Appendix 2. The Nordic aFRR Capacity Market

The contents of Appendix 2 describe the common Nordic aFRR Capacity Market and include:

2a		Market definition
2b		Market rules
2c		Initial Geographical Distribution and ex-ante reservation of Cross-zonal Transmission Capacity
	(1)	Calculation of the Initial Geographical Distribution
	(2)	Restrictions for Cross-zorder Transmission Capacity reservations
2d		Bid optimisation and bid selection
2e		Cost sharing among the Parties
	(1)	Calculation of the Sharing key
	(2)	Cost sharing model

2a. Market definition

The aFRR Capacity market will be defined by:

(1) its geographical scope, consisting of the Bidding Zones in which Balancing Capacity is procured;
(2) a pre-determined set of Imbalance Settlement Periods (ISPs) during which aFRR Balancing Capacity is procured.
(3) a pre-determined volume (MW) of aFRR Balancing Capacity to be procured per ISP.

The pre-defined volume of Balancing Capacity to be procured includes separate volumes for:

- Upward aFRR, that is aFRR for upregulation
- Downward aFRR, that is aFRR for downregulation

The Regional Group Nordic determines (1), (2) and (3) annually. Updates to (1), (2) and (3) will be published in Revision Document RD2 and communicated through the web pages of the parties.

2b. Market rules

The following market rules will be monitored as stated in the relevant Revision Document. The Regional Group Nordic is responsible for audits and revisions, as described in the main text of the Agreement.

(1) aFRR Balancing Capacity will be procured on a daily basis.
- Daily tender

(2) Balancing Capacity will be procured per Imbalance Settlement Period (ISP).
- For selected blocks of ISPs, see 2a Market definition, (3).
- BSPs will be allowed to couple ISPs in blocks of ISPs.

(3) Gate closure will be 20:00 CET D-2.

(4) The aFRR Capacity Market will use the same time zone as the Day-ahead Market.

(5) Minimum bid size will be 5 MW and be in 5 MW steps.

(6) Portfolio bids will be possible in Sweden, Denmark and Finland. In Norway, bids will be per station group.
- Portfolio bids will be per Bidding Zone.

(7) Single bids less than 50 MW can be marked as indivisible.

(8) Asymmetrical and symmetrical bids will be possible.

(9) Bids may be linked: up and down regulation and in time (block bids). Bids may also be presented as a bidding curve.
- Bidding curves cannot be combined with linking of up- and downregulation bids.

(10) The aFRR Capacity Market will be settled pay-as-bid.
- The Euro (EUR) will be the currency of the aFRR Capacity Market.
- BSPs will receive a pay-as-bid availability payment for each ISP in which the aFRR resource is available for activation.

(11) Full availability will be required with the exception for force majeure.

2c. Initial Geographical distribution and ex-ante reservation of Cross-zonal Transmission Capacity

2c (1) Calculation of the Initial Geographical Distribution

The calculation of the Initial Geographical Distribution considers a situation in which the Short-term Imbalance in each individual Bidding Zone is assumed to be equal to the historical average Short-term Imbalance of the Bidding Zone. The Short-term Imbalance is the imbalance that is mitigated by aFRR (currently between 5-30 minutes).

If aFRR is distributed among Bidding Zones proportionally to the historical average Short-term Imbalance values, aFRR is then only used to mitigate Short-term Imbalances in the Bidding Zone where it is allocated.

Minimum and maximum values will be defined separately for positive and negative imbalances:

- the Bidding Zone's share in the sum of the positive absolute Short-term Imbalance will be the value for the downward aFRR;
- the Bidding Zone's share in the sum of the negative absolute Short-term Imbalance will be the value for the upward aFRR.

