HOW DO WE ENSURE LONG-TERM RELIABILITY OF FUTURE POWER SYSTEMS?

Resource adequacy, also know as system adequacy, is the ability of the system to meet firm demand during stressful periods. Wind and solar—like other forms of generation, storage, demand response and transmission—can enhance long-term reliability. However, incorporating all these technologies makes long-term reliability assessments more complex.

How does resource adequacy change with the evolving energy systems?

Traditionally, the stressful events considered in resource adequacy assessments were peak demand periods. These were required to be managed according to a certain planning criterion, for example, limiting the likelihood of a loss-of-load event to be less than one day in ten years. Today, stressful events are increasingly trending towards periods of high load after the subtraction of wind and solar output. In addition, planning criteria may be more comprehensive, including metrics like thresholds for loss-of-load hours or the magnitude of loss-of-load.

Systems dominated by fuel-burning thermal power plants have been assessed from the perspective of capacity adequacy, which is determined by the firm capacity contribution (MW) of resources. However, it is less useful for systems dominated by wind and solar resources, because wind and solar resources may have plenty of nameplate capacity but may not be generating that nameplate capacity during a stress event. There may also be sufficient storage capacity installed, but if the storage is not charged, it cannot help with a stress event. Even thermal and hydro resources can face limitations in their generation output, such as through extreme weather events. A cold snap can compromise widespread fuel availability through frozen gas well-heads or frozen thermal generators, and hydro's water supply may be reduced during drought conditions. Therefore, energy adequacy, or the sufficiency of MWh of energy during a stress event, becomes more important for systems that have high levels of wind, solar, and storage, as well as in futures with extreme weather conditions and climate change. Modeling these extreme conditions and their impact on generator availability are critical.

Other factors that create stress for power systems include increasing electrification of buildings and transportation and other load growth due to, for example, data centers and new manufacturing.

The timing of stress events within a day and within a year may change with electrification, climate change and the expansion of wind and solar.

Can wind and solar contribute to resource adequacy?

Yes! Wind and solar resources can contribute to resource adequacy. They can produce power during periods of stress on the system. Their capacity value, or contribution to resource adequacy, depends on their resource availability, the system demand, and other resources on the system.

As more solar is added to a system, the capacity value of each solar resource declines. In a summer-peaking system, the first solar plant may provide a good contribution to resource adequacy. But as more solar is added, the net demand peak shifts to later in the day, eventually reaching the evening when additional solar no longer affects the peak. At this point, the capacity value of new solar resources will go to zero. The capacity value of wind will also decline as more wind is added, unless wind resources with different generation profiles are available, such as wind peaking at night versus during the day.

Storage also has capacity value, although it also declines with more installed capacity, unless the duration of the resource can be extended. Then again, through the portfolio effect, the capacity value of combined solar and storage, as well as wind and storage, can be higher than the sum of their individual capacity values (Figure 1).

