European Electricity Flows in 2017

German export sets the exchange pattern

Fig. 1 shows the net flow of electricity across national borders for selected European countries in 2017. Exchange data for 15 countries, used for the overview, are available as hourly time series at http://pfbach.dk/.

The 2017 exchange pattern is similar to the pattern in 2016. Only four of the 15 countries provide the electricity export (negative figures in table 1)[1].

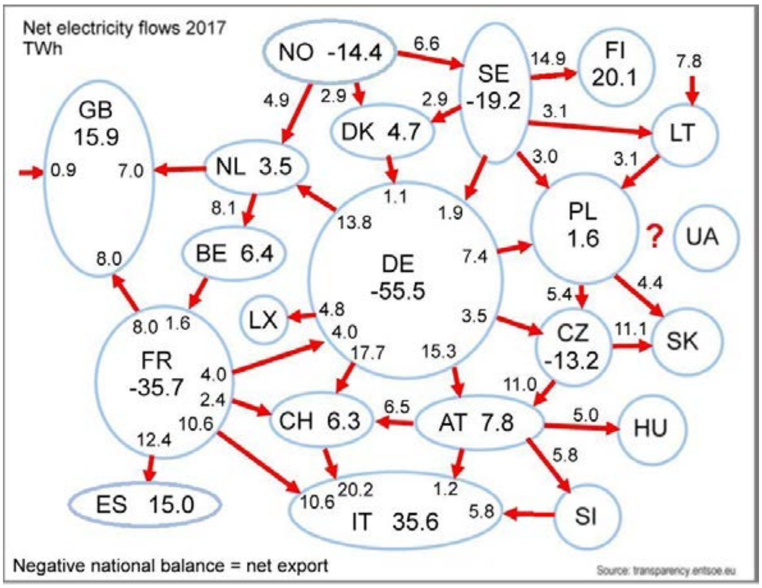

Fig. 1 - Europe has a western, a central and an eastern power corridor

2017	Net imp. GWh
IT	35616
FI	20114
ES	14993
GB	9556
LT	8822
AT	7807
BE	6447
CH	6365
DK	4687
NL	3539
PL	1635
CZ	-13243
SE	-19173
FR	-35647
DE	-55454

Table 1 - Net imports 2017

Temporary imbalances are natural for a nation, but it is not clear why some countries maintain considerable surpluses or shortages of energy as annual averages, year after year. Do they reflect national policies, or do they just happen accidentally?

There is no doubt that wind and solar power create imbalances in some regions and in some periods, but they must not necessarily create annual imbalances. International trade is necessary for maintaining a reasonable security of supply, hour by hour, and for utilizing excess power from non-dispatchable sources. Therefore, increasing importance is attached to the efficiency of the European electricity markets.

Electricity supply in Europe is developing into an integrated power system, where most countries are becoming more and more dependent on other countries. The result is a growing transport of electricity.

Grid bottlenecks and curtailment of wind power occur increasingly. There is a race between the installation of new non-dispatchable power sources and the construction of new power lines.

It has been argued in the past, that wind and solar power would be produced and consumed locally and without impact on long-distance electricity transport. In 2018, reality is different. Wind and solar power create regional imbalances. Most electricity surplus comes from Scandinavia and the northern part of Germany, while most of the demand is located in southern Europe. The result is transfer of electricity from north to south and an urgent need for more grid capacity, particularly in Germany.

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[1] Great Britain (GB) includes England, Wales and Scotland, but not Northern Ireland.

Why is Germany's Electricity Export Growing?

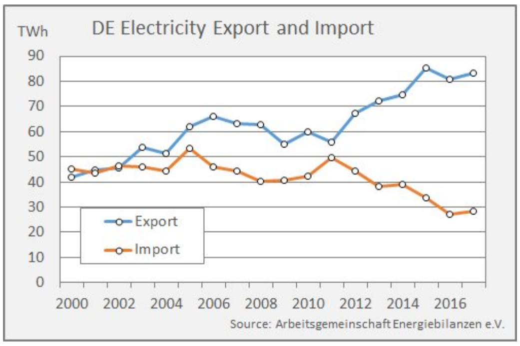

Fig. 2 – Increasing net export since 2011

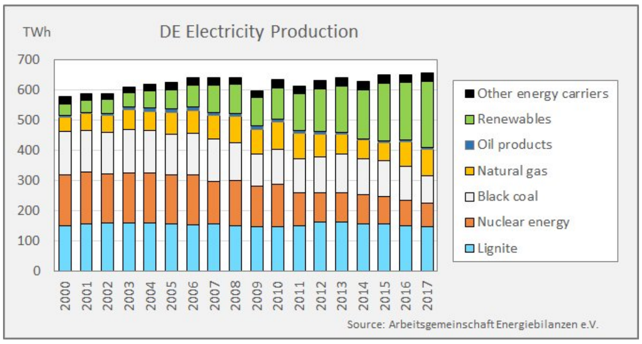

Fig. 3 – The changing electricity production

A large amount of non-dispatchable electricity production is the result of the German energy transition (die Energiewende). It has changed the composition of energy types in German electricity supply since 2000 (fig. 3). In 2017, renewable energy made about 36% of the electricity production. The question is why the net export of electricity keeps growing.

