

After German nuclear shutdown

Increasing cost of balancing services

The operation of the German power system has a strong influence on the electricity markets in Europe. Germany has for several years been a large net exporter of electricity. There has been some concern about the security of supply in Europe after the gas crisis in combination with the German closure of all its nuclear power plants.

The German net export of electricity is an interesting indicator, but it is not that important, because it reflects random changes of other variables (table 1). The electricity consumption in Germany is about 500 TWh per year.

Germany has sufficient electric energy, even after the complete nuclear shutdown. Germany has other challenges. This note identifies the following issues:

- Unchanged use of fossil fuels
- Can Germany absorb more solar power?
- Increasing cost of system services
- Volatile spot market prices

DE	Net	Nucl.	Wind
TWh	export	prod.	prod.
2016	53,9	80,2	77,4
2017	55,5	72,2	102,6
2018	49,7	71,8	108,3
2019	33,8	71,0	124,3
2020	19,1	60,9	130,0
2021	19,6	65,4	113,4
2022	27,6	32,8	125,3

Table 1 - German net export of electricity since 2016

The same share of fossil fuel as in 2016

In 2016 the German share of electricity production based on fossil fuels was 43.9%. In 2022 the share was 43.6%. The German electricity sector did not contribute to a reduction of greenhouse gas emission during these years. A replacement of 50 TWh fossil production by nuclear energy could have reduced the fossil share from 43.6% to 33.7% in 2022.

Can Germany absorb more solar power?

Wind and solar power are fluctuating and non-dispatchable. Increasing shares of fluctuating production require new measures for maintaining the constant balance between demand and supply.

The Danish TSO, Energinet, reported in June 2023 about two situations in the spring of 2023, when all regulating reserves were exhausted¹. One was on Easter Monday, 10 April 2023. There was a surplus of production, not only in Denmark, but particularly in Germany (fig. 1).

Low demand for electricity on Easter Monday contributed to the export up to 23.5 GW.

It is remarkable that the production, which is supposed to be controllable, was nearly constant throughout all 24 hours of that day.

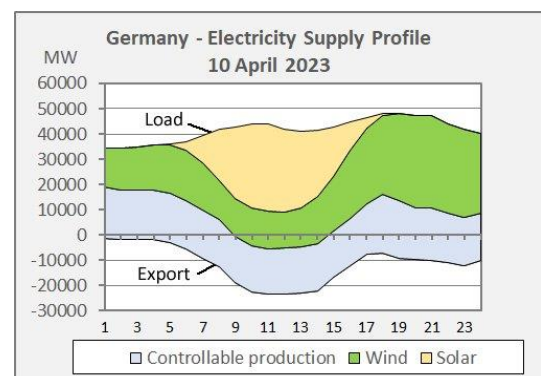


Fig. 1 - Solar and wind exceeding demand

¹ http://pfbach.dk/firma_pfb/references/pfb_two_critical_grid_incidents_in_denmark_2023_06_27.pdf

The solar and wind combination was not exceptional. In 2023, solar production has been up to 40 GW, and wind production up to 50 GW. A much larger combined production than the 50 GW recorded on 10 April cannot be excluded.

Solar power will regularly create a need for export during the summer season. June 2023 is an informative illustration (fig. 2).

