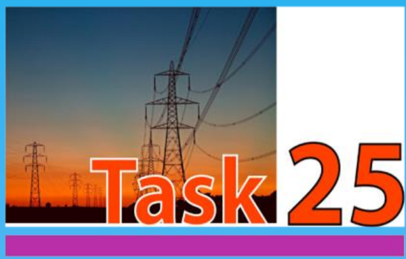
Task 25 Fact Sheet

IMPACTS OF WIND POWER ON POWER SYSTEM STABILITY



Design and Operation of Power Systems with

As electrical grids integrate higher shares of wind power, assessing the impacts of wind generation on power system dynamics is increasingly important. Blackouts are very costly for our society and reliability must be kept at a very high level. There is emerging evidence that wind power plants can enhance system stability when the latest technology is adopted and incentives for its use are provided.

How are power system stability and blackouts traditionally managed?

System operators must continuously monitor the stability of their system, identify potential unforeseen events (like a sudden failure of a power plant or an overhead line), devise strategies to minimise their effect, and implement measures which improve the robustness of their system to disturbances (Figure 1).

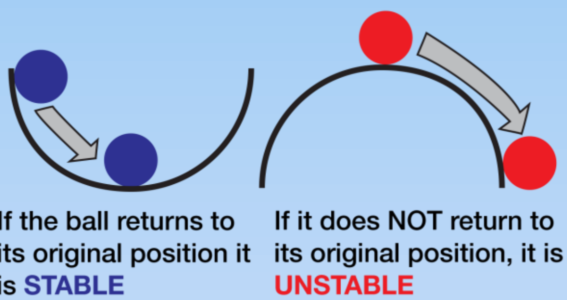


Figure 1. After a perturbation, if the ball returns to its original position the system is STABLE; while If it does NOT return to its original position the system is UNSTABLE. (Source: Kundur et al., 2004).

During fault conditions the system response needs to be assessed on the timescale of fractions of a second. Stability issues may vary depending on demand level, the network topology, and the portfolio of generation on-line supplying the energy needs.

How can wind power impact the stability of a power system?

Wind power is not a likely cause of system disturbances. However, wind variability and uncertainty may complicate situations caused by faults.

This can be mitigated through operational practice. The four types of stability are:

- Voltage stability: Modern wind turbines can support voltage stability by controlling their reactive current output, if control is suitably designed.
- Transient stability: A network fault (e.g. a tree branch short circuiting an overhead line) may result in the flow of large (damaging) currents which can cause generators to accelerate and lose 'synchronism' with the rest of the power system after a few seconds. Modern wind turbines are required to 'ride-through' most such conditions. In addition, they can enhance the stability of the system by injecting reactive current and support the voltage in their local area when required.
- Small-signal stability: Individual generators may slowly oscillate against each other for a period of seconds to minutes following a small disturbance. Wind power plants are unlikely to initiate or contribute to such oscillations. However, their presence may change the direction and magnitude of power flows and alter the number and location of conventional generators online. This can impact the ability to damp such oscillations; however, wind power plants can be configured to provide damping capability.
- Frequency stability: If there are problems providing sufficient online generation, the frequency will start to fall. If the frequency cannot be restored within several seconds there will be a danger of system collapse and a blackout. Frequency stability can be challenging for smaller power systems, especially during instances when more than

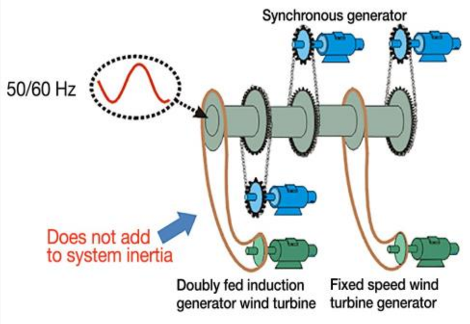


Figure 2. Synchronous power system – operates at close to a constant frequency (50 or 60 Hz), and generators with their rotating masses are connected so that their masses provide inertial support and tend to keep the frequency constant. Older wind power plants may also provide some inertial support. Most modern wind turbines are connected through power electronics and will not provide and intertial response (or similar) unless the controls are suitably designed.

