IRENA IEW 2023 Side Event

Planning for the renewable future: electricity demand profiles in the clean energy transition

13 June 2023; 12:15-13:45
Location: Friedhoff Hall, Green Center • Colorado School of Mines • Colorado, USA

Event Proceedings

Background

In 2017, IRENA published the report *Planning for the Renewable Future – long-term modelling and tools to expand variable renewable power in emerging economies*, to provide an overview of the considerable knowledge that had been developed to represent variable renewable energy (VRE) sources like solar and wind in long-term models. This report benefitted immensely from thoughtful engagement during IEW side events held in Beijing in 2014 and in Abu Dhabi in 2015, as well as thorough commentary by a number of conference attendees during the review process.

IRENA is now expanding on its work under the *Planning for the Renewable Future* series, through thematic reports which aim to address additional methodologies in long-term planning and modelling that can foster the integration of high shares of VRE.

As all energy planners and modellers know, perhaps the most basic function of long-term analysis is to understand how future supply will meet future demand. While the representation of VRE supply has continued to improve since the release of IRENA's *Planning for the Renewable Future* in 2017, the representation of electricity demand continues to be a common challenge. While this has always been the case, due to the naturally uncertain socio-economic drivers behind electricity demand, additional complexities have emerged as part of the ongoing clean energy transition. Low-cost VRE in combination with digitalization is enabling power sector-coupling with transport, industry and buildings which will affect the size and profile of electricity demand, as well as how flexible it may be in the future. **Understanding how to best represent future electricity demand profiles in the context of the clean energy transition will be crucial to ensure that VRE supply can continue to be expanded at pace.** Developing countries face an additional challenge of planning for rapid demand growth, as well as the changing nature of what electricity may be used for.

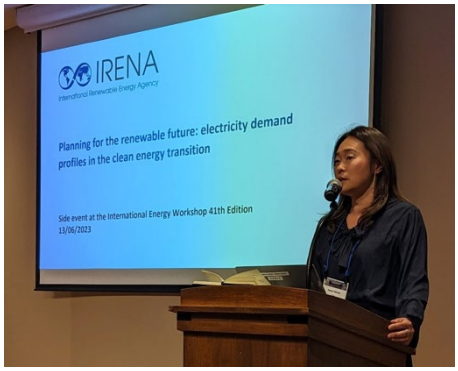
For this reason, IRENA's next thematic installment of the *Planning for the Renewable Future* series will aim to provide an overview of best practices, tools, and methodologies to develop electricity demand profiles in long-term planning and modeling, to make better-informed decisions for the integration of high shares VRE.

Event summary

Welcome

Brian O'Gallachoir (University College Cork), host of the side event, welcomed the attendees and expressed his hope that they were enjoying the conference and their meal. He introduced the topic of discussion, which centered around the evolving role of demands in power systems models. The goal was to explore how power systems can be adjusted to accommodate these changes, understand the challenges they present, and determine if the current models are suitable for these purposes. Brian shared his background as the host of the International Energy Workshop in 2016. He also mentioned his long-standing involvement with IEW since 2008 and highlighted the importance of the IRENA side event, as well as the tradition of connecting IEW with the summer workshop and the International Energy Agency technology collaboration program on energy systems modeling. Brian expressed delight at being a sponsor of IEW and mentioned an upcoming workshop they would be hosting. He emphasized the value of the IRENA side events in facilitating discussions on various aspects of energy modeling. Previous discussions in Abu Dhabi and Beijing focused on renewable energy, and the current event aimed to continue that conversation by exploring demands in renewable energy power systems. Brian introduced Asami Miketa from IRENA, who would deliver the opening presentation. Following the presentation, there would be a panel discussion featuring leaders in the field to address questions regarding the role of demand, challenges in integrating it with variable renewable energy supply, and the adequacy of existing models. Brian encouraged active participation from the attendees, inviting their contributions, thoughts, and reflections on the challenges faced in understanding the changing dynamics of power systems and the availability of sufficient data and suitable models.

