Renewables Grid Initiative

Third RGI Future Scenario Exchange Workshop 11th July 2017

Protocol

This protocol aims to provide:

- A recap of the work done so far
- A high level brief of the "Grid stress test" presented by TenneT
- The main insights and comments of the workshop
- A brief of the afternoon communication session
- Conclusions and next steps

1. Attendee list

Name	Organisation
Tom Brown	FIAS
Eva Schmid	Germanwatch
Tina Mieritz	NABU
Nora Nording	Amprion
Alice Collier	RSPB
Blanda Prousch	innogy SE
Jeroen Mentens	Elia
Sébastien Lepy	RTE/ENTSO-E
Stephan Singer	CAN International
Enrico Carlini	Terna
Eva Hegge-Goldschmidt	50Hertz
Antina Sander	RGI
Andrew Carryer	RGI
Stephanie Ropenus	Agora Energiewende
Marius Strecker	TenneT
Paul-Georg Garmer	TenneT
Antonella Battaglini	RGI
During the joint session with the communication workshop	
Maximilian Schulze-Vorberg	50Hertz
Martin Groll	TenneT
Roman Hagen	Swissgrid
Rafael Rafael de Heredia Martínez	REE
Stephanie Bätjer	RGI
Theresa Schneider	RGI
Urszula Papajak	RGI

2. Recap of the work done so far

The first workshop of the series was held in Berlin in July 2016. The studies looked at were the "Energiewende Outlook 2035" and "Strategic Grid 2025" presented by 50Hertz and Swissgrid respectively.

The 4 most important common messages from the first workshop were:

- Ambitious scenarios are economically manageable.
- Grids are always needed, even in a decentralised prosumer scenario.
- Cross border capacity is vital for enabling RES integration.
- Actions from citizens and decision makers are needed.
- "Extreme" scenarios from studies are not perceived as extreme by NGOs, but still relatively conservative

The second workshop was held in Brussels in February 2017. The studies looked at were e-Highways (presented by Amprion), 'Infrastructure needs for local communities' from RTE and ADEME's '100% renewable electricity mix?' study.

The 6 most important common messages from the workshop were:

- High shares of renewable energy sources require transmission corridors to go from the outskirts to the centres of population in Europe
- We can build on the existing grid to enable the energy transition
- A full commitment to 100% RES is economically feasible from a market perspective
- Renewables can support each other mutually in a superregional way provided there are grids to enable this
- Very high shares of generation from RES in Europe require complementation from seasonal storage or another long term solution
- We need to improve are knowledge of the impacts of sector coupling

You can find all information about RGI's future scenario exchange and the summary of the workshop series here.

3. Structure of the Workshop

In addition to jointly learning about the studies and scenarios, it is the ambition of RGI to effectively communicate the insights that have been gained throughout this workshop series and to increase accessibility and common understanding for a wider audience. For this purpose, the workshop day was divided into two parts. The morning session dealt with the stress test study, with the afternoon being a joint session together with TSO communication experts, in which the above joint messages of the previous workshops were looked at, and initial ideas for edits, additions and for their effective communication were gathered. Participants of a separate RGI communication workshop (hosted in the morning) joined up with the group in the afternoon for this purpose.

4. TenneT presents the "Grid Stress Test"

TenneT presented the "grid stress test"; the study[1] was completed by the consultancy Consentec on behalf of TenneT and with the think tank Agora Energiewende as an advisor. It looks to understand how transmission requirements in Germany are affected if new green energy expansion pathways are pursued or new novel transmission grid technologies are developed and implemented, with all scenarios designed for a target year of 2035. The study used the NEP Scenario B 2035 as the reference scenario.

