Editorial: The need for global modelling

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About this issue

During the deliberations of the Intergovernmental Panel on Climate Change (IPCC) for the preparation of its Second Assessment Report, published in 1996, we found particularly in the scientific working groups dealing with mitigation of climate change impacts, that there was a lack of well thought-through scenarios on a global level, which could shed light on the options for risk aversion.

However, the need for such studies had begun to become recognized in the scientific community, and several groups started work on scenarios dealing with different classes of strategies. This means that a better basis will be available to the teams working on the IPCC Third Assessment, and this special issue of IJGEI offers the first results from such studies, along with a set of methodology papers and papers offering a survey and critical appraisal of some recent energy scenario work.

Why are scenario studies relevant for discussing greenhouse policy options? For the purpose of assisting decision-makers, a way must be found of describing a given energy system in its social context, which is suitable for assessing systems not yet implemented. Simple forecasts of demand and supply based on economic modelling cannot directly achieve this, as economic theory deals only with the past and occasionally the present structure of society. In order to deal with the future, economic modellers may attempt to invoke the established quantitative relations between components and assume that they stay valid in the future. This produces a 'business-as-usual' forecast. Because the relations between the ingredients of the economy, e.g. expressed through an input-output matrix, vary with time, one can improve the business-as-usual forecast by taking into account trends already present in past development. However, even such trend-forecasts cannot be expected to retain their validity for very long periods, and it is not just the period of forecasting time that matters, but also changes in the rules governing society. These may change due to abrupt changes in technology used (in contrast to the predictable, smooth improvements of technological capability or average rate of occurrence of novel technologies), or they may be changed by deliberate policy choices. It is sometimes argued, that econometric methods could include such non-linear behaviour, e.g. by replacing the input-output coefficients by more complex functions. However, to predict what these should be cannot be based on studies of past or existing societies, because the whole point in human choice is that options are available, which are different from past trends. The non-linear, non-predictable relations that may prevail in the future, given certain policy interventions at appropriate times, must therefore be postulated on normative grounds. This is what the scenario method does, and any attempt to mend economic theory also implies invoking a scenario construction and analysis, so in any case this is what has to be done.

It is important to stress that scenarios are not predictions of the future. They should be presented as policy options that may come true only if a prescribed number of political

actions are indeed carried out. In democratic societies this can only happen if preceded by corresponding value changes affecting a sufficiently large fraction of society. Generally, the more radically the scenario differs from the present society, the larger must the support of a democratically participating population be. For non-democratic societies a scenario future may be implemented by decree, with the negative implications of such a procedure.

The actual development may comprise a combination of some reference scenarios selected for analysis, each reference scenario being a clear and perhaps extreme example of pursuing a concrete line of political preference. It is important, that the scenarios selected for political consideration are based on values and preferences that are important in the society in question. The value basis should be made explicit in the scenario construction. Although all analysis of long-term policy alternatives is effectively scenario analysis, particular studies may differ in the comprehensiveness of the treatment of future society. A simple analysis may make normative scenario assumptions only for the sector of society of direct interest for the study (e.g. the energy sector), assuming the rest to be governed by trend rules similar to those of the past. A more comprehensive scenario analysis will make a gross scenario for the development of society as a whole, as a reference framework for a deeper investigation of the sectors of particular interest. One may say that the simple scenario is one that uses trend extrapolation for all sectors of the economy except the one focused upon, whereas the more radical scenario will make normative, non-linear assumptions regarding the development of society as a whole. The full, normative construction of future societies will come into play for scenarios describing an ecologically sustainable global society, whereas scenarios aiming only at avoiding or coping with one particular problem, such as the climate change induced by greenhouse warming, are often of a simpler kind.

The first section on methodology contains four papers: *Nakicenovic and Grübler* discuss the methodology of modelling greenhouse emissions and energy systems across the board, exhibiting historical data and indicating development trends in terms of energy intensities. *Audus* discusses the abilities of a number of economic and engineering models used in describing energy systems in a regime of changing technology, and *Diesendorf* gives a critical essay on the way some of these traditional economic models are used in connection with greenhouse mitigation strategies. Finally, *Yoshida*, *Ishitani* and *Matsuhashi* suggest a way of remedying technical shortcomings of traditional input-output analysis in the case of multiple intertwined production streams.

The second section includes five papers dealing with energy demand, conversion, transmission and the supply technologies for utilizing solar and wind energy, all in a way suited for use in scenario studies. *Nørgård* discusses the importance of the back-end of the energy conversion chains, and brings out the strong coupling to social models made necessary due to the demanded end-product being in the form of goods and services, never energy in itself. *Yoshida et al*. look closely at the options for the Japanese transportation sector, in terms of alternative fuels, *Andersen and Jensen* assess the progress in wind turbine technologies and prospects for further market penetration, and *Mills* does the same for solar power and heating technologies. A comment on the opportunities offered by new transmission technologies is made by *Nielsen and Sørensen*.

Section three contains the most recent global energy scenarios for the mid-21st century: *Kuemmel* looks at systems based on continued use of fossil fuels, but with either cleaning of flue gases not only for conventional pollutants, but also for carbon dioxide, or alternatively removal of CO_2 before combustion, relying on hydrogen as the main energy

carrier. *Sørensen and Meibom* construct an energy demand scenario based on high efficiency of energy conversion and use, as well as a supply scenario based on renewable energy obtained from biomass, hydro, wind or solar sources. By using a geobased display system, the spatial match or mismatch between supply and demand is visualized and a discussion of the need for energy trade is made, in conjunction with discussions of temporal matching through either energy storage or exchange. This allows a detailed evaluation of two variants of the scenario: one in which decentralization of energy production is in focus, and another with more generous use of centralized facilities such as solar farms on marginal land or wind parks placed off-shore. The latter is shown to be considerably more resilient, but both scenarios require extended international trade of energy. In the final two papers, *Jefferson* comments on the quality of the WEC energy modelling work, and *Petersen and Gundermann* extract some conclusions from the Danish government's extended practical experience with use of energy scenarios in their planning efforts.

We have thus taken the reader through a tour starting with defining the methods and assessing the inventories of tools and resources, then following the model makers along their difficult road of addressing the many uncertainties in defining the requirements and assessing the development paths of future societies, to the final gigantic task of putting it all together in one or more consistent scenarios, with all the subsystems working together in time and space, and identifying the implementation steps needed, in order to give decision-makers the right signals on what they have to do and what may happen 'by itself' in appropriately regulated markets.