NBM
Nordic Balancing Model

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Nordic TSOs proposal for common settlement rules for the intended exchange of energy as a result of FCP and ramping and for the unintended exchange of energy, within the Nordic Synchronous area, in accordance with EBGL article 50.3 and 51.1

Explanatory document

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DISCLAIMER

This explanatory document is submitted by all transmission system operators (TSOs) of the Nordic synchronous area to all national regulatory authorities (NRAs) for information purposes only accompanying the Nordic TSOs' proposal for a common settlement rules in accordance with Article 50(3) and 51(1) of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing.

Summary of the proposed settlement rules

The Nordic TSOs propose that the intended exchange of energy as a result of FCP and the unintended exchange of energy will be calculated and settled per border of the two bidding zones exchanging the energy, with the settlement period equal to one ISP. The settlement price is the average of the balancing energy prices in the dominating direction for the mFRR product in the Nordic synchronous area. The volume of energy exchange is equal to the difference between the measurement and the control program at the border, where the control program includes all intended exchange of energy except FCP exchange. Furthermore, the Nordic TSOs propose that the settlement of intended exchange of energy as a result of a predefined ramping period is based on the same principles as described above. The volume of energy exchange is calculated based on a predefined ramping period and the change in the aggregated netted schedule per border at an ISP shift.

The design of the Nordic balancing market is in a transit period with several EBGL and SOGL driven changes currently under development, which will be implemented within upcoming years. These changes will also have consequences for the TSO-TSO settlement described in this explanatory document. The implementation time for the Proposal in accordance with EBGL Article 50(3) and 51(1) is expected to be before other market design implementations are ready. This results in challenges related to the robustness of the Proposal.

The changes for which the Nordic TSOs have identified expected effect on the settlement will be implemented gradually and independent of each other. However, the full effect of the changes will result in a wider fundamental change of the balancing model in the Nordics. The expected independent changes affect the main components of the Proposal, such as the actual volume determination (in practise) and pricing. Some of these changes can already be accounted for in the Proposal, but for others it is expected that the TSOs need to amend the Proposal to be able to comply with the legal requirements once new market design is implemented. When all expected changes affecting the Proposal are implemented, it is possible to start an overall review of the Proposal and validate with historical data if there are more suitable alternatives for TSO-TSO settlement to be considered. Thus it is expected that the Proposal needs to be reviewed one year after the Nordics have implemented ACE based balancing.

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Content

1 Introduction

This explanatory document describes the scope and content of the Nordic TSOs' proposal for common settlement rules for unintended exchange of energy (Article 51.1) and for intended exchange of energy as a result of FCP energy and ramping (Article 50.3) in accordance with Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (EBGL).

The structure of the document is as follows. After this general introduction, current settlement rules and the expected future changes due to the new Nordic Balancing Model and European harmonization are described. This is followed by the proposed settlement rules for FCP energy exchange and unintended exchange in Chapter 2 and proposed settlement rules for ramping energy in Chapter 3. Chapter 4 describes the rationale behind the choice of one legal proposal for the two articles in EGBL. Chapter 5 discusses how the Proposal aims to take into account the expected changes in the future and also the expected reviews of the settlement rules. In Annex 1, a detailed definition for calculating the energy volumes of intended exchange as a result of FCP and unintended exchange across a border is presented.

1.1 Current settlement rules

Today, TSO-TSO settlement in the Nordics identifies only one pooled volume to be settled between TSOs. This volume is the difference between the scheduled exchange as a result of the day-ahead and intraday market and the actual physical exchange. Special regulation across a border is also accounted for, and deducted from the measured value. This volume therefore include FCP energy and unintended exchange of energy, but it also includes other types of energy flows such as intended exchange of balancing energy and netting of demand.

This total volume is currently settled per border and priced with the average of the regulating power price in the dominating direction of the two bidding zones sharing the border. The regulating power price in the main direction is today the same as the imbalance price for consumption. If there is a price difference between the two areas, the TSOs are exposed to this difference, either negative or positive. Settlement is done in accordance with the Nordic System Operation Agreement and bilateral settlement agreements between the Nordic TSOs.

