Electricity in Denmark 2018

The Danish Electricity Balance 2018

DK 2018	Demand	Supply
Load	34.164	0
Wind	0	13.898
Solar	0	953
Central	0	9.574
Local	0	4.515
Export	2.182	0
Import	0	7.406

Table 1 – Danish electricity balance 2018 (GWh)

Wind energy made 41% of the gross electricity consumption or 38% of the total balance. The trading opportunities in the international electricity markets made the high share of wind energy possible.

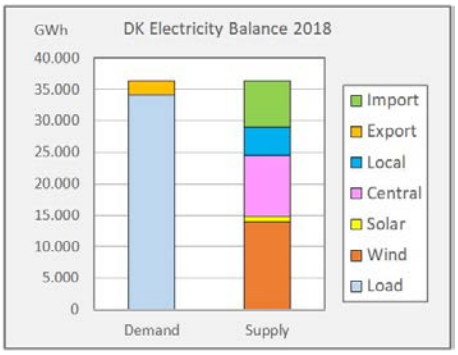

Fig. 2 - Danish electricity balance 2017

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 43% of the demand in June 2018 (fig. 3).

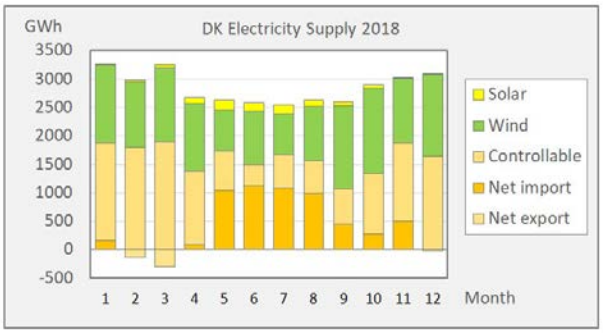

Fig. 3 - Electricity supply by month in 2018

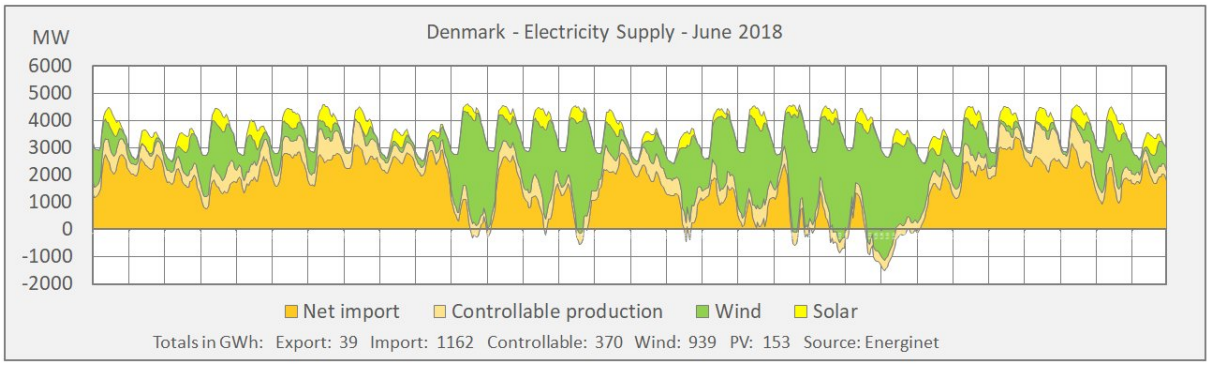

Fig. 1 – Import was the main source of electricity in June 2018 (more charts on http://pfbach.dk/)

Wind power can change within a few days from more than demand to nearly nothing. The minimum wind power output was one MW on 9 November 2018 (3rd hour).

The following maximum hourly values were found for 2018:

- Domestic load: 6088 MW on 28 February 2018
- Net import: 3391 MW on 26 June 2018
- Net export: 2891 MW on 5 April 2018

- Controllable production: 4924 MW on 27 March 2018
- Wind power: 4850 MW on 23 October 2018
- Solar power: 715 MW on 2 July 2018

Increasing Spot Prices and stabilized CHP Production

Broken Spot Price Trend:
The spot market value of demand is used as the average spot price of the year in fig. 4. The spot prices dropped by 50% from 2010 to 2015. Since 2015, the spot prices have been increasing.

Shrinking European capacity reserves have been mentioned as possible reasons of the change. If this is the case, the market seems to work as intended.