Opening presentation



Asami Miketa (International Renewable Energy Agency) introduced herself as a representative from IRENA based in Bonn, Germany. She mentioned that the institution has been supporting the IEW since 2012 and explained that IRENA is an intergovernmental organization focused on assisting governments and policymakers in planning and transitioning to a sustainable energy future. She emphasized the importance of bridging the gap between policymaking and the scientific community. She highlighted the benefits of the side events organized by IRENA, and cited examples of workstreams at IRENA, such as the AVRIL project on addressing variable renewable energy in long-term energy planning and the LTES Network, which is a community of government practitioners working on scenarios. She mentioned the participation of the United States and thanked the EIA for joining the LTES network. Asami acknowledged their collaboration with ETSAP and Brian, expressing gratitude for their contributions. She also mentioned collecting valuable information and conducting surveys to understand the interests of government practitioners. The results showed that the scientific

community is considered important, leading to the focus of the side event on demand profiles. Asami discussed the need for predictability in energy systems due to the expected increase in solar and wind energy and the electrification of various sectors. She also mentioned the evolving consumption patterns, human behavior, market response to policies, and climate impacts as crucial factors to consider in long-term scenarios and energy modeling. The presentation concluded by highlighting the questions that would be discussed during the event.

Scene setting interventions

Brian O'Gallachoir (UCC) invited several experts to share their insights on the expected changes in demand profiles, specifically related to the electrification of various sectors. The panelists included Jeff Blandford from Electric Power Research Institute (EPRI), Doug Arent from National Renewable Energy Laboratory (NREL), Anna Krook Riekkola from Luleå University of Technology (LUT), and Bruno Merven from the University of Cape Town (UCT).

What are the expected changes in the demand profile due to the electrification of end-use sectors, such as mobility, heating in buildings, and industry, and how will this impact electricity usage in the short to medium term? how the electrification of mobility is going to impact on our electricity demand profiles?

Doug Arent (NREL) mentioned that there is significant modeling experience and expertise in this area, particularly for the light-duty fleet, with several models developed in the US and other countries. He emphasized the importance of considering the linkage between behavior, market structure, and demand profiles. Unmanaged mobility demand can have negative effects on the operation of power systems, especially those relying on renewable energy sources. He raised questions about how to model and understand the operating environment, particularly in terms of managed charging profiles. Doug pointed out that the level of detail regarding the demand profile is still uncertain and subject to numerous questions. While a significant increase in demand is expected due to electrification, the specific details and nuances of the demand profile remain to be explored further.

How do you perceive the profiles of energy demands in Africa, considering a different context and focusing not only on mobility but also on other aspects of energy use?

Bruno Merven (UCT) mentioned that there is a significant expectation of electrification in cooking. However, he highlights that many countries in Africa lack established demand profiles, which leads to spending a lot of time gathering data for the base year of modeling. Bruno also emphasized the importance of considering the industry's structure in different geographies, as it presents exciting opportunities. It's not just about electrification in cooking and transportation but also about the impact on mining and the transition from diesel generators to alternative sources. He highlighted that the uncertainty surrounding the rate of electrification and its growth rate should be considered when modeling the energy system in Africa.

In terms of industry, we have heard about the possibilities in the electrification of industry, including the switch to hydrogen which also has an associated electrical demand. Do we have a good understanding of the energy use profile in industry, particularly in relation to this trend towards electrification?

Anna Krook Riekkola (LUT) stated that there is a preliminary understanding of the consistent energy requirements in industries. However, the uncertainty lies in the extent of electrification and the number of industries in each country. In Sweden, for example, many industries are relocating to take advantage of renewable energy opportunities. She mentioned that scenarios suggest a wide range of potential electricity demand increases, ranging from 100 TWh to 200 TWh or even 3 times that amount. This uncertainty needs to be considered when analyzing industry electrification and electricity usage. Regarding the use of hydrogen in industry, she highlighted that it is desired as a constant energy source, however, a flexible approach can be adopted by producing excess hydrogen during periods of cheap electricity and storing it for use during times of higher prices. She explained that this flexibility can assist in managing fluctuations in wind energy production. The main challenge is the cost of hydrogen electrolyzers, but research indicates that larger electrolyzers may be more cost-effective, contributing to better energy balancing.

In the context of demand variability and the challenges of managing it, is there anything specific you would like to add regarding demand variability in buildings? What are the key strategies for managing demand in the context of VRE-demand power systems?

Jeff Blandford (EPRI) highlighted the importance of both electrification and efficiency in the building sector. While electrification and efficiency measures offset each other in terms of total electricity demand, they have significant impacts on demand patterns and people's behavior. He mentioned that the results show a shift towards winter peak demand, driven by factors like vehicle charging and temperature effects on batteries and that this shift requires a different approach to capacity planning. He emphasized that modeling could provide a structural understanding of demand flexibility, particularly with the increasing share of renewable generation and the flexibility of vehicle charging. However, he mentioned that challenges exist in terms of user participation, infrastructure, and charger availability, especially in aligning charging infrastructure with solar generation. The cost of providing enough flexibility is another consideration, as the value of flexible demand is a small component relative to the total cost of the service. He also mentioned that flexibility can be applied in different time scales, addressing both energy capacity needs and operational adjustments for consistency.