The day-ahead (DA) and intraday (ID) market model enables identification of importing and exporting areas for the energy flows resulting from the market clearing. Flows between these importing and exporting areas are ex-ante allocated to specific borders depending on capacity assumed to be available.

In the current Nordic balancing markets, activation of balancing energy is made based on the frequency, which is common for all LFC areas. The energy flows resulting from the activations are as such not assigned to specific borders, meaning the intended exchanges of mFRR and aFRR energy are not identified for specific borders, and therefore there is currently no separate settlement for these volumes. As a result of this, only the exchange from the DA and ID market is used to compare with the actual physical flows to determine the volume to settle between TSOs. Determination of intended exchanges of aFRR and mFRR or netting of demand would today require the application of arbitrary assumptions.

In summary, given the current Nordic balancing market design, the same settlement rules as under EBGL 50.3 and 51.1 in the Nordics must therefore also apply for intended exchange as a result of mFRR and aFRR energy exchange before the new market design is introduced. This is further discussed in Chapter 5.

1.2 Expected changes towards ACE based balancing

In the near future, fundamental changes to the current balancing practice and market design will be implemented which will have an effect also on settlement in the Nordics. The changes in balancing for the Nordics are a result of the European harmonization of aFRR and mFRR markets and the implementation of the new Nordic Balancing Model, under which the balancing of the Nordic synchronous area becomes based on the individual LFC area control error (ACE) instead of the common frequency. This is referred to as ACE based balancing.

As will be shown in Chapter 2, the settlement volume resulting from the frequency containment process and unintended exchange are dependent of how other exchanges of energy are defined per border. The identification of the agreed exchange of energy due to aFRR and mFRR, including netted demands, per border becomes possible with the implementation of the new Nordic Balancing Model, more in detail by introducing and updating the cross-border balancing energy markets for frequency restoration reserves. These will take into account both mFRR and aFRR products and enable netting of demand between LFC-areas[1]. This will enable to define the traded balancing/netted energy per border, and further enables to in practice calculate more accurately the FCP and unintended exchange of energy.

Other expected changes in the future include the harmonization of the imbalance settlement period (ISP), the European harmonized balancing prices and reviews of imbalance price calculation, as well as possible pricing of FCP towards providers. These changes are expected to have direct or indirect effects on TSO-TSO settlement. With this Proposal, the TSOs attempt to take into account as many foreseen changes as possible in the

[1] The Nordic TSOs are not expected to join the imbalance netting platform (IGCC), but netting will in addition we handled in the platforms for activation of balancing energy for FRR (with reference to Article 31 (1) d) in the EBGL).

balancing markets. The effects of these expected changes and how the proposal can take them into account is discussed further in Chapter 5.

2 Settlement rules for FCP energy exchange and unintended exchange

In this section the proposed settlement rules for FCP energy exchange and unintended exchange are introduced.

2.1 Definition of FCP energy exchange and unintended exchange for volume determination

In addition to the intended exchanges from the day-ahead and intraday markets, as well as from the FRR process and other agreed TSO-TSO exchange purposes, including congestion management and system security related actions, there will be energy flows between the TSOs due to the intended exchange as a result of FCP and unintended exchanges.

The frequency containment process is triggered by frequency deviation which occurs when there is a net imbalance between load and generation in the synchronous area. Unintended exchanges do not lead to frequency deviations but are still unplanned exchanges. An example of this is flows occurring due to netting which is not intended, which can happen due to the activation time of FRR when (local) activation is selected by the activation optimisation functions instead of netting of demand or in-between the optimisation cycles (in this document both examples are referred to as unintended netting).

For the purpose of determining the volume of FCP energy exchange and unintended exchange of energy, a definition of the energy volumes has been developed. The full derivation is presented in Annex 1.

FCP energy exchange and unintended exchange across a border is defined as the difference between the measured energy exchange across the border subtracted by the control program[2]. For the purpose of this document, the control program contains all agreed exchange of energy across the border such as market results from the day-ahead and intraday trade, as well as TSO-TSO exchanges, where the latter includes all intended exchanges such as aFRR and mFRR energy activation, including netting of demand, ramping or any other agreed TSO-TSO exchange. By this assumption, the difference between the measured value and the control program is the sum of FCP energy exchange and unintended exchange. This relation is presented in the equation below.

$$MEAS - CP = FCP_{ex} + UE$$

[2] The term control program is used here to simplify all the agreed energy exchanges between TSOs under one factor. The control program used for the power calculations is not in scope of the settlement proposal and will be defined in Synchronous area operational agreement by SOGL Article 118(1)(g).

