Proceedings

Brain storming session on the modelling of renewables for policy making

IRENA special session at International Energy Workshop

June 5, 17:45-19:15, Room 6, Building 1, Xijiao Hotel

Background

Within IRENA's mandate to promote accelerated use of renewable energy for sustainable development, one of the 6 priority areas defined by IRENA's member states and thus reflected in IRENA's current work program is 'mainstreaming renewable energy options and strategies in energy plans'.

To achieve this goal, IRENA is tasked to work with countries and regions to help reflect the real potential of renewable energy technologies in long-term regional and national energy master plans. In particular, there is a strong request from IRENA member states to help them enhance the quality of power sector planning, taking into account the renewable energy integration challenges and opportunities. More and more experience is gained in the context of developed countries, but different types of planning challenges may be expected for the planning in the context of developing countries, where the power system needs to expand possibly by a factor of 2-5 in the coming decades.

As a response, during the coming months IRENA conducts a comprehensive assessment of current planning methodologies with respect to the variable renewable energy (VRE) technologies in the context of mid-term (20-30 years) planning in developing countries. The objective of the assessment is to review the extent and the ways in which existing modelling methodologies address the short-term operational characteristics of VRE (constraints and possibly benefits), and the relevance/irrelevance of particular characteristics of VRE to the mid-term planning and policy making.

Three questions that IRENA put forward to start the discussion are follows:

- What are the key short-term operational properties of VRE that need to be addressed in the long-term investment planning?
- How best can we address these operational properties of VRE in long-term investment planning models?
- What are the key knowledge gaps?

Objective and format of the session

Against this background, IRENA organized a brainstorming session to discuss the following issues: (1) formulating relevant questions, (2) mapping out the pertinent issues, (3) identifying existing methodological approaches and initiatives, and (4) identifying of existing expertise.

It was attended by about 70 international energy modelling experts and benefitted from the contributions from 25 experts.

Agenda

17:45-17:50	Opening by Hans-Holger Rogner (International Institute for Applied Systems Analysis)
17:50-18:00	Introduction of the topic by Asami Miketa (International Renewable Energy Agency)
18:00-18:10	Input discussion 1: Operational challenges related to variable renewable energy, based on Chinese experience by Kaare Sandholt (China National Renewable Energy Centre)
18:10-18:20	Input discussion 2: Findings from ongoing European wide study ADVANCE by Elmar Kriegler (Potsdam Institute for Climate Impact Research)
18:10-18:25	Statements on modelling approaches: Bruno Merven (University of Cape Town/IRENA), Ryoichi Komiyama (University of Tokyo), Brian Ó Gallachóir (University College Cork), Manuel Welsch (Royal Institute for Technology (KTH), Sweden)
18:25-19:15	Open discussion, moderated by Hans-Holger Rogner
19:15	Closing

Summary of the discussion

Opening:
Mr. Hans-Holger Rogner (International Institute of Applied Systems Analysis, Austria) welcomed the participants to the IRENA special session.

Based on his experience as a former head of a planning support unit at the International Atomic Energy Agency, he described capacity building needs in energy planning in developing countries and importance of making planning methodology available and accessible to energy planners. He explained that the outcome of the session will help IRENA to support its member countries in implementing long-term renewable energy goals into existing power sector expansion plans.

Mr. Rogner further discussed the importance of bridging between the scientific community and practical energy planning, as well as possible role of international organizations like IRENA to facilitate bridging these communities.

He emphasised the importance of scientific knowledge to support the decision making and asked fellow energy modellers gathered in the room to actively participate in the open discussion.

Introduction of the topic:

Ms. Asami Miketa (IRENA, Germany) explained that one of the most asked questions that IRENA gets from its member states is how much renewable energy can we integrate into the power system. To address this question from the perspective of network impacts, IRENA is developing a methodology using a dynamic grid simulation model which is to be applied to a well-defined system. Case studies have been conducted primarily in the context of island grids.

