Models and Simulations 4
Toronto, 7. May 2010

The Construction of Energy Scenarios

- How the future comes out of energy models -

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Content

1. Background
My PhD-Project

Energy scenarios play an important role in the discussion about the future of energy supply. They **are published as experts' reports** by specialized scientific institutes and generated **using computer models**.

At the same time their **claims for validity** and **the way the models are used to fulfill these** are largely unclear.

Initial question: How are energy scenarios constructed and what claims to validity are raised with them?

Object of investigation: The field of energy economic systems analysis in Germany

Christian Dieckhoff | Institute for Technology Assessment and Systems Analysis | 7. May 2010

1. Background
My PhD-Project

Two perspectives on the topic:

→ Analysis as a “scientific” practice of scenario modeling

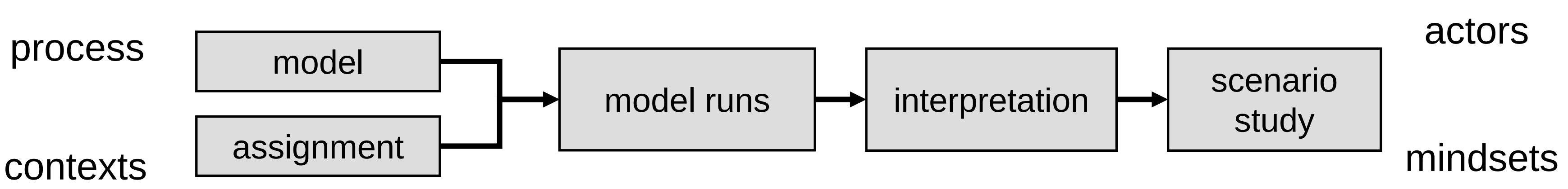
→ Analysis as a consultation practice of science by politics

Method: Qualitative analysis on basis of semi-structured interviews in two waves

Sample: Eight experienced modelers, one per institute

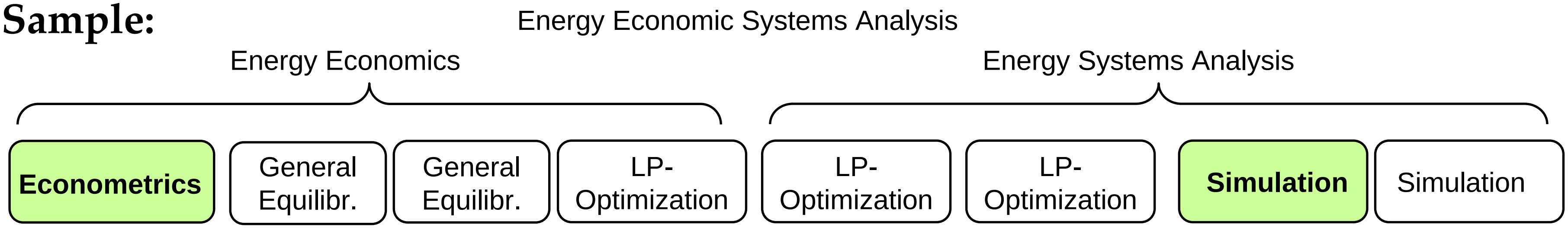
Sampling strategy: Maximization of variance in model types and context settings

Aim: Explorative **reconstruction of eight individual scenario construction processes, the involved mindsets, actors and contexts**



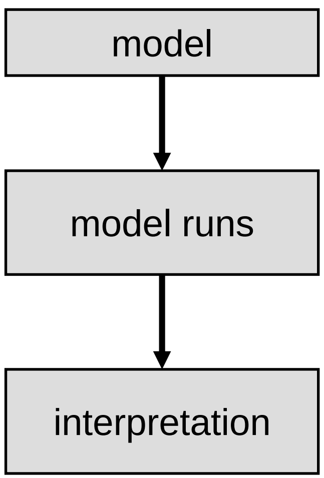
2. Introduction to my talk
Focus

Sample:



→ For this talk: selection of **two instructive cases**

Presentation of empirical results:



→ Model types (Background)

