Fact Sheet

STORAGE AND WIND POWER

Wind power will increase balancing needs in the power system. Today system operators balance by adjusting output levels of some of the power plants. In the future, storage options can also help with the balancing task; however, their use will depend on whether or not they are cost effective compared with other options.

What are the benefits of storage?

Storage provides a flexible element in the balancing task of power system operation. Storage can act as either generation or demand, helping with the task of maintaining the balance between demand and generation at different time scales. Storage also has value in power systems without wind. About 100 GW of pumped hydro storage has already been built worldwide. Example of how wind and solar already impact the use of existing pumped hydro storage is given in Figure 1.

Why is storage not used more in power systems?

The benefit of storage must be weighed against its cost. Building storage means investing to something that does not generate new energy, but actually wastes part of the energy when storing it. This is why generators that change their output levels as needed will usually provide flexibility more cost efficiently. Storing fuels, or water in reservoirs, is the most cost effective form of storage today. Thermal storage is also more cost effective than electrical storage.

Storage technologies are still developing and costs are decreasing. Storages may have several revenue streams, from electricity markets (storing energy for hours or days) to grid support markets (providing quick responses to manage the frequency).

Will storage become more cost effective with higher shares of wind and solar?

The fact that "the wind doesn't always blow" is often used to suggest the need for dedicated energy storage to handle fluctuations in wind power. Dedicated energy storage ignores the realities of both grid operation and the performance of a large, spatially diverse wind-generation resource. Because power systems are balanced at the system level, no dedicated back-up with

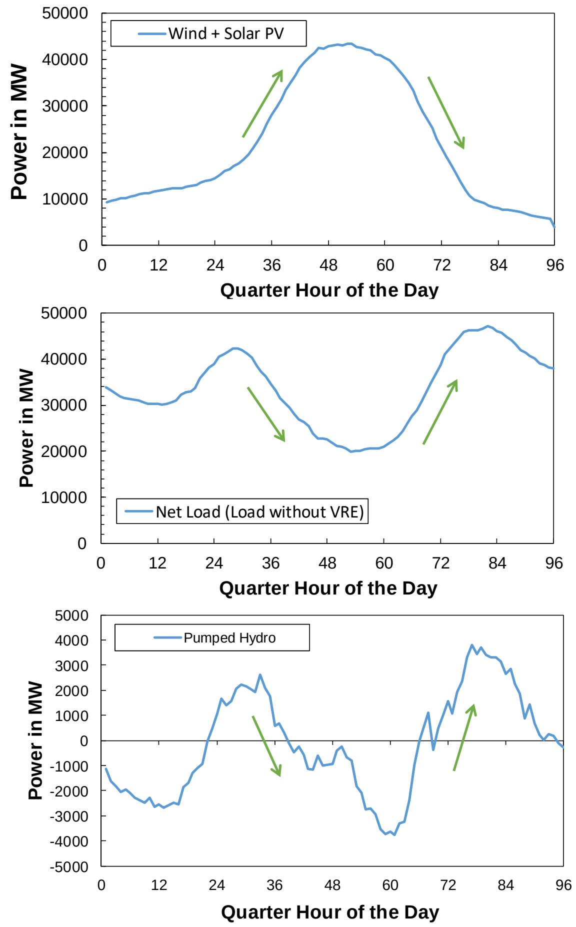

__Figure 1.__ Pumped hydro power plants already see a change in their daily pattern for pumping (negative) and generating (positive) in Germany (8 Aug 2019). VRE=Variable Renewable Energy. (Source: FfE, from ENTSO-E data).

storage is needed for any single technology. Storage is most economic when operated to maximize the economic benefit of an entire system. So far there has been more challenge in power system operation when "wind blows too much at low demand" than "no wind at high demand".