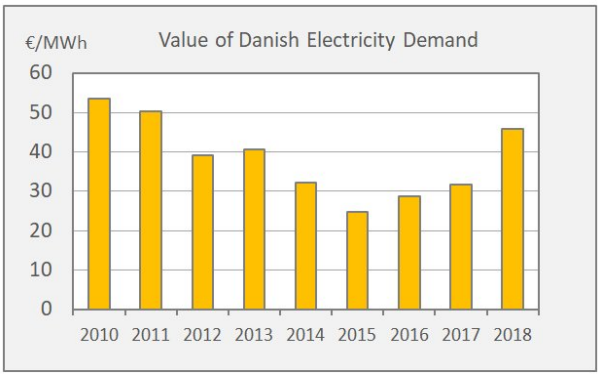

Fig. 4 – Apparently a new trend in spot prices

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.

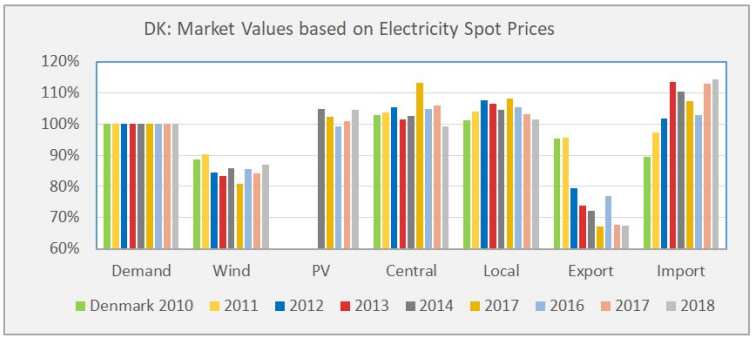

Fig 5 - Increasing gap between import and export prices

CHP Output stabilized:
The combined heat and power production (CHP) may decrease further in the next few years, because the support for local CHP systems is expected to stop in 2018, and because the replacement of coal by biofuels may lead to more local heat production without electricity and correspondingly less electricity production on the large CHP units.

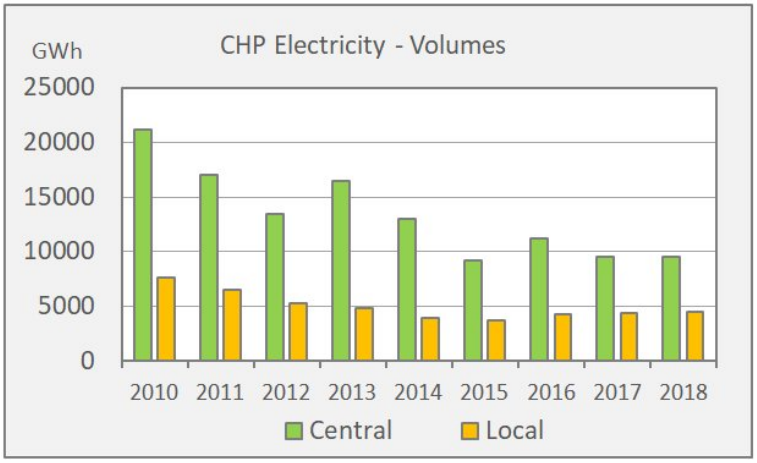

Fig. 6 - From 29 TWh in 2010 to 14 TWh in 2018

This 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 and Germany.

Denmark imported 3.9 TWh from Norway and Sweden in 2017 and 1.3 TWh from Germany (fig. 7). The Danish net import was 5.2 TWh.

The total transit form Norway and Sweden to Germany was 2.5 TWh. Transit in the opposite direction was 1.9 TWh.

The exchange between DK1 and DK2 was mainly from west to east.

