Danish flows of electricity and money in 2024

Following my article on net flows in Europe in 2024[1], I have received a request to shed light on the traffic on each of Denmark's international electricity links.

The results turned out to be quite interesting.

As usual, there was a significant transit of electricity through Denmark in 2024, mainly from north to south, but also from east to west (fig. 1 and 2).

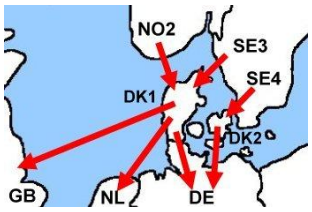

Fig. 1 - Denmark's central position in European electricity transmission

The column labeled "Transfer" shows the total traffic on each interconnection. The total traffic for all interconnections exceeds Denmark's own electricity consumption.

DK	Import	Export	Transfer	AF24 Max imp	AF24 Max exp	Oper. Avail.	Result Utilized
2024	GWh	GWh	GWh	MW	MW		
DK1-NO2	8.064	1.710	9.773	1.632	1.632	81%	68%
DK1-SE3	3.321	811	4.131	715	715	64%	66%
DK1-DE	2.530	6.881	9.410	2.500	2.500	90%	43%
DK2-SE4	7.248	568	7.817	1.300	1.700	76%	66%
DK2-DE	959	4.030	4.989	1.000	985	81%	57%
DK1-NL	1.678	2.316	3.995	700	700	87%	65%
DK1-GB	1.367	5.138	6.505	1.400	1.400		53%
DK1>DK2	1.278			590			
DK2>DK1	1.231			600			49%
Internat.	25.166	21.454	46.620				

Fig. 2 - The total exchange exceeds Denmark's electricity consumption of 38 TWh in 2024

"AF24" is the latest edition of the Danish "Analysis Assumptions", in which the Danish Energy Agency translates political intentions into concrete plans. The column "Oper. Avail." shows the proportion of the nominal possible transport that could be transferred in 2024, when the operational constraints are respected.

The column "Result Utilized" shows the actually transferred energy in relation to the nominal transport capacity in 2024. For DK1-SE3, the result is slightly above the operational limits. Only the HVAC[2] connection DK1-DE and the HVDC connection over the Great Belt (DK1-DK2) are below 50%

DK	Imports			
	Buyer's	value	Seller's	value
2024	1000_€	€/MWh	1000_€	€/MWh
DK1-NO2	723.480	89,72	441.228	54,72
DK1-SE3	276.951	83,4	118.380	35,65
DK1-DE	82.532	32,62	71.595	28,30
DK2-SE4	546.425	75,38	345.031	47,60
DK2-DE	50.764	52,96	42.228	44,05
DK1-NL	135.700	80,86	125.105	74,54
DK1-GB	143.065	104,66	101.294	74,10
Internat.	1.958.918	77,67	1.244.861	49,47

Fig. 3 - Significant price differences for electricity imports in 2024

Cash flow and congestion fee

The economic results (fig. 3) are based on spot prices, which are set for each price zone hour by hour. The economic results should be considered estimates. The spot markets are important, but some of the exchanges are priced through other channels.

[1] http://pfbach.dk/firma_pfb/references/pfb_france_consolidated_its_role_as_eruropes_main_exporter_of_electricity_in_2024_2024_02_04.pdf
[2] HVAC: High voltage alternating current HVDC: High voltage direct current

Fig. 3 shows the market value of **imports** to Denmark in 2024. For Danish buyers, the market value is calculated hour by hour as imported quantity times spot price in price zone DK1. For sellers, the value is calculated as exported quantity times spot price in the seller's price zone.

The capacity of the connection between two price zones limits the transfer. When a connection is fully loaded, the spot prices in the two price zones become different. This means that buyers pay a higher price than sellers receive.

The total value of imports for buyers was €1.96 billion, while the value for sellers was €1.24 billion. Correspondingly, the value of **exports** (fig. 4) was €1.79 billion for buyers and €1.47 billion for sellers.