Where

- *MEAS* is the measured energy volume,
- *CP* is the control program, including all agreed TSO-TSO exchanges
- FCP_{ex} is the energy exchange as a result of FCP, and
- *UE* is the unintended exchange of energy.

Based on the definition of ACE in SOGL article 3.2(19), the following relation is introduced

$$MEAS - CP = FCP_{ex} + UE = \int_0^t ACE(t) - k_i \int_0^t \Delta f(t)$$

Where

- $\int_0^t ACE(t)$ is the energy imbalance of an area due to ACE, over period t, and
- $k_i \int_0^t \Delta f(t)$ is the compute value of energy activation for FCP within the area as a result of the frequency deviation, over period t.

The FCP response within an area to frequency deviation is not necessarily equal to the FCP exchange across the border(s) of that area since the area might have an imbalance that has contributed to the realized frequency deviation. Therefore, the following generally holds:

$$FCP_{ex} \neq k_i \int_0^t \Delta f(t)$$

As a result of the above, the actual exchanged volume of FCP energy is not possible to identify analytically. Calculating the FCP energy exchange would require application of arbitrary assumptions. By extension it is not possible to identify unintended energy exchange explicitly.

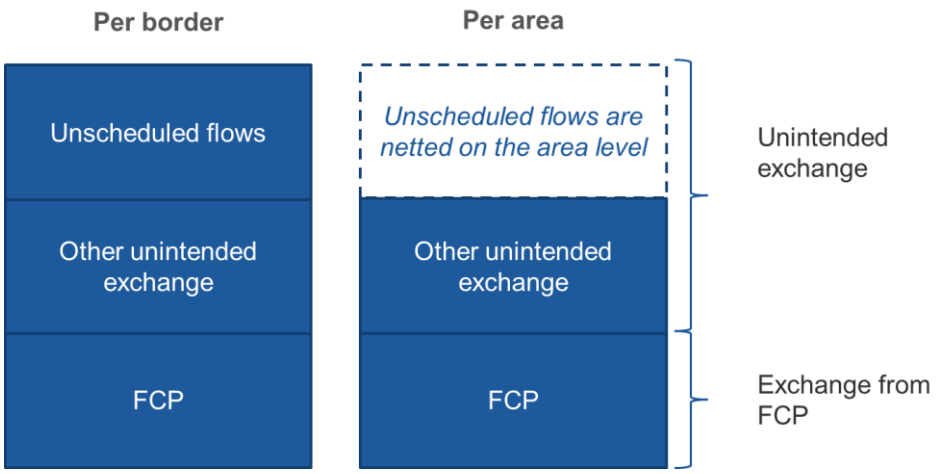
In this proposal, the energy exchange from FCP and unintended exchange is therefore not separated, but pooled into one volume. The proposed settlement rules result in settlement of the actual energy exchange.

2.2 Per border settlement

The pooled FCP energy and unintended exchange can be identified either per-border or per-area, which are two fundamentally different approaches. The per-area approach will only consider the aggregate deviation from intended exchange per area, while the per border approach will consider deviation from the planned values on each area border individually.

In an AC grid it is unlikely that cross-border flows will exactly match the intended exchanges as identified in the different energy and balancing markets, even if the area in total is exporting or importing according to plan. Such deviations from intended exchanges are here referred to as unscheduled flows. On an area level unscheduled flows are always netted.

Today, unscheduled flows are settled in the Nordics in the lump-sum settlement per border.



It is currently not possible to determine the "optimal" settlement approach between per border or per area. The choice between the two approaches can be interpreted as what in practice is the optimal solution. For the Nordic TSOs to assess what in practice is the best solution, it is necessary to know the volumes of the different components. The flows can be assessed, even if it is not possible to split the exchanged volumes[3]. Such knowledge will only be available when all required changes related to ACE based balancing are in place. This will enable for an analysis of the impact of a change in settlement practice.