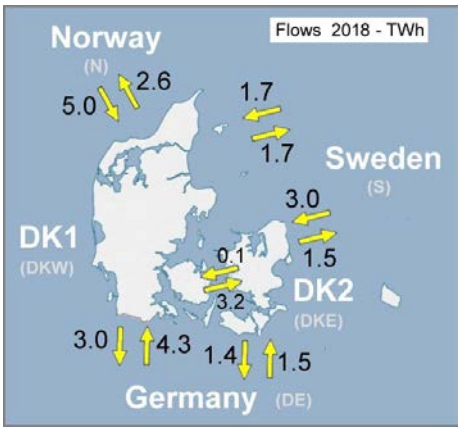

Fig. 7 - Danish electricity exchanges 2018

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

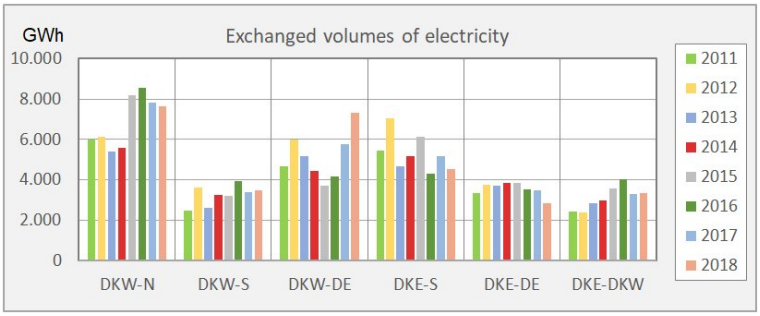

Fig. 8 - Total exchange in both directions 2011-2018

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

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.

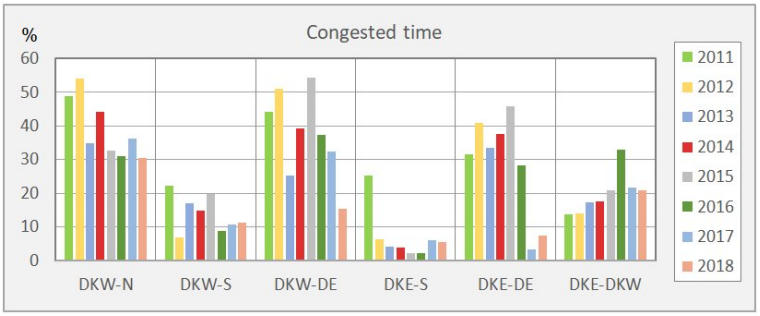

Fig. 9 – Most demand for trade in the north-south direction

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.

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).

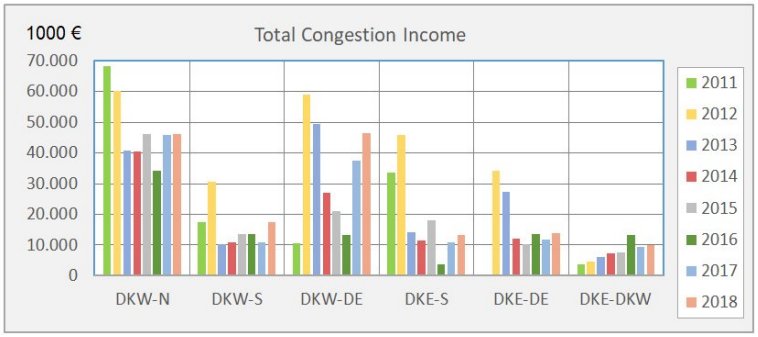

Fig. 10 - Large variations in congestion income from year to year

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.

The congestion income per MWh transferred is an indicator of the importance of a link and of the need for additional capacity (fig. 11).

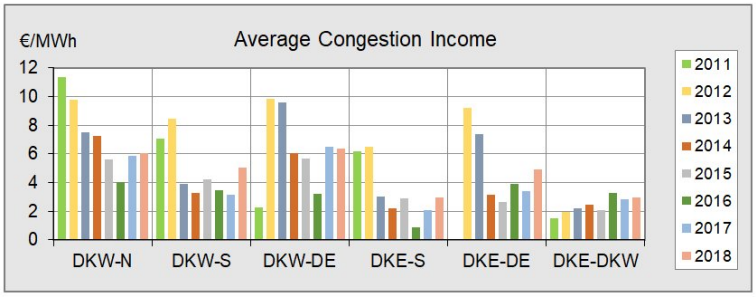

Fig. 11 - The owners of a link share the congestion income.

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.

