

**e-Highway2050 conference Unveiling the Electricity Highways Project Results:
“Europe’s Future Secure and Sustainable Electricity Infrastructure”**

Day 2 Highlights - Wednesday 4 November

Before the start of the session III during the second day of the conference, Gérald Sanchis of RTE and coordinator of e-Highway2050 project summarized the main outcomes of the first day:

- A common understanding on the need for more grid was raised in the previous sessions.
- The results of e-Highway2050 should influence the next TYNDPs. In this respect, some concrete output of e-HW were mentioned as quick measures to implement. Innovation is necessary for an efficient integration of RES.
- Technology is already available, however its implementation in the present grid should be clarified,
- Regulatory framework should be adapted in order to achieve the grid architectures proposed,

Finally, it was highlighted the good cooperation of the partners and their complementarity for the achievements of the project.

Session III: Novel Planning Methodologies at Pan-European Level

Introducing the session, **Thomas Anderski** of Amprion and leader of e-Highway2050 Work Package 2 on grid development for long term planning presented the main results of that work package. The key objective was to define energy scenarios and grid structures that reach EU climate targets in 2050. The five e-Highways2050 scenarios used for the grid analysis were selected to cover a full range of the main drivers: demand, RES, exchanges, fossil fuel with CCS, nuclear. For each scenario, the grid analysis identified the main transmission requirements between 95 clusters in Europe. The complete transmission grid architecture was designed to optimise the trade-off between grid capex costs and system operation costs.

The key result of the modelling is that corridors are needed in all of the scenarios to allow use of renewables and use smoothing effects in weather-driven renewables. Many common corridors are needed in at least 4 of the 5 scenarios – these represent ‘no regrets’ investments for Europe with the benefits of the grid investments exceeding costs, often by a considerable distance.

As transition, Gérald Sanchis highlighted the key methodological improvements provided by the core study presented by Thomas Anderski. However some improvements are expected in the future by more advanced methods investigated also in the project but not applied to the core study. These advanced methods have been presented by Patrick Panciatici afterwards.

Patrick Panciatici of RTE and leader of e-Highway2050 Work Package 8 explained that traditional grid studies are often conducted on the basis of expert assessment. More advanced methods are sometimes proposed but at national level, for single scenarios and with the use of very simple snapshots used to model uncertainty. With massive integration of wind and solar, complexity is increasing and new approaches are needed. Therefore, the objective of Patrick’s work package within the e-highway2050 project was to produce new tools and methodology for optimisation-based approach to long-term grid planning. Applying this methodology should produce an optimal design of a very large grid, including a modular development plan over a very long time horizon.

Patrick set out a six-step process for optimisation-based grid planning, which addresses three key challenges:

- Spatial complexity: the grid must be relevant from the level of smart cities to the level of the entire continent of Europe
- Stochastic complexity: both weather and human behaviours are highly variable and must be understood in a stochastic manner
- Temporal complexity: the relevant timelines for grid adequacy ranges from minutes to decades

Panel debate with contribution from Tomasz Jerzyniak, DG Energy

Responding to the presentations, **Tomasz Jerzyniak**, Unit Networks and regional initiatives of the European Commission's DG Energy set out a view from the European Commission on the key learnings from the e-Highway2050 study alongside a summary of what the Commission is already doing in the areas of network planning.

Tomasz noted that the e-Highways2050 study gives a unique picture of the long-term need for transmission grid reinforcement. Therefore, he invited the e-Highways2050 project team to present the results to colleagues in DG Energy, including the teams working on projections and long term development. It is important that the results are further developed and regularly updated. ENTSO-E will need to play a key role in this with the e-Highway2050 approach mainstreamed in the TYNDP.

The key lesson from the e-Highway2050 study is that in order to meet our energy and climate objectives, we need transmission grid reinforcement in all scenarios with developments by 2030 to make sure that we are on the path to 2050. Tomasz highlighted that reinforcement is already taking place – but it doesn't happen in isolation as work is needed to overcome challenges such as public acceptance, technology issues and access to finance.

The Commission is working to support the development of the European grid. It presented plans for meeting the 10% by 2020 interconnection target earlier this year, and will make specific proposals in the third quarter of 2016 for reaching the agreed 15% interconnection target for 2030. The new list of Projects of Common Interest has been agreed and will be approved by the college of Commissioners on 18th November; this will include 25 projects double-labelled as electricity highways alongside their regional designation.

Session IV: Long-term Grid Development – Technology and Operations

Eric Peirano of Technofi and leader of e-Highway2050 Work Package 3 on technologies presented the two main results of that work package. First he detailed the database of cost and performance of generation, storage, demand and transmission technologies at 2050 as built by the project in terms of methodologies. He announced that such a database might be a powerful common tool for the power system community, for example as a common reference database in further studies.

Second, he discussed the approach that was followed to identify existing technology gaps that need to be filled in order to implement the transmission requirements resulting from the system simulations carried out in the project. He concluded by observing that the majority of the transmission requirements identified by e-Highway2050 could be covered by a limited set of modular solutions for terrestrial and submarine links. Furthermore, the ongoing RD&D effort to improve the present technology on the transmission capacities as well as its use (e.g. submarine for high depths, DC technology) shall be continued.

Rui Pestana of REN and leader of Work Package 4 presented the main challenges for the operation of the transmission network in the grid architectures developed in the e-Highway2050 scenarios. More specifically he restated the challenges for operation today and stressed the new ones as expected by the TSO community within the 2050 time horizon: more renewables, increased power exchanges, more HVDC links some of them being embedded within existing AC systems. He further detailed the phenomena studied including steady state phenomena ('N-1' overloads, 'N-1' voltage profiles, short-circuit current) and dynamic phenomena (frequency stability and small signal analysis). The test cases considered reinforcements with AC and DC lines for each scenario at 2050 based on the ENTSO-E grid at 2030 and focussed on the continentally synchronous Europe.

