iea wind

Task 25 Design and Operation of Energy Systems with Large Amounts of Variable Generation

Fact Sheet

HOW MUCH WIND AND SOLAR CONTRIBUTE TO SYSTEM ADEQUACY?

How much wind and solar energy is available when electricity consumption, the demand, is high? Generation capacity adequacy of the power system has to be evaluated to make sure that there is enough power plant capacity available for all peak demand situations. A capacity value indicates how much of the installed wind or solar power capacity can be counted on during peak demand.

How to manage situations of high demand and low wind and solar energy?

System operators need to plan for sufficient capacity during possible peak demand situations. All power plants have the possibility of failure during critical hours. This is why total installed power plant capacity exceeds plausible peak demand estimates to make sure that there is enough capacity available. An extra margin of power plant capacity that is 12% to 15% of peak demand is normal. Import from neighbouring areas can also be counted.

Adding any generation capacity will increase the reliability of the power system (Figure 1). Wind and solar are often added as an extra energy resource while keeping other power plants in the system. These other plants will be available at peak times with low wind and solar production.

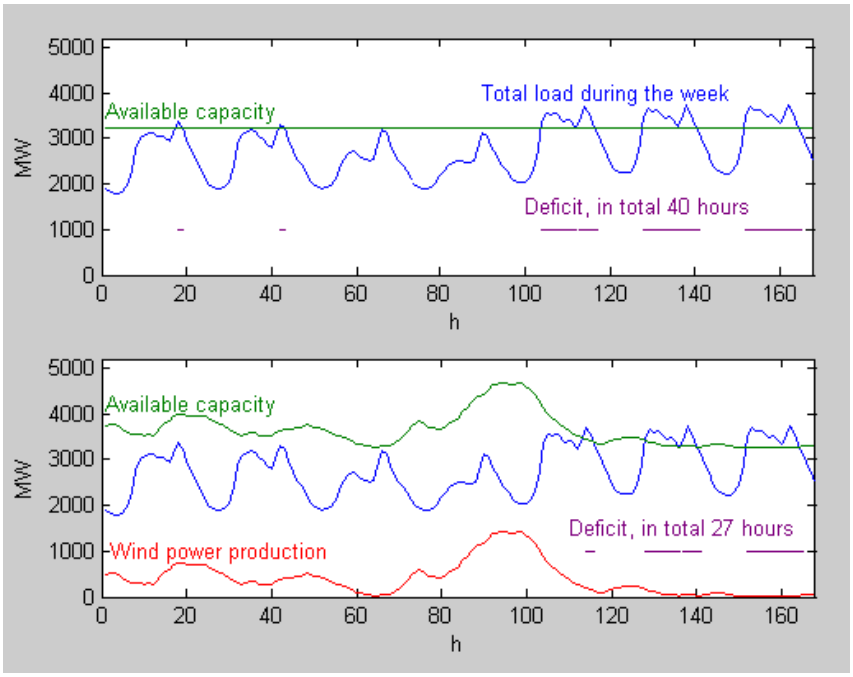

Figure 1. *Adding generation capacity to an existing system will increase the reliability – the amount of hours with capacity deficit decrease (Source: Lennart Söder, KTH).*

At larger wind and solar shares older power plants may have to retire, and then the capacity value of wind and solar power becomes a relevant question. Usually in addition to wind and solar power, enough other power plants have to be kept in the system. In future flexible demand can help: in times of scarcity of generation, some electricity consumption can reduce.

How to estimate the capacity value of wind power?

The capacity value tells how much a power plant contributes to system reliability. Power system reliability can be estimated by calculating the probability that there is not enough available power plant capacity to meet the demand (Loss-of-Load Probability LOLP).

