wholeSEM Annual Conference 2015

6 & 7 July 2015

Hybrid Energy Modelling – Linkages and Interdisciplinarity

Conference Report

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Summary

The 2nd Annual Conference of the wholeSEM consortium (Whole Systems Energy Modelling) was held at Murray Edwards College, University of Cambridge on 6th & 7th July 2015.

This was a conference focused on interdisciplinary energy modelling, with an invited audience of over 100 leading energy modellers from the UK and 15 other countries. Interestingly this diverse mix of experts was drawn not just from academia but also from government, think-tanks, consulting and firm's in-house expertise. The capacity building aspect of the conference was boosted by a PhD poster session with quick fire presentations. In the face of fierce competition the best poster prize was won by Kathrin Volkart of the Paul Scherrer Institut in Switzerland, with her poster on: Integrating global energy-economic system modelling and life-cycle assessment.

The overall aim of the 2nd wholeSEM conference was to compare and contrast disciplinary energy models approaches, and to discuss the insights they provide. The conference explored the strengths and shortcomings of current energy modelling, conceptual issues in combining disciplinary approaches, and the benefits and pitfalls of hard- and soft-linking of energy models.

The conference communicated in real time with wider stakeholders via the Twitter feed at @wholeSEM using the event hashtag #wholeSEM15. Full details of the conference including PDF versions of presentations is at: www.wholesem.ac.uk/events/annual-conference/annual-conf-15

Key themes emerging from the discussions at the conference were:

- The impressive rise over the last 10 years in UK energy modelling in terms of the number of practitioners, new areas of study (e.g., behaviour and technology linkages), and new techniques from other fields (e.g. agent based modelling, life cycle assessment).
- The need to build on this capacity to provide timely and targeted insights to policy makers and industrial decision makers, especially considering the potential mismatch between the long cycle of model development and the rapid timeframe of decision making for policy analysis and for technology investment.
- The trade-offs in energy modelling between complexity vs. simplicity. There is a tendency towards bigger, more data intensive, more computationally demanding model formulations at the potential loss of understanding and model parsimony.
- Transparency is a key requirement, not just of the models but of the modelling process and the modellers themselves – busy decision makers may never fully understand a model, but they need confidence in the model construction, calibration and application process.
- That both modellers and model users need to break out of disciplinary silos and combine insights from alternate analytical perspectives and from real world markets, societal process and technology policies.

The conference concluded with **key ongoing challenges for interdisciplinary energy modelling**

- What is the optimal and practical level of model transparency and open access. Here, the differences between academia and consultancy should be acknowledged?
- What is the optimal and practical level of model complexity vs. simplicity?
- How do we codify best practices in linking models of different types and from different disciplinary backgrounds?
- How do we better engage both technical as well as very senior (non-technical) policy and industrial decision makers?
- How to develop models when policy objectives are often not explicit?

At the conclusion of the wholeSEM conference, participants were challenged to go out and build bilateral and multilateral links to address these key themes and ongoing challenges.

Sessions and Discussions

Full details of the conference including PDF versions of presentations are at: www.wholesem.ac.uk/events/annual-conference/annual-conf-15. Key points taken from individual session chairs were:

Plenary: Keynote speaker: Mark Howells, KTH Royal Institute of Technology, Stockholm (Respondents: Adam Hawkes, Imperial College London; Martin Haigh, Shell; Mark O'Malley, University College Dublin)

Professor Mark Howells' key note presentation was on Supporting Policy Coherence - Challenges and Successes in Extending Energy Systems Models to other Resources

- Extending energy systems analysis to cover water and land linkages can provides powerful new insights
- Such broad analysis though needs to consider what we are modelling, how much complexity is necessary and how do we cover market distortions or non-marker drivers
- Communication of integrated and systemic risks is key
- Drawing appropriate model boundaries is critical for coverage vs. tracability.

Session 1a: Codifying and modelling social energy practices and demand changes. Speakers were Malcolm Jay, Department for Transport; Ruchi Choudhary, University of Cambridge; Kevin Lomas, University of Loughborough

- Uncertainty is a reality in all types of energy modelling, the challenge is finding appropriate ways to deal with it
- Analysis of energy demand is required at multiple levels from the international to the individual consumer
- Getting accurate data on energy consumption, particularly related to heating and temperature, is difficult. We need to combine different types of measurements and data sources to create a reliable data set to base models on.

Session 1b: Improved modelling of technological change and diffusion. Speakers were Oliver Rix, Baringa and Dr Ren Orans, E3; Brian O'Gallachoir, University College Cork; Chris Heaton, Energy Technologies Institute.