The Nordic TSOs therefore propose to continue with the current settlement practice with settlement per border as there today is no well-reasoned argumentation to change. The Nordic TSOs will undertake an evaluation of the settlement rules one year after the implementation of ACE based balancing when historical data is available which enables for analyses of the different impacts and outcome of settlement per border and per area, and if there would be reason to propose an amendment.

2.3 Price base and calculation

Article 51.1(a) and 51.1(b) in EBGL specify that the settlement price of unintended energy exchange shall reflect the price of balancing energy activation. No requirement for the price base for FCP energy exchange is specified in the EBGL.

The suggested price base for settlement of FCP energy exchange and unintended exchange is therefore the balancing energy prices in the dominating direction for the applied mFRR product in the Nordic synchronous area.[4] This is the same price base as currently used for TSO-TSO settlement in the Nordics. It also constitutes the imbalance price for

[3] By comparing the volumes derived per area and border, it is possible to quantify the volume of unintended exchange due to unscheduled flows. By calculating ACE and kΔf and comparing them, it is possible to identify the total volumes of FCP and unintended exchange from unintended netting for the synchronous area.

[4] By dominating direction is meant the direction of the net balancing energy of a given uncongested area, where the latter may consist of one or several bidding zones.

consumption in today's imbalance settlement. Further, the balancing energy prices for mFRR (direction dependent) are the reference prices for balancing energy from FCR and aFRR. The balancing energy price for mFRR is therefore central for the settlement of balancing energy to both balance responsible parties and balance service providers and between the TSOs in the Nordics today.

As the settlement is proposed per border, the volume will be priced at the average of the price base on each side of the border, resulting in exposure to the price difference, positive or negative.

The volume to be settled is a pooled sum of energy volumes, where it can be argued that different price bases for the different components would be the most correct approach. Without further knowledge of the volume composition, the use of a general reference price can be argued to be the most neutral choice, and the mFRR price in the dominating direction is therefore a good representation in the Nordics today.

This will however be challenged in the future, when we will have separate pricing of balancing energy from aFRR, potentially a revised pricing of balancing energy from FCR and potentially more than one activation method for mFRR (scheduled and direct activation). It will therefore be natural to revise the price base in the future, and within a per border settlement approach, it may be the case that the imbalance price (which the Nordics today indirectly uses) fully or partly will be a better representation. It is however today not recommended to use the imbalance price as a general price base, as it is not decided how the imbalance prices will be set in the future in the Nordics when there is more than one balancing energy price for FRR. The Nordic TSOs aim to have a mostly harmonized imbalance price calculation, but there is no legal obligation and thus no guarantee of a harmonized imbalance pricing.

In the proposal it is explicitly written that at the point in time when there is more than one FRR product price for balancing energy available, the proposal shall be reviewed. It is expected that during that time it will be also decided how the imbalance price will be calculated for the Nordic countries.

2.4 Settlement period

As the chosen price base is the balancing energy price in the dominating direction of the applied mFRR product, and as settlement is done per border, the natural choice of settlement period is equal to the imbalance settlement period. The settlement period of intended exchange due to FCP and unintended exchange between the Nordic TSOs shall therefore be equal to the ISP. Currently the ISP is one hour in Nordics, but it will be changed to 15 minutes in the future. Even though it is expected that the Nordics will implement 15 minute ISP at the same time, the proposal takes into account, for sake of robustness, that in case there would not be a harmonized ISP

within the Nordics, the settlement period will be the shortest of the ISPs of the relevant settlement parties.

3 Settlement rules for ramping energy

In accordance with SOGL article 136, the calculation of the ACE for each LFC area shall be performed based on the control program calculation including a common ramping period. In this section, the proposed settlement rules for ramping energy as a result of the common ramping period are introduced. A Nordic ramping period for the AC grid has not yet been determined. This proposal therefore takes a general approach which is foreseen to accommodate any potential ramping period introduced in the future in accordance with SOGL article 136.

