At the end of 2022:

European Energy Markets are Challenged

Europe prepares for rotating blackouts

A series of stable years caused European countries to neglect the need for fuel reserves, dispatchable backup capacity and diversified international sources of fuel. Lessons learned during the oil crises in the 197s are forgotten. Other goals have become more important than security of supply.

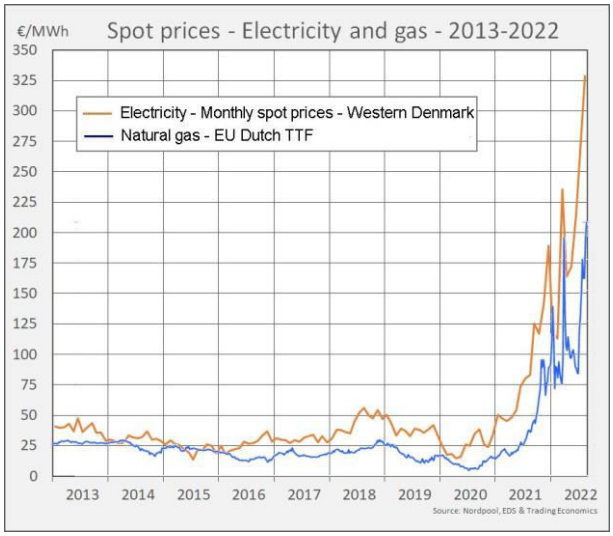

Fig. 1 - Low energy prices in 2020 were the first indicators of market instability.

It is easy to blame external events such as the war in Ukraine for the change, but the war did not break out until February 2022. Nobody has admitted to have ignored the need for reserves.

Energy systems do usually have reserves for normal annual variations. Larger reserves might be desirable to prevent extreme prices and power cuts after unexpected market changes.

The price volatility can be seen as an early warning of supply problems. Several European countries are preparing procedures for rotating blackouts, which may become necessary under extreme conditions during the upcoming winter.

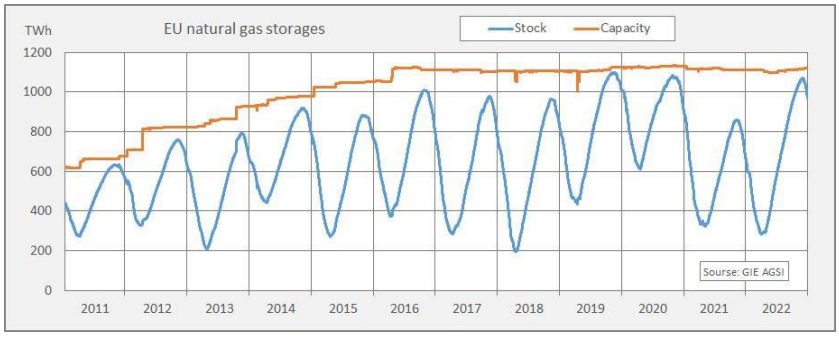

Fig. 2 - Full European gas storages prior to the winter 2022-23

Are the European natural gas storages sufficient?

The EU-countries succeeded in filling their gas storages in 2022 from other sources than Russia. The combined storage capacity is 24% of the annual consumption. This is not impressive when the dependence of single fuel suppliers is high. The total EU consumption of natural gas was 4229 TWh in 2020 (Eurostat).

Europe's dependence om Russian gas has increased from 24% in 2010 to 30% in 2020[1].

Gas storage capacities are very unevenly distributed among the EU countries. The storage capacity may depend on natural local conditions or on economy.

The UK closed its Rough gas storage in 2017 because expensive maintenance works were necessary. In 2022, the facility was partly reopened. UK's gas storage capacity was thereby increased by about 50%, but is still low.