- Major transformations are very similar in different countries with different models, hence value in international modelling collaboration
- Multi-model approaches give range of energy transition insights – e.g., all GHG gas mitigation, high renewable penetrations, employment impacts etc.
- Modelling scenario narratives gives integrated insights across the whole UK energy system –power, heating, transport, industry & infrastructure

Session 1c: Interdisciplinary modelling of the whole energy system I. Speakers were Alison Hughes, University of Cape Town; Joe DeCarolis, North Carolina State University; David McCollum, IIASA

- Uncertainty of parameters within and across models must be tested
- Development goals as well as environmental and energy goals should all be considered simultaneously
- Structural uncertainty must also be tested – it is not sufficient to only consider parameters
- The inclusion of behavioural parameters and the costs within them are at an early stage of development but may prove to be extremely important

Session 2a: Incorporating spatial and temporal detail in infrastructure. Speakers were Russell McKenna, Karlsruhe Institute for Technology; Keith Bell, University of Strathclyde; Goran Strbac, Imperial College London

- There can be an optimal scale of decentralised energy design, management and pricing
- It's got to work – the engineering detail in modelling electric power systems is critical
- Flexible technologies and demand side measures can be hugely cost saving in the evolution to a low-carbon energy system'

Session 2b: Energy-land-water trade-offs and constraints (the Nexus). Speakers were Alex Archibald, University of Cambridge; Iain Morrow, AEA-Ricardo; Holger Hoff, PIK

- Coupling between biophysical systems and integration with human systems is a major model area but feedback from biophysical systems into human systems still insufficient
- Costs are not only factor in policy makers perspectives – land use change, jobs, etc are important and do not fit neatly into cost optimization energy models
- Goal of Nexus modelling is to identify reductions in stresses on resources and provide more realistic thresholds for resource use for other systems – including energy system

Session 2c: Interdisciplinary modelling of the whole energy system II. Speakers were Chris Dent, Durham University; Jonathan Cullen, University of Cambridge; Sheila Samsatli, Imperial College London

- Typical uncertainty analyses of energy system models generate very sparse coverage of the uncertainty space. Constructing a statistical emulator of the model gives mathematical rigour and comprehensiveness to the treatment of uncertainty.
- The embedded energy of steel material flows can be visualised using Sankey diagrams to show the material intensity of steel with exergy, instead of tonnage
- The new STeMES model integrates wind-hydrogen-electricity networks in Great Britain at a high temporal and spatial scale.

Day 1 was concluded with a wrap-up session on model methodologies and model linkages. The two discussants – from a governmental and senior academic perspective – were Alec Waterhouse, DECC; and Peter MacGregor, University of Strathclyde. [See the summary for key messages and ongoing challenges.]

Following the Conference Dinner at Emmanuel College, the after dinner speaker – James Smith (ex CEO of Shell UK, current Chair of Carbon Trust) gave a wide ranging set of challenges to the energy modelling community from the perspective of a senior industrial decision maker.

Session 3a: Practices and demand linking to Technological transition. Speakers were Evelina Trutnevyte, ETH; Martino Tran, University of Oxford; Sonia Yeh, UC Davis; Thomas Roberts, University of Surrey

- The main focus of this session was to analyse, predict and consider demand-side influences, particularly the role of consumer behaviour, in future energy scenarios.
- The need to acknowledge and work with the certainties and uncertainties associated with modelling energy transitions was strongly emphasised.
- A novel techno-behavioural dynamics approach focusing on the networked interactions between technology and human behaviour was proposed for assessing future impacts of technology on society and environment.
- The opportunities and challenges of incorporating consumer choices and their behaviour in 4E models used for analysing policies related to climate change were discussed.
- A social practice theory based approach was proposed as an effective alternative to the traditional rational choice approach to model domestic energy consumption.

Session 3b: Technological transition linking to Infrastructure spatial and temporal detail. Speakers were Kenneth Karlsson, DTU; John Barton, University of Loughborough; Kannan Ramachandran, PSI; Nazmiye Balta-Ozkan, University of Cranfield

- The advantages of using a rich geographical data set on population and demand density to determine the efficient technological mix for supplying residential heat demand via district heating networks.
- Under the application of a high-temporal-resolution power system model (FESA), the value of energy storage was strongly related to avoiding curtailment of intermittent renewables
- Ignoring the impact of temporal fluctuations of electricity demand on long-term energy system modelling may lead to suboptimal outcomes.
- Businesses can decisions on their locations based on the existing energy and other urban infrastructure.

