Nordic Balancing Philosophy

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1 Purpose

The purpose of this report is to document the Nordic balancing philosophy to make sure that all Nordic TSOs have the same understanding of the principles and strategy behind the current rules and procedures for balancing. The report focuses on describing the current philosophy but will also describe where work is ongoing or planned to make changes or adjustments. This paper can be a basis for related work in other Nordic or national groups.

Work has also started to implement the network guidelines which may have impact on the philosophy in a future phase.

In a potential phase 2 these impacts can be described but it is not in focus for this paper.

2 Framework for balancing

2.1 Quality standards

2.1.1 Frequency quality

Requirements on frequency quality according to SOA (appendix 3; 1.1):

"*The requirement of the highest permissible variation in the frequency during normal state is between 49.90 and 50.10 Hz. The goal is to maintain 50.00 Hz.*
The number of minutes with frequency deviation shall be kept at a minimum. The goal figures for frequency deviation shall be established annually, and the number of deviations with underfrequency and overfrequency shall be recorded."

The goal for frequency deviations outside normal frequency band is not more than 10 000 min/year. (ref. to RGN 9.5 2014)

<u>Elaboration of understanding:</u> the dispatchers do not necessarily strive to maintain exactly 50.00 Hz at all time. They rather try to optimize operation within the normal range. At certain conditions e.g. morning hours where the consumption ramp is foreseen but not known in a minute base level the dispatchers often chose to keep the frequency higher than 50.00 Hz in order to have a better margin.

The calculation of the minutes outside the normal frequency band is made by using the first 5 s frequency value of every minute. This one sets the value for the whole minute.

The frequency deviation is followed up weekly and a frequency statistics report is created by Statnett (Landssentralen) and forwarded to the other TSOs. The frequency statistics is reported to RGN on a regular basis. The development over the years is shown in the figure below.

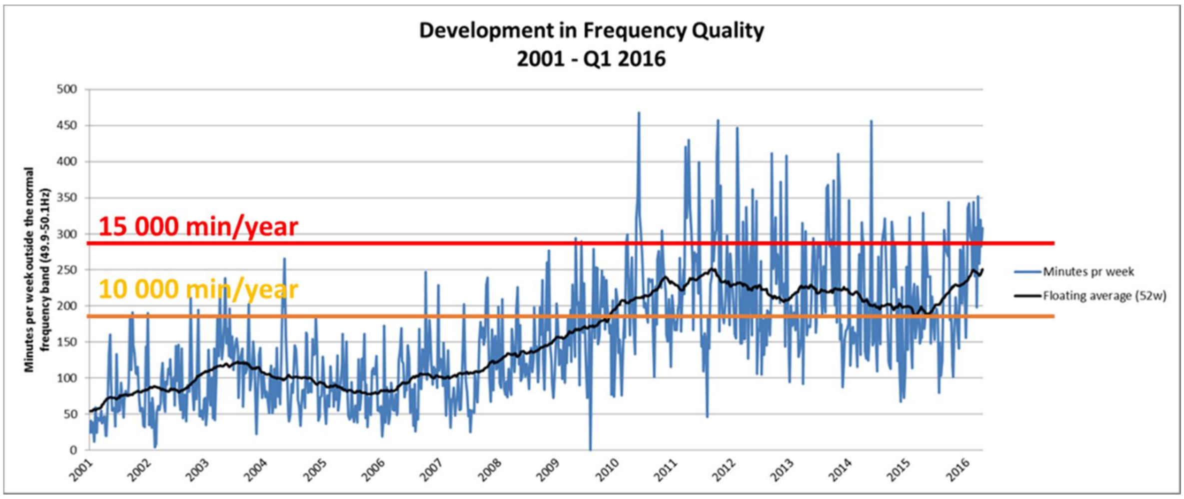

Fig 1: The blue curve represents minutes outside the band per week. With a yearly maximum of 10 000 min/year it gives a weekly max of around 190 min/week. The black curve is an accumulated yearly average which is to be compared to the goal of 10 000 min/year.

2.1.2 Time deviation

Requirements on time deviation according to SOA:
"The time deviation is used as a tool for ensuring that the average value of the frequency is 50.00 Hz. The time deviation ΔT shall be held within the time range of - 30 to + 30 seconds. At ΔT = 15 seconds, Statnett and Svenska kraftnät shall contact each other in order to plan further action. The frequency target has a higher priority than the time deviation and the costs of frequency regulation."

2.2 Responsibilities for balancing

Balance regulation is regulation in order to maintain the frequency and time deviation in accordance with the set quality standards.

2.2.1 TSO responsibility for balancing

Within each country the respective TSO is responsible for operational security which includes having sufficient resources available for maintaining the operational security within the given limits. This may include agreements/arrangements with other TSOs within available grid capacity.

<u>From SOA §12:</u>
Each subsystem is responsible for planning itself into balance hour by hour, as well as for upholding its own balance during the hour of operation.

The Parties shall collaborate towards minimising the cost of balance regulation by utilizing, to the greatest extent possible, one another's regulation resources when this is technically and financially appropriate.

The balance regulation of the Nordic system is divided up into two balance areas. One of these balance areas is the synchronous system while the other balance area is Western Denmark.

From SOA §5, last paragraph:
Unless otherwise agreed, the Parties shall be responsible for ensuring that measures taken within their own subsystems, which impact upon the operation of the system, shall not burden the other subsystems.

<u>*Elaboration of understanding:*</u>
Each TSO is responsible for that sufficient balancing measures are available for the TSO to handle imbalances that may occur within its control area as well as potential fault situations. The term "upholding its own balance" in SOA shall be understood as the ability to see to that the flow on the interconnectors to other control areas can be adjusted if needed to correspond to the resulting schedule from the energy markets.

