iea wind

Task 25

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

Fact Sheet

ELECTRICITY MARKET IMPACTS OF WIND AND SOLAR

In wholesale power markets, the hourly price is set by the marginal cost of the last activated unit in the system. Since wind and solar power have no fuel cost, they push the price down by replacing more expensive fuel-consuming power plants. As wind and solar gradually become the primary power supply sources, market prices will drop on average, but price variations are likely to increase. This gives incentives for flexible demand and storage, which, in turn, will decrease the number of zero-price hours and associated renewable energy curtailment.

How are electricity market prices cleared?

A fundamental element of all power markets is the short-term market clearing where all actors (producers and consumers) place volume-price bids for their portfolios, the last activated unit determines the price and traded volume, also called the marginal unit.

For markets to be efficient, power producers bid their marginal cost, which depends on fuel and emission costs, and consumers with flexible demand bid in their opportunity cost, that is, the alternative (marginal) value of consumption. If there is not enough generation to meet fixed demand, the market is cleared by load curtailments, causing the price to reach the value of lost load, or a predefined price cap if set by the regulator.

Power producers earn money when the resulting price is above their marginal cost, which, in theory, will ensure cost recovery of investments in ideal market conditions.

How do wind and solar impact prices?

Wind and solar plants have near-zero marginal costs since they are weather-driven without inherent energy storage. Due to this property, these plants will be dispatched first, and they push more expensive power plants out of the market. Consequently, electricity market prices fall.

However, the price effect of more wind and solar depends on the supply curve of the other power plants in the system, as illustrated in Figure 2. If the supply curve is dominated by one power plant type, the price impact of moderate amounts of wind and solar will be limited.

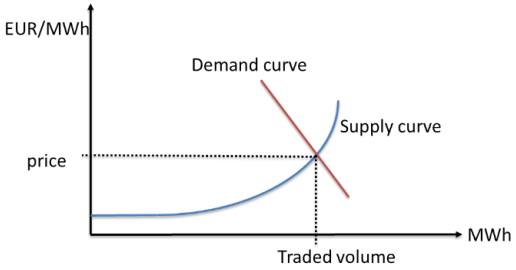

Figure 1. *In power market clearing, the market cross is the intersection of the supply curve and the demand curve, determining the traded volume and the price received by all actors.*

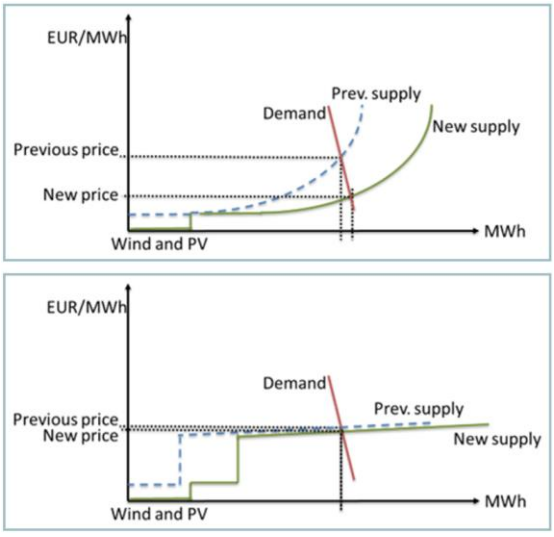

Figure 2. *The impact of wind and solar photovoltaics (PV) on market clearing outcome depends on the rest of the supply curve. Top: Supply curve with diverse supply mix. Bottom: Supply curve with homogeneous supply mix.*