→ Single model run

→ Integration to scenario analysis

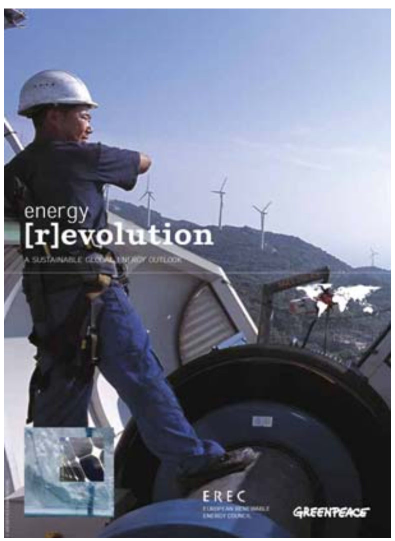
→ Statements made

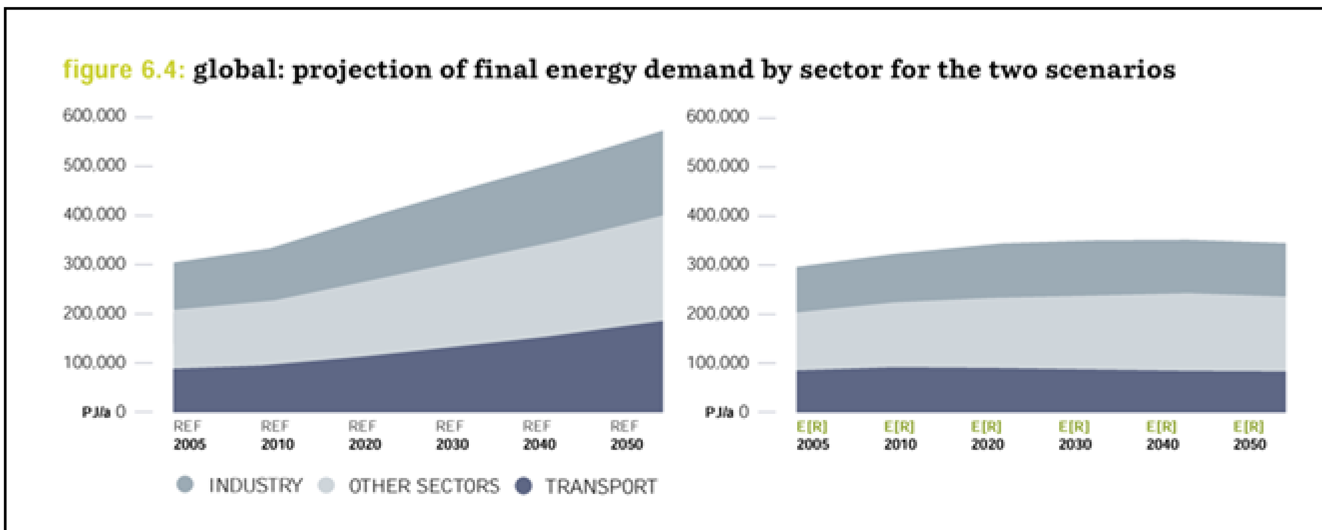
2. Introduction to my talk
Definition of basic terms

A "**model**" is a mathematical structure, realized as a computer program, to which a certain meaning is ascribed ("representation of reality").

A "**scenario**" is a specific interpretation of a model run, in which a statement about the future is made

A "**scenario analysis**" is the interpretation of a group of model runs (typically 1-4)





[1] Teske, Sven et al., 2008: Energy (R)evolution - A Sustainable Global Energy Outlook.

