



JOINT NREL-ADVANCE WORKSHOP ON RENEWABLE ENERGY SOURCES

An expert meeting carried out within the framework of the
European Commission FP7 ADVANCE project
Wednesday, Feb 20, 2013, Potsdam

REPORT

Objectives

According to many climate change mitigation scenarios, the variable renewable energies (VRE) wind and solar are key options for mitigating greenhouse gas emissions. Since their energy source fluctuates, they increase the challenge of matching load with electricity generation. Options for ensuring grid stability include storage, increased geographical averaging through increased transmission lines, or demand-side management.

Integrated Assessment Models (IAMs) are the main tool to analyze the long-term energy system transformation pathways needed for stringent climate mitigation, and are accordingly used to derive long-term targets for deployment of variable renewable energy technologies. IAMs face a considerable challenge concerning their temporal resolution: They have to span a whole century to cover the relevant long-term climate dynamics, while also representing the effects of very-short-term dynamics (down to hourly scale) on investment decisions in the power sector. Also, they require aggregated resource potential data sets to represent the regionally differentiated availability of solar and wind resources.

The aim of this expert workshop was to bring together IAM modelers and experts on variable renewable energies to discuss the development of consistent, up-to-date resource potential datasets, to explore the main characteristics of the VRE system integration challenges as well as ways to represent these integration challenges in IAMs. The agenda was organized around two main sessions, the first covering the existing knowledge and main insights from VRE experts, the second covering the IAMs and defining the interfaces and collaborations to transfer the expert knowledge into IAMs. The workshop connected the modelling efforts in the ADVANCE project with the existing Renewable Initiative coordinated by NREL and IRENA to maximize synergies between the two projects.

Part I: Stock-taking (Chair: Elmar Kriegler)

The workshop started with a welcome and short introduction to the workshop objectives by Elmar Kriegler, Coordinator of the ADVANCE project.

RE Working Group: Improving the Representation of Renewable Energy Technologies in IAMs for Climate Scenario Analysis (Doug Arent, NREL)

Doug Arent provided an overview of the work NREL has done on analyzing variable renewable energies in the US, including the Western Wind and Solar Integration Study and the Renewable Electricity Futures Study. Using detailed grid models and taking a systems perspective allowed to analyze both negative and positive system effects of increasing the share of wind and solar in power systems.





Arent stressed the importance of continuous interaction and exchange between IAM modelers and VRE experts working with more detailed models, and offered an intensive collaboration between NREL and the ADVANCE teams. In order to facilitate this interaction, the Renewable Initiative was created, which is a vessel for exchanging data and modeling approaches between different modeling and research teams.

A further focus point was the problem of resource potential dataset derived from coarse resource data. This was illustrated on the example of an NREL wind potential analysis for the US, where most of the good wind sites were overlooked when using reanalysis data on a 120km grid, compared to using reanalysis data derived from a more detailed grid level.

RES and IAMs: Lessons learned from EMF27 & plans for ADVANCE (Gunnar Luderer, PIK)

Gunnar Luderer presented insights from the previous modeling comparison study EMF 27 on the deployment of renewable energy in IAM scenarios. While a substantial increase of renewable energy is robust across most models, the size of this increase varies strongly between different models. Three main determinants for VRE deployment were identified in the course of the EMF27 study: resource assumptions, technology cost assumptions, and the modeling of VRE integration challenges.

Luderer then explored how WP5.1 of the ADVANCE project could contribute to reduce the uncertainties on these drivers, with a special focus on developing improved modeling approaches for representing integration challenges.

Objectives and Activities of the International Renewable Energy Agency (Asami Miketa, IRENA)

Asami Miketa presented IRENA's activities concerning analysis of VRE integration and capacity building on VRE modeling. With a membership of 160 countries, IRENA is uniquely positioned to take a country-by-country view on VRE integration and explore the similarities and differences between different countries' challenges. They especially focus on questions from emerging economies and less developed countries, having performed a study on VRE integration in Africa and planning to do a similar exercise in Latin America. IRENA thereby offers a complement to the US/EU-focused experts from NREL and DLR, and could help the IAM modelers to develop parameterizations for all world regions.

