

Nordic and Baltic Sea Winter Power Balance 2022–2023

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Regional adequacy working group under
Baltic Sea System Development Steering Committee

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Executive summary



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Executive summary

Main messages

- The Nordic and Baltic Sea region will experience one of the most challenging winters in recent history due to several unfavourable conditions in the European energy markets.
 - The war in Ukraine is causing a lot of uncertainties in the electricity, gas, and coal markets as imports from Russia have been reduced or ended.
 - Long drought during the summer in Europe has left hydro reservoir levels lower than usual before the winter.
- Nordic and Baltic Sea region sees positive power balances for both average and cold winter, however, the margins are small (3...8%) with many uncertainties. The uncertainties are linked in the availability of electricity generation with gas, nuclear, hydro and wind, which could change the balance significantly.
 - Even though the regional balance is positive, the excess is not distributed evenly between the countries. It calls for good coordination between system operators and high availability of the transfer capacities between the zones to deliver the energy to where it is most needed.
 - If uncertainties take place, price areas might need to activate TSOs' reserves to avoid demand curtailment. An analysis of this resolution does not identify the need for demand curtailment, but it is not impossible, and TSOs are informing the public and making contingencies to be prepared for it.
- Regardless of electricity adequacy, it is expected that the electricity prices will be high throughout the winter due to limited supply of different fuels and general uncertainty in the energy markets. Therefore, it is beneficial for every consumer to analyse their electricity use, which also helps with the electricity adequacy.
 - Currently around 5% of the electricity use in the region is price sensitive i.e. consumers lower their electricity use at certain price levels. Enabling more flexibility in the demand sector lowers prices and helps with the adequacy of electricity.
- An energy balance was analysed on a regional level for two separate cases – an average winter consumption and the coldest projected winter's consumption. In these cases, the Nordic and Baltic Sea region reaches an electricity demand of around 620 and 646 TWh, respectively.
 - It is expected that around 70...75% of this could be generated from energy sources that do not have any issues with fuel supply. Remaining 25...30% would need to be generated from coal, lignite, or gas. Based on current analysis of fuel supply this can be covered.
 - Wind power and hydro contribute the most to the energy balance during both average and coldest winter. This helps to conserve a lot of fossil fuels like coal, lignite and gas, which can be used during times with low renewable production.

Risk mitigation actions

What is being done to lower the risks?

Short term

- Several communication campaigns are ongoing which will inform the public of the awaiting challenges; guides on how to save energy and lower energy bills; how to act during crisis etc.
- Electricity saving measures are being implemented. A mandatory 5% reduction in peak hours and additional voluntary target of 10% reduction for overall electricity consumption will be implemented in all Member States.
- Contingency plans during gas shortage and/or electricity shortage are developed, rehearsed and improved.
- Decommissioning plans are being reviewed.
- The transmission system operators are closely monitoring all the developments in the electricity system. Security of supply analyses for gas and electricity are made on a European level together with ENTSO-E and ENTSO-G. The system operators are also doing analyses on a regional and country level to identify risks before they occur.
 - Insights from these will be shared with the public and market participants in the form of press releases, webinars, published analyses, interviews and social media.
- Different support schemes are implemented to help the energy consumers with their bills.
- Preparations of administrative actions in the energy market to save fuel or redistribute it if the need arises.

Long term

- The dependence from Russia in the energy sector is being decreased. The Baltics are preparing for desynchronization from the Russian grid. Fuel supply chains are being diversified. Overall assessment of supply chains is taking place.
- Coordination between TSOs on unit outages is being developed.
- More ambitious plans on RES deployment and grid reinforcements are developed to manage new distributed energy sources.
- Flexibility markets are being developed and matured.

Situation description

What are the main causes of current challenges in the European energy system?

- The energy markets in Europe are experiencing unforeseen challenges in the form of rapid price increase for most energy carriers and major uncertainties on adequacy of fuels and electricity. These are mainly caused by three simultaneous troublesome events: war, drought, and extensive maintenances due to aging of thermal power plants.
- Russia invaded Ukraine on the 24th of February 2022. As a response to the aggression the EU Member States have agreed to sanction the energy imports from Russia, to cut off an important source of income for Russia.
- During previous years, Europe had relied on Russia for about 40 % of its natural gas supply. The supply is now reduced and is considered unreliable. The situation is complex and reducing the reliance of Russian energy imports requires alternative fuel supply chains, which may take years to set up. The reduced supply and little elasticity of demand for gas have significantly increased the natural gas prices around Europe, for example the natural gas price on the Dutch TTF market in August 2020 was 11 €/MWh, in August 2021 it was 50 €/MWh, in August 2022 it reached 349 €/MWh, but has since lowered to 169 €/MWh as of 3rd October 2022.
- In addition to different fuels, the Baltics and Nordics were also importing around 7 TWh of electricity last winter from Russia, which is now completely cut-off. This reduction in imported electricity and shortage of fuels directly affects the electricity prices in Europe, which has reached the market cap twice during the last 6 months. Electricity is also essential for the industrial sector, meaning that the price of electricity is also one of the main drivers of inflation in Europe.
- In addition, the effects of climate change are becoming more evident, as Europe is experiencing the biggest drought in 500 years, which reduces hydro electricity generation and further complicates the transporting of energy carriers like coal. Some rivers have dangerously low water levels, which makes ship transportation harder.
- At the end of 2021, it was discovered that many French nuclear reactors have corrosion in the piping, which meant that a systemic inspection must be conducted for the power plants. Around half of the French nuclear fleet is offline for maintenance and it is still unclear when it will be back on the market.
- All these events combined are seriously challenging the European power market.

Situation description

How does it affect the Nordics and the Baltic Sea area countries?

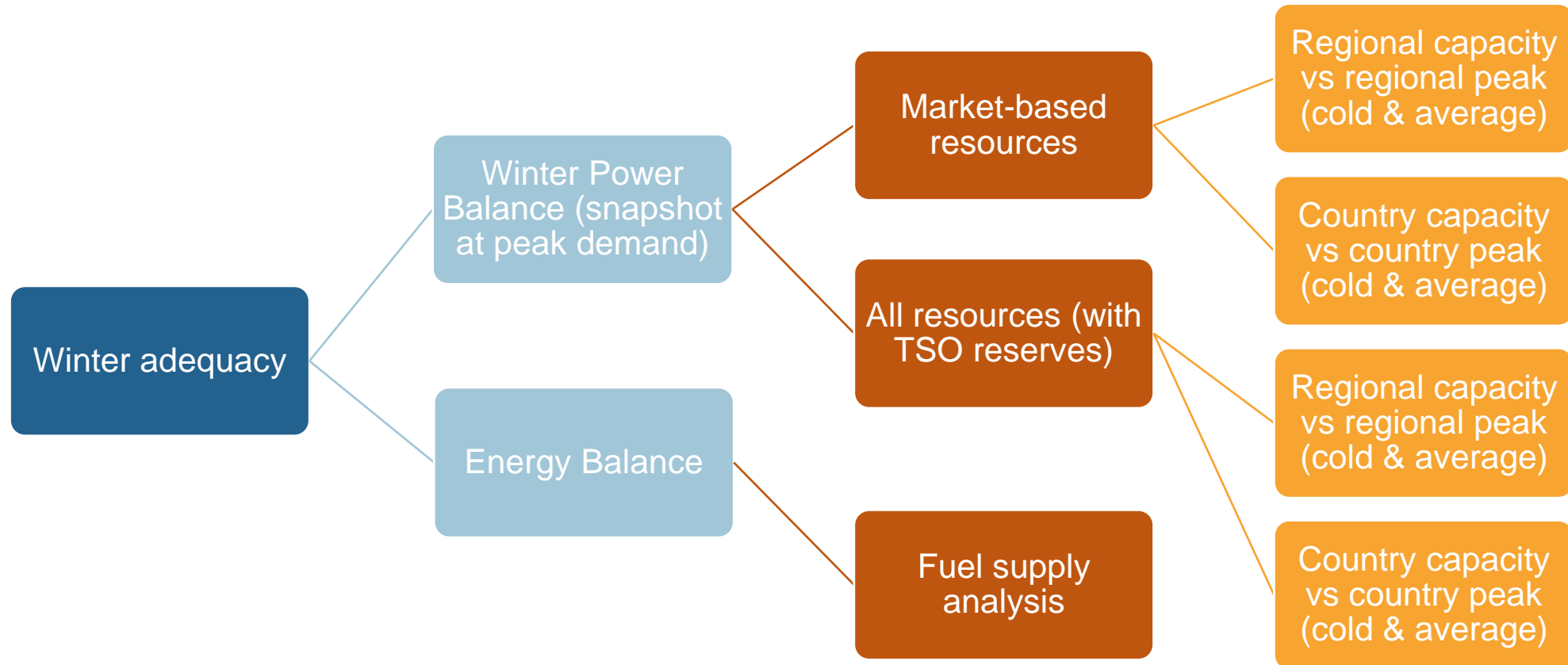
In addition to the system-wide challenges the Nordic and Baltic Sea area system operators have identified several local vulnerabilities, which are related to the electricity system specifics of each country:

