Renewables Grid Initiative

# Second RGI Future Scenario Exchange Workshop 10th February 2017

Protocol

This protocol aims to provide:

- A recap of the work done so far
- A reminder of the scenarios and conclusions presented by Amprion, RTE and ADEME,
- The main insights and comments from the workshop,
- Some new joint messages,
- Conclusions and next steps.

## 1. Attendee list

| Name | Organisation |
|---|---|
| Fawaz Al Bitar | EDORA |
| Thomas Anderski | Amprion |
| Antonella Battaglini | RGI |
| Enrico Carlini | Terna |
| Bram Claeys | ODE - Organisation for Sustainable Energy |
| Alice Collier | RSPB |
| Carmen Davila | REE |
| Janus de Bondt | Elia |
| Simone Ertel | Amprion |
| Modesto Gabrieli Francescato | Terna |
| Roland Joebstl | EEB |
| Gerald Kaendler | Amprion |
| Thomas Köbinger | 50Hertz |
| Timm Krägenow | TenneT |
| Anna Leidreiter | World Future Council |
| Sébastien Lepy | RTE/ENTSO-E |

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|---|---|
| David Marchal | ADEME |
| Jeroen Mentens | Elia |
| Laetitia Passot | RTE |
| Catalina Rams Ramos | REE |
| Antina Sander | RGI |
| Marie Schimmelmann | 50Hertz/RGI |
| Stephan Singer | CAN |
| Marius Strecker | TenneT |
| Jan vande Putte | greenpeace |
| Matthew Wittenstein | IEA |
| Edoardo Zanchini | Legambiente |

## 2. Recap of the work done so far

RGI is preparing study briefs in English on the studies presented in the future scenario exchange workshops. This includes the studies "Energiewende Outlook 2035" and "Strategic Grid 2025" presented by 50Hertz and Swissgrid respectively in the first workshop that was held in Berlin in July 2016 as well as the studies presented in this second workshop.

The 4 most important common messages from the last 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.

Another realisation from the workshop in July was that "extreme" scenarios from studies are not perceived as extreme by NGOs, but still relatively conservative.

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

## 3. Amprion presents 'e-Highways'[1]

Amprion presented results and methodology from the working package 2 "Grid Development for Long Term Planning" which is the Amprion led part of the "e-Highway2050" study. The study aims to provide a long-term grid expansion plan on a European level, using as a starting grid in 2030 which is based on the Ten Year Network Development Plan (TYNDP) 2014 reference case published by the

[1] For more detailed information please visit http://www.e-highway2050.eu/e-highway2050/

European Network of Transmission System Operators for Electricity (ENTSO-E). Based on the premise that European climate targets for 2050 have to be met, possible future developments of the energy transition are derived and subsequently analysed. The required European grid architecture is derived for each scenario and assessed with the goal of identifying 'no-regret' measures that are required in each scenario.

The scenarios examined in the study were derived by combining different futures (uncertainties of the situation in 2050) with different strategies (chosen options on how to achieve the climate targets). However, scenarios chosen for the study had to fulfil 3 criteria, namely being consistent, achieving the climate targets and challenging the planned grid infrastructure. Thus only 5 scenarios were finally investigated.

**e-Highway2050 Scenarios**

1. **Large scale RES** – fossil phase out combined with a high share of nuclear, central RES and international energy exchange, highly increased demand
2. **100% RES** – a mix of central and decentralised RES generation is enabled by strong international energy exchange, covering an increased demand
3. **Big & market** – a mix of various technologies for large scale generation
4. **Fossil and nuclear** – lowest share of RES, climate targets and high demand are covered by a combination of nuclear and fossil with CCS
5. **Small & local** – fossil phase out, high share of decentralised RES allows for a local coverage of the demand

The scenarios were based on a main set of variable quantitative assumptions:

- Development of demand, including assumptions on population growth, GDP per country, new uses of electricity and efficiency. It varies between – 10% and + 60% compared to 2013. Individual forecast of changes in load pattern for each scenario.
- Development of generation mix, including assumptions on share of fossil fuel, nuclear, RES and centralised storage. The share of RES varies from 30% to 100%, the share of decentralised generation from 5% to 60%.
- Development of energy exchanges within the EU and to connected regions
- Further assumptions, e.g. weather (monte carlo simulation based on real data), flexibility and DSM, investment costs of RES to optimise their allocation, hydro plant construction, expansion and repowering, connection to Solar in North Africa, security of supply on a European level, policies and regulations of each country

In the study, the European grid was simplified by means of geographical clustering, taken into account regional differences as for instance RES potential and population development. As a result, 95 clusters, constituting the central-nodes for the grid model, represent the system. The assumptions for each scenario where first made on a macro area level for Europe and subsequently allocated in a top-down approach on a country level and then on a cluster level. The required grid is derived iteratively with consideration of various factors, until security of supply is established.

