IRENA Workshop on

Addressing the Geo-Spatial Aspects of Variable Renewable Energy in Long-Term Planning

12-13 December 2019 Bonn, Germany

Session concept notes

Content

The Overall Goal of the Workshop

Since 2015, IRENA has been supporting its Member States to enhance the quality of energy planning and modelling with high shares of Variable Renewable Energies (VRE) through the AVRIL project, short for 'Addressing Variable Renewables in Long-term Energy Planning'. IRENA launched its first report under the AVRIL project in 2017, focusing on strategies for practitioners to represent VRE in long-term modelling of crucial system requirements, including the representation of adequate firm capacity, system flexibility, transmission capacity, and stability. Those strategies have since been disseminated to energy planning practitioners in governments through several regional workshops in South East Asia, Central Asia, Latin America and the Arab region.

The unique geospatial aspects of VRE were introduced in the first AVRIL report, in the context of representing transmission investment needs within the long-term generation and transmission capacity expansion planning, and how this may be assisted with geo-spatial data. Since then, accessibility to geo-spatial data and tools has been significantly improved, and hence increasingly included in the government planning processes. Another emerging aspect is for planners to better reflect potentials for distributed renewable energy pathways, including embedded generations and decentralized rural electrification in the long-term energy planning process both in well-developed and under-developed grid systems.

Experts worldwide have rolled out novel and sensible approaches to such issues, but a clear overview of options for energy planning practitioners is still needed to broaden their application. To address this gap, IRENA plans to develop a thematic update of to the first AVRIL report which elaborates the geo-spatial aspects of VRE in long-term energy planning, along with practical examples of solutions to reflect those aspects in long-term energy scenarios. The ultimate objective of the report is to equip energy planners of Member States with practical knowledge regarding analysis and methodologies to represent the geospatial characteristics of VRE in long-term energy models used for national energy policy planning purposes.

In the past, the AVRIL project has benefited by bringing together the global research community and government planning practitioners to find practical solutions relevant to energy policy planning. In keeping with that tradition, this workshop intends to invite experts, researchers and institutions to share their insights with government planners and contribute to the upcoming IRENA report on long-term modelling of VRE with geo-spatial analysis.

The workshop has three main objectives:

1. To discuss the current use of geospatial information in long-term energy planning processes of governments;
2. To collect inputs from experts on the latest developments regarding data and methodologies that could bring practical advancements;
3. To discuss the planning methodologies and interlinking geospatial aspects, that help to optimise the VRE linked long-term investments falling under multiple concern areas such as system flexibility, grid infrastructure and electrification pathways.

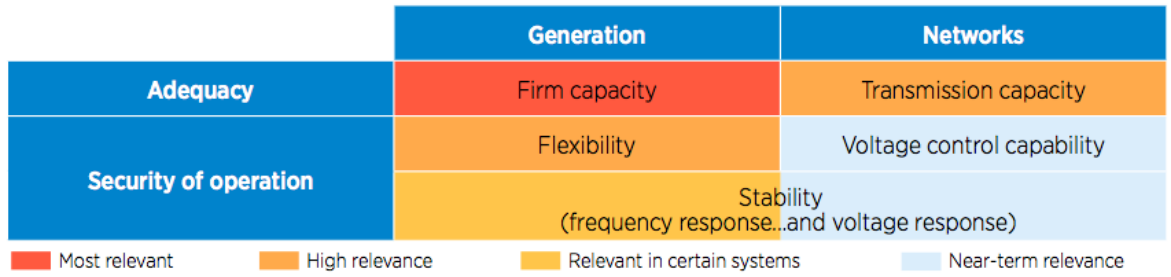
Information Notes for Workshop Day-1: Thursday, 12th December 2019

Session 1: Introduction

9:15 – 10:00

The session will feature two presentations from IRENA. It will start with an introductory presentation giving an overview of the workshop structure, a recap of the 2017 AVRIL report and IRENA regional workshops on long-term energy planning, followed by a scene-setting presentation describing the IRENA AVRIL findings in regards to spatial impacts of VRE on long-term investment planning, identified solutions, supporting data and tools and a brief context on potential new topics relating to planning of distributed generation based on VREs.

