A comparison of modelling tools for energy planning

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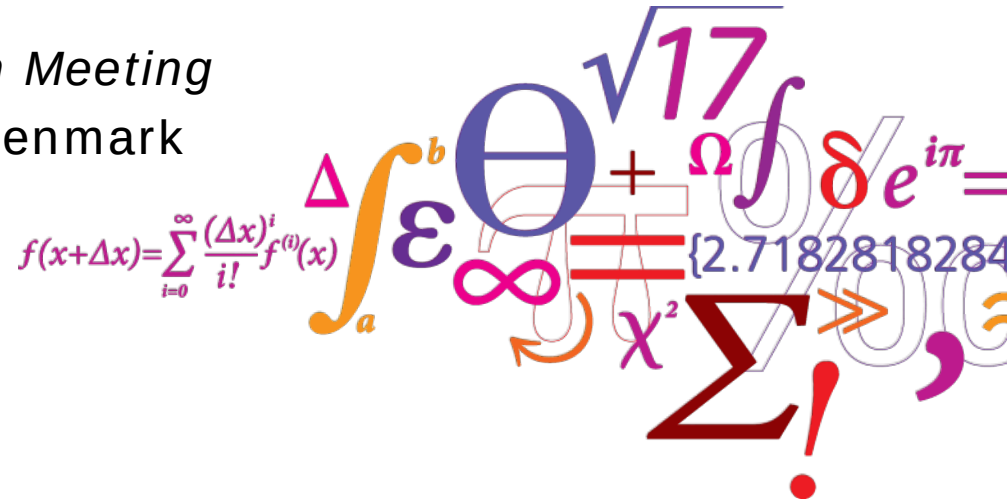

DTU Management Engineering
Department of Management Engineering

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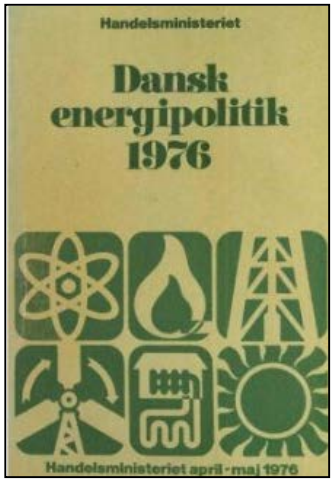
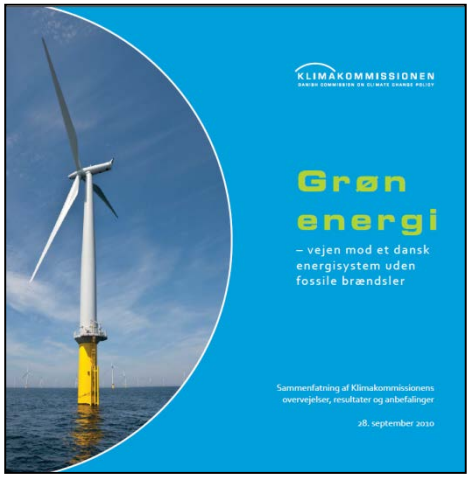
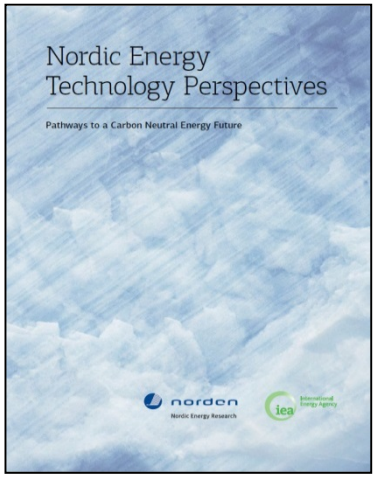
What is energy planning?

- "The process of developing **long-range policies** to help **guide the future** of a local, national, regional or even the global **energy system**" (Wikipedia)
- Incorporates: energy policy, energy economics, engineering, social science
- Focuses on: sustainability, resilience, flexibility, efficiency, affordability etc.