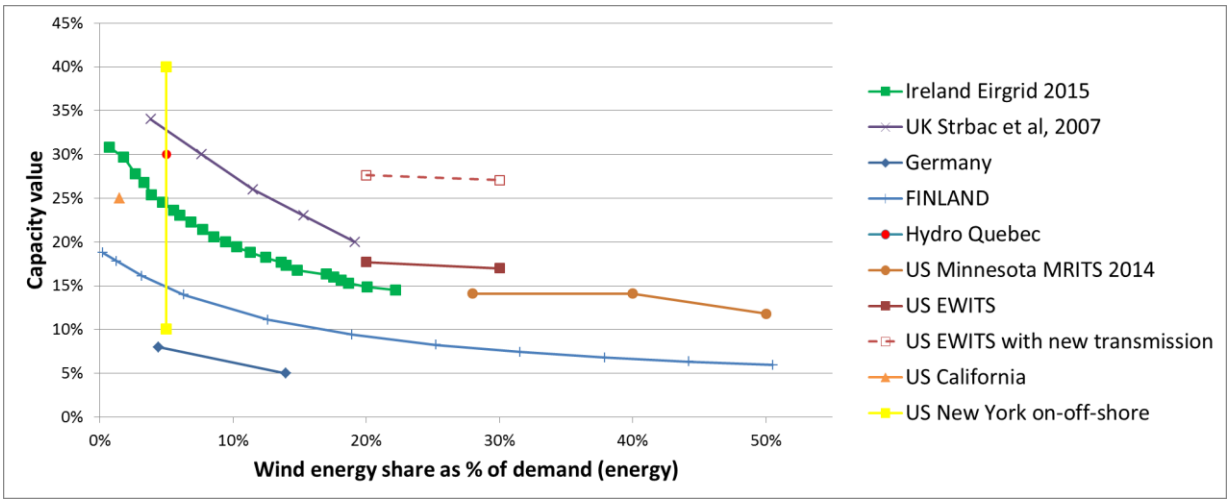

Figure 2. *Examples of capacity value result from different wind integration studies. The capacity value will depend on the power system: mainly the available wind power during peak demand periods, the larger the system the higher the value. Capacity value will decrease with increasing amount of wind power. Source. Task 25 (Holttinen et al 2016).*

Generation capacity is modelled with the forced outage rates of generators. The aggregate wind and solar output of a power system is composed of hundreds or thousands of individual turbines and solar panels, so it is not feasible that all will fail to produce at once. For wind and solar the risk is whether there will be wind and solar irradiation available. For solar, even short term storage can help the reliability. For wind power the combined generation of many sites situated further away can remain much higher than a single turbine output. Aggregated generation over a large region can still contain days with low wind power generation. Taking into account the possibility to share generation through transmission built between areas need to be captured by multi-area modelling.

For wind power capacity value, hourly electricity demand and wind power generation from more than 10 years are needed to give a robust estimate. Using historical data makes sure that any correlations that wind may have with demand are captured. Simulating the system with and without wind gives the additional demand that can be served by wind power when the LOLP is kept the same.

How much can wind power be relied upon during peak demand periods?

For wind the capacity value is smaller than for conventional power plants, in the range of 5% to 40% of installed capacity (Figure 2). This is often close to the average power generated. The capacity value depends on timing of winds: for example it is small on land in New York state where wind usually does not blow in periods of high demand, and it is higher offshore where wind tends to blow at times of high demand.

Capacity value of wind power tends to decrease when the share of wind energy increases. For larger areas the capacity value is typically higher, as it is more likely that the winds will blow somewhere during peak demand periods – this is illustrated by the Eastern US case where building transmission to connect larger areas shows a considerably larger capacity value for wind power (Figure 2).

In future energy systems, there may be more flexibility in demand and that will reflect also how much generation capacity needs to be built to ensure reliability.

Associated publications

- Milligan, M. et al. (2009). **Wind power myths debunked**. IEEE Power & Energy Magazine, 7(6), 89–99. https://doi.org/10.1109/MPE.2009.934268
- IEA (2019). **Status of Power System Transformation 2019: Power system flexibility**. https://www.iea.org/reports/status-of-power-system-transformation-2019
- Holttinen, H. et al. (2016). **Design and operation of power systems with large amounts of wind power**. Final summary report, IEA WIND Task 25, Phase three 2012–2014. http://www.vtt.fi/inf/pdf/technology/2016/T268.pdf
- Greening the Grid (2015). **Using wind and solar to reliably meet electricity demand**. Fact sheet available at https://greeningthegrid.org/Grid-Integration-Toolkit

More information

This Fact Sheet draws from the work of IEA Wind Task 25, a research collaboration among 18 countries. The vision in the start of this network was to provide information to facilitate the highest economically feasible wind energy share within electricity power systems worldwide. IEA Wind Task 25 has since broadened its focus to analyze and further develop the methodology to assess the impact of wind and solar power on power and energy systems.

See our website at
https://community.ieawind.org/task25

See also other fact sheets

Storage and Wind Power Fact Sheet
Balancing Power Systems with Wind Power Fact Sheet
Variability and Predictability of Wind Power Fact Sheet
Wind Integration Issues Fact Sheet