Electricity in Denmark 2019

The Danish Electricity Balance 2019

DK 2019	Demand	Supply
Load	34.260	
Wind		16.145
Solar		963
Central		6.589
Local		4.755
Export	1.955	
Import		7.729

Table 1 – Danish electricity balance 2019 (GWh)

Wind energy made 47% of the gross electricity consumption or 45% of the total balance. The trading opportunities in the international electricity markets made the high share of wind energy possible.

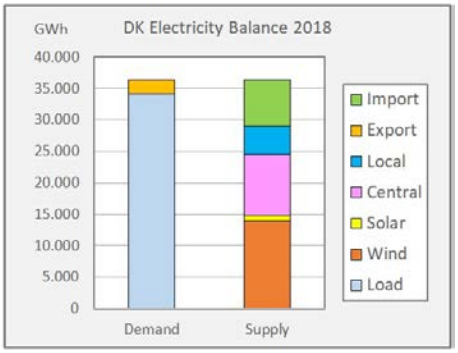

Fig. 1 - Danish electricity balance 2019

The controllable (or dispatchable) production (central and local CHP) in Denmark depends on heat demand. It is replaced by import during the summer season when the heat demand is low and most thermal power plants are out of service for maintenance (fig. 2).

The increasing dependence on imported electricity seems to have been without problems, so far. Import was 45% of the demand in June 2019 (fig. 3).

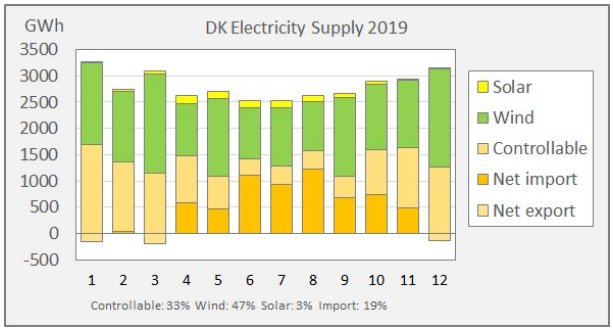

Fig. 2 - Electricity supply by month in 2019

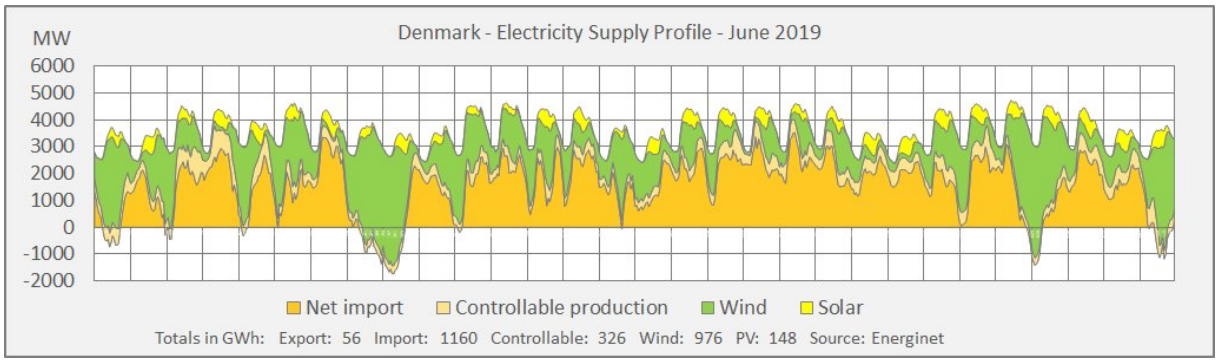

Fig. 3 – Import was the main source of electricity in June 2019 (more charts on http://pfbach.dk/)

Wind power can change within a few days from more than demand to nearly nothing. The minimum wind power output was six MW on 1 April 2019 (4th hour).

The following maximum hourly values were found for 2019:

- Domestic load: 6441 MW on 10 December 2019
- Net import: 3531 MW on 20 June 2019
- Net export: 2601 MW on 5 February 2019
- Controllable production: 4310 MW on 23 January 2019
- Wind power: 5441 MW on 10 December 2019
- Solar power: 768 MW on 11 May 2019

Volatile Spot Market and Decreasing CHP Production

Spot Price variations from year to year:
The spot price level for a year can be calculated as a plain average. By weighting the average with electricity demand variations, an average market value of the demand is found (fig. 4).

The variations from year to year are considerable. The average Nordpool system price for the first three months of the year in 2019 was 46.88 €/MWh and 15.45 €/MWh in 2020.