Capacity Limitations Cause Concern in Denmark

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

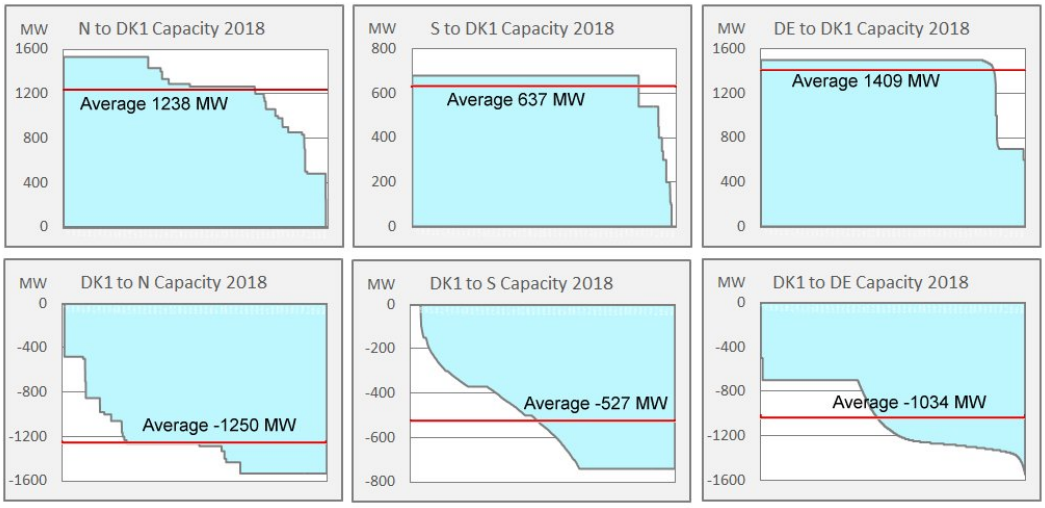

Fig. 12 - Available capacities for DK1 in 2018 - Duration curves – Export capacity < 0

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.

Fig. 12 demonstrates some characteristics for the interconnections for DK1 (or DKW).

The capacity limits for the Skagerrak link (DK1-N) seem to be technical reductions for the interconnector itself. There have been cable failures, and the reductions are symmetrical for the two directions. The link has four poles. At least one pole has been available every hour of the year.

The Konti-Skan link (DK1-S) has two poles. The link has been unavailable for 160 hours for import to DK1 and for 328 hours for export from DK1 in 2018. The reductions are asymmetrical. The average capacity for export from Denmark is 527 MW or 71% of the full capacity.

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. In 2017, the average export capacity from Denmark was only 33% of the maximum capacity, and export was completely blocked for 1860 hours or 20% of the year. The reason was congestion in internal German grid. In 2018, the average export capacity from DK1 had changed from 529 MW to 1034 MW.

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

The AC interconnection with Sweden has reduced the export capacity for 83% of the hours. The average capacity is about 59% of the maximum capacity (71% in 2017).

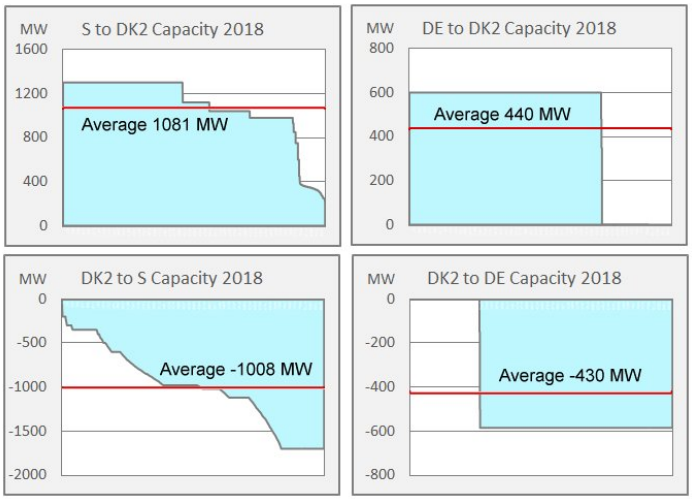

Fig. 13 - Available capacities for DK2 in 2018 - Duration curves – Export capacity < 0

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] AD: 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 4).

Spot Prices	Period	Nordpool						
	01-01-2018	SYSTEM	DK1	DK2	DE	NO2	SE3	SE4
	31-12-2018							
Average	€/MWh	43,99	44,06	46,21	44,48	43,25	44,54	46,37
Minimum	€/MWh	2,17	-15,00	-15,00	-76,01	1,92	1,59	1,59
Maximum	€/MWh	198,29	144,33	255,02	128,26	105,02	255,02	255,02
St.Dev.	€/MWh	9,94	15,06	16,72	17,77	9,38	12,06	14,23
Negative	Hours	0	51	40	133	0	0	0

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

Germany had negative spot prices in 133 hours in 2018. The two Danish price zones have 51 and 40 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 18 €/MWh in Germany and about 10 €/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 and Austria). 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.