On the other hand, and more relevant to this workshop, awareness on possible operational challenges associated with the higher share of variable renewables, raises questions about the appropriateness of existing long-term (20-40 year time frame) energy modelling/planning tools regarding the representation of variable renewable energy. The perception of the inappropriateness of the existing tools may partly be true and partly untrue. While a large number of projects have been initiated to enhance the modelling features to address challenges associated to the modelling of variable renewable technologies, there are also communication issues with policy makers on the use of modelling tools for planning purposes.

She explained that IRENA is initiating the assessment of modelling of variable renewable energy for policy making, particularly in the context of developing countries. IRENA would like to take advantage of the gathering of the world leading modelling expert at the IEW and this special session is taken to be the inputs to define the scope of the assessment.

Ms. Miketa tentatively defined the question to be answered as: how and to what extent short-term operational characteristics associated with variable renewable energy should be incorporated in the long-term capacity expansion optimization models.

She described four operational properties of VRE that may potentially affect the economic choice of energy mix in the long-run. They are:

1) Intermittent nature of VRE introduces larger variability which requires higher flexibility of the system (i.e., reserves, storage and DSM)
2) Mainstreaming wind turbines is not able to provide inertia or governor response, consequently require higher operational reserves for frequency response in the case of contingency
3) Dispersed nature of sources of wind and solar introduce voltage control challenge over the localized grid which may require enhancement of grid or voltage control system.
4) Cost of connecting remote locations: but the resources do not have to be in remote locations

The operational properties of VRE could be addressed in the long-term investment planning models in various ways, and they may be linked with temporal resolution, cost parameterization, and technical constraints. On each of the points, she translated them into modelling methodological questions and

further discussed possible methodological features to address them. Key open questions include, among others, the level of replication of the flexible system operation in the model (requires temporal resolutions), the parameterization of different type of reserve requirement, assessment of the costs of measures to affect the integration of RE, and the assessment of the grid investment needs associated with RE.

She also discussed the importance of communication. The right terminologies and knowledge need to be established to communicate with the policy makers about the technical feasibility of a given modelling results.

Against this background, she acknowledged that a number of institutions begun looking into this topic and asked the participants to actively contribute in the discussion to identify the knowledge gap and possible solutions.

Input discussion 1:

Mr. Kaare Sandholt (China National Renewable Energy Centre (CNREC), China) presented operational challenges related to variable renewable energy based on Chinese experience. The CNREC is a research institute and develops models focusing on providing policy advice to the government.

He described the power production mix of China over the last 8 years and pointed out that the share of renewable energy is currently small although at the absolute level, the wind capacity is growing rapidly. The added capacity increased about more than 75 GW in last 5 years. However the percentage of renewable energy is not growing.

He then shared the insights on how the model development needs evolved as more renewables are deployed. He showed a slide based on a China's example, and explained that similar patterns are found in most countries including Denmark where he is originally from.

When a country is about to start deploying wind power, little consideration is given to how to integrate them. Also planning questions for long-term investment decisions were not on the table in China before 2013. Once deployment starts, grid planning becomes the first major issue. With occurrence of incidence in the grid due to bad wind turbine, requirement not fulfilled or due to a lack of requirement, the attention is paid to how to maintain grid stability, how to make planning for wind firms, and how to set up a grid code. Particular since 2007 a lot of work have been conducted focusing on grid evaluation modelling to support answering these questions. He is in an opinion, that these analysis has limited relevance to policy making/discussion, and system operators should be able to handle it.

Since around 2009/2010, a curtailment issue became a big problem in some regions of China. How to dispatch a system with the presence of more wind became an important analytical question and modelling of a dispatch of a system is important in this context. An Analytical time frame of hourly base dispatch is sufficiently relevant in most cases.

The next stage would be a more active approach to policy making promoting renewable energy. The key analytical questions become policy measures for RE promotion (CO_2 tax, RE quota, active investment in long distance transmission line etc.) and their impacts. Tools are needed to assess these policy measures.