System integration – a bottom-up taxonomy (Falko Ueckerdt, PIK)

Falko Ueckerdt presented a categorization of integration challenges based on three distinct characteristics of VRE, namely that their output is variable, that their output is uncertain, and that VRE resources are location-specific. These three characteristics can lead to system integration costs, which can accordingly be classified as profile costs, balancing costs, and grid-related costs. Based on a substantial literature review and preliminary modeling exercises, profile costs seem to be substantial, grid costs are lower but still relevant, and balancing costs seem to be of a negligible size when taking an aggregated IAM viewpoint. Ueckerdt then elaborated options to reduce integration costs, and how they might be represented in IAMs

RE resource potentials (Patrick Sullivan, NREL, and Yvonne Scholz, DLR)

Patrick Sullivan presented ongoing work at NREL to create a new resource dataset for onshore wind, based on CFDDA reanalysis data from NCAR. Once finished, this dataset might be used and implemented by the ADVANCE modeling teams. He made a proposal for a suitable data format for exchange with the IAM teams, and a dataset vetting process was defined in the ensuing discussion.





Yvonne Scholz discussed the global renewable data available at DLR, and proposed to create a dataset for the two solar technologies photovoltaics and concentrating solar power. Exclusion areas have a substantial effect on resource potentials, so it would be beneficial to either harmonize exclusion assumptions or allow resource dataset users to specify criteria for exclusion areas.

Representation of RE integration in IAMs (Yvonne Scholz, DLR and Patrick Sullivan, NREL)

Concerning the challenge of VRE system integration, Yvonne Scholz briefly presented the REMIX model and its main characteristics. REMIX is a Dispatch and Investment model that covers all European countries and covers a full year in hourly time steps. It therefore allows to analyze both the local integration challenges from wind and solar, as well as the benefit that improving the grid connection between different countries can have in smoothing VRE feed-in and thereby reducing integration challenges.

Patrick Sullivan then discussed NREL work on VRE integration and emphasized the offer to directly assist with implementing new modeling approaches in IAMs. During a research stay at IIASA, he had integrated new constraints into the MESSAGE model to better represent additional requirements for power system flexibility arising from VRE additions. The MESSAGE parameterization was based on a large number of runs with a more detailed power system model by NREL.

Part II: The way forward (Chair: Leon Clarke, PNNL)

Exchange on the different IAMs current integration approaches

In the following, each of the participating IAM teams briefly presented the approach currently implemented in their IAM, envisioned improvements in the process of the ADVANCE project, as well as needs in terms of resource potential data, time series or technology parameterizations.

Leon Clarke, GCAM (PNNL)

GCAM takes a two-pronged approach. For the US, the model encompasses 4 time slices to which VRE contribute differently, and the model can trade between different load segments with the help of a storage technology. For the rest of the world, electricity is a homogeneous good, and integration costs are added as VRE-shares increase.

Shinichi Fujimori, AIM/CGE (NIES)

Due to its CGE nature, AIM does currently not have a detailed technology representation of VRE integration challenges, but rather relies on the substitution stiffness of the CGE formulation.

Tobias Wiesenthal, POLES (JRC)

POLES recently increased the number of renewable technologies included in the model. Concerning VRE integration, it requires back-up capacity when VRE-shares increase, and there is a region-specific hard upper bound on VRE shares. The POLES team is working on introducing storage, and thinking about adding a dispatch sub-module with hourly resolution to better represent the challenges of VRE integration.





David Gernaat, IMAGE (PBL)

IMAGE has a number of explicit VRE integration challenges, but the parameterization is outdated and was based on very coarse data. Also, the interaction between the back-up capacity constraint and the investment algorithm creates an implicit upper bound for VRE deployment.

Nils Johnson, MESSAGE (IIASA)

MESSAGE is working on the introduction of explicit equations for capacity adequacy and system flexibility together with NREL. Further plans for ADVANCE work include the addition of concentrating solar power as well as regionally differentiated parameterizations of the integration equations.

Giacomo Marangoni, WITCH (FEEM)

WITCH contains an aggregated wind/solar-technology, with integration challenges implicitly represented in the limited substitutability of the CES production function. Plans for ADVANCE work are to split the VRE technology into explicit wind, PV and CSP technologies, as well as adding explicit integration constraints.