The AVRIL report established key system properties that are affected by the high penetration of VRE in power systems, as shown below. Some of these properties are more directly relevant for long-term investment decision making than others. The report discusses how best to reflect these considerations in long-term capacity expansion planning. Chapter 4 discuss the increased model resolution as a cross-cutting solution, while Chapter 5 to 8 discuss solutions to address firm capacity, flexibility, transmission capacity, and stability constraints, respectively. The relevance of the geospatial aspects is mentioned throughout the report.



Session 2: Country Experience

10:00 – 10:45, Part-1
11:05 – 11:50, Part-2

Session brief:

The objective of the session is to get insights into the geo-spatial depth in the national/regional long-term energy planning processes of governments. The energy planning practitioners invited to speak at this session have been developing long-term energy scenarios for national policy-making using modelling tools either within a respective national government or within specialised agencies affiliated with a government. The planning practitioners are asked to briefly present the geospatial features of analytical frameworks involved in energy planning within their respective countries.

The session will start with a short overview presentation from IRENA, sharing the general findings collected through regional workshops held in Africa, Central Asia, Latin America and the Arab region. The rest of the session will be comprised of short presentations by energy planning practitioners.

Session Format: 10 minutes of presentation for each presenter including a couple of minutes for Q&A

Guiding Questions for the Presenters:

Presenters are requested to address the following key questions during their presentations:

1. What are the roles of energy system modelling in long-term policymaking?
2. What methods are used to estimate and account for geospatial factors in long-term energy planning models? If applicable, how are capacity credit of VRE, transmission constraints and flexibility requirements addressed?
3. What kind of geospatial data resolutions, processing tools and widgets are used and how and where do you get your data from?
4. What are the challenges in representing long-term VRE impacts and limitations of current geo-spatial tools and long-term energy models to capture this?

Session 3: Increasing Spatial Resolution of Long-term Generation Expansion Models

11:50 – 13:00

Session brief:

Building on Chapter 4 of the AVRIL report, the objective of the session is to discuss a balance between the benefits of increasing model resolutions on the one hand and keeping a model simple on the other. In this regard, the discussion will start with agreeing on essential long-term investment implications linked with VREs, and then discuss smart ways of improving spatial resolution beyond simply increasing it further.

Long-term energy planning models used for generation expansion planning have a long (15-40 years plus) planning horizon, which limits greater spatio-temporal detail, often because of limited computational capability. On the other hand, temporal details are crucial for models to capture the variability of demand and supply. Conventionally, supply-side variability was not always a significant factor, but this has changed with VRE expansion. Insufficient representation of the variability of supply could lead to a sub-optimal or even an inadequate capacity mix, as the costs linked with periods of VRE over- or under-production are insufficiently represented, and the need for flexibility in the system may be underestimated. Given the VRE's temporal characteristics and resource availability are strongly linked with their geographical locations, model spatial details play an equally essential part in capturing supply variability. However, this can be expected to multiply the computational workload.

This session will focus on all the benefits and challenges of increasing spatial resolution. The session will start with an introduction by the moderator, followed by two input presentations highlighting the additional analytical capabilities to generation expansion models brought by increasing their spatial resolution. Authors of the two studies that were cited in the AVRIL report will share insights from NREL's Regional Energy Deployment System Model (ReEDs) and DLR's REMix model. Input presentations will be followed by moderated open discussion.

For further reading: [AVRIL report chapter 4.2]

Proposed guiding questions for the presenters and moderators:

The key guiding questions for the session are as follows:

1. What is the location-specific spatial and temporal characteristics of VRE that are essential to be captured in long-term expansion planning?
2. To what extent it is advisable to increase spatial modelling depth depending on the following objectives:
    a. Generation Adequacy
    b. System Flexibility
    c. Transmission Capacity
    d. Any other objectives (e.g., demand-side response)
3. How to deal with trade-offs such as computational effort and complexity which comes with increasing spatio-temporal resolution? What is the right balance of increasing complexity vis a vis keeping it simple and practical for the purpose of government planners? Are smart spatio-temporal aggregation methods solutions?

Introduction to the session by the moderator

The moderator is asked to give a brief discussion of the AVRIL chapter 4 and introduce the above-described objectives of the session.