Given the power system's need for high time resolution to ensure reliable electricity supply, a challenge arises when incorporating new energy demands into the system that may not require the same level of time resolution. In this context, what are the key factors that need to be considered in developing strategies to effectively manage the power system in the face of increased demand variability and supply-side variability from renewables?

Doug Arent (NREL) suggested that there are various approaches to identifying manageable segments and areas of flexibility in energy services to effectively manage demand. He used fleet charging as an example, highlighting the need for fleet vehicles to be fully charged within specific timeframes. While this demand pattern can be modeled and analyzed, it is essential to determine if the overall system can support it, including local storage. Additionally, he mentioned that there is potential demand that is subject to market conditions and participant willingness, whether it be from households, industry buildings, or consumer vehicles. Doug highlighted that utilizing concepts like virtual power plant aggregation or connectivity charges

can help assess visibility and market participation, however, the success of these models depends on having the necessary structures, consumer behavior policies, and regulations in place. He emphasized the importance of addressing questions related to consumer engagement, excitement, and appropriate policy and regulatory frameworks to effectively manage demand.

Generally, our models are better at capturing technology than human behavior. What strategies do you think should be considered when it comes to managing a power system with high levels of variable renewables and a changing demand profile?

Bruno Merven (UCT) mentioned that having flexibility in both operational and installation processes is crucial when managing a power system with high levels of VR and changing demand profiles. He suggested that it is important to have the ability to roll out new capacity at a pace that aligns with the variability of renewables. This requires adequate infrastructure, such as credit infrastructure, to support the installation of new capacity as needed. Bruno also raised the question of how to ensure model resilience and incorporate the concept of resilience when running models for capacity planning.

Are our current models capable of effectively dealing with the uncertainties and complex interactions between technology, markets, policy, and society when it comes to managing high levels of uncertainty, such as VR and changing demand profiles? In other words, are our models fit for purpose in capturing and addressing the multifaceted challenges presented by these uncertainties?

Anna Krook Riekkola (LUT) explained that the effectiveness of models varies depending on the approach used. Stochastic programming and examining optimal solutions are two approaches, but there's also value in looking at the potential production flexibility for different purposes and exploring how it can work in reality. She highlighted that rather than trying to capture every detail, running various scenarios and exploring different measures and flexibility solutions can provide insights into what can happen and identify important opportunities.

Where should we prioritize improvements in models to better capture uncertainties and complex interactions? Do you have any reflections on how we can enhance the models to capture these aspects more effectively?

Jeff Blandford (EPRI) suggested that there are two key aspects to prioritize when improving models for capturing uncertainties and complex interactions. Firstly, the structural piece, which involves understanding how the structure of electricity demand is changing and how it influences changes in the demand profile. He mentioned that this requires incorporating incentives, replications, and technologies with more detail to gain deeper insights into these profiles. Secondly, dynamic flexibility is a challenging aspect to incorporate into power system models, and it may take time to develop commercial tools for it. However, he added that using models in an optimization context can help showcase the potential value of load shifting and guide decision-making regarding market opportunities and areas for improvement, such as demand response from industrial customers.

Doug Arent (NREL) emphasized the importance of collaborating with social science colleagues to gather more data on consumer behavior and expectations. He suggested that incorporating this data into models can help challenge persistent myths, such as the belief that electric vehicles need to be charged every night. By breaking down these paradigms and obtaining granular data, the modeling approach can be improved and aligned with actual consumer behavior.

Anna Krook Riekkola (LUT) agreed with the importance of collaborating with social scientists and suggested being selective in choosing the right researchers to work with. She recommended focusing on social scientists who are forward-looking and exploring potential future behaviors, rather than those solely focused on historical patterns. Anna emphasized the need to consider the possibility of behavioral changes and to explore different scenarios for the future.

Inputs from the floor

Contribution 1 (economist from India):

She mentioned that she works at the intersection of energy, environment, and development. She is currently involved in designing a national-level scheme in India that focuses on promoting solar-based induction cooking in rural areas. One of the key challenges they face is the need for battery support due to unreliable grid connections and low-capacity electricity connections in these areas. She shared that they have been working with the Ministry of Power to design a solution that involves battery support. However, the cost of implementing this solution, at around 1000 USD per household, has been a hurdle. In addition to the rural scheme, she mentioned that they are also combining the induction cooking initiative with an existing urban solar rooftop scheme to provide incentives for urban users to invest in solar-based solutions. The researcher has also conducted studies on how farmers are transitioning from diesel-based to solar-based systems, finding that solar farms can effectively replace diesel-powered water pumps but not electric fans, resulting in significant carbon emissions reduction.