- The Baltic States: Estonia, Latvia, and Lithuania, have been preparing to disconnect from the IPS/UPS (Russian) electricity system and connect to the Central European electricity system for several years now. According to the initial timeline synchronous work with central-EU should be achieved by 2026, however, considering the current geopolitical situation the risks of being disconnected from the Russian system before 2026 have significantly increased. The Baltics' system operators with many partners have prepared for an emergency disconnection and are able to synchronize with the Central European system within hours if the need arises. The synchronization project, however, still has many other important milestones and new equipment to be installed that would ensure a long-term safe operation. In addition, due to substantial installed capacity in gas-fired power plants, secure operation of the Baltic power system depends on improving diversification of natural gas supply routes.
- In the southern part of Norway, the reservoir levels for hydro are very low due to an extraordinarily dry previous winter and summer. Together with the overall energy crunch in Europe puts Norway in a position where production from hydro reservoirs needs to be reduced to be sure to handle security of supply in case of a long cold winter with reduced inflow and import possibilities. For Norway, the most critical time horizon is not winter, but the spring when the temperatures are still low, and snow has not yet melted because then the water levels are at its lowest. The situation is carefully monitored by the system operator and national authorities.
- In Germany, coal-fired reserve power plants have been permitted to return to the market and coal-fired power plants that are planned to be shut down in the next few months can be kept in the market with the aim to reduce the gas demand for electricity generation. In Germany, the operation of the three remaining nuclear power plants Emsland, Isar 2 and Neckarwestheim 2, which were otherwise due to be decommissioned by end of 2022, shall be extended until April 15, 2023. The most critical concern for Poland is the shortage of coal. 87% of the total thermal capacity is using either coal or lignite for fuel. Currently the coal storage facilities of power plants have reached low fuel stockpiles and coal import from Russia has ended, resulting in decreased resupply. Poland also has domestic coal production, but it is not enough to cover the missing supply and increasing production takes time, longer than what is left until winter.
- Finland, like other countries bordering Russia, had a notable import of natural gas and electricity from Russia. Both imports have been cut off in May 2022, weakening gas and electricity supply. Fortunately, Olkiluoto 3 nuclear power plant is in test production phase and the regular electricity production is scheduled to start on 14th of December. The gas import by pipeline is replaced by leasing a floating LNG terminal with a regasification capability. There is on-going construction of port structures for the terminal both in Finland and Estonia to secure the gas supply.

Analysis methodology

Methodology

Adequacy of electricity is analysed with a power & energy balances



Methodology: Power balance

Can the peak demand of the winter be covered with available resources?

- Deterministic approach assesses power balance (domestic generation – domestic consumption) of the expected annual peak demand hour for the upcoming winter in the Nordic and Baltic Sea countries. The highest peak demand usually occurs in January
 - Focus is on Nordic and Baltic Sea region, which comprises of Norway, Sweden, Finland, Denmark, Germany, Poland, Estonia, Latvia and Lithuania.
 - Normal conditions refer to an expected (median) peak demand during winter months for each country. Severe conditions refer to a highest expected peak demand for each country (using 95th percentile or equivalent method).
 - Information about the available generation capacity of the upcoming winter was gathered by ENTSO-E in the end of September. TSO-s are analyzing how much of the available capacity can contribute to covering of the demand peak. No interconnectors or imports are included in the quantitative analysis, but these are considered qualitatively
 - This analysis is using the same input data as the probabilistic, ENTSO-E Winter Outlook 2022-2023. Both are using the PEMMDB (Pan-European Market Modelling Database) for input data.

Methodology: Power balance

Can the peak demand of the winter be covered with available resources?

Production

- Net generation capacity is based on each TSOs data, which has also been submitted to the ENTSO-E Winter Outlook analysis
 - Generation capacity is separated into market-based and all resources (including non-market-based resources such as strategic reserves or balancing reserves). The approach of all resources quantifies what is the capacity at TSOs disposal before resorting to demand curtailment due to adequacy problems.
- Available generation capacity during peak demand period in January has been assessed for the analysis, which considers:
 - Planned unavailability of generation units
 - Country-specific availability of thermal and hydro generation is based on each TSOs estimates
 - Region-specific availability of wind generation is based on regional analysis conducted by the TSO experts. Availability of wind generation is set to 11% for each country, which reflects the lowest 5th percentile of wind generation in the region during January-February according to Pan-European Climate Database data
 - Availability of solar generation is assumed to be 0% for each country
 - Average availability of weather-dependent other non-RES and other RES generation in January based on PEMMDB.

Consumption

- Peak demand of each country is based on ENTSO-E Winter Outlook demand data, which considers interdependent climate data and is adjusted according to expectations of the upcoming winter season
 - Average winter power balance considers expected peak demand. P50 peak demand is the 50th percentile i.e. median of annual peak demand over the 35 climate years
 - Cold winter power balance considers highest expected peak demand. This peak demand is the third highest peak demand over the 35 climate years and roughly equals to the “coldest 1 of 10 winters” scenario from the previous Winter Power Balance reports.
 - Simultaneous regional peak demand is the highest same-time peak for all countries for one climate-year. This is always lower than sum of separate peak demand per country and is mainly driven by countries with high demand.
- Price-sensitive demand or demand side response has been highlighted in the „all resources“ scenario
 - During high-price periods, the price elasticity of consumption might reduce the peak demand compared to the presented values. The extent of this is not seen in the map but is seen highlighted in the regional „all resources“ graphs.

Methodology: Energy balance

How much electricity can be produced from sources without fuel supply issues?