3.1 Definition of ramping energy for volume determination

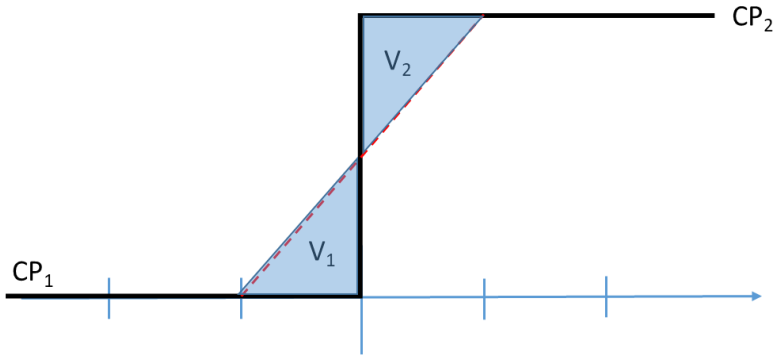
At the shift of a market time unit (MTU) the original DA and ID schedules follow a stepwise change.[5] Such stepwise changes cause unnecessary stress on the LFC-controllers which are predictable and of short duration. This is not beneficial. In addition, adding a ramp is an agreement between the TSOs that defines how changes should occur in the system, and give incentives to TSOs for such profiles to be followed. In the addition, the actual change in of generation and load have ramps, so adding a ramp will in general (not always) be more reflective of the actual changes in the system.

The ramping period is a time period starting on an agreed point in time in the first ISP and ending at the point in time where the market schedule for the subsequent ISP has been reached. The time period can either be symmetrical or asymmetrical around the ISP shift. It can be a predefined time period with a start and end time or only a predefined start time and a ramping rate. The latter will result in a varying end time dependent on the change in volume at each ISP shift.

During the ramping period the original DA and ID schedule is allowed to change linearly instead of requiring to keep the original market result schedules and thus avoid to require the stepwise change in the ISP shift. Once a ramping period in accordance with SOGL article 136 is introduced in the Nordics, the volume calculation of intended ramping energy is dependent on the ramping period. The calculation of the ramping energy in accordance with this proposal allows for a ramping period equal to zero. This would mean setting the control program equal to the original DA and ID schedules.

[5] Below we will use the term ISP instead of MTU as these correspond today.

A theoretical symmetrical ramp is shown in the figure below where V_1 is the ramping energy volume in the first ISP, V_2 in the second ISP, CP_1 is the control program (disregarding the ramp) in the first ISP and CP_2 in the second ISP. The presented example and related equations are only applicable for a symmetrical ramping period.



If we assume a predefined ramping period, *RP*, symmetrical around the ISP shift, the ramping energy volume faced by a TSO, V_{ramp}, can be defined as the sum of volume V_1 and V_2 in the figure, where the two volumes are equal.

$$V_{ramp} = V_1 + V_2 = V_1 \times 2$$

Then volume V_1 can be calculated as following

$$V_1 = \frac{\frac{(CP_2 - CP_1)}{2} \times \frac{RP}{2}}{2}$$

Which results in the following ramping energy volume

$$V_{ramp} = \frac{\frac{(CP_2 - CP_1) \times RP}{4}}{2} \times 2 = \frac{(CP_2 - CP_1) \times RP}{4}$$

The control program (disregarding the ramp) can differ between each ISP while the ramping period is expected to be predefined as one constant value equal to a specified time.

Any deviations from the predefined ramp will result in a difference compared to intended exchanges and the energy volume will be included in the energy settled as unintended exchange and FCP energy in that area. This is not defined as intended exchange and therefore not handled as ramping energy.

3.2 Price base, calculation and settlement period

Without ramping, the TSOs would have to balance the power imbalances due to the continuously changing nature of consumption and the physical ramping restriction for (some) generators. This is done using either aFRR or mFRR, including netting of demand. Ramping is thereby an exchange of energy on a specific border predefined by the TSOs.

By this follows that the prices for aFRR and mFRR are the relevant alternative prices for the ramping exchange, as the structural mismatch due to not using the ramping would have been handled through netting of demand or activation. Today this is priced at the mFRR price (direction dependent), the price in the dominating direction being the most neutral choice as a general reference price. The same price base as for FCP energy exchange and unintended exchange is therefore proposed for ramping, meaning the balancing energy price in the dominating direction for the applied mFRR product in the Nordic synchronous area.

