Have the technical experts lost influence?

The Vulnerable Power System in Southern Sweden

The electricity spot prices are sensitive indicators of irregularities in the power grid concerned. The southern Sweden and the southern Norway are currently experiencing very high prices in the day-ahead market. This note outlines the market conditions for the southern Sweden. It follows a similar analysis for the southern Norway.

Volatile spot prices with regional differences

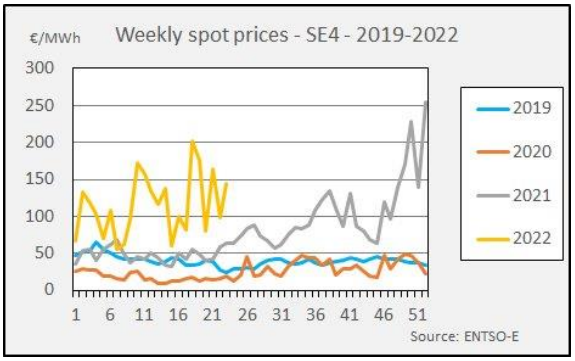

Fig. 1 - High and volatile spot prices since 2021

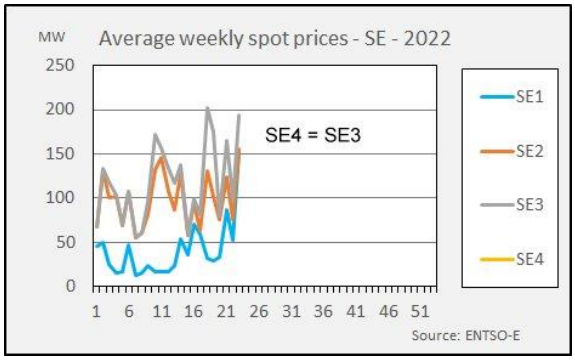

Fig. 2 – Different regional spot prices

A rather normal year 2019 was followed by a 2020 with surplus of energy and low prices in the electricity markets. Shortage of natural gas in 2021 caused uncertainty about the future and a turbulent price picture (fig. 1).

SE1 made together with NO3 and NO4 a Nordic low price region in most hours in 2022 up to now. It means that transfer of electricity was limited at the southern borders of SE1 and NO3 (fig. 2 and 3). Even the border between SE2 and SE3 is increasingly congested.

Grid limitations (bottlenecks) cause price differences.

Some people are wondering if it is possible to redesign the electricity market with the same price for all domestic consumers, but with high prices for exported electricity.

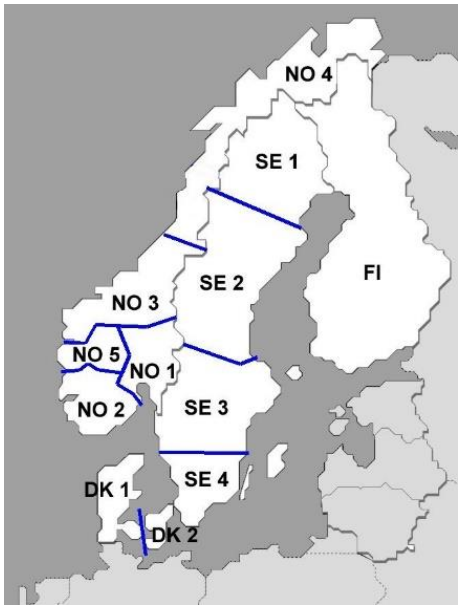

Fig. 3 - The Nordpool price zones

The Nordpool market system has been based on the same principles since the early 1990's. All market systems are compromises between conflicting interests. The general purpose is to let the market optimize the allocation of resources, even internationally. Protectionist measures would probably blur this target and reduce total efficiency.

In any case, a fundamental change of the Nordic day-ahead market should be carefully considered, because the current model has served quite well since the market introduction.

International links from SE4

SE4 has the following international links:

- The HVAC Øresund cables to Denmark (DK2): 400 kV
- The HVDC Konti-Skan links to Denmark (DK1): 0.25 + 0.35 GW – 1965, 1988
- The HVDC Baltic Cable to Germany: 0.6 GW - 1994
- The HVDC SwePol to Poland: 0.6 GW – 2000
- The HVDC NordBalt to Lithuania: 0.7 GW – 2015

SE4 is a transit area. Electricity moves from north through SE4 to the export terminals.

Since the decommission of two 600 MW units at the Barsebäck nuclear power plant, SE4 had only a modest electricity production (table 1). About half the production is wind energy.

SE4	Load	Estimated generation	International export	From SE3
	TWh	TWh	TWh	TWh
2019	23,7	7,9	8,8	24,6
2020	23,6	8,0	13,6	29,3
2021	24,4	7,9	12,1	28,7
½ 2022	11,7	4,8	8,4	15,3

Table 1 - SE4 energy balances

The lack of production capacity and the demand for export is challenging the Swedish transmission system. The transfer capability may be reduced due to lack of heavy stabilizing synchronous units in the area. Exchange capacities have frequently been limited by grid congestion.

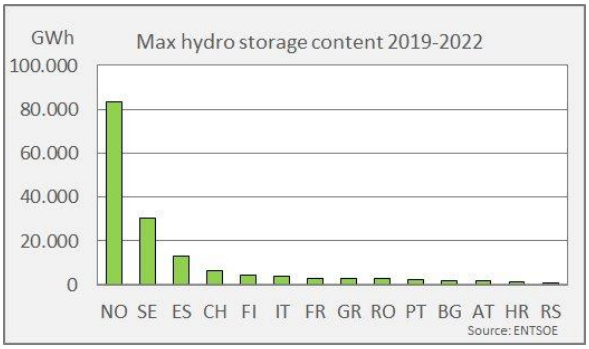

Fig. 4 - Sweden has the second largest hydro storage capacity in Europe

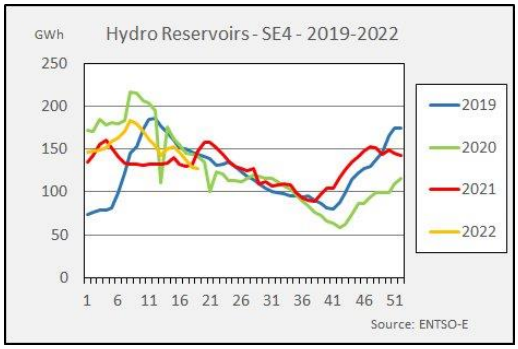

Fig. 5 - SE4 has less than 1% of the Swedish hydro storage capacity

The Swedish hydropower system covers nearly half the demand for electricity in Sweden. Most of the capacity is located in the northern half of the country.

The Swedish production data at ENTSO-E were in complete before 2022. The SE4 time series for 2022 gives an impression of the system (table 2).

Complete		Max		Load-	Min	
	GWh	MW	Date	factor	MW	Date
2022_se4_onshore	2.511	1.687	29.01.2022	36%	19	18.04.2022
2022_se4_load	11.661	4.218	20.01.2022	66%	1.495	06.06.2022
2022_se4_hydrores	766	286	17.02.2022	64%	22	17.06.2022
2022_se4_fossil gas	2	190	09.02.2022	0%	0	01.01.2022
2022_se4_other	889	620	16.03.2022	34%	61	17.06.2022
2022_se4_solar	150	662	08.05.2022	5%	0	01.01.2022

Table 2 - Wind power is the main production source in SE4

Spot price variations depend on location of technical limitations

The national transmission system operator (TSO), Svenska Kraftnät, must perform a series of technical analyses in the day-ahead-planning in order to make sure that the system is

operated safely. It is relatively simple to check if any part of the grid would be overloaded in case of the sudden loss of a component (an N-1 event). It is more complicated to check if there are sufficient resources available for maintaining minimum voltages and system stability during N-1 events.

The lack of heavy rotating units in SE4 makes this area particularly vulnerable to disturbing events in the grid. Therefore, Svenska Kraftnät must set safe limits for the transfer capabilities. It means that crucial power lines cannot be fully utilized.

If the international links from SE4 have more capacity than the border between SE3 and SE4 or any other place within Sweden, then price differences will move to local borders and SE4 will "import German prices". Therefore, decisions on new interconnectors should be kept back until the local grids have been sufficiently reinforced. This is not only a matter of building new lines. The missing stabilizing properties of large rotating power stations can be replaced by other rotating units (synchronous compensators) and by static units (STATCOM).

The national long-term plans should consider the balance between the strength of the internal grid and the capacity of interconnections in order to minimize internal price differences.


Göteborgs-Posten 05:00 - 24 jun, 2022

Karin Pihl: Orimligt att svenska hushåll ska betala tyska elpriser

Ledare • Svenska konsumenter kan inte påverka vilken energipolitik som förs i övriga EU. Ändå drabbas vi av andra länders usla val. Det måste bli ändring på det.

Fig. 6 - "Unfair that Swedish households must pay German electricity prices"

There would not be price differences in a European grid without bottlenecks. This ideal is neither realistic nor desirable. Bottlenecks and price differences are unavoidable, but they can be influenced in the long-term grid planning.

Some people think that the electricity market is to blame, but it works as intended. If market rules are adjusted to solve the problems, it will affect the efficiency of the international electricity markets.

From technical to political power system planning[1]

Sweden used to have a robust and well balanced power system. A comparison of main figures in 1990 and 2021 shows some essential changes. In 1990, the nuclear capacity was well distributed in the southern half of Sweden. Most of the hydropower capacity was located in the northern part of the country. The 400 kV transmission system was suitably designed for the transport needs at the time (table 3).

Sweden	1990	2021
	GWh	GWh
Hydro	71459	74200
Wind	4	26672
Nuclear	65250	51708
Other	2374	8950
Total prod	139087	161530
Load	140390	139684

Table 3 - 1990 data from Nordel annual report 1990. The production data for 2021 may be incomplete.

The electricity market was developed after 1990.

The regional price differences in 2021 indicate a disharmony between production and transmission systems. What went wrong?

[1] The situation in Sweden mentioned in previous notes published on 22 October 2020 and 13 May 2019

The gross consumption in 2021 was about the same as in 1990. Swedish electricity production had and has a low emission of CO_2 compared with most other countries. 12 GW wind power was added, mainly in the northern part of Sweden. Why?

The result is increased transport from north to south. It takes more transmission capacity to move wind energy than for instance nuclear energy due to the much lower capacity factor. It takes several years to get the necessary permissions for a new transmission line. This is an important constraint in the planning process. The commission of new wind power should depend on the existence of the necessary transmission capacity. The wind power was installed without the necessary upgrade of the transmission system. Why?

Six nuclear units have been decommissioned: Barsebäck 1 and 2 (1999 and 2005), Oskarshamn 1 and 2 (2017 and 2016) and Ringhals 1 and 2 (2020 and 2019). Why?

We do not know the planning procedures. Our Swedish colleagues are no doubt as brilliant as they always were, but they may be less influential. There may be good reasons for the development. Answers to the following questions might help us to understand:

- What was the purpose of installing 12 GW wind power? The wind energy production in 2021 had the same magnitude as the Swedish electricity export. Was wind power built for electricity export?
- Was the installation of wind power coordinated with the planning of the transmission system and why not?