The TSOs shall also have measures to handle reduced transmission capacity in case of tripping of lines or for other reasons after confirmation of the schedule from the energy markets.

Imbalances in each control area shall not lead to violation of the operational security limits in other control areas or burden other control areas (subsystems) as described in SOA §5.

The requirements for mFRR volumes in SOA are currently defined to handle national N-1 incidents. The TSOs must however also have measures available to handle imbalances and more comprehensive faults which may occur within the TSOs control area and on the borders to other control areas. This must be described clearer in SOA.

As the Nordic TSOs cooperate in using reserves in a region in common balancing arrangements, a prerequisite for the arrangements is that the TSOs are collectively responsible for making sufficient reserves available for regional balancing with minimum volumes agreed between the TSOs in the region. Location of the reserves may be considered from a regional perspective taking congestions in the grid into account. This does not reduce the national TSO responsibility but contribute to a more efficient use of the regional resources. This must be described clearer in SOA.

The TSOs are responsible for the ability to balance their own control area. For regional balancing, the TSOs are responsible for making reserves available with minimum volumes agreed between the TSOs in the region. These issues are not sufficiently specified in the current SOA.

2.2.2 Distinction of TSO and BRP responsibility of balancing

In the Nordic balancing model, the BRPs are expected to balance their portfolio per hour before operational hour. This is done by trade in NP day-ahead, in the intraday market and bilateral trade between BRPs within bidding zones. Gate closure for intraday trading is 1 hour before operational hour. Gate closure for bilateral trade is not harmonised.

After day-ahead trade, the BRPs will provide the TSOs with information needed for balancing such as preliminary production plans for the next day. The gate closure for sending final information used for settlements to the TSOs is 45 minutes before operational hour. After that, the responsibility for balancing is taken over by the TSOs.

The gate closure time of 45 min was decided and harmonised in 2009. The background for the decision was described as follows: *"The goal of the decision is common provisions to market players and at the same time find a balanced solution which guarantees TSOs' need for reasonable time to plan as close as possible to the operating hours (release from Nordel 29 June*

*2007)".*This allowed for a closing time for the intraday market one hour before the operating hour as well as the possibility for TSOs to plan the balancing and possibly take more proactive actions.

System imbalances may however occur right up until and during the actual operational hours. Some imbalances are unforeseeable while the TSOs can prepare themselves for others. The imbalances are due to:

- Current market set up where the trade is performed on hourly basis whilst the consumption changes continuously. This means that there will be imbalances within the hour even if the BRP plans are correctly balanced.
- Differences between forecasted and actual consumption and production.
- Events causing loss of production or consumption.
- Differences between hourly energy plans and actual flow on HVDC (ramping)
- Special regulations by the TSOs.
- Self-regulations by BRPs.

The Nordic TSOs are the ones who before and during operational hours have the best overall information regarding the balance situation and potential congestions. The Nordic TSOs are responsible for the balancing after the intraday gate closure by using the cheapest bids for balancing in the Nordic area.

> *It is the TSO responsibility to balance the system by using available means after the intraday gate closure and during the operational hour in order to maintain the frequency and to secure a stable operation. The roles between TSO and BRP for balancing and the procedures should be further clarified and harmonized.*

2.3 Operational planning data

2.3.1 Productions plans – basic definitions

Production plan is a schedule with hourly or quarterly resolution that BRPs send to the TSOs to notify the TSO about expected production.

- *Hourly production plan* (market notification in Denmark) is the hourly production schedule the BRPs send to the TSO with hourly resolution.
- *Quarterly production plan* is a production schedule with quarterly resolution. Requirements for quarterly production plan are rules describing that quarterly production plans must be made in a specified way (applied in Norway and Sweden).
- *Operational schedules for DK1 and DK2* are power schedules with 5 minutes resolution; the schedules shall be updated at any time by the BRP if changes occur in planned production. Any lack in conformity between schedule and production will have impact on the specific Danish 15 minute balance settlement.

2.3.1.1 Tools for the TSO to adjust production plans

Quarterly adjustments of hourly production plans
This is a requirement applied by the TSOs in Finland, Sweden and Norway on the BRP when the hourly production plan changes more than 200 MW at hour shift to reschedule their plan

with quarterly steps 15 minutes before hour shift, at hour shift and 15 minutes after hour shift in order to adjust the plans to better correspond to the consumption pattern.

Smoothing of hourly production plans
In Norway a voluntary alternative to the requirement above, "Smoothing", is implemented. The system service allows the TSO to reschedule hourly production plans D-1 into production plans with quarterly steps. In the smoothing process, Statnett level out hourly plans in quarterly steps based on known information at the time to reduce deterministic imbalances per quarter.

Production shift schedules is a system service used after intraday gate closure that allows the TSO to reschedule the changes in the production plans to better correspond to the consumption pattern.

2.3.2 Production forecast

In addition to the production plans sent by the BRPs, the TSOs make own production prognosis for intermittent production like wind power, which are used in the planning of balancing.

2.3.3 Consumption forecast

Each TSO has its own tools for a consumption forecast which are used in the planning of balancing. The tools are based on historical data and are calendar- and temperature dependent.

BRPs do not send their prognosis of consumption as separate information to the Nordic TSOs.

2.3.4 HVDC scheduling

The HVDC schedules are based on the hourly results for exchange between bidding zones separated by DC cables in the day-ahead and intraday energy markets. These exchange plans are recalculated to ramping power plans according Nordic and specific rules. The rules are determined by regional needs (frequency, congestions), local needs (voltage, local congestions) and administrative rules agreed between TSOs.

The HVDC scheduling process is operated bilaterally between the connected TSOs.

2.4 Products for balancing

To balance a system, different types of reserves must be available.

Due to the fact that the grid is not a copper-plate and congestions occur in the grid, there is a need for a distribution of the reserves through specific agreements (SOA) or market arrangements.

