts
- external costs of future renewable energy technologies are small
- technology foresight methods shall be applied to explore technology development potentials in long term strategy development
- 'dynamic LCA' of long term future technologies is a key for supporting prospective Technology Assessment – but this is beyond ISO standards

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Using external costs in sustainability assessment (II)

- External costs are helpful in communicating a quantitative link between environmental impacts and welfare losses
- External cost information is more complex than a price tag in a store. Be aware of non-quantifiable externalities.
- Do not use 'total costs' as a one-dimensional decision criteria. Real life never is that easy …
- Policy decisions need to be taken to react on current environmental pressure without being able to identify a cost-optimal level of intervention. In such a situation, decisions should be guided by the precautionary principle rather than waiting for scientific evidence that can prove a cost-optimal strategy.

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Thank you very much for your attention!

contact us:

wolfram.krewitt@dlr.de

or visit the websites:

www.dlr.de/tt/system

www.needs-project.org

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