The overarching purpose of the study, from the perspective of TenneT, was to enhance the political debate and inspire further research with regards to finding new ways to increase grid capacity beyond 2030 that does not rely on further grid expansion. Forecast growth of RES in the north of Germany, coupled with the politically decided closure of larger generation units across the country and cross border European electricity trade, creates an implicit future demand for more north-south interconnection. TenneT believes that, beyond 2030 (or beyond what is planned in the Germany national EnLAG and BBPIG plans), public acceptance of this new infrastructure will be too low, making the realisation of any more projects unfeasible. At the same time, by 2030, Germany will not be done with the shift from thermal to renewables based electricity generation. The study therefore stresses the impact of scenarios that assume a wide-ranging roll out of innovative technologies on the existing and currently planned grid that is able to increase capacity.

4.1 The Scenarios

The scenarios used in the study were split into two groups. **The Energy Economy scenarios** take into account the impact of the most prescient policy measures and technical developments, these include:

- The mid term phase out of coal,
- Accelerated RES deployment,
- Significant fall in battery storage costs,
- Increasing local off grid generation,
- Increased sector coupling,
- Increase in flexible demand.

The **"energy economy" scenarios** were determined by calculating regional export-import balances for the 16 German states based on the different scenario assumptions. Transmission requirements are then approximated by the sign and magnitude of these balances, aggregated for the year 2035. It is important to note that no formal numerical grid model was applied for calculating these scenarios.

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[1] https://www.tennet.eu/de/unser-netz/rund-um-den-netzausbau/netzstresstest/

[2] NOVA is a German acronym for the optimisation, enhancement and expansion of the grid (*Netzoptimierung, -verstärkung und -ausbau*). According to this principle, grid optimisation and

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The Technology Scenarios explore the impact of technical innovations on the planning and operations of the grid. The solutions proposed in these scenarios are considered by TenneT to be implementable only in the mid-term, as there exists considerable research and development to make such technology widespread. The technology scenarios were based on real world grid analysis based on the data provided by TenneT for the German 2025 Grid Development Plan, including the grid topology and network node related time series data.

Grid Stress Test Scenarios

Energy Economy scenarios

1. **Zero Coal Power** - Complete phase out of coal by 2035. Lost generation is replaced with wind (total of 135GW) with 16GW offshore and 70% of additional onshore located in the 3 most northerly German states.
2. **Decentralised -** Expansion of RES through on-site PV coupled with storage. Batteries assist with system stability. 150GW of PV installed by 2035. Both "even geographical distribution" and "80% concentration in the south" alternatives looked at.
3. **Flexible Demand** – Consumers can increase consumption in situations of excess generation, incl. industrial demand management (10GW potential), and Power-to-Heat (45GW potential). Regional differences in potential are accounted for, with demand flexibility exploited only in the northern German states that typically see excess in-feed. It is assumed that demand flexibility is applied exclusively in a "grid friendly" (no market-driven flexibility deployment) manner.

Combination Scenario – Combination of the three above scenarios. This included no coal past 2035, coal replaced by PV (150GW limited, regionally distributed mainly in South). Storage potentials are taken from "*Decentralised*" scenario.

Technology Scenarios

4. **NOVA principle enhanced –** New static capacity improvements (technical improvement of existing lines to increase capacity) and dynamic capacity improvement (the deployment of power line monitoring to dynamical increase capacity) implemented and grid planning optimised. Including:
    - Transmission capacity upgraded universally across HV grid to 380kV (capacity increases to 3,600 A, up from current standard of an average 2,720 A)
    - STATCOMs (a regulatory device that stabilises the grid by providing reactive AC power) used to overcome current limitations.

- Innovative power line materials deployed to allow larger diameter lines without the increased weight – meaning that weight thresholds for the towers would be maintained requiring no new tower development
- Grid expansion augmented through the installation of multi terminal underground HVDC lines by 2035. 3 north-south corridors assumed with 4GW capacity each.

5. **Automated System Operation –** Accelerated adoption of digitalised control engineering. Required control data and control connectivity considered available. The scenario assumes:
    - Automatic intervention in grid utilisation behaviour is achieved to manage temporary overcapacity and ensure error tolerant n-1 grid operations. Done through cutting flow to inoperative powerline and replacing downstream power by activating storage or by throttling demand so balance is achieved.
    - Transmission grid stations are equipped with power electronics (e.g. DC back-to-back converters) to actively manage load flows. Enabling a more even distribution of power system load.

