# Proceedings of the G-STIC Session:

## Planning energy positive solutions

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

**13:30 – 15:30, Thursday, November 29, 2018, Brussels**

## Event background

The world's energy system is facing profound changes. Innovations in the way energy is generated, distributed and used, as well as the ways in which energy systems operate and link with wider infrastructure, are paving the way for completely new landscapes around the world. Those with responsibility for policy and investments are looking to minimize the risk of poor choices and take full advantage of disruptive technologies. However, the expansion and decentralisation of actors and technologies in new clean energy landscapes can create uncertainty and pose significant challenges in coordination. Long-term energy scenario analysis – which explores socio-technical pathways over 20+ years – has traditionally been an invaluable tool in addressing such issues, but **are today's long-term energy scenarios up to the task of capturing transformational change?**

As part of IRENA's new Clean Energy Ministerial Campaign (CEM) on "Long-term Energy Scenarios (LTES) for the Clean Energy Transition", this session aimed to answer that question. Drawing on the expertise of government planners, scenario developers, and attendees at G-STIC, the event explored:

- What aspects of the relationship between centralised and new decentralised technologies or solutions are missing in current long-term scenarios of clean energy transitions to 2030-2050?
- How can the relationship between centralised and new decentralised solutions be better reflected in LTES?
- How can long-term energy scenario development be harmonised among national and sub-national levels and stakeholders? Examples of good practice?

After interventions by an expert panel, the audience was invited to share their thoughts on the topics in an open and dynamic discussion, which will contribute to the output of IRENA's CEM LTES Campaign.

## Programme

**Moderator: Dolf Gielen (Director, IRENA Innovation & Technology Centre)**

**13:30 - 13:40: Introductory presentation from Moderator**

**13:40 - 14:30: Panel interventions (spoken, ca. 7 min each)**

- Aisma Vitina (Special Advisor, Danish Energy Agency)
- Alec Waterhouse (Head of Modelling, UK Department for Business, Energy and Industrial Strategy)
- Pieter Boot (Head of Department, PBL Department of Climate, Air and Energy)
- Tiina Koljonen (Research Team Leader, VTT Technical Research Centre of Finland)
- Felix Matthes (Research Coordinator, Öko-Institut)
- Alex Roehrl (Sr. Economic Affairs Officer, UN DESA)

**14:30 - 14:45: Moderator questions and panel discussion**

**14:45 - 15:30: Open interventions and interactive discussion**

# Summary of the discussion

## 1. Introductory presentation

The session was opened by the **Moderator, Dr. Dolf Gielen, Director of the IRENA Innovation & Technology Centre** who welcomed the participants to the side event, being held as part of the "Energy Positive Communities" track of G-STIC.

He noted that IRENA has received many questions from its 159 member countries regarding the best strategies to introduce more renewables as part of an overall energy transition, which is a more difficult question today than it was 20 years ago. The reason being that we see at this moment a lot of innovations coming together – both on the energy side, and in areas that have direct impact on the sector, notably digitalisation (e.g. blockchain, aggregators peer-to-peer trading, etc.). The question is now which of these are really important for the coming decades. At the same time, there is the question whether today's models suited to address the impact of these new options, as they are typically based on centralised generation, with one-way electricity flow form the grid. What we see now is very different, with examples like a rooftop solar PV system, attempting to maximise self-consumption with a battery and EV connection, potentially selling electricity to your neighbour – a model not in the mind of model designers 20-30 years ago.

He then raised another important issue around infrastructure and the transition. Especially in Europe, there is a strong emphasis on decarbonisation scenarios for 2050, and big questions remain around what a decarbonised system would look like, and are models suited to assess this type of transition.

With these types of questions in mind, Denmark and Germany initiated a new Campaign under the Clean Energy Ministerial, on Long-term Energy Scenarios for the Clean Energy Transition, with IRENA as operating agent. He noted the three main focus areas of the campaign: 1. Better development of scenarios; 2. Better use of scenarios for decision making; and 3. Capacity building for scenario development and use. With 11 countries and a number of high-level technical partners joining the campaign – many of which are represented in this panel and audience – it is clear these topics are timely and important ones.

Noting that the session will lean toward the themes of transition and innovation seen at G-STIC thus far, Dr. Gielen outlined the discussion's three guiding questions:

- What aspects of the relationship between centralised and new decentralised technologies or solutions are missing in current long-term scenarios of clean energy transitions to 2030-2050?
- How can the relationship between centralised and new decentralised solutions be better reflected in LTES?
- How can long-term energy scenario development be harmonised among national and sub-national levels and stakeholders (where decentralised solutions are often planned)? Examples of good practice?