Energy system models

Fig.1 Energy flows in an energy system model

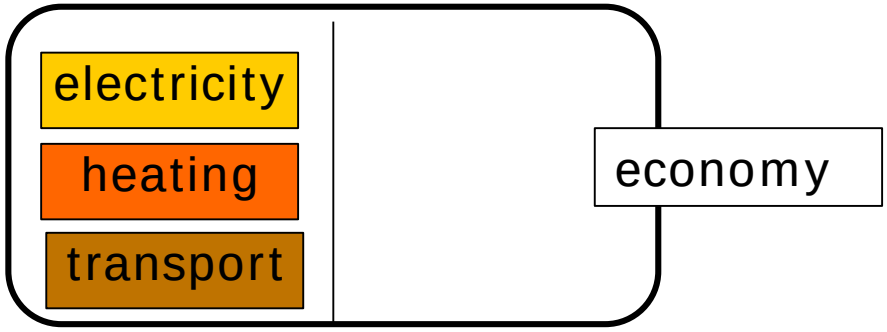


Fig.2 Partial-equilibrium

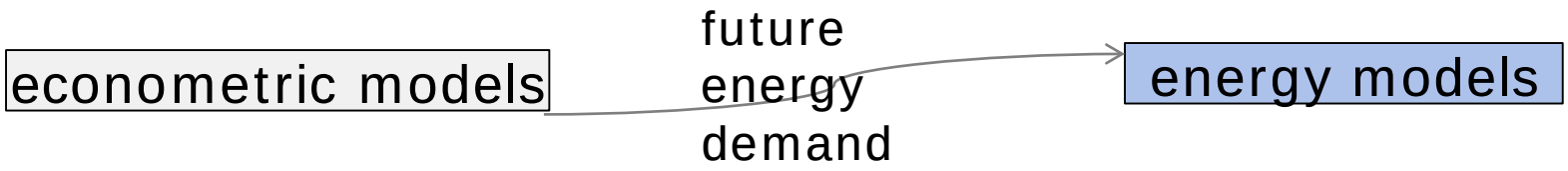


Fig.3 Exogenous energy demand

Energy system models (2)

- Utilize:
  - mathematical programming (depicting the energy quantities flow)
  - engineering process analysis (technically detailed description of energy technologies)
  - econometrics (demands, behavioural aspects) (Rath-Nagel & Voss 1981)

Selected modelling tools (commonly used in Denmark)

Balmorel

ETSAP TIMES

TIMES-DK

EnergyPLAN

Sifre

energyPRO

Balmorel

Versatile model for analysing electricity and combined heat and power sectors in a regional or (inter)national perspective

Used by e.g. Technical University of Denmark (DTU), Danish Energy Association, Ea Energy Analyses, China National Renewable Energy Centre (CNREC)

Available at: http://eabalmorel.dk/

Deterministic input/output tool for optimising the operation of a given energy system

Used by e.g. Aalborg University, PlanEnergi

Available at: http://www.energyplan.eu/

Modelling software package for combined techno-economic design, analysis, and optimisation of energy projects

Used by e.g. PlanEnergi and several Danish district heating companies

Available at: http://www.emd.dk/

Sifre

Mixed-integer linear optimization tool simulating energy flows and energy prices in all sectors of the specified energy system in discrete time steps

Developed and used by the Danish TSO Energinet.dk and external collaborators

Expected to be available online

TIMES-DK

IEA ETSAP (Energy Technology Systems Analysis Program)-TIMES model developed by DTU for Denmark

Includes all sectors in the Danish energy system, finds least cost pathways to targets for renewables or emission reduction, links to Geographic Information System (GIS) data

Used by DTU and Danish Energy Agency

ETSAP-TIMES is developed by IEA community

Technical / scientific overview

Tool	Optimization type	Implementation
Balmorel	Investment optimization	Programming in GAMS, solvers e.g. CPLEX
EnergyPLAN	Operation optimization	Delphi Pascal
energyPRO	Optimization: user-defined or auto-calculated operation strategy	Delphi
Sifre	Operation optimization	Mixed-integer linear programming (MILP) in C#
TIMES/TIMES-DK	Investment optimization	GAMS programming, VEDA front- and back-end, Excel

Technical/scientific overview (2)

Tool	Sectoral representation	E.g. issues solved
Balmorel	Electricity + heat (+ EVs)	Electricity markets; expansion of DH; role of demand response
EnergyPLAN	Electricity+heat+transport	100% RES energy systems, energy storage; national energy strategies
energyPRO	Flexible: electricity + heat, (transport as "energy plant“)	CHP plants participating in the spot market; compressed-air energy storage
Sifre	Electricity+heat+transport+gas	Electrolysis and biomass conversion scenarios for Sønderborg, Denmark
TIMES /TIMES-DK	Electricity+heat+transport	TIMES: Future role of hydrogen; regional energy strategies and many more…

Practical overview

		User-friendliness		
Tool	**Cost**	**User interface**	**Access to the code**	**Computational time**
Balmorel	Free tool, commercial GAMS license	N	Y	Long (if all Nordic system modelled hourly)
EnergyPLAN	Free	Y	N	Short
energyPRO	Commercial	Y	N	Short (increases if large model)
Sifre	Internal – expected to be free?	Y	N	Short (runs at Energinet's servers)
TIMES	Free model generator, commercial GAMS & VEDA license	Y	Y/N	Short (time-slices)

Guiding questions for tool choice

- **Who is the tool addressed for?**
  - Public: has to be (made) available online
  - Project participants: online availability not a requirement
- **Who are the project participants?**
  - Researchers
  - Non-researchers with some energy knowledge (e.g. utilities, municipalities)
  - Non-researchers with no energy knowledge
- **How much time is planned for learning the tool (from non-user to confident user)**
  - Up to a man-month?
  - Longer?

Guiding questions for tool choice (2)

- **How much time is planned in the project for modelling?**
  - up to 3 man-months
  - more than 3 man-months
- **What kind of analysis is required?**
  - operation optimization
  - investment optimization
- **Is access to the source code required?**
- **Should the tool link with GIS?**

Conclusions

- Energy planning
  - process of **developing future energy policies**, focusing on: sustainability, resilience, flexibility, efficiency, affordability…
  - energy system modelling allows developing techno-economic scenarios for energy planning facilitation

- Both **technical / methodological** and **practical** aspects can affect the usefulness of the tool

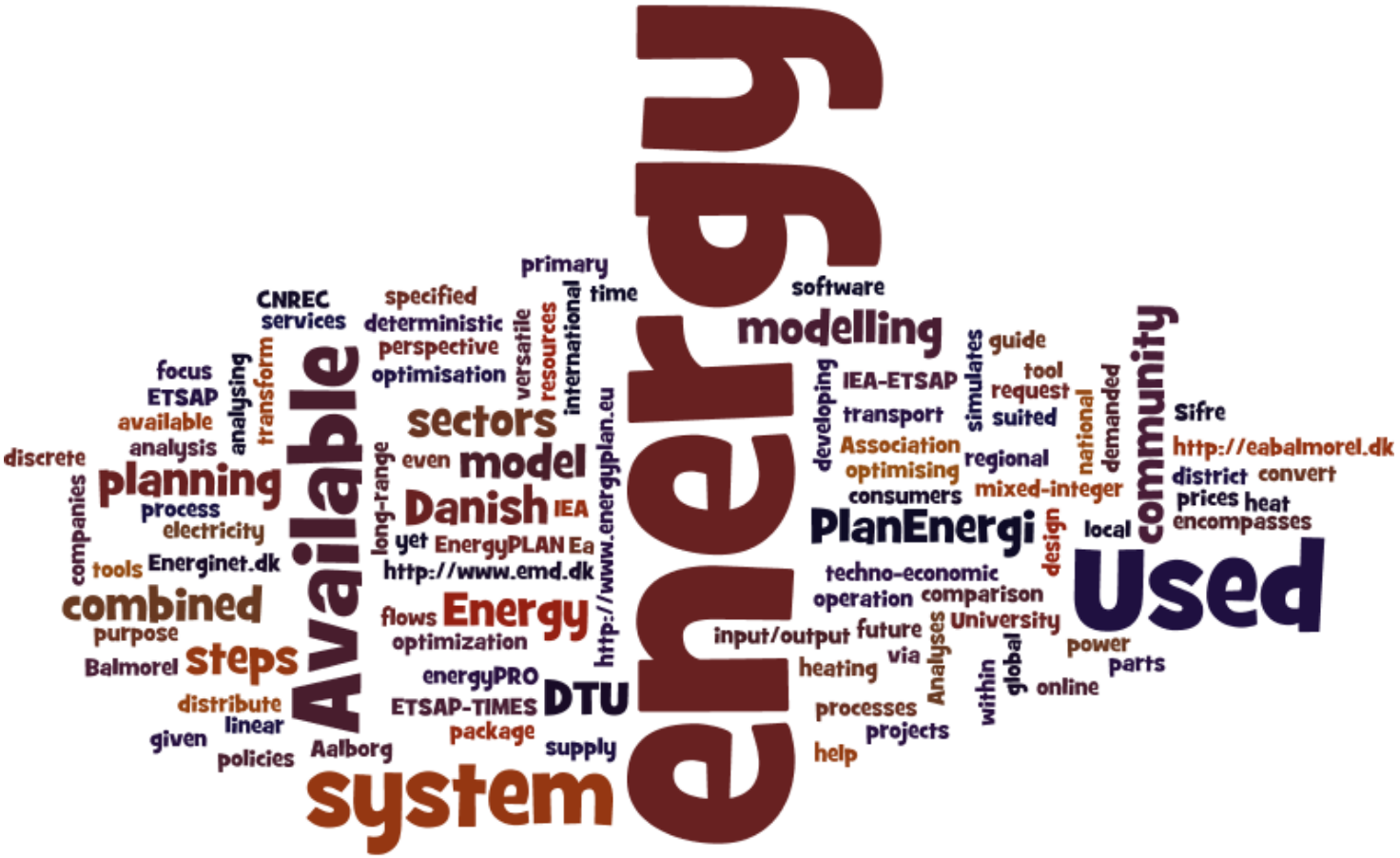
- Energy system models/modelling tools
  - all are **flexible** enough for many applications
  - each has it's strengths and weaknesses = some more suitable for selected research questions than others

Conclusions (2)

- **Main differences**:
  - Balmorel and TIMES-DK are investment and operation optimization tools; Sifre, energyPRO and EnergyPLAN are operation optimization tools
  - Various sectoral and technology representation

- Main **aspects to consider** before choosing the tool:
  - Project participants
  - Preparation and modelling time available
  - Type of analysis

Questions?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Available
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combined
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Energy
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primary
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software
CNREC
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specified
deterministic
perspective
optimisation
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Balmorel
developing
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