

Two critical grid incidents in Denmark in 2023

An attempt to understand the background

Energinet¹ published on 6 June 2023 information about two critical incidents in April and May 2023² on its web site. The trouble indicators were extreme prices in the regulating power market, which is the system operator's last tool before direct interventions against producers or consumers.

The two cases are interesting because the fluctuating power production in Europe grows faster than the infrastructure, which is supposed to absorb the variations. This development puts a pressure on the regulating power markets. It will sooner or later be necessary to introduce additional measures.

Easter Monday, 10 April 2023

The Danish down regulating resources were exhausted for the CET-hours 14 and 15 (12 and 13 UTC) at the price € 2,200 per MWh.

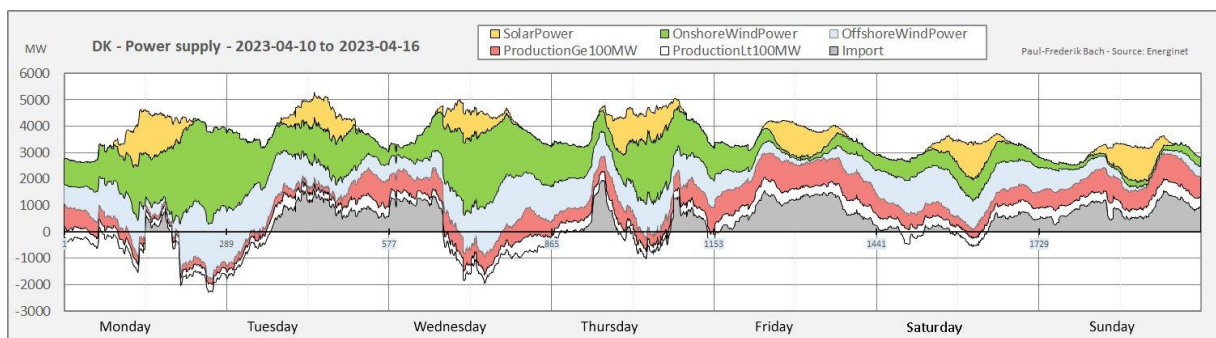


Fig. 1 - Danish production pattern week 15 2023. Most offshore wind power closed down Monday afternoon.

Energinet argues that the real output from wind and solar power can be very different from the day-ahead forecasts. However, the change Monday afternoon was not a change in wind, but a controlled down-regulation of offshore wind (fig. 1) for other reasons. So, what happened?

The two Danish price zones reached a fair balance during the critical hours. The reason for the extreme regulating prices must be found abroad.

Differences between the real output and the day-ahead forecasts in Denmark are shown in fig. 2. The peaks indicate how much power the intraday market and the regulating power market must be able to mobilize. Three peaks exceed +1000 MW while two peaks exceed -1000 MW.

These magnitudes will probably increase with the future growth of wind and solar power.

¹ Energinet is the Danish transmission system operator (TSO)

² <https://energinet.dk/om-nyheder/nyheder/2023/05/24/to-ekstremdog-bod-pa-vanvittige-prisstigninger-og-bragte-elsystemet-taet-pa-kanten/> (unfortunately not available in English)

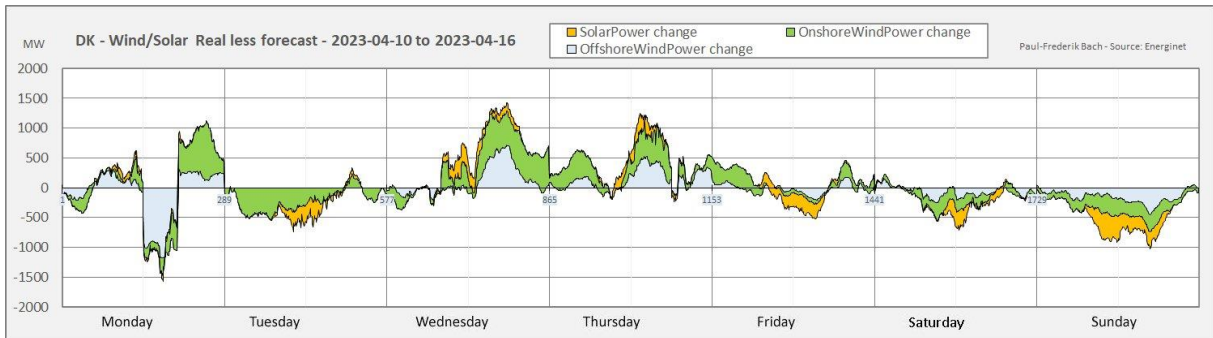


Fig. 2 – The difference between real output and day-ahead forecasts exceeded 1000 MW several times in week 15. Note: Forecast data can be missing.