The reserve products used in the Nordic power system are shown in figure 2.

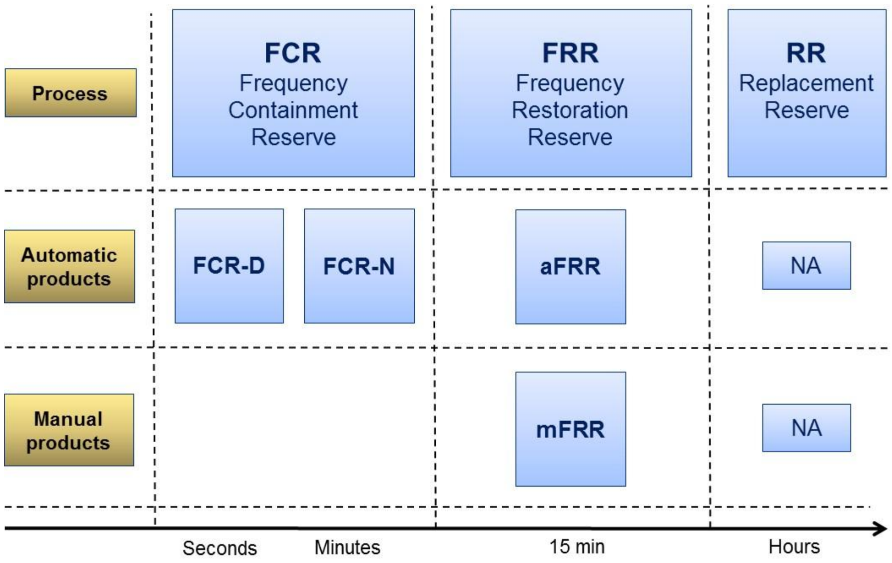

Fig 2: Reserve products in the Nordic Power system.

2.4.1 Frequency Containment Reserves (FCR-N and FCR–D)

Frequency containment reserves are by definition operating reserves with the purpose of balancing the system within the normal frequency band and in case of disturbances.

2.4.1.1 Frequency Containment Reserve - Normal (FCR-N)

FCR-N is a specific Nordic product with the purpose of balancing the system within the normal frequency band (49.90<f<50.10 Hz). FCR-N is not used in DK1.

According to existing SOA the FCR-N shall be at least 600 MW in the synchronous system. This volume is divided between the control area within the synchronous system as national requirements on the basis of annual consumption in Eastern Denmark, Finland, Norway and Sweden in the previous year.

2.4.1.2 Frequency Containment Reserve – Disturbance (FCR-D)

FCR-D has the purpose of balancing the system in case of disturbances where frequency drops below 49,90 Hz and to stabilize the frequency after the disturbance. After a large disturbance in production, inertia prevents the frequency from dropping below an acceptable level before FCR-D stabilizes the frequency at a steady state level.

According to existing SOA there shall be a FCR-D of such a volume and composition that a dimensioning incident (DI) (largest fault of production or HVDC deducted by 200 MW for frequency dependent load) does not cause a steady state frequency below 49.5 Hz in the synchronous system. Current SOA do not have a requirement for minimum inertia in the system, or a specification of the minimum frequency level for the frequency drop. These parameters must be specified.

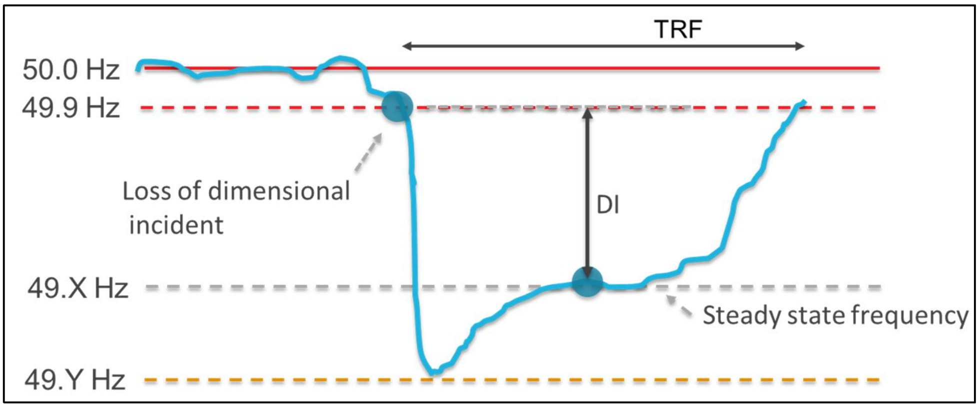

Fig 3: Simplified you may say that the inertia defines the lowest frequency point after the Nordic DI, the FCR-D defines the steady state frequency and the FRR defines the time to restore frequency (TRF). The minimum acceptable steady state frequency is implicitly stated in the SOA and is 49.5 Hz.

The activation of the FCR-D shall not result in other problems in the power system. When the transmission capacity is being determined, the location of the frequency controlled disturbance reserve shall be taken into account in the TTC calculation.

Distribution of the requirement for the FCR-D between the subsystems of the interconnected Nordic power system shall be carried out in proportion to the dimensioning fault within the respective subsystem. Distribution of the requirement shall be updated once a week or more often if necessary.

<u>The 2/3 rule:</u>
According to the SOA, at least 2/3 of each subsystem's FCR requirement shall be maintained in the subsystem. ENTSO-E Regional Group Nordic (RGN) has decided exceptions from this rule for Energinet.dk and Fingrid within certain limits. This is conditioned on that grid capacity is secured to transfer the extra volume of FCR cross national interconnections. Countertrade is made when needed.

Statnett also practices a limitation on sale of FCR-N of max 1/3 of Norway's FCR-N requirement. This means e.g. that Norway cannot deliver 1/3 of the requirement of both Sweden and Finland in the same hour.