Presentation block

Format: Two input presentations of 10 minutes each followed by 5 minutes of Q&A each (either with the audience or with the moderator)

The moderator may like to ask the speakers follow-up questions aiming at elaborating speakers' views on the session objectives.

Moderated discussion block – ca. 35 minutes

Format: Open discussion comprising moderator questions, insights, audience comments and insights from their experiences

Opening intervention from Ms Marianne Zeyringer, Associate Professor (Energy Systems), University of Oslo

Moderator is requested to engage the planning practitioners as much as possible so that the discussion is kept relevant to their needs, rather than driven by research interests.

Session 4: GIS tools, Data-processing Widgets and Climate Impacts

14:00 – 15:45

Session brief:

Following Session 3, where the data needs for long-term capacity expansion models have been established, the objective of this session is to generate further insights into long-term modelling data and its pre-processing requirements, while keeping in mind data intensity and accessibility challenges faced by many government's practitioners.

This session will focus on GIS data availability, quality matrices and pre-processing practices in the context of long-term energy planning. Following the introduction of the session by the moderator, and building on a review of the data sources and methodologies cited in the AVRIL report, the session will start with two input presentations highlighting state-of-the-art GIS tools and datasets that interface with long-term energy models employed by NREL and the Joint Research Center of the European Commission. A third presentation will be given by IRENA to discuss the available GIS data services from the IRENA Global Atlas team.

Finally, this session introduces a new topic of capturing climate change impacts and representing global climate scenarios, when preparing input RE data for long term models. We will explore the insights on the data sources for long term climate variables, available spatio-temporal resolutions and related pre-processing needs such as data bias corrections. The session would also try to interlink the impacts of long term hydrological changes relating to climate change. An expert researcher from Vrije Universiteit Brussel will share his insights on this topic.

After the input presentations, a researcher from Flemish Institute for Technological Research will give a five minutes demonstration on a Dynamic Energy Atlas for Belgium which will be followed by moderated open discussion.

For Further reading: [AVRIL report chapter 5.1 & 7.2]

Guiding questions for the presenters and moderators:

The key guiding questions for the session are as follows:

1. What is the status of quality and availability of geospatial data and pre-processing tools from online platforms and services?
2. What are the most practical geospatial data resolutions, e.g. in terms of GIS grid size, temporal granularity (i.e. hourly or quarter-hourly) at different geographic scales? How accessible are they?
3. How effectively can open-source or commercially-available geospatial data (including online zoning information resources) be used in the generation capacity expansion planning performed by governments?
4. How do climate change scenarios interlink with forward-looking RE resource predictions and to what extent are geospatial dimensions relevant in this regard?

5. How to address uncertainty linked with meteorological variables under climate change scenarios (namely radiation, wind speed and precipitation)?

Introduction to the session by the moderator

The moderator is asked to introduce the objectives of the session described above.

Presentation block

Session Format: Four input presentations of 10 minutes each followed by 5 minutes of Q&A each (either with the audience or with the moderator)

The moderator may like to ask the speakers follow-up questions aiming at elaborating speakers' views on the session objectives.

Moderated discussion block – ca. 40 minutes

Session Format: Open discussion comprising moderator questions, insights, audience comments and insights from their experiences

Opening intervention by Craig Hart, IEA

Moderator is requested to engage the planning practitioners as much as possible so that the discussion is kept relevant to their needs, rather than driven by research interests.

Session 5: Distributed Variable Renewable Energy (VRE)

Unlike other sessions, these parallel sessions address topics that are not covered in the current AVRIL report. The participants will be divided into two groups depending on their interest.

Both sessions follow the same format as below.

Introduction to the session by the moderator

The moderator is asked to introduce the objectives of the session described below (see guiding questions).

Presentation block

Session Format: Two input presentations of 10 minutes each followed by 5 minutes of Q&A each (either with the audience or with the moderator)

The moderator may like to ask the speakers follow-up questions aiming at elaborating speakers' views on the session objectives.

Moderated discussion block – ca. 40 minutes

Session Format: Open discussion comprising moderator questions, insights, audience comments and insights from their experiences

Moderator is requested to engage the planning practitioners as much as possible so that the discussion is kept relevant to their needs, rather than driven by research interests.

