A challenging summer for Nordic power systems

Cable faults and large price gaps were characteristic of the Nordic power systems in the summer of 2020. The rough picture was that Norway had a surplus of power while Sweden had a power shortage due to insufficient transmission capacity. The Nordic power market was always based on strong interconnections. How could it go that wrong?

Did the Swedish TSO underestimate wind power development?

The Swedish Wind Energy Association (SWEA) claims that the Swedish TSO (Svenska Kraftnät, SKN) has underestimated the development of wind power in Sweden [1]. The result is insufficient investments in reinforcements of the transmission system.

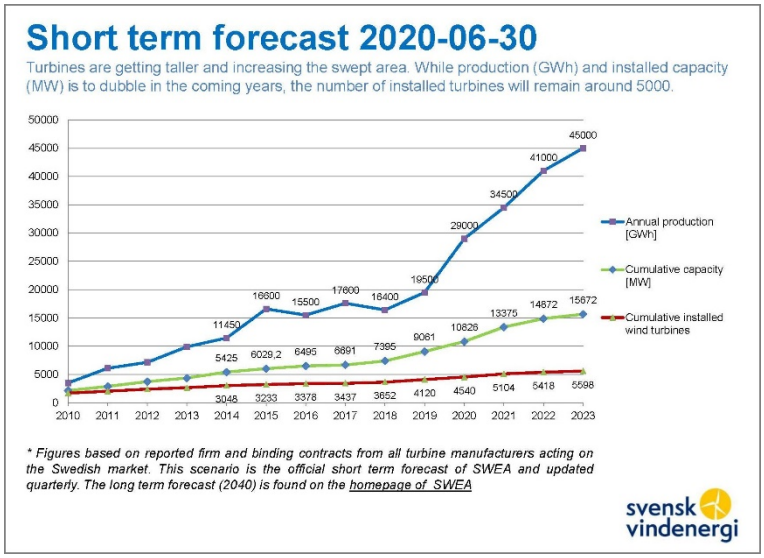

Fig. 1 - A steep growth in Swedish wind energy expected for 2020

The Swedish electricity supply problems during the summer 2020 seem to support the views of SWEA.

SWEA now expects the wind energy production to reach 29 TWh in 2020 (fig. 1).

In 2012, SKN expected 13 TWh in 2020 (Ten Year Network Devevlopment Plan, TYNDP).

It is another important fact that a large part of the Swedish wind power expansion is concentrated in price area 2, which is number two from north.

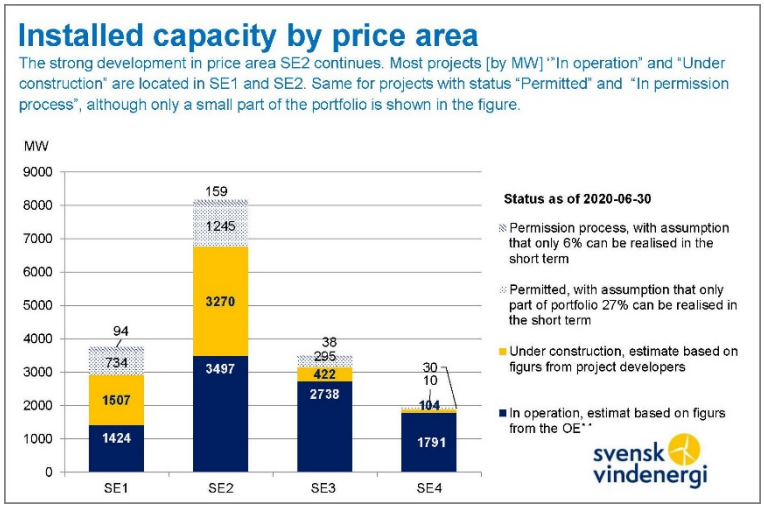

Fig. 2 – Concentration of Swedish wind power in price area 2

Sweden has the main part of its hydro resources in area one and two. The grid was always heavily loaded with transfer of power to SE4 and DK2 (East Denmark) in the south. Decommission of nuclear power in south and new wind power in north will increase the transfer.

Wind power has a lower average utilization than controllable power. The consequence is that it takes more transmission capacity to move a GWh wind energy from the production sites to the demand centres.