The results need to be understood by the policy makers and at the same time they should be accepted by the system operators from the dispatch point of view. In Chinese context, least cost optimization models (market models) are suited for evaluation of policies measures.

He acknowledged the difficulty that there is no universal model that can solve all country specific issues, and each issue has its own characteristics and requires a specific model to address it. He emphasised that a model based policy analysis needed to be convincing to the policy makers while it has to be found credible by a system operator.

He then discussed the CNEREC's market model, called CREAM-EDO (China RE, electricity, district heating optimisation model). Transmission constraints among the provinces are explicitly modelled. The CREAM-EDO model is suited and sufficient to respond to current policy making needs in China. This type of model would be suitable for most of countries but use of it would be very different from country to country.

Link to his presentation is found here.

Input discussion 2:

Mr. Elmar Kriegler (Potsdam Institute for Climate Impact Research (PIK), Germany) presented, on behalf of his colleagues, their work on two perspectives on RE grid integration: First, a bottom-up perspective showing the drivers and magnitude of VRE integration costs and second, modelling VRE integration in global long-term models (Integrated Assessment Models) within the EU-ADVANCE project led by PIK.

He discussed that to better inform long-term strategic planning decisions on how much renewable energy can be incorporated into a given regional/national power systems, a good set of models is needed to represent sufficient scope and detail. This is challenging partly because it is difficult to translate high-detail modelling results such that they can inform long-term models with a large spatial and sectoral coverage.

Dispatch models can be used to evaluate the impact of VRE but these are static assessments of a given utility set up. Integration costs can be estimated within a given system. In the case investment models are used, simplified assumptions are needed. The core of the planning challenges is how to integrate these two types of models, i.e. how to consider short-term variability issues in long-term investment decisions.

PIK is coming from a global planning perspectives. They developed tools of how to represent variability and integration challenges in Integrated Assessment Models. Their experience with abstraction and simplification of the integration challenges can be utilized in answering some of the planning questions with respect to RE.

To structure the discussion, he identified three cost components that are associated with integration of RE into the system. They are profile costs (linked with inflexibility and underutilization of existing thermal plants), balancing costs (linked with forecast errors), and grid-related costs (liked with site specificity of

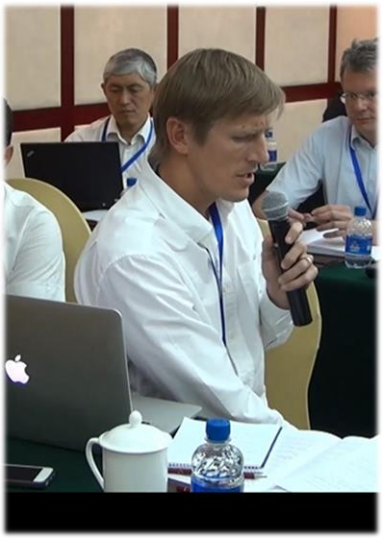
RE resources). Based on the literature survey, profile costs are the most significant, followed by grid related costs and balancing costs, although they are based on the developed countries experience.

Three major initiatives look into how to improve the representation of RE in Integrated Assessment Models. They are JISEA/NREL Renewable Initiative, EMF 27, and EU FP7 ADVANCE project. The EMF 27 reviewed the status quo of how the RE is represented in global models, and identified that the state of the art is not satisfying. Within the ADVANCE project, in order to improve the representation of RE, simplified approaches to represent grid integration challenges are explored by comparing different modelling methodologies.

Link to his presentation is found here. Link to PIK's relevant research papers are found here.

Mr. Rogner commented that simplicity should not be underplayed. Particularly in the context of energy planning in the developing countries, adding extra complexity is not necessarily the best solution, given model based analysis is a communication tool with policy makers.