- Based on weather conditions the winters might be significantly different from the system adequacy viewpoint.
- In this analysis two scenarios are chosen- winter with an average consumption and the winter with the highest overall electricity consumption
 - For the Baltic Sea region these values are 620 TWh and 646 TWh respectively during October until April.
- Corresponding available resources were analyzed by creating a simplified merit order based on whether there are strong indicators of shortage of such a fuel on the market or not. The last fuels in the merit order are gas, coal, and lignite, which were identified as critical.
- In this balance interconnector limits and hourly demand is not considered which simplifies the balance significantly, but still enables an overview of what sources of energy are available in the region.
- The average and cold winter were analyzed by
 - Assessing the theoretical maximum production from different sources if there would not be any shortage of fuel. This was based on known availability of power plants, their forced outage rates and availability profiles depending on the weather.
 - Considering the known restrictions of fuel supply and seeing how much critical fuel would be needed in the Baltic Sea region to cover its consumption for the winter.

Winter Power Balance 2022–2023

Regional power balances (1/2)

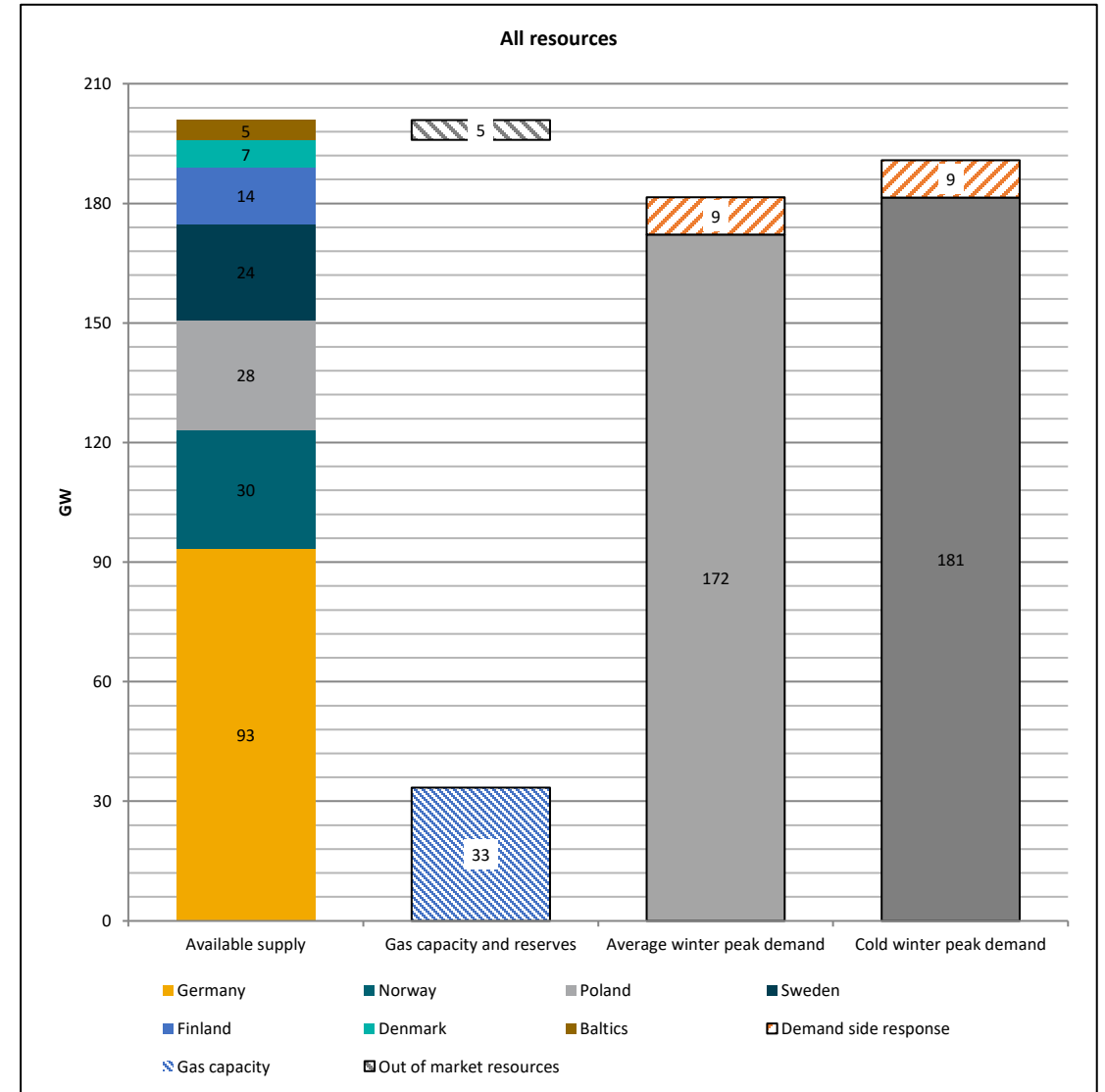
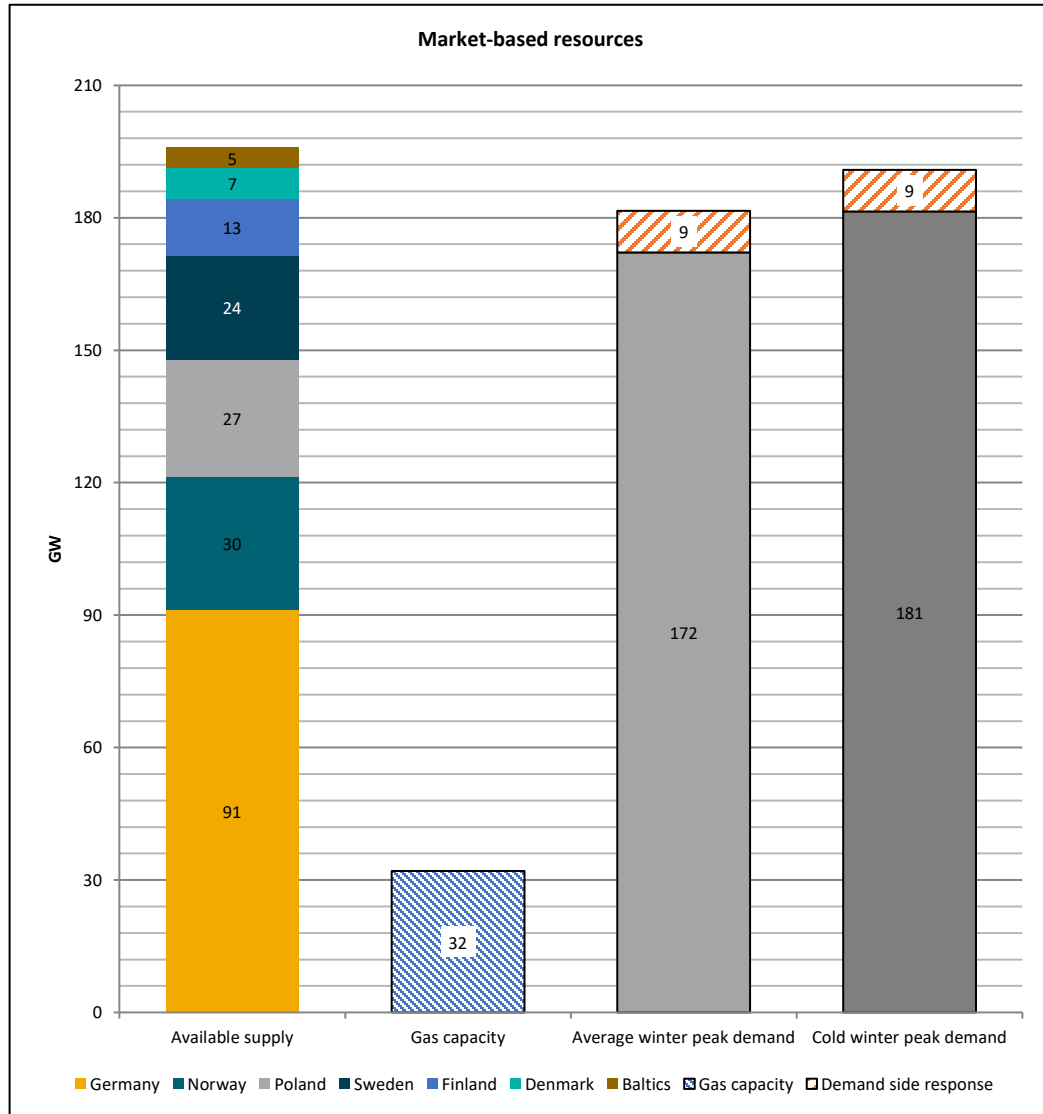
Market-based resources