The spot prices in the four Swedish price areas would be equal, if no barriers prevent the free flow of demanded power from north to south. When demand for transport exceeds capacity, the prices are different. Large price differences were clear signs of the capacity problems during the summer 2020 (fig. 3).

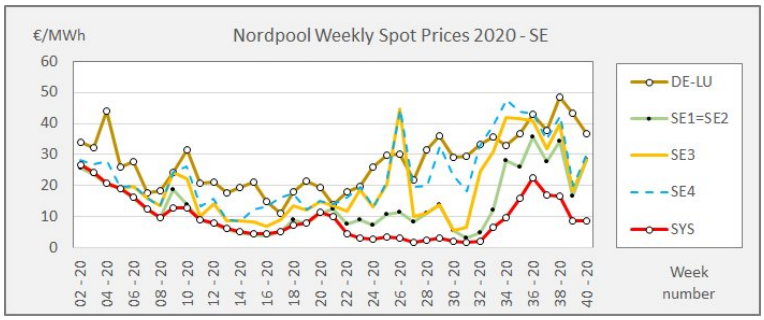

Fig. 3 - Weekly Swedish spot prices in the summer gap between low Nordpool system prices and high German spot prices.

The areas three and four experienced high prices, particularly during the weeks 24 to 36. SE3 joined SE4 with high prices in some weeks and SE1/SE2 with low prices in other weeks depending on local power balances and bottleneck locations.

Some Swedish media wrote about an electricity crisis [2, 3 and 4]. The Swedish prices would be close to the system price under normal circumstances. The ceiling is usually the price in Germany/Luxembourg.

Poor availability of interconnectors

Besides missing reinforcements in Sweden, offshore cable faults have limited exchanges during the summer.

Norway had the power, which could have relieved the Swedish supply problems, but the Norwegian power was trapped behind bottlenecks.

