Scenarios Forum 2019

Proceedings of Session #35: Renewable-based Electrification: How can we Improve Scenarios for Clean Energy Transition?

Part of IRENA's CEM Campaign "Long-term Energy Scenarios for the Clean Energy Transition"

9:00 – 10:45, Wednesday, March 13, 2019
University of Denver (Joy Burns Center, JBC 231)
Number of participants: 20
Target audience: Energy modellers

While clean electricity is one of the main enablers for a clean energy transition, representing transition pathways with high shares of electrification across sectors is evolving territory to many models and scenarios. Accounting for the contribution of variable sources of energy (e.g. solar and wind) and associated technology solutions in end use can be challenging, for example, given limitations in geospatial and temporal granularity. Furthermore, innovation related to digitalization may have profound impacts on the fundamentals of future of energy systems, thus compounding the uncertainty inherent in long-term scenarios.

Against this background, this session aimed to address the question – how can long-term energy scenarios better account for the potentially transformational changes related to renewables-based electrification? Panellists presented recent work on long-term energy scenarios that approaches this question from various geographical and sectoral angles, and where gaps need to be filled to better represent the complexities of this topic.

This session will inform the Campaign on "Long-term Energy Scenarios (LTES) for the Clean Energy Transition", organized under the umbrella of the Clean Energy Ministerial (CEM). The session was co-organized by IRENA and JISEA/NREL, the operating agent of the Campaign and a technical partner to the Campaign, respectively.

Programme

Moderator: Jeffrey Logan (Chief Analyst, Strategic Energy Analysis Center, NREL)

9:00 - 9:05: Introductory remarks from the Moderator

9:05 - 9:25: Introductory presentations

- Daniel Russo (IRENA)
- Jeffrey Logan (NREL)

9:25 - 10:25: Panel interventions (each ca. 15 min oral presentation, 5 min Q&A)

- *Electrification Futures: Scenarios for Demand-Side Adoption in the United States*; Caitlin Murphy (NREL)
- *Electrification in Baltic energy technology scenarios*; Tomi Lindroos (VTT Technical Research Centre of Finland)
- *What future for electrofuels in transport? - Analysis of cost-competitiveness in global climate mitigation*; Mariliis Lehtveer (Chalmers University)

10:25 - 10:45: Panel discussion and open interventions from the audience

[Poster session]

- *Future fuels in the shipping sector assuming stringent CO2 reduction scenarios: Results from the global energy transition (GET) model*; Maria Grahn (Chalmers University)

Summary of the discussion

1. Introductory presentations

Two introductory presentations were made to provide background on the topic and frame the session:

Daniel Russo (IRENA) began with a presentation that outlined emerging issues in energy scenario development, and a new CEM Campaign on Long-term Scenarios for the Clean Energy Transition led by IRENA to address those issues. He introduced the specific focus of the session, on three questions related to electrification in long-term scenarios:

- What aspects of deep electrification based on renewables are missing in current long-term scenarios of clean energy transitions to 2030-2050?
- Where do presenters see the largest uncertainties in the evolution of electrification with renewables?
- How can the complexities and uncertainties of deep electrification based on renewables be better reflected in LTES?

Jeffrey Logan (NREL) then followed with a presentation which provided background on NREL's work and another important CEM Campaign – the 21st Century Power Partnership – which addresses issues across the spectrum of power system transformation. He introduced the session's panellists and the ongoing NREL Electrification Futures Study, which simulates electricity demand in a highly electrified future for the United States – the focus of the first panel intervention – and how it could be supplied.

2. Panel interventions

Caitlin Murphy (NREL) began by highlighting the complexity of electrification as a topic – as it spans multiple sectors and jurisdictions, meaning the power sector may have to respond to signals in other parts of the economy in a more accelerated fashion than in the past. In this context, the aspects of electrification leading up to the interaction with renewable energy supply – i.e. the demand-side impacts of deep electrification. The main theme of the presentation is the need to apply high-resolution modelling across a broad scope to understand the effects of electrification in a meaningful way, in several dimensions – technological, spatial, and temporal.