Contribution 2 (School of Mines in Paris):

He provided his contribution, focusing on the European context and the challenges related to security of supplies and long-term flexibility. He emphasized the impact of extreme events on variable renewable output, mentioning the occurrence of low wind events during the night in winter. He highlighted the cascading effect of these events, where multiple instances can significantly affect the security of supply and the sizing of long-term facilities. Additionally, he discussed the modification of winter demand load, particularly in relation to the introduction of heat pumps for heating decarbonization in France and Germany. He also emphasized the importance of considering the uncertainty and sizing of long-term flexibility to accommodate the increasing demand from heat pumps.

Contribution 3 (biologist at the US Geological Survey):

She emphasized the need to consider variability in operational constraints, in addition to load variability, in power systems. The researcher highlighted the example of Germany, where bat monitoring is used to forecast and manage curtailment requirements to reduce collisions. She suggested that more research and forecasting efforts should be focused on minimizing conflicts and improving the balance between generation and load in the context of renewable energy technologies, such as wind turbines. She also mentioned the need for similar practices in the United States to address potential conflicts and optimize system performance.

Contribution 4 (postdoctoral researcher from the University of Texas at Austin):

He provided insights from a systems thinking perspective regarding the first question. He emphasized the importance of considering the reciprocal relationship between the electrification process and the changes in demand profile across different end-use sectors. The researcher stressed the need for a holistic analysis that encompasses both aspects, rather than examining them in isolation.

Contribution 5 (electrical engineer pursuing a PhD in sociology):

He shared his perspective on the integration of social sciences in research. He highlighted the challenges of collaboration between different disciplines, noting that initial attempts may be inefficient due to differences in approaches and goals. He mentioned that engineers tend to focus on specific targets and may not fully consider human factors, while social scientists explore diverse aspects such as individual behavior and social assessment. Despite these challenges, the contributor emphasized the value of interdisciplinary collaboration and he believes that it would enhance the research community.

Contribution 6 (Somnath Basj):

He shared their thoughts on the first question regarding the cooking situation and the need for battery storage. He suggested that Pumped Storage Hydro (PSH) could be a more suitable solution than costly battery storage. He mentioned that India, being a tropical country with abundant wind and solar resources, has great potential for renewable energy generation. He also mentioned the potential energy capture from rivers, particularly in the northern part of India, and highlighted the work of the Indian Institute of Technology (IIT) in this area.

Contribution 7 (visiting researcher from Turkey at the Colorado School of Mines):

He shared his perspective on the challenges of electrification and the importance of collaboration with universities. He expressed their concern about the potential problems arising from heavy reliance on electrification and emphasized the need to address current issues and explore alternative approaches. He also mentioned their work on analyzing satellite images and utilizing AI algorithms to study geothermal resources and subsurface conditions. He appreciated the community for providing a platform that bridges the gap between scientists and practitioners.

Contribution 8 (Norwegian University of Life Sciences):

He highlighted the increasing domestic demand in a state they studied, particularly during mornings and evenings. He mentioned that the government is currently investing heavily in solar energy, due to its cost-effectiveness, instead of focusing solely on managing demand, the contributor suggested considering supply management as well. He emphasized the importance of looking at the issue from both demand and supply perspectives.

Contribution 9 (Argonne National Laboratory):

She discussed the importance of managing charging practices for electric vehicles to optimize the system's capacity and minimize the need for extensive battery storage. She raised the question of how to incentivize consumers to adopt managed charging behaviors. She proposed a capacity-based approach, suggesting that consumers could receive bill credits for keeping their unmanaged charging below a specified level each month. She expressed curiosity about calculating the capacity value of EVs that are grid-managed and the potential impact of such a credit-based incentive. She believed that this approach might capture people's attention more effectively than existing incentive schemes.

Closing

Brian O'Gallachoir (UCC) expressed gratitude for the diverse and valuable contributions made by the participants, which covered various topics including rural contexts, energy security, social sciences, bats, and pump hydro. He appreciated the opportunity for both panel discussions and audience participation, which was intentionally designed to encourage engagement. He also extended thanks to IRENA for organizing the event and anticipated a summary of the proceedings to be made available on the website. He concluded by inviting any additional remarks from Asami.

Asami Miketa (IRENA) expressed her gratitude to Brian and acknowledged the valuable contributions made by the participants. She noted that due to time constraints, some colleagues may not have been able to share their contributions and encouraged them to reach out to IRENA representatives for further discussion. Asami reassured everyone that she and her team would be available until the end of the event to address any queries or engage in further conversations.