To begin the discussion, an example was given of the difficult decision many now face whether to maintain, upgrade or go beyond existing gas grids – these are fundamental decisions that lock in infrastructure and major investments for half a century, but there is uncertainty around how to proceed due to emerging new – and often decentralised – options.

## 2. Panel interventions


**Aisma Vitina (Special Advisor, Danish Energy Agency (DEA))** began by outlining two points she would like to get across for the discussion: 1. Data availability and transparency, and 2. Modelling capabilities, and what we're actually optimising for.

To give a sense of the Danish experience in these areas, particularly linked to issues of centralisation and decentralisation, she gave the example of Denmark's long experience with "Technology Data Catalogues" which contain up-to-date and reviewed costs and characteristics of energy technologies. The creation of the catalogues coincided with Denmark's heat planning law in response to the oil crisis, as planners envisioned a greater role for district heating, which is very decentralised – there are currently in Denmark 6 large city networks, and around 400 more decentralised district heating networks. To develop the necessary expertise for such an expansion, the DEA began the systematic process of providing key assumptions, data, and methodological planning advice, with municipalities to choose how centralised vs. decentralised their approach would then be.

Ms. Vitina then gave another example of Danish wind power, which for many years saw standard farm sizes of only three windmills (i.e. quite decentralised but still grid-connected, and therefore necessary to account for in national planning) – from the first entrants of these in 1977, there is publicly available data on production from every turbine, which has high value for both developers and grid planners. This example, along with Denmark's district heating experience, shows the importance of data openness, transparency, and sharing between national and decentralised stakeholders to support planning processes.

Moving to her second point, Ms. Vitina noted that it is key to understand what models are optimising for – if your model is only capable of representing centralised options then of course they will not arrive at decentralised alternatives, which also need to be included (e.g. solar rooftop, EV options). There is also nothing necessarily special *a priori* about centralised vs. decentralised options, rather one should opt for solutions that make sense in context. The example is given of the Danish requirement to prove socio-economic benefit for expansion of district heating networks, or transition to individual heating options.

A final point was made on progress being made in other parts of the world – for example in Vietnam, where the energy sector has traditionally centralised and top-down characteristics, there are now instances where local provincial governments are saying no to large coal plants being sited in their regions, showing an interesting interplay. In Indonesia, they have just completed a national energy planning strategy, which was a top-down exercise, but as individual provinces are addressed there is a necessary bottom-up reconciliation going on.

**Alec Waterhouse, Head of Modelling at the UK Department for Business, Energy and Industrial Strategy,** continued the discussion based on the UK's long-term energy scenario modelling experience. He outlined three principles that govern the suite of models developed to understand the energy

transition in the UK – economic benefit to the UK, maintaining energy security, and meeting the UK's legislated carbon budgets. The overall model is based on the TIMES platform, complemented by a suite of subsidiary models for various sectors. These models support exploration of possible futures for primary service demand, and how the system may respond to the emergence of decentralised use of energy, e.g. EV charging or batteries for peak shaving.

Mr. Waterhouse then outlined five scenarios considered in the UK Clean Growth Strategy, noting that there are a number of challenges associated with this approach. First among them is a strong assumption in modelling that the past is a good indication of the future, which is not necessarily the case. Second, models are parametrically driven and therefore need a lot of data, so considering technologies that haven't been deployed at scale – or even at all – is difficult without having large uncertainty ranges. Third, understanding of customer behaviour is quite limited, and new interactions with energy use could deliver unanticipated dynamics – the example of the recent turning point in attitudes toward the use of plastics in the UK was given.

Generally, in terms of disruptive new technologies in the long term, there are real difficulties in anticipating when they could arrive at scale and whether they will have an impact. Workshops in which alternative futures are considered often produce storylines, but converting those storylines into hard model parameters is still a process that's being improved. The fact that models currently in use have a long history of development – e.g. 30+ years in the UK – also means a full change in modelling approach comes at a high cost, so there's a big question around how much better new approaches are at representing the current state of affairs. On a final note, Mr. Waterhouse stressed the importance of model assurance processes, as errors can easily enter large, complex modelling frameworks.