4.2 Main conclusions of the study

Energy Economy Scenarios

- There exists a need for additional north-south transmission requirement in all scenarios. This requirement is significantly reduced in the Decentralised scenario where PV paired with storage (across Germany) replaces additional wind capacity in the North.
- An effective combination to reduce this required transmission capacity is considered to be the following: A phasing out of coal which is replaced by PV in Southern Germany and storage, coupled with the nationwide deployment of grid-friendly flexible demand management. In such a case grid requirements could be reduced by up to 40%-45% beyond 2030 through such geographical optimisation of RES deployment.
- The expansion envisaged by the current German grid development legislation (EnLAG and Bundesbedarfplan) remains essential and cannot be reduced.

Technology Scenarios

- Enhancing the application of the NOVA principle[2] beyond its current form would lead to the increase in capacity of existing power lines, reducing incidences of line overloading whilst improving transmission rates. Such an

[2] NOVA is a German acronym for the optimisation, enhancement and expansion of the grid (*Netzoptimierung, -verstärkung und -ausbau*). According to this principle, grid optimisation and enhancement have priority over the expansion of the grid.

enhancement would necessitate the reform of numerous emission (noise, EMF) standards.

- The implementation of an HVDC overlay grid would reduce excess load in the AC grid with any residual cases of line overload resolved through re-dispatch or further grid expansion. However, this would involve the construction of several 10GW lines, requiring significant investment.
- Gradual transition to the "Automated System Operation" would enable a uniform loading in Germany's grid infrastructure (85% reduction in line overloads on the reference scenario) whilst preventing loop flows.
- Additional research and development into technologies and solutions outlined in the scenario is essential.

5. Insights and comments

5.1 Appreciation of TenneT provoking an important discussion, especially with policymakers

Many in the group demonstrated an appreciation of the study presented, seeing it as helping to launch a debate on what we could/should do to increase the capacity of our existing infrastructure, taking into account the assessment of TenneT, that there exists an upper limit to how much new grid infrastructure people will accept in the mid to long term. Provoking a debate with policy makers, and how they can help enable and encourage the types of technology presented in the Technology Scenarios, was stressed as being particularly important.

5.2 Methodological limitations of the study

Some participants saw the study as limited in its scope in several ways. Firstly, a numerical grid model was not included for the "energy economy" scenarios; rather, regional export-import balances are calculated for each scenario with transmission requirements estimated on these balances. Such an approach is valuable as it gives a simplified indication of how much transmission capacity will be required. However, such simplicity poses limitations when drawing real-world conclusions on the basis of the results. The temporal aggregation of the import-export balances over the year 2035 suppresses any information on peak import-export flows, which are relevant for dimensioning the grid.

It was also commented that, as the geographical scope of the study is limited to Germany, European electricity trade is not taken into account at all in the analysis. Due to Germanys central position in the European electricity market and its North-South connection classified as Projects of Common European Interest this poses a serious drawback.

Finally, it was commented that an implicit assumption of the analysis is that all demand-side flexibility and storage capacities operate in a grid-friendly, i.e. system-friendly, way. However, it is yet unclear how such behaviour would be incentivized.

5.3 A proper debate on technical guidelines and legislation is required

5.3.1 Increasing flexibility of guidelines and legislation

It was considered evident by workshop participants that, by assuming increased line capacity, you could reduce future grid requirements. Many of the techniques presented in the technology scenarios such as upgrading capacity universally across the HV grid to 380kV (capacity increases to 3,600 A, up from current standard of an average 2,720 A) could break noise emissions standards, limits on EMF and guidelines on thermal limits. A proper debate as to where such limits are appropriate and in what situations such standards could be more flexible (dynamic line rating etc.) should be had. Including a discussion on how new technologies could mitigate any impacts (for example, it has been observed that for newer cables, noise emission is reduced because of a different surface).