50% of load is met by wind power. but this is not yet a problem for larger systems. Modern turbines can also help improve frequency stability. A wind turbine, due to the mass of the rotating blades, has a large stored rotational energy. Modern wind turbines have the capability to temporarily release some of this stored energy providing a fast frequency response (commonly known as an emulated inertial response).

Can wind power help the stability of the power system?

Yes, wind power plants can actually improve the stability of a well-designed system. They can provide a fast power response to aid frequency stability and a reactive power response to support the voltage during steady-state and fault conditions. They can also inject active and/or reactive power to damp system oscillations (Figure 3). The system support responses from wind power plants are well documented but are not widely deployed. This is because wind stability responses may not be required at existing wind power share levels, financial incentives to deploy these capabilities do not currently exist, and because their impact on (individual) power system operation has not been fully studied. A growth in the wind power share of future power systems will likely be matched by a growth in the role that wind generation plays in maintaining the stability of that system.

Associated publications

Flynn D. et al. (2017). Technical impacts of high penetration levels of wind power on power system stability. Wiley Interdisciplinary Reviews: Energy and Environment, Vol. 6:e216.

Kundur et al. (2004). Definition and classification of power system stability. IEEE Trans. PWRS, vol. 19, no. 3, pp. 1387-1401.

Miller N. et al. (2014). Western Wind and Solar Integration Study Phase 3 – Frequency Response and Transient Stability. Executive summary and full report available at: www.nrel.gov/electricity/transmission/western_wind.html

EirGrid and SONI (2010). All Island TSO Facilitation of Renewables Studies. Available at www.eirgrid.com

The Irish power system has been studied in detail for current and (potential) future stability issues. Ireland is a small-sized island power system where there are fewer large rotating masses to provide inertia to resist changes to the system frequency, and thus all changes occur more quickly, even without wind power being present (Figure 2). Already in 2015 Ireland has experienced up to 67% contribution from wind generation at certain times, with an annual average wind energy share of ≈20%. Ireland has targeted a ≈37% share of wind energy by 2020, implying many more individual periods with very high wind power shares. In order to reach higher shares in the future, special measures have to be taken such as enhanced performance monitoring of all generation plants, the introduction of new system support (ancillary) services, and strengthening of the existing transmission network.

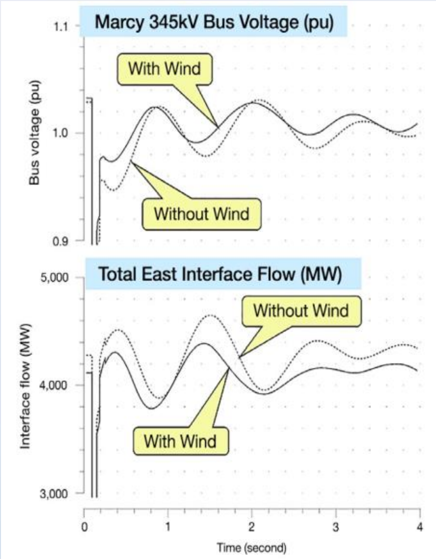


Figure 3. Analyses showing how voltage and transient stability are improved after a critical fault event, in cases with wind system support and without wind providing system support. (Source: Miller et al., 2014)

More Information

This Fact Sheet draws from the work of IEA Wind Task 25, a research collaboration among 18 countries. The vision is to provide information to facilitate the highest economically feasible wind energy share within electricity power systems worldwide. IEA Wind Task 25 works on analysing and further developing methodologies to assess the impact of wind power on power systems.

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

See also other fact sheets

Transmission Adequacy with Wind Power
Wind Integration Issues