Robert Pietzcker, REMIND (PIK)

REMIND currently contains explicit wind, photovoltaics and concentrating solar power technologies. As VRE shares increase, the model requires storage to be built and also curtails some of the produced electricity. Plans for ADVANCE are the introduction of residual load duration curves to better represent the interaction between VRE and the rest of the power system.

Main points raised in the discussion about the way forward:

Doug Arent, NREL: It would be good to have diagnostic scenarios from all the IAMs to allow judging the realism of the currently implemented approaches. Questions to ask are “do you get a realistic amount of VRE?”, “can you do 450 without nuclear and CCS?”, “what is the impact of the new resource dataset?”.

Elmar Kriegler, PIK: What is the added value of running the new scenarios? We already have the EMF27 scenarios. The main difference between the models will be the difference in integration modeling.

Leon Clarke, PNNL: Scenarios would help to do fingerprinting of the models. We shouldn't see the scenarios as “results”, rather as “development work”, or as part of the stock-taking/ diagnostics.

Gunnar Luderer, PIK: As ADVANCE is more about modeling than about scenarios, we should try to have a limited number of scenarios. Next steps should be: taking stock of the integration approach, tailor the VRE potentials, clear up problems with the reporting template, run the scenarios.

Patrick Sullivan, NREL: We need to start improving the IAMs – let us not waste time on more scenarios when the main task is modeling.

Robert Pietzcker, PIK: To start working on the IAMs, we first need the diagnostic scenarios to show us where the main problems lie, and how to prioritize. With IAMs, it is not possible to “add every realistic constraint there is” – IAMs are too numerically demanding. You need to identify the most important constraints.





Tobias Wiesenthal: To test the limits of the integration challenge: try to force the models into very high RE shares. Shouldn't we also think about renewable heat?

Gunnar Luderer: WP5.1 focused on power system. RE heat would be interesting, but only if all other power sector aspects are covered.

Asami Miketa, IRENA: It would be good to have some IAM scenarios with high VRE shares to allow analyzing what would be the impact of high VRE deployment on climate mitigation and economic development.

Robert Pietzcker, PIK: To improve VRE modeling in IAMs, it would be extremely useful to have a large number of scenarios with different wind and solar shares calculated by a more detailed, hourly power sector model. These scenarios could then serve to parameterize IAMs, validate existing modeling approaches or assist the creation of new algorithms.

Yvonne Scholz, DLR: Currently, REMIX is mostly used in "validation mode", where we check if a set of VRE and conventional capacities can meet load in each hour of the year in the EU. It could probably be improved to a "greenfield investment mode", where optimal capacities for different VRE shares are calculated. This might then be used to create a number of scenarios to which IAMs could be compared.

Gunnar Luderer, PIK: Given the number of IAMs and bottom-up experts contributing to this WP, it might be useful to publish the results and findings together in a Special Issue in a suitable journal.

Doug Arent, NREL: A special issues sounds like a promising idea to have a wide visibility of the results. Possibly, John Weyant would be willing to host the Special Issue in "Energy Economics".

Next Steps

1. Finish wind potential data set (NREL)
2. Iterate with IAM teams (NREL, PIK, all teams)
3. Do stock-taking of integration approaches (PIK)
4. Define scenario matrix: (PIK/NREL)
 - a. old/new resource potentials
 - b. high/low integration costs
 - c. high/low technology costs
 - d. no Nuclear, no CCS
5. Define reporting template (PIK)
6. Run scenarios (All teams)
7. Organize an ADVANCE WP5.1 meeting at the SNOWMASS workshop, where the scenarios can be discussed with VRE integration experts from NREL (NREL/PIK)

The next months will be used to collect in-depth information on both the current implementation of VRE Integration in the models as well as the approaches envisioned by the pioneer models MESSAGE, REMIND and POLES to start content-based interactions between the teams. Furthermore, possibilities for the interface and information exchange between the DLR and the large-scale IAMs will be developed until the next meeting. Also, a cooperation with the Renewable Initiative was started that could lead to improved renewable data input to the IAMs.

