International UCL-CIRED workshop

26-27 March 2014, London

Innovative techniques for Quantitative SCenarios in ENergy and

Environmental research (IQ SCENE)

Workshop Report

28 May 2014

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1. BACKGROUND

Quantitative scenarios form the core of future analysis in 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. Some of these techniques involve a large number of scenarios. Different rationales motivate these researchers: 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.

The international workshop "Innovative Techniques for Quantitative Scenarios in Energy and Environmental Research – IQ SCENE" was organized in London on 26-27 March 2014. This workshop was a joint initiative of UCL Energy Institute (UK) and CIRED (France) with contributions form RAND (USA). It was funded through WholeSEM (UK Whole Systems Energy Modelling Consortium) outreach grant.

The workshop brought together over 30 researchers from nine countries in Europe and North America, working in energy and environmental fields. The mission of the workshop was:

  (i)   For the first time, to bring together the key researchers that use the innovative techniques for developing, analysing and choosing quantitative scenarios in energy and environmental research;

  (ii)   Gather these existing techniques into one toolbox, share experiences and thoughts for future research;

  (iii) Actively disseminate the workshop results in the academic community.

This report briefly describes the workshop, summarises its key outcomes and lays out the future follow-ups. Further information on the workshop, including presentation abstracts and slides, is available online at: http://www.wholesem.ac.uk/iq-scene/iq-scene

2. INDIVIDUAL WORKSHOP CONTIRBUTIONS

The workshop started with the keynote speech by Rob Lempert from RAND (USA), who questioned whether interacting with computers could help people choose better scenarios. Afterwards, two academics Bert de Vries from Utrecht University (the Netherlands) and Franck Lecocq from CIRED (France) as well as two practitioners Thomas Counsell from the UK Department of Energy and Climate Change and Martin Haigh from Shell (UK) discussed challenges in developing and using quantitative scenarios in energy and environmental research and decision making.
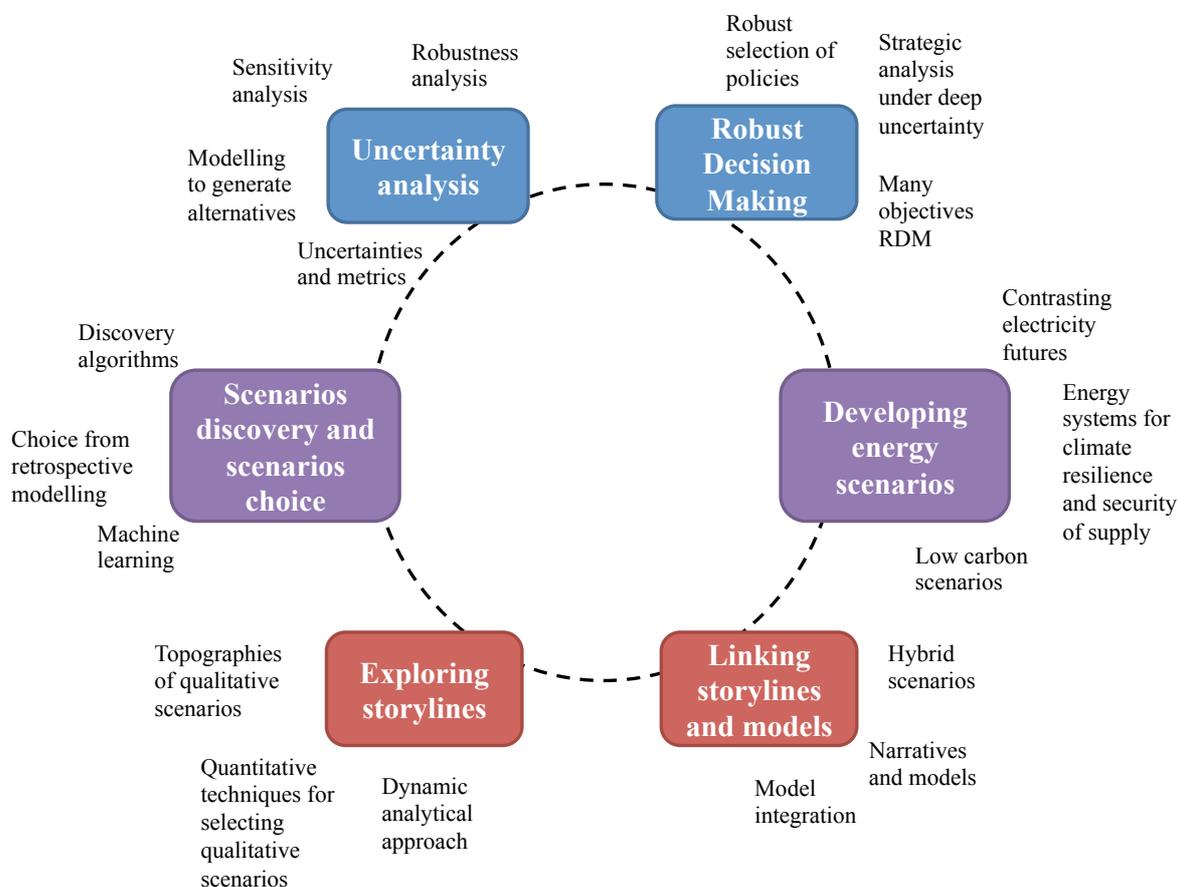
Figure 1. Themes of the individual workshop presentations

