

Innovative Techniques for Quantitative Scenarios in Energy and Environmental Research: a Review

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Abstract: Quantitative scenarios form the core of the future analysis in the energy, climate and other environment-related fields. A growing number of researchers worldwide start using innovative techniques for developing, analysing and choosing quantitative scenarios. Some of these techniques involve a large number of scenarios. Different rationales motivate these strands of research: better system understanding, uncertainty analysis, development of robust strategies, selection of a small set of scenarios, ability to link storylines with quantitative scenarios and other. These techniques are argued to provide both novel research insights and policy-relevant scenario exercises. A workshop, organised by UCL Energy Institute and Cired, on 26-27 March 2014 brought together the key researchers, who use such innovative techniques for developing, analysing and choosing quantitative scenarios in energy and environmental research. The workshop aimed at gathering these existing techniques into one toolbox, consolidate experiences and draw avenues for future research. This conference paper gives an overview of the workshop results. It presents and analyses innovative quantitative techniques for developing state-of-the-art research-based and highly policy-relevant scenarios.

Keywords: quantitative scenarios; energy and environment; tools and insights.

1. BACKGROUND

Quantitative scenarios form the core of the future analysis in the energy, climate and other environment-related fields. While various techniques for developing, analysis and choosing quantitative scenarios are well-established in research and decision making already, a growing number of researchers worldwide advance these techniques further, use them in novel ways and develop new techniques. The recent international workshop “Innovative Techniques for Quantitative Scenarios in Energy and Environmental Research – IQ SCENE,” which took place on 26-27 March 2014 in London, United Kingdom, aimed to bring together researchers from energy and environmental fields to discuss the use and development of such techniques. This conference paper summarizes the cross-cutting themes that emerged in the workshop. Further material from this workshop is available online at (UCL Energy Institute & Cired, 2014).

2. EMERGING THEMES IN THE IQ SCENE WORKSHOP

The workshop participants at first presented and discussed a mix of own methodological advances and applications. The topics covered a range from energy and climate change to water management and ecosystems. Clusters of these topics are presented in Figure 1. The geographical scopes of the applications ranged from the global scale, to regional (e.g. the Mediterranean basin, Southern Africa), national (e.g. UK, Israel, Germany, US, India) and local scales (e.g. Berlin, the rural region of Southern Thuringia in Germany, Lower Rio Grande Valley in Texas, the Island of Corvo in Acores, Lake Kinneret in Israel). Some studies presented scenarios, developed by state-of-the-art quantitative

or qualitative models for research purposes, while other studies introduced processes of co-developing scenarios with stakeholders or decision makers.

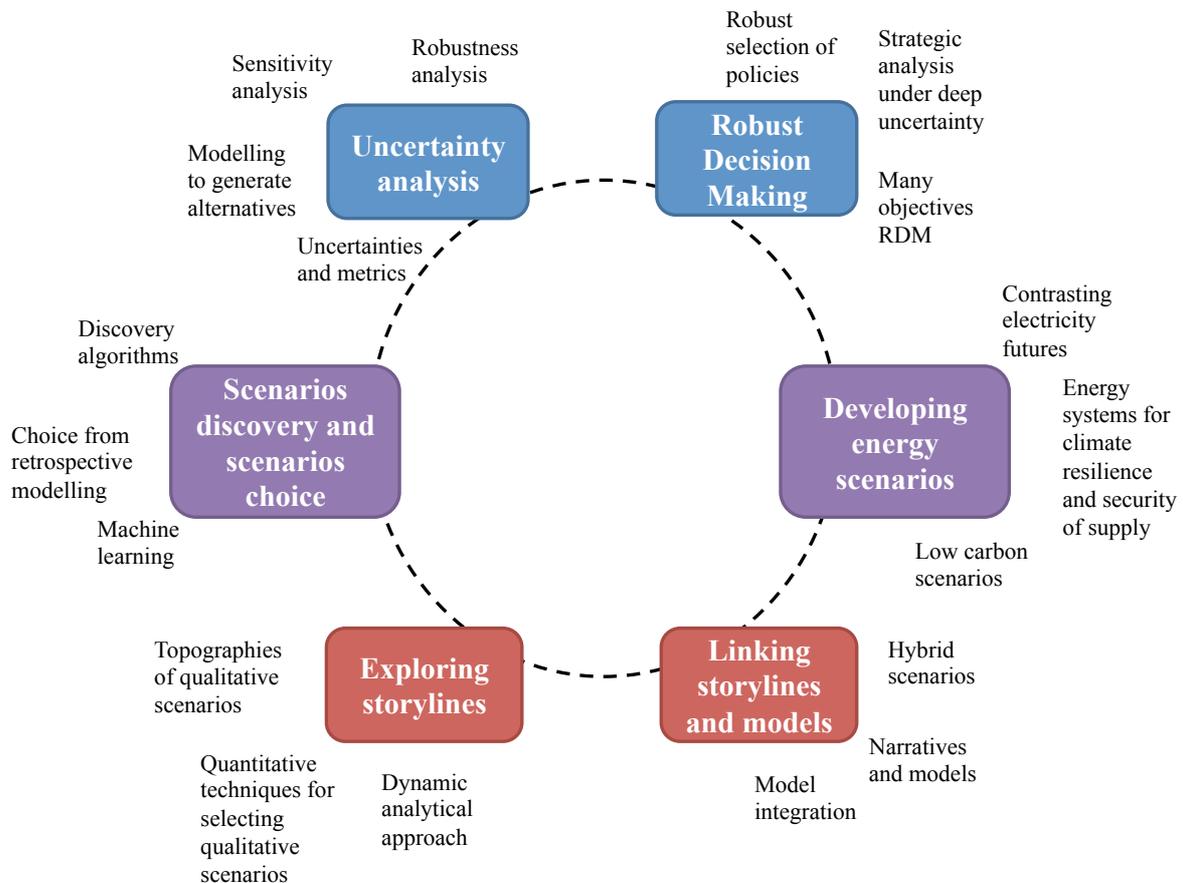


Figure 1. Themes of the workshop sessions.