- During a peak demand it is estimated that around 196 GW of market-based generation will be available in the region.
- The peak demand of the region is estimated to be 182 GW during an average winter. This makes the power balance to be positive by 14 GW.
- The peak demand is estimated to be 191 GW during a cold winter and the power balance is positive by 5 GW.

All available resources

- In addition to the market-based resources there are also around 5 GW of non-market resources such as strategic reserves and balancing reserves. This capacity is part of the available supply but will not participate in the day-ahead electricity market.
- The activation of reserves is very situation specific- some might be activated before demand curtailment while other still need to be held to balance outages in the energy system. It comes down to operational decisions of TSOs to activate balancing reserves to cover demand.
- It is estimated that around 9 GW of demand is price sensitive during the peak hour and would lower its demand before the market cap of 4000 €/MWh. Most of the other non-market resources will only be activated if the market-based capacity is exhausted and price cap is achieved.

Regional power balances (2/2)

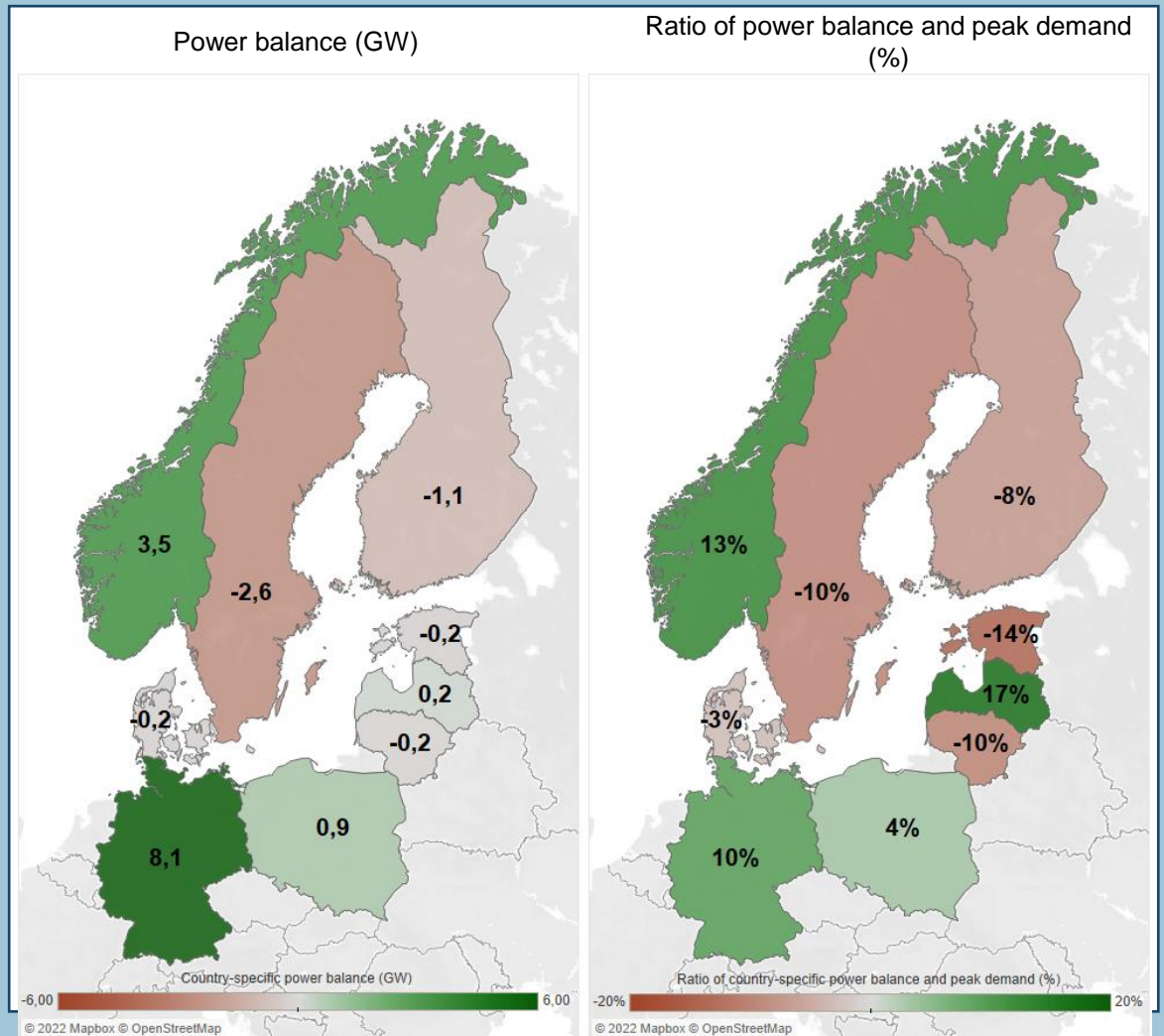


Country-specific power balances (1/2)