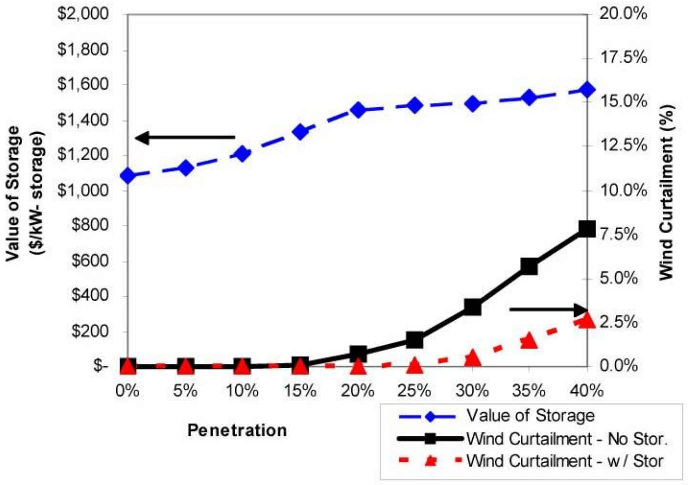

__Figure 2.__ Value of storage will increase when share of wind increases. At higher shares of wind power, storage capacity will also reduce curtailments needed for wind power in situations where wind is high and demand is low. (Source: LBNL, US).

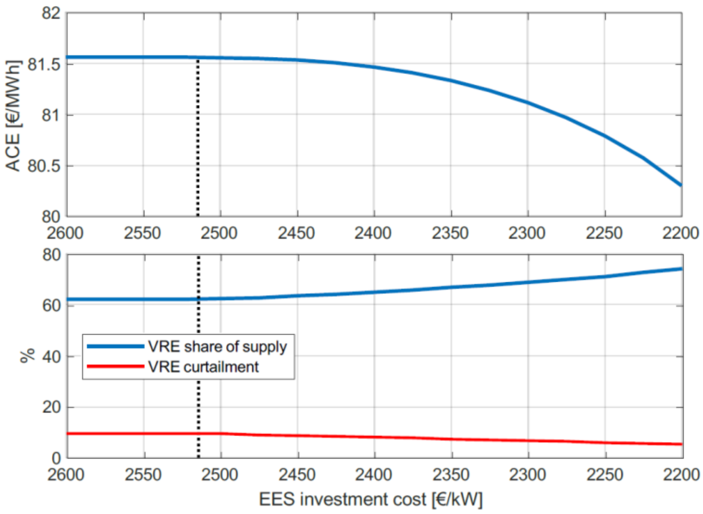

__Figure 3.__ As the cost of storage decreases, it becomes cost effective to install storages to absorb wind and solar curtailment, and thus increase the cost effective share of wind and solar in the system. ACE=Average Cost of Electricity for the power system, EES=Electric Energy Storage, VRE=Variable Renewable Energy. (Source: Korpås & Botterud 2020).

There is already experience of surplus energy that is curtailed (wasted) in times of low demand. New storage could reduce curtailed energy (Figure 2) and can also have value in providing grid support services. Having storages in power systems is shown to increase the cost effective share of wind and solar (Figure 3).

High shares of wind and solar will increase the value of storage. However, there will be competition to storage: more flexible generators and demand side options. Demand side can consume more when surplus of electricity is available and less when there is scarcity of electricity.

Also transmission lines can enable larger areas to be balanced (surplus energy may not occur simultaneously with neighbouring areas). Research work suggests that the share of wind needs to be more than 50% of yearly demand before storage options become cost efficient – unless there is no possibility to use transmission with neighbouring areas. For solar power storage is an enabler in lower shares than for wind.

Associated publications

- Easac (2017). Valuing dedicated storage in electricity grids. www.easac.eu
- 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
- Korpås, M.; Botterud, A. (2020). **Optimality Conditions and Cost Recovery in Electricity Markets with Variable Renewable Energy and Energy Storage**. MIT CEEPR Working Paper 2020-05.
- Nyamdash, B.; Denny, E.; O'Malley, M.J. (2010). **The viability of balancing wind power with large scale energy storage.** Energy Policy, 38, 7200-7208. https://doi.org/10.1016/j.enpol.2010.07.050
- 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
- Greening the Grid (2015). **The role of Storage and Demand response.** 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

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