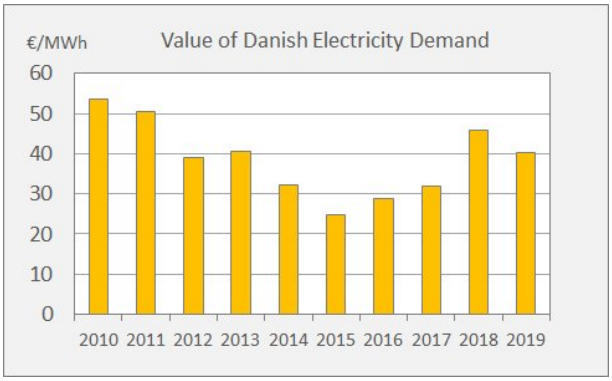

Fig. 4 – Apparently a new trend in spot prices

Different Market values:
Market values are compared in fig. 5 by setting the value of demand to 100%. There are remarkable differences between the value of wind and solar energy and between export and import.

The import prices have been moderate so far. This may explain the decreasing thermal electricity production in Denmark.

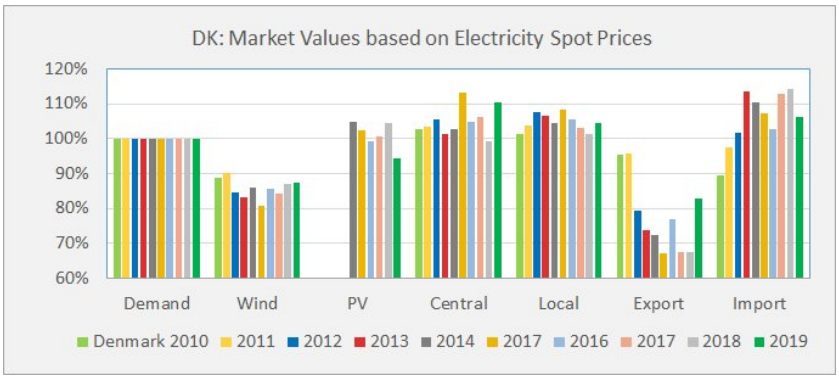

Fig. 5 - Increasing gap between import and export prices

CHP Output stabilized:
The replacement of coal by biofuels leads to more local heat production without electricity and correspondingly less electricity production on the large CHP units. The combined heat and power production (CHP) may decrease further in the next few years, because the support for local CHP systems has stopped.

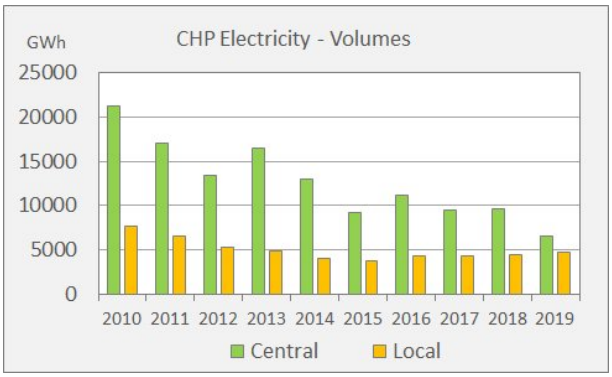

Fig. 6 - From 29 TWh in 2010 to 11 TWh in 2018

The decreasing CHP production is a dilemma because the CHP systems are the most important domestic sources of flexibility for wind power integration.

Exchanges and Congestion Income

Denmark exchanges electricity with Norway, Sweden, Germany and the Netherlands. The Cobra cable to Holland was ready for operation from September 2019.

The Danish net import from Norway and Sweden in 2019 was 2.3 TWh and from Germany 3.4 TWh (fig. 7). The resulting Danish net import was 5.8 TWh.

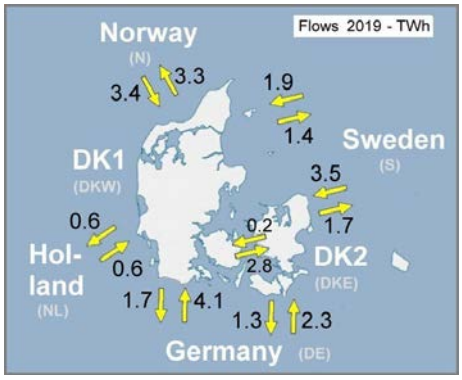

Fig. 7 - Denmark's net import was 5.8 TWh in 2019

The total transit from Norway and Sweden to Germany was 2.6 TWh. Transit in the opposite direction was 4.9 TWh. The main transit direction has changed since 2018. The exchange between DK1 and DK2 was mainly from west to east.