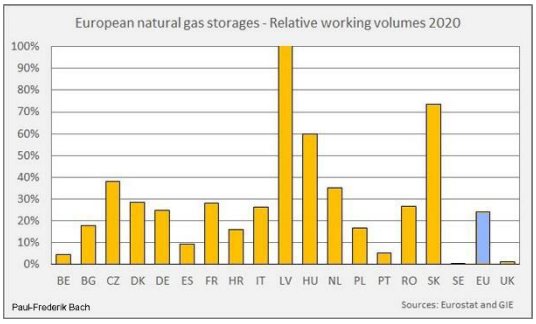

Fig. 3 - Very different gas storage capacities

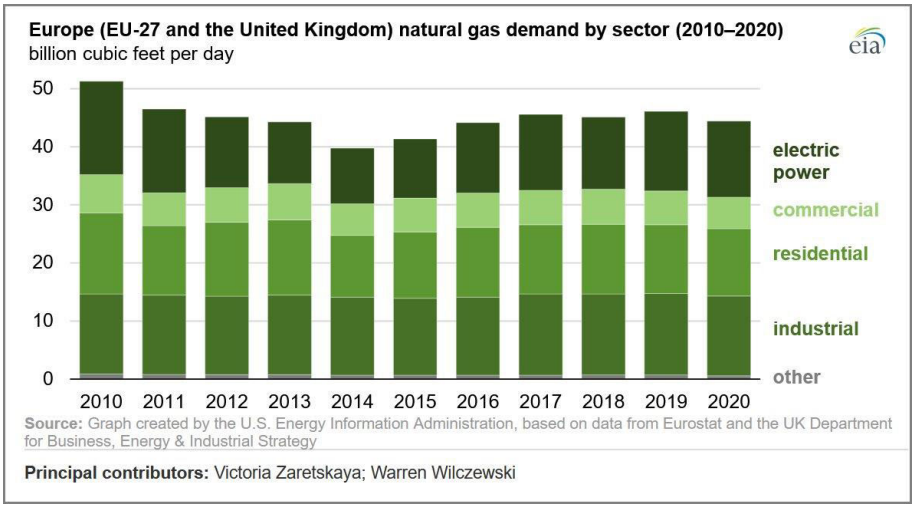

Fig. 4 - About a third of the gas was used for electricity in EU27 and the UK

Europe needs dispatchable generation

Wind turbines and solar panels cannot be dispatched and they cannot store energy. It is obvious that it is becoming increasingly difficult to balance the combined European power systems.

There are plans for adding flexible consumption (P2X). The theoretical idea is to use surplus wind energy for fuel production on P2X facilities. The fuel will be available for the generation of electricity during calm periods. This chain will require large investments and have a low utilisation and a very low efficiency. Such projects will probably never keep up with the need for balancing capacity.

The result will be that a large part of additional wind power must be exported to neighbours, who often will be in the same situation. The result is very low or negative prices. Traditional thermal power stations are gradually being closed down due to decreasing utilisation. Therefore, the share of dispatchable capacity will shrink unless this segment is paid for being standby for wind and solar power. This would add considerably to the cost of wind and solar energy.

[1] Source: EIA, the U.S. Energy Information Administration

There is a risk that reduced carbon emission will be achieved at the cost of security of supply and reasonable consumer prices. Therefore, it is important to balance the development of carbon free generation and balancing measures.

Swedish U-turn in favour of nuclear power

Sweden used to have 12 nuclear units in the southern part of the country. The generation was typically 45% hydro, 45% nuclear and 10% CHP.

6 of the 12 nuclear units have been decommissioned and replaced by wind power, mainly in the northern part of the country. In 2018, the energy distribution was 39% hydro, 41% nuclear, 10% wind and 10% CHP[2].

This trend has together with an increasing export from the southern part of Sweden increased the electricity transport from north to south in Sweden (fig. 5).

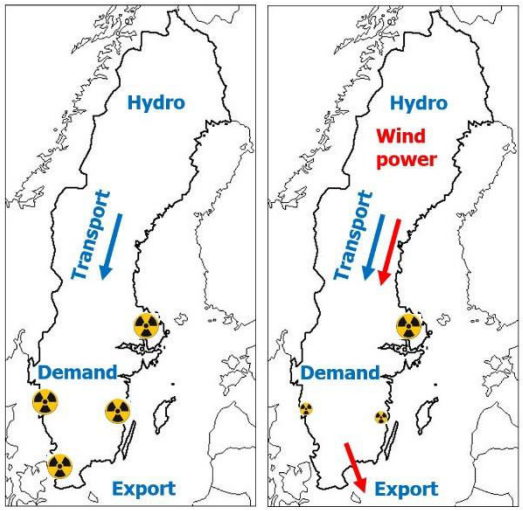

Fig. 5 – Swedish electricity before and now

From 2021 spot prices of electricity in the four Swedish price zones began to move apart with low prices to the north and high prices in the southern zones (fig. 5). The price differences were created by bottlenecks in the Swedish grid, which had not been sufficiently reinforced for the new transport pattern.

