The Electricity Markets and the Storm “Urd”.

A typical winter storm swept across Denmark during the Christmas days of 2016. The generation of wind energy was correspondingly high, and the Danish wind industry claims that the Danish electricity consumption was 110% covered by wind energy on 26th December. This note adds a few facts.

Wind and wind power in Denmark during the days from 22nd to 27th December are shown in fig. 1.

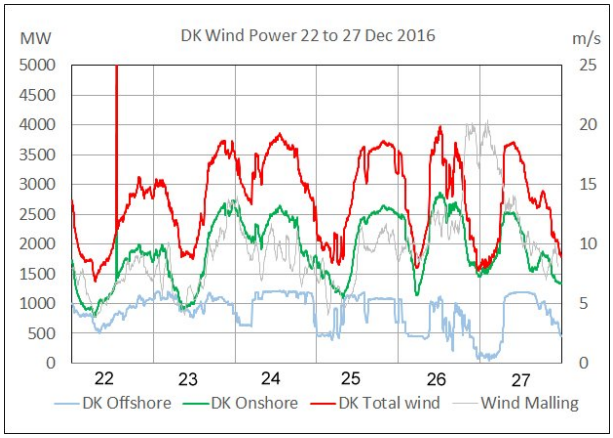


Fig. 1 - Danish wind and wind power (Energinet.dk)

It is remarkable that wind and onshore wind power have a nice covariation until the night of the wind peak between 26th and 27th December. That night the offshore wind was practically disconnected.

The reductions were probably commercial decisions because any additional export of electricity would be loss giving.

The spot prices in Denmark and in the neighbouring countries may contribute to an overview of the situation (fig. 2).

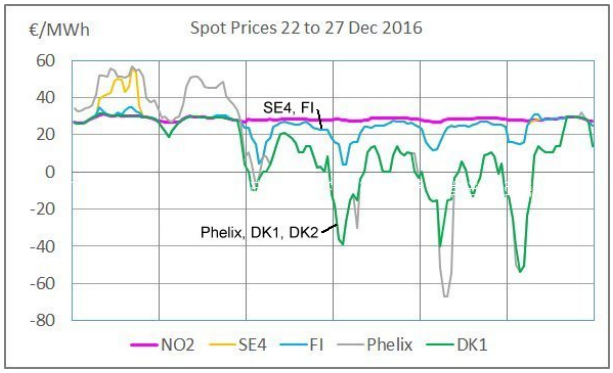
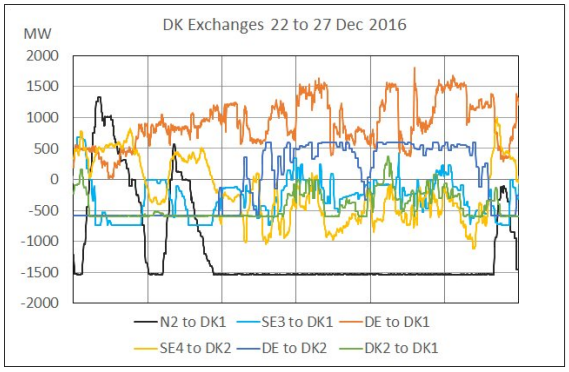


Fig. 2 - Spot prices 22 to 27 December 2016

One extreme is the very stable price in southern Norway about 28 €/MWh. Germany is the other extreme with spot prices varying from a “normal” level about 50 €/MWh down to below -50 €/MWh[1]. Denmark and southern Sweden (SE4) follow the volatile German spot market nearly all the way to the negative minimum prices.



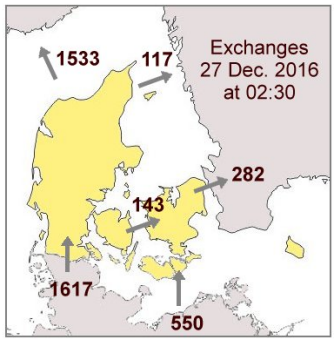


Fig. 3 - The chart is confusing, so a map with power exchanges during wind peak on 27 December has been added (Source: Energinet.dk)

The power exchanges in fig. 3 tell more details about the grid conditions.

[1] PHELIX is the Physical Electricity Index for the German/Austrian/Luxembourg market

The export from Germany to Denmark was 2167 MW or about the full transfer capacity at the two borders. According to Nordpool Spot the export to Sweden was only 61 MW during the hour between 02:00 and 03:00. The export from Sweden was 1423 MW to Norway and 1257 MW to Finland for the same period.