2.4.2 Frequency Restoration Reserves (automatic and manual)

Frequency restoration reserves are by definition operating reserves necessary to restore the frequency back to 50 Hz and by that the activated FCR. FRR could be both automatic and manually activated. Manual FRR is also used to mitigate congestions.

2.4.2.1 Automatic Frequency Restoration Reserve (aFRR)

The product aFRR was introduced in the Nordics in January 2013. The background for implementing and developing aFRR in the Nordic was the deteriorating frequency quality and aFRR was (2011) identified and agreed as one of the main measures to stop the weakening of the frequency quality. A benefit is that aFRR can be based on a merit order and take congestions in the grid into account. Additionally, aFRR has a faster response than mFRR and will due to that restore the frequency faster than mFRR.

The aFRR product shall be seen as an automatic “complement” to mFRR in the FRR process. The aFRR reserve differs from FCR in the way that the reserve is remotely controlled by a centralised controller while FCR is locally controlled. There is also a difference in activation time. In hours where aFRR is active, there is an interaction between FCR and aFRR where FCR stabilizes the frequency while aFRR brings frequency back to 50.00 Hz given sufficient available volumes.

aFRR can be exchanged between synchronous systems. To secure this, a reservation of grid capacity may be necessary.

Up until December 2015 an agreed volume of aFRR for specific hours was procured in the synchronous system with the same distribution key as FCR. From January 2016 the procurement has been put on hold because Svenska kraftnät decided not to procure aFRR in 2016 until a permanent Nordic solution was agreed between the Nordic TSOs.

2.4.2.2 Manual Frequency Restoration Reserve (mFRR)

The manual part of FRR, mFRR, is used for power balancing and to handle congestions in normal and disturbance situations. mFRR is the main balancing resource which when activated replaces both remaining FCR and aFRR activations and brings frequency back to the frequency target. In case of proactive activations, the mFRR may be activated in the opposite direction of FCR and aFRR. Due to limited volume of aFRR and many congestions in the grid, the Nordic system is dependent on mFRR activations. It is expected that mFRR will continue to be the main balancing resource in the system.

In SOA there are currently only national requirements for sufficient upward regulation mFRR to handle the largest dimensioning fault in each subsystem (control area in GL SO).

However each area separated by congestions must have sufficient volumes of mFRR or other relevant means available to handle imbalances in both directions including BRP imbalances, potential outages/disturbances of production, consumption or grid elements like e.g. HVDC connections.

The market players can submit bids to the Nordic Regulation Power Market (RPM). The RPM is a tool for the TSOs to perform the balancing and is set up in a market based way meaning that the bids are activated in price order when needed. This is considered as an efficient (and a socio-economic) way of using the Nordic resources.

The required activation time in RPM (15 min) is a Nordic compromise between need for frequency and congestion control and the need for liquidity in the market. Different delivered response times of different production units, e.g. hydro and slower thermal plants have to be taken into account in the balancing process. In addition to 15 min mFRR, automatic reserves and mFRR with faster response time than 15 min secure that the system, after an operational disturbance, can be restored within the normal frequency band within 15 min.

There are different capacity arrangements for mFRR in the Nordic countries. Both voluntary bids and resources that TSOs pay capacity payment for are submitted to the RPM for activation. The reserves with capacity payment are for securing capacity for disturbances, congestions or imbalances. Peak load reserves may also be available for mFRR. The different resources are gathered in a Nordic merit of order list for activation.

FCR stabilizes the frequency while FRR brings frequency back to the frequency target. All categories of reserves need to be distributed in the system due to congestions in the grid.

Use of mFRR for special regulation

Special regulation means regulation ordered by TSO in the regulating power market for a reason other than the needs of balance management. For this purpose, TSO uses bids which are suitable in terms of congestion management or other specific reasons, and the bids are not necessarily used in the price order.

Special regulation is priced in accordance with the bid activated; however in case of up-regulation, the special regulation price must be higher or equal than the up-regulating price for the hour in question. Correspondingly, in case of down-regulation, the special regulation price is lower or equal than the down-regulating price for the hour in question. Special regulation is not taken into account in the determination of the price of imbalance power.

mFRR can also be activated from the Nordic RPM to support or balance another synchronous system. Currently these activations shall not influence the Nordic marginal prices in the RPM, and the used bids must be marked as special regulation.

When calculating the RPM prices afterward each hour, the most expensive bids are allocated for special regulations.

Interaction between Nordic and other synchronous areas

mFRR can be exchanged between synchronous systems. mFRR can also be traded from a power system outside the common Nordic RPM to support or balance any Nordic bidding zone. There are currently different views whether mFRR activated from an adjacent power system outside the Nordic RPM shall influence the pricing in the RPM in the same way as bids ordered from the Nordic regulation list.

The Nordic RPM can also support surrounding systems with mFRR for balancing of those systems. Currently this is not directly influencing the marginal pricing in the Nordic RPM.
There is also the possibility to use imbalance surplus or deficit without activating mFRR for exchange with other systems.

The TSOs are currently applying different rules for bid activations due to disturbances and reduced capacity on interconnectors from the Nordic countries.

Only actions taken to balance the Nordic system influence the imbalance prices in the Nordic RPM.

As increasing exchange outside the Nordics will have more impact on the operational work of balancing, harmonised rules adapted to operational conditions must be developed.

2.5 Pricing methods

2.5.1 Balancing prices

The objective is the optimal use of the regulation bids in the merit order. When congestion occurs between two Elspot areas in the operational phase, the TSOs jointly determine when the areas no longer can be mutually regulated. If it is not possible to use the bids in price order, a separation of the regulating prices occurs.