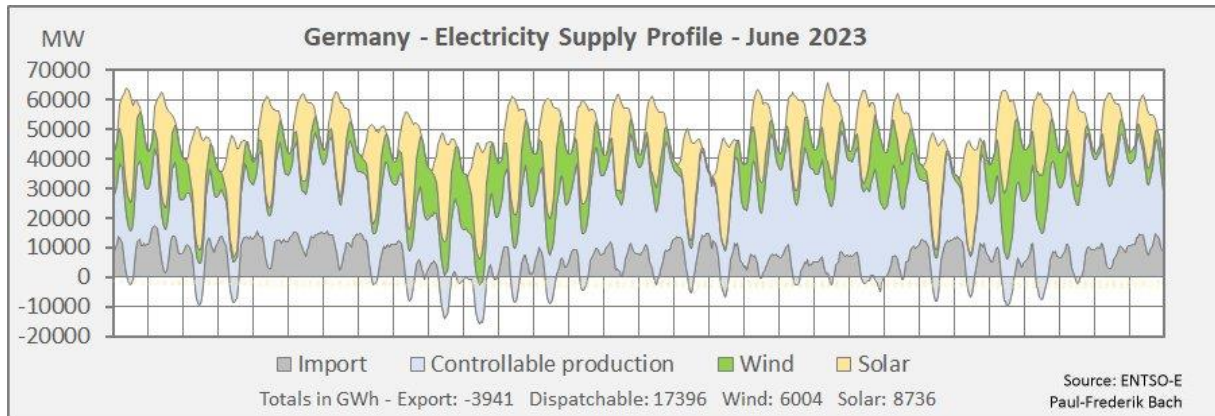


Fig. 2 - Solar power peaks covering more than 80% of demand in weekends

Peaks of solar power caused an export peak during all the weekends in June. It is obvious from fig. 2 that exchanges with neighbouring countries have absorbed variations due to German wind and solar power. Other countries are also installing solar power.

Germany seems to approach a limit for installed solar power unless corresponding balancing measures are installed.

Increasing cost of system services

When electricity production and consumption are out of balance, the system operator must require balancing power from providers of that sort of services. The providers can be domestic and foreign.

Increasing shares of non-dispatchable power (wind and solar) takes increasing amounts of balancing services. Therefore, the cost of balancing services is an indicator of the stress on the power system.

The German Bundesnetzagentur (Federal Grid Agency) publishes comprehensive annual reports on the conditions of the German transmission grids².

The transmission system operators (TSO) must purchase a range of system services in order to maintain or restore normal security of supply. The monitoring reports publish the cost of 12 system services (fig. 3).

Balancing services are parts of the system services.

² https://www.bundesnetzagentur.de/EN/Areas/Energy/DataCollection_Monitoring/start.html

There must be reserves for sudden disturbing events and capacity for neutralizing unbalances. Some services clearly depend on the need for balancing while others can serve both purposes.

Selling system services and particularly balancing services has become an important business.

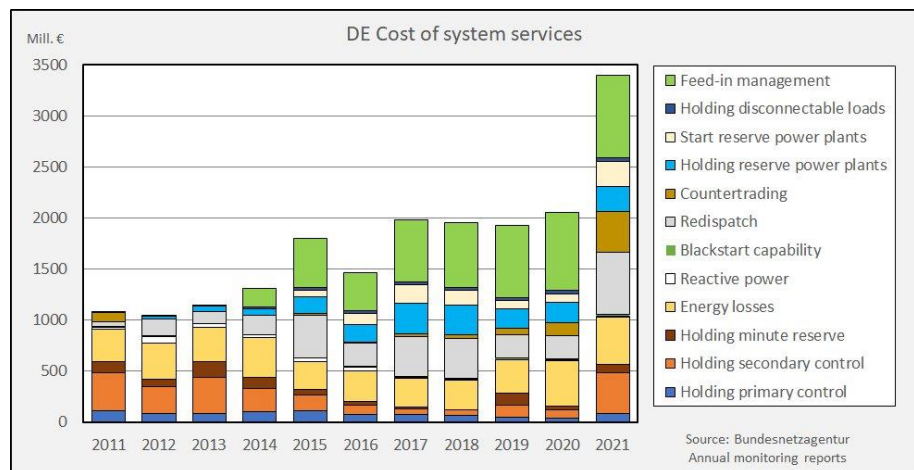


Fig. 3 - The cost of system services may reflect the energy crisis in 2021.

On fig. 4, the cost for balancing has been extracted from fig. 3. The cost of balancing is an increasing part of the cost of system services.