**Pieter Boot, Head of Department at PBL Department of Climate, Air and Energy,** then spoke from the PBL experience as the institution responsible for harmonising national/regional energy planning. He noted that the Netherlands has a centralised history of modelling, with use of TIMES/MARKAL comparable to the UK. The first step away from national modelling was to incorporate international power flows through a European model. Modelling supports implementation of the Netherlands climate legislation, but also a climate agreement process among wider stakeholders, which includes all regions (i.e. provinces, municipalities), with modelling needed to be open and transparent to provide basis for interaction between parties.

Due to the challenges of computing time, one thing PBL has decided to do is develop a simpler model to complement the large centralised models, which can represent different types of decision makers with different time horizons/cost considerations, making it easier to explore different options.

Dr. Boot went on to explain the process of regional energy strategies which have to be developed by some 30 regions in the Netherlands, in which they develop their ambitions. This requires a new model, as it doesn't make sense to divide their national model into 30 regions, and has been started by only looking at the building sector. The new model is open source, with building-level granularity on every street, so municipalities themselves can perform the analysis using the same framework. Based on regional input, PBL then will compute whether all strategies add up to national figures. One way to limit challenges in this process is to have only one long-term reference scenario as a baseline, in order to standardize regional plan comparisons.

An example was given of detailed model results for a particular region, showing expected energy efficiency label improvements at the building level. This type of result allows cities to analyse district heating benefits,

and specifically which areas a new system would have to reach depending on the evolution of high-efficiency buildings measures, which could reduce the need for district heating investment.

**Tiina Koljonen, Research Team Leader, VTT Technical Research Centre of Finland,** moved on to give a perspective from Finland. She began by providing some background on modelling and scenario use in Finnish policy making – energy and climate strategies have been developed since the early 90s, but as the world becomes more complicated, modelling frameworks have also become more complicated. For example, the framework behind the recent 2014 low carbon roadmap included ca. 10 different models (i.e. TIMES, sectoral models, land use and market models), which raises challenges in presenting results. Transparency has therefore become a key solution to disseminate information among stakeholders, policymakers, and researchers. Dialogue between stakeholders is a large part of scenario building and results distribution, which can support acceptance.

As policies now become more ambitious, harmonising analysis of actual sub-national implementation with national modelling also gains importance. The example of VTT's coordination of the urban component of the Nordic Energy Technology Perspectives project was given, with Dr. Koljonen noting that it revealed a lot of new information, and made it clear that sub-national modelling is very important to complement national scenarios. This is particularly the case for distinctions between rural and urban systems – it is difficult to say which new technologies are missing from models overall, as rural and urban options will look very different, particularly regarding centralisation and decentralisation. While cities have great potential for GHG mitigation in their consumption, rural regions appear to have the greatest challenges related to agricultural and industrial production.

Dr. Koljonen ended by noting two broader challenges. First, many theorized approaches to modelling new disruptive energy sector dynamics make reference to big data, but often that big data does not yet exist. More work also needs to be done on integrated modelling of materials production, and representing behavioural elements. There is also interesting debate on the role of biomass in the future, with Finland's large forests being preferred by some as a carbon sink rather than source of production.

**Felix Matthes, Research Coordinator at the Öko-Institut** offered four points as part of his intervention. First, providing background on the German context, he noted that German government has almost entirely outsourced modelling work on energy and climate policy issues. This creates a certain flexibility in modelling approaches, but also a unique interface between analysis and policy making, as well as analysis and *politics*. Germany is also on the road to a share of 40% renewables, which means that there is an increasing body of actual evidence related to renewables that needs to be reflected in models.

Second, discussing the actual problem that modelling is meant to address, he first noted that no modeller would like to look back at results from their models decades ago. Despite the difficulty in actually providing accurate visions of the future, the good news is that the future transition is no longer about specific technology or cost evolutions, but more about managing structural change. The four dimensions to this change are: 1. Much greater amount and distribution of installations; 2. Technologies which are much more capital intensive; 3. Much higher variety of system/market participants; and 4. Significantly different spatial patterns. To give an example of these, it was noted that for 100 years the German electricity system was run with 300 generating units – this summer it will arrive at 1.8 million (and over 30% renewable). These structural changes need to be reflected in modelling, that is, models should reflect: market designs for a more capital and coordination-intensive system; more infrastructure-intensive systems which creates the planning issue of long lead-times; and a greater variety of economic appraisals being conducted by system actors.

