Energy technology and energy economics: Analyses of energy efficiency policy in two different model traditions

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Background

- Models are widely used for energy policy analyses
  - Top-down (economic) models
    - Behaviour of economic agents
  - Bottom-up (technology) models
    - Detailed technologies
  - Hybrid models
    - Demand effects in bottom-up models
    - Technology details in top-down models
- Why do the results differ?
  - Competitive market and social planner's optimal solution should be similar
- Our focus is on the methods:
  - Differences and similarities between engineering and economics applications
  - Example: Analyse EU's energy efficiency policy in 2030, applied to Norway

The numerical models

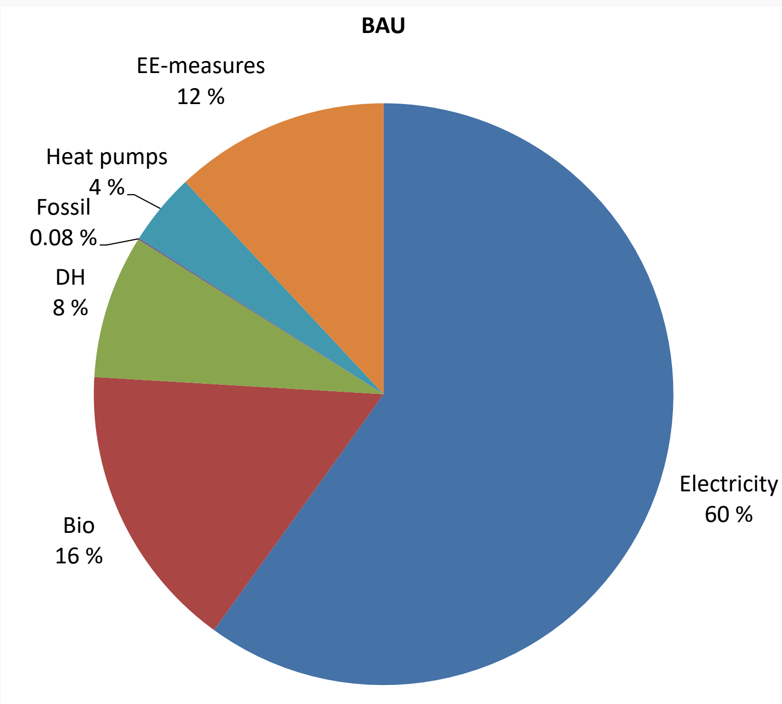
- Bottom-up (technology) model TIMES-Norway (IFE)
  - Partial model of the Norwegian energy system
  - Technology optimization model
    - Which combination of technologies and energy carriers minimizes the total system costs of meeting *given demand for energy services*?
  - Detailed description of current and future technology options
- Top-down (economic) model with hybrid features SNOW-NO (SSB)
  - General equilibrium model (CGE) of the whole Norwegian economy
    - Modelling of energy goods is less detailed than in TIMES
    - But energy markets are part of the wider economic context
    - Interactions between all markets
  - Market agents optimize
    - Consumers and producers maximise utility and profit
    - Supply and demand effects in the markets
  - Technologies are “aggregated” to substitution elasticities
    - Mostly based on historical or current data
    - NB! Investments in energy efficiency measures in households include the same technologies as in TIMES