The workshop participants then 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 the stakeholders or decision makers.

3. CROSS-CUTTING WORKSHOP THEMES

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 methodology and covered three overarching types of scenario techniques:

(i)   Building and analysing 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 Sections 3.1-3.3 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.

3.1 Building and analysing large numbers of scenarios

Objectives
- Improving understanding of models.
- Identifying 'differences that make a difference'.

Methods
- Two approaches were discussed: using a range of different models versus using a single model to generate large numbers of scenarios.
- Choice of factors for analysis e.g. what input parameters should be probabilistic? Model iteration (by analysts and in conjunction with stakeholders) was considered

important. The policy goal in question can also focus the analysis. Another approach might be to initially batch parameters together to understand where the focus should be and then analyze specific parameters in greater detail and leave others out.

- The issue of the sample size was also raised, which can either be determined through statistical methods or through iterative analysis, observing whether increasing the number makes a difference.

Types of insights

- Understanding what drives the outcomes in analyses.

- This is important for helping stakeholders filter out the issues that do not really matter, and helping policymakers focus on critical factors, and develop consensus about where the focus should be.

- Related to the above is the issue of model legitimacy from the stakeholder's perspective and the potential to use their own models to address this. This is of course challenging to understand and use models that have been developed by other organizations, and to run them many times.

Challenges

- Where this approach is used, there was the issue of understanding the model outputs, particularly in complex, non-linear models.

- Key challenges arise from using a number of different models due to differences in model focus, structure, assumptions etc.

- Another key challenge was the communication of results. A number of presentations, particularly from RAND participants, presented approaches to trying to distil key metrics from large numbers of scenarios for policy makers' consumption – and only providing additional information as necessary (to avoid overload).

- Some resistance in different communities from running large numbers of scenarios for different reasons:
  - Strong desire to use a given set of input parameters;
  - Technical and resource implications;
  - Concern about releasing 'incorrect' results e.g. if using probability distributions;
  - Preference for running many models to generate scenarios as opposed to a single model;
  - Resistance to new approaches.

Future research needs

- How can we learn and develop best practice?
- Can an analysis toolbox be developed? For scenario generation, the methods might be specific to the models being used, while for analysis and visualization of results, techniques might be more generically applied.
- For data mining and analysis, different statistical packages were mentioned, such as CART and C4.5. Visualization packages typically used in Tableau and R.

3.2 Choosing small sets of scenarios

Objectives

- Different stages of decision process may require different scenarios.

Methods

- Small scenarios from scratch, or extracting small number of scenarios from larger number of model runs.
- Scenario Diversity Analysis, Cross-Impact Balances, Modeling to Generate Alternatives, EXPANSE.

Types of insights

- Key characteristics of small sets of scenarios
    - o Plausibility or consistency, diversity.
    - o But what plausible scenarios are important? Most probable? Most risky or vulnerable?

Challenges

- Scenarios as products or scenario-building process (we have less experience on the process).
- Evaluations of scenario development approaches.
- Enthusiasm of stakeholders for scenarios at initial stages.
- Issues with 'path of least resistance' – scenarios cannot be too implausible, but they also need to be interpretable.
- Issues with developing consistent scenarios across scales.

Future research needs

- Good to maintain analytic diversity.
- Is there a tension between consistent and diverse scenarios?

- Need to continue to test uptake of scenarios by stakeholders ('lab work'; build bridges between scenario research and practice).

3.3 Linking approaches

Objectives
- There is a diversity of objectives, depending on the guiding question, situation and even the background of the involved researchers.
- Eliciting, validating, and utilizing a wider class of information (extended system boundaries, qualitative information, social aspects), expertise, experiential knowledge and preferences than is available in modeling and vice versa.
- Engaging practitioners into model design (improving the models, shared ownership, trust building).
- Communication of results by translating quantitative information into a qualitative picture, consensus and acceptance building, making the results more widely accessible and acceptable.