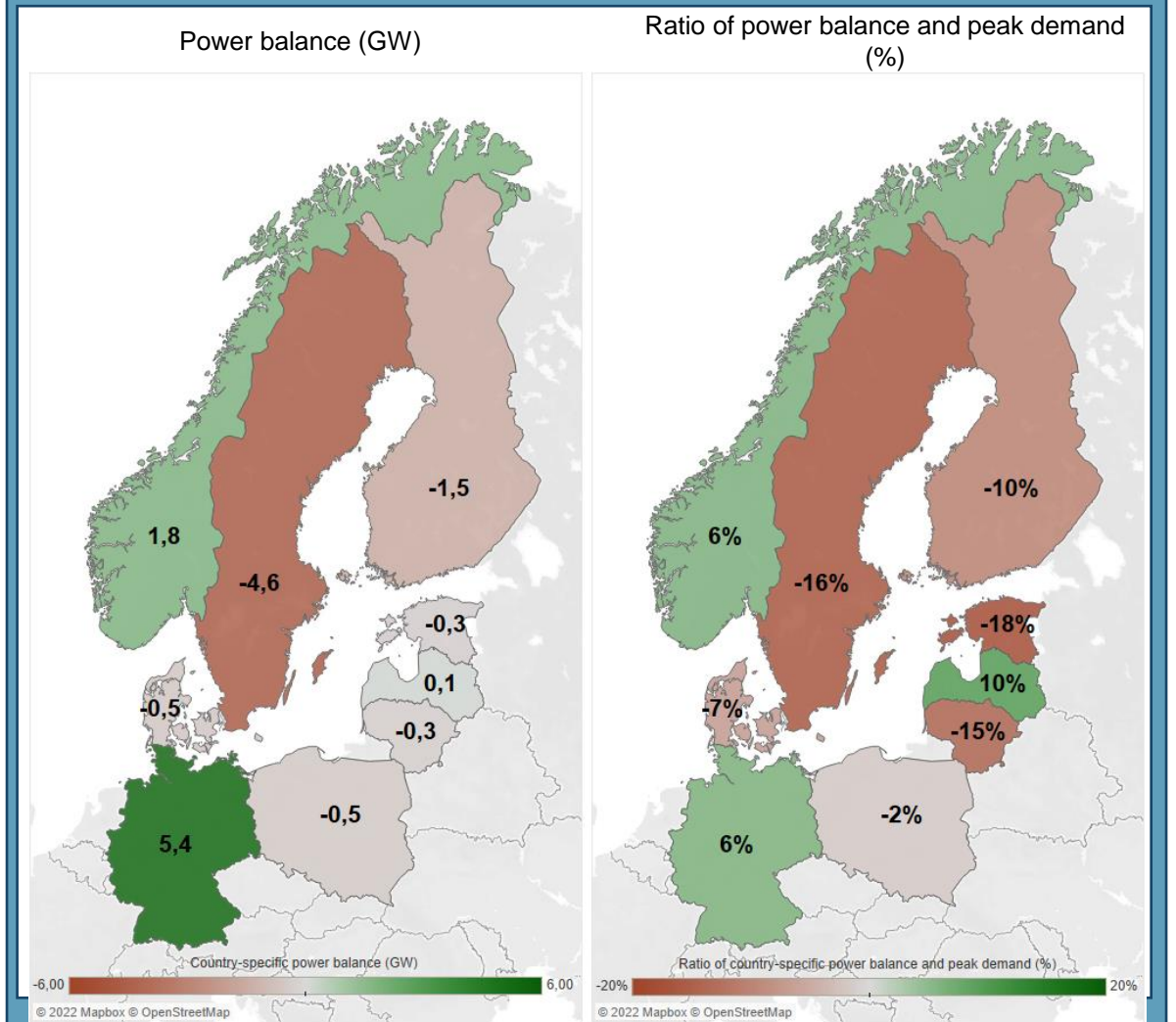
- The excess of supply that is seen from previous slide, regional balance, is distributed unevenly between the countries and it is mostly in Germany and Norway. For it to reach where it is most needed a good coordination between system operators and high availability of the transfer capacities must be ensured.
- Imports from neighboring countries can only happen if there is both available transmission capacity and a production surplus in the exporting country, something that may be limited during periods of high demand in the region. A map showing maximum transmission capacity between bidding zones can be found in the appendix.
- Based on the power balance Latvia, Germany, Norway and Poland can cover their peak demand in an average winter with their local resources.
- Latvia, Germany and Norway can also cover the cold winter peak demand locally, but other countries need to rely on imports from neighboring countries to meet the peak demands.
- It is expected that some of the demand will react to the price signals coming from the market and lower their consumption. Some countries can also activate non-market resources if market-based resources, including DSR, and import is not enough. More detailed graphs can be found in the appendix. The resolution of this analysis cannot identify whether there is a need for demand curtailment, but it is not impossible. Some TSOs have made communication campaigns towards the public to notify what steps are taken in that case.

Country-specific power balances (2/2)

Average winter peak demand



Cold winter peak demand



Reminder: These country peak demands can happen at different times and should not be summed together. The regional simultaneous peak demand is always lower than sum of individual country peak demands.

Winter energy balance 2022-2023

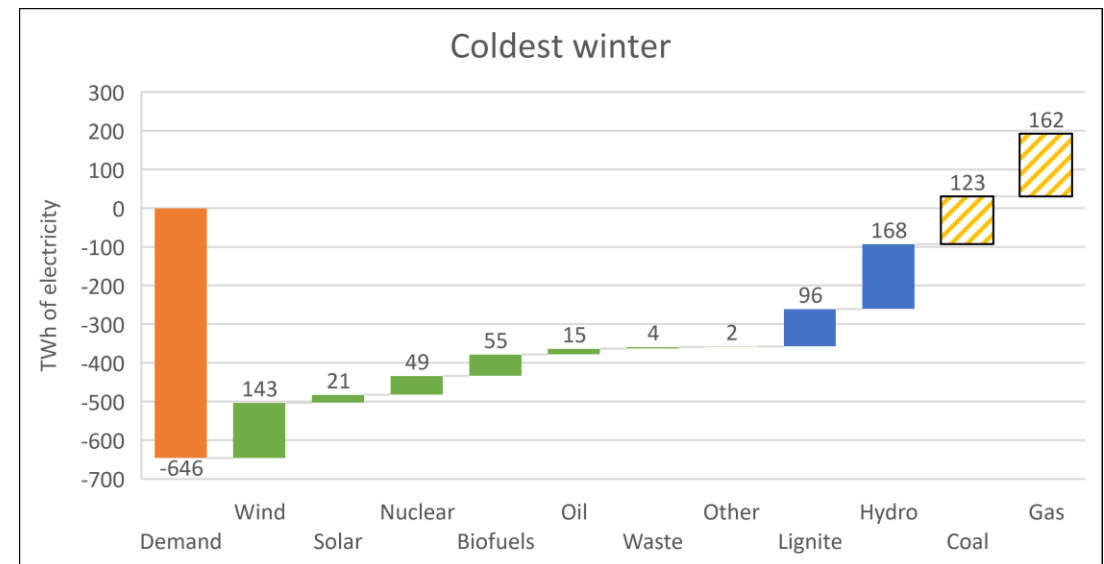
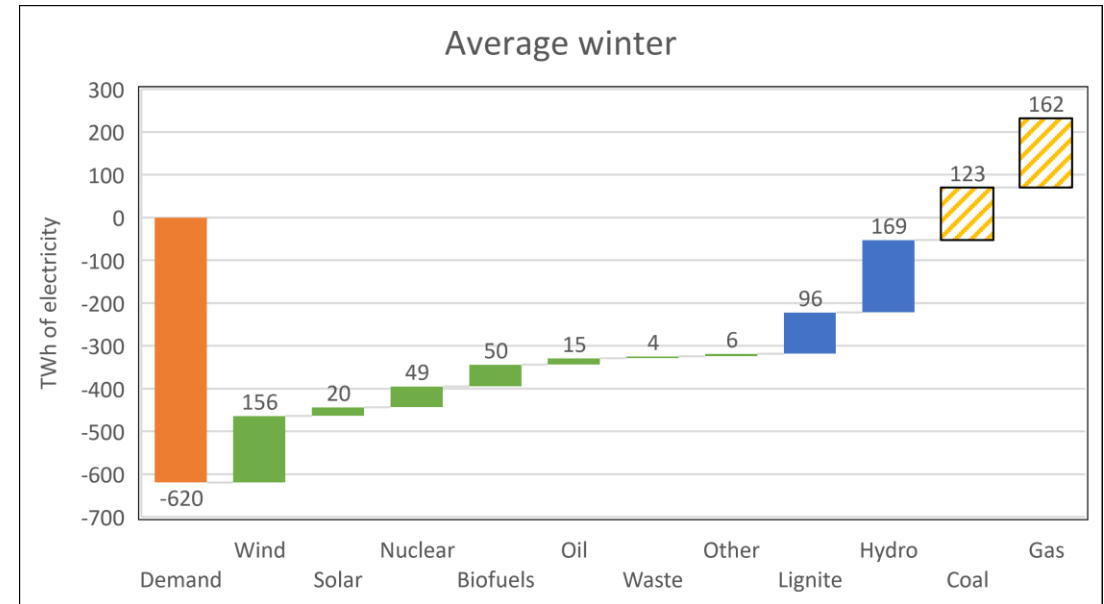
Regional energy balance based on only availabilities

Average winter

- Hydro generation would be able to produce the most energy in the region with 169 TWh, with gas generation second with 162 TWh, wind generation is third with 156 TWh. The contribution from renewables is significant and every MWh of energy produced from these sources means that fuel for dispatchable generation can be saved for times when intermittent renewables are not producing.