The third point raised was about the concept of decentralisation, and why it brings limited value to the debate. As decentralisation is a fuzzy term, we have to be more specific in what we would like to reflect – not "decentralised" technologies broadly but: generation options that are either close to consumption or far from consumption; key flexibility options whose spatial patterns may not align with those generation options (and whether those flexibility options are close to production); and what the actual coordination model between generation and flexibility will be. The final point is important, as you can have a highly distributed system of generation and flexibility, but there are extremes in coordination models between e.g. self-consumption and individual optimisation vs. a centrally-coordinated market, which entail very different infrastructure needs.

These more specific aspects must now be incorporated into modelling, particularly since they are highly relevant to the main bottlenecks emerging for the future transition. Those bottlenecks are no longer about technology availability or cost, but – at least for densely populated country like Germany – are the availability of land in certain spatial patterns and the timely rollout of infrastructure.

Finally as a fourth point, Dr. Matthes explored what this means for the future ecosystem of modelling. To answer the questions which are relevant, three approaches are required. First, sensitivity analysis is needed to address uncertainties, which means screening-style models which are robust but also fast enough to deliver sensitivity analysis that potentially delivers hundreds of scenarios. This is something that goes beyond the typical use of models like TIMES/MARKAL. Second, models must be able to represent much higher spatial and temporal resolution, and this usually means they can only be sectoral models – e.g. in Germany detailed modelling of electricity, covering 402 counties, the network, and European integration, can take two weeks to run. This isn't compatible with sensitivity analysis, but still needs to be done to explore spatial patterns.

The third dimension is to reflect the changing structure of agent's decision making from textbook economics and macro-optimisation (investment decisions strictly based on NPV analysis, operational decisions strictly based on short-term marginal costs) to a system with economic appraisals more typical for decisions on consumption goods or based on micro-optimization approaches (which may be irrational in macro models). This will require a new model in the overall suite required, which is partly integrated and faces the same issue as the others – the need for sufficiently high-quality data, particularly related to new emerging bottlenecks. For instance, if land is becoming a major bottleneck, the quality of county-level data needs to be assured.

**Alex Roehrl, Sr. Economic Affairs Officer, UN DESA**, began by noting that IRENA's campaign on long-term energy scenarios is not just important in and of itself, but also for discussions that happen at the global level, e.g. at the UN. Modelling is key at the UN secretariat to support fact-based discussion of high-level policy goals. To give a concrete example, national reporting on progress around the Sustainable Development Goals would benefit greatly from lessons learned regarding scenario development and application. Additionally, UN ECOSOC will be focusing soon on the topic of scenarios and new technologies, which could benefit from the output of these types of discussions. The UN has also gathered national strategies on new technologies, which could be helpful to inform the energy scenario development debate – e.g. 27 national strategies just for artificial intelligence.

In terms of lessons from scenario exercises seen in UN countries, it is always preferable if models and scenarios can be applied in a way that is relevant to a specific question, while acknowledging model development cannot always start from scratch. The question in relation to decentralised solutions often relates to what part of the system should actually be modelled, and a complex model with a wide scope is not always necessary and may provide misleading insights. It should also be remembered that ultimately, scenarios are often most useful as a communication tool, and thus it is valid and helpful to also report on non-modelled decisions or implications to better inform discussion.

Regarding technologies that may not be well-reflected in scenarios, it was noted that new technologies not necessarily related to energy – especially digital technologies – should still be understood in term of their energy implications. The energy use of bitcoin, or the implications of blockchain and big data on communications between energy users, were given as examples. Finally, the potential for wholly new breakthroughs in modelling was explored, with a call to remain open about highly advanced, integrated, and even real-time models to be used to inform policy making in the long term.

## 3. Moderator conclusion and panel discussion

The **Moderator, Dr. Dolf Gielen,** provided a brief synthesis of the interventions before additional panel discussion. He noted that first, in all countries represented and at the UN level, there is a strong interest in scenarios in order to improve decision making. There is also a recognition that the system which we are trying to understand is changing, with new types of decision making that may not be very well reflected by scenarios based on least-cost system optimisation. In response, scenario development will see a trend toward more end-use specific models, with city and sub-national modelling informing more comprehensive national scenarios, and a trade-off between complexity and operational capability due to the need for wide sensitivity analysis.

Issues were also raised around analysis of behaviour and disruptive technologies, with more work needed to understand how these can be incorporated into modelling behind long-term scenarios. In order to capture the influence of new technologies, scenario developers will also need to somehow address new aspects such as land and infrastructure availability. Even the best models will still have key data requirements, so assuring data quality and making use of increasing real-world evidence will be important.

