

BRIEF ON POWER NETWORKS

Interconnecting & upgrading the grid

Introduction

The mission of Roadmap 2050 is to provide a practical, independent and objective analysis of pathways to achieve a low-carbon economy in Europe, in line with the energy security, environmental and economic goals of the European Union.

The Roadmap 2050 project findings can be summarized as follows: The decarbonisation of the European power sector is practical, technologically and economically feasible and a pre-requisite for meeting the EU goal of at least 80% lower greenhouse gas emissions by 2050.

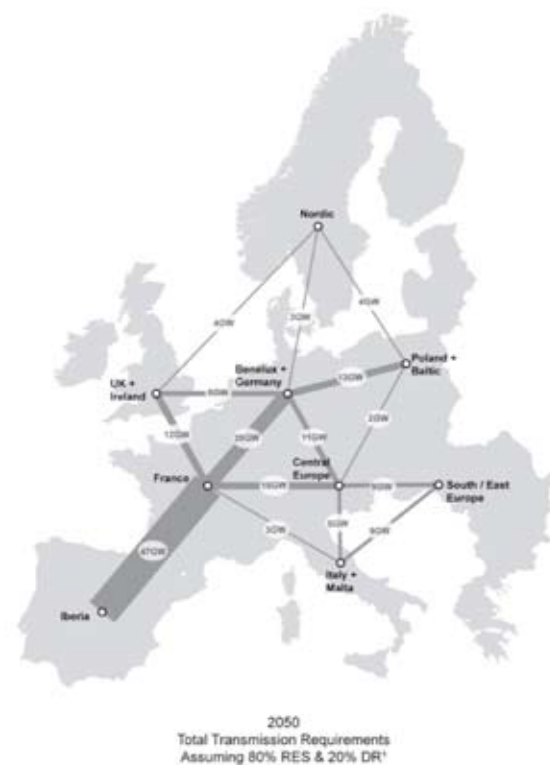
Roadmap 2050 examines the costs and benefits of the following decarbonisation pathways for the European power sector:

- 40% renewables, with the remaining 60% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear
- 60% renewables, with the remaining 40% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear
- 80% renewables, with the remaining 20% supplied evenly between non-renewable low-carbon technologies: CCS and nuclear

The study has also assessed the technical and economic feasibility of a scenario with 100% renewable electricity, requiring no nuclear power and limiting CCS application to heavy industry.

INTER-REGIONAL TRANSMISSION REQUIREMENTS

COMPARED TO CURRENT TRANSMISSION INFRASTRUCTURE, THE REQUIREMENTS FOR TRANSMISSION CAPACITY BETWEEN THE REGIONS DEFINED IN THE TECHNICAL REPORT ARE SIGNIFICANT.



The decarbonisation of the European power sector is central to the decarbonisation of the economy as a whole. One of the fundamental elements common to all of the decarbonisation scenarios studied in the Roadmap 2050 report is the major expansion of interconnection capacity between the national transmission networks in European countries and the coordinated operation a trans-European wholesale power market. Greater trans-European interconnection and market operation is the key to the integration of a geographically dispersed and technologically diverse mix of renewable technologies across the European power system. This in turn creates a virtuous cycle, driving down the costs of integration and decarbonisation by enabling the sharing of resources across regions.

Changes in network infrastructure and operation are critical since this will create the option to deliver decarbonisation through a range of generation mixes, including those involving high levels of renewable generation, securely and affordably. In particular it is necessary to:

- Increase interconnections between power systems to optimise the use of resources between Member States
- Establish an institutional framework, designed and governed by regional stakeholders, to execute regionally integrated infrastructure planning and market operations to meet the objectives of reliability, efficient markets, and full decarbonisation of power by 2050.
- Significantly improve demand response through smart grid applications

Effective grid development, operation and coordination will play a key role in maintaining the reliability of the overall power system at 99.97% or above, which is the current standard in Europe and was set as a prerequisite for all decarbonisation scenarios studied in the Roadmap 2050 report.

A new transmission grid for Europe

A large amount of new trans-European transmission, up to 170 GW of inter-regional transmission capacity, is required to guarantee reliability in any of the decarbonised pathways.

Major capacity expansion and interregional connections are foreseen in several parts of continent in all scenarios. Given the geographical and technological distribution of resources assumed in the study, the most notable challenge appears to be the expansion of connections between Iberia and France. However, the actual architecture will be highly dependent on the specific allocation of resources. For instance, by envisioning more wind outside of Iberia and less solar in Iberia, the required expansions may be more balanced across Europe. Nonetheless, in any conceivable scenario a significant amount of additional transfer capacity is required.