Parallel Session 5A: Grid-connected Distributed VRE

16:15 – 17:30

Session brief:

The objective of this session is to generate insights into the relevance of grid-connected distributed renewable generation resources for long-term expansion planning, and how they can be better captured in such models (especially those employed by governments).

Use of VREs, particularly solar PV, has rapidly expanded its role as generation connected to distribution grids, serving the load near its origin. Compared to candidate centralised generation resources, such distributed VREs are small, modular and manifest in large quantities. Being located within distribution segments of the power supply chain, the visibility of these resources to planners is a key challenge to capture in the traditional model of centralised generation expansion planning. Distributed VREs also have a direct impact on how much ‘residual’ demand should be reflected in traditional models for planning generation adequacy, flexibility requirements and transmission capacity. Cost-effective management of distributed generation, by definition, therefore requires the integration of

conventional generation planning with transmission and distribution planning. It also calls for being open to unconventional solutions which may be needed to reflect sector-coupling initiatives, aggregated operations, or incentivising consumer preferences.

This session will focus on all the aspects of grid-connected distributed generation that directly affect the key system properties that are considered under the optimisation objective of long-term generation expansion planning. Following the introduction of the session by the moderator, the session will start with two input presentations by experts from FZ-Juelich and TU Munich, addressing how distributed VREs can be reflected in long-term planning. Input presentations will be followed by moderated open discussion.

Guiding questions for the presenters and moderators:

The key guiding questions for the session are as follows:

1. What are long-term investment implications linked with grid-connected distributed generation based on VREs and to what extent do these resources substitute investments in non-distributed generation and transmission?
2. To what extent grid-connected generation need to be captured by long term capacity expansion models, and what should be the modelling depth? Should there be a recommended threshold of a distributed-VRE share, above which implications should be captured in long-term planning?
3. What are the challenges in incorporating the grid-connected distributed generation in long-term expansion models?
    a. Data
    b. Future evolution of the hourly generation profiles
    c. Uncertainties around fast-developing digitalization trend and technologies around it

Parallel Session 5B: Distributed VREs - Energy access, rural electrification, mini-grids, stand-alone technology

16:15 – 17:30

Session brief:

The objective of this session is to generate insights on incorporating rural electrification planning in long-term power systems planning, and the use of geospatial information to facilitate the planning process.

In many developing parts of the world, expanding access to electricity is a key priority. In addition to grid extensions, off-grid systems such as mini-grids and standalone systems are also options for rural electrification. The use of renewables (such as solar PV) is also increasingly explored as a generation option for unelectrified communities. The planning process will have to assess the technical potential and cost/benefit of each of these options. To do so, one needs to consider the spatio-temporal

availabilities of resources, as well as the different physical locations, sizes and consumption patterns of rural communities.

The reliability and cost of connecting to the grid will affect the extent of electrification through grid-extensions, but at the same time, the choice of electrification options will have implications on those grid characteristics. For example, grid-extensions to previously unelectrified communities would increase centralised electricity demand. Long-term planning of centralised power systems will, therefore, have to address rural electrification planning in a more integrated manner. A challenge lies in harmonising the different spatial granularities considered by the plans.

All the aspects state above will be the points of focus during this session. Following the introduction of the session by the moderator, the session will start with two input presentations by experts from PBL Netherlands and KTH Sweden, addressing how the development of distributed VREs under the broader context of electrification can be reflected in long-term central energy planning. Input presentations will be followed by moderated open discussion.

Guiding questions for the presenters and moderators:

The key guiding questions for the session are as follows:

1. What are the key challenges of rural electrification planning?
2. How should the development of distributed VREs in the context of energy access be reflected in long-term planning, especially in deciding between grid extension, mini-grids, and stand-alone systems? What are the factors driving decisions on mini-grid vis a vis grid extension?
3. What are the strategies for harmonizing the requirements (such as the granularity of data) and outcomes of long-term planning of centralised power systems and electrification planning?