As for FCP energy exchange and unintended exchange, this price base may be less correct in the future, and a revision may be necessary. The imbalance prices may be a relevant alternative.

From the above, it follows that the ramping energy should be settled per border and therefore priced at the average of the price base resulting in exposure to the price difference, positive or negative.

Ramping volumes are settled on a border between two TSOs. Over a set of several ISP shifts, a TSO is both selling and buying ramping energy. If in the first ISP the TSO is selling ramping energy, it will be buying the ramping energy in the subsequent ISP, and vice versa. Thus in case there is no structural change in ramping direction combined with structural price difference in imbalance prices between the ISPs, the TSOs financial result over time should converge towards a small number. From this perspective it might be a practical choice to agree to set the settlement price as zero.

However taking into account, that there can be is a structural pattern in the price difference of the subsequent ISPs together with the direction of ramping, it would mean that there is a different value of energy in each ISP, which should be taken into account in the pricing. Thus it can be argued that the exchange of ramping energy shall be settled in accordance with the same rationale as for all other energy exchange, resulting in exposure to the price difference and the value of energy at a certain point of time.

The Nordic TSOs propose to settle the ramping energy at the average of the balancing energy price in the dominating direction for the applied mFRR product in the Nordic synchronous area at the relevant border per ISP.

4 One proposal for article 50.3 and 51.1

As explained earlier in this document, it is not possible to separate the volumes from exchange of FCP and unintended exchange. Therefore, the Nordic TSOs have decided to develop one legal proposal covering both EGBL article 50(3) and 51(1). If the Nordic TSOS were to develop two separate proposals, the proposals would be heavily interdependent of each other and would therefore need to refer to each other. They would also need

to be revised together in case of amendments. For the sake of robustness and clarity, the Nordic TSOs have therefore decided to establish only one legal proposal[6].

5 Effect of new market design on the Proposal

The TSOs expect that the Proposal in accordance with EBGL Article 50(3) and 51(1) shall follow the implementation timeline set in EBGL Article 5(5), which means that the deadline for the proposal implementation is by 12 months after relevant regulatory authority approval. This means that taking into account the maximum 6 months' time for NRA approval according to Article 5(6), the expected deadline for the implementation of the Proposal would be in December 2020. Thus the Proposal is developed such that it is possible to implement it by the expected deadline of December 2020.

After the year 2020, expected changes in market design of the balancing energy market will be implemented which will have an effect also on the TSO-TSO settlement. Three core issues for TSO-TSO settlement that are expected to be changed due the EBGL requirements and Nordic development towards ACE based balancing are:

- volume determination of intended exchange, which currently constitutes the essential part of the actual calculated volume of unintended exchange and FCP energy exchange;
- European harmonization of the balancing energy prices, which provides a core part for the imbalance pricing;
- harmonization of the imbalance settlement period.

The Proposal is developed to take into account the expected future changes to the extent possible. The dependencies with the Proposal and expected implementation schedules of above listed items are described in below chapters.

5.1 Volume determination of intended exchange

The unintended exchange is the energy that is not defined as intended and its volume calculation can be theoretically defined as the difference between the measured energy exchange per TSO-TSO settlement period and all the intended exchanges, as explained more in detail in chapter 2.1. As the different intended exchange volumes are part of the equation, the actual volume determination of intended exchange has a significant effect on the volume of unintended exchange.

[6] It would be possible to make a separate proposal for ramping, but for the sake of simplicity, we have kept it together with the proposal for FCP and unintended exchange.

The EBGL defines a set of energies referred to as intended exchange in article 50(1) and 50(3). The list of intended exchange of energy is interpreted as non-exhaustive, as there can also be agreed energy exchange between the TSOs. This could for example include the energy as a result of counter trade, emergency situations and similar. The determination of the volume of intended exchange resulting from aFRR and mFRR exchange for each separate area or border is something that the Nordics are currently not doing. It is expected that the energy volumes will be defined per border at the latest when the Nordic TSOs are joining the European platforms.

The challenge with the implementation timelines is that the legal deadline for the implementation of the common platforms is not before 30 months after NRA approval of the implementation framework proposals. The earliest deadline could be assumed to be by the end of year 2021, and the deadline can be postponed even further depending on the required approval process. This means that the way intended exchange of energy is defined changes at the latest when other balancing market design features change. This logically leads to the consequence that the unintended exchange volume calculation will have a different, more accurate, result when it is possible to actually separate the intended exchange volumes.

