EWEA
THE EUROPEAN WIND ENERGY ASSOCIATION

2050: Facilitating 50% Wind Energy

Recommendations on transmission infrastructure, system operation and electricity market integration

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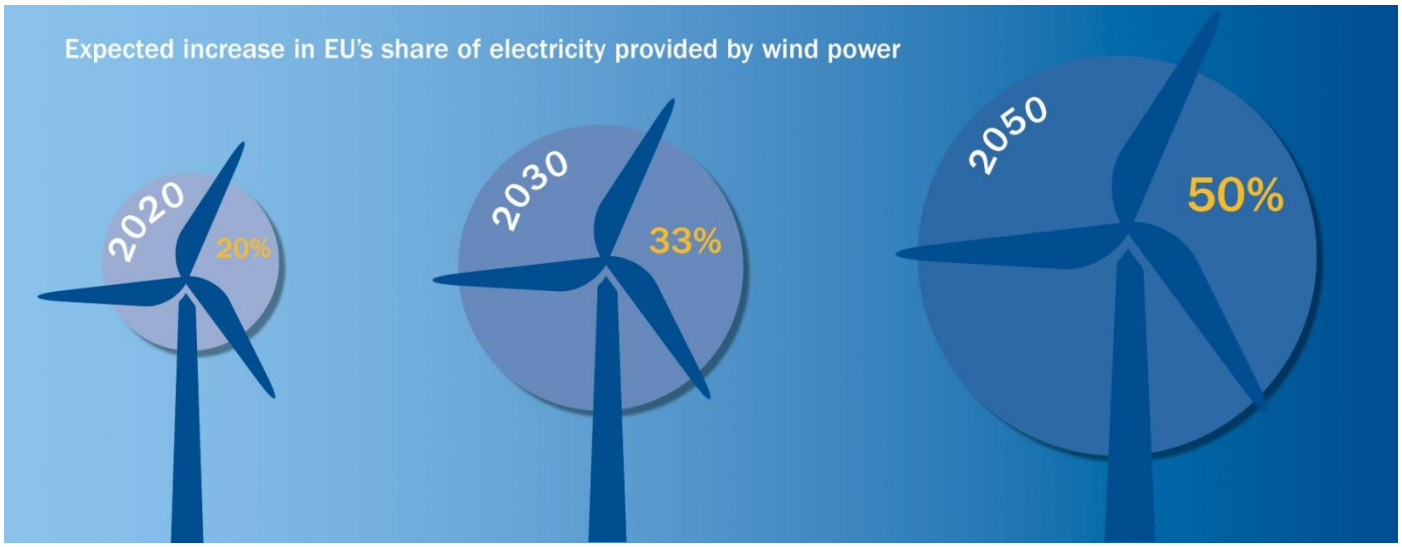

Introduction and rationale

The Heads of State have committed to reducing greenhouse gas emissions by 80-95% by 2050. This will only be possible with a 100% renewable energy power system in Europe by that date, with 50% of Europe's electricity provided by wind power. Wind power contributes to all of the EU's energy policy objectives – increased competitiveness, energy security and fighting climate change.

More new wind power capacity was installed in the EU in 2009 than any other electricity-generating technology. 39% of all new capacity installed in 2009 was wind power, followed by gas (25%) and solar photovoltaics (16%). Europe decommissioned more coal, fuel oil and nuclear capacity than it installed in 2009. Taken together, renewable energy technologies account for 62% of new power generating capacity in 2009. It was the second successive year that renewable energies have accounted for the majority of new investments, with wind power accounting for 35% of all newly installed capacity in 2008. The total wind capacity installed by the end of 2009 will, in a normal year, produce 163

TWh of electricity, meeting 4.8% of total EU power demand[1].

On 7 October 2009, the European Commission published its Communication on "Investing in the Development of Low Carbon Technologies (SET-Plan)"stating that wind power would be "capable of contributing up to 20% of EU electricity by 2020 and as much as 33% by 2030" were the industry's needs fully met. EWEA agrees with the Commission's assessment. With additional research efforts, and crucially, significant progress in building the necessary grid infrastructure over the next ten years, wind energy could meet one fifth of the EU's electricity demand in 2020, one third in 2030, and half by 2050.

Meeting the European Commission's ambitions for wind energy would require meeting EWEA's high scenario of 265 GW of wind power capacity, including 55 GW of offshore wind by 2020. The Commission's 2030 target of 33% of EU power from wind energy can be reached by meeting EWEA's 2030 installed capacity target of 400 GW wind, 150 GW of which would be offshore. Up to 2050 a total of 600 GW of wind energy capacity would be envisaged, 250 GW would be onshore and 350 GW offshore[2]. Assuming a total electricity demand of 4000 TWh in 2050 this amount of installed wind power could produce about 2000 TWh and hence meet 50% of the EU's electricity demand[3].

To achieve this level of ambition a number of actions need to be taken. Alongside an adequate transmission infrastructure it is necessary for the efficient integration of large amounts of wind energy to have market rules that allow for operation of the system such that there is an efficient international power exchange. Both the development of physical infrastructure and market integration are therefore closely linked and must be carried out in a coordinated way.

In this context it should be mentioned that the large-scale integration of RES is not only crucial to meet the targets mentioned above, but also to ensure security of supply as domestically-sourced energy like wind power brings major benefits in terms of reduced reliance on imports. By the same token it will ensure the competitive advantage and global leadership Europe has in the field of renewable technologies, such as wind power, a lead that could be challenged: The 2010 Renewable Energy Attractiveness Index now cites the US and China as the best investment opportunity for renewable energy[4]. Europe needs adequate grids and functioning markets for wind power and a globally leading wind industry.

[1] According to the latest figures from Eurostat, final electricity consumption in the EU-27 was 3,372 TWh in 2007

[2] See : Pure Power, 2009, page 69 : http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/Pure_Power_Full_Report.pdf

[3] Ibid

[4] European Commission communication, May 2010: Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage

The challenges that lie ahead are numerous, and this paper focuses on transmission infrastructure, changes in system design and operation, and the development of integrated cross-border electricity markets. For a large scale integration of wind power to happen in the most economical way Europe's electricity grid needs major investments, with a newly built offshore grid, major grid reinforcements on land and, in the long-term, a long-distance overlay grid. The present EU framework with newly established bodies ENTSO-E and ACER, as of 2011, together with the ongoing intergovernmental "North Seas Countries' Offshore Grid Initiative", are steps in the right direction in the short term and the political momentum for grid development and RES integration is evident.

Practical solutions must be found now on how to best incentivise a Europe-wide offshore grid, onshore transmission reinforcements and a trans-European overlay grid to ensure the flow of substantial amounts of onshore and offshore wind energy to consumers across Europe, while improving competition in the internal electricity market.

However, as transmission infrastructure requires several years, if not decades, to be built and features long lifetimes, **a long term vision on grid assets is urgently needed to guide current and future investments**, together with an optimal use of the existent grid**.**

This paper therefore aims to fill this gap from the wind energy perspective and give a set of recommendations to prepare for the development and planning a future European power system. The following recommendations cover both most urgent changes to alleviate severe shortcomings which already now hamper the large scale integration of wind energy and a range of advice which will be necessary to further ensure a smooth transition to a power system with the bulk of electricity demand covered by wind energy in the long run up to 2050. More precisely, the recommendations in this paper cover the following aspects:

- Conceptual and operational aspects of future power systems : proper flexible low carbon generation mix – interacting with a more responsive demand side
- The challenge of providing adequate network infrastructure
- Electricity market design for large-scale wind power
- Institutional and regulatory framework
- Research and Development

Finally, roles and responsibilities of the main stakeholders in the power sector are outlined to illustrate the required level of cooperation to carry out the recommendations stated below.

Recommendations:

Future Power system concepts

This section addresses adequate integration solutions for power systems in Europe with high wind penetration levels including measures to increase flexibility sources in the system such as forecasting, reserve requirements and ancillary services.

- In future developments of the European power systems, increased flexibility should be encouraged as a major design principle In this context flexible generation, demand side management, interconnections and storage solutions are key design features. Besides using the existing plants – even the slow base load plants - in a more flexible way, planning for replacing ageing plants and future generation mix should favour flexible generation (for example hydropower) to enable the integration of large scale variable generation, mainly wind and solar photovoltaics. Providing better access to flexible reserves situated in neighbouring control areas through power exchange should be encouraged as a means to improve the system flexibility.
- Adequate use of short-term wind power forecasting in combination with short gate closure times should be made wherever possible to reduce the need for extra reserve capacity needed at higher wind power penetration levels. Efficient integration of wind power implies to integrate forecasting in the control room of system operator. In order to control the possible large incidental forecast errors, reserve scheduling should be made possible in as short as possible time frames (short gate-closure times), assisted by real time data on wind power production and site specific wind conditions. The cost-benefit ratio of applying centralised forecast systems is very high – because of the high reduction in operational costs of power generation corresponding to reduction in uncertainty.
- State-of-the-art wind power technology with advanced control features is designed not only to produce electricity in a cost-effective way but also to enhance grid performance by providing ancillary services. Using these power plant characteristics to the full extent with full regards at minimising system costs and minimum curtailment of wind power is essential for efficiently integrating high levels of wind power penetration.

Grid infrastructure upgrade

Upgrading the European network infrastructure at transmission and distribution level is vital both for the creation of an Internal Energy Market in Europe and a fundamental step on the way to large scale wind power integration. This section points at urgent measures to overcome barriers to the expansion of the network towards a truly pan-European grid.

- The European transmission grid needs to be reinforced and expanded to enable the foreseen penetration levels of wind power. The TYNDP and its regular updates

should reflect the realistic wind power generation forecasts by providing sufficient corridors of adequate capacity. The TYNDP developed in close consultation with the stakeholders should be the main tool providing a pan-European planning vision for grid infrastructure in line with long-term EU policy targets and industry ambitions. New technologies such as underground HV DC VSC should be used where it can accelerate the implementation by overcoming public acceptance barriers.

- In the short term, maximum use should be made of methods to optimise the utilisation of the existing infrastructure and transmission corridors such as dynamic line rating, rewiring with high-temperature conductors, power flow control devices, FACTS and improved operational strategies.
- Specifically to access the huge European offshore resource, a transnational offshore grid should be constructed. The value of such a grid is very high, not only for the deployment of the offshore potential, including deep floating offshore, but also for the trading of electricity in Europe. A staged approach is recommended starting from existing subsea interconnection plans of TSO's and gradually moving to a meshed offshore network. Demonstration projects connecting offshore wind farms to two or three countries should be built on the short term to test the concepts and to assist the development of suitable technical and regulatory solutions. The consequences for the onshore grid in terms of network reinforcement in the coastal zones or deeper overlay connections to load centres should be considered in an early stage.
- Accelerated development and standardisation of transmission, storage and demand side management technology is needed. More specifically the uptake and standardisation of multi-terminal HV DC VSC is recommended in order to achieve a timely deployment in the offshore grids and later in onshore overlay Supergrids.
- Innovative and effective measures need to be deployed such as 'smart grids', also termed 'active networks', 'intelligent grids' or 'intelligent networks', assisted with adequate monitoring and control methods to manage high concentrations of variable generation especially at distribution level.
- Proper regulatory formulae need to be developed to provide the attractive legal conditions and incentives to deploy initiatives in multistate transmission infrastructure. This can be helped by building on the positive experience of "coordinators", particularly where the coordinator has a clearly defined (and limited) objective - such as is the case with the French-Spanish connection.
- A large geographical spread of wind power on a system should be encouraged through planning and payment mechanisms and the establishment of adequate interconnection. From a system and cost point of view that will reduce variability, increase predictability and decrease / remove situations of near zero or peak aggregated wind power output.
- In the long term, European transmission planning should be extended to third countries as long as these projects have a direct impact on the internal EU network countries (in particular Mediterranean countries – Medring - and EU neighbouring countries)
- The cost of the upgrade of the European network should be socialised. One reason to do it is that grids are natural monopolies. Grid connection charges should be fair and transparent and competition should be encouraged. Regulators must recognise that the benefits of developing a truly European grid network would lie not only in overcoming the present congestions on some of the main transmission lines but would also provide for savings in balancing and system operation costs and enabling a functioning IEM,

- Where market failures in network development due to natural monopoly and competition effects can be restrained, grid investments could be brought about by innovative market-driven mechanisms designed to attract financial stakeholders willing to invest in grid assets e.g. pension funds and infrastructure funds. Incentivisation for grid infrastructure should therefore not prohibit TSOs or private stakeholders from developing additional merchant transmission lines. By the same token transparent information related to grid infrastrucutre planning should be made available by TSOs to all interested stakeholders.

Power market design

Given the large wind energy penetration levels in the future, markets that lead to an efficient allocation of wind and other renewable generation capacity are due to be put in place, both to ensure electricity market integration and market integrity throughout Europe.

- The uptake of functioning intra-day markets is crucial for the efficient integration of large amounts of wind energy and for cost-efficient system operation in general. The application of intra-day wind power forecasting for low reserve requirements should be ensured.
- In order to maximize the economic benefits from interconnections, its capacities should be allocated via implicit auctions, i.e. market coupling or splitting algorithms. Optimally, these algorithms should be flow based.
- Harmonised capacity calculation methodologies will help provide the maximum possible capacities to a wider European market for each time horizon by respecting TSOs security standards.
- Cross-border balancing markets should be also developed on an intra-day basis as this will provide for further system operation savings. The trade-off between savings in investments for flexible power plants and sharing of reserves across borders should be investigated with dedicated models.
- A single central auction office for market coupling could be established in the EU.
- In the short run, power systems with wind energy penetration levels of 10-12% of gross electricity demand need, beside more flexible plants, also the slower power plants (with start-up times above one hour) to participate in the intra-day rescheduling.
- In the long term, potential synergies of market integration with the development of a future “smart” power system should be exploited. A future smart grid will allow for all market participants, including consumers to react to electricity price fluctuations by adapting their consumption behaviour to the actual price. Along with the technical progress on Smart Grids, the uptake of “Smart Markets” with practical IT tools even at consumer level (“ebay for electricity”) could therefore provide a further building block for a future power system characterised by flexibility.
- Transparent and regularly updated information should be available to all market players in order to analyse the best market opportunities. It will not only ensure fairer market behaviour, but also provide for the best possible imbalance management in a market based and non-discriminatory way which will facilitate the integration of wind power.

Institutional and regulatory aspects

In order to create political momentum and a 100% renewable energy power system by 2050 the right institutional and regulatory framework must be put in place. National and European decision makers need to develop a long term vision with adequate targets and milestones to this end, accompanied by further evolutions of prominent legislative initiatives such as the RES Directive and the 3rd package.

- In the short term financing schemes for pan-European transmission grid reinforcements should be developed at EU level. A sufficiently financed TEN-E replacement instrument should become the main support mechanism for European electricity networks providing support throughout the whole investment cycle, with a substantially increased budget. Furthermore, the use of structural funds and the EIB for new energy infrastructure investments should be fully exploited.
- In addition, national promotional banks (Caisse de Dépôt, KfW, etc.) should be sought as active consortional lending partners, co-sponsors for equity funds and partners for network expansion projects.
- Coordination between Member States on cross-border infrastructure both on the planning and regulatory levels must be made compulsory to harmonise procedures and speed up authorisation procedures. To this end, harmonised planning (including spatial planning) and authorisation processes fully supporting the TEN-E and related mechanisms are needed.
- European energy regulators and ENTSO-E could implement regional committees to ensure a swift completion of regional/transnational infrastructure projects. Furthermore, the set-up of one central authorising body within a MS in charge of cross-border projects is worth exploring.
- Best use of the 3rd Package deliverables must be made through the swift establishment of binding Framework Guidelines and Network Codes to put in place a clear legal framework for cross-border transmission management.
- The challenge of creating the necessary infrastructure for reaping one of Europe's largest indigenous energy sources – offshore wind power – should be coordinated at European level. A suitable business model for investing in the offshore power grid and interconnectors should be rapidly introduced based on a regulated rate of return for new investments.
- The visions developed by EWEA and backed-up by studies like OffshoreGrid should be taken forward and implemented by the European Commission, Member States and ENTSO-E in a high-level stakeholder group.
- In the long term up to 2050 there is a need for constructing an overlay grid and this involves multistate lines. The proper regulatory and financial framework should be established for the construction of such a "supergrid", with a regulated rate of return.
- In the regulatory process initiated at European level to develop a European network code, it is recommended to develop a clear set of wind power specific requirements for grid connection. This step is urgently needed in view of the significant increase in

foreseen wind power penetration and should be of particular benefit to wind turbine manufacturing industry, wind plant developers and operators and transmission and distribution network operators.

- A specific European wind power connection Code should be established within the frame of a European Code for Network Connection.
- The technical basis for connection requirements should be continuously developed in work carried out jointly between TSOs and the wind power industry in studies at European and international level. It is believed that if the proposals can be introduced at European level, it will set a strong precedent for the rest of the world.
- The European Commission together with relevant stakeholders (TSOs, regulators, power exchanges and traders) must enforce a comprehensive EU market integration strategy by implementing a target model and roadmap covering forward, day-ahead, intraday and balancing markets as well as capacity calculation and governance issues. Regional Initiatives should converge into a single European market already by 2015.
- Adequate mechanisms for market monitoring should be put in place. Consequently, competent authorities must have full access to all relevant information for the purpose of monitoring activities and implementing any ex-post investigations and necessary measures to mitigate market power or prevent potential abuse of it.
- TSOs must provide for full transparency in balancing markets in order to trigger fairer market behaviour and adequatly value balancing services.
- A capacity market should be developed with mechanisms to favour flexible renewable generation. Proper methods for the valuation of wind power capacity in such markets should be established, including specific market rules for providing reserve and also energy storage capacity in the long term.

Research and Development

An appropriate framework for coordinating the identification of the research needs is established with the Wind Energy Technology Platform under the 7th EU Framework Programme for research. Specifically in the field of grid integration, a dialogue is set up between the Wind Initiative and the Grid Initiative under the European Industrial Initiatives which constitute the Strategic Energy Technology (SET) Plan.

- There is great need for further short-term and long-term R&D in wind energy development at national and European level, in order to further develop onshore and offshore technology, enable the integration of large scale renewable electricity into European energy systems and maintain European companies' strong global market position in wind energy technology.
- Operation: Developing methods of incorporating wind power uncertainties into existing production planning (scheduling) tools and models is important, and in this area more R&D is needed. The significant economic benefits of improved forecasting accuracy justify investment in large wind observational networks. Additional R&D efforts are needed to improve the meteorological input for prediction methods.
- Specifically on grid integration of wind energy, more research is needed, in the context of the SET Plan's Wind Iniative and Grid Initiative, in the following areas:

a. Grid connection solutions for offshore wind farms to HV AC and HV DC grids, and the development of multiterminal HV DC grids

b. Wind plant capabilities for providing system support, and novel control and operating modes such as Virtual Power Plant

c. Balancing power systems and market operation in view of design of future power systems with increased flexibility

d. Transmission technologies, architectures and operational tools

e. More active distribution networks and tools for distributed renewable management and demand side response

f. Tools for probabilistic planning and operation, including load and generation modelling, short term forecasting of wind power and market tools for balancing and congestion management

- Further research on storage and demand-side management technologies is needed which may not be exclusively related to wind energy integration, but in general pave the way for a more flexible power system.

Roles and responsibilities:

Wind power is capable of supplying a share of European electricity supply comparable to the levels currently being met by conventional technologies such as fossil fuels, nuclear and large hydro power. The envisaged level of wind energy penetration will require cooperation among decision makers and stakeholders in the electricity sector on making the necessary changes to the European grid infrastructure that has been developed with traditional centralised power in mind. This paper is therefore addressed to the following stakeholders which are due to play a crucial role in this process:

- Wind industry: Wind turbine and component manufacturers, project developers, wind farm operators, engineering and consulting companies, R&D institutes and national associations. The wind industry does and will maintain to continuously improve wind turbine technology in order to facilitate system operation in close cooperation with the power sector.
- System operators: Transmission and distribution system operators and owners. Particularly the newly established ENTSO-E with its remit to provide every two years a 10-year network development plan and draft binding network codes will play an essential role in lining out the framework for a future european grid management and planning.
- Power sector: Power producers, energy and storage suppliers, energy traders, power engineering companies, R&D institutes, sector associations.
- National and European Energy Regulatory Authorities: The newly established Regulators body ACER has currently only a monitoring and advisory rather than a

decision-making role. Nevertheless their advise will be crucial to ensure that cross-border grid management rules under the 3rd Package are properly implemented. It is likely that their remit will increase in the long-term when further legislative initiatives such as a possible 4th Package are put forward.

- Public authorities: Energy agencies, ministries, national and regional authorities, R&D institutes and European institutions are key to provide political guidance when creating the regulatory framework for grid planning and management. Up to 2050 there will be a need for additional political initiatives and targets to follow up on the 3rd Package and TEN-E instrument and refine this European legislation. A further shift in energy policy from a national domain to a truly Europeanised policy area can be expected.
- Users: Industrial and private electricity consumers, energy service providers, will see their role shifting from sheer grid users to ones that are involved directly in a more flexible power system with local storage solutions, the uptake of electric cars and an ICT supported demand-side management.