As the workshop participants came from a wide range of research backgrounds and brought in a diverse set of methodologies and applications, three cross-cutting themes were chosen for knowledge integration. These themes focused on three overarching types of scenario techniques:

- (i) Building and analyzing large numbers of scenarios;
- (ii) Choosing small sets of scenarios;
- (iii) Linking approaches (qualitative and quantitative, different disciplines, different models, different scales, different stakeholders) for scenario studies.

Emerging insights from these cross-cutting themes are summarized in the sections 2.1-2.3 as the outcomes of the interactive, semi-structured discussions among the workshop participants. These summaries are not exhaustive and complete overviews of the fields, but still map out the key of objectives, methods, challenges and avenues for future research in scenario studies.

2.1 Building and analysing large numbers of scenarios

The techniques for building and analysing large numbers of scenarios were perceived valuable for (i) improving the understanding of energy and environmental models and (ii) for identifying the drivers, outcomes and key uncertainties of the modelling outputs. Especially for identifying the key variables and “differences that make a difference,” such techniques can help researchers, policymakers and stakeholders to filter out the inferior issues and to focus on critical ones in consensus building and decision making.

Large numbers of scenarios are developed (i) by using a single quantitative model and running it a large number of times or (ii) by combining scenarios from multiple models. Then, the resulting large sets of scenarios are mined for data and patterns using statistical approaches (CART, C4.5) or by visualizing the scenario results. While a number of new studies are emerging, where large numbers of scenarios are constructed and analysed, there is still a need to synthesise these approaches into a toolbox of techniques and define the best practice.

The development and use of a large number of scenarios is often hindered by the fact that such analyses require high resources for running the models and analysing their results. Data mining and interpretation of results, especially from large-scale, complex models, is a challenging task even for researchers themselves. This poses another challenge of communicating such complex results to stakeholders, policy makers and other scenario users. In terms of the robustness of the analysis itself, the results are dependant on the model structure, assumptions and subjective choices of parameters for the construction of scenarios, which need to be carefully documented and critically reflected on.

2.2 Choosing small sets of scenarios

For informing research and decision making, there is a need to choose smaller sets of scenarios from the afore-described large numbers of scenarios. Depending on the different stage and objectives of the decision making or research process, different small sets are valuable: sets of several most plausible (consistent) scenarios, sets of diverse (or maximally different) scenarios, sets with scenarios of most influential uncertainties, or sets that highlight the key vulnerabilities.

Small scenario sets are commonly developed from scratch or are selected from large numbers of scenarios on the basis of a subjective judgement on what scenarios are relevant. Formal techniques for scenario selection offer more systematic and comprehensive ways to choose scenarios. Examples of such techniques include scenario diversity analysis, cross-impact balance, modelling to generate alternatives and EXPANSE.

As of today, still little knowledge exists on what small sets of scenarios are useful for decision making and research and how they should be best developed and chosen. Often a balance needs to be found between consistency, diversity, importance and other characteristics of scenarios, but hardly any guidelines exist. Further research is thus needed to improve knowledge basis in this area, including careful post-hoc evaluations of scenario studies.

2.3 Linking approaches

The theme on linking approaches (such as qualitative and quantitative approaches, different disciplines, different models, different scales, different stakeholders) was acknowledged to be the most diverse cross-cutting theme from sections 2.1-2.3. Generally, there is a wide range of objectives in research and decision making that require linking different approaches for developing scenarios. Approaches are primarily linked for eliciting, validating and utilizing wider types of information that cannot be captured with a single approach. Engagement of decision makers and stakeholders into the co-design of scenarios was seen as key not only for improving the scenarios, but also for promoting their use for real-world decision support and consensus building.

There is a growing body of scenario studies that link different approaches, but all these studies are primarily developed on an individual basis. Examples of such approaches are attempts to soft-link or hard-link several quantitative models, to link storylines and quantitative models, to engage stakeholders in model development or to develop interactive platforms for decision support.

Such multitude of approaches that are tacit rather than systematized makes it difficult to define the best-practice approaches in order to advance the field and to help researches make meaningful choices of the approach. While many studies already exist, the workshop participants also thought that complete or substantial integration is not always achieved and the different types of approaches

remain rather individual. Thus, future research needs to focus on systematizing such practices of linking diverse approaches and defining the best practices. Rather than providing a single, one-size-fits-all approach, typologies of approaches would be useful. Eventually, such approaches also need to be carefully evaluated both in real-world applications and in laboratory-like experiments.

4. FUTURE DIRECTIONS

In addition to the afore-described content-focused insights from the workshop, there was a general agreement among the workshop participants that scenarios are the key tools for future analysis in energy and environmental research. Scenario techniques can hardly be replaced with anything else. As there is a growing number of researchers using innovative, systematic techniques to develop, analyze and choose scenarios, there is also a growing need to share the research and practical experiences. The workshop participants generally agreed that there is a need to keep bringing the researchers together to discuss advances in scenario studies. Thus, initiation of a scenario community was seen as timely and the IQ SCENE workshop perhaps gives the first step to.

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6. REFERENCES

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