The Electrification Futures Study is a multi-year, multi-report project to work on this issue, with the first publications addressing how electric technologies may evolve over time (based on an extensive scenario analysis of cost and performance in buildings, transportation, and industry), how they could feed into demand-side adoption scenarios, and how that could affect load profiles (based on a high-resolution "dsgrid" model of hourly profiles by end-use equipment types). Ongoing and future work is now looking at supply side and broader power sector impacts of widespread electrification.

In terms of technologies, granularity in both cost and performance is key - e.g. the efficiency of end-use equipment will have a large impact on the extent to which and way in which it could help with renewables integration. The temporal resolution of the load profile modelling in the EFS study can also give a sense of how an aggregated demand profile of a given electric equipment stock may align with renewable resources in a particular area, or how substitution or shifting could affect that alignment.

Results from the EFS electric technology adoption work find that in a scenario of transformational electrification (based on strong policy support), 61% of space heating, 52% of water heating, and 94% of cooking services could be electrified by 2050 in the buildings sector. It was reiterated that the high-technological granularity across sectors is key to provide insights for renewable integration planning, given various demand profiles and flexibility characteristics of different equipment compositions. Similar themes are present in transportation sector results, which show different penetrations in specific categories (e.g. transit buses vs. light-duty vehicles) despite 76% electrification of miles travelled in a high scenario. A broad insight from the results is the need to not only focus on annual demand growth for planning, but also peak demand growth; the study shows peaks can change significantly—in terms of magnitude and timing during the year, both of which are region-specific—and this requires adequate modelling resolution to understand.

Clarifying questions:
[Audience - PIK]: US electrification currently at 20% and study explores potential doubling of that share – is infrastructure (e.g. transmission and particularly distribution lines) sufficient to cope with this or does it pose a planning issue?
A: Current study does cover transmission, including both long-distance transmission capacity (to send electricity to demand centers that are far away from generation sources) and spur-line capacity (to connect new renewable plants, for example, to the existing network). Distribution system impacts are also being studied now, to determine extent of necessary upgrades or mitigation using distributed energy resources.

[Audience - Boston University]: What is the role of efficiency? Seems to be substantial opportunity for managing amount and timing of consumption.
A: Currently being studied in capacity expansion modelling – see that varying efficiency of technologies doesn't involve so much of a shift in technology demand (only in aggregate), but rather a significant impact on how much the bulk power system needs to be expanded to accommodate the same level of electrification.

Jeffrey Logan (NREL): Regarding transport, see very little shift in diesel for heavy-duty trucks – is there a reason they wouldn't be fuelled by hydrogen or biofuels?
A: This is due to the scope of the study, which so far focused only on plug-in EVs and hybrids.

Tomi Lindroos (VTT) introduced the Baltic Energy Technology Scenarios work, which provides further insights into electrification by also exploring the decarbonisation of supply options for electricity, district heating, and other energy sectors in the three Baltic countries. Modelling was performed by soft-linking two energy system models to better cover overarching EU-wide energy and climate targets and still provide detailed modelling of power and heat sector. TIMES-VTT was used to model

electricity and heat demands, and Balmorel was used to model detailed supply for power and district heating, including the integration of variable renewable generation.

One of the key findings, which is common in other similar studies, is that power and heat lead emissions reductions by providing clean electricity and heat to other sectors – e.g. in the Baltic results, emissions from electricity and district heating reduce by ca. 90% by 2050. From a decarbonisation perspective, only after those sources are decarbonised does it make sense to increase electrification of transport, as such electrification would otherwise fail to reduce transport sector emissions (this is particularly the case in Estonia which uses significant oil shale to produce electricity). It was also found that a lack of decarbonisation/electrification options in industry could result in medium-term emissions growth if industrial activity is assumed to increase.