In summary the analysis confirms that the European network in 2050 will be much more complex to operate and that studies will continue to face a major challenge of how to handle very large power flows across Europe. Finally, it is foreseen that stability phenomena will limit long distance transmission, and so solutions such as real-time Wide Area Control Systems (WACS) will be needed to preserve the security of the synchronous areas.

Panel debate with contribution from Henrik Dam, DG Energy European Commission

The moderator **Kai Adam** of Swissgrid introduced all panellists: in addition to the two speakers, the panel included Silvia Moroni of Terna, Peter Lundberg of ABB representing T&D Europe, Volker Wendt of Europacable, and Henrik Dam of the European Commission.

Henrik Dam of the European Commission's DG Energy observes that the e-Highway2050 project was very useful in putting forward some technology developments and introduced the European Commission perspective with respect to new operational technologies for the power system. He highlighted some of the many projects that the EC is supporting for research into new power system operational technologies: operating HVDC network close to "n-1", new power technologies, use of ICT and in a longer term perspective superconducting technologies. He reminded the audience that that three of the ten key actions of the SET Plan are relevant to the context of this conference. Such actions will be associated with a new governance framework in the continuity of the European Electricity Grid Initiative (EEGI) and the Smartgrid ETP, a European innovation platform.

Several questions were then raised by the audience on technologies more specifically on superconductivity, storage, meshed HVDC grid and on the multiplicative factors to extrapolate costs. Many questions also concerned the operations of the grid in 2050 in relation to frequency control and voltage profiles.

In response, **Rui Pestana** confirmed that the e-Highway2050 does not rely on the development of an overlay grid, rather it is about reinforcements at the existing AC voltages supported by some reinforcements in the form of DC cables. He also added that the centralized operation has to do with governance: he referred to the Pegase project results and to the regional initiatives ongoing but also to the results of WP5 of e-Highway2050: we would need more cooperation with the regional operational centres but there is no need for additional layer.

Peter Lundberg of ABB and **Volker Wendt** of Europacable confirmed that from the perspective of data providers the database includes the best view currently available for technologies. Volker Wendt outlined that we are more in an evolution mode than in a revolution phase, as demonstrated by the exponential evolution of HVDC in the last four years. He also reminded the conference of the

very recent regulatory initiative taken by Germany to prioritise underground HVDC lines as well as to allowing for partial undergrounding. He concluded by noting the importance of installation costs in underground cable projects.

The moderator asked about the intention to offer open access to the technology database. Eric Peirano confirms the willingness of the project to move towards this, subject to agreement on the financing of the hosting and maintenance of the database. A participant welcomed a common database since it will reduce risks in the appraisal of cost of future infrastructure.

Session V: Long Term Grid Development – towards an efficient implementation

Bernard de Clercq of Elia and leader of e-Highway2050 Work Package 5 addressed the topic of governance and regulatory framework. The baseline conclusion of the e-Highway2050 project was that in any scenario there was a need for more transmission grid – however this does not require the creation of a new layer of grid. How to tackle the related planning, design and financing challenges of the 2050 grid architecture remains an open question.

Bernard presented five main areas of the regulatory analysis related to network development. Firstly, transmission network design is driven by a top-down planning approach based on the TYNDP. Secondly and thirdly, the main message to the regulatory regimes on finance and ownership is to provide a fair, predictable risk-reward mechanism that will limit investment uncertainty. Fourthly, we need a fair and appropriate cost allocation. Lastly, on technical and market operation, it is key to go towards more cooperation and market integration.

Gianluigi Migliavacca of RSE and leader of e-Highway2050 Work Package 6 shared the new Benefit cost analysis (BCA) methodology developed within the project, the e-Highway2050 toolbox and the main results of the analysis. The project started with the scenario development. The study next considered what kind of investments would be needed for grid development. Finally, a benefit-cost assessment was carried out in order to choose among the different alternatives.

Summing up the results, he emphasised that even in the scenario with the greatest use of underground cables, benefits clearly outweigh the costs for all three strategies (OHL only, re-use of corridors, cables only). Therefore even the most expensive scenario justifies the investments, with network investments being much more efficient than additional generation investments in all scenarios. Moreover, the three strategies differ in terms of technology costs, rather than the benefits. The most important factors for the benefits are CO₂ emissions and social welfare.

Markus Gronau of TU Berlin and leader of Task 4.3 of the Work Package 4 presented the modular plan from 2030 to 2050, and the related methodologies used to create scenarios and grid architectures for 2040. For the extended grid in 2040 where there is a frontloading of grid investment, the maximal costs were higher than the benefits in three out of five scenarios. For the common grid in 2040, which evenly shares the network build between 2030-2040 and 2040-2050, the benefits exceed the costs for four scenarios, and are level in one scenario. Therefore, the common grid model is a good “least-regret” trade-off between the five scenarios for 2040, and be delivered for less than 100 billion euros of investment in the European grid between 2030 and 2040.

Closing session

Wrapping up the event, **Patrick van Hove** of the European Commission’s DG Research and Innovation warmly congratulated and thanked all project partners on the very successful outcome of

e-Highway2050. This interesting project stands at the intersection of research and energy policy. It has produced very interesting, wide-ranging results starting with the methodology, the scenarios, the technology database and not the least the project's booklet presenting its results in a clear, accessible way.

He highlighted the importance that the final project results are used as well as being disseminated to stakeholders. He emphasised that we do research to try to envisage how the future will look like but we also need to focus on its implementation. Therefore, he challenged the audience as to how we can make sure that this modular plan is a living document for the years to come.