Methods
- A wide range of approaches, often on individual basis.
- Including, but not limited to multiple model, storylines, conceptual models, fuzzy logics, mental maps.
- Linking two quantitative approaches is very common, but now there is a growing number of qualitative-quantitative links.
- Stakeholder engagement exercises, web-based interfaces.

Types of insights
- Feeding into development of better models, adapting the models to the specific context at hand through stakeholder engagement.
- Interpreting and validating modeling outcomes through the lens of story telling by different stakeholders.
- Making decision by combining modeling and preferences.
- Building the understanding and acceptance by practitioners of the models.

Challenges
- Lots of expertise is tacit and not codified and thus it is angreat challenge to tap into that.

- Diversity of approaches and their choice on individual basis.
- Robustness of stylized facts.
- Influencing people through the model.
- Depends on the discipline.

Future research needs

- Systematizing approaches for linking, based on objective.
- Conducting experimentation on how different people interact and use the tools.

4. FOLLOW-UPS OF THE WORKSHOP

In addition to the content-focused insights, described in Section 3, 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, analyse 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, the follow-up activities of this IQ SCENE workshop were greatly supported by the participants. Some aspirations were raised about starting a scenario community, which was seen as a timely initiative now and for which the IQ SCENE workshop could serve as an initial step.

Based on the feedback and suggestions of the workshop participants, these follow-up activities are foreseen to date:

- The ResearchGate project "IQ SCENE: Innovative Scenarios Techniques" was created as a mailing list and a platform for knowledge sharing. The workshop participants are invited to join this project and actively engage in sharing and discussing their research updates. In order to join this project, please email Evelina Trutnevyte (e.trutnevyte@ucl.ac.uk, evelina.trutnevyte@alumni.ethz.ch) or Celine Guivarch (guivarch@centre-cired.fr) and you will be added to the group. The link is: https://www.researchgate.net/project/IQ_SCENE_Innovative_scenario_techniques

- The process of a special or virtual issue of an academic journal will be initiated in order to publish the individual workshop contributions and tie them up into a joint issue.

- The workshop mission and findings will be further disseminated through other events and meetings, e.g. in 7th International Congress of Environmental Modelling and Software and other conferences.

- As the idea of the follow-up workshop was greatly supported by the participants, we are currently exploring opportunities for that.

5. APPENDIX

5.1 Workshop participants

Surname	First name	Institution, country
Barton	John	Loughborough University, UK
Carlsen	Henrik	SEI-Stockholm Environment Institute, Sweden
Contestabile	Monica	Nature Climate Change, UK
Counsell	Thomas	Department of Energy and Climate Change, UK
de Vries	Bert	Utrecht University, the Netherlands
DeCarolis	Joe	North Carolina State University, USA
Drouet	Laurent	Fondazione Eni Enrico Mattei, Italy
Gal	Gideon	Israel Oceanographic and Limnological Research, Israel
Galloway	Stuart	University of Strathclyde, UK
Gerst	Michael	Dartmouth College, USA
Gilbert	Nigel	University of Surrey, UK
Guivarch	Celine	CIRED, France
Haigh	Martin	Shell, UK
Kasprzyk	Joseph	University of Colorado Boulder, USA
Konadu	Dennis	University of Cambridge, UK
Kwakkel	Jan	Delft University of Technology, the Netherlands
Lecocq	Franck	CIRED, France
Lempert	Robert	RAND Corporation, UK
Milne	Scott	Energy Technologies Institute, UK
Pfenninger	Stefan	Imperial College London, UK
Popper	Steven	RAND Corporation, USA
Prehofer	Sigrid	ZIRIUS, Germany
Pye	Steve	UCL Energy Institute, UK
Rozenberg	Julie	CIRED, France / World Bank, USA
Sabio	Nagore	UCL Energy Institute, UK
Samsatli	Sheila	Imperial College London, UK
Schweizer	Vanessa	University of Waterloo, Canada
Shivakumar	Abhishek	KTH Royal Institute of Technology, Sweden
Sobral Mourao	Zenaida	University of Cambridge, UK
Strachan	Neil	UCL Energy Institute, UK
Trutnevyte	Evelina	UCL Energy Institute, UK
Voinov	Alexey	University of Twente, the Netherlands

5.2 Workshop programme

Day 1, Wednesday, March 26
Venue: Court Room, Senate House, Malet Street, WC1E 7HU London

