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Generation Adequacy – market measures to secure it and methodology for assessment

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Introduction

Power markets are at a crossroad. The structure of power generation capacity is changing towards more intermittent renewable energy, less base load generation and fewer flexible power plants. The rising share of wind power leads to increased variability in power production. As a result, low prices and market uncertainties are influencing the profitability of conventional generation, which has accelerated the retirement of conventional thermal and nuclear power plants, and increased the risks of investing in new capacity. The changes are seen across Europe, which has brought the concern regarding generation adequacy and the ability of a power market to supply this, back on the agenda.

The supply-demand balance is influenced by the shift in the generation mix, and several studies state that the risk of capacity shortage is increasing at national levels and for certain time periods. The Nordic area as a whole, however, is expected to have a significant energy surplus on an annual basis.

A well-functioning power market is a key enabler to solve the so called trilemma of a cost-efficient transition to a low-carbon power system that still provides a high level of security of supply and competitive prices to businesses and citizens. For this, the European Commission launched a winter package of measures called "Clean Energy for All Europeans". Some of the principles for the variety of measures are increased flexibility of generation and load, scarcity pricing, and increased coordination across borders. The overall ambition is that future power markets will be able to send clearer price signals to producers, consumers and investors. Additionally, there needs to be enough transmission capacity to form prices in large enough areas.

Well-functioning markets ensure generation adequacy

In essence, generation adequacy is about ensuring that supply meets demand or vice versa. To enable this in a market-based solution, it is of vital importance that prices hold all relevant information on the tightness of the balance between supply and demand. This will incentivise producers to regulate production and consumers to adjust demand. In scarcity situations, the price must increase above the variable generation cost, thereby incentivising investments in new generation capacity. Long-term price levels need to enable recovery of investment costs for flexible production. Thus, securing adequate capacity is first and foremost a question of getting prices right.

However, many decisions and incentives affect the generation capacity and the consumption patterns in the Nordic power market. Several of these are defined outside the area of responsibility of the TSOs, for example subsidy schemes for renewable energy, energy taxes, environmental regulation, industrial policy etc. Thus, an increased coordination on policy measures between the Nordic countries, especially for those that have an effect on the common Nordic market, would be beneficial. This should also include the creation of common Nordic design principles for strategic reserves, if needed in the future.

In addition, adequacy assessments need to be on a regional basis in order to include cross-border capacity in the evaluation. Here methods developed for Pan-European adequacy assessment can provide the basis if adjusted for Nordic risks and supplemented with specific Nordic sensitivity analyses. This approach is currently employed for the first Nordic generation adequacy report to be published in Q3 2017.

Elements in getting prices right to support generation adequacy

The power market model needs to be updated to ensure that it delivers a continuous high level of generation adequacy. The Nordic TSOs have identified several areas within the current market model that should be developed further, in order to accommodate the changes in the power system in a marked-based and efficient way. The suggestions for market measures have a time span of the next five years and consist of the following:

- Ensure that market prices are allowed to guide investments in generation capacity.
- Ensure that the value of generation adequacy is duly incorporated into analyses of the economic benefit of transmission grid investments internally, between the Nordic countries and to the neighbouring regions.
- Internalize the risk of shortage in the market prices, especially in the balancing market, to enable flexible consumers and producers to capitalize on their flexibility in realtime.
- Linking wholesale and retail markets closer together in order to ensure that consumers receive the price signals in time to respond.

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- Conduct pilot projects to promote demand response and examine possible market concepts for aggregators.
- Increase use of market-based solutions for ancillary services where possible in order to let the market know what the TSOs need.

The Nordic TSOs have already investigated and started a substantial amount of initiatives in order to "get the prices right" and improve our knowledge for decision making. Specifically, the TSOs are working on four concrete projects that will contribute to solve the adequacy challenge:

- **Higher time resolution in the power markets:** Introducing higher time resolution in the power markets will reduce the magnitude of structural imbalances, which in turn frees up reserves and improves the frequency quality in the Nordic power system.
- **Full cost of balancing:** Improving the incentives for balancing responsible parties to be in balance by exposing them to the true cost of imbalances. This will also contribute to the adequacy situation by improving market rules to bring more flexibility.
- **Common Nordic capacity calculation methodology:** Adopting a common capacity calculation methodology in the Nordic region will maximize the welfare created from the utilization of the grid, which will be important also for tackling the regional adequacy challenges.
- **Empowering consumers:** Enabling consumers to benefit from potential flexibility in their demand by utilizing smart technology and developing new services and products in retail, wholesale and balancing markets.

A critical element of realizing the full potential of Demand Side Response (DSR) could be the facilitation of the aggregator role that allows third parties to aggregate multiple loads and offer these as additional flexibility to the market. The Nordic TSOs have recently completed a project aimed at developing guidelines for 3rd party aggregation in the balancing markets in the Nordic countries. The project has investigated which market conditions and aggregation models that are most suitable for the Nordic countries, and identified barriers and opportunities for old and new market players. In addition, several national pilot projects in the four Nordic countries focus on increasing demand side response and facilitate aggregation.

Adequate transmission capacity supports supply-demand balance

Transmission capacity plays a key role in meeting the generation adequacy challenge by enabling cost-effective utilization of generation resources. Increased transmission capacity between the Nordic countries and continental Europe allows for export of power surplus as well as import in situations of scarcity. The same applies to transmission capacity within the Nordic countries. The Nordic countries are strongly interconnected, but further reinforcements are planned and foreseen to be needed in the future. The status of planned and potential interconnector projects is reported in the Nordic Grid Development Plan 2017.

In this context, it should also be noted that transmission capacity alone cannot ensure generation adequacy in the Nordic market. Investment in generation capacity as well as realization of the potential for flexible demand is key to ensure the supply-demand balance.

Intervene only if markets fail to deliver

If the above mentioned measures are not sufficient for the energy-only market to ensure a balance between demand and supply, or initiatives are needed to bridge the gap in a transitional period, then strategic reserves are preferred as market wide capacity mechanisms.

Today, two Nordic countries – Sweden and Finland – have strategic reserve mechanisms to ensure balance between supply and demand in extreme situations. Generating units are kept available for occasions when the market is not able to cover demand. Both power plants and loads may serve as peak load reserve. Power plants and loads that act as peak load reserve are fully reserved for the use of the peak load reserve system, hence they cannot participate in the commercial market.

Strategic reserves should be designed so that their interference with market price formation is as small as possible. The Nordic TSOs therefore recommend that future strategic reserves should:

- be designed to address the nature of the problem identified in adequacy assessments at the European or regional level,
- be regional if capacity or demand can contribute across borders, though bearing in mind that establishing a common Nordic strategic reserve is complex and requires thorough analysis.
- not interfere with price signals in the markets.

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This is in line with suggestions in the winter package "Clean energy for all Europeans", where capacity mechanisms, including strategic reserves, are seen as a last resort, i.e. if the markets after removal of potential regulatory distortions cannot ensure a desired supply-demand balance. The suggested rules on capacity mechanisms will complement existing state aid guidelines by creating a European framework and concrete rules for cross-border participation.

To ensure a valid regional assessment of the necessity of strategic reserves, it is essential to monitor the demand-supply balance very closely, before suggesting measures concerning a possible regional strategic reserve.

Improved methodology for Nordic adequacy assessments

The Nordic TSOs are developing a common platform for assessing long-term generation adequacy. This centres on identifying and quantifying the risks to the future delivery of power to consumers. To this end, a probabilistic approach is employed, which captures the uncertainty related to variable generation, plant and interconnector outages, and the effect of weather conditions on demand. This is an improvement over the deterministic approach, which only considers worst-case scenarios by comparing peak load with average availabilities on generation and transmission facilities. The deterministic approach fails to capture the many different combinations of events that could lead to adequacy issues. The probabilistic approach therefore gives a better understanding of how the different elements of the power system contribute to generation adequacy.

The assessment is conducted using the market model BID[1] and builds on ENTSO-E's annual Mid-Term Adequacy Forecast, which models all of ENTSO-E, including the Baltics and Turkey, and corresponds closely to actual price areas. Flows across the perimeter (for example to and from Russia) are modelled as fixed flows based on historical data. To give a relevant regional focus, specific sensitivity analyses of Nordic interest are conducted.

The methodology takes its point of departure in the normal operating scenario including all market measures such as exchange on interconnectors and demand responses. The risks associated with operation of the power system in times of stress and the mitigation measures here used, are hence not included in the evaluation.

The first step in determining the risks to generation adequacy is to construct a large number of possible future states based on the uncertainty surrounding the demand for power, and the availability of power plants and interconnectors. Each future state is established on the basis of historical data. The key inputs for generating future possible states are:

- Wind and photovoltaic production
- Outdoor temperatures (which result in load variations)
- Hydro conditions (normal, wet or dry years)
- Scheduled and unscheduled outages of power plants and interconnectors

The climatic variables are correlated by nature. Therefore, the climatic data relating to a given variable for a specific year is combined with data from the same climate year for all other variables. Through this process, different distinct climate years are constructed with demand and intermittent energy production specified for each hour of the year. In contrast, the availabilities of power plants and interconnectors are randomly selected considering given probability parameters (this only relates to unscheduled outages, scheduled outages are fixed throughout the year). A future state is produced by combining a climate year with a randomly generated availability profile. **Figure 1** illustrates this Monte Carlo method[2].

Construction of Monte Carlo Years

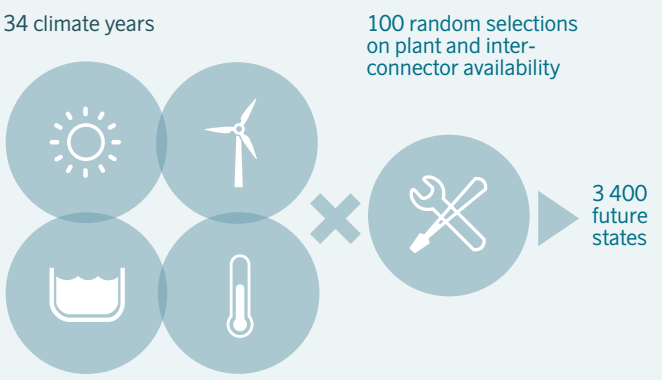

Figure 1: Illustration of the construction of future states (graphics created by Elia, Belgian Transmission System Operator).

[1] *Better Investment Decisions (developed by Pöyry Management Consulting).*
[2] *Graphical illustrations created by Elia, Belgian Transmission System Operator.*

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By combining each climate year (34 in the latest Pan European Market Model Database) with 100 different random selections on plant and interconnector availability, 3 400 future possible states are produced.

The second step involves identifying periods of structural shortage, i.e. times when there is insufficient available power to meet demand. This occurs when multiple events coincide, such as low wind during a winter day with a fault on a large power plant. To this end, an hourly simulation is carried out where the model optimises the distribution of interconnector capacity in order to maximise the minimum regional capacity margin. This is done for all hours in all 3 400 future states. Averages across these years will give the expected state of the system.

The last step is to quantify risks through different indicators, and illustrate how much capacity is needed to mitigate the risks. This level can not be interpreted as a requirement for strategic reserves, as none of the Nordic countries has set a risk target for security of supply. Furthermore, the periods with the most significant imbalances need to be analysed in detail in order to understand the cause, as well as assess whether model weaknesses may cause over- or under-estimation of loss of load.

The most commonly used risk indicators are loss of load expected (LOLE) and expected energy not served (EENS). LOLE is the expected number of hours per year in which generation adequacy problems occur. It is not the expected number of hours in which consumers may be disconnected, as both short-term and long-term mitigation measures are available to the TSOs. EENS is the amount of demanded power in MWh that cannot be met in a given year. EENS therefore combines both the likelihood and the potential size of any supply shortfalls. The third indicator used is the Capacity Margin, which is the capacity or demand response in MW needed for obtaining balance in each hour.

In addition to the above described basic application of the probability based generation adequacy assessment method, the joint Nordic Generation adequacy study is investigating the effects of the following situations, which may pose a threat to the demand and supply balance in the Nordic region:

- Extreme weather conditions
- Closure of thermal capacity (nuclear and CHP)
- Lasting grid constraints
- Import capacity from Russia

Two other sensitivities of interest which are being investigated are:

- New HVDC lines (as suggested in the TYNDP18)
- Location of future wind production

Conclusions

The common basis for the Nordic TSOs is that the market design must create a framework for market-based solutions, which can pave the way for the demand-supply balance. This is in line with the ambition of the winter package from the European Commission.

The Nordic TSO's work on generation adequacy relies on energy-only markets with higher time resolution, where the market is the main driver for ensuring generation adequacy. This clarifies the role of the TSOs somewhat, as generators and consumers decide on investments and consumption based on market signals, while the TSOs support the development of an efficient market framework and sufficient transmission capacity.

The Nordic TSOs have already made changes and adjustments, or are in the process of implementing them. In several of the areas in question, new legislation and political decisions may be needed, or agreement will have to be reached among the Nordic countries or in the EU.

One of the prerequisites for finding the right measures is however, the correct assessment of generation adequacy on a national and regional scale. This will be ensured through the application of a probability based modelling tool with input data used for ENTSO-E's annual Mid Term Adequacy Forecast, supplemented with specific Nordic sensitivity analyses. First results of this consistent Nordic assessment will be available Q3 2017.

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June 2017