Large-scale electrification was also found to be the cheapest way to achieve both emissions reduction and renewable energy targets in the study, particularly due to wind and solar PV cost declines. In terms of district heating, large heat pumps emerge as the cheapest source when supplied by low-cost wind power in the region. In a relative sense, the largest increase in electrification comes in the transport sector (roughly none to ca. 30% by 2050), given that other sectors with higher current shares of electrification increase at a slower pace. It was noted that this echoes results shown in the previous intervention, despite different models and geographies.

Looking at weekly supply dispatch from the modelling, a result that stands out is the high dependence of least-cost results on what other EU countries decide to do, given lower cost – and thus lower import prices – of other countries renewable resources. This speaks to the importance of clarifying relevant geospatial boundaries for electrification scenarios and planning. Political decisions related to the share of cross-border interconnection will be important determinants. Another interesting result was to see the district heating network used as small-scale storage on a diurnal basis, through use of low-cost solar to generate district heating cheaply with large-scale heat pumps in the afternoon to be used later on. Speaking to the importance of time resolution and understanding peak demand, however, it was found that some less-utilised thermal capacity still needed to remain online to meet winter heating needs.

A key final point regarding the sensitivity of electrification results to assumptions around legislation or taxation – e.g. a 30 EUR/MWh grid tariff effectively blocked entry of large heat pumps when added to the model.

Clarifying questions:
[Audience - Chalmers University]: Potential of options to decarbonise cement and steel industries through electrification? Example of Swedish initiative to do so was given.
A: This example is the only one known that could be in place at least in the next five years or so – in strong decarbonisation scenarios the modelling defaults to CCS for these end-uses and industrial processes.

[Audience - PIK]: For the transport sector, is the model simply a cost comparison or does it somehow take into account spatial elements such as distribution of cities, population density, or infrastructure, and whether those help or hinder electrification?
A: Given the lower spatial granularity of the TIMES model, transport demand is an exogenous assumption, which is taken from the dedicated transport models used by the countries.

[Audience - Central European University]: Were any specific support policies assumed for EVs?
A: Only cost competitive deployment in the results, based on assumptions and an additional 10 EUR/MWh penalty to reflect infrastructure costs.

Mariliis Lehtveer (Chalmers University) introduced her presentation on the topic of electrofuels – carbon-based fuels made from carbon dioxide and hydrogen with electricity as the primary energy source (e.g. methane, methanol, gasoline, etc.) – but from a broader perspective of global decarbonisation. These fuels are increasingly present in regional and country-level studies, with motivations ranging from absorbing excess variable renewable power generation to increasing running hours of dispatchable generation. For the transport sector, electrofuels may represent a potential alternative to bioenergy, which could have more beneficial applications elsewhere. Electrofuels may also have the advantage of using existing infrastructure and equipment stock, particularly in energy-dense transport applications.

Under stringent global climate change mitigation scenarios, however, the role of electrofuels and factors driving their penetration has however not been studied thus far. Using a cost-minimising systems engineering model of the global energy system (GET) out to 2100, a wide range of scenarios were developed to explore this issue, varying cost of electricity from variable sources, and the availability of biomass, carbon storage, and hydrogen in transport. Initial results show that electrofuels only emerge in the transport sector in the absence of carbon storage, as the value of permanently removing carbon from the atmosphere is higher than reusing and re-emitting it under stringent climate targets. This result was robust to a Monte Carlo analysis, which was performed with 500 model runs with and without storage also varying extra parameters such as cost of electrolysers, synthesis reactor and direct air capture. Without carbon storage, however, the cost of renewable electricity and level of synthesis efficiency begin to play a role in penetration of electrofuels. Without considering climate targets, the current costs of electrofuels make them unlikely to be adopted at a large scale on a competitive basis. A general insight from these findings is thus the importance of also considering the global context of regional or sectoral studies, particularly how that context could change the most cost-effective application of electrification technologies.