Session 3c: Infrastructure spatial and temporal detail linking to Energy-land-water nexus. Speakers were Helen Houghton-Carr, CEH; Andrew Lovett, University of East Anglia; Richard Taylor, E4tech; Rick Lupton, University of Cambridge.

- Inclusion of water use in hydrological models allows resource quantity and quality to be linked with resource use and waste production.
- The representation of ecosystem services national capital objectives within energy models at different spatial and temporal scales needs improvement.
- The Biomass Value Chain Model (BVCM) models the UK bioenergy sector in detail – at a 50-km level and takes into account the potential yields of different crops, the performance of various biomass-to-energy technologies, and transport networks and storage.
- The challenge in modelling resource flows in an energy system is different spatial and temporal scales: very detailed modelling is good but the challenge is the lack of data whereas using a coarse scale may result in loss of important behaviour.

Session 4a: Practices and demand linking to Infrastructure spatial and temporal detail. Speakers were Benjamin Hobbs, John Hopkins University; Alex Rogers, University of Southampton

- Models offer a way of exploring scenarios with a delay between decision making and implementation of new technologies within energy networks.
- Gaps in data on the thermal dynamics of buildings can be closed by combining complementary data sets on actual energy use and the construction of buildings.

Session 4b: Technological transition linking to Energy-land-water nexus. Speakers were Geoff Hammond, University of Bath; Ying Qin, University of Cambridge; Marta Dondini, University of Aberdeen.

- Environmental footprinting provides an, albeit imperfect, approach to evaluating 'manufactured' and 'natural capital' that arise from the Energy-Land-Water demands of humanity.
- Links between water and energy in China are extremely important. Under a BAU scenario, China's energy sector will not comply with the "3 Red Lines" industrial water policy
- The eECOSSE model is extremely accurate to predict soil carbon after land-use change (LUC) from arable/grassland to willow, miscanthus and short-rotation forest

Session 4c: Interdisciplinary modelling of the whole energy system III. Speakers were Phil Summerton, Cambridge Econometrics; Garima Vats, TERI; Birgit Fais, UCL

- Model linkages requires iterative two-way interlinkages, e.g., the feedback from changes in the economy should be fed back to energy system via changes in demand
- A country such as India require linked energy system, CGE, water and air pollutant models to understand overall impacts of policy and other drivers
- From a systems perspective, there is a strong risk that the early investments into the development of a national lead market in niche renewables (e.g., marine) will not directly pay off in the long term.

Day 2 concluded with a final session on application of linked models to decision maker needs. The four discussants combined academia, government and consulting perspectives, and were Filippo Gaddo, Arup; Jan Imhof, Aurora Energy Research; David Joffe, Committee on Climate Change; and Jonathan Radcliffe, University of Birmingham. [See the summary for key messages and ongoing challenges.]

The conference was closed by Jim Skea, who awarded prizes for the top 3 PhD Posters to:

1st Prize - Kathrin Volkart, Paul Scherrer Institut, Switzerland
Integrating global energy-economic system modelling and life-cycle assessment

2nd Prize - Mauricio Ugalde, University of Edinburgh
Sustainable Energy Transition Strategies: a study case employing applied economic modelling

3rd Prize - Will Usher, UCL
Sensitivity Analysis of an Energy System Model

About the Whole Systems Energy Modelling Consortium (wholeSEM)

The whole systems energy modelling consortium (wholeSEM) is a ground breaking, multi-institution initiative to develop, integrate and apply state-of-the-art energy models.
Our aim is to employ extensive integration mechanisms to link and apply interdisciplinary models to key energy policy problems, with substantive bilateral engagement with stakeholders in academia, government and industry. Funded by EPSRC, the consortium is led by University College London and consists of Imperial College London, the University of Cambridge and the University of Surrey. The corsortium is led by Professor Neil Strachan and administered by Liz Milner, both based at UCL Energy Institute.

Energy models provide essential quantitative insights into the 21st Century challenges of decarbonisation, energy security, energy equity, and cost-effectiveness. Models provide the integrating language and framework that assists energy policy makers – focusing at different scales and time periods – to make improved decisions and trade-offs in conditions of pervasive uncertainty. Whole systems energy modelling also has a central role in helping energy supply companies to make technical and economic decisions with regard to future energy technologies and infrastructure, as well as in the assessment of the potential role of societal and behavioural change.

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