Coldest winter

- Significant difference from the previous climate year can be seen in the wind generation, as it produces 13 TWh less than in the other scenario.
- Generation units like CHP plants have a weather dependent electricity production. Many such plants fall under the biofuels category and have a higher availability during a colder winter- this means that 5 TWh of more electricity could be produced from biofuels.
- Thermal plants that use nuclear, oil, lignite, coal and gas have the same availability as during an average winter. Their importance increases with a cold weather as demand grows and the share of renewable sources decreases.



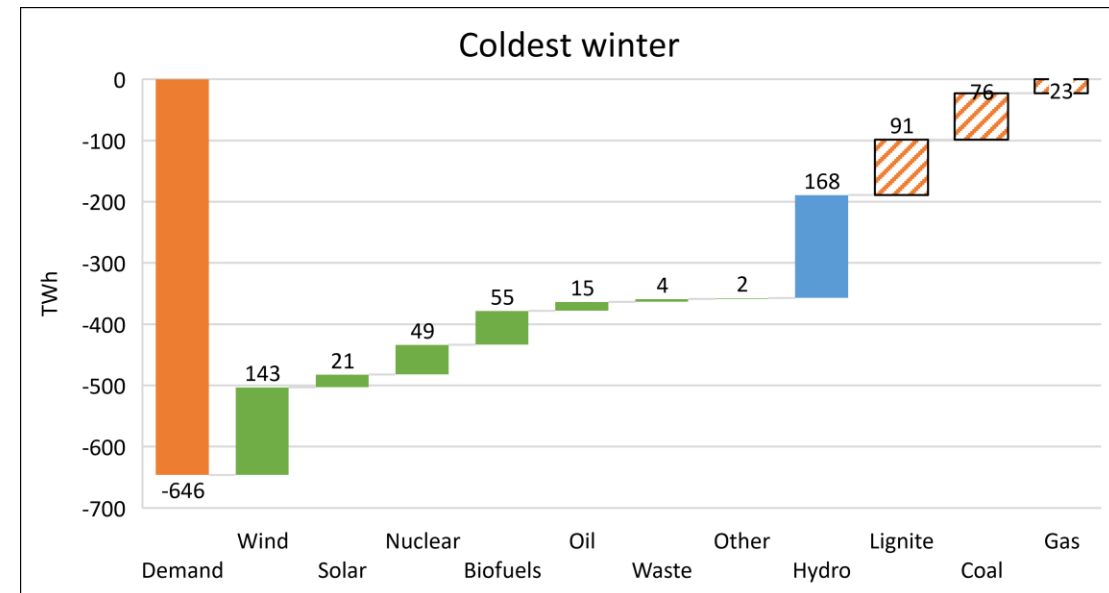
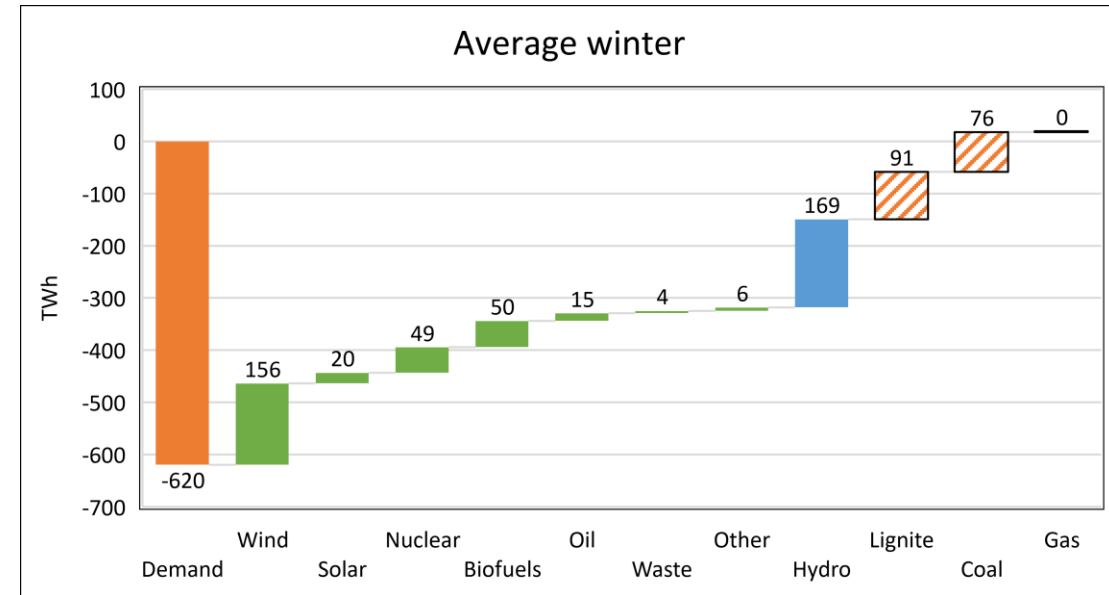
Regional energy balance considering known restrictions

Average winter

- By comparing available energy sources during winter and total consumption while taking into account known restrictions in the fuel supply for coal and lignite it can be seen that Baltic Sea area could cover all of its consumption without gas. This is a high-level overview, and an hour-by-hour dispatch would show many bottlenecks between regions and fuel availabilities.

Coldest winter

- In this case around 23 TWh of electricity is needed from gas, which translates to around 48 TWh of gas for the winter.
- For reference as of 11th October there is 291 TWh of gas stored in gas storages around the Baltic Sea area countries



Country comments

Country comments

Germany

- In Germany, coal-fired reserve power plants have been permitted to return to the market and coal-fired power plants that were planned to be shut down in the next few months can be kept in the market a little longer with the aim to reduce the gas demand for electricity generation.
- German gas power plants previously contracted as non-market resource cannot return to electricity market due to the existing legislation.
- In Germany the operation of the three remaining nuclear power plants Emsland, Isar 2 and Neckarwestheim 2, which were otherwise due to be decommissioned by end of 2022, shall be extended until April 15, 2023. The relevant legal framework shall be revised at short notice.
- The probabilistic approach of the ENTSO-E Winter Outlook is state-of-the-art. National and geographically limited analyses should also be conducted based on probabilistic methods, otherwise (e.g. using power balances) a limited and misleading view on adequacy could be shown.

Denmark

The Danish Energy Agency has imposed on Ørsted to continue and reestablish the operation of the following three power plants: Esbjergværket Blok 3, Studstrupværket Blok 4 and Kyndbyværket Blok 21.

- Esbjergværket Blok 3 were supposed to be decommissioned on March 31st in 2023 and is consequently already counted in the power balance due to the cut-off date of 1st of January.
- The two remaining power plants are currently being prepared to be recommissioned until 30th of June 2024 and Esbjergværket Blok 3 will continue operation until this date as well. However, Ørsted has not yet given a final date for when Studstrupværket Blok 4 and Kyndbyværket Blok 21 will be ready to produce - currently they are undergoing maintenance and being readied for operation as soon as possible. Consequently, their availability at the cut-off date of 1st of January is associated with some uncertainty, though as a best estimate their combined 620 MW of electricity capacity has been counted in the power- and energy balance.