Clarifying questions:
Caitlin Murphy (NREL): Tested sensitivity of result to cost of storing carbon geologically? E.g. middle cost scenarios?
A: Yes, there are also scenarios which vary the cost of storage, but do not significantly affect the results.

Jeffrey Logan (NREL): Assuming low-temperature electrolysis in the study? Surprising to see little variation even if electrolyser process less expensive.
A: Yes re. electrolysis method, with varied efficiency. Our sensitivity analysis covers the whole cost range.

Tomi Lindroos (VTT): Speaks to one of the biggest assumptions in IAMs, whether CCS is available or not.
A: Agreed, and important to note that without carbon storage (i.e. less than 500 GT of storage available), results do show electrofuels emerging in all model runs.

[brief discussion re. future studies in shipping and aviation]

3. Panel discussion and open interventions

Jeffrey Logan (NREL): What do the results of these studies tell us about the need for R&D on key electrification technologies – what might be the most important breakthroughs to make these results realistic?

Caitlin Murphy (NREL): Sees transportation as a key area given the large opportunity and relatively fast transition seen possible in modelling. There is especially room to take recent breakthroughs in light-duty vehicles and expanding them to other transport sectors.

Tomi Lindroos (VTT): Would agree about transport, and would add district heating and large heat pumps – there is relatively less research in this area given it's not important in many countries, but for those with extensive district heating systems or potential, it is a challenge

Mariliis Lehtveer (Chalmers University): Regarding district heating from a broader climate change mitigation perspective – would caveat that we may not want to electrify bio-based systems if they can contribute at some point to negative emissions, as for that large point sources are needed. From an ongoing study on long-term decarbonisation in Sweden, finds that there is still a lot to do in industry electrification. The potential for industry to support long-term variation management may also prove to be important, given that flexibility in heating and transport sectors is largely shorter-term.

Tomi Lindroos (VTT): An additional point that in the case of very limited sustainable biomass resource, would consider more difficult-to-decarbonise sectors such as aviation to be potentially more critical than heat.

[Audience – IIASA]: From the angle of scenarios and mitigation scenarios in particular, there is a strong challenge even to the Shared Socio-economic Pathways (SSPs) that scenarios are out of date with recent developments in solar and wind costs, which are enabling transition even in the absence of strong climate policy – given that, do the panellists have thoughts on non-cost policies that could be needed? And do they see other systemic shifts needed for transition (e.g. fuels) possibly happening based on renewable innovation in the absence of climate motivation?

Caitlin Murphy (NREL): In terms of power sector, have done scenarios with carbon policies which are meant to reflect things done historically, and actually see deeper emissions reduction purely based on economic sensitivity, e.g. low-renewable cost trajectories.

Mariliis Lehtveer (Chalmers University): A comment that in an ongoing study actually struggling to use the SSPs since they're not ambitious enough for Europe, to reflect existing targets what's already happening.

[Audience - Boston University]: Having looked at this from a city scale in Boston where they are considering the electrification of thermal load a s a potential solution, sees three core drivers – the cost of renewables but also T&D capacity; cost of energy efficiency; and the cost of storage (electricity, thermal, grid vs. small scale). These costs and potentials are going be significantly different depending on location, so micro-level drivers (e.g. district and local decision making) and scenarios will be driving evolution in many cases. Finds that having clarity on the technological outlook is important for planners to understand boundaries.

[Audience - Chalmers University]: Would also recommend expanding focus to revenue streams as well as costs – new revenue streams and opportunities to offer flexibility in different markets can drive adoption of electrification technologies (particularly in heating).

Tomi Lindroos (VTT): Would agree that heating is an example of something that is often very locally-driven, e.g. it's the jurisdiction of municipalities, cities, or an individual company to decide how urban areas are supplied. Their revenue (based on market structure and/or regulations) can therefore determine the possibilities for electrification – have ongoing work to model investments of individual companies and see if it aligns with higher-level scenarios.

Caitlin Murphy (NREL): EFS study also has upcoming work to investigate utility business models and how they may impact electrification (and vice versa).