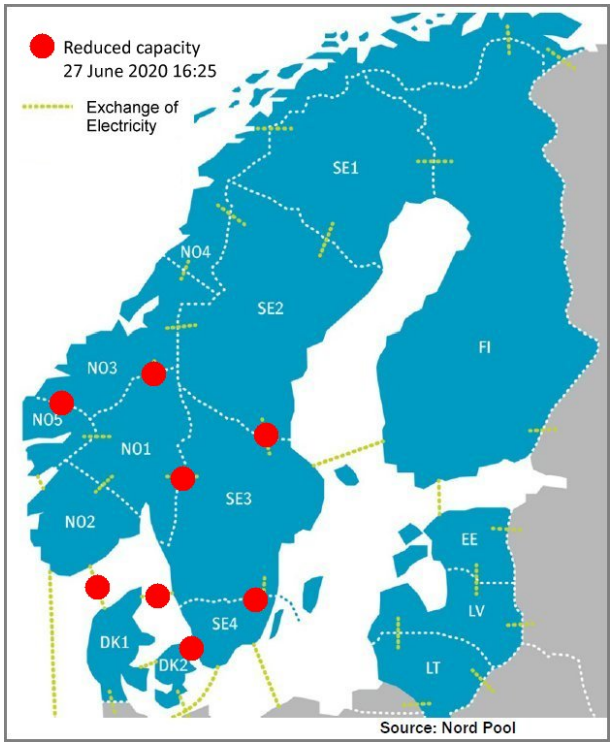

Fig. 4 - Example of bottlenecks causing price differences

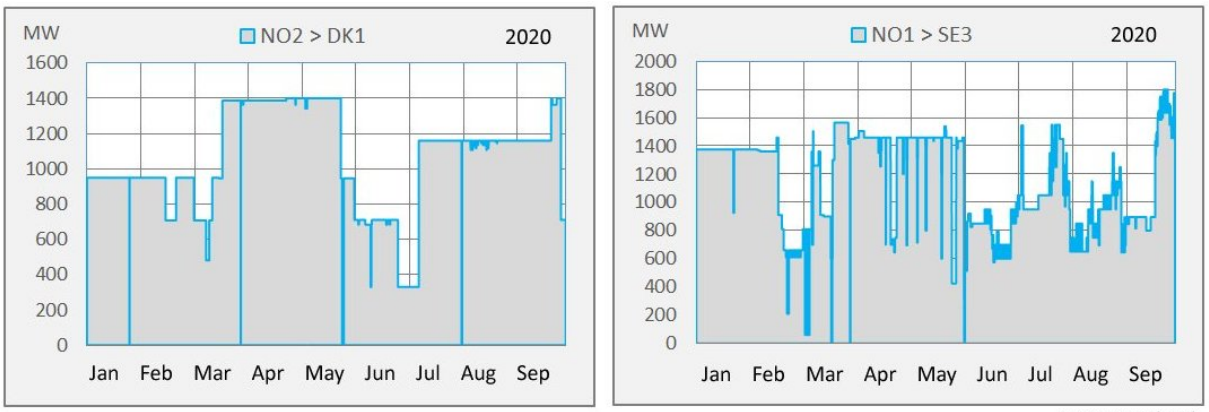

Fig. 5 - Available capacity for two important Nordic power corridors, Norway to Denmark and Norway area 1 to Sweden area 3

Fig. 5 shows that two important Norwegian export corridors were operating at half capacity or less during the spring flood season in June. For the Skagerrak interconnector to Denmark, the main reason was cable faults. From 27 June to 8 July, only one of the four poles was available.

The reduced export capacity caused a rapid increase of water levels in Norway (fig. 6). Area 2 has about a third of the Norwegian storage capacity. The risk of overflow caused concern and made the spot prices in Norway drop to nearly nothing (fig. 8).

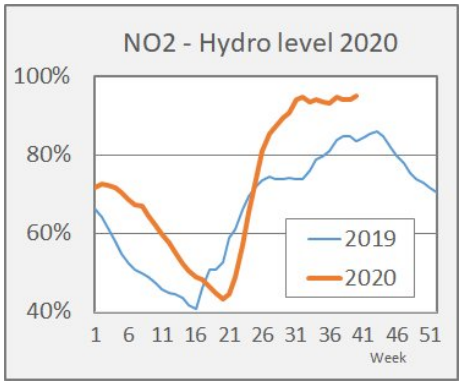

Fig. 6 - Hydro reservoir content, southern Norway (price area 2)

Other links have offshore cable faults in 2020. The Kontek link from East Denmark to Germany (DK2-DE) has been unavailable since 31 August 2020, and the Cobra cable from West Denmark to the Netherlands (DK1-NL) has been unavailable since 26 September 2020.

Average availability - Jan. to Sep. 2020			
Area 1	Area 2	Import	Export
DK1	NO2	75%	67%
	SE3	72%	87%
	DE	62%	54%
	NL*	98%	82%
	DK2	99%	99%
DK2	SE4	76%	70%
	DE**	89%	54%
SE3	SE4	100%	78%
	NO1	63%	71%
NO2	NL	88%	74%
* Uavailable since 26 Sep 2020 Cable fault			
** Unavailable since 31 Aug 2020			

Table 1 - Selected availability data

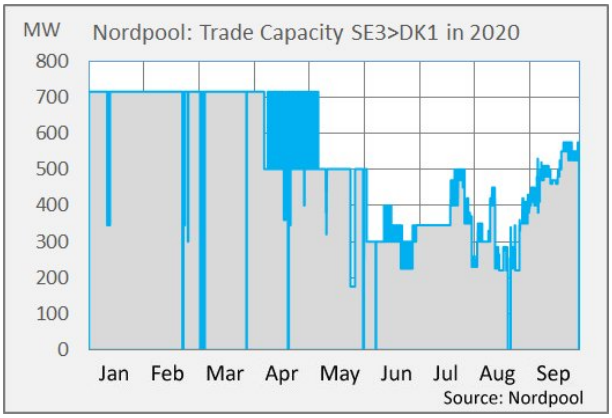

Fig. 7 - Reduced availability SE4 to DK2

The shortage of power in the southernmost part of Sweden (SE4) rubbed off onto Denmark's possibility to purchase power in Sweden (fig. 7).

The unusual price gap

Fig. 8 is an attempt to show the price development in 2020 for a large number of price areas. The period January to August was chosen, because September was less characteristic.

"SYS" is the Nordpool system price. In a grid without bottlenecks with a free flow of power, the system price would be valid for all price areas. Bottlenecks and price differences are normal, but a separate price formation for all Norwegian price areas is unusual.

The August profile is typical for 2020 (fig. 8). SE1 and SE2 have the same low price, but at a higher level than for the Norwegian price areas. SE4, FI and DK2 have very high prices in common with the Baltic States. SE3 and DK1 seem to share price level with Germany (DE/LU). This profile is in good accordance with the transfer capabilities in the grid.

