

Balmorel - energy system modelling with open source code and data

Energy research has a long tradition of applying modelling and optimization. In this article Danish energy expert Hans Ravn will describe the Balmoral energy model covering the countries in the Baltic Sea.

The Balmorel model is an energy model covering the countries in the Baltic Sea Region with emphasis on the electricity and combined heat and power sectors. The model may be used for analyses that cover some or all countries bordering the Baltic Sea, and include aspects of energy, environment, and economy.

The purpose of the Balmorel project is to support modelling and analyses of the energy sector in the region. The project maintains and develops the Balmorel model. Thus, the project contributes:

1. A model - the Balmorel Model. This model consists of the model structure and the corresponding data for the Baltic Sea Region.
2. Experience exchange in relation to modelling.
3. Cooperation on application of the Balmorel model for analyses of aspects of energy, environment, and economy in the region.

Model characteristics include representation of electricity and heat; environmental aspects; international aspects, including electricity transmission lines; representation of several handles for energy and environmental policy, e.g. taxes and emission limitations. Two energy modelling traditions



are represented (sometimes referred to as the top-down and the bottom-up approaches). Thus technical and engineering (bottom up) aspects and aspect from the economic tradition (top down) are integrated. Examples of applications include:

- Analysis of market power in the electricity sector is presently undertaken. As a first step, the classical Cournot and Bertrand models will be implemented in the Balmorel model.
- Application in relation to evaluation of Danish environmental and energy policy in the nineties.

- Economic analyses in the electricity sector in Lithuania.

- An analysis of two environmental instruments in relation to the electricity sector: tradable green certificates (TGC) and tradable emission permits (TEP) in the Baltic Sea Region. See the figure which illustrates that these markets need not cover the same geographical areas.

Open source model and data

The characteristic point in relation to the Balmorel project, which probably makes it unique in the energy sector, is

the *open source* spirit. Hence, project generated information, including all details, can be freely downloaded from the home page of the project, www.Balmorel.com. This in particular includes the model structure source code (the model is formulated in the GAMS modelling language) and the corresponding data for the Baltic Sea Region.

The underlying idea is that data and modelling should be common to all parties dealing with common problems. Access to data and models is a source of strength which should be available to all interested parties. In complicated processes involving several possibly conflicting parties a model may serve as a means of communications. Thus, it provides a set of data; it provides interpretations of the working mechanisms in the system; and it may serve the purpose of identifying and formalising relevant questions for discussion.

Anybody that is interested can take the model from the home page and use it as desired, including modifying it. Hopefully, such activities will feed back into the Balmorel project, such that model improvements, data updating and experiences gained by the users may be made available to others.



The Balmorel model is in its present state indeed suitable for a number of relevant analyses, therefore the challenges are the following:

- To maintain and improve on the model in the open source perspective. It is quite easy to make the present version available to all interested parties, using the internet. The difficult part is to ensure that the experience, the updates and the improvements that are made when somebody is using the model, can be channelled back to the project and in turn made available to and benefit other parties. How can this process be organised such that it functions smoothly and efficiently?

- The basic version of the model aims at covering the whole geographical area of the Baltic Sea Region, handles the long term perspective, e.g. up to 2030, and represents the basic elements of the energy sector. Most surely, any user will like to include some specific functionality. This will be possible in many cases, and quite easy due to the application of a modelling system. However, if all new functionalities are included as options in the basic version of the model, then it becomes more difficult to understand and apply. How can it be organised that many special options are kept alive without clouding the basic model?

- Since the basic version of the model aims at the large perspective with respect to geography and time, some detail has been sacrificed for computational reasons. However, most users would like to include some more details because they feel that the results will be better this way. Sometimes they are right. But computational times easily grow uncomfortably long, see next.

Computational challenges

The present basic version of the model applies deterministic linear programming. This gives acceptable

computational times with the standard level of detail. But we experience increased pressures to extend the model in ways that may imply unacceptable computational times. Three extensions are much desired:

- A finer resolution of the time within the year (presently the year is divided into 144 time segments).
- Introduction of mixed integers to represent the unit commitment aspects (i.e., when to stop and start production units)
- Stochastic optimisation to represent hydro power and wind

Any comments or suggestions? We will be pleased to receive your ideas at the home page, www.Balmorel.com.



By Hans Ravn.

Hans Ravn has in many years worked with mathematical programming as a problem solving tool.

Hans Ravn is Msc., Ph.D. and doctor of science from the Technical University of Denmark. He has worked in both the academia at the Technical University of Denmark and Risø Research Facility and in the industry, where he was project manager at Elkraft. Generally he is considered one of the leading energy experts in Denmark, and has been involved in numerous energy policy-related projects during the last 20 years.