### *3.1 Main conclusions of study*

- The ‘no-regret’ reinforcements are driven by RES and they increase exchange capacities mainly between countries. They are needed even in the ‘Small and local’ scenario.
- The grid can offer the major advantage that RES can be allocated in the more profitable areas and using smoothening effects across Europe.
- Renewable sources show balancing effects on a superregional level, which are enabled by the grid. Thus, interconnection capacities should be among the top priorities.
- A revolution of the grid towards a superposed grid layer on a voltage level above 380 kV (Overlay-Grid) is unnecessary, as it is possible to build on the existing grid infrastructure.
- The planned reinforcements from the TYNDP reference case are sustainable with regard to the EU 2050.

## 4. RTE presents ‘Infrastructure needs for local communities’

RTE presented their study ‘Infrastructure needs for local communities’, which is based on the idea of cities that are self-sufficient in terms of their energy supply. The study aims to understand infrastructure needs for ensuring security of supply for a small town, which produces the same amount of energy as it consumes within a year (albeit not necessarily at any given point in time).

The study is supposed to answer the central question

- Does RES make the 20-100 kV grid obsolete?

**RTE Scenario**

1. **Small France** – the overall French climate and consumption pattern is downscaled to a 25.000 inhabitant city with an annual electricity consumption of 200 GWh. Generation is balanced mix of PV and wind.

The need for infrastructure is determined by looking at the probability curve of the residual load, resulting from a Monte Carlo simulation.

### *4.1 Main conclusions of study*

- The transition to self-sufficiency can be done, but only provided that a complementary back-up infrastructure (grid, storage, steerable back-up generation, DSM…) is available.
- An area, which is on an annual average self-supporting by PV and wind needs a complementary supply infrastructure with a capacity sized at about

its peak load both to secure supply and export its RES generation surpluses. The existing grid is sufficient to provide the service.

- There will always be a need for HV networks. Their use will evolve. Existing networks (as they are) may in many cases be suited for this evolving role. They can be complemented with DSM, storage, back-up generation etc.

## 5. ADEME presents '100% renewable electricity mix?'[2]

ADEME presented their study 'Is a 100% Renewable Electricity Mix possible?', which aims at understanding how an electricity mix that is completely based on RES can operate in France. The study focuses on cost-optimising the French generation fleet and its operation under various assumptions, ensuring that the hourly demand-supply balance is met. The central questions of ADEME's work looked to understand:

- What kind of challenges emerge if the amount of renewable energy in the electricity mix in France is substantially increased?
- What are the electricity generation mixes that best suit various sets of assumptions concerning technological developments, consumption and public acceptance?
- How are the different renewable energy generation technologies geographically distributed?
- What are the economic impacts of an electricity system with a high level of renewable energy penetration?

**ADEME Scenarios**

**14 different scenarios** were considered, with variations from the **baseline scenario** regarding the following inputs:

- Between 40 and 100% RES inclusion capability
- Societal aspects, e.g. energy conservation, public acceptance
- Technical and economic developments, including cost of technology, maturity of emerging technologies and financing of RES projects
- Possibility that specific emerging technologies don't manage to prevail or that extreme weather conditions occur throughout the year
- Existence of alternative infrastructure, i.e. sub-transmission networks (grids at lower voltage level which are connected to the transmission grid and take over certain transport functions)

The scenarios formulated to answer these questions were based on a main set of variable quantitative assumptions, namely:

- By 2050 the overall energy consumption of all sectors is halved. However the reduction in the electricity consumption is comparably small.