The Skagerrak link from Denmark to Norway was running at about 1530 MW from 23 December at 21:15 to 27 December at 16:00.

The overall picture is a movement of a power surplus in Germany, Denmark and Sweden towards Norway and Finland. If we assume that Norway and Finland cannot absorb more power a curtailment of wind power in northern Germany, Denmark and Sweden is unavoidable.

When the negative prices outweigh the subsidies per produced MWh Danish traders prefer to stop wind farms. This is probably the explanation of the reduced Danish wind energy output during the nights and particularly during the night between 26th and 27th December.

I have collected some daily totals from Energinet.dk's 5 minutes recordings (with reservation for possible inaccuracies):

		22	23	24	25	26	27
Consumption	MWh	100.233	93.880	80.503	81.455	78.499	86.211
Production	MWh	100.781	114.077	114.040	99.656	92.130	102.078
Thermal	MWh	45.793	46.895	34.989	31.028	25.451	38.480
Wind	MWh	54.635	66.756	78.730	68.534	66.362	63.097
Solar	MWh	354	426	321	94	317	501
Net export	MWh	548	20.197	33.538	18.202	13.630	15.867

Table 1 - Danish totals 22 to 27 December 2016

A certain thermal production was maintained throughout the period for two reasons:

- The heat supply for the district heating systems depends on the CHP units
- The synchronous generators are necessary for a stable and secure operation of the power system.

The Australian market operator, AEMO, recently published its third report on the 27 September blackout in South Australia. The report indicates that South Australia may have relied too much on its wind power during bad weather. I shall make a comment on this new information in a separate note.

It is a common assumption that Denmark exports cheap electricity and imports expensive electricity. Annual average figures show that there is a difference, but it is smaller than most people believe.

Observations from a few extreme days cannot be used for an evaluation of the international electricity trade. Fig. 3 shows that the interconnections are used intensively for balancing purposes. It is hard to imagine how Denmark could have balanced its power systems during the observed period without interconnections. The present share of wind energy would definitely have been impossible.

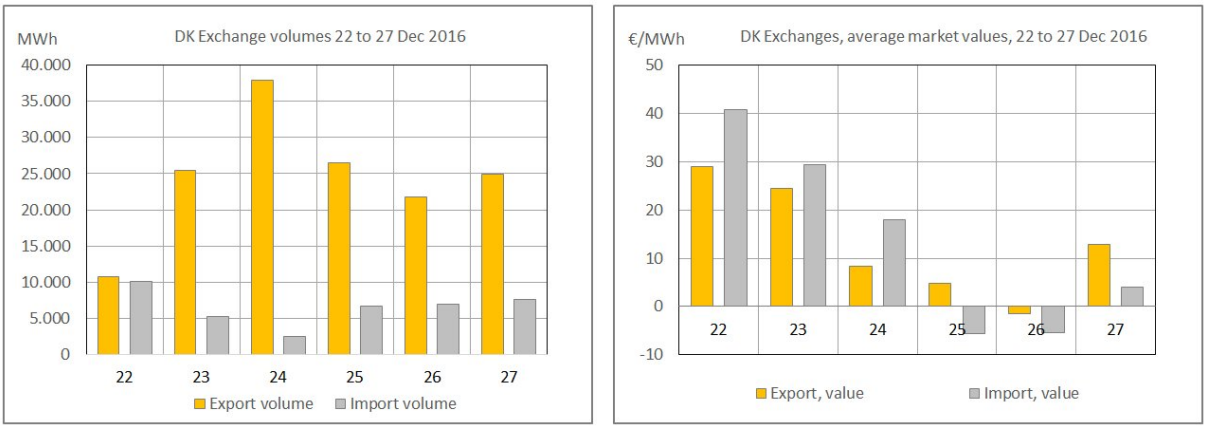


Fig. 4 - Power exchanges and market values

The very low prices from 24 December to 27 December seem to support the Danish curtailment of wind power. It would not have made sense to produce more wind energy and pay Swedish traders for absorbing it.

Wind power was probably also curtailed in Germany. In spite of the low prices, it may have been cheaper to export to Denmark than to increase the curtailments in Germany.

Apparently, the power grids and some of the interconnectors were operated close to the security limits. The power grids are vulnerable in bad weather. Therefore, it is necessary to operate the power systems with suitable reserves for the possible loss of grid components or electricity production.

The future will be a race between new fluctuating power sources and grid reinforcements. It is easier to install a new wind farm than to build a new power line. Therefore, we will probably see an increasing extent of wind power curtailment within the next few years.