9:30 – 10:00	Registration
10:00-10:05	Welcome by Neil Strachan (UCL Energy Institute) and Franck Lecocq (CIRED)
10:05-10:15	Introduction to the workshop by Evelina Trutnevyte (UCL Energy Institute) and Celine Guivarch (CIRED)
10:15 – 11:15	Keynote speech by Robert Lempert (RAND)
11:15 – 11:45	Coffee break
11:45– 13:00	Panel discussion "Challenges in developing and using quantitative scenarios in energy and environmental research and decision making"

- Thomas Counsell (UK Department of Energy and Climate Change)
- Martin Haigh (Shell)
- Franck Lecocq (CIRED)
- Bert de Vries (Utrecht University)
- Panel discussion chair: Neil Strachan (UCL)

13:00 – 14:00	Lunch

Venue: UCL Energy Institute, Central House, 14 Upper Woburn Place, WC1H 0NN London

14:00 – 16:00   **Parallel session "Uncertainty analysis"**
Chair: *Rob Lempert*
Presentations:

- *Joe DeCarolis* "Improving model-based scenario analysis with stochastic optimization and modeling to generate alternatives"
(Discussant: Steve Pye)

- *Gideon Gal* "Learning from uncertainty in lake ecosystem model scenarios"
  (Discussant: Joe DeCarolis)

- *Julie Rozenberg* "The cost of climate change mitigation: uncertainties and metrics matter"
  (Discussant: Gideon Gal)

- *Steve Pye* "A systematic approach for analysing the robustness of a UK low carbon energy future using uncertainty analysis"
   (Discussant: Julie Rozenberg)

Parallel session "Scenario discovery and scenario choice"

Chair: *Celine Guivarch*

Presentations:

- *Jan Kwakkel* "Scenario discovery in heterogeneously typed data"
  (Discussant: Stuart Galloway)

- *Evelina Trutnevyte* "Using retrospective UK power system modelling to inform the scenario choice for the future"
   (Discussant: Jan Kwakkel)

- *Michael D. Gerst* "Combining threshold- and cluster-based scenario discovery methods to improve scenario interpretation and usability"
  (Discussant: Evelina Trutnevyte)

- *Stuart Galloway* "A machine learning approach to determining viable energy future scenarios"
  (Discussant: Michael D. Gerst)

16:00 – 16:30   Coffee break

16:30 – 18:00   **Parallel session "Exploring storylines"**

Chair: *Evelina Trutnevyte*

Presentations:

- *Vanessa Schweizer* "Toward mapping topographies of qualitative scenarios: an investigation of a comprehensive scenario set"
  (Discussant: Celine Guivarch)

- *Henrik Carlsen* "Combining quantitative techniques for selecting qualitative elements of socio-economic scenarios adapted to a specific problem"
  (Discussant: Vanessa Schweizer)

- *Celine Guivarch* "Enhancing the policy relevance of scenarios through a dynamic analytical approach"
  (Discussant: Henrik Carlsen)

Parallel session "Robust decision making"

Chair: *Julie Rozenberg*

Presentations:

- *Laurent Drouet* "Robust selection of climate policies under current knowledge of uncertainties"
  (Discussant: Steven Popper)

- *Joseph Kasprzyk* "Framing energy and environmental planning problems using many objective robust decision making"
  (Discussant: Laurent Drouet)

- *Steven Popper* "Strategic energy analysis under deep uncertainty"
  (Discussant: Joseph Kasprzyk)

Day 2, Thursday, March 27

Venue: UCL Energy Institute, Central House, 14 Upper Woburn Place, WC1H 0NN London

9:00 – 10:30   **Parallel session "Developing energy scenarios"**

Chair: *Neil Strachan*

Presentations:

- *Stefan Pfenninger* "Contrasting different electricity futures by comparing a large number of optimized scenarios" (Discussant: Scott Milne)

- *Abhishek Shivakumar* "Modelling facility energy systems for enhanced climate resilience and security of supply" (Discussant: Stefan Pfenninger)

- *Scott Milne* "Exploring low carbon scenarios with the ETI's Energy Systems Modelling Environment (ESME)" (Discussant: Abhishek Shivakumar)

Parallel session "Linking storylines and models"

Chair: *Bert de Vries*

Presentations:

- *Sigrid Prehofer* "Constructing hybrid scenarios to enhance socio-technical system understanding and to improve coupling the story with quantitative modelling" (Discussant: Alexey Voinov)

- *John Barton* "Synthesis of qualitative narrative and quantitative models into consistent descriptions of low carbon energy transitions" (Discussant: Sigrid Prehofer)

- *Alexey Voinov* "Exploring low-carbon transitions by means of

model integration"

(Discussant: John Barton)

10:30 – 11:00	Coffee break
11:00 – 12:00	Interactive sessions
12:00 – 12:15	Short break
12:15 – 13:00	Summary of the interactive sessions, general feedback session and next steps