Failure to build-out this inter-connection capacity would “lock out” the predominantly renewable-based decarbonisation scenarios, leaving Europe exposed to the specific risks inherent in predominantly non-renewable decarbonisation scenarios. Whilst the inter-regional transmission links may be significant between some regions, the overall projected growth rates in terms of investment are within historical norms and continue the current trends in capacity build-out.

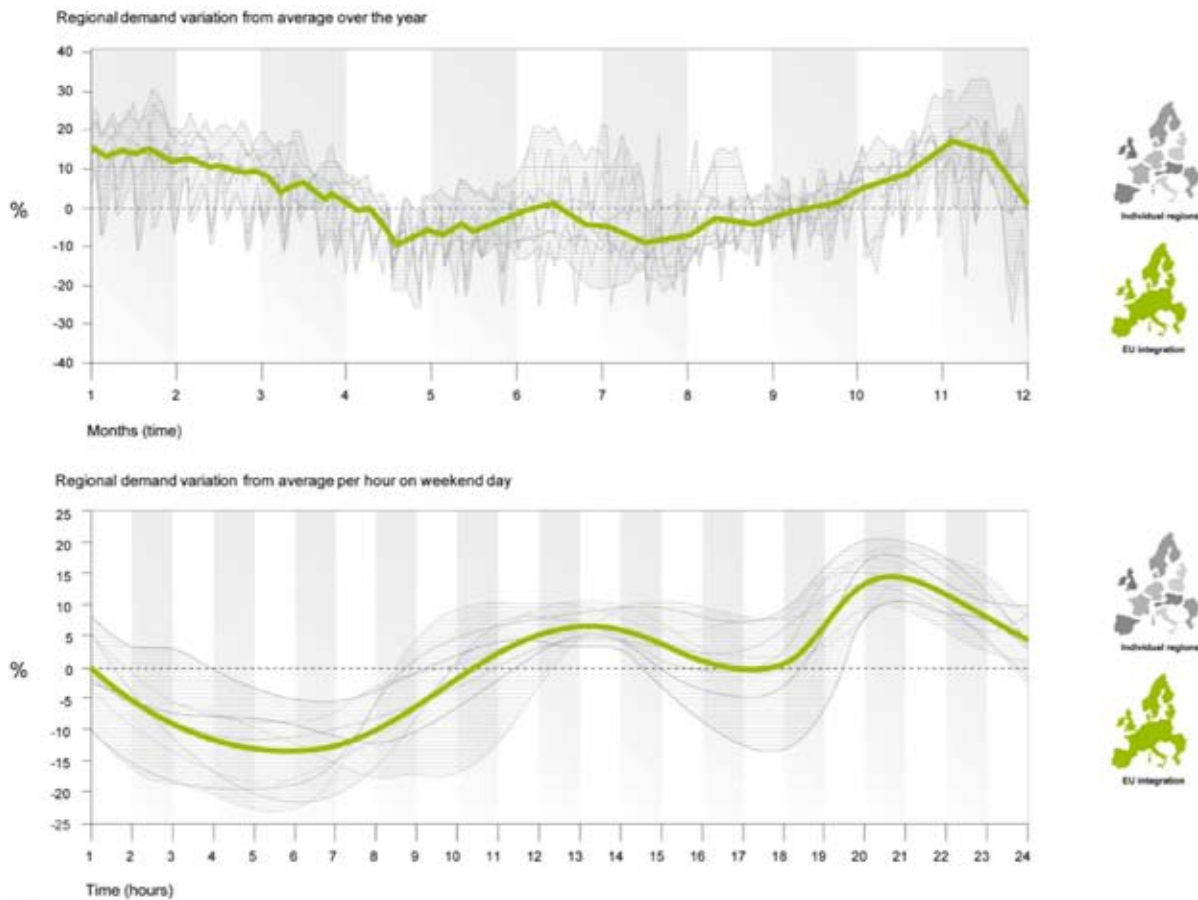
The optimal use of the grid to balance the various demand requirements and supply capacity available across Europe is central to the overall cost calculation of the Roadmap 2050 project. Timely delivery of inter-regional transmission capacity is key to all decarbonisation scenarios.

Benefits of interconnecting the grid

On the demand-side, we see that overlaying intra-day demand curves cancels out much of the overall volatility. On the supply side, we found a comparable level of benefit from wide geographic integration, with the well-documented local variability of renewable primary energy sources like wind and solar largely disappearing with the level of trans-European integration envisaged here.