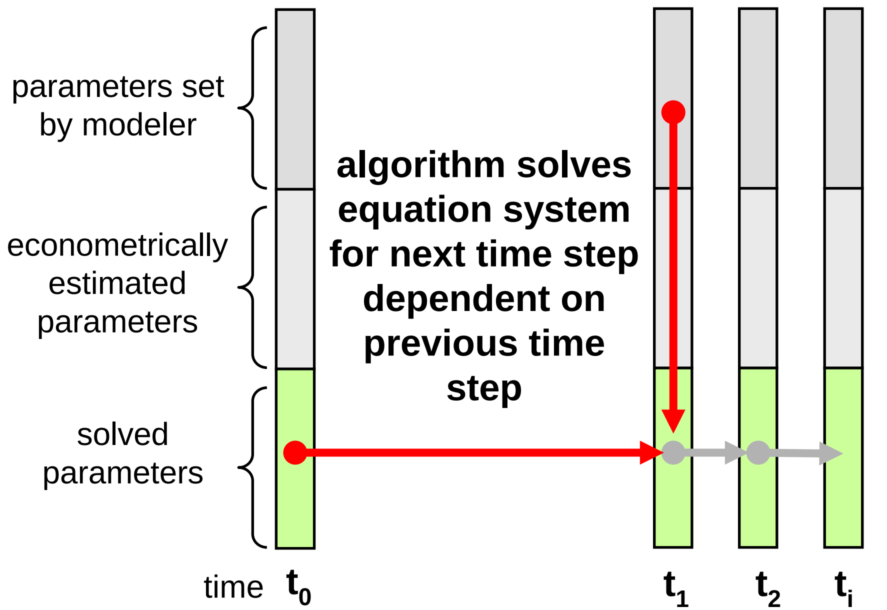
3.1 Empirical results
The models

Case „Econometrics“	Case „Simulation“
Self description: **“Econometric input-output-model”**	Self description: **“Simulation model”**
Theoretical reference: Econometric theory / delimitation from neoclassic theory	Theoretical reference: -
mathematical realization: **differential equation system**	mathematical realization: **linear accounting**
algorithmical realization: OLS-Estimation, Gauss-Seidel-Solver	algorithmical realization: basic arithmetic
data basis: time series of IO-tables, statistics	data basis: energy statistics
object of representation: German economy including environmental parameters	object of representation: German energy system
structuring principle: **economic sectors** corresponding to national statistics	structuring principle: **technical processes** (reference energy system concept)

3.2 Empirical results
The single model run

Case „Econometrics“

Basic principle:



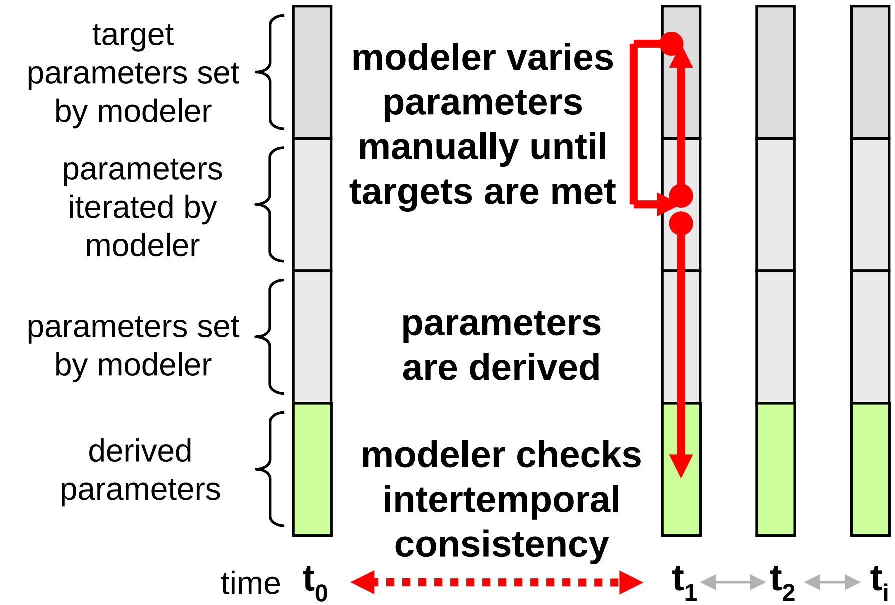
Cit: „**The model is developing into the future**“ (source: Interview; transl. by author)

→ **Intertemporal connection by algorithm**

→ **Representation of structure and temporal behavior**

Case „Simulation“

Basic principle:



Cit: “We attempt to **represent the energy system in lines and boxes**” (reference energy system concept) (source: Interview; transl. by author)