It caused great commotion and a widespread feeling that something was terribly wrong in Swedish electricity supply.

The new Swedish government is based on an agreement, the Tidö agreement, issued on 14 October 2022. According to the agreement, restoring a functioning electricity system is the most urgent public matter in Sweden.

Among the decisions are:

- Government credit guarantees for investments in nuclear power
- New rules must be introduced that prevent politics from arbitrarily shutting down nuclear power plants
- An investigation into the restart of the Ringhals Nuclear Power Plants 1 and 2
- Better conditions for hydropower and cogeneration
- The ban on restarting closed reactors must be removed.

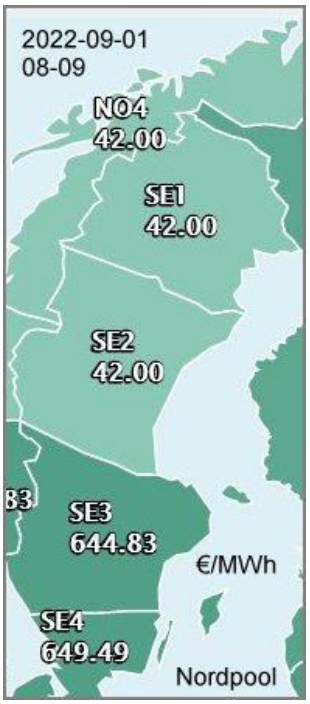

Fig. 6 - A divided market

The intention is to contribute to achieving the Swedish climate goal of net zero emissions in 2045 and to restore stable and low electricity prices.

[2] Energy in Sweden 2020. An overview. Swedish Energy Agency

Increased price level in Southern Norway due to new interconnections

NO2 is one of Norway's important areas for hydro generation, storage and international links. There are local transmission lines to NO1 and NO5, and the following international HVDC links:

- The Skagerak links to Denmark: 0.5 + 0.35 + 0.7 GW - 1977, 1993 and 2015
- The NordNed link to the Netherlands: 0.7 GW - 2008
- The NordLink to Germany: 1.4 GW – May 2021
- The North Sea Link to England: 1.4 GW – October 2021

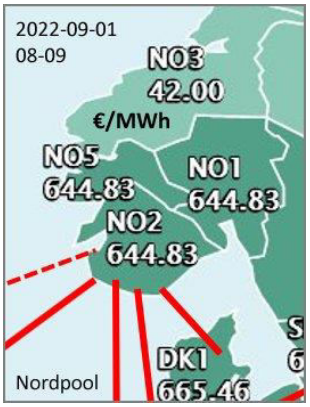

Fig. 7 – Grid bottlenecks have moved northwards

The HVDC interconnections used to be "natural" bottlenecks, which protected the Norwegian price zones against continental wholesale prices. The new links to Germany and England have changed the situation and the price areas NO1, NO2 and NO5 have adopted continental price levels.

Norwegian consumers depend heavily on electricity for direct heating and transport. Therefore, the price increase has caused considerable consternation in the regions concerned.

As a consequence, the planned 1.4 GW NorthConnect link to Scotland was placed on hold by the Norwegian government.

Norway has a large hydro storage capacity. The maximum content is about 65% of the annual national electricity consumption.

The inflow of water to the hydro systems vary considerably from year to year. There are years with surplus of energy and years with deficit. Export of electricity has reduced spillage of water and import has prevented shortage.

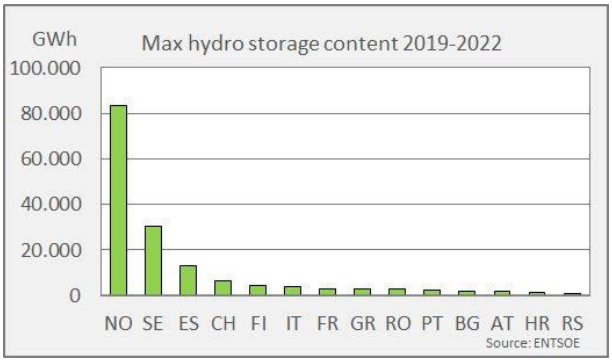

Fig. 8 - Norway has more than half the total European hydro storage capacity

The total European hydro storage capacity is about 160 TWh. The total EU gas storage capacity is 1,012 TWh. By generating electricity from gas, the conversion losses can be 40% to 60% depending on method. The total EU electricity generation was 2,664 TWh in 2020 (Eurostat).