DK	Exports				Congestion
	Buyer's	value	Seller's	value	fee
2024	1000_€	€/MWh	1000_€	€/MWh	1000_€
DK1-NO2	57.235	33,48	45.387	26,55	291.677
DK1-SE3	38.227	47,16	35.608	43,93	160.557
DK1-DE	720.251	104,68	654.901	95,18	76.490
DK2-SE4	28.742	50,56	28.032	49,31	199.818
DK2-DE	341.198	84,66	286.558	71,10	64.086
DK1-NL	178.603	77,11	135.925	58,68	53.245
DK1-GB	425.265	82,77	282.274	54,94	184.717
Internat.	1.789.520	83,41	1.468.684	68,46	1.030.591

Fig. 4 - Market values of Danish electricity exports in 2024

The differences of €710 million (fig. 3) and €321 million (fig. 4) were parts of the so-called **congestion fee** or **bottleneck charge**, which are allotted to the network owners.

In Danish foreign trade in electricity in 2024, the total payments of buyers are estimated to be €3.75 billion, while sellers are estimated to have received €2.71 billion. Thus, the total congestion fee for network owners amounts to €1.04 billion or 28% of total turnover.

Congestion fee is a significant but uncertain revenue

The transmission systems are not equally stressed every year. Therefore, the congestion payments can vary greatly from year to year. For example, there was a lot of public criticism after 2021, when the gas crisis led to stressed transmission networks and very large congestion revenues in Sweden, Norway and Denmark. This does not mean that the scheme is wrong, but such cases can help identify weak links that should be strengthened.

Do TSOs maximize their own profit?

Transmission system operators (TSOs) determine the transmission limits based on security calculations. In Europe, they are also the ones who receive the congestion fees, which are important sources of revenue. This gives rise to a theoretical conflict of interest, because they have the opportunity to maximize their revenues (Fig. 5).

If the transfer capacity is always higher than the demand, there are no price differences and thus no congestion charge. If, on the other hand, the transfer capacity is zero, there is no transfer and thus no congestion charge. Between these two extremes there is a maximum.

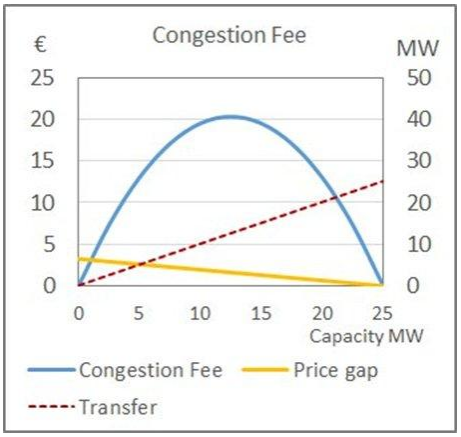

Fig. 5 - The congestion fee dilemma

There is no reason to assume that the possibility is abused by European TSOs, but on the other hand it is not practically possible to investigate whether the transmission capacities are determined based on fair criteria.

In the US, system operators are not shown that trust. Abuse is prevented by system operators not being able to own transmission networks. Therefore, the term Independent System Operator (ISO) is used instead of Transmission System Operators (TSO). This removes the conflict of interest, but can lead to other problems.

The dilemma exists both for daily operations and for investments. The optimization of a grid expansion is often done based on criteria for security of supply. If bottlenecks never occur in a transmission grid, too much has been invested in the grid. It can be difficult to find the right level.

An undersized grid does not necessarily result in interruptions in supply, but rather in production changes and thus more expensive operation. It also means higher congestion fees. Therefore, we must assume that Norwegian and Swedish limitations on the capacity of international connections will result in greater price differences and thus increased congestion income.

This would be a completely wrong development. Therefore, one could hope that better coordination of the European electricity markets could solve the problems that Norwegians and Swedes have experienced, and thus enable optimization of the European transmission grids based on common overall considerations.