Germany has different types of renewable energy (fig. 4). Wind and solar power make about 24% of the electricity consumption in Germany. Other renewables produce about 12% of consumption.

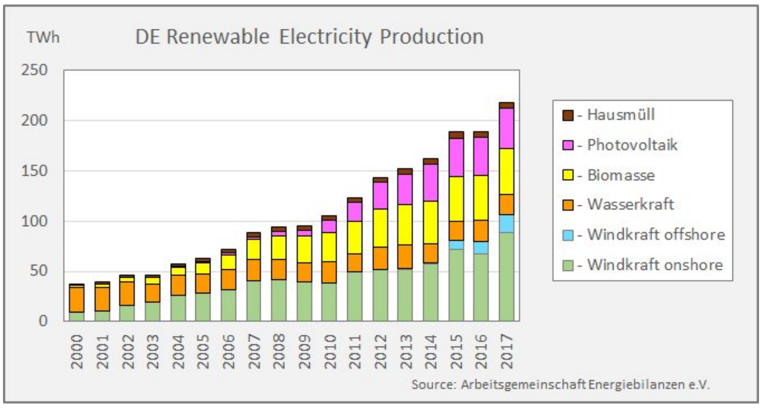

Fig. 4 – Wind and solar energy make 67% of the renewable energy

In order to understand the German export level, it is necessary to examine the available production capacity.

The maximum hourly load in 2017 is estimated at about 96 GW.

The total German production capacity in February 2018 was 208 GW[2]. This capacity includes security standby (1 GW), grid reserve capacity (7 GW) and power stations, temporarily shut down (3 GW). The remaining 197 GW are available to the electricity market.

The non-dispatchable capacity (wind and solar) is 90 GW. The remaining 107 GW are supposed to be dispatchable. The minimum simultaneous output of wind and solar power in 2017 was 312 MW (0.3%). The low figure indicates an insignificant capacity value. The maximum simultaneous production from wind and solar power was 52 GW in 2017.

The estimated dispatchable reserve capacity during the annual peak hour is 107 +1 +7 – 96 = 19 GW or 20% of the maximum demand, which is supposed to be sufficient backup capacity, even without foreign support. However, the free capacity is not necessarily installed on the locations, where it is needed.

[2] Auswertung Kraftwerksliste Bundesnetzagentur nach Kraftwerksstatus und Energieträger. Stand 02.02.2018.

Wind and solar power do not contribute significantly to the security of supply, but they reduce the capacity factor (in 2017) for the market-operated production from 64% to 48%. Low utilization of the power stations may develop into economic problems.

The export of 55.5 TWh in 2017 improves the average capacity factor from 48% to 54% and may relieve the economic stress.

The case demonstrates a dilemma for thermal power stations in Europe, where an increasing share of wind energy reduces the demand for energy from traditional power plants. Idle capacity will intensify the competition in the spot markets for energy, press down price levels, increase exchanges and strain the power grids. Decommissioning power plants will be pushed forward. Eventually, it will take additional capacity mechanisms to maintain full backup capacity for wind and solar power.

In Denmark, thermal power stations have been closed down or mothballed, and foreign backup is required for maintaining normal security of supply.

The German Single Price Policy Restrains Electricity Import

The German green paper about electricity markets[3] has been followed by a consultation process and in 2015 by a white paper[4].

Since the 1980s, the European Union (EU) wanted traditional monopolies in electricity supply replaced by competition. The development of electricity markets followed gradually. Last, the energy transition is challenging the German electricity market. Some of the indications are grid congestions, negative spot prices and wind power curtailments.

The white paper explains how the existing market will be transformed into "electricity market 2.0". Twenty measures are supposed to solve the problems. However, the green paper consultations also confirmed a few overriding principles, which will be decisive for the interrelations between the German electricity market and other European markets.

The most important overriding principle is that Germany will **retain an electricity market with only one price zone**. It means that the grid operators must use counter trade and downgrading of interconnections for preventing grid congestion. The whitepaper says that one common spot price for all Germany is of particular importance to the mechanical industry in Germany.

The arguments seem to be weak. The model does not give proper incentives for load management and it has restrained the international trade, particularly electricity import.

The white paper acknowledges that the present conditions are untenable (page 14):

> *"It is stressed several times that the grid capacities in central Germany are not currently sufficient to transport the electricity from the generation centres in the north and the east to the centres of demand in the south of Germany. In order to rapidly tackle grid congestions and to limit expensive redispatch measures, the electricity grids should be rapidly expanded. The* grid expansion *is not only a favourable flexibility option; it is also the precondition for*

[3] Mentioned here: http://pfbach.dk/firma_pfb/pfb_german_green_paper_oct_2014.pdf
[4] https://www.bmwi.de/Redaktion/EN/Publikationen/whitepaper-electricity-market.html

functioning electricity trading and important for the continuation of the single price zone, say e.g. the transmission system operators and EPEX SPOT."