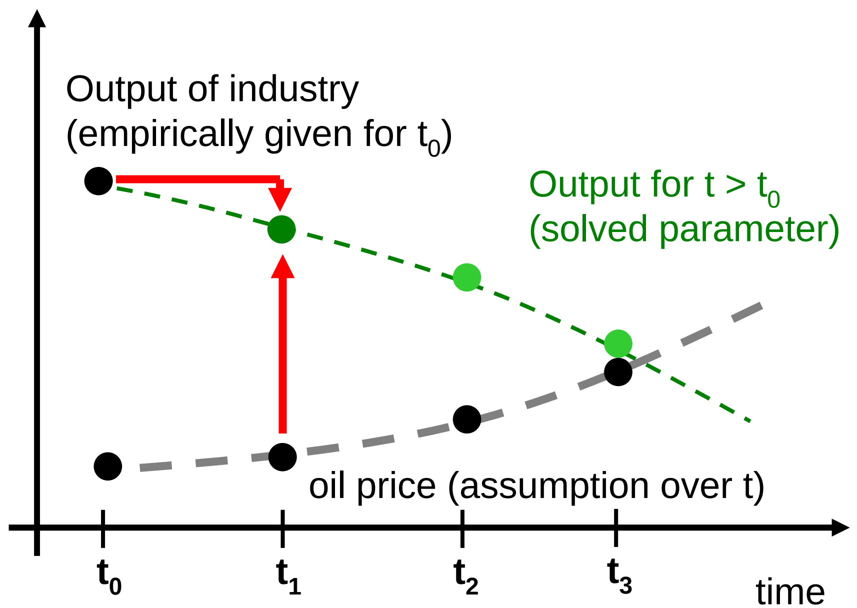
→ **Intertemporal connection by modeler**

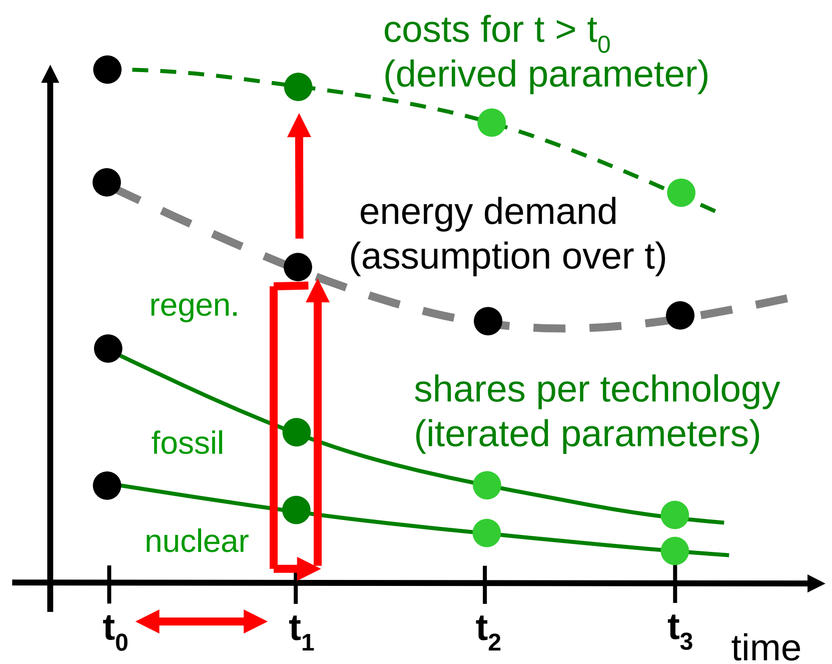
→ **Representation of structure**

3.3 Empirical results

The single model run

Case „Econometrics“	Case „Simulation“
Illustrating example: Given the (empirical) output for the German industry for t_0 and the assumed oil price over t, the output for $t > t_0$ is calculated.	**Illustrating example:** The total energy demand over t is assumed. Modeler varies the shares of different technologies in all time steps until energy demand is met. Given the assumed price per kWh the total costs are derived for all time steps.