[2] For the complete report please visit http://www.ademe.fr/en/a-100-renewable-electricity-mix-analyses-and-optimisations

- Demand: drop of e-consumption, new uses, new demand profiles based on single use cases, strong assumptions on flexibility, peak demand like today
- RES: 15 RES technologies are modelled, taking into account local differences. Assumptions on costs and prices are made. LCOE differs for each region accounting for the local quality of RES potential. In Europe: 80% RES (from ECF scenario).
- Interconnections are defined for a theoretical grid, which is required to provide the optimal exchange capacity between the 21 regions in France. Interconnections are fixed to around 20 GW into or out of France.
- Storage: is included in generation mix. 3 types of storage are regarded: short-term (6 h), weekly PSH, interseasonal storage (gas und paired electrolyser).

### *5.1 Main conclusions of study*

- Several 100% RES mixes are possible under various assumptions and constraints: They consist mainly of PV and wind.
- The total cost of electricity varies only slightly between 40% and 100% RES, with 80% being slightly cheapest.
- Storage and flexibility as well as complementarity in between RES are essential. However, only a system with more than 80% RES requires inter-seasonal storage.
- Inter-regional network growth within France is required to pool potentials. Up to 3 times the interconnection capacity compared to the demand is needed.
- The 3 main drivers for cost are energy efficiency, social acceptance and cost of technologies. If a share of non-renewable generation is present in the grid, the costs are less dependent on social acceptance than in a grid with very high shares of renewables.

## 6. Insights and comments

### *6.1 Differentiating between decentralised and centralised RES*

There was a discussion around the differences between decentralised and centralised generation from RES. Some participants are wishing for even more extreme decentralisation scenarios (100% decentralised RES) whereas others would like to avoid the debate at all and concentrate on the differences resulting from RES compared to fossil generation. It was pointed out that due to spatial and weather restrictions, there is a limit to the share of decentralised RES in the European context.

### *6.2 Evaluating the measures that can enable the energy transition*

The RTE study showed that a city cannot be self-sufficient by means of RES only, but needs infrastructure, eventually complemented by other measures, to enable system adequacy. A cost comparison between the different options, such as grid reinforcement, storage, steerable back-up generation, DSM, sector coupling (or decoupling) should provide further insights on which way to choose, especially when it comes to the choice between storage and grid infrastructure.

### *6.3 Integrating other sectors and understanding their intercorrelation*

With respect to the climate targets and reduction of greenhouse gas emissions, the electricity sector cannot be regarded in isolation, as changes only there are not enough. Especially sector coupling by power-to-X applications (power-to-gas, power-to-heat, power-to-fuel, etc.) can make significant differences regarding factors like emissions and costs in all sectors involved. To take account of these intercorrelations, some participants suggested including these sectors in the scope of future studies. Furthermore, it is crucial to develop an understanding of which energy services will shift from other sectors to the electricity sector and how power plants and industry will adapt to the changes.

*NOTE: ADEME is working on a power-to-X study researching on the question how RES in the electricity system can make other sectors greener.*

### *6.4 Predicting technology development and the influence of future incentives on consumption patterns*

Key elements that enable the energy transition and are expected to evolve significantly in the future are efficiency, flexibility and sector coupling. However, many of the technologies that are likely to be employed to realise these concepts are still in a development stage. It is therefore important to find a common understanding of how these uncertainties should be included in future study and to develop a joint communication strategy towards relevant stakeholders on why these technologies are believed to play such an important role in the transition.
It was proposed to put more emphasis on researching the possibilities of the demand side, including smart applications and DSM, in future studies.

### *6.5 Evaluating environmental impacts and public acceptance*

One of the challenges of RES is their extensive usage of space. This leads to the question if there is enough space and resources available to realise 100% RES in Europe, taking into account that certain resources, e.g. biomass, are used by other sectors too.
Regarding public acceptance, the wish for including stakeholder influence and social acceptance in the modelling process was expressed, taking into account threats but also possible benefits that may come from the prospect of e.g. job creation or increased tax revenues. Time savings which can be reached for building solutions which are socially more acceptable should be monetized. It was pointed out, that modelling of social acceptance is very tough and imprecise.
However, measurable scientific criteria exist especially for the assessment of environmental impacts, e.g. the EU commitments on biodiversity. Hence they should be included in future research.