The Nordic TSOs have aimed to write the Proposal such that it takes into account the future changes in the volume determination of intended exchanges to the extent possible, but it should still be robust also for the time before the platforms can calculate the volumes of intended exchanges resulting from aFRR and mFRR processes. Article 4 of the Proposal includes the intended exchanges in accordance with Article 50(1) of EBGL and this refers to the volumes that are defined in the future by the European platforms. However, as long as there is no such volumes defined, these volumes cannot be taken into account in the volume calculation for unintended exchange and FCP energy exchange. So for the time period when it is not possible to calculate the intended exchange, the volumes of the mFRR and aFRR exchange will end up in the common volume of unintended exchange and FCP energy exchange and be settled in accordance with the same price.

Before the European platforms are implemented, there is no legal obligation, but voluntary development of Nordic balancing markets, which may give possibility for the Nordics to define already earlier the intended exchanges of mFRR and aFRR. These volumes will then be treated as agreed TSO-TSO exchange and separated from the volume of FCP and unintended energy exchange.

5.2 European harmonization of the balancing energy prices

In the future there are also upcoming changes of the pricing related to the balancing market design. It is expected that the fully harmonized balancing prices in Europe in accordance with EBGL Article 30(1) are implemented as

part of the European balancing platforms. The Nordic TSOs expect that from a legal point of view there is not yet any requirements of a harmonized price base at the point in time when the settlement proposal is to be implemented.

As explained in chapter 2.3., the Nordic TSOs argue that for per border settlement the logical price used for the unintended exchange and FCP energy exchange is to be in line with imbalance pricing. In the future, it is expected that the price used for imbalance settlement will be calculated based on the harmonized balancing prices. It is expected that there in the future will be different balancing price components; balancing price for the aFRR product, balancing price for mFRR scheduled activated product and also possibly for a direct activated mFRR product. However, as long as there is uncertainty about how and when the imbalance price calculation will be affected, it is not possible to decide on a robust future calculation of the TSO-TSO settlement price. A price calculation that includes aFRR and possibly both a direct and scheduled activated mFRR energy balancing price is not relevant until such changes are implemented. Therefore, these prices are not included in the calculation before this point in time.

However, today there is a common balancing energy market for mFRR in the Nordics which serves as a price base for the imbalance price (equal to the imbalance price for consumption before the Nordics move to single position). Therefore, that price can serve well as a basis for the TSO-TSO settlement for the time when there is only one balancing energy market and one activation approach. When the Nordics will have more than one FRR balancing energy price there will be an amendment of the proposal.

5.3 Harmonization of the imbalance settlement period

The choice for the TSO-TSO settlement period is the imbalance settlement period. There is an expected change from the current one hour imbalance settlement period towards 15 minutes imbalance settlement period. By setting the TSO-TSO settlement period equal to the imbalance settlement period, the Proposal is robust to the upcoming change.

5.4 Future review of the Proposal

The above chapters 5.1 – 5.3 describe how the settlement will be affected when the market design gradually will change in the future, and possible small amendments that may be required (in particular chapter 5.2). However, among the gradual changes there is also a significant change expected, which is the change of the Nordic way of balancing. This change to so called ACE based balancing will provide the basis to review whether an area based settlement methodology or continued per-border settlement would be the best solution in practice for the future. Currently there is not enough data and knowledge to review whether an area-based settlement is more desirable, and there is no theoretical optimal solution. Thus, the proposal is developed to be implemented by the end of year 2020, but when

the Nordic TSOs have implemented the ACE based balancing, a one year period is suggested for collecting data to carry out analyses which can be used as a basis for the review of the Proposal.

6 Annex 1

Below a definition for calculating the energy volumes of intended exchange as a result of FCP and unintended exchange across a border is presented. All parameters written in lower-case letters indicate power measurements, while parameters written in upper-case letters indicate energy measurements. The ACE value throughout the document is closed loop ACE, unless otherwise stated. For simplicity, it is assumed that the measurement error is equal to zero.