The increase in transmission capacity and cross-border coordination of market operations will also allow sharing of reserve capacity between regions reducing total reserve requirements by ~40%, avoiding significant redundant investment. This is an immediate priority – the level of decarbonisation to which Member States are already committed by 2020 could result in up to 70% more investment

COMBINING REGIONAL DEMAND CURVES REDUCES VOLATILITY



than necessary if the grid and market integration recommended here is not pursued aggressively.

Finally, expanded interconnectivity and increased responsiveness of demand together dramatically reduce the amount by which various resources must be curtailed (turned down when their output would result in surplus production). Studies previously undertaken at the level of individual Member States have found high levels of curtailment, resulting in the need to substantially overbuild zero-carbon capacity in order to reach the required levels of power decarbonisation. Because installed generating capacity is the most costly component of the power system, it is beneficial to avoid this to the extent possible. A key finding of Roadmap 2050 is the dramatic extent to which a reasonable amount of transmission expansion and smart grid deployment, both of which are considerably cheaper than installed generating capacity, can reduce curtailment of all resources.

Energy independence and energy security are enhanced

All of these beneficial effects are augmented as the interconnection spreads over a wider geographic area. A trans-European transmission grid including close cooperation between the European TSOs will increase the energy independence and security of European countries. Within the EU-27, self-sufficiency of the regions will remain high, with 8 of the 9 regions studied generating over 90% of their required demand. That means national energy security increases compared to current levels.

A critical complement to investment in trans-European interconnections is improvement in demand response through smart grid applications at the local distribution network level. Demand response will reduce the peak capacity required, thereby lowering the costs of the power system. As importantly, it allows surplus zero-

carbon energy to be used when it's available and transferred to times of day when it's not, maximising yield and minimising cost. Thus the networks opportunity is both large-scale and very local in nature, and the benefits are dramatic at all levels.

Challenges

The Roadmap 2050 project focussed on the financial challenges and regulatory mechanisms that would be required to access the benefits of a transformed European power network. Other significant challenges presented by the required grid transformation include some factors that are not considered by the study, including public acceptance of new infrastructure and the widespread adoption of demand response.

Development of regulatory and energy policy frameworks will be required to mobilise increased flows of private sector investment, leveraged where appropriate by public sector investment, into the grid infrastructure necessary to enable decarbonisation and the optimal use of Europe's energy resources, but also to ensure that the costs and benefits are shared equitably across European consumers, who will all benefit from the reduced and more stable energy costs and increased security of supply.

Way forward

Roadmap 2050 did not set out to create a planning-level grid solution, and the "lines" shown on the maps should not be interpreted in that fashion. Clearly a more granular study involving broad stakeholder participation at a regional level, coordinated by ENTSO-E between Member States, will be required to turn these broad conclusions into actual infrastructure plans.

It will necessary for the EU and Member States to work together to produce long term indicative forecasts of regional demand and corresponding zero-carbon supply strategies, which can form the basis for regionally coordinated long-term networks plans based on the trinity of supply security, efficient markets and full decarbonisation. The European Commission could take the lead in conducting a study of operating experience with various models for addressing the challenge of multi-jurisdictional coordination of market operations, both inside and outside of Europe.

Member State regulators should be given the responsibility and the authority to cooperate across borders on regionally integrated infrastructure development, to establish a regulatory framework that allows grid development to lead strategic supply developments, and to enable a risk/reward balance that appropriately rewards investors for capitalizing these developments.

Member States should work with TSOs and utilities to ensure that wholesale market arrangements will enable investors to take advantage of the import/export opportunities afforded by the creation of a strategic interconnection plan.

Member States and key partners would benefit from establishing an ambitious timetable for the implementation of a fully smart power network, including maximum opportunities for demand response and distributed renewable generation, and from introducing a clear imperative on regulators to ensure that industry is incentivised to deliver.

Member State governments and the European Commission should work together to commission detailed studies to flesh out these concepts at a regionally specific level.

Glossary

CCS	Carbon Capture and Storage
GW	Gigawatt
TSO	Transmission System Operator

The Roadmap 2050 project is an initiative of the European Climate Foundation (ECF) and has been developed by a consortium of experts funded by the ECF. In addition, a wide range of companies, consultancy firms, research centres and NGOs have further supported the preparation of this report. The ECF is the sole author of the Roadmap 2050 report, is solely responsible for its content and will act as a guardian of the content.

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