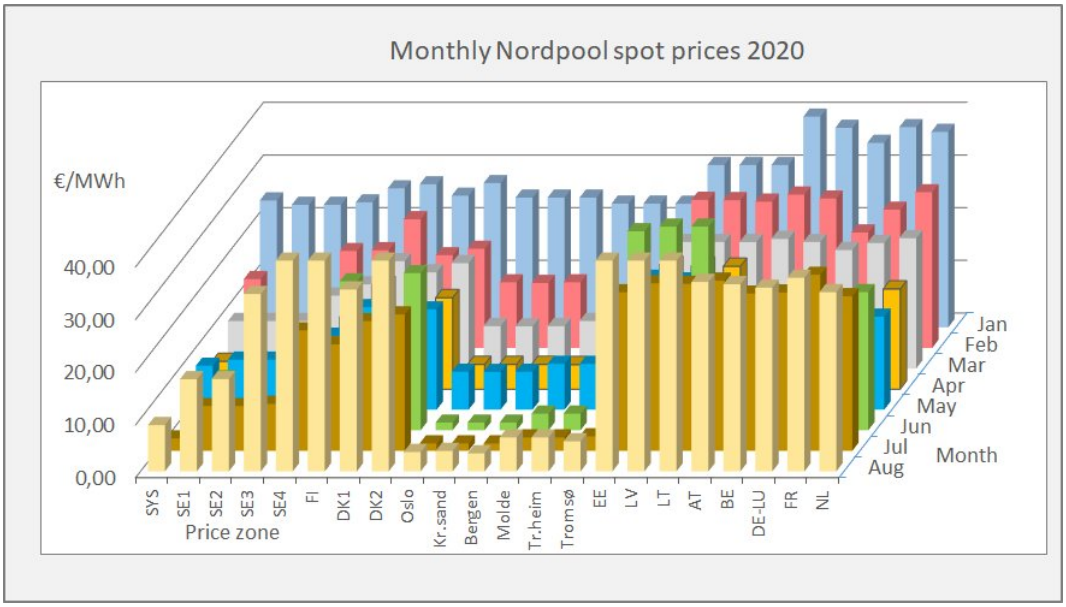

Fig. 8 - The Norwegian price areas (in the middle) went their own way in 2020

An hour in September: More than € 2000 for one MWh

The spot prices are good indicators of unusual operational conditions. In fig. 3, the weekly average spot prices seem to peak in week 38, for DK1 at € 46.85 per MWh and for DK2 at € 47.25 per MWh. One day in that week, September 15th, has particular high average prices, for DK1 € 70.20 per MWh and for DK2 73.22 per MWh. This day has one extreme hour, 19 to 20, when the spot price was € 189.25 for all price areas in Sweden and Denmark.

According to the *regulating prices*, the shortage of power was worst in Denmark and particularly for DK1 (table 2). It is not known if the shortage had any operational implications in Denmark, but we know that the wind power output was low for several European countries (fig. 9), compared with another randomly selected day (September 9th).

€/MWh	Up	Down
DK1	2016.07	189.25
DK2	899.00	189.25

Table 2 - Regulating prices 15 Sep hour 19 to 20

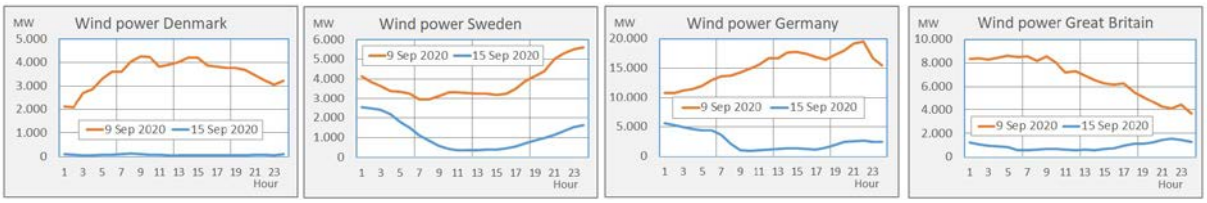

Fig. 9 - Wind power output Sep 9th and 15th for Denmark, Sweden, Germany and Great Britain (UTC hours)

Such situations are rare. California has used rotating blackouts during heat waves in September this year. An interruption of power supply is not the end of the world. Load shedding could be introduced as a regular measure, but if it is considered not to be acceptable, full back-up capacity for wind power seems to be needed.