Again, page 17:

"Grid expansion is urgently needed to maintain the single price zone. This is stressed in numerous comments. If grid congestions remain in place in the long term, says e.g. BNetzA, it would be impossible to maintain a single price zone. For this reason, the grid expansion must be realised quickly."

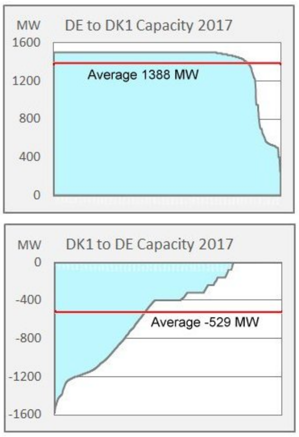

Fig. 5 - Duration curves for available capacity DE-DK1

In most cases, grid expansions cannot be realised "rapidly" or "quickly" in Germany. It will take years before the German congestion problems have been reduced to a reasonable level.

It is a part of the German congestion policy to change internal grid congestions into limitations at the national borders. This policy is not optimal and it has a considerable impact on the neighbouring countries. Fig. 5 shows as an example that the average transfer capability from West Denmark (DK1) to Germany in 2017 was reduced to about 35% of the nominal capacity. The export from DK1 was totally blocked in 22% of the hours in 2017.

Nordpool Spot has been using price zones for congestion management for many years in the Nordic countries (fig. 6). The advantage is that the price zones reflect the physical limits in the grid and bring the operational pattern closer to the economic optimum.

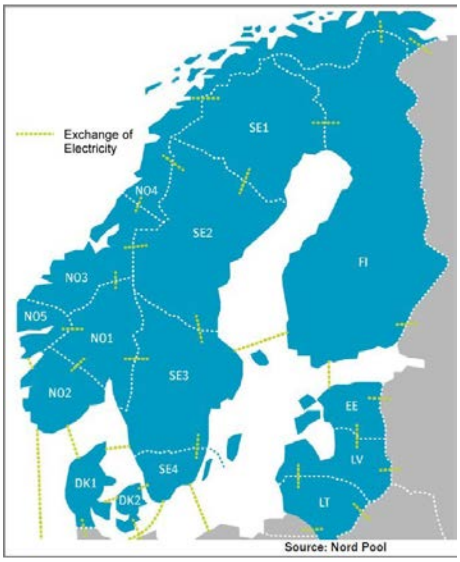

Fig. 6 - Nordpool Spot - Price zones

Well-chosen grid reinforcements can reduce price differences to a reasonable level. For hours without congestions, there will be one common spot price for all zones as for a single price zone.

Due to the geographic conditions, it is bad economy to expand the Nordic grids to eliminate all bottlenecks. This will also be the case in Germany.

Therefore, the German congestions could be managed optimally by an electricity market with a few price zones, at least as a temporary solution.

Another overriding principle is the introduction of a **capacity reserve** in order to prevent capacity shortage during periods with low output from wind and solar power.

The capacity reserve is different from the *grid reserve* (7 GW in 2018, see p. 2). The grid reserve is kept available for *redispatch*, when local grid congestions must be relieved by moving production within the country. A *capacity reserve* is kept available for situations with insufficient market based capacity. Neither grid reserve nor capacity reserve can be traded in the electricity market. Both types of reserve are paid for and activated by the grid operators.

An alternative model is the *capacity market*. Both the capacity reserve and the capacity market can be organized in different ways.

In a market without a capacity arrangement, very high spot prices may occur occasionally. The price peaks are supposed to give investors incentives to add new capacity. A capacity reserve will stabilize spot prices and prevent extreme price peaks.

The European countries prepare different capacity arrangements, but these choices have less impact on neighbouring countries than the congestion management.

Integration of Renewables Always Lagging Behind

The lack of coordination between the installation of non-controllable power sources, such as wind and photovoltaics, and the necessary infrastructure for transport, balancing and utilizing the new energy sources is striking. This is the case in Germany and in several other countries.

The result is negative spot prices, congested grids, curtailed wind power and increasing export of electricity. The purpose of the energy transition was to reduce emission of greenhouse gases (GHG), but due to the incoherent power system, the German targets for 2020 will not be met.

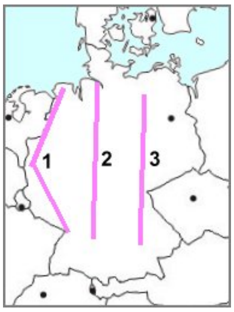

Fig. 7 - New HVDC links

The German electricity market cannot give the proper incentives to producers and consumers due to the single prices market model.

Large new HVDC transmission systems are under construction from north to south in Germany (fig. 7). When these links are commissioned in several years from now, the share of wind and solar power will have increased further, and the remaining nuclear power will be phased out. The new links will probably not end the difficulties.

Suitable integration measures, such as flexible consumption, energy storages and grid reinforcements, should be ready for use in due time before the commissioning of new non-dispatchable power sources.