We have no information about the German planning of system operation on 10 April, but fig. 3 shows the result. The electricity demand during the day hours was between 45 and 50 GW. Solar generation was up to 35 GW on the top of 14 GW wind power and about 20 GW traditional production.

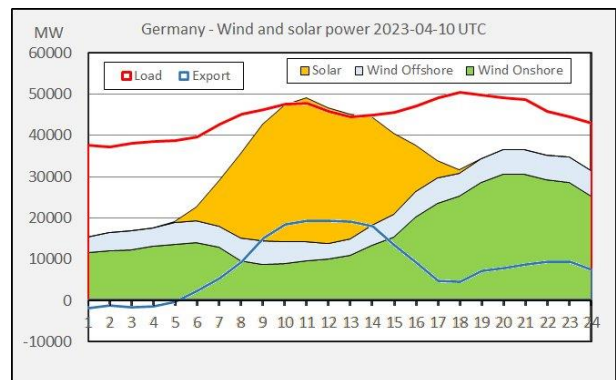


Fig. 3 – Germany, 10 April 2023

There were negative spot prices for DE and DK1 in the day-ahead market, but the levels were not alarming and far from the € 2,200 per MWh in the regulating power market (table 1).

DateUTC	HourUTC	DateDK	HourDK	SYSTEM €/MWh	DK1 €/MWh	DK2 €/MWh	DE €/MWh
10-04-2023	12	10-04-2023	14	2,34	-7,84	9,99	-8,82
10-04-2023	13	10-04-2023	15	0,77	-7,33	1,76	-7,77
10-04-2023	14	10-04-2023	16	1,42	-3,10	2,21	-4,07
10-04-2023	15	10-04-2023	17	2,80	-0,07	2,30	-0,07
10-04-2023	16	10-04-2023	18	25,60	19,49	25,54	19,49

Table 1 - Moderate negative spot prices for DE and DK1

We assume that the day-ahead plan was made with a reasonable balance for each country. The Danish forecasts seem to have been quite accurate. Did the German 20 GW surplus catch the German system operators unawares?

The Large German export on 10 April caused a heavy transit through Denmark (fig. 4). The transit may have pressed the Danish grids and limited Energinet’s operational options.

Why did a likely combination cause trouble?

Many questions remain unanswered. Did German priority rules prevent a curtailment of German wind and solar power?

Balancing the German power system seems to be a more serious challenge than balancing the Danish power system. The maximum German load in 2023 was 72 GW. The maximum solar and wind output in 2023 were about:

- Solar: 41 GW
- Wind onshore: 45 GW
- Wind offshore: 8 GW

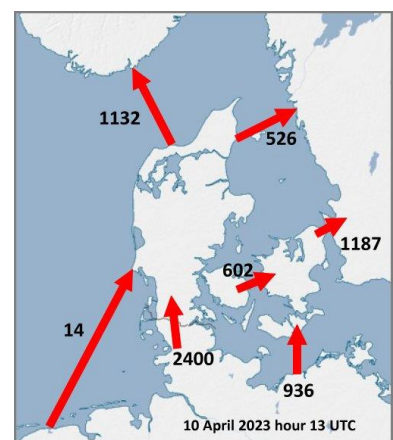


Fig. 4 - No room for Danish export

Wednesday, 10 May 2023:

The Danish up regulating resources were exhausted for the CET-hour 18 (16 UTC) at the price € 4,699.75 per MWh (about 35,000 DKK/MWh).