Country comments

Norway

There is a worry about reservoir levels in Southern Norway for the winter. The reservoir fillings are at very low levels due to low precipitation and high export caused by high continental fuel and power prices since previous winter and up to now. Also limited transfer capacity from north to south in Norway and between Norway Sweden may have affected this situation.

Some actions are taken by Statnett and the authorities, as rising attention level to yellow. There are still no restrictions on generation and/or export, but the producers are kindly requested to save water for the coming winter. To secure the supply in case of reduced import possibilities further actions may be taken. More restrictions may be imposed by the authorities during the autumn. Recently the authorities have increased the monitoring of the generation from the major reservoir generators in Southern Norway. This is reported by Statnett. Statnett has also been instructed to work out an analysis of extremely severe situations (SAKS) which was finished within 1st October.

Under normal situations, there should be enough import capacity to cover any deficit. But if there is no generating surplus in other countries to export to Norway, there may be a problem. Rationing of demand may then be necessary in a short period before the snow melting starts in the spring. Especially if there will be low precipitation during the autumn and winter. Anyhow the high power prices are expected to lower the demand somewhat, both by customers reducing the demand and companies shutting down. And the demand is usually lower in spring than mid-winter.

Before reservoirs run empty, available generating capacity is only reduced by minor amounts due to reduced head of water etc. If the reservoirs are empty, the generating capacity will be reduced dramatically. This capacity will then not be available in the market. Hence the issue in Norway is more lack of energy or water resources during the spring, rather than an adequacy problem during the winter. In many ways this is a similar problem as gas shortage in Europe. There is a significant higher level of uncertainty of several factors important for the energy sectors in the coming months.

Sweden

Sweden's power balances show need for import during peak conditions. The power sector in Sweden is only to a very limited degree dependent on fossil fuel. However, the development in other countries may affect adequacy in Sweden, mainly relating to the availability of import.

The Swedish Energy Agency has launched an information campaign to lower demand, and routines for load shedding are rehearsed.

Northern Sweden (SE1 and SE2) have a strong surplus, while southern Sweden (SE3 and SE4) has a large power deficit. As such, transfer capacity from north to south is critical for adequacy, and very often runs at max available capacity. At times, southern Sweden is dependent on imports from other countries as well.

The nuclear reactor Ringhals 4 is currently unavailable and is not included in the power balance figures in this report. The plant is planned to return on Jan 31, but the outage period could be prolonged which would lower adequacy for the late winter.

Sweden has a strategic reserve of 562 MW, which is not included in the figures for market-based power balance.

Country comments

Finland

Fingrid has informed consumers that they should be prepared for power shortages in case of unfavourable scenarios. In typical and mild winters, the risk of power shortages is comparable to the previous years. However, there are several uncertainties that increase the risk of a power shortage. These and other notable developments affecting adequacy include:

- Schedule for the commissioning of the Olkiluoto 3 nuclear power plant. A possible delay in the commissioning of the plant would significantly reduce the adequacy of electricity in Finland.
- Availability of imports from Sweden and Estonia. In previous years during peak consumption, significant amounts of electricity have been imported from Sweden and Estonia, as well as from Russia.
- Possible failures of significant domestic power plants or electricity transmission connections in operation, as well as problems with the availability of power plant fuels, especially natural gas.
- The rapid growth in wind power capacity contributes to improving the availability of electricity in Finland, but the impact of wind power on the adequacy of electricity is determined by wind conditions.
- Energy saving and timing the use of electricity outside of peak morning/afternoon hours improves adequacy of electricity significantly. Finnish electricity use decreased by around 7 % in September 2022 compared to last year, and therefore the peak demand expectation during cold winter was decreased from around 15 100 MW to around 14 400 MW.

Estonia

We understand that to make it through these challenging times the TSO-s and other stakeholders must coordinate their efforts between each other and work together. It is important that we should coordinate outages as well as we can between TSO-s and market players to avoid another case where several major power plants are out for maintenance or outage at the same time. We see that three key things this winter are high availability of generating units and transfer capacities, coordination between countries, and flexibility of the demand sector.

The power balance for the upcoming winter is worse than previous year. Previously we expected an excess of 100 and 200 MW between supply and demand, but this year it is expected to be -200 and -300 MW. We are expecting a slight increase in demand, but the biggest difference comes from a more conservative approach to power plants' availability. During the last winter we saw two days where prices reached 650 and 1000 €/MWh, which was very high for that year, and we saw that much of the capacity that we expected to be available in the market was not. In addition, the forced outages of bigger thermal plants are more frequent than expected so that capacity is rated further.

An unexpected desynchronization from the Russian grid would mean that the gas demand would increase significantly because many power plants that use gas as a fuel will need to be held in must run regime to provide inertia to the grid.

Country comments

Latvia

TSOs of the Baltic States and Poland have prepared an emergency synchronization solution in case if this could become necessary. In addition, steps had been made to accumulate a substantial amount of gas in the Latvian Inčukalns underground gas storage necessary for the 2022/2023 heating season. But, possible unplanned desynchronization from IPS/UPS power system could lead to increased generation and reserves adequacy risks during the next winter.

In case of urgent desynchronization from IPS/UPS power system due to unexpected disconnection from Russian side there could be some problems with generation adequacy and system services. Latvian TSO is doing everything to mitigate these actions and keep secure system operation for the coming winter, but in case of urgent and unexpected desynchronization most likely we have to rely on electricity imports from neighboring countries.

Lithuania

Since the basis of traditional production in Lithuania is a few old gas-fired units, sufficiency is ensured by imports. During the winter period, similar as last winter period, the adequacy of the Lithuanian electricity system will be negative and ~200 MW of import capacity will be needed to meet the peak demand. Therefore, we see the risk that the situation in other power systems may lead to restrictions on import possibilities (cascading effect).

Poland

Current tight adequacy situation and concerns on coal and also gas supply availability makes all dispatchable generation to be very important for being able to ensure secure and adequate operation of the Polish power system. Significant reduction of coal supply will negatively affect the Polish load/generation balance and threaten security of supply.

The exact extend of potential electricity generation shortages in the winter period will depend on the situation with respect to gas supply to EU. Also, in case of significant gas shortages in Europe, affecting gas generation in a number of EU countries, we expect a change of power flows pattern across Europe (transfer capacities for the market purpose).