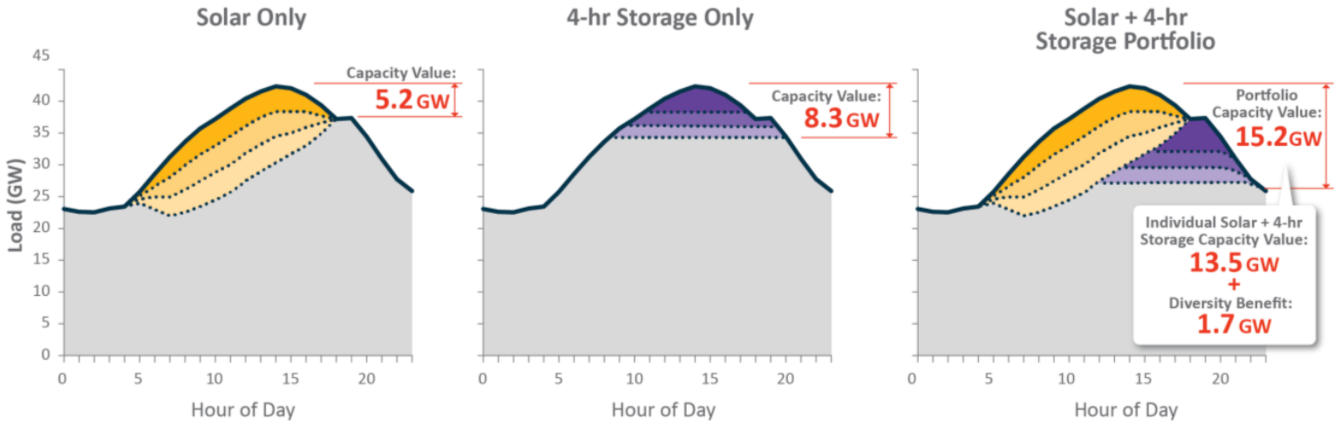

Figure 1. *Through the portfolio effect, the capacity value of a combined solar and storage portfolio is larger than the sum of the individual capacity values of solar and storage. The dotted lines represent increasing the solar and storage capacities in 5-GW steps (Source: Schlag et al., 2020).*

Is supply the only way to provide resource adequacy?

No, supply is not the only way to provide resource adequacy. Another way to provide resource adequacy is to reduce demand. This can be done through demand response, retail pricing, price-sensitive loads that bid into wholesale markets, transmission demand charges, and distributed energy resource programs.

Another way to provide resource adequacy is through transmission to neighbouring regions. If one region is short of supply, imports from neighbouring regions can help to maintain reliability. Sometimes multiple regions are short of supply due to extreme weather. In these cases, a very interconnected grid can help because a region may need to rely on their neighbours' neighbours.

Figure 2 shows how a 2 GW transmission line connecting two diverse regions acts like 4 GW of new generator capacity (2 GW of capacity in each region). The reason is that one region experiences stress in winter and the other in summer. The transmission line allows the resources in one region to help the other during its stress events and vice versa.

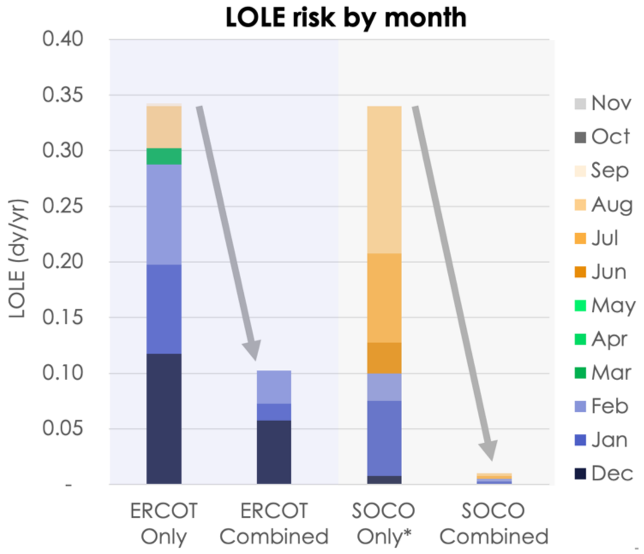

Figure 2. *A 2 GW transmission line between ERCOT and SOCO could reduce the loss-of-load-expectation of ERCOT and SOCO by 71% and 97%, respectively. (Source: ESIG, 2022).*

Associated publications

- Holttinen, H. et al. (2021). **Design and operation of energy systems with large amounts of variable generation**. Final summary report, IEA WIND TCP Task 25. https://doi.org/10.32040/2242-122X.2021.T396
- Greening the Grid (2015). **Using wind and solar to reliably meet electricity demand**. Fact sheet available at https://greeningthegrid.org/Grid-Integration-Toolkit
- Schlag, N. et al. (2020). **Capacity and reliability planning in the era of decarbonization: Practical application of effective load carrying capability in resource adequacy**. https://www.ethree.com/elcc-resource-adequacy
- ESIG (2022). **Multi-value transmission planning for a clean energy future**. https://www.esig.energy/multi-value-transmission-planning-report

More information

This Fact Sheet draws from the work of IEA Wind TCP Task 25, a research collaboration among 17 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 TCP 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://iea-wind.org/task25/

See also other fact sheets

Storage for Power Systems
Balancing Power Systems with Large Shares of Wind and Solar Energy
Variability and Predictability of Large-Scale Wind Power
Wind and Solar Integration Issues