Germany's single price market has distorted the price signals

German energy policy is a main reason for the European energy crisis. Germany is decommissioning its entire nuclear fleet (fig. 9). At the same time, Germany has made itself depending on natural gas from Russia.

Germany has replaced the dispatchable nuclear capacity by fluctuating wind power in the northern part of the country. The result is an additional flow of electricity from north to south. The flow frequently exceeds the capacity of the transmission grid and creates bottlenecks.

It is important for Germany to have the same spot price for all parts of the country. This attitude prevents the use of price zones for controlling the flows. Redispatch is an alternative method, which allocates payments to market participants for changed trading plans.

It has cause some public attention in Denmark that Germany pays Danish wind turbines for stopping during windy oeriods.

With two or more price zones the electricity market could give German market participants price signals for a correct allocation of the energy resources. It would give higher spot prices in the shortage areas in south and lower prices for the surplus areas in the north.

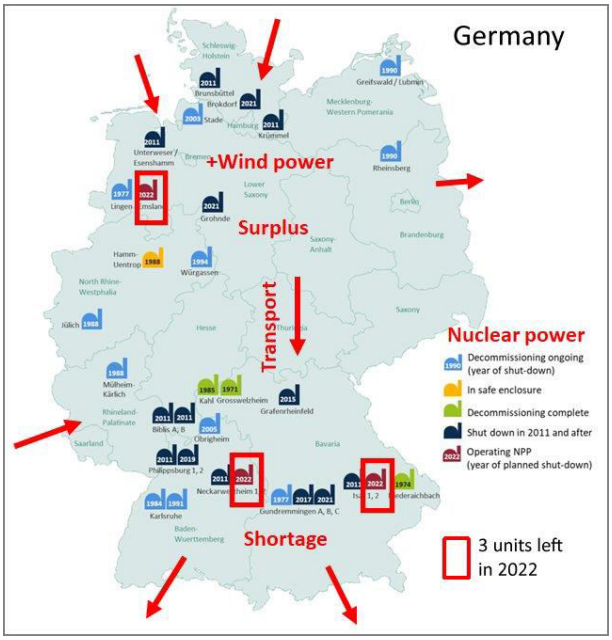

Fig. 9 - German grids stressed by wind power and transit

It would give enterprises incentives to locate new activities in the north. Besides, Germany's Nordic neighbours would see a lower price level.

Large HVDC schemes are under construction for eliminating he bottlenecks. However, it is difficult to build transmission lines in densely populated areas, and it can take one or two decades. The transmission capacity seem always to be behind the need for transport.

French nuclear problems contribute to European energy shortage

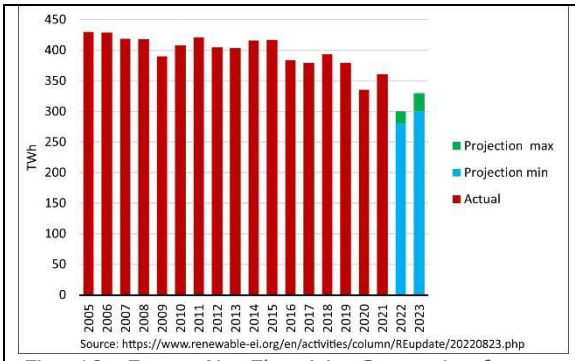

Fig. 10 - France Net Electricity Generation from Nuclear Power 2005-2023

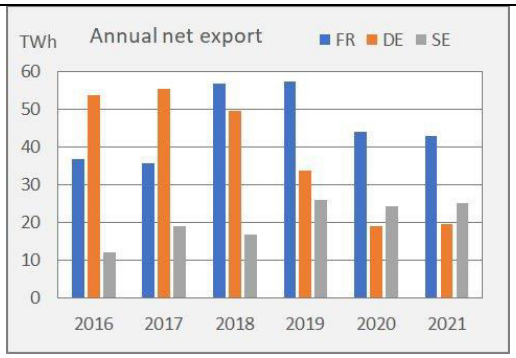

Fig. 11 - The three big European power houses expect further reduction of their export volume

The French nuclear generation has been decreasing for several years (fig. 10). The output in 2022 is expected to be 60 TWh lower than in the previous year.

