Explanatory document concerning proposal from all TSOs of the Nordic synchronous area for the determination of LFC blocks within the Nordic Synchronous Area in accordance with Article 141(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

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This document is released on behalf of all TSOs of the Nordic synchronous area only for the purposes of the public consultation on the determination of LFC blocks within the Nordic Synchronous Area in accordance with Article 141(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. This version of the LFC blocks determination proposal does not in any case represent a firm, binding or definitive TSOs' position on the content.

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Explanatory document concerning proposal from all TSOs of Nordic synchronous area for the determination of LFC blocks within the Nordic synchronous area

1. Introduction

1.1 LFC process in general

Load-frequency control (LFC) is a critical process of the power system in ensuring operational security and stable system frequency. Effective LFC is possible only if the TSOs cooperate to balance generation and demand in real time to achieve stable system frequency of 50 Hz.

In order to ensure the quality of the common system frequency, it is essential that a common set of minimum requirements and principles for Union-wide LFC and reserves have been defined as a basis for both the cross-border cooperation between the TSOs and, where relevant, for utilizing characteristics of the connected generation and consumption.

Article 141(2) of the Commission Regulation (EU) No 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission operation ("SO Regulation") requires that by 4 months after the entry into force of the SO Regulation all Transmission System Operators ("TSOs") of a synchronous area submit a common proposal regarding the determination of the LFC blocks ("LFC Proposal") to all National Regulatory Authorities ("NRAs") for approval pursuant to Article 6(3)(g) of the SO Regulation. According to Article 6(6) of the SO Regulation the LFC Proposal needs to be submitted to ACER as well, who may issue an opinion on the proposal if requested by the NRAs.

Approach taken in LFC Proposal has an effect to all LFC related issues within the SO Regulation, such as the LFC structure and operational rules, the quality criteria and targets, the reserve dimensioning, the exchange, sharing and distribution of reserves, and the monitoring related to LFC.

This document is an explanatory document accompanying the LFC Proposal.

2. Legal obligations

The legal requirements for determination of the LFC blocks are set by Article 141(2) as follows:

> *"By 4 months after entry into force of this Regulation, all TSOs of a synchronous area shall jointly develop a common proposal regarding the determination of the LFC blocks, which shall comply with the following requirements:*
>
> *(a) a monitoring area corresponds to or is part of only one LFC area;*
>
> *(b) a LFC area corresponds to or is part of only one LFC block;*
>
> *(c) a LFC block corresponds to or is part of only one synchronous area; and*
>
> *(d) each network element is part of only one monitoring area, only one LFC area and only one LFC block."*

The load-frequency control block or the LFC block is defined by Article 3(18) of the SO Regulation as:

> *"a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC blocks, consisting of one or more LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control*".

The load-frequency control area or the LFC area is defined by Article 3(12) of the SO Regulation as:

> *"a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control"*.

The monitoring area is defined by Article 3(145) of the SO Regulation as:

> "*a part of the synchronous area or the entire synchronous area, physically demarcated by points of measurement at interconnectors to other monitoring areas, operated by one or more TSOs fulfilling the obligations of a monitoring area*".

Article 141(11) allows TSOs of several LFC areas to form the LFC block if certain requirements are fulfilled:

> *"All TSOs of two or more LFC areas connected by interconnections shall have the right to form an LFC block if the requirements for the LFC block set out in paragraph 5 are fulfilled."*
>
> *"All TSOs of each LFC block shall:*
>
> *(a) endeavour to fulfil the FRCE target parameters of the LFC block as defined in Article 128; and*
>
> *(b) comply with the FRR dimensioning rules in accordance with Article 157 and the RR dimensioning rules in accordance with Article 160. "*

Article 6(6) of the SO Regulation also requires that the LFC Proposal describes the expected impact on the objectives set in Article 4 of the SO Regulation as well as a proposed timescale for the implementation:

> "*The proposal for terms and conditions or methodologies shall include a proposed timescale for their implementation and a description of their expected impact on the objectives of this Regulation. Proposals on terms and conditions or methodologies subject to the approval by several or all regulatory authorities shall be submitted to the Agency at the same time that they are submitted to regulatory authorities. Upon request by the competent regulatory authorities, the Agency shall issue an opinion within 3 months on the proposals for terms and conditions or methodologies*."

It is also relevant, when determining the LFC structure, to take into account the following additional provisions of the SO Regulation as determined LFC blocks, LFC areas and monitoring areas have effect on those articles and their obligations:

- Operational agreements (synchronous area operational agreement in accordance with Article 118, LFC block agreement in accordance with Article 119, LFC area operational agreement in accordance with Article 120)
- Frequency quality (Articles 127 – Article 138)
- Load-frequency control structure (Article 139 – Article 151)
- Operation of load-frequency control (Article 152)
- Frequency containment reserves (Article 153 – Article 156)
- Frequency restoration reserves (Article 157 – Article 159)
- Replacement reserves (Article 160 – Article 162)

In addition, when determining LFC blocks, the general principles of provision of information set in Article 15 of Regulation (EC) No 714/2009, shall be taken into account.

The LFC Proposal fulfils and takes into account the above mentioned requirements as presented in Chapter 6.

3. Load-frequency control (LFC) of the SO Regulation[1]

3.1 LFC principles

The SO Regulation sets an obligation for responsibility for LFC processes (frequency containment and frequency restoration processes) and the respective process quality to TSOs. At the same time, the SO Regulation recognizes the fact, that due to the physical properties of synchronously operated transmission systems, frequency is a common parameter for the synchronous area. For this reason, all TSOs operating in a synchronous area are obliged to cooperate, and they are dependent on this cooperation to keep the system frequency within acceptable ranges. The cooperation among TSOs requires a clear definition of responsibilities for LFC processes, organization of reserve availability and assignment of individual quality targets.

The definitions of these responsibilities are harmonized across synchronous areas by formulation of requirements for the LFC structure in the SO Regulation. The LFC structure includes control processes within process activation structure set in Article 140 of the SO Regulation and geographical responsibilities as process responsibility structure set in Article 141 of the SO Regulation.

The process activation structure defines (Article 140 of the SO Regulation):

- Mandatory control processes which have to be implemented and operated by one or more TSOs in each synchronous area; and
- Optional control processes which may be implemented and operated by the TSOs in each synchronous area.

Accordingly, the process responsibility structure defines (Article 141 of the SO Regulation):

- Obligations for TSOs to operate and apply control processes for the respective geographical areas (monitoring area, LFC area, LFC block and synchronous area); and
- Responsibilities and obligations related to the control processes applied for geographical areas.

LFC principles set responsibilities for each TSO in relations to other TSOs within a synchronous area to apply LFC processes as a member of LFC block, LFC area and monitoring area to maintain system frequency and its quality.

3.2 Responsibility for LFC process

The framework of the load-frequency control processes is in general (see also Figure 1):

- The frequency containment process (FCP) stabilizes the frequency after the disturbance at a steady-state value within the permissible maximum steady-state frequency deviation by a

[1] More information can be found at ENTSO-E document: Supporting Document for the Network Code on Load-Frequency Control and Reserves, dated 28.06.2013 (https://electricity.network-codes.eu/network_codes/)

joint action of frequency containment reserves (FCR) within the synchronous area. This action happens immediately after an incident having affect to balance between generation and demand in the synchronous area, i.e. causing deviation in the system frequency.

- The frequency restoration process (FRP) controls the frequency towards its setpoint value by activation of frequency restoration reserves (FRR) and replaces the activated FCR. The activation of FRP is triggered by the disturbed LFC area either automatically (by aFRR) or manually (by mFRR). FRR dimensioning rules are defined on the LFC block level.
- The reserve replacement process (RRP) replaces the activated FRR and/or supports the FRR activation by activation of replacement reserves (RR). The activation of RRP is triggered by the disturbed LFC area. RR dimensioning rules are defined on LFC block level.

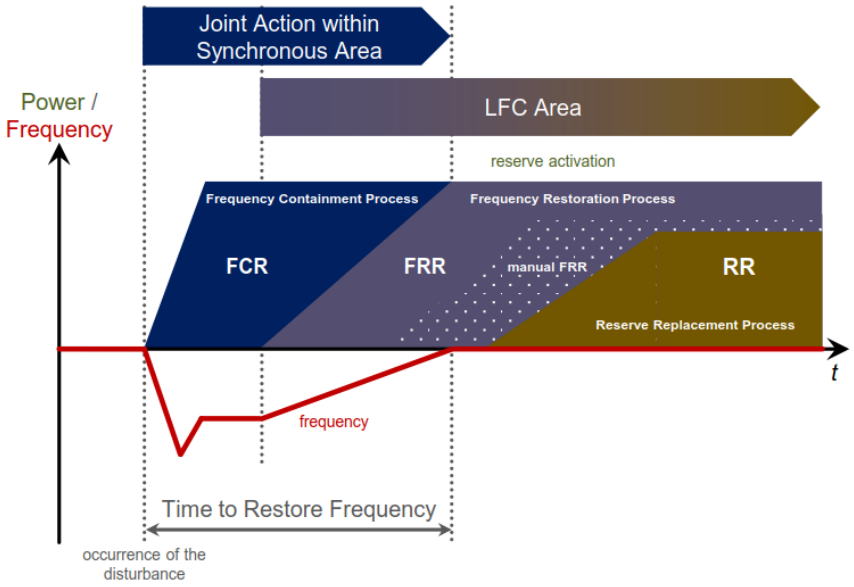

Figure 1. Activation of LFC processes and reserves (under assumption that FCR is fully replaced by FRR) as a function of time after a disturbance related to power deficiency.

The operation of LFC processes are attached to operational areas. The area hierarchy is illustrated in Figure 2. Each synchronous area consists of one or more LFC blocks, each LFC block consists of one or more LFC areas, and each LFC area consists of one or more monitoring areas. This hierarchy means that each network element within a synchronous area will belong only one monitoring area, one LFC area and one LFC block.

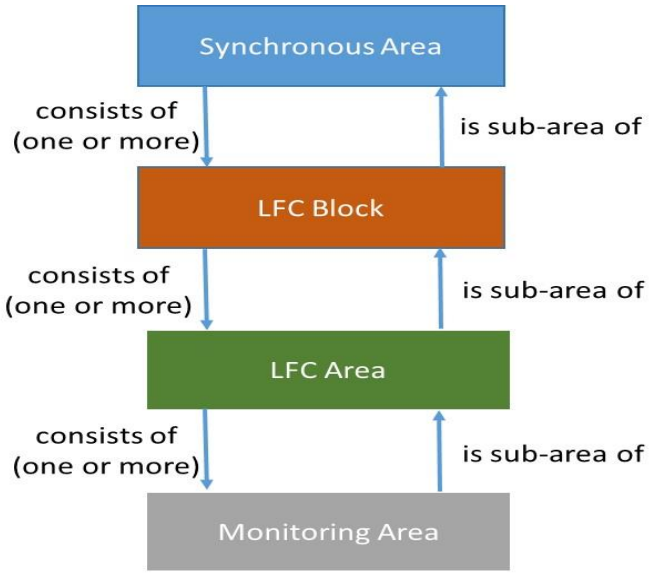

Figure 2. Types and hierarchy of geographical areas operated by TSOs for LFC.

These different area types are necessary to define responsibilities of single TSOs in the common task of system frequency quality and allowing a harmonised approach for all synchronous areas within EU. Table 1 summarises the different area process obligations defined in the SO Regulation.

For instance, a TSO operating an LFC area has the obligations:

- to measure and monitor the actual power exchange;
- to calculate and monitor the Frequency Restoration Control Error; and
- to operate a Frequency Restoration Process

At the same time, all TSOs operating LFC areas within the same LFC block have the obligation to cooperate with other TSOs of the LFC block to fulfil the area process obligations, e.g. to fulfil the Frequency Restoration Quality Target Parameters. Also TSOs in the LFC block have to organize the availability of a sufficient amount of FRR and RR according to dimensioning criteria (where an LFC block consists of more than one LFC area the TSOs shall agree on individual frequency restoration quality target parameters).

The TSO(s) within LFC area are responsible of frequency restoration process and monitoring the frequency restoration control error for the LFC area. If there are several LFC areas within a synchronous area, frequency control is managed by monitoring power flows over the LFC area borders: the actual power flows between LFC areas are compared to scheduled flows (calculated on the basis of exchanges in the day-ahead and intraday markets) to find out frequency control error in each LFC area. The frequency control happens thus by monitoring flows across LFC area borders and applying up- and down-regulation within the LFC area to decrease difference in scheduled and actual flows over LFC area borders. This control is called Area Control Error (ACE) regime. This regime is applied to frequency control, when several LFC areas exist within a synchronous area or within a LFC block.

Area Control Error ("**ACE**") is a measure of the instantaneous power imbalance in an area of the power system. ACE is calculated by comparing the flow on all borders of an area with the planned flows, correcting for flows due to the activated primary reserves (FCR) and agreed balancing contracts. Modernized ACE uses modern IT solutions to combine the balancing needs, available transmission capacity and available balancing resources in a coordinated and optimal way.

Table 1. Obligations for LFC related to different areas.

Obligation	Monitoring Area	LFC Area	LFC Block	Synchronous Area
Online calculation and monitoring of actual power exchange	MANDATORY	MANDATORY	MANDATORