Summary and recommendations

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Chapter 2

Summary and recommendations

Summary
Within the past ten years, cumulative global installed wind power capacity has increased from approximately 48 GW in 2004 to around 320 GW at the end of 2013, an average annual growth in the order of 20%. In 2030 onshore wind installed capacity is expected to exceed 1,000 GW, while offshore might exceed 200 GW.

Denmark has a goal of meeting 50% of its power consumption from wind by 2020. The European Technology Platform for Wind Energy (TPWind) sees wind energy as the leading renewable energy technology which could provide up to 34% of EU electricity by 2030.

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To make wind energy fully commercially competitive with other energy sources in terms of the cost of energy (CoE) is the primary driver in the technology development. Another important issue is to improve the predictability and system services of wind energy production and hence to enable higher penetration in the grid.

Onshore wind power is becoming increasingly competitive with conventional fossil-based electricity generation. However, offshore wind power is still much more expensive than onshore. Offshore CoE can be reduced through upscaling of turbines and industrialisation of other parts of the plant, and the industry is on track to achieve its target of cutting costs by approximately 40% by 2020.

Emerging wind energy technologies

If the 55 kW turbines of the mid-1980s were directly scaled up, the newest 6–8 MW turbines would weigh about 10 times as much as they do. To lower the CoE, designers have tailored the turbines even more carefully to the conditions under which they operate; advanced designs using less materials and higher reliability remain the main ways of reducing CoE for future turbine designs, too.

Many factors have aided the move to lighter blades, of which the most important has been the development of blades that are much more slender and flexible than their predecessors. This development is leading to blades with new geometry with passive control, advanced thick airfoils and new processes and materials. Several manufactures are introducing direct-drive generators without gearboxes in order to increase reliability. New concepts for towers include building them from serially produced concrete segments.

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Balancing energy systems with high shares of wind energy

The integration of high shares of wind energy into today's energy systems has several related, but separate, challenges due to the variability and predictability of the energy production.

The inherent uncertainty of wind power generation leads to deviations between forecast and actual wind production, and hence to unexpected fluctuations in the power supply. To minimise the effect of these fluctuations the system operator needs access to sufficient reserves. A high share of wind energy also means that wind energy must take a larger responsibility for the stable operation of the energy system and provide system services, which are known as ancillary services.

Demand control will reduce balancing needs on the supply side. Electrical storage can provide additional control capacity that could replace the need for flexible thermal power generation.

Improved forecasting models and a shift from hourly to minute-based forecasts will reduce uncertainty in wind power production and need for reserves.

Wind power economy and market signals

For wind power, a number of EU countries leave the classic feed-in tariffs that paved the way for the cost reductions we have seen to date. The main reason is wind's increasing market share: wind power now has to interact better with the remainder of the power system, and should react to market signals. The EU's current legislative plans point towards a stronger future focus on cost reduction and competition.

The investment cost per kW for onshore turbines today is typically around 1,200–1,400 €/kW (9,000–10,000 DKK/kW). The CoE ranges from approximately 0.06–0.07 €/kWh (0.4–0.5 DKK/kW) at sites with low to medium average wind speeds, to approximately 0.04–0.05 €/kWh (0.3–0.4 DKK/kW) in good coastal positions.

The CoE from offshore turbines in high-wind locations is close to 0.09 €/kWh (0.7 DKK/kWh) for a standard offshore installation with an investment cost of 3,000 €/kW (22,000 DKK/kW).

O&M costs are increasingly attracting more attention. Manufacturers are attempting to lower these significantly by developing new turbine designs that require fewer regular service visits and less planned downtime.

Wind power creates jobs

The European Wind Energy Association estimates that by 2020 there will be 520,000 jobs in the European wind energy sector and almost 800,000 jobs by 2030. Globally 834,000 people were employed in the wind industry at the end of 2013.

There has been a shift from jobs requiring unskilled manpower to highly skilled jobs. For example in Denmark, jobs requiring master's degrees and PhDs have grown consistently. Highly trained staff is scarce, and require intensive effort in education and research if their numbers are to grow.

Environmental and social impacts of wind energy

The compliance of wind farms with local and regional environmental requirements and guidelines, and the social acceptance of wind power, are both essential if wind is to meet its ambitious targets for growth. Recent research in Denmark is seeking new opportunities to understand and improve the democratic processes linked to the construction of large facilities for wind energy and other renewables.

Recycling of wind turbines attracts greater attention

The institutional and organisational structures for recycling wind turbines are still quite uncertain. There is a need to develop policies encouraging the recyclability of wind turbines.

A high share of wind energy also means that wind energy must take **a larger responsibility for the stable operation of the energy system** and provide system services, which are known as ancillary services.

See our recommendations for academia, industry, and authorities on the next page.

Recommendations

The following recommendations address issues that need attention if Denmark is to meet the ambitious targets set by the government for the growth of wind power.

Academia

- The most important role of academia is to develop the instruments and support the innovation in industry. The instruments are based on research and take the form of new knowledge, models, education and new ideas.
- It is important to find the right balance between short-term and long-term objectives in future R&D. Incremental innovations will probably have a faster effect on CoE compared to long-term research, but in time the latter is likely to have more impact.
- There is a need for more R&D on metallic and composite materials for more efficient use and substitution in future wind turbine designs.
- There is a need for more R&D in ways to dismantle wind turbines into recyclable materials and to look at the potential markets for products made from recycled materials.
- The use of rare earth materials is increasing, for example in magnets. There is a need for more R&D on recycling or recovery of rare earths and magnets.
- A challenge, both technical and economic, is to ensure that ancillary services continue to be provided at the lowest cost consistent with not compromising system security or reliability.

Industry

- The wind industry is maturing and moving in the direction of mass production. Thus the industry needs to learn from other sectors, such as car manufacturers, how to do that in a cost-competitive way.
- The largest growth rate of the wind sector is expected offshore. There might be a need for larger companies with the ability to develop, produce and deploy entire offshore wind farms.
- Industrial development of new smart power protection systems has the long-term potential to mitigate some of the present needs for ancillary services.

Authorities

- It is important to continue with reliable policies and stable support frameworks for R&D and industrial implementation, as well as fixed long-term targets for wind capacity growth.
- Regulators should pay attention to the system integration of wind power. This also needs to be reflected in the design of support systems (e.g. feed-in premiums, with guaranteed total income levels, instead of tariffs), and the design of markets for ancillary services.
- In the long term, adequate investment incentives must be provided for controllable backup power.
- There is a need for policies that stimulate OEMs to design for recyclability. Valuable experience might be gained from comparable industries.