### *6.6 The importance of fully understanding inter-country transmission flows and dependencies*

A criticism was that almost all studies presented so far rely on the interconnections to other European countries, which usually are modelled with less ‘extreme’ development then the country of focus in the respective study in the scenarios. An example is the assumption from the ADEME study of having 20% conventional generation left in all countries outside of France even when an energy mix with100% RES is regarded for France. This allows counting on import of conventional energy when it is not possible to cover the national demand with RES or on provision of system services from conventionals abroad. Thereby external sources enable a local energy transition, without consideration of the possibility that neighbouring countries might have a 100% RES target as well and will therefore not be able to provide these services in reality. As a solution, a stronger European collaboration and joint scenario development is required to derive feasible results.

Another question is, if the entire Europe will move in the same direction. There are scenarios missing that examine what happens if e.g. Western Europe and Eastern Europe will develop in an opposite direction.

### *6.7 The need for better market design and political incentives*

It was suggested to research to which degree capacity markets or other cost and revenue systems are required to foster the transition towards 100% RES. A point of discussion was whether political incentives should be designed based on cost or on potential usefulness of the technology in question, especially with regard to power2X applications that feature low efficiency and high prices today. It was pointed out that from a technical perspective, there are often several technologies that can provide a certain service and that the prices will determine which one will prevail. Still, in order to increase RES shares above 50% market design and acceptance should be regarded in more detail.

### *6.8 Understanding what it means to operate a grid with 100% RES*

The wish for deep dive on the operational challenges of a system with very high RES share was expressed, as this is one key factor in evaluating possible future generation fleets. Furthermore, a common understanding on criteria and tools to evaluate the optimal generation mix for specific regions within Europe needs to be derived. It was proposed to place a focus on generated energy instead of installed capacity here, as the overall goal is reducing CO2 emissions. Otherwise, there is a risk of phasing out conventional generation, which can provide crucial system services, to early.

For the future, DSOs should be included in these discussions, as they evolve not only around the transmission grid, but the entire electricity system.
With regard to the changes in the European energy landscape the question arises, how the roles of system operators will evolve in the future. It was suggested to investigate on the question if having a common TSO is a reasonable approach for system operation in the future and how system borders could be defined.

## 7. Possible messages to be derived

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 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.

### *7.2 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 or different infrastructure 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.

### *7.3 A full commitment to 100% RES is economically feasible from a market perspective*

The ADEME study showed that there is only a small difference in 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.

### *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. These properties have to be complemented, but cannot be replaced by other solutions such as battery storage.

### *7.5 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.

### *7.6 We need to understand sector coupling better*

Resource consumption and greenhouse gas emissions happen across a wide range of sectors. Especially heat and transport are generally on the list of sectors which are envisaged to be electrified in the future and hence will be coupled with the electricity sector somehow. The aspect of sector coupling needs to be understood much better, both to make more evident which role this can play to combat climate change and with regards to the consequences for future grid requirements.

## 8. Open questions and next steps

### *8.1 Merge findings of the presented studies*

It was suggested that the TSO colleagues, who have presented studies in the first two workshops, compare their findings regarding key underlying assumptions, policies and future corridor needs in order to identify the expansion projects that are commonly regarded as most urgent. The results are considered valuable for stakeholder communication.

### *8.2 Derive guidelines for practical use cases*

It was furthermore wished that practical guidelines for specific use cases would be derived from the findings of the studies. Those should answer for example following questions: How can we use the findings in discussions around European policy development? How can we communicate that we need the 100% transition and how can we enable it in terms of market design? How do studies presented so far translate into specific corridors we want to see happening? How do we get to the point where we go from studies to actual project and field campaign work?

### *8.3 Bring the discussion to larger venues*

In order to reach more people and propagate the belief that an electricity system with a very high share of renewable sources is technically, economically and environmentally feasible, a discussion like the one taking place within the frame of these workshops should be brought to larger venues.

### *8.4 Identify the role of TSOs and RGI in enabling the energy transition*

Once the challenges regarding the expansion of RES are identified and the role that markets have to play is understood, the roles that today’s actors will play in this transition have to be defined. How can RGI enable and support the expansion of RES? Which role should TSOs play in enabling political decisions or and supporting communities that would like to become more independent of the grid? How do these expectations match with their current background that does not allow discrimination of parties connected to their grid?

### *8.5 Organise third "Future Scenario Workshop"*

The upcoming future scenario workshop will have an emphasis on joint message development and policy development options. Furthermore, another study will be presented.