Invited intervention 1:



Mr. Bruno Merven (IRENA consultant/University of Cape Town, South Africa) spoke about his experience of modelling variable renewable energy in MESSAGE/MARKAL type of models during last few years. His approach to modelling VRE is to approximate some VRE characteristics. For example, he estimated the capacity credit by using average wind and solar maps to represent the level of non-dispatch ability of VRE. He also used GIS information to represented grid enhancement needs associated to disperse location of RE resources. Mr. Merven also started to cross-check the results with dispatch models using "spreadsheet" or "matlab" based tools. Based on this experience, he argued that increasing temporal resolution would help but only to a limited extend as it still does not help accounting the stochastic nature of the VRE. In the developing countries, where the total system size is small, stochastic nature of VRE sources (as well as of thermal units) would impacts the system significantly as one unit would be relatively large compared with the system size. A deterministic approach with demand represented by a single node and characterizing supply with annual average solar maps would not be adequate. There it is necessary to add more details.

Link to his relevant research papers are found here.

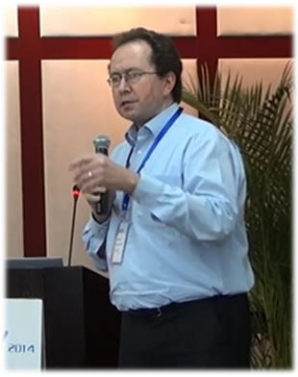
Invited intervention 2:

Mr. Ryoichi Komiyama (University of Tokyo, Japan) shared Japanese experience in modelling the massive integration of VRE in the power system. After the Fukushima accident, it is a national government goal to utilize RE to a maximum extent. His research team is collaborating with the government to develop a super-large linear model with 10 second time resolution and with 100 million constraints, explicitly considering the variability of RE. He offered three take away from his experience. Firstly, modelling transmission line is important, particularly in the case of Japan, because large wind resources are located far away from the demand centre, Tokyo. Transmission line investment is capital intensive, while financial variability of such investments would be an important factor as the utilization rate dedicated to VRE may be low. Secondly, the modelling of ramp-product is very important. In the case of Japan, due to specific meteorological conditions, the capacity factor of wind is estimated to be zero and solar to be near zero. Finally, in order to represent the proper response to the contingency, non-synchronous VRE's inability to provide inertia moment need to be represented. His model uses a matrix called SNSP (System non-synchronous penetration) which is already used by an Irish system operator. In his model SNSP is assumed to be 50%.

He proposes that future research agenda is to change the modelling approaches from modelling supply to meet demand, to modelling demand to meet supply.

Link to his presentation is found here. Link to his relevant research papers are found here.

Invited intervention 3:



Mr. Brian Ó Gallachóir (University College Cork) discussed the importance of modelling the whole energy system rather than the power system alone. Traditionally system operators tend to project forward electricity demand and load profiles based on historical trends and without adequately considering new demands, in particular from the possible electrification of transport and of residential heat. He also discussed the importance of inertia and the fact that VRE generally do not contribute to system inertia. Much attention has been paid to matching the variable supply and demand profiles, but we need also to take into account that wind turbines are typically connected non-synchronously to the grid. Ireland has the world largest penetration of VRE in a synchronous power system in a small island grid; therefore it has been a good test bed for some of the integration challenges. He discussed the benefit of soft-linking different modelling tools which each are suited to addressing different questions. There is no single silver bullet modelling tool - in many cases, different issues and challenges can be best investigated using appropriately selected models. We then need to find clever ways in which different models can communicate with each other. As an example, his team takes the results from an energy system model (focussing on long term energy system evolution) and uses them to build electricity dispatch models (to consider operational power system issues), and feeds the results back into the system model in a form of constraints.

It is important to acknowledge that all the models have strength and weaknesses thus the soft-linking provides opportunities for making use of the strength of each models

Link to his relevant research papers are found here.