Voltage problems due to closing nuclear plants

The owner of the Ringhals nuclear power station, Vattenfall, has planned to decommission unit 1 and 2 [5]. Unit 2 ended operation at the end of 2019. Unit 1 will be operational until the end of 2020. However, Vattenfall stopped the unit earlier, when the market price did not

justify production [6]. This act caused voltage problems in central and regional networks in the southern part of Sweden, and the TSO, Svenska Kraftnät, had to pay Vattenfall SEK 300 million for the continued operation until the end of the year.

A report by Energiforsk AB has analysed the Swedish voltage problems [10]. The summary concludes:

> *With the decommissioning of Ringhals 1 and 2 a proportionally big part of the reactive power capability and voltage control in the area will be lost. The future commissioning of a STATCOM at Stenkullen and the South-West link will certainly help to improve these aspects. However, due to the complexity of the situation (with changing power flows and grid characteristics) it cannot be concluded in this report if these measures are sufficient to maintain stable and reliable voltage control in the future.*

This wording suggests that the investigation is not yet complete. A thorough analysis should have been made years ago, when the decommissioning of Ringhals 1 and 2 was decided. The blackout in 2003 demonstrated the importance of the reactive resources from the Ringhals power station.

Planning by the TSO, Svenska Kraftnät

This paper suggests that Svenska Kraftnät is lagging behind in developing the Swedish transmission grid. We do not know if Svenska Kraftnät has slept in the class, or if they met difficulties beyond their own influence.

In a brochure, Svenska Kraftnät presents a reinforcement plan to be carried out in 20 years at the cost of SEK 53 billion [7]. The brochure has no date, but the press reports [8 and 9] are from the end of September 2020. It looks like SKN has presented their old plans in a new brochure. Svenska Kraftnät has published 10-year plans in 2016 [11] and 2020 [12]. The investment plan from 2016 could easily be extrapolated to SEK 53 billion in 20 years (fig. 10).

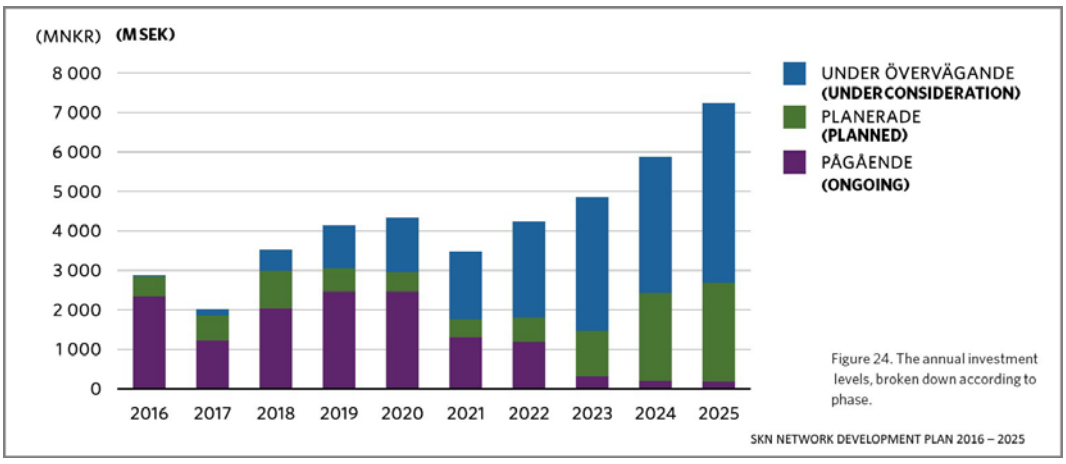

Fig. 10 - Svenska Kraftnät Investments 2016-2025

Reinforcements of transmission systems have begun too late

This paper has presented evidence that the Nordic transmission systems do not have the capacity to serve the supply system, as it has developed within the last few years. Supply problems are inevitable if the additional need of transmission-capacity for wind power has not been anticipated in due time. The question is if load shedding or new backup capacity will be chosen for solving the increasing capacity problems here and in other European regions.

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