Main reasons[3]:

1. The "Grand Carénage", a program focusing on safety upgrades and reactor lifetime extensions taking place from 2014 to 2025
2. The COVID-19 pandemic has derailed the maintenance of reactors which is usually tuned like clockwork
3. Discoveries of cracks in pipes resulting from stress corrosion have led to the temporary shutdowns of 12 reactors of the most recent reactors for inspections
4. Unfavourably dry and warm weather conditions make it more complicated to cool reactors which must either reduce their output or temporary shut down
5. The endless delays to start operating Flamanville-3 under construction since 2007 results in a lack of 1,630 MW

France, Germany and Sweden are the largest exporters of electricity in Europe. They have different challenges as mentioned above. As a result, Europe is facing energy shortage. It may take several years to restore the necessary storage, backup and balancing facilities.

ENTSO-E: Highest risk of power cuts in Germany and Denmark

ENTSO-E, the European association for the cooperation of transmission system operators, has analysed the security of supply in its European Resource Adequacy Assessment, 2022 Edition (ERAA).

This edition analyses the years 2025, 2027 and 2030. The results of the statistical calculations are presented as LOLE (Loss of load expectation, hours per year).

In the 2027 results (fig. 12), the highest risks of power cuts are found for Germany, Luxembourg and West Denmark.

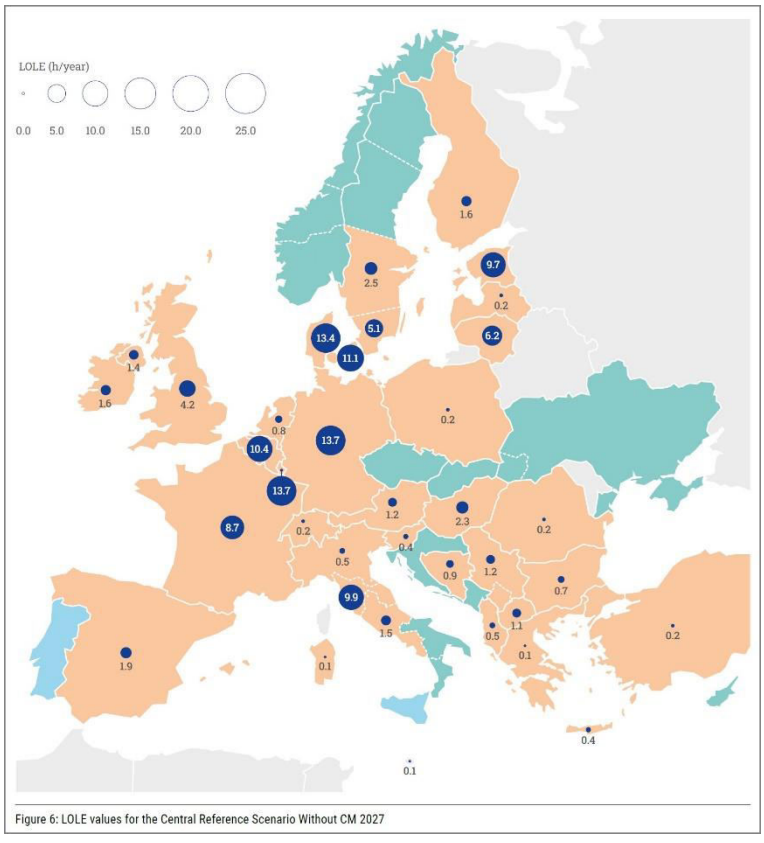

Fig. 12 - In 2027, the expected outage time is 13.7 hours in Germany

The Danish system operator, Energinet, explains that the high risk in 2027 is due to increased electricity demand, i.e. for power-to-X, but that the Economic Viability Assessment (EVA) indicates that new OCGT and CCGT capacity could add new reserves between 2027 and 2030.

[3] Source: https://www.renewable-ei.org/en/activities/column/REupdate/20220823.php