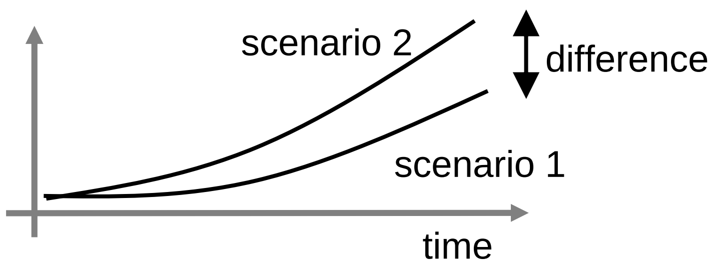
From a single model run to a scenario analysis

Case „Econometrics“	Case „Simulation“

Process of scenario generation:

1. **Define problem** to be analyzed: effect of a policy measure
2. Translate problem into parameter settings
3. **Calculate the first scenario**
4. **Vary parameter** (translate policy measure into parameter settings)
5. **Calculate the second scenario**
6. **Subtract** both runs
7. Interpretation

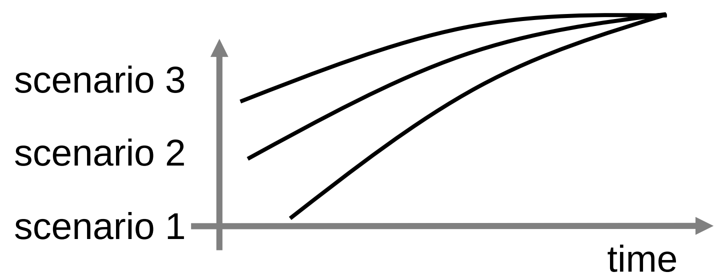
Structure of the scenario analysis:



Process of scenario generation:

1. Design **semi-qualitative descriptions of the scenarios** („storylines“), one per model run; **define target values**
2. Model run: **Translate storyline into quantitative values** as shown before
3. **Repeat for each storyline** (typically 3-4)
4. Interpretation

Structure of the scenario analysis:



(Modeler's) Interpretations of the model runs

Citation Case "Simulation":

„Sobered by the limited accuracy of forecasts about foreseeable trends already at the beginning of the 70s, people began to **describe alternative future paths in scenarios in form of "if-then"-statements**. (…) In energy scenarios consistent paths are described, which are **considered to be possible** from the current state."

(Source: Publication of interviewee, 2002; trans. by author)

Citation Case "Econometrics":

„In principal I agree with the opinion that of course **the future is open**. It can not be predetermined in advance in the sense of natural laws. This is totally clear. But at least **we can [make] such if-then-statements**."

(Source: Interview; trans. by author)

Problem of imprecise rhetoric → Analysis in two steps

(I) (Modeler's) interpretations of the **single model runs**

(II) (Modeler's) interpretations of the **scenario analysis**

(Modeler's) interpretation of the single model run

Common expression:

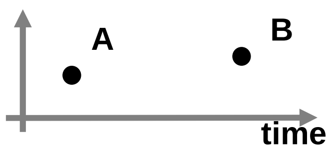
"if the assumptions become reality, then the future will develop as shown"

Problem: What indicates "assumption"?

→ Two possible readings:

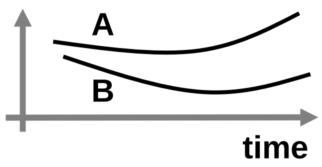
a) Given A at t_0, B occurs at t_1

("*inter*temporal conditional prediction")



b) Given A(t), B(t) follows

("*intra*temporal conditional prediction")



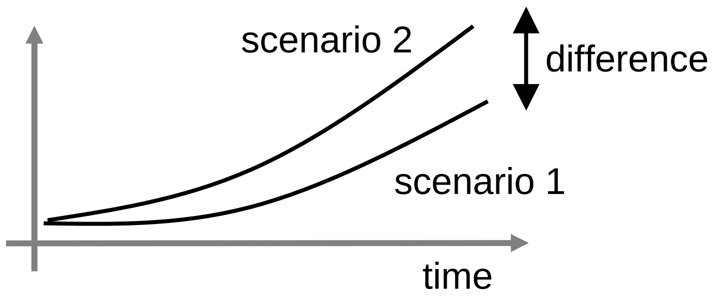
Diagnosis: Conditional predictions are made. But the rhetorical expressions of the interviewees do not allow a decision on what kind of statement is precisely made with a single scenario.