The *inputs* to this methodology are:

- $Imb_i(t)$: One minute values of imbalance per Bidding Zone *i*
  - The Imbalance data shall be collected for the historic periods (hours, weekday, month) corresponding to when aFRR Capacity is procured. If no decision is made for when aFRR Capacity shall be procured, the contracting hours from last year shall be used.
- One minute values are calculated by Statnett's data warehouse based on several inputs, including:
  - Flow after intraday day

- Measured flow on AC tie lines[1] out of an area
- Frequency bias factor
- aFRR activation signals
- mFRR
- Quarterly movements

The Short-term Imbalance for each Bidding Zone *I*; this is calculated by:

$$Imb_{short,\,i}(t) = \frac{1}{t_s}\int_{t-t_s/2}^{t+t_s/2} Imb_i(\tau).\,d\tau - \frac{1}{t_l}\int_{t-t_l/2}^{t+t_l/2} Imb_i(\tau).\,d\tau$$

in which, t_s is 4 minutes and t_l is 30 minutes

Since upward aFRR and downward aFRR are considered separately, negative Short-term Imbalance (driver for upward aFRR) will need to be considered separately from positive Short-term Imbalance (driver for downward aFRR). Therefore $Imb_{short,\,i}(t)$ in $Pos\_Imb_{short,\,i}(t)$ and $Neg\_Imb_{short,\,i}(t)$, is split according to

$$Pos\_Imb_{short,\,i}(t) \quad \begin{cases} Imb_{short,\,i}(t) \text{ if } Imb_{short,\,i}(t) > 0 \\ \text{'no value'} \text{ if } Imb_{short,\,i}(t) \leq 0 \end{cases}$$

$$Neg\_Imb_{short,\,i}(t) \quad \begin{cases} Imb_{short,\,i}(t) \text{ if } Imb_{short,\,i}(t) < 0 \\ \text{'no value'} \text{ if } Imb_{short,\,i}(t) \geq 0 \end{cases}$$

The averages are calculated over time of the existing values of $Pos\_Imb_{short,\,i}(t)$ and $Neg\_Imb_{short,\,i}(t)$:

$\overline{Pos\_Imb_{short,\,i}}$: Average of Short-term Imbalance for Bidding Zone i for times that Short-term Imbalance is positive;

$\overline{Neg\_Imb_{short,\,i}}$: Average of Short-term Imbalance for Bidding Zone i for times that Short-term Imbalance is negative;

The total amount of Nordic aFRR, $Nordic\_aFRR$ shall be distributed among the Bidding Zones in proportion to the imbalance.

For each Bidding Zones *i,* this will result in an allocation of downward aFRR $aFRR_{Downward,\,i}$ and an allocation of upward aFRR $aFRR_{Upward,\,i}$ as follows:

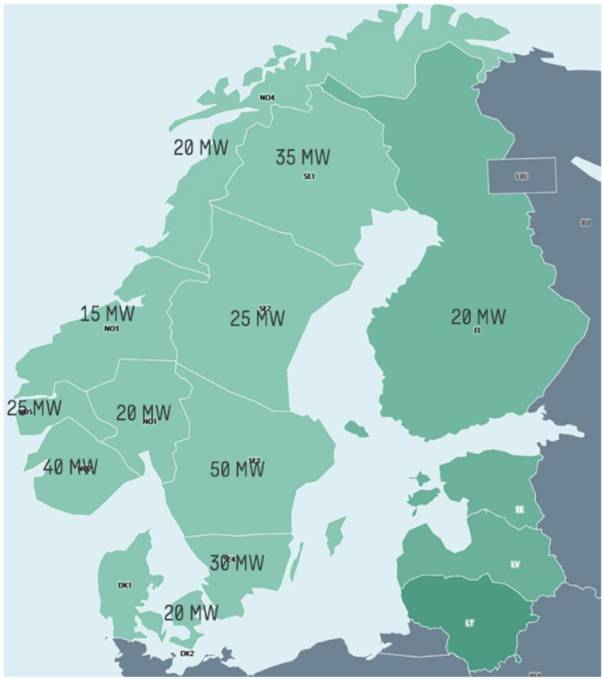
$$aFRR_{Downward,\,i} = \frac{\overline{Pos\_Imb_{short,\,i}}}{\sum_{i=Elspot\ areas}\overline{Pos\_Imb_{short,\,i}}} \cdot Nordic\_aFRR$$

$$aFRR_{Upward,\,i} = \frac{\overline{Neg\_Imb_{short,\,i}}}{\sum_{i=Elspot\ areas}\overline{Neg\_Imb_{short,\,i}}} \cdot Nordic\_aFRR$$

[1] Fennoskan DC cable is also included in the calculation of the short-term Imbalance, thus treated as an AC tie line.

The sets of $aFRR_{Downward,i}$ and $aFRR_{Upward,i}$ are the Initial Geographic Distribution and consequently the *output* of the methodology.

The figure below shows an example of a possible Initial Geographic Distribution when 300 MW aFRR Balancing capacity is procured.



Example of an Initial Geographic Distribution for upward regulation, with a total procured volume of 300 MW

The calculations for Initial Geographic Distribution will be published in Revision Document RD1, and they will be communicated through the web pages of the parties. The updating of the Initial Geographic Distribution is expected to be done annually.

2c (2) Restrictions for Cross-zonal Transmission Capacity reservations

Transmission capacity may be reserved ex-ante in both directions on interconnectors between the Bidding Zones in the Nordic Synchronous Area; there are however some circumstances which call for restrictions on interconnectors.

When calculating the value of transmission capacity for the calculation of an ex-ante Cross-zonal Transmission Capacity reservation, the following shall apply:

- A maximum of 10% of the forecasted Day-ahead Market transmission capacity may be reserved on each interconnector.
- When calculating the value of CZC for upregulation in the forecasted flow direction, an uplift will be placed on the value of Day-ahead Market transmission capacity:
    - if there is no forecasted Day-ahead Market price difference between the two Bidding Zones, the value of the uplift will be 0.1 EUR/MWh;
    - if there is a forecasted Day-ahead Market price difference between the two Bidding Zones, the value of the uplift will be the forecasted price difference between the two Bidding Zones plus 1 EUR/MWh.

- When calculating the value of CZC for downregulation against the forecasted flow direction, an uplift will be placed on the value of Day-ahead Market transmission capacity:
    - if there is no forecasted Day-ahead Market price difference between the two Bidding Zones, the value of the uplift will be 0.1 EUR/MWh;
    - if there is a forecasted Day-ahead Market price difference between the two Bidding Zones, the value of the uplift will be the forecasted price difference between the two Bidding Zones plus 1 EUR/MWh.
- When calculating the value of CZC for upregulation against the forecasted flow direction or for downregulation in the forecasted flow direction an uplift equal 0.1 EUR/MWh will be placed on the value of Day-ahead Market transmission capacity.

Additional transmission constraints may be provided in order to restrict the market optimisation algorithm. The reason for this is that there could be situations in which, despite the reservation of Cross-zonal Capacity and a lack of Bottlenecks, the procured amounts of aFRR could result in situations that are not considered secure from a technical/operational perspective.

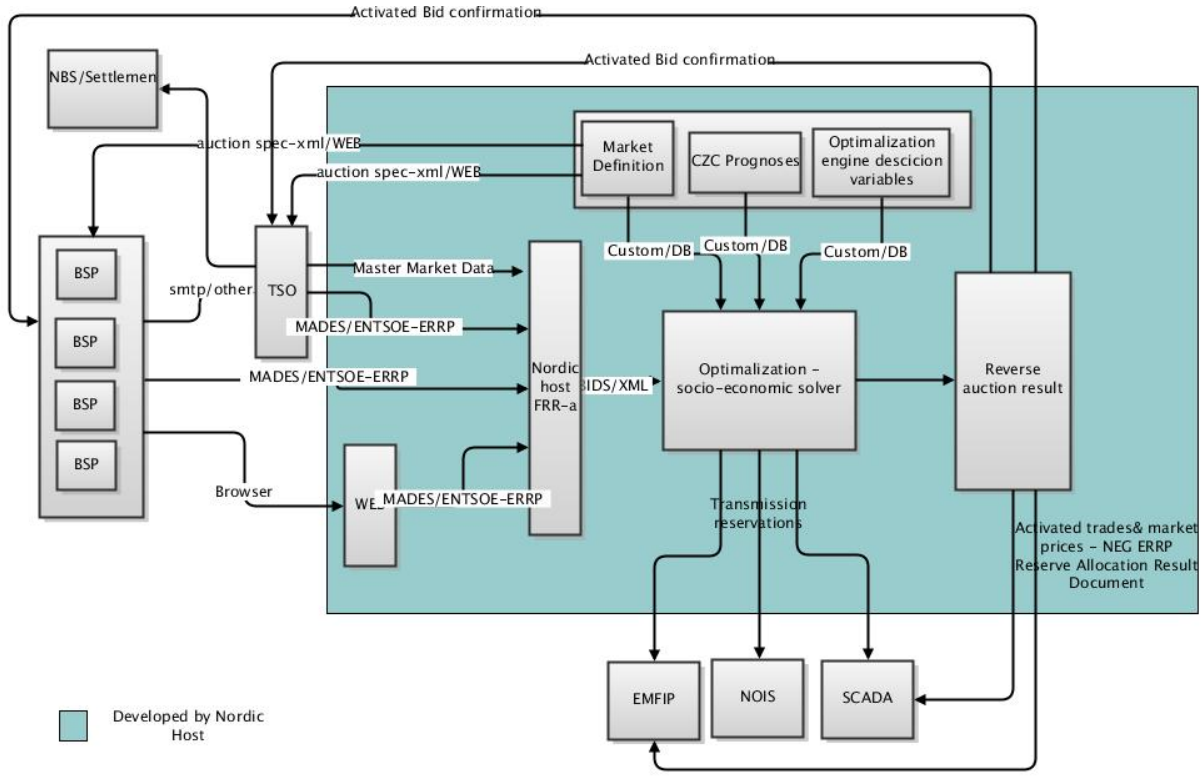
Each TSO is able to apply reservation restrictions to interconnectors between individual Bidding Zones, or groups of Bidding Zones, in the following circumstances:

- For interconnectors where NTC reservation is not effectively influencing the flow[2] (e.g. for NO3-NO1 where the NTC is decided based on the estimated flow, not the capacity limit, due to the stronger Swedish grid that runs in parallel)
- In order to prevent the supervision of flows from exceeding limits of acceptable complexity (e.g. in the case that aFRR capacity west of Hasle is more than 200 MW);
- Due to internal issues within the Bidding Zones.

In all cases, the reasons for limiting the market results will be transparently published. The channel for publication will be operated by the Market Operator and the publication language will be English.

[2] Initially the following corridors will be excluded: NO4-NO3, NO4-SE2, NO3-NO1, NO5-NO2.

2d. Bid optimisation and bid selection



The bid format will be based on ENTSO-E Reserve Resource Process (EERP), a standardised bidding format for the procurement of Reserve Capacity.

ENTSO-E's Market Data Exchange Standard (MADES) communication protocol will be used for the exchange of data.

BSPs will initially have three different options to send in their aFRR Balancing capacity bids:

- Directly to the host
- Via a web interface,
- With the existing bid format and protocol via the connecting TSO.

Connecting TSOs will have full access to all bidding data, also when bidding data is sent directly to the host.

Value of Day-ahead Market transmission capacity

A forecast tool will forecast the market value of Day-ahead Market transmission capacity. The forecast will be based on Day-ahead Market results from the previous day:

- Prices for each Bidding Zone per ISP,
- Commercial flows per ISP,
- Day-ahead Market transmission capacity per ISP for each interconnector. Published data on unavailability of production, consumption and transmission assets will provide additional input to the forecast.

The value of Day-ahead Market transmission capacity will be the main input to the calculations to determine whether reserving Cross-zonal Transmission Capacity for aFRR Balancing purposes on an interconnector between two Bidding Zones leads to increased socioeconomic welfare. If the Day-ahead Market results from the previous day are considered to be a poor indicator of the value of the Day-ahead Market transmission capacity, this will form additional input to the forecast; details of this methodology can be found in RD3. In all cases, the reasons for limiting the market results will be transparently published. The channel for publication will be operated by the market operator and the publication language will be English.

Bid optimisation, bid selection and transmission capacity reservation

In an iterative process, bids are selected and Cross-zonal Transmission Capacity is reserved until an acceptable solution is found.

Transmission capacity will only be reserved if the aforementioned calculations show that a reservation increases socioeconomic welfare. Consequently, transmission capacity will only be reserved if the price difference between the relevant Bidding Areas is larger in the aFRR Capacity Market than in the Day-ahead Market.

The optimisation will be done taking into account the following restrictions:

- Initial Geographical Distribution,
- bids from BSPs,
- the forecasted value of Day-ahead Market transmission capacity.