5.3.2 Retaining the N-1 principle through automation

The “Automatic System Operation” scenario assumed that intervention in grid utilisation behaviour is achieved to manage temporary overcapacity and ensure error tolerant n-1 grid operations. It was commented by workshop participants that the automation of grid operations that retains the n-1 principle through switches, software and algorithms should play an important role in improving utilisation, with policy stakeholders especially being made more aware of such potential.

Many participants felt that there is a need to move in such a direction but that we are not yet in a position to achieve such a transformation. Some of the challenges mentioned were that the regulatory system needs to be adjusted in order to reward the efficient “intelligent” management of a system more than for the building of new infrastructure. Another issues that needs to be resolved is cyber security risks.

5.4 Investment/R&D costs needed for such significant system upgrades are considered lower by TenneT than potential re-dispatch costs.

The investment costs required to upgrade the grid with the technology described were considered by TenneT to be lower than the total re-dispatch costs, estimated at by the German regulator at potentially €4 Billion in 2024, if nothing is done and congestion increases. This means that proper well-funded research complemented by pilot projects is considered “money well spent” with regards to reducing total costs of the system in the mid/long term.

6. Afternoon session on communication

6.1 Group discussions on the RGI joint draft messages

The group broke up into groups to discuss the communication messages RGI has drafted from the takeaways of the first two workshops (see Annex). Participants were asked to assess the appropriateness of the messages, who they could be targeted at and for what purpose they should be used.

The general thoughts on the messages were the following.

- The messages need to be formulated differently and focus on different aspects depending on if they are aimed at citizens or at political actors.
- The messages should be simplified for forcefulness.
- The more sources the messages are backed by, the more their power increases.
- When finalised, the messages should be packaged in a way that all organisations can use them directly as a communication tool to their members/stakeholders.

RGI will be working to address the above comments and those made on the individual messages. Work will be on-going in the second half of 2017 to formulate a set of adjusted draft messages, which will be circulated, edited and finally approved by RGI members and participatory organisations of the workshop series. More information on this work will be forthcoming in the next few months.

6.2 General discussion on modelling and communication

The final session was a general discussion on how scenario development and modelling exercises can improve their participation and communication. Modelling is traditionally an activity which is done rather independently of stakeholders, however proper stakeholder engagement is an indispensible element of modelling today. It is needed to integrate knowledge and insights of different sectoral experts in an environment where new technologies are developing fast and where society has much clearer expectations and it is also needed to increase the legitimacy of the final product. In addition, results of modelling need to be translated into a language which is accessible for a larger group of stakeholders. Finding words which explain modelling and its results in enough detail but without highly technological terminology is a challenge on its own. It is for these reasons that modelling and communication/stakeholder engagement need to coordinate well in the work they do.

As an introduction to the discussion, Sébastien Lepy as Head of the ENTSO-E System Development Team described how ENTSO-E has been/still is trying to improve processes for consulting stakeholders early in the TYNDP to consolidate different opinions across Europe or find solid information on the different variables that the modelling needs to cover. ENTSO-E currently adheres to public workshops, consultations and a designated stakeholder group to receive its input. The future vision is however to develop scenarios jointly, independent of the TYNDP, which are made openly accessible to different parties for their modelling efforts.

Discussants agreed that the issues of finding a suitable language that allows people to access the scenario building process is important. Rather than jumping immediately into figures, those new to modelling and scenario building need to be taught the basic principles which will allow them to provide more valuable input to the scenarios. This was seen as something RGI should continue to focus on.

Finally, it was considered important that when communicating a study or a set of future scenarios, care should be taken to communicate that they are an experimental look at a set of potential futures, not a prediction of the future. The bulk of decision-

making power that mould the future of the electricity system in Europe, and which can turn certain desirable scenarios into reality, lies largely with citizens and politicians.

The workshop participants agreed that a more dedicated exchange on how different grid developers organise their stakeholder engagement would be a beneficial exercise.

7. Next steps

- RGI will form a working group to consult on the key messages of the workshop series.
- RGI will organise the 4th Future Scenario Workshop with a focus on what the development potential of the most important future technologies are. This will potentially involve the work of the IEA/IRENA.