The control program is in these calculations assumed to contain all agreed exchanges to and from an area, including TSO-TSO trade, so called intended deviations, except for FCP energy exchange.

The derivation of the definition starts with the definition of ACE in accordance with SOGL article 3.2(19), for the purpose of presenting the relation between FCP energy exchange and unintended energy exchange across a border to activated FCP energy and ACE within an area.

Let's assume the ACE power calculation for area i, in accordance with the ACE definition in SOGL:

$$ace(t)_i = \Delta p(t)_i + k_i \Delta f(t), (1)$$

where $k_i \Delta f(t)$ is the computed value of FCP energy activation for area i, not the exact physical reaction, but rather an assumption. And as

$$\Delta p(t)_i = meas_i(t) - cp_i(t), (2)$$

where $meas_i(t)$ is the momentary measurement and $cp_i(t)$ is the momentary power value of the control program, we can further write

$$ace_i(t) = meas_i(t) - cp_i(t) + k_i \Delta f(t), (3)$$

Now if we want to have an energy measurement for the time period from 0 to t, we take the integral over the whole equation and the following holds:

$$\int_0^t ace_i(t) = \int_0^t meas_i(t) - \int_0^t cp_i(t) + k_i \int_0^t \Delta f(t), (4)$$

Now as the net measurement will tell the actual net flow from or to the area, the integral over the time period t of the power measurement values should be same as the energy value measured for the time period t, assuming the measurement error is equal to 0.

$$MEAS_i = \int_0^t meas_i(t), (5)$$

where $MEAS_i$ is the net energy flow value metered over the time period t.

Taking into account equation (4) and (5) we can write

$$MEAS_i = \int_0^t meas_i(t) = \int_0^t ace_i(t) + \int_0^t cp_i(t) - k_i \int_0^t \Delta f(t), (6)$$

The measured energy net flow can be divided into the different volumes of intended exchange of energy. One part of intended exchange is the energy defined in the control program and that energy for period *t* is assumed to be given. It is denoted CP_i, which is equal to the integral of the momentary power measurements

$$\int_0^t cp_i(t) = CP_i, (7)$$

The energy exchanged as part of frequency containment process (FCP) is also considered as intended and simply denoted as $FCP_{\text{ex.}}$ Now unintended energy denoted as UE is energy that is not exchanges as intended. Now we can write:

$$MEAS_i = CP_i + FCP_{ex} + UE, (8)$$

and using equation (8), and (6) the equation:

$$MEAS_i = CP_i + FCP_{ex} + UE = \int_0^t ace_i(t) + \int_0^t cp_i(t) - k_i \int_0^t \Delta f(t), (9)$$

And as equation (7) holds, we can subtract CP_i from the equation:

$$MEAS_i - CP_i = FCP_{ex} + UE = \int_0^t ace_i(t) - k_i \int_0^t \Delta f(t), (10)$$

And as

$$MEAS_i - CP_i = \Delta P_i, (11)$$

The following simplified formula is derived:

$$\Delta P = FCP_{ex} + UE = \int_0^t ace_i(t) - k_i \int_0^t \Delta f(t), (12)$$

Now the only values we will have in a real situation are the ΔP and the $k_i \int_0^t \Delta f(t)$.

As $k_i \int_0^t \Delta f(t)$ is the computed value for FCP energy activation in area *i* it is not necessarily equal to the actual FCP energy activation. Furthermore, an activation within an area is not necessarily equal to the exchange across the border(s) from that area. Therefore, it is assumed that the following holds:

$$FCP_{ex} \neq k_i \int_0^t \Delta f(t), (13)$$

As a result of the above, the actual exchanged volume of FCP energy is not possible to find based on this definition. It is therefore not possible to, using this definition, determine the share of FCP energy exchange and the share of unintended energy exchange.

The following equation is therefore to be used for calculating the actual energy exchange across a border as a result of FCP and unintended exchange:

$$MEAS_i - CP_i = FCP_{ex} + UE$$

Where $MEAS_i$ is the measured energy exchange over the settlement period, and CP_i is the energy to be exchange over the settlement period in accordance with the control program. The energy exchange from FCP and unintended exchange will not be separated, but pooled into one volume, using the above reasoning.