The outputs from the optimisation tool are:

- the selected bids,
- reserved Cross-zonal Transmission Capacity (MW) per interconnector; the Day-ahead Market transmission (trading) capacities communicated to the power market on the day before delivery will be decreased by this amount.

If the optimisation fails, there will be back-up routines that will aim to minimize the market impact, as described in RD3.

2e. Cost sharing among the Parties

2e (1) Calculation of the Sharing key

The financial obligation for the procurement of aFRR capacity will be shared between the TSOs according to a Pollution-based Sharing Key, which is based on the Polluter-Pays Principle per Control Area.

The indicator for the ‘pollution’ shall correlate with the need for aFRR, i.e. if the total pollution as indicated by this indicator decreases, the need for aFRR shall decrease as well. Consequently, when costs are allocated to the different Parties (e.g. TSOs) based on this indicator, this shall provide an incentive to the Parties to reduce their ‘pollution’.

The indicator for pollution is the imbalance minus the rolling average of the previous ISP. The "90% percentile" is used as the ‘pollution’ indicator for aFRR capacity. It is a good proxy for the maximum

use of contracted capacity and consequently for the need for contracting that amount of capacity. It is not sensitive to special conditions (including disturbances) and outliers that are caused by data errors.

The *inputs* to this methodology are:

- $Imb_i(t)$: One minute values of imbalance per Control Area *i*
    - The imbalance data shall be collected for the historic periods (hours, weekday, month) corresponding to when aFRR Balancing capacity is procured. If no decision is made for when aFRR Balancing capacity shall be procured, the contracting hours from last year shall be used.
- One minute values are calculated by Statnett's data warehouse based on several inputs, including:
    - Flow after intraday day
    - Measured flow on AC tie lines out of an area
    - Frequency bias factor
    - aFRR activation signals
    - mFRR
    - Quarterly movements

The Short-term Imbalance for each Control Area *I*; this is calculated by:

$$Imb_{aFRR,\,i}(t) = \frac{1}{t_s}\int_{t-t_s/2}^{t+t_s/2} Imb_i(\tau).\,d\tau - \frac{1}{t_l}\int_{t-t_l/2}^{t+t_l/2} Imb_i(\tau).\,d\tau$$

in which, t_s is 5 minutes and t_l is 60 minutes

The calculation is made by each Control Area. All calculations will be published in Revision Document RD4.

All Parties shall have access to the methodology for imbalance calculations, and shall have access to all background data upon request. The Parties are jointly responsible for the data quality and the calculation methodology.

2e (2) Cost sharing model

Control Areas with more procured aFRR Capacity than its aFRR obligation are termed *exporting Control Areas*. Control Areas with procured aFRR Capacity below their aFRR obligation are termed *importing Control Areas*.

Balancing Capacity offers from BSPs will be settled pay-as-bid. The methodology to share the costs arising from this settlement will be based on the principle that exporting Control Areas first fulfil their own aFRR obligation with the cheapest available Balancing Capacity bids from the bottom of the bid curve, after which the remaining bids are "exported" to importing Control Areas. Importing Control Areas pay the average cost of the capacity imported across all Nordic Control Areas.

In more detail, the above methodology entails the following:

1. The choice of cost sharing methodology will not affect the optimisation process. The common Nordic procurement of aFRR Balancing Capacity will be made optimally on a Nordic level. This means that Balancing Capacity will be procured where it is cheapest, taking into account the Initial Geographical Distribution and cross-zonal restrictions.

2. An obligation per Control Area is defined by the chosen sharing key, see 2e (1).

3. In Control Areas where the amount of procured Balancing Capacity exceeds the local aFRR obligation, the local aFRR obligation will be met by the cheapest bids in that Control Area.

    - If the amount of procured Balancing Capacity in a Control Area exceeds the aFRR obligation, the excess bids (more expensive) will be paid for by the remaining Control Areas' TSOs.
    - If the amount of procured Balancing Capacity in a Control Area does not meet the area's obligation, the residual aFRR obligation is met by "import" from Control Areas with excess capacity.

4. Importing Control Areas pay the average price of the "imported" capacity. In other words, the total cost of the excess capacity is divided among importing Control Areas in relation to how much they "import".