Annex

The messages that were discussed in the group sessions

This section presents some initial key messages which seem to have reached a broad level of consent by participants and which could (in the future) be communicated jointly. **These messages should not be seen at this stage as a communication commitment by any individual participant or participatory organisation.**

7.1 Ambitious green scenarios are considered economically manageable from a grid and market perspective

The results from the 50Hertz and Swissgrid studies demonstrated that even in the high RES future scenarios presented the costs involved are manageable, at least concerning the extra high-voltage grid. This message is vital to bust the common myths that are held by many when thinking about the energy transition.

The ADEME study showed that there is only a small difference in the average electricity price between systems with 40%, 80% or 100% renewable generation. This sends an important message to all the countries that have already committed to integrating a certain share of renewables into their grid. From an economic point of view it means that in terms of renewables integration it makes little difference to take a small step towards the energy transition versus taking a big leap forward towards full commitment for the energy transition. If we commit to the energy transition a bit, we can therefore also commit fully (from an economic point of view).

7.2 If high RES scenarios are the "desired" future, action from citizens and decision makers must be immediate.

If we find the high RES scenarios desirable, then there is an immediate requirement for NGOs and citizens to start defining in more detail what they want the energy system of the future to look like. Such a process needs to be a collaborative process between NGOs and TSOs to develop a joint understanding of what a desirable but consistent scenario could look like.

7.3 Grids are always needed, even in decentralised high-prosumer scenarios

People producing and storing their own electricity (50Hertz assumption for 2035: 2.1million small storage units combined with PV installations) was fully incorporated into the prosumer scenario by 50Hertz. No link was found between a rise in the prosumer take up and reduced requirement for grids. Requirements of grid strengthening/expansion in prosumer scenarios are similar to the other scenarios presented, with the exception of the competitive renewable led transition.

7.4 Renewables can support each other mutually in a superregional way provided there are grids to enable this

Locally, the level of demand and the real-time electricity production from wind or solar usually don't match. However, the difference between supply and demand becomes smaller when looking at larger areas. Since weather conditions are different

across Europe there is always locations where electricity generation is higher than demand and locations where demand is higher than generation. Different regions can therefore mutually support each other. This mutual support is enabled by the grid and should be taken advantage off.

7.5 High shares of renewable energy sources require transmission corridors to go from the outskirts to the centres of population in Europe

One challenge of RES is their spatial requirements. The higher their share in the generation fleet, the more RES will have to be installed at the 'outskirts' with low to no population. Consequently, they require main transmission corridors to go from the outskirts to the centres of consumption, thereby enabling the transition to more RES.

7.6 Sufficient cross border interconnector capacity is vital to enable RES

This should be followed with coherent and easy to understand justifications for required interconnectors. Understanding how to communicate the importance of the Pan-European context without scaring people.

7.7 We can build on the existing grid to enable the energy transition

The results from the 'e-Highways' study shows, that we don't need a higher voltage level than what the TYNDP already foresees in order to handle the changes that may arise in the European energy landscape in the future. Instead, it is possible to build on the existing 380kV AC or HVDC grid by reinforcing and expanding it where it is necessary. This holds true for scenarios with conventional power mixes, with large central RES or with high shares of distributed RES likewise.

7.8 TSOs are in "good shape" to facilitate high RES scenarios

The TSOs that presented studies with focus on their respective grid are in the position to say that they are able to cost effectively facilitate a range of potential high RES futures, if it is what "society decides upon".

7.9 Very high shares of generation from RES in Europe require complementation from seasonal storage or another long term solution

While grids will allow to optimally seize renewables across a large geographic area, there will be a threshold share of renewables in the system which in addition to grids requires seasonal storage. This seasonal storage will become indispensible in long phases of little sun and low wind (likely a couple of weeks during the European winter). Geographical balancing will then no longer be sufficient to respond to the overall demand. Potential solutions such as power-to-gas and power-to-heat are still in early stages of development. Further research to develop and evaluate different options is needed to get prepared for the times with very high shares of renewables in the system.