The HVDC link to Norway was reinforced in 2015 from 1000 MW to 1700 MW technical capacity (fig. 8). The exchange increased correspondingly.

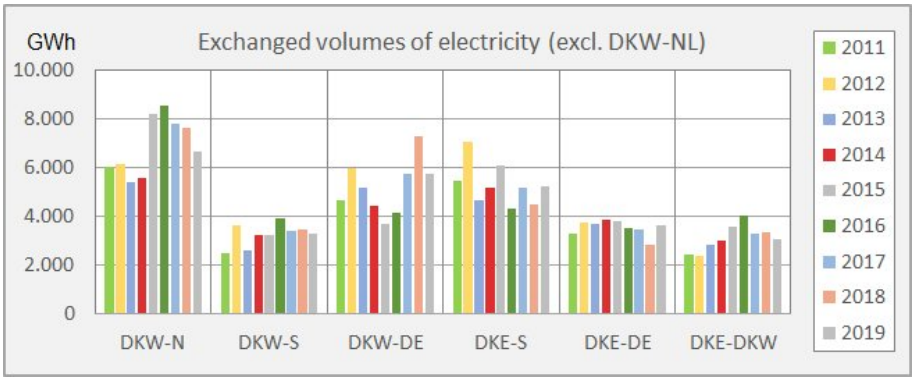

Fig. 8 - Total exchanges (both directions)

An interconnector is congested when the demand for transfer exceeds the available capacity

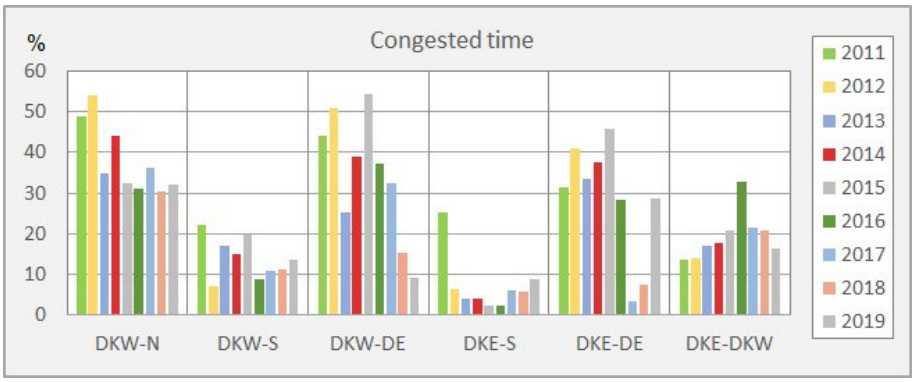

Fig. 9 - Most congestion at the borders to Norway and Germany

Fig. 9 shows the time with congestion for each link and each year. A low share of congested hours suggests that the interconnector capacity is too large, while a high share might suggest that the capacity is too small. For some links and some years, congestion has occurred for about 50% of the hours.

The electricity flows change from year to year. The future electricity balances in Europe are uncertain. This must be considered in the planning of future interconnections. On the other hand, unforeseen events usually increase the need for international trade. Unforeseen

events happen. Therefore, it has been claimed that there has not yet been reason to regret investments in stronger interconnections.

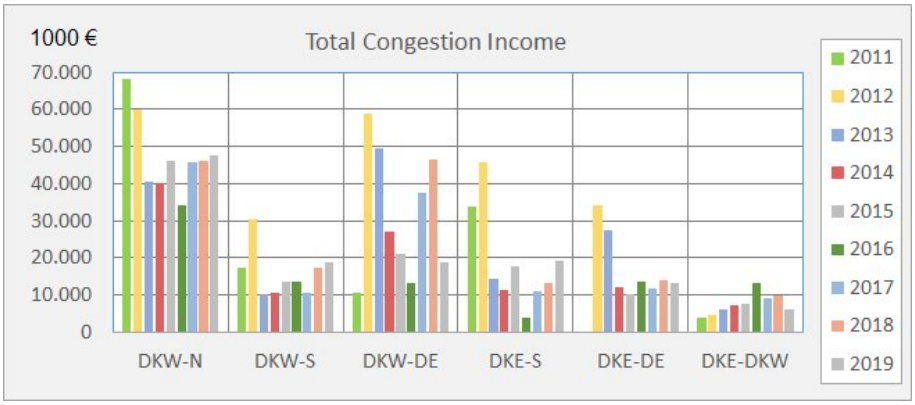

Fig. 10 - Large variations in congestion income from year to year

Trade across a congested border causes different market prices and a surplus of money. The surplus is the congestion income (or bottleneck fee), which is usually shared between the grid owners (fig. 10).

