Typology for Energy/Economic Models

Denise Van Regemorter

CES KULeuven

Brasilia, ETSAP Workshop 22 November 2007

Content

- Typologies for energy/environmental/economic models
- Overview of the different types
- Linkage possibilities and needs
- Some conclusions

CENTER FOR ECONOMIC STUDIES

KATHOLIEKE UNIVERSITEIT LEUVEN

Typologies considered

- Economic and environmental coverage of the model
  - what part of the economy, environment, etc does the model cover
- Solution algorithm
  - Simulation versus Optimisation
- Calibrated versus econometric estimation
- Purpose/Use of the model
  - Forecasting, policy/scenario analysis, …
- Deterministic versus Stochastic
- Geographical coverage
  - World, country, region, city
- Time horizon
  - Short, medium, long term to very long term (100-200 years)

Economic/Energy/Environmental coverage

- IAM models: Integrated Assessment models
- Macroeconomic models: CGE models, Macroeconometric models
- Partial Equilibrium Models: energy system models
- Sectoral models: covers only one specific part of the energy system

For all, there is always a trade-off between time horizon, geographical and sectoral detail

IAM models

- Cover mostly the entire economy but some only the energy system (e.g. TIAM) and for the entire World, they consider a very long term horizon (100 to 300 years)
- Include
  - the impact on the environment, e.g. temperature increase for climate change
  - the feedback on the economy through damage function (when macroeconomic)
- Because their very long term horizon and world coverage, rather simplified regarding
  - economic mechanisms,
  - sectoral and technical disaggregation,
  - regional disaggregation
- **Policy question/analysis**:
  - Very long term cost-benefit analysis of climate change
  - Game theoretic approach for climate negotiations

Macroeconomic models

- Two types:
  - Macroeconometric models, oriented towards short to medium term analysis with the focus on the dynamics of adjustment
  - General equilibrium model, oriented towards long term analysis with the focus on the equilibrium after all the adjustment
- Sectoral and geographical detail depends on the objective of the model.
- Economic theory underlining the model structure can differ between models
- When for environmental/energy policy analysis, include an environmental module for modelling the emissions and abatement possibilities. Sometimes also the feedback on the economy of the environment.
- Those models are what is called 'Top-Down' models.

This type of models integrates the different mechanisms present in the energy models but in a less detailed, less technical and more schematic way (e.g. substitution between technologies is represented with production function).

- **Policy question/analysis**
  - Macroeconomic impact of energy/environmental policies
  - Choice of policy instruments
  - Burdensharing of climate target between regions/countries

Partial Equilibrium models

- Cover the energy system, i.e. the demand and supply of energy/energy services, but the macroeconomic background remains exogenous.
- They are generally 'technology rich', they are called 'Bottom-Up' models in the literature.
- Other possible characteristics:
  - Learning by doing
  - External cost linked to energy
- Representation sometimes limited to supply and cost accounting, the demand being considered as fixed focussing then only on the technological options.
- **Policy question/analysis**
  - Impact on the energy system of energy and environmental policies
  - Role of technological options
  - Impact of resource constraints

Linkage(1)

- **Full integration/linkage**: no experience of full linkage, i.e. integration of a detailed macroeconomic model with a detailed partial equilibrium model but some experiences with simplified/detailed.
  - MARKAL-MACRO: a simplified macro part is added to the full energy model, it allows consistency between macroeconomic evolution and evolution in the energy system (e.g. saving will be consistent with the need of investment in the energy system
  - Technology modelling in general equilibrium models: experience with GEM-E3 with technology based modelling of the electricity sector
- The IAM models are fully integrated but then all parts are very simplified.

Linkage (2)

- **From macro to partial**: the macro model generates a consistent macroeconomic and sectoral evolution which is used to generate the exogenous variables for the energy model
  - e.g. GEM-E3 for TIMES
- **From partial to macro**: energy module, associated with macroeconomic models,
  - A simplified energy model is added to the macro model,
  - Or the energy module is an aggregation of a specific energy model and indirectly linked to it.

Is Linkage needed?

- The different categories do not answer the same type of policy questions:
  - therefore linkage not necessary needed
- Important however
  - For macroeconomic models to integrate, though in a simplified way, the different possible responses of the energy system to the policy which is analysed.
  - For partial equilibrium models to integrate price mechanism to reflect partly the possible interaction outside the energy system.
  - To calibrate the two types of model to same type of behavioural or technological assumptions when used for joint policy analysis to ensure consistency
    - substitution elasticity of production function in macro model should reflect the technological substitution in energy model
- Examples of joint policy analysis
  - distributional issues between economic agents or countries are better addressed with macroeconomic models
  - technological opportunities, interaction between demand and supply in energy markets, better addressed with energy models

Other Classification Criteria (1)

- ***Optimisation versus simulation***
  - Optimisation: minimise/maximise explicitly an objective function (profits, costs, welfare, consumer and producer surplus) under a number of constraints
  - Simulation: the model is specified as a set of equations with an equal number of variables and solved by solving a system of equations directly or with a iterative procedure.
  - The solution algorithm does not imply that there is no optimisation behaviour behind simulation models, through the equations specification.
    - e.g. energy demand equation in energy simulation model derived from the maximisation of a welfare function under budget constraint.
    - or many general equilibrium models are written as a set of equations equal to the number of variables but the solution corresponds to a maximisation of welfare through the specification of the equations.
- ***Calibration/Estimation***
  - mostly related to macroeconomic models.
  - macroeconomic models developed for medium term forecasting and policy analysis: parameters are mostly econometrically estimated.
  - general equilibrium models: parameters are mostly calibrated given exogenous assumptions regarding price and income elasticities.
  - energy demand models: econometrically estimated parameters are used in equation for future demand, instead of technological data as in technico-economic models.

Other Classification Criteria (2)

- ***Purpose/use of the model***
  - for projection it is important that the model reflects the dynamic adjustment.
  - for the long term however it is important to have a transparent theoretical structure and assumptions and clear equilibrium conditions.
- ***Stochastic/deterministic***

Uncertainty about future climate, technology development, energy prices induced the development of different stochastic framework:

  - stochastic versions of energy models: definition of hedging strategies
  - portfolio models for the choice of energy technologies.
- ***Other dimensions***
  - geography, time horizon, are more subcategories not always predetermined for a model but can depend on the study.
    - a model is not necessarily flexible regarding these dimensions: econometric models are more appropriate for short to medium horizon while calibrated model or equilibrium models are more for the long term.
    - In multi country models, it is essential to model the different linkages between countries to have a consistent modelling framework for policy analysis.

Conclusion

- The different categories of models have all their specificities.
  - The choice of which model to use will depend on the type of policy to be evaluated or the type of analysis to be made, on the regional coverage needed.
- Complementarities between the different types of models:
  - a consistent combination of models (not necessarily linked) can contribute to the evaluation of a policy in its various aspects:
- Technico-economic model: fully detailed for the choice of technology with sectoral disaggregation, explicit technological evolution overtime, direct cost within the energy system
- Macroeconomic model: analyses the feedback on the rest of the economy, distributional impact, differentiated impact by policy instrument