Invited intervention 4:

Mr. Manuel Welsch (Royal Institute for Technology (KTH), Sweden) discussed his experience of putting operational constraints into a bottom up model OSeMOSYS. His experience shows that if we focus only on capacity credit and reserve margin, we miss important dynamics in the long-term models. Inclusion of the operational constraints does affect the long-term choice of technologies in a significant way. One way of incorporating the operational constraints is to establish a dispatch model for one year to cross check the results of long-term model. A compromise solution that KTH team had deployed is to include key constraints into the long-term model, such as operating reserve requirement (how much upward reserve, downward reserve, primary and secondary reserves are required, and to which extend a given technology can contribute to this requirement). With this approach, they managed to get the long-term modelling results (based on 12 time slices per year) very close to the detailed dispatch model (with hourly time resolution).

Link to the relevant research papers are found here.

Open interventions from the floor

Mr. Govinda R. Timilsina (World Bank) spoke based on his 20 years of experience with electricity modelling. He expressed the view that if we stay with cost-minimization to be the principal concept, renewable energy will not be competitive for the next decades. It is mainly due to the low capacity factor of RE. Compared to coal, currently solar and wind technologies have a three times lower capacity factor and they are two times more expensive. He argues that the factor of 4 of cost reduction for RE would unlikely to happen in the decades to come. He proposes that modelling approach need to change, from least-cost approach to clear technology promotion approach. As long as we are stack with the least-cost modelling approaches, the renewable technologies will not be part of the solution. There is a trade off between using simple tools and detailed tools, which is why the right balance has to be found against the model development costs. The choice of a tool may not be so relevant because RE is not an economic decision but a political decision. Tools can be useful to provide comfort to the political decision.

Mr. Rogner commented on the importance of representing technological and operational limitations in analysing political commitments on RE.

Ms. Nadia Maïzi (Paris Institute of Technology, France) shared her experience from research work for France to expand RE, in which they developed a criteria for reliability. She discussed that in order to define “proper modelling tools”, questions to be addressed need to be framed appropriately by the policy makers. Only then the modellers can adapt existing models accordingly. This is what her team asked the policy makers. In the context of France, whether nuclear co-exist with RE was the main concern. Their research showed that in fact due to the nuclear help keep the reliability (where Loss of Load Expectation (LOLE) for France - the number of hours per annum in which, it is statistically expected that supply will not meet demand - is less than 30 min in 2014 and increases to 2h30mn in 2016). Their model is able to address the question

of what would be the right level of reliability. The cost and the reliability should be balanced. Each country has its own issues and models have to address those issues.

Link to her relevant research papers are found here.

Mr. Rogner commented that it is important to acknowledge that the reliability requirement may be quite substantially different between developing countries and developed countries.

Mr. Iain MacGill (University of New South Sales, Australia) commented on the use of residual load duration curve and definition of the profile costs. He argued that the profile cost is not specific to the highly variable renewable technologies but it is specific to technologies with low operating costs, for example nuclear. He further discussed that the value of energy is a more important issue. The tendency here is to consider variability as a problem of wind, however it can also be viewed as a problem of coal and nuclear being inflexible. Inflexible plants with ramp rate, minimum utilization rate, start up costs, etc., have lower value than flexible plants. In the long-term modelling, it should not be about imposing costs on renewable, and the modelling methodology need to allow to take into account the fact that inflexible plants have a lower value.

Mr. Geoff Blanford (Electric Power Research Institute (EPRI), USA) commented that this research area is developing fast and that last three years great ideas have been coming out, including those presented at this year's IEW. He discussed two methodological issues. The first point is the importance to use a suite of models. He discussed that the validation of reduced form of models using partial, but rich in detail model would be a good way to go. It is important to have a suite of models. The second point is that the way that the renewable energy price is often not efficient. For example, the solar roof top PV is priced at the fixed retailed price and not with the real time price signal. To reflect such economic/business model aspects of RE is an important agenda, for example in the US context.

Link to his presentation is found here.

Mr. Axel Pierru (King Abdullah Petroleum Studies and Research Center (KAPSARC), Saudi Arabia) discussed a non-OECD country perspective. Most of the bottom up energy system models are useful for a country with competitive liberalized markets and price equals marginal costs. In the non-OECD context, this assumption may not hold. With presence of subsidy, the standard bottom up system model approach may not be useful. A mixed complementarity problem approach would be more useful as it allows analysis of deviations from marginal prices and specific pricing policies.