Congestion income is exchange multiplied by price difference. Thus, there will be no income if either exchange or price difference is zero.

The congestion income is an important income for the grid owners.

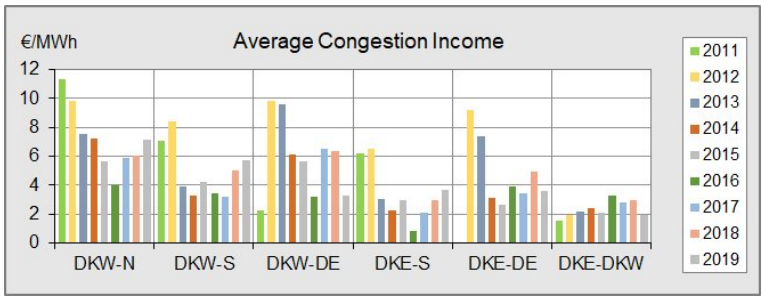

Fig. 11 - The owners of a link share the congestion income.

The congestion income per MWh transferred is an indicator of the importance of a link and of the need for additional capacity (fig. 11). There are normally only small spot price differences between the two Danish price zones. The average congestion incomes from the Great Belt Link are correspondingly low in spite of a fair utilization.

Export of Danish Wind Power Limited by Sweden and Germany

The transmission system operators (the TSOs) define the commercial capacity of a link. It can be much lower than the technical capacity.

The commercial interconnector capacities are reduced when

- the link itself has a technical limitation and when
- there is a risk of grid overloads or power failures in the adjoining grids.

In some cases, TSOs reduce the capacity in order to protect local commercial interests or to maximize their own profit. Such reasons are less acceptable, but undetectable, because only the TSOs have the capacity to analyse the technical limits of the grids.

The Skagerrak link (DK1-N) had a very poor performance in 2019. I did not find the reasons on Energinet's homepage. The link has four poles. At least one pole has been available every hour of the year. The availabilities were only 65% from Norway to Denmark and 69% in the

opposite direction. The steps on the duration curves (fig. 12) indicate technical reasons such as cable faults.

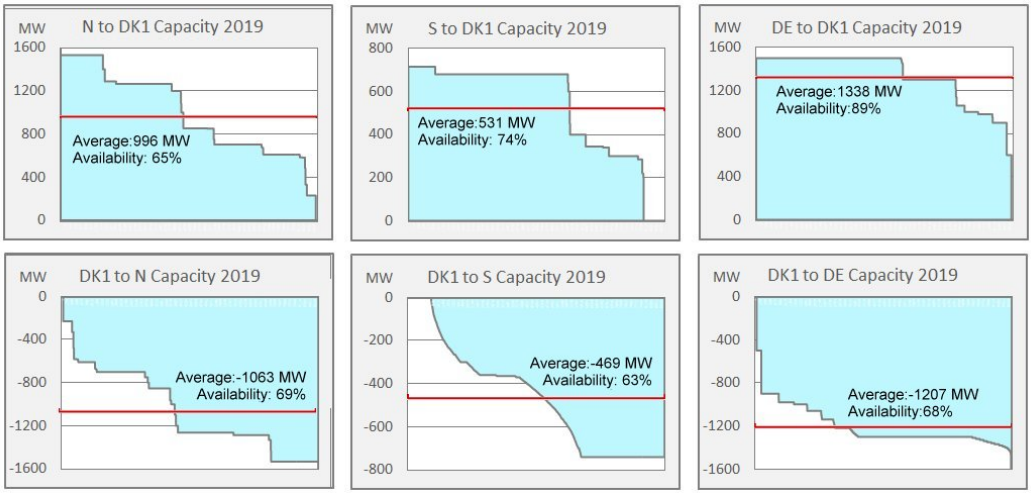

Fig. 12 - Available capacities for DK1 in 2019 - Duration curves – Export capacity < 0

The Konti-Skan link (DK1-S) has two poles. The link has been completely unavailable for about a month in 2019. The availabilities are poor, 74% from Sweden to Denmark and 63% in the opposite direction. The smooth shape of the duration curve from Denmark to Sweden suggests limitations in adjoining grids.