The panel responded further to the interventions, with **Alec Waterhouse** noting that for the analysis of the UK's fifth carbon budget, a cloud-based technology was used to run upwards of a thousand different scenarios in TIMES to explore uncertainties, showing there is room to go beyond the typical use of such traditional model frameworks. He also noted that while least-cost optimisation may not be the best approach to analysing the future energy system, a key benefit vs. more complex approaches (e.g. based on AI or neural networks) is the ability to clearly trace results to inputs. More complex approaches can become a black box in terms of explaining why certain solutions emerge.

**Felix Matthes** continued by raising the importance of understanding scenario purpose – e.g. are they being developed to establish or legitimize targets (e.g. decarbonization or nuclear phaseout), to explore new strategies, or to drive implementation. For example, least-cost scenarios can be important for strategy development and understanding infrastructure lead times. However, if actual implementation is the goal, almost no politician is interested in economic efficiency at an aggregate level, but by distributional effects – therefore using macro-cost-optimisation tools without understanding distributional impacts will not answer many of the key questions of policy makers.

**Pieter Boot**, adding one point to the session's summary, noted the key role of scenario communication. He gave the example of an initiative to improve the quality of PBL models, which made it clear that users often simply wanted to better understand the reason for model outcomes – better communication can sometimes have more impact than better models.

**Tiina Koljonen** seconded the strength of scenarios as communication tools. Picking up on the point around more structural change, she noted that challenges will inevitably arise in developing radical scenarios. For example, shifting agriculture wholly to vertical farming in a simplified scenario can result in a quadrupling of total electricity demand – it raises the question of how to best represent such an impact in long-term scenarios.

**Aisma Vitina** noted that how long-term scenarios are developed and applied can also depend on country experience – for example in Denmark, due to the long history of usage politicians are able to deal with more detailed nuances of least-cost scenarios, and the DEA's "frozen policy scenario" serves as a solid foundation for most Danish strategies. However she agreed that when it comes to implementation, more detailed scenarios, and scenarios which investigate socioeconomic or esoteric aspects, are usually needed.

**Felix Matthes**, drawing on his recent experience in the German coal commission, made the point that although we are interested in disruptive developments and technologies, from a sub-national perspective disruption is often not the preferred societal outcome. This raises another potential target function for long-term scenarios, which could be steady and managed structural change.

## 4. Open interventions from the audience

**Guy Vekemans (VITO)** opened the interventions from the audience, raising the Belgian view of long-term opportunities at different geographic scales that might be beyond national borders – e.g. the North Sea or harbours in different countries that nevertheless coordinate approaches. There is potential for these emerging dynamics around renewables and new technologies to pose additional long-term planning challenges.

**Mark Howells (KTH Stockholm)** was interested in expanding the point regarding increasing actors in future systems and the shift toward commoditisation, and how new interdependencies that emerge as a result might influence security of services. He also asked for thoughts on the UK's "DECC Calculator", which he considers an excellent tool to better understand long-term options.

**Tiina Koljonen** replied with the example of Nordic cooperation around future scenarios, noting that although Norway emerges as a central source of cross-border hydro and wind power, discussions with the actual Norwegian government reveal plans to use those sources internally. Similar complications emerge with Finnish bioenergy. It is therefore important to interrogate future scenarios of increased actor distribution and interdependence, and compare scenarios produced by different stakeholders.

**Felix Matthes** noted that despite areas for improvement, modelling in the EU is actually quite advanced in many ways, and does usually consider the role for certain "neutral territories" as the North Sea. There was also agreement regarding the importance of sharing assumptions across borders, particularly since sustainable hydrogen or biomass imports are often key decarbonisation options in national long-term scenarios.

**Aisma Vitina** noted that long-term maintenance of security of supply will likely come through a package of measures and actions by different stakeholders, similar to the ways in which Denmark's variable resources are managed with its neighbours at the moment.

**Alec Waterhouse** noted that a new version of the UK Calculator is being developed, named after David Mackay, the late former Chief Scientific advisor of DECC who was a driving force behind the initiative. The new calculator will be released next year and will incorporate a major step change in functionality, allowing users to select the start, finish, and levels of ambition.

A question was raised from a representative of the UN focus group on children and youth regarding whether new models will be accessible to the public (particularly the example of the Netherlands) given the role of civil society in contributing to long-term scenario development, particularly with the rise of prosumers in many long-term visions. **Pieter Boot** confirmed that PBL's spatial model in use by municipalities will be available to the public for use.

**For any questions or more information, please contact LTES@irena.org.**