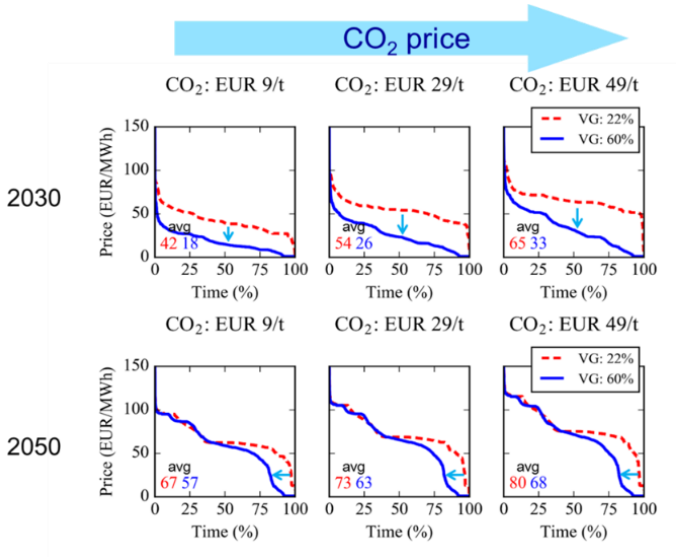

Figure 3. *Simulated price effect of variable generation (VG) in Europe in 2030 and 2050 for varying CO_2 prices. In 2030, there is a mix of baseload, mid-merit and peaker plants with different fuels, while in the 2050 scenario most baseload plants have been pushed out and replaced with mid-merit and peaker plants. (Adapted from: Helistö et al. 2017)*

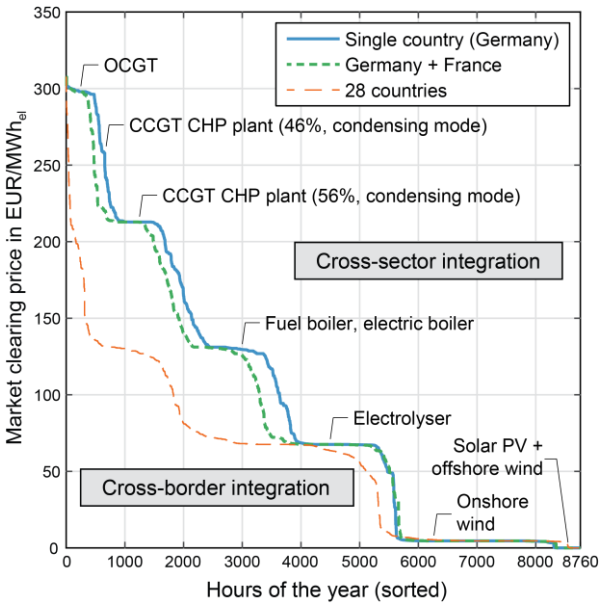

Figure 4. *Simulated electricity price duration curve for Germany in a carbon-neutral scenario showing the price signal effects of cross-sector and cross-border integration on electricity prices. (Adapted from: Böttger and Härtel, 2022)*

What happens to the prices when systems start to be dominated by wind and solar?

The price impact of wind and solar changes over time as the rest of the power system adapts to higher shares of wind and solar, as shown in Figure 3. Initially, market prices will fall. If there is more wind and solar generation available than needed by the consumers, prices will drop to near zero or even below, as generation must be curtailed to ensure balance in the power system (see Balancing fact sheet).

In the long term, the impact is smaller than commonly expected. This is because, in the long term, the generation fleet is better optimised for the increased wind and solar generation in the power system. This is observed in Figure 3, where the shape of the price duration curve is noticeably changed from 2030 to 2050 due to the optimised developments in the power plant fleet.

Over time, lower prices will also be an incentive to increase demand. If price variations are large at the same time, it will be beneficial to utilise more demand flexibility and install various forms of energy storage.

Such efforts will help stabilise and push the prices upwards. As near-zero prices become less frequent, the profitability of wind and solar improves, encouraging further investments in renewables. Figure 4 presents a simulated price duration curve in a scenario with widespread demand response and flexibility, particularly from newly-electrified sectors (heating, transport, fuel production). In addition to the continued importance of cross-border trade, price-setting technologies are becoming visible on the demand side. These submit bids and price signals based on their marginal value of consumption.

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
- Korpås, M. et. al. (2022). **Addressing Market Issues in Electrical Power Systems with Large Shares of Variable Renewable Energy**. 18th Int. Conf. on the European Energy Market. https://doi.org/10.1109/EEM54602.2022.9921152
- Helistö, N. et al. (2017). **Sensitivity of electricity prices in energy-only markets with large amounts of zero marginal cost generation**. 14th Int. Conf. on the European Energy Market. https://doi.org/10.1109/EEM.2017.7981893
- Böttger, D. and Härtel, P. (2022). **On wholesale electricity prices and market values in a carbon-neutral energy system**. Energy Economics, 106, 105709. https://doi.org/10.1016/j.eneco.2021.105709

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

Balancing Power Systems with Large Shares of Wind and Solar Energy
Flexibility for Power Systems
Flexibility Through Electrification
Wind and Solar Integration Issues