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Main challenges for modeling policy instruments in energy system models: First results

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Agenda

1. Introduction
2. Energy models for policy evaluation
3. Main challenges for policy modelling
4. Conclusion

1. Introduction

Starting point: Changing role of energy modelling

Originally: Energy system models developed mainly in the 1970s with focus on energy security issues

→ energy prices as the principle driver

→ evaluation of technical potentials for cost-effective energy savings

Today: Challenge of climate change has changed energy policy

→ role of energy modeling in decision making and policy design has increased

→ fundamental shift in research priorities

→ main question: *What can be achieved with different types of policy instruments given behavioral and policy constaints?*

How can these new challenges be met by energy system models?

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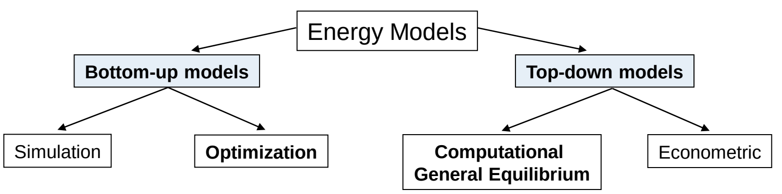
2. Energy models for policy evaluation



Main characteristics

- Technology-oriented represen-tation of the energy system
- Rooted in engineering principles
- Decision-making based on minimization of **financial** costs

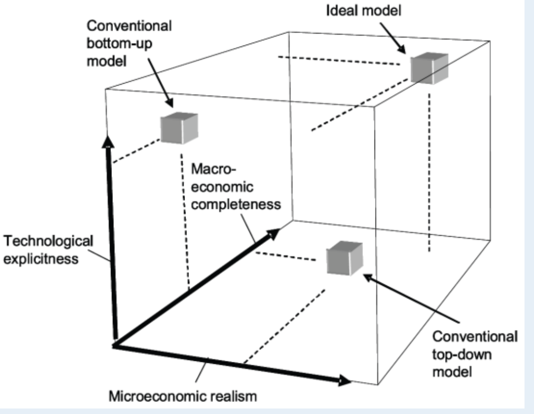
- Evaluation from a macro-economic perspective; high level of aggregation
- Rooted in economic principles
- Formulation based on production functions with ESUB

Results on policy evaluation and abatement cost estimates depend substantially on model choice

What would be the attributes of an ideal energy model for the evaluation of different types of policy instruments?

Three dimensions according to Hourcade et al. (2006):

- Technological explicitness
- Microeconomic (behavioural) realism
- Macroeconomic completeness



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Comparison of the two main modelling approaches

Bottom-up	↔	Top-down
High level of technological detail Impacts of specific (esp. **new**) technologies and interactions can be assessed No one-sided reliance on historical trends Large data requirements Macroeconomic effects are mostly ignored Focus mainly on minimization of financial costs, consumer behaviour not (sufficiently) taken into account		Consumer behaviour taken into account Incorporation of macroeconomic feedbacks Limited data requirements Main parameters (ESUB, AEEI) estimated based on historical trends → discontinuities / impacts of new technologies cannot be included High level of aggregation → impacts of technology-specific instruments difficult to represent

Cf. Swan, Ugursal (2009), Jaccard (2009)

3. Main challenges for policy modelling

Two main areas for improvement in energy system models can be identified

- **Improve microeconomic realism**
  - Change of perspective: social planner (overall least cost optimization of the energy system) → individual decision-making of agents
  - Include parameters of consumer behaviour
- **Take into account macroeconomic feedbacks**
  - Increase the flexibility of energy system models by including price elasticities (partial equilibrium approach)
  - Link with a general equilibrium model
  - Introduce rebound effects into the model

(1) Consumer behaviour

Most importantly: the energy efficiency gap

Definition: There exists a large gap between the actual investment in energy efficiency and the socially optimal level (cf. Jaffe & Stavins (1994)).

What are the reasons for these market barriers?