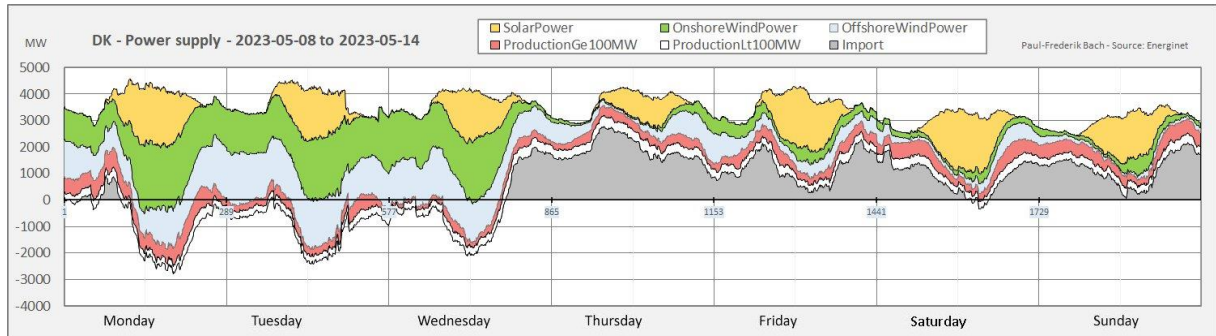


Fig. 5 – The wind fell faster than forecasted Wednesday afternoon

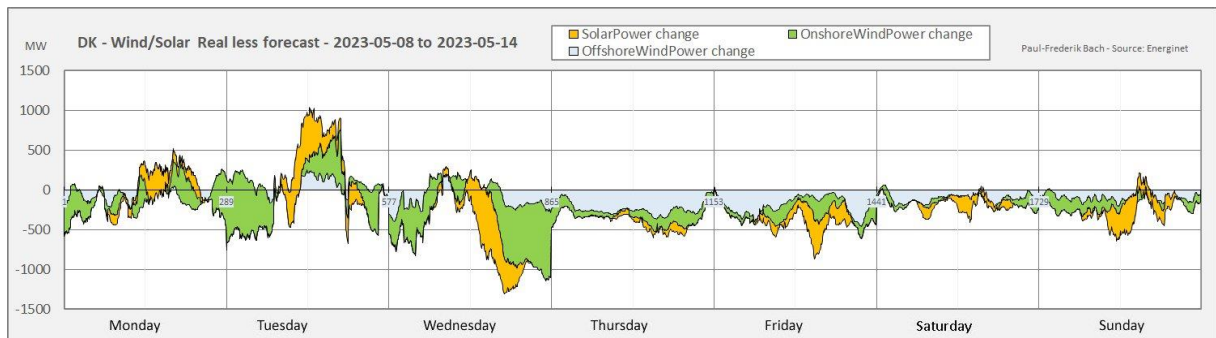


Fig. 7 - !000 MW production was missing Wednesday evening in comparison with the day-ahead planning

The fall of wind power from Wednesday to Thursday was completely unexpected.

About 16:00 on Wednesday afternoon it was realized that the wind forecast was wrong (fig. 7). The forecasts are updated 5 hours ahead, 1 hour ahead and "current". The one-hour forecast changed from 17:00 and the 5 hours forecast from 21:00.

Energinet had 81 bids for upwards regulation and activated them all and paid € 4,699.75 per MWh. The next move could have been load-shedding.

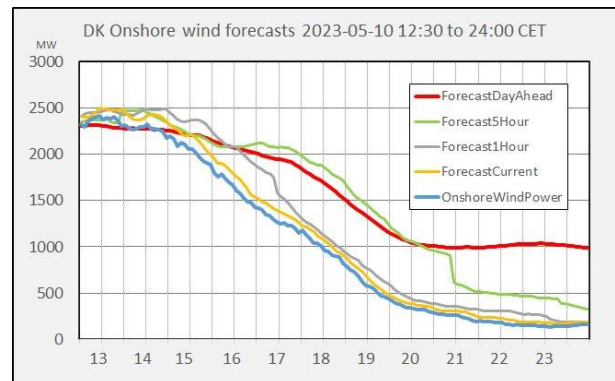


Fig. 6 - The gap between the day-ahead forecast and the onshore wind output was nearly 1000 MW at the end of the day.

Energinet requests market participants to respond to price signals

A balance responsible market participant is supposed to stick to his schedule. In case of deviations from the schedule, he must pay a market price for up- or down-regulations, which the system operator purchases in the regulating power market.

In a concluding comment, Energinet asks these market participants to contribute to the system balance, at least by keeping their own physical balance, but also, when possible, by responding to price signals in the regulating power market. Both economy and security of supply for the whole system are at stake.

Active participation in the regulating power market can be a profitable business.

Energinet mentions that offshore wind parks frequently contribute to the regulating power market, while onshore wind parks and solar power parks usually don't.

Energinet does not mention the role of the neighbouring countries. The regulating power market is a Nordic market, but Germany has an access through the so-called *Special Regulation*.

There is a lot of less qualified guessing about regulating resources in the public debate about the future limits for fluctuating power sources. The complex rules make it difficult for outsiders to analyse such critical incidents, as mentioned in this note. Therefore, Energinet's statement is welcome. Evaluations with further details might contribute to an even more qualified public debate and maybe also mobilize more regulating capacity.