Mutually regulated areas consist of several Elspot areas which obtain the same regulating prices. The reasons for different regulating prices of different Elspot areas can be excess transmission on corridors between Elspot areas, or if trading or operational rules restrict activation of bids from the NOIS-list in the price order. The TSOs determine jointly when and between which areas the separation of regulating prices occurs.

2.5.2 Imbalance price

The principle for the pricing of BRP imbalances is to reflect the value of the activations to balance out the imbalances. Today, imbalance price is determined as the marginal price of activated bids for balancing purposes in dominating direction per hour in the RPM market.

Two different price models are applied for the imbalance in the production and consumption balances respectively:

- A two-price system is applied for the imbalance in the production balance between measured production and production plan. Purchase and sales of imbalance power will be settled at different prices.

- In the one-price system, which is used for the consumption balances between measured consumption, trade and production plan (if any), the purchase and sales prices of imbalance power are identical. During an up-regulating hour, the price of imbalance power is the up-regulating price, and during a down-regulating hour, the price of imbalance power is the down-regulating price. If no regulations have been carried out during an hour, the price of imbalance power is the spot price.

Reflections on current pricing of imbalances:

- *only manual regulations are determining the imbalance price*
- *the system is also regulated by automatic reserves (FCR and aFRR) which are not taken into account in the imbalance price*
- *balance and special regulation is closely linked and there is a need for clarification how especially one-sided special regulations shall affect the imbalance prices*

2.5.3 Publishing of prices

The regulating prices are not determined until the hour has passed. This is due to that it is need for assessing which bids that have been used for normal balancing and which for congestions in order to determine the correct prices for the market.

Prices and volumes are to be published on Nord Pool no later than 60 minutes after the hour of operation.

It is important that the market receives a correct price signal on an accurate base. In order to avoid self-regulations from BRP that could disturb the balancing process performed by the TSOs, preliminary prices are currently not published during operational hour.

2.6 Ramping of exchange on HVDC connections

The trading plans on the HVDC connections from the Nordic synchronous area change so much from one hour to the next that the changes in power flows at the change of hours must be restricted to manage in balance regulation. Restrictions are placed on the gradient for change in flow (max 30 MW/min), and as Operational handbook for Continental Europe requires that all changes in scheduled flow on interconnectors between countries must be done within a few minutes, the changes to the trading plans from one hour to the next in the energy market must also be restricted. This change may be a maximum of 600 MW from one hour to the next on each of the following connections: NorNed, Estlink, Russia, Skagerrak, Konti-Skan, Kontek, Great Belt, Baltic Cable, NordBalt and SwePol Link. For Skagerrak and Konti-Skan, the total change of the trading plans on the two connections is restricted to a maximum of 600 MW.

These limits were determined on the basis that the total change for the Nordic synchronous system at one hour shift should not exceed an acceptable maximum level. Recent development with increased number of HVDC connections, changed flow pattern and new network guidelines requires that the limits are re-evaluated.

Current ramping rules need to be re-evaluated and adopted to the new network guidelines.

2.7 Tools for the operators

The TSOs balance the system based on the information that is available for the operators. Each TSO has their own real time monitoring and control system (scada) and a planning system.

The TSOs also have their own systems for prognosis of consumption and wind and even if the bases for them are similar there are some differences as well. For the areas of consumption and wind prognosis a possible joint forecast tool could therefore be a future beneficial development.

As one tool to collect the planning data on a Nordic level, the Nordic TSOs use a common platform called NOIS (Nordic Operational Information System). The NOIS system was introduced in 2002 and has since then been developed to match upcoming needs and new operational functions used for Nordic coordination have been implemented.

The information compiled in NOIS is meant to give the operators a basis on which they can plan and estimate the need of balancing in the upcoming hours. As the information in NOIS is provided by each TSO it is of great importance that the submitted data is comparable when it comes to resolution and quality to be able to perform proactive balancing.

An important part in the balancing process is the ability to compare the planning data with real time measurements. This gives valuable and immediate information on trends that can be used when deciding balancing actions. There are currently different levels of detailed real time information among the TSO's and this is therefore an area where development is needed.

3 Balancing process

Balance regulation within the synchronous system shall be conducted in such a way that specified quality standards regarding frequency and time deviation are met. Requirements regarding frequency response and frequency controlled reserves shall also be maintained. Furthermore, balance regulation shall be conducted in such a way that the transmission capacity is not exceeded.

The planning of balancing is based on all available information from all TSOs. It is Statnett and Svenska kraftnät, from here on referenced as the Balance Operators, which jointly decides and executes the balancing actions. Sweden and Norway represent approx. 75% of the annual consumption of the synchronous system and thus it is agreed in the SOA that Svenska kraftnät and Statnett have the task of maintaining the frequency and time deviation within the set limits.

Energinet.dk belongs to two different synchronous areas. Although DK1 is part of the Nordic mFRR market, DK1 is balanced as its own area inside the Central European synchronous system and shall keep its balance on the Danish – German border. Activation of reserves in DK2 for optimisation of the balance in the Nordic system is done in cooperation with the Balance Operators.

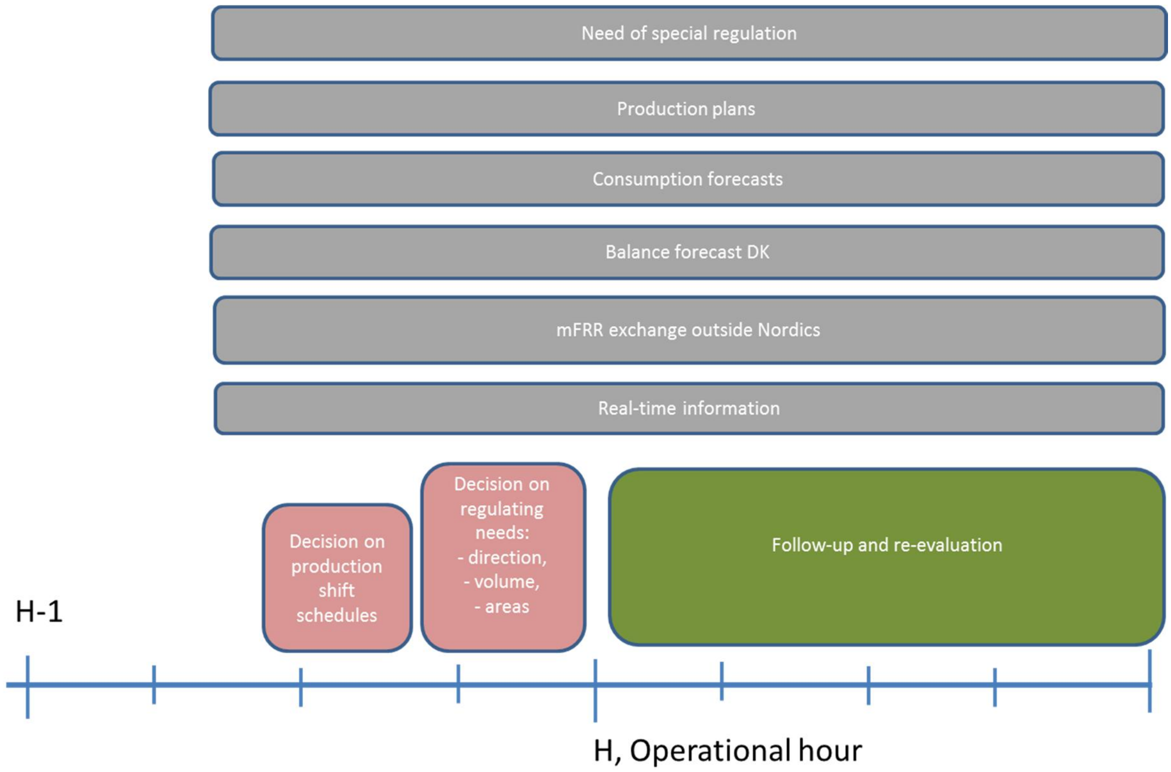

Fig 4: Illustrative example of the balancing process. The operators need to consider a lot of information in order to make decisions.

3.1 Before Day ahead market closing

The operational balancing process can be considered as a long term process starting years ahead entering into long term capacity contracts with suppliers of reserves, followed by long to short term outage planning, long to short term capacity planning on interconnectors, ending up with forecasts for power balance and dynamic stability from weeks before, days ahead up to hour of operation.

The following text focuses on the balancing process that takes place a couple of weeks ahead and later.

3.1.1 Adequacy for mFRR

A common Nordic objective is to assess sufficiency in available resources in the balancing with respect to N-1 criteria and if sufficiency cannot be ensured by normal procedures, take specific actions. Thus this is especially important in situations with risk of power shortage or lack of regulation bids in either direction. For the assessment, each TSO makes a power balance evaluation in various time frames. The TSOs have different principle views regarding if reserves shall cover only N-1 faults or some additional potential imbalance or "lock-in" of reserves as well.

Methods to ensure availability of resources for balancing

Statnett has a seasonal and weekly capacity market for mFRR where called bidders are obliged to bid into the RPM in upward direction with contracted capacity in the RKOM. This option is used in the winter season.

Svenska kraftnät has long term contracted gas turbines to ensure the volume of dimensioning fault. These are submitted (by Svenska kraftnät) to the merit order list as “special RPM bids”. In situations with several simultaneous outages on the gas turbines and where the volume for dimensioning fault cannot be secured otherwise, a reduction of the transmission capacity for the market is made.

Fingrid has own and contracted reserve power plants to ensure the sufficiency of mFRR resources. Additionally, Fingrid has introduced a balancing capacity market to ensure the sufficiency e.g. during maintenance work in the reserve power plants.

At Energinet.dk, the availability of mFRR resources is achieved by long term contracts (5 years) for upregulation in DK2 and daily capacity markets for upregulation in DK1

During normal state of operation, Svenska kraftnät and Energinet.dk coordinate the fast active disturbance reserve in Southern Sweden and Eastern Denmark (south of cross-section 4) in accordance with a distribution rule which for the presence states that the TSOs are responsible for maintaining 300 MW of fast active disturbance reserve each, for the region south of cut 4.

Energinet.dk shares reserves between DK1 and DK2 with an amount of up to 300 MW. The flow on the Great Belt connection is from DK1 to DK2. The free capacity in the opposite direction is used for sharing of reserves between DK1 and DK2. The volume of manual reserves in DK1 have been reduced by 300 MW, 600 MW of manual reserves are still maintained in DK2. Normally the amount of N-1 reserves in DK1 is covered by purchasing abt. 300 MW before spot marked and voluntary bids in the regulating power marked. In the exceptional situations where the outcome of the spot market has given a flow greater than 300

MW from DK2 to DK1 on the Great Belt connection, Energinet.dk calculates whether it requires purchasing up to 300 MW of manual reserves in DK1 after spot market.

Svenska kraftnät and Fingrid contracts peak load reserves during winter season. The reserves are primarily to be used in Elspot to prevent a curtailment situation. The volume not activated in Elspot can be available as RPM bids.

3.1.2 Allocation of capacity for exchange of reserves in the planning phase

The fact that the grid is not a copper-plate, leads to requirements for distribution of all types of reserves. For each interconnection between bidding zones, a Total Transmission Capacity (TTC) is defined. From this capacity a margin, the Transmission Reliability Margin (TRM), is subtracted to find the capacity available for planning purposes, the Net Transmission Capacity (NTC). The NTC is normally made available for the energy markets (day ahead and intraday). A prerequisite for this is that different types of reserves are distributed in the system to reduce the risk for system problems including overload in the grid.

In some specific cases the TSOs have used either partly reservation of NTC or counter trade to allocate capacity for exchange of automatic balancing products to be able to change the pre-defined distribution of the reserves when this is beneficial. (see Fig.5 below).

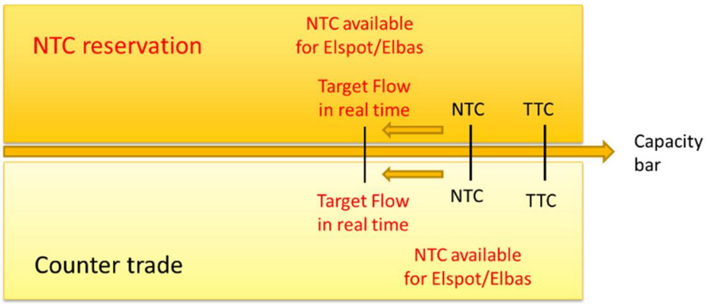

Fig.5: Two different methods for redistribution of reserves in different time frames (before and after elspot).

3.2 After Day ahead market closing

After the clearing in Nord Pool, the BRPs submit preliminary plans on production, trade (in some countries) and RPM bids for the next day. Together with exchange plans between Elspot areas from Nord Pool, this gives the TSOs a first overview on how the next day is planned hour by hour. It gives e.g. indication if there will be congestions in some hours.

To ensure that sufficient resources are available an assessment is made both separately by each TSO but also as coordination between the balance operators. This assessment is made based on the following information:

- Preliminary prognosis on consumption (hourly/quarterly resolution in TSO tools and operational experience of consumption pattern)
- Preliminary production plans (hourly and quarterly resolution)
- Day ahead exchange plans on AC- and DC-connections (hourly resolution, 5 min linear piecewise plans and knowledge of ramping pattern)

- Potential congestions from exchange schedules in the energy market
- Preliminary RPM bids

During winter time in Sweden and Finland the first balancing action is to consider if peak load reserves (production) are needed for balancing and should be put/kept on stand-by for the next day. This is decided shortly after the elspot result is known.

Should there be a risk for lack of mFRR in Sweden or Finland, the responsible TSO asks for additional bids from the providers in the RPM. This is however only a request as there are no legal obligations for the BRP to participate or to submit all available capacity.

In Norway the bid volumes in the RPM is evaluated and if found insufficient, BRPs are requested by instruction to bid in all available mFRR which have been registered as flexible at Statnett, both consumption and production.

After day ahead market closing, Energinet.dk receives market notifications and operational schedules from the BRPs. Although the balancing process when coming to hour of operation can be different for DK1 and DK2 the process for planning the balances are equal for DK1 and DK2.

The market notifications forwarded by the BRPs, are used as a basis for settlement of the BRPs' hourly imbalances (MWh/h) including any regulating power trade.

The operational schedules (5-minutes power schedules) comprises the BRPs' operational schedules including regulating power, if relevant, and is used by Energinet.dk for the continuous monitoring and handling of the balance in the power system.

Energinet.dk checks that the BRP's market notification for production, consumption or trade is in balance, the BRPs will receive a status report. Energinet.dk also checks that the operational schedules for upcoming day have been forwarded and that regulating power bids for reserve obligations (long term contracts and daily auctions) has been forwarded.

3.3 After intraday gate closure

When plans and bids are known 45 minutes before operational hour, the Balance Operators have the following updated information as basis for their planning of the balancing approximately one hour ahead:

- Updated prognosis on consumption (hourly/quarterly resolution in TSO tools and operational experience of consumption pattern)
- Updated production plans (hourly and quarterly resolution)
- Updated exchange plans on AC- and DC-connections (hourly resolution, 5 min linear piecewise plans and knowledge of ramping pattern)
- Potential congestions from exchange schedules in the energy market
- Available RPM bids
- Real time information (note that there are some lack of available real time data for e.g. wind production)

All information above with exception on real time information is compiled in NOIS (see chapter 2.7).
Based on the planning information in NOIS and real time information, Svenska kraftnät and Statnett are evaluating an expected balancing volume in the synchronous system in the next

hour and Energinet.dk is doing the same for Jutland. This is done by assessment of the present operational situation and estimate how this could remain or change depending on the plans for upcoming changes in production, consumption and exchange.

Based on these evaluations an optimal use of RPM bids in the two systems is agreed between relevant TSOs and new power schedules over HVDC are made. This is normally done 30-40 minutes before operating hour as ramping up or down on some of the HVDC connections currently starts 10-15 minutes before the hour shift. In normal cases the Balance Operators make the final decision on which bids to activate from the start of the next hour approx. 15 min before the hour shift.

The bids are used in price order. However, there are some differences in the Nordic on how the reserves with capacity payment are activated vs. the voluntary RPM bids.

Svenska kraftnät and Fingrid activate voluntary bids first and after that pre-contracted bids. This is due to that both the peak load and disturbance reserves can be seen as subsidized in comparison to the voluntary RPM bids sent by BRPs. Peak load reserve can only be submitted to RPM during the winter period and only in certain circumstances. Peak load reserves have priority to disturbance reserves when available on RPM.

When activating mFRR, Energinet.dk and Statnett do not distinguish between voluntary bids and bids with capacity payment.

When one control area only has mFRR corresponding N-1 left in the NOIS list, reserve capacity can be "shared" between the control areas after an evaluation of and if the operational security allows it.

In addition to Nordic mFRR and especially in cases where there are few RPM bids in certain Nordic areas there can be possibilities to buy supportive power from TSOs outside the Nordics for balancing purposes. In general these resources (or prices for them) are not known in advance and e.g. the operator at Svenska kraftnät contacts the counterpart to ask if it is possible to activate bids for exchange.

In the same period as evaluation of expected imbalances for the next hour is made, the Balance Operators assess whether the planned production changes in the Nordic area and the HVDC exchange around hour shift is too large and hence will impact the frequency in a way that cannot be met entirely by balance regulation in the minutes before and after operating hour. If so there is a need to advance or delay parts of planned production steps at the hour shift. The power schedules may be changed from 30 minutes before hour shift.

This is mainly important during morning and evening hours and also around day shift. If the changes are deemed to be high, the balance operators make a plan on how to level out these changes by an agreement with BRPs to reschedule the production. In situations with congestions, there is also a need to decide in which order the rescheduling should take place. E.g. in case of close to congestion on Hasle from Norway to Sweden it may be wise to start with increased production in Sweden/Finland 15 minutes before hour shift and decreased production in Norway in the first 15 minutes after the hour shift. In Norway and Sweden it is sometimes possible to reschedule production steps within the hour if there are available production changes to reschedule.

In this first assessment a plan for volumes to be shifted both before and after the hour shift is made. The volumes to be shifted after the hour might be reassessed closer to the hour shift if something unplanned occurs that would interfere with the initial plan.

The production shift scheduling is made by calling the BRP and when relevant it is also made a check if the BRP has any activated RPM bids that can affect the rescheduling.

3.4 During operational hour

During the operational hour the Balance Operators have to follow the trend of the operational situation and continuously estimate upcoming need of readjusting the balancing. This is done in the same way as planning before the hour (as described above) but with a shorter time span in mind.

There are always risks of unpredictable events such as trip of production etc. When this occurs the operators have to make fast decisions on how to relieve the situation. The operators make a judgement based on the available real time data and planned information in order to make a decision on appropriate action. In such cases bids with faster response time than 15 min can be given priority over the price order if needed. These are handled as special regulations. The bids that are skipped will thereafter be activated if needed and the special regulation will be changed to balance regulation when bids no longer are skipped.

When congestion occurs between two Elspot areas in the operational phase, the TSOs jointly determine when the areas no longer can be mutually regulated.

There is congestion between the Elspot areas when it is not “possible” to carry out balance regulation on the basis of a joint regulation list without deviating from the normal price order of the NOIS list. The reason for this not being “possible” can be flows that are too high on the cross-border link itself or on other lines/transmission constraints or operational/trading rules which entail that it is not permitted to activate bids in the joint regulation list. For regulations carried out for network reasons on the border between Elspot areas, the cheapest bids in the subsystems which rectify the network problem are normally used.

Regulations for both frequency and congestions must be performed simultaneous and depending on which need that is the dominant there will be an iterative process in choosing the right actions to take.

Congestions have priority over frequency.

3.4.1 Need of regulation for low/high frequency and no congestions

If there are no congestions to take into account the regulations are performed by activating bids in price order.

3.4.2 Need of regulation for high/low frequency and exceeding NTC

In the operational phase, the operators will normally have NTC as the "target flow". When the flow exceeds the "target flow" in real time, the operators will have to consider if this is due to activations of automatic reserves or not. If the frequency is 50.0 Hz so there is no aFRR and FCR activations, then mFRR needs to be activated to bring the flow back to the "target flow" to prepare for potential upcoming imbalances. If the frequency is different from 50.0 Hz, then the operators will have to evaluate which share of the flow higher than the "target flow" that is due to activations of FCR and aFRR before deciding on potential activations of mFRR.

When NTC is exceeded the following measures are relevant dependent on frequency:

- Low frequency
  Up-regulations must be activated in the importing area
- High frequency
  Down-regulations must be activated in the exporting area
- Frequency 50 Hz
  First regulation in the importing area and thereafter in the exporting area

When any of the two allowed congestion management methods are used, the "target flow" will change and be lower than NTC. The "target flow" will be the same if counter trade or reservation of grid capacity is used. A combination of the two methods is also possible.

3.4.3 Need of regulation for high/low frequency and with “full" grid corridors

When the need of regulation is primarily for frequency but the planned flow on grid corridors is “full”:

- Low frequency
  Up-regulations are activated in the importing area until there is a sufficient margin in the flow and thereafter activation in the exporting area can be done if needed.
- High frequency
  Down-regulations are activated in the exporting area until there is a margin in the flow and thereafter activation in the importing area can be done if needed.

The volume of regulations on both sides of the congestion is dependent on the distribution of aFRR and FCR.

3.4.4 Congestion management

Congestion caused by a reduced transmission capacity to/from an Elspot area after Elspot pricing due to disturbances or forced outages, are managed using counter trading and special regulations.

There is an issue on how long a "target flow", an NTC or a TTC can be exceeded. This is first of all a question about expected development for the relevant flow, probability for severe additional incidents and how much the limits are exceeded.

The system is in general dimensioned for exceeding of the TTC in up to 15 minutes in case of a failure. In normal operation, the "target flow" should be NTC or lower as described in 3.1.2. to be prepared to handle an N-1 fault. It could be relevant to introduce an indicator for system performance with minutes higher than TTC per year on some highly congested corridors in the same way as minutes outside the band for frequency. In case of congestions in the energy market, the flow should be equally distributed on each side of the "target flow" to reduce costly adverse (opposite direction to price difference) balancing power. However a common operational view is that the TRMs on many corridors are too small in practice to fulfil this due to uneven FCR-distribution, ramping on HVDC, changing consumption and other dynamic variations through the hour.

3.4.5 Correction of time deviation

In connection with planning and performing the balancing the Balance Operators also have to take into account and plan for keeping the time deviation within limits. The action to reduce time deviation is to deliberately keep the frequency a bit higher /lower than 50.00 Hz for a time.

This shall be performed in predicted stable situations where it is less likely that a lower/higher frequency will cause/worsen a potential disturbance.