Market failure

Market mechanism does not result in optimal resource allocation

→ Policy intervention might be justified

Examples:
- information shortages
- owner-tenant dilemma
- financial constraints

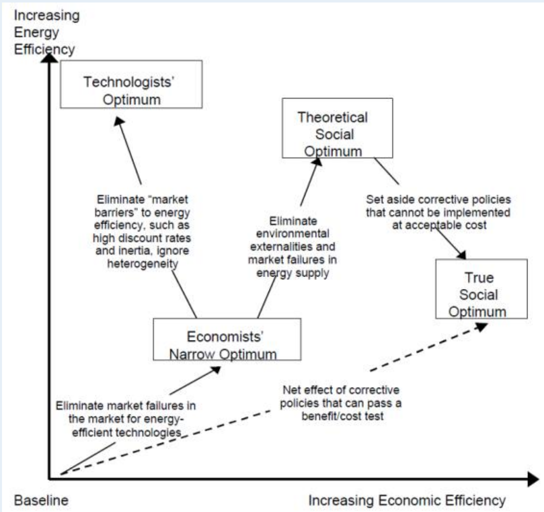
Non-market failure

Consumers behave rationally, some factors are not observed

→ Policy intervention not justified

Examples:
- Transaction costs
- Differences in quality
- Risk premium
- Market heterogeneity
- Non-economic factors

Graphic depiction of the energy efficiency gap



Different notions about the energy efficiency gap can lead to different optimal levels of energy efficiency („Technologists'" versus „Economists'" Optimum)

→ evaluation of policy instruments depends on the underlying definition of the optimal level of energy efficiency

Cf. Jaffe et al. (1999)

How can consumption behaviour be taken into account in energy system models?

1. Discount rate

Used to reflect the opportunity costs of capital

Different types:
- *Social discount rate*: economic opportunity costs of capital
- *Private discount rate*: used when analyzing the investment options of private enterprises
- *Implicit/subjective discount rate*: empirically observed rates used in investment decisions of private households; hurdle rates

→ To integrate the impact of investment barriers in energy system models, often high subjective discount rates are applied; in some cases, the discount rates are then reduced in the scenario analysis to model the effect of certain policy (cf. Božić (2007), Mundaca (2008))

Criticism: empirical foundation? intransparent; market and non market failures are mixed up

2. Alternative: Behavioural parameters in hybrid modelling

Example: hybrid model CIMS (cf. Jaccard et al. (2003))

- Integrated, technology-rich energy-economy model
- Technology choice is not only based on financial costs, but explicitly takes into account a number of behavioural parameters:
  - Private discount rate (average time preference rate)
  - Intangible costs
  - Parameter representing market heterogeneity

- More transparent representation of consumer behaviour
- Parameters need to be estimated empirically, significant uncertainties
- Even more difficult to determine how different types of policy instruments might influence each parameter

Example: Comparision of model approaches

How does the inclusion of additional cost parameters and parameters reflecting consumer behaviour change the results from bottom-up energy models?

Study by *Murphy, Jaccard (2011)*: Comparison of results on GHG abatement potentials and cost in the US with a **conventional bottom up approach** (McKinsey) and the **CIMS Hybrid Model**

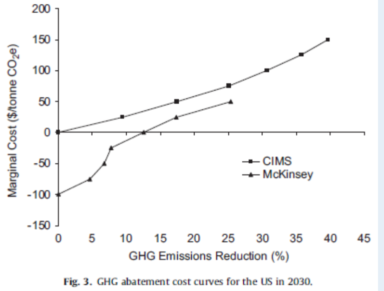


Fig. 3. GHG abatement cost curves for the US in 2030.

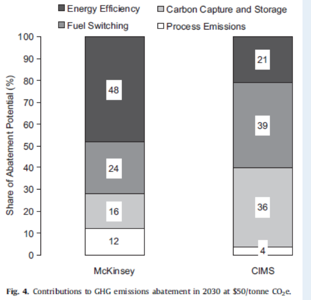


Fig. 4. Contributions to GHG emissions abatement in 2030 at $50/tonne CO_2e.

(2) Macroeconomic feedbacks

Rebound effects

Energy efficiency improvements are likely to consistently fall short in delivering the expected energy savings potential as associated cost savings may actually encourage greater demand for energy services (cf. Jevons (1865), Sorrell (2007)).

→ **Energy savings predicted in simple engineering models tend to be too high**

- direct rebound effect → Can be taken into account in energy system models with the help of price elasticities of demand
- indirect rebound effect
- Economy-wide rebound effect

→ More difficult to model as effect relates to income and general economic growth → link to General Equilibrium Model required

4. Conclusion

- Given the high level of technological detail and the comprehensive representation of all interactions within the energy system, energy system models can make a significant contribution to the evaluation of policy instruments.
- Major challenges consist in the integration of parameters on consumer behaviour and decision making as well as the inclusion of macro-economic feedbacks.
- Special attention needs to be paid to the empirical foundation of additional parameters. For a comprehensive evaluation of policy instruments, energy system modelling needs to be combined with other methodological approaches (issue of triangulation).
- At the same time, basic characteristics of energy system models should be maintained (linearity, process-oriented representation, etc.).

Thank you for your attention!

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