The AC[1] interconnection to Germany has changed since 2017. The reason is an intervention from the EU competition authority. According to an agreement between the parties involved, the minimum export from Denmark was set to 750 MW. The formal availability has improved considerably, but extensive use of *special regulation* may have influenced the results.

Fig. 13 shows duration curves for DK2 (East Denmark).

The AC interconnection with Sweden has reduced the export capacity for 65% of the hours. The average capacity is 66% of the maximum capacity.

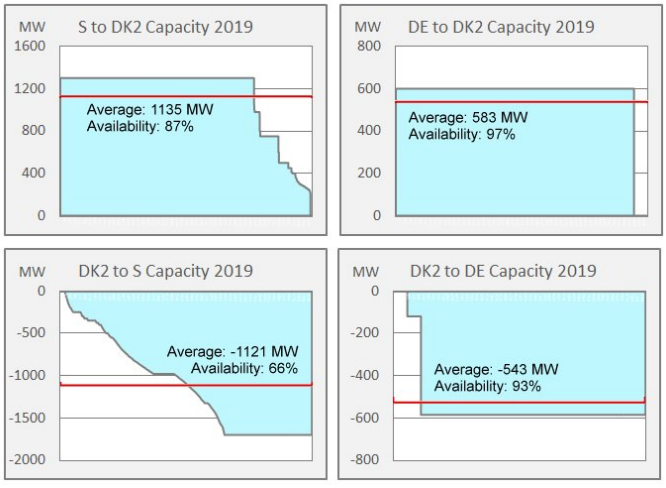

Fig. 13 - Available capacities for DK2 in 2019 - Duration curves – Export capacity < 0

The reduced export capacity towards Sweden and Germany has caused some concern in Denmark. Denmark expects to install new wind power capacity in spite of the limited capacity of domestic facilities for utilizing the overflow of wind energy. Exchange with neighbouring countries is by far the most important Danish means to absorb wind power variations. The barriers for export to Germany and Sweden call for alternative solutions for utilizing Danish wind power peaks.

[1] AC: Alternating Current contrary to DC or Direct Current

Negative Spot Prices Spreading from Germany

There are conflicting trends in the German "Energiewende" (energy transition). On one hand, there is a steady growth in the use of renewable energy for electricity production. On the other hand, the use of lignite as power station fuel continues. The result is that the German targets for CO_2 emission in 2020 seem to be unattainable.

The most important renewable sources are wind and photovoltaics (PV). Other important renewables are hydropower and bio fuels. The share of wind energy was about 21% and PV about 8%. The corresponding Danish figures are 41% and 3%. Nevertheless, Germany seems to have more difficulties from wind power than Denmark.

The German spot prices reveal some of the problems (table 2).

Spot Prices	Period	Nordpool						
	01-01-2019	SYSTEM	DK1	DK2	DE	NO2	SE3	SE4
	31-03-2019							
Average	€/MWh	46,88	42,23	43,75	40,90	48,02	46,49	46,89
Minimum	€/MWh	29,90	-48,29	-48,29	-48,93	37,12	2,90	2,90
Maximum	€/MWh	84,97	109,45	109,45	121,46	109,45	109,45	109,45
St.Dev.	€/MWh	7,61	17,00	16,73	18,95	8,52	10,74	11,11
Negative	Hours	0	75	66	89	0	0	0

Table 2 - Spot prices for Denmark and its neighbours (DE is Germany)

The overall balance has tipped. The spot price in Norway and the Nordpool system price have usually had the lowest average. In 2019, the German average price was lowest due to a surplus of electricity and a reduced export from Norway.

Germany had negative spot prices in 89 hours in 2019. The two Danish price zones have 75 and 66 hours with negative prices. Norway and Sweden did not have negative spot prices at all. The standard deviation is an indicator of the price volatility. It was nearly 19 €/MWh in Germany and less than 9 €/MWh in southern Norway (NO2).

It is a main problem in Germany that most of the wind power is concentrated in the northern part of the country. It is much faster to build wind turbines than to reinforce the grids. It is another problem that Germany is only one price zone (together with Luxembourg). The result of these two problems is that the volatile German electricity market rubs off onto the Danish markets, and that most Danish wind power peaks cannot be exported to Germany.

Denmark depends on exports of wind power variations. The alternative is curtailment of wind energy. There are limitations on export to Sweden and Germany. There is still Norway left, but it is understandable that the Danish TSO, Energinet works hard to establish interconnections to new markets, i.e. the Netherlands and England.