The cost of balancing the power system found a new level from 2015. The Monitoring Report 2016 just states that an increase took place from 2013 to 2015, but without any further explanation.

The change from 2020 to 2021 reflects the extreme market prices for electricity in 2021.

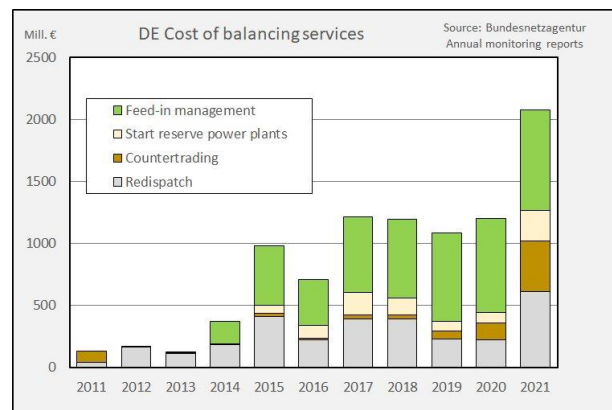


Fig. 4 - A new level for cost of balancing from 2015

In order to eliminate that influence, fig. 5 shows the amount of electricity traded for balancing the German power system. Unfortunately, this information was available only from 2015.

The growth of volume from 2020 to 2021 is less dramatic than the increase of cost. Nevertheless, the general trend from 2015 to 2022 is slightly increasing.

The balancing energy in 2021 was about 6% of the German electricity consumption. It is hard to say when it is too much, but when the balancing resources are exhausted as in Denmark on 10 April, security of supply can be at risk in one or more countries.

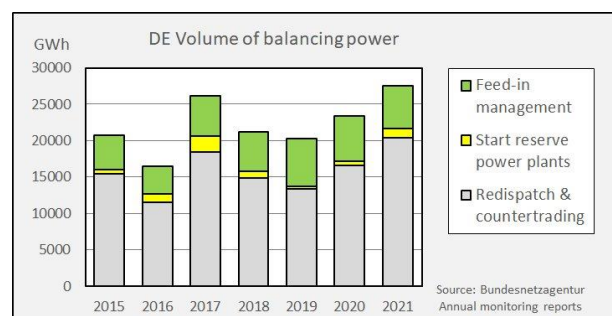


Fig. 5 - Most of the balancing volume is redispatch and countertrading

Volatile spot market prices

Price responsive demand was an early idea for absorbing variations in the generation from wind and solar power. Significant price variations are preconditions for this concept. Such

variations are now normal. The Danish distribution companies offer hourly prices depending on wholesale spot prices for retail customers. Many consumers have begun to adjust their consumption patterns in accordance with the current electricity price.

Solar power peaks, particularly during weekends, can press the German spot prices down (fig. 2 and 6).

The increasing cost of balancing services indicates that a stronger price response is desirable. A price response from retail customers will not be sufficient. It must be followed by a large-scale response at wholesale level, for instance from P2X plants.

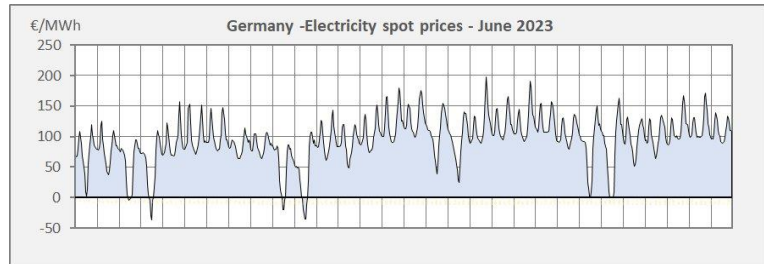


Fig. 6 - Low spot prices in weekends

The capacity of price responsive demand must be increased substantially in order to pave the way for additional wind and solar power in Germany and in its neighbouring countries.