Observation: Taking into account the reconstructed practices of the model application above, there is a tendency that case "econometrics" procedurally fits to reading a) and case "simulation" fits to reading b).

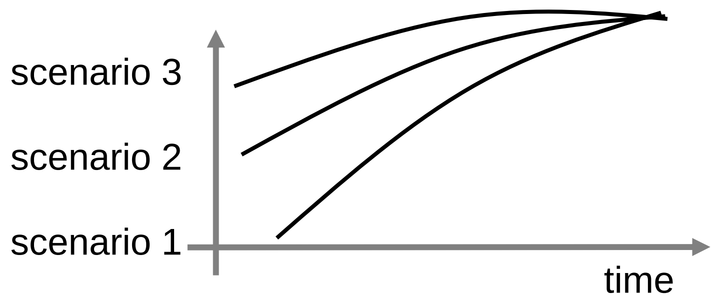
3.7 Empirical results
(Modeler's) interpretation of the scenario analysis

Case „Econometrics"	Case „Simulation"

Structure of the scenario analysis:



Structure of the scenario analysis:



Cit: „You need this reference development, this baseline, this prediction, because you then do alternative calculations where you vary one parameter, a policy-parameter. This can be a tax for example, you raise a tax rate. And now you don't just want to know the direct effects, but really **the total effects** including all indirect interrelations (…)" (Source: Interview; trans. by author)

Cit: "From our point of view the appeal of scenarios is especially to **demonstrate opportunities for action to politics**. (…) Then it is the task of science to show politics 'You can reach [that aim] in a **spectrum of future paths**', in different scenarios precisely." (Source: Interview; trans. by author)

→ Interpretation of the difference as the effect of the (policy) measure

→ Interpretation of scenarios as opportunities for action

3.8 Empirical results
Synthesis

Case „Econometrics“	Case „Simulation“
Summary of reconstruction: - The model is interpreted as a representation of structure and (temporal) behavior - a single scenario is interpreted as a conditional prediction - The difference between the scenarios is interpreted as the effect of a (policy) measure → Motive: **Calculate futures and derive effects**	**Summary of reconstruction:** - The model is interpreted as a representation of structure - a single scenario is interpreted as a conditional prediction - The scenarios are interpreted as opportunities for action → Motive: **Futures depicted in numbers**
Synthesis: - model's role: guarantee structural and temporal consistency - modeler is no integral part of scenario generation → Predominantly **deterministic perspective on the future**	**Synthesis:** - model's role: guarantee structural consistency - modeler guarantees temporal consistency, is integral part of scenario generation → Predominantly **constructivist perspective on the future**

4 Questions and Hypotheses

Epistemological perspective on future:

→ In what sense can a statement about the future be valid?

→ On what preconditions is a conditional prediction a valid statement about the future?

→ Which role can a model play in giving reason to such a statement?

Hypothesis: The future is epistemically not accessible. A "valid" future can only be valid in the sense of not contradicting our currently valid models of the world. Currently valid is what does not contradict past experiences (empirically proven).

→ Valid futures are intrinsically affirmative

→ If science is restricted to generating valid statements about the future, science must be affirmative.

4 Questions and Hypotheses

Science-sociological perspective on future:

There is no epistemic foundation for statements about the future, I am looking at one half of a semantic game between science and politics here.

Hypothesis: The "scenario-concept" works as a "boundary object"[2] between science and politics. Both sides can interpret it system-specifically: For science this is the accepted way of making statements about the future. For politics it is the accepted way of being advised and generating legitimacy.

[2] Star, S.L. & Griesemer J.R., 1989: Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. In: Social Studies of Science. 19, No. 4, p. 387–420

Source: Teske, Sven et al., 2008 - Energy [R]evolution. A Sustainable Global Energy Outlook.

Thank you for your attention!