Mr. Niko Bauer (PIK, Germany) raised three points. The first issue is that published renewable resource potential assessments tend to focus on annual average values, as this does not allow the modellers to capture the variability. Short term variability and inter-annual variability are both important in determining a system configuration to have enough reserve capacity for balancing purposes.

Mr. Shunsuke Mori (Tokyo University of Science, Japan) commented on the impacts of information and communication technologies. Intermittent property is not only on the supply side but also on the demand side. He talked about a presentation made at the Harvard. There was an experiment that the IT-controlled refrigerators were used to balance the supply and demand. Active control of air conditioning system can do the same. Just like the information transmission, energy supply tag can be added to power transmission to allow the demand side management using the new information and communication technologies. Contribution of such IT-controlled devises to demand side management and to balancing the demand and supply needs to be addressed more appropriately in modelling work.

Mr. Manuel Welsh (Royal Institute for Technology (KTH), Sweden) commented on reliability requirement. Understanding how much reserve is required to achieve a certain reliability level is a challenge. It may be worthwhile to consider splitting different reliability level for different users, such as hospitals, households, and industries.

Mr. Sandholt (China National Renewable Energy Centre (CNREC), China) elaborated on the thinking behind the choice of the model for CNREC. Soft-linking the models is important and they also use such an approach. They use electricity and district heating system model, demand side model, technology based model for grid evaluation, and CGE model for economic evaluation. The models are to be soft-linked but not hard-linked. He emphasised that this is a time consuming development effort. The most developed model, electricity and DH model is detailed but flexible enough to answer most of the policy questions. It is not meant for answering very specific research questions, as it takes too many efforts. Thus finding the right balance is important. For example, their power and DH model is deterministic model but introduced statistical representation of wind. This was the same issue with hydropower in North European system. To CNREC, the main research question concerns the inflexibility of the existing power system and the impacts of making it more flexible, thus the selection of the model is done just to be sufficient to address such issues.

Mr. Kris Poncelet (VITO, Belgium) pointed out the relevance of the forecasting mechanisms for renewable energy. He illustrated the impact of new forecasting mechanisms by stating that an abrupt change in balancing market prices was observed in Belgium after the introduction of a new forecasting mechanism. The quality of forecasting impacts the required level of operating reserves needed to guarantee system reliability and might therefore be an important aspect to consider when modelling the integration of VRE in developing countries.

Link to his relevant research papers are found here.

Mr. Jiang Kejun (Economic Research Institute, China) introduced their publication which they put together two years ago on the topic of RE integration. Since then during the last two years the solar PV and wind market grew substantially. Chinese government is interested in RE as clean energy technology to control air pollution, which is why the government decided to give subsidies. It is possible that the RE share can reach 20% by 2050, going beyond their low carbon scenario indicates. The level of demand, technology costs, technical constraints, smart grid development are the key determinant to influence the level of RE. Furthermore, transmission line investment is also an important factor. They have some short-term constrains with transmission line but in the long-term such constraints are expected to be resolved.

Mr. Brian Ó Gallachóir (University College Cork, Ireland) commented that one of the biggest challenges that they face is not necessarily the modelling itself but the engagement of the policy makers. The policy makers look for answers but the models can provide insights rather than answers. It takes time to get the message across that and what the model can provide are insights, not answers.

Wrap up

Mr. Roger summarized the discussion. The first point is that one size of the model does not fit all, which is why a specific model for a specific question is needed. The second point is that long-term and short term do not have to be thrown together. For instance, we cannot know the wind availability and load requirement in 2040. Good top down models that address financial and political considerations, as well as bottom up model that address technical constraints are needed. Concerning the idea of testing the results of expansion planning against detailed dispatch models, he is in an opinion that given uncertainty and difficulty of representing detailed systems and technology configurations, the usefulness of such validation exercise may be limited. He thinks we should not worry about a detailed representation of 30 or 40 years from now.