Session Concept Notes for Workshop Day-2: Friday, 13th December 2019

Session 5 (continued): Joint discussion of parallel sessions 5A and 5B

09:30 – 10:00

The moderators of the parallel sessions 5A and 5B will brief the entire group the summary of discussions during the respective sessions, followed by participant remarks, questions and answers.

Session Format: 10-minute brief by a moderator of a respective parallel session, followed by 5 minutes of additional remarks from the audience

Session 6: Representing grid investments in capacity expansion models

10:00 – 12:10 (Coffee Break from 11:00 till 11:20)

Session brief:

Building on Chapter 7 of the AVRIL report, the objective of this session is to discuss the methodologies to incorporate the grid investment needs linked with VRE investment in the long-term capacity expansion models, and assess to what extent the advanced model-based approaches that employ geo-referenced information are effective and practical.

Location specificity of the VRE sources may imply significant transmission investment costs when planning long-term scenarios with high shares of VREs. In the AVRIL report, two types of approaches were discussed: simplified approach based on exogenously defined relationship between the VRE investment and transmission investment ("linking grid investment needs with VRE expansion" – AVRIL chapter 7.1), and more advanced approaches that integrate geo-referenced data directly into the generation planning decisions ("site-specific representation of generation and transmission" – AVRIL chapter 7.2).

The simplified approach may be suited for applications to global or regional modelling analysis where incorporating the geo-spatial information to a full scale is not practical. There may be cases that such a simplified modelling approach is required for national application as well. Approaches that we identified in the AVRIL report include linking the transmission investments to VRE exogenously outside a generation expansion model and then generically adding to VRE investment costs (e.g., establishing and implementing a per-unit transmission cost for VRE capacity). Such an approach may include developing a transmission grid cost function and optionally may include distribution cost function based on expert assessments.

The other approach is to determine transmission costs linked to VRE resources within long term generation models using a higher number of geospatial nodes, each represented with temporal demand and generation profiles. Such kind of models can capture the trade-off between resource quality and grid investment needs of candidate VRE resources. It also accounts system flexibility to a greater extent while optimising generation resources, especially when aided by underlying grid models. Although data intensity and complexity of such kind of models is often a challenging factor for government practitioners, simplifications can be brought. Iterative soft linking between long and short term models can be one option. Other option could be to use zoning based approach which interfaces explicitly identified VRE zones having distinct transmission cost mark-ups along with the advantage of co-optimizing multiple sectoral preferences while defining VRE zones such as road accessibility, transmission route acceptability by public/private authorities.

In this session, we seek to explore different approaches to better reflects the grid investment needs in the generation expansion modelling. After the introduction of the session objective by the moderator, the session will start with two input presentations by the experts from DNV-GL and DLR Germany, discussing the simplified approaches cited in AVRIL report of 2017, and the recent developments since then.

They are followed by two more inputs presentations by an expert from the University of Patras, highlighting the use of the geospatial information in their multi-nodal approaches, and by an IRENA expert highlighting the use of zoning approaches in the IRENA SPLAT model of Africa.

For further reading: [AVRIL report chapter 7]

Guiding questions for the presenters and moderators:

The key guiding questions for the session are as follows:

1. Can the simplified approach of using grid costs based on per unit VRE capacity be established as a rule of thumb and what's the effectiveness of these approaches?
2. How does the representation of grid investments affect generation investment decisions in long-term models?
3. How critical is it to represent the possible trade-off between resource quality and transmission investment in long-term capacity expansion models? What are the relevant uncertainties involved and how to address them?
4. What are some geospatial case studies to employ methodologies that co-optimize generation, transmission and flexibility investments in the long term?
5. What are the approaches to evaluate infrastructure requirements beyond power systems, e.g., gas, district heating system? How do we make a holistic assessment of the energy sector including distributed generation options?

Presentation block

Session Format: Four input presentations of 10 minutes each followed by 5 minutes of Q&A each (either with the audience or with the moderator)

The moderator may like to ask the speakers follow-up questions aiming at elaborating speakers' views on the session objectives.

Moderated discussion block – ca. 50 minutes

Session Format: Open discussion comprising moderator questions, insights, audience comments and insights from their experiences

Moderator is requested to engage the planning practitioners as much as possible so that the discussion is kept relevant to their needs, rather than driven by research interests.