iea wind

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

Fact Sheet

BALANCING POWER SYSTEMS WITH LARGE SHARE OF WIND AND SOLAR ENERGY

Power system operation includes balancing supply and demand at each instant. This is done by adjusting output levels of some of the power plants. Wind and solar energy will introduce more uncertainty and variability in the system and increase balancing needs. Demand side and storage options, as well as wind and solar power plants, can also be used to provide balancing.

How are power systems balanced?

Power generation is scheduled usually one day ahead. The generation scheduling process provides sufficient capacity to meet the demand (electricity consumption) at each hour. This means having enough power plants on-line to meet the load, taking into account that some of these plants need several hours from scheduling request to power generation.

The dispatch (output levels) of power plants can still be fine-tuned close to real time when more accurate knowledge of demand level is known.

When generation and demand are in balance, the frequency of the power system is close to the nominal frequency (50 or 60 Hz). When generation is higher or lower than demand, the frequency will start to increase or decrease. Sufficient flexibility - the ability to change the output level of generation or demand - needs to be available to balance the demand and supply in time frames of seconds and minutes to maintain the frequency.

Power systems are balanced at the system level. This means that minute-to-minute variability and uncertainty are combined, from all the consumers, and all power plants, including wind and solar. Only the net system imbalances between demand and generation are corrected by using balancing power.

The real-time balance during the operating hour is maintained by operating reserves. Today reserves are provided by the power plants which are able to adjust their output level quickly in response to balancing needs (Figure 1). In the future, increased balancing can come from demand, storage, as well as from wind and solar power plants.

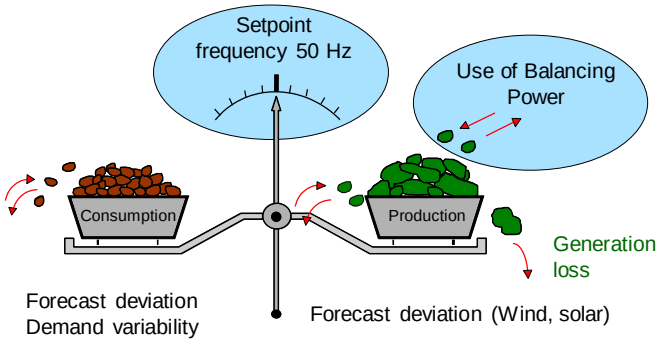

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Figure 1. *Keeping the frequency of the power system means balancing generation and demand in real time.*

How to manage variability and forecast errors in wind and solar energy?

Adding wind and solar energy will impact the scheduling and operation of other power plants as well as the operating reserve (Figure 2).

Increasing or decreasing wind and solar generation is usually seen in the generation forecasts the day-ahead. This will impact how much other generation is scheduled.

Unforeseen variations and forecast errors will be handled by operating reserves. The reserves will be called upon based on total system imbalances (Figure 3). Variations of demand and wind and solar generation often cancel each other out, and other times wind and solar generation will cause more reserves to be activated.

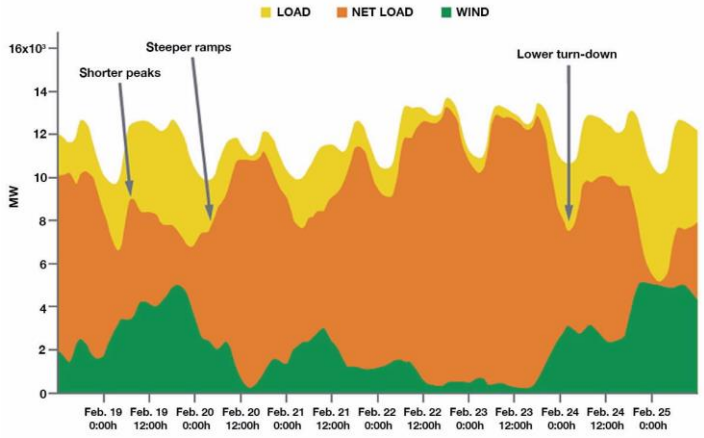

Figure 2. *Example of how wind power changes the demand that conventional generation follows (Source: 21st Century Power Partnership 2014).*

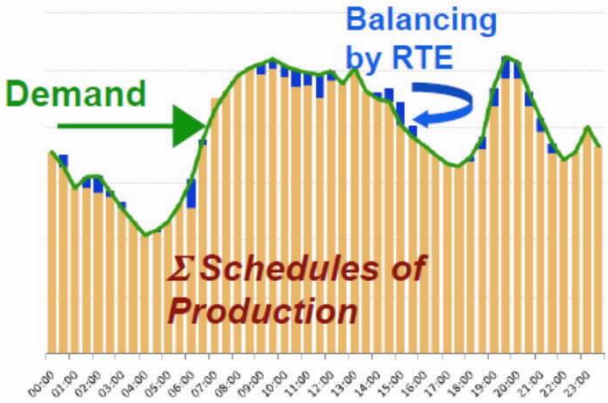

Figure 3. *Scheduling the generation units to cover the anticipated demand is usually made day-ahead. Dispatch can be fine-tuned closer to real time. During the operating hour, balancing (operating reserves) are used to maintain the balance — load following by manual dispatch and automatic regulation in some power plants to follow the second to minute variability. (Source: RTE, the transmission system operator of France).*

How to make sure there is enough flexibility to balance power systems with large share of wind and solar energy?

Often there is more flexibility available in the existing generating units than is used today, both day-ahead and real-time. However, increasing flexibility will be an important consideration when anticipating larger shares of wind and solar energy in a power system.

Increased flexibility can decrease the operational costs of the power system since there are more options available for balancing. Flexibility can be shared with neighbouring regions through the use of interconnecting transmission (trading electricity between areas). Wind and solar power plants can offer fast responses, when other options are not available. Another source of flexibility is offered by the consumer side; this is called demand response. Electrification of other energy sectors, like transport and heating, will bring new demand types that may have more flexibility than today's electricity consumption.

Flexibility is affected by operational practices. For example, balancing needs can be reduced by using shorter dispatch intervals (the time between requests for generation and actual delivery of power) and providing updated forecasts closer to real-time. In general, operating larger balancing areas helps systems accommodate more wind and solar power by reducing total variability and pooling more sources of flexibility.

Associated publications

- Holttinen, H. et al. (2019) **Design and operation of power systems with large amounts of wind power.** Final summary report, IEA WIND Task 25, Phase four 2015–2017. https://community.ieawind.org/task25/ourlibrary
- IEA (2019). **Status of Power System Transformation 2019: Power system flexibility**. https://www.iea.org/reports/status-of-power-system-transformation-2019
- Greening the Grid (2015). **Sources of operational flexibility**. Fact sheet available at https://greeningthegrid.org/Grid-Integration-Toolkit
- 21st Century Power Partnership (2014). **Flexibility in 21st Century Power Systems**. http://www.21stcenturypower.org/publications.cfm

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
Capacity Value of Wind Power Fact Sheet
Variability and Predictability of Wind Power Fact Sheet
Electrification Fact Sheet
Transmission Adequacy with Wind Power Fact Sheet
Wind Integration Issues Fact Sheet