Mr. Sandholt, while agreeing with the possible irrelevance of representing the future systems in great details, argues the usefulness of such exercise as a way to convince policy makers. To showcase that 'it is dispatchable' is useful way.

Mr. Rogner discusses that educating the policy makers on the policy uncertainty is important and they should understand that the models cannot predict future. Models can provide insights to make a case based on solid analysis.

Ms Miketa thanked the participants for active participation to the discussion and informed that she would follow up with the contributors.

Mr. Yong Chen (IRENA, UAE) emphasised the importance of engaging the policy makers and the role of IRENA to possibly bridge the academics and policy making leading to a better informed policy making. He appreciated guidance and advices from the group.

Research Papers:

Elmar Kriegler:

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- LUDERER G., KREY, V., KATHERINE CALVIN, K., MERRICK, J., MIMA, S., PIETZCKER, R., VAN VLIET, J., and WADA, K. (2013): The Role of Renewable Energy in Climate Stabilization: Results from the EMF27 Scenarios. Climatic Change.http://link.springer.com/article/10.1007%2Fs10584-013-0953-7

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Bruno Merven:

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Ryoichi Komiyama:

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Brian Ó Gallachóir

- DEANE, J.P., CHIODI, A., GARGIULU, M., and Ó GALLACHÓIR, B. (2012): Soft-linking of a power systems model to an energy systems model. Energy 42, p. 303-312. http://www.sciencedirect.com/science/article/pii/S0360544212002551

- DEANE, J.P., ÁINE, D., and Ó GALLACHÓIR, B. (2013): Quantifying the Impacts of National Renewable Electricity Ambitions using a North-West European Electricity Market Model. 10th International Conference on the European Energy Market, April 2013. http://energyexemplar.com/wp-content/uploads/publications/North-West%20European%20Electricity%20Market%20Model.pdf

Manuel Welsch:

- WELSCH, M., DEANE, P., HOWELLS, M., ROGAN, F., Ó GALLACHÓIR, B., ROGNER., H.H. and BAZILIAN, M. (2014): Incorporating flexibility requirements into long-term energy system models – A case study on high levels of renewable electricity penetration in Ireland. Applied Energy. http://www.sciencedirect.com/science/article/pii/S0306261914008836

- WELSCH, M., HOWELLS, M., HESAMZADEH, M., Ó GALLACHÓIR, B., DEANE, J.P., STRACHAN, N., BAZILIAN, M., KAMMEN, D.M., JONES, L., ROGNER, H.H. and STRBAC, G., (2014): Supporting security and adequacy in future energy systems: The need to enhance long-term energy system models to better treat issues related to variability. International Journal of Energy Research. http://onlinelibrary.wiley.com/doi/10.1002/er.3250/abstract;jsessionid=98A995DDE82309A46BCEA4D3AC156313.f03t03

Nadia Maïzi:

- BOUCKAERT, S., DROUINEAU, M., MAZAURIC, V., ASSOUMOU, E. and N. MAÏZI, N. (2013): Smart Grids and Reliability of power supply: Demand response impact on future power mixes. IEEE PowerTech
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- BOUCKAERT, S., MAZAURIC, V. and MAÏZI, N. (2014): Expanding renewable energy by implementing Demand Response. International Conference on Applied Energy. Taipei, 30 May- 2 June 2014.

- BOUCKAERT, S., WANG, P., S., MAZAURIC, V. and MAÏZI, N. (2014): Expanding renewable energy by implementing dynamic support through storage technologies. International Conference on Applied Energy. Taipei, 30 May- 2 June 2014.

- DROUINEAU, M., MAÏZI, M. and MAZAURIC V. (2014): Impacts of intermittent sources on the quality of power supply: The key role of reliability indicators. Applied Energy 116, Pages 333-343. http://www.sciencedirect.com/science/article/pii/S030626191300977X

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