Appendix: Supporting illustrations of the report



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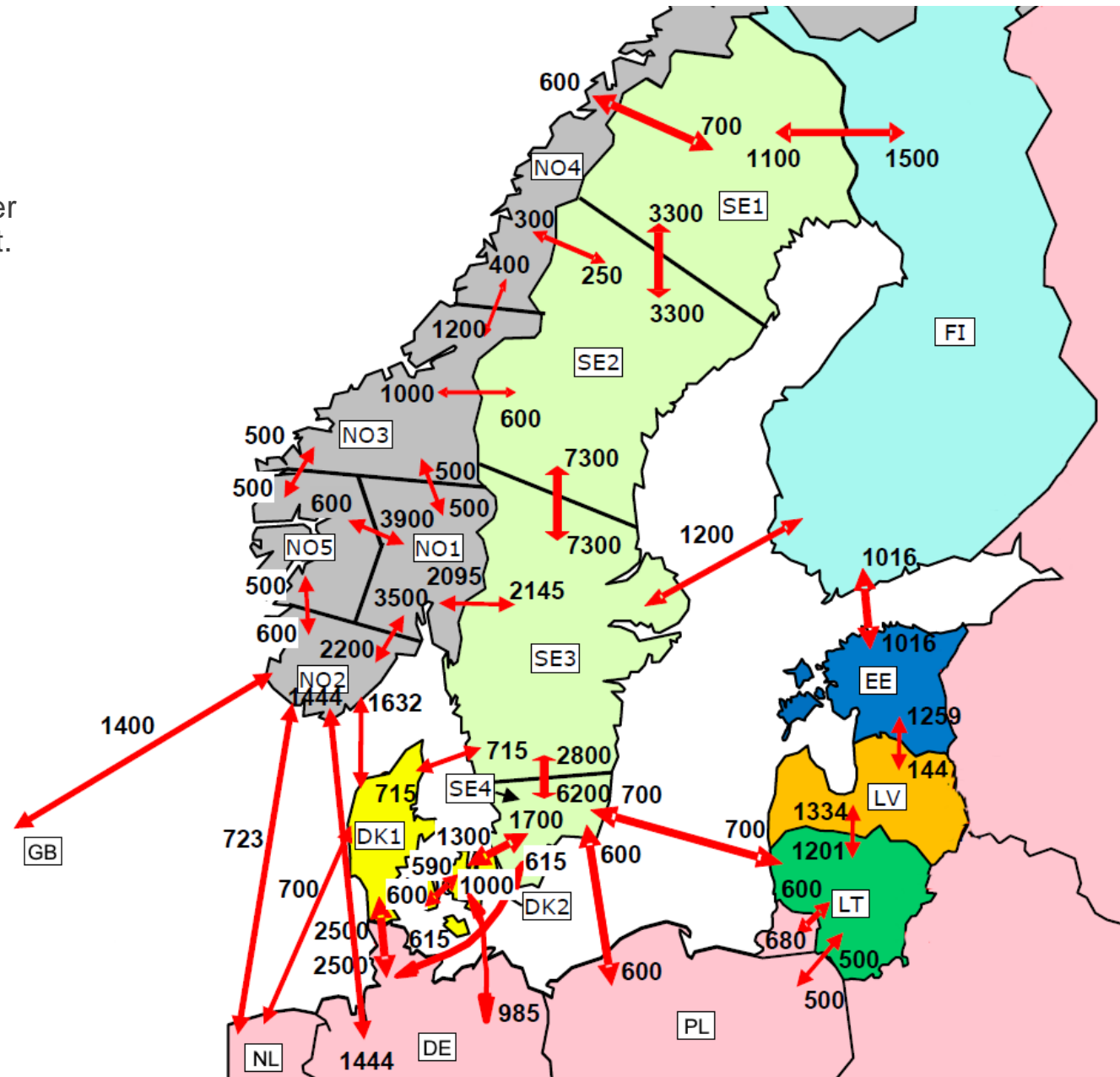


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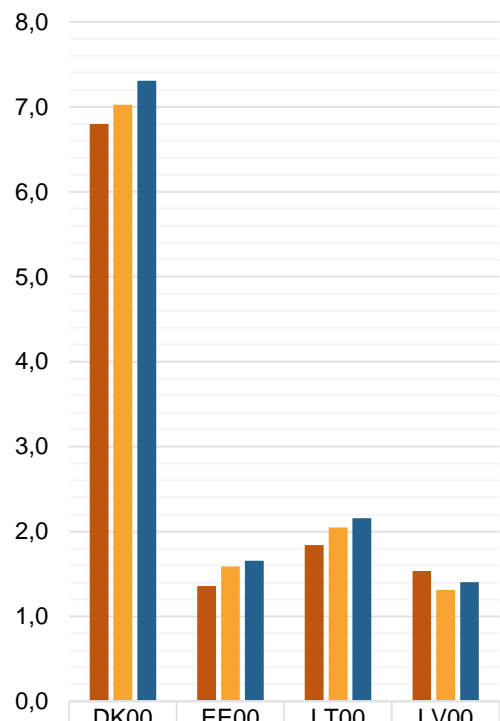
Transfer capacities

Transfer capacities between bidding zones are important for power adequacy. It enables a surplus area to support an area with deficit.

Shown in this map is maximum NTCs (net transfer capacities) for 2022. The actual capacity varies due to grid conditions, power flows and maintenance and may be lower (or zero) for a given hour.

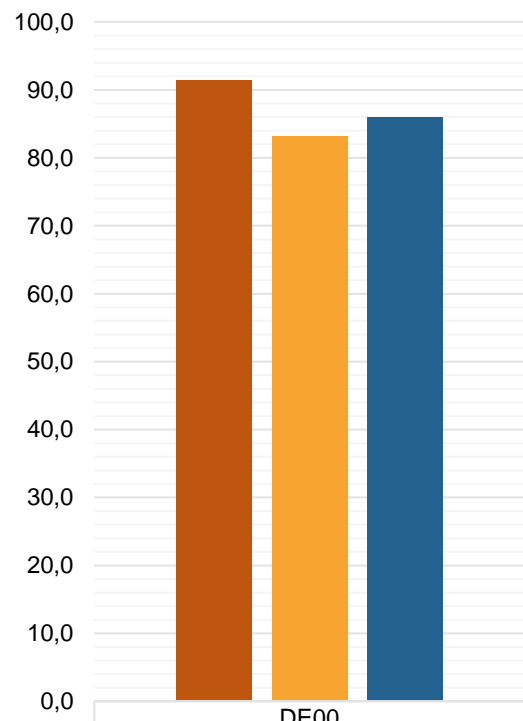


Market-based power balances by countries



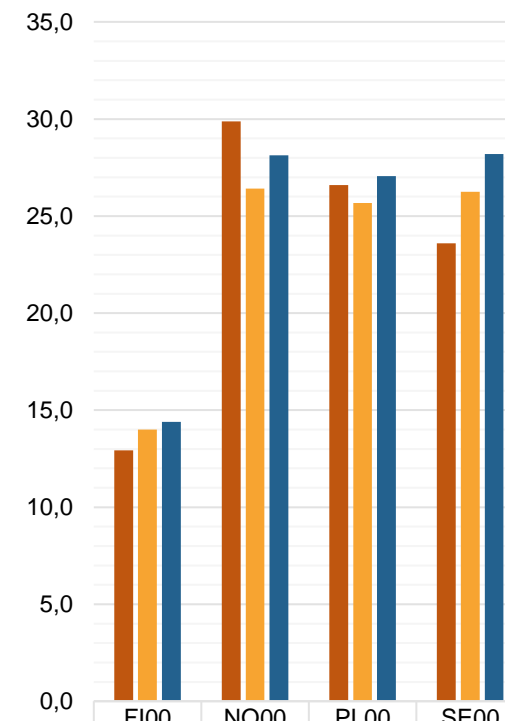
Supply	6,8	1,4	1,8	1,5
Average winter peak demand	7,0	1,6	2,0	1,3
Cold winter peak demand	7,3	1,7	2,2	1,4

Supply Average winter peak demand
Cold winter peak demand



Supply	91,4
Average winter peak demand	83,2
Cold winter peak demand	86,0

Supply Average winter peak demand
Cold winter peak demand



Supply	12,9	29,9	26,6	23,6
Average winter peak demand	14,0	26,4	25,7	26,2
Cold winter peak demand	14,4	28,1	27,1	28,2

Supply Average winter peak demand
Cold winter peak demand

All resources available before demand curtailment