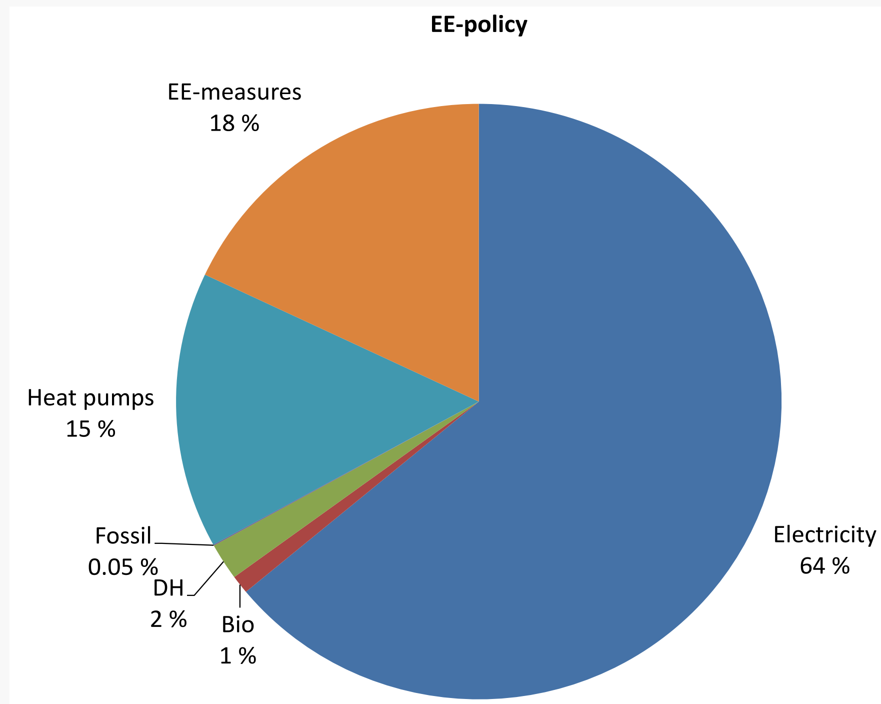
Modelling of energy efficiency policies

- Energy efficiency policies in EU and Norway focus on residental buildings
  - Increased energy efficiency in housing (for heating purposes) in 2030
- Baseline scenario for 2030
  - Similar assumptions in TIMES and SNOW based on
    - Ministry of Finance (2013) long term projections for key economic indicators
    - Adopted energy and climate policies («New 2030 Policy»)
- Energy efficiency policies in 2030
  - TIMES: 27% reduction in households' use of purchased energy
    - Energy efficiency investments (insulation etc.)
    - Change in energy production technologies
  - SNOW: 27% reduction in energy use for heating purposes
    - Energy efficiency investments (insulation etc.)
    - Reduce demand for housing services

Results: Households' energy use in TIMES

- Demand for energy services fixed
  - No change in behaviour
  - Composition effects:





Energy for heating purposes in households in BAU and EE-policy scenarios. 2030

Results: Comparison

- In TIMES-Norway: No behavioural changes
  - Demand for energy services fixed
  - 27% cap on purchased energy use:
    - Heat pumps become profitable and replace district heating and bio-energy (firewood)
  - Households' electricity use increases by 1%
  - Domestic electricity price does not change
  - No repercussions to the rest of the economy
- In SNOW-NO: Behavioural changes drive the results
  - 27% reduction in energy use
    - Investments in energy efficiency measures
    - Households' electricity demand is reduced a lot
    - Demand for housing services is reduced
    - Substitution towards other goods and services
  - Domestic electricity price falls
  - Electricity intensive industries expand

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Results: Energy use and costs

Percentage change from baseline scenario	SNOW-NO	TIMES-Norway
Household electricity consumption	-26.7	1
Household energy consumption	-27.0	-27
Demand for housing services (SNOW) Demand for energy services (TIMES)	-5.8	0
Use of dwelling capital	-3.2	n.a.
Domestic price of electricity	-15.5	-1
Welfare	-1.0	n.a.
System costs	n.a.	3

Explanation behind the different outcomes

- Demand response effects omitted in TIMES
  - Disregard repercussions and interactions between different markets
- Technology details omitted in SNOW
  - Non-marketed energy (heat pumps, solar) is potentially important
    - Different energy carriers included, but not different technologies using the same energy carrier
  - However, the “aggregation” of detailed energy efficiency measures into elasticity of substitution performs well

Closing remarks

- Our comparison illustrates the importance of using different approaches when designing and evaluating policies
  - The models emphasize different aspects of energy policy effects
  - The models complement each other
    - Overlook important information if focus either on technology effects or on economy-wide effects
- Learning about each others' approach
  - The analyses provide quality checks of each other
  - Common language and better understanding of the other approach is part of the learning
  - Whether to strive for hybrid models or to use the different approaches together and iterate is less important

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Thank you for your attention!

Bye. B., K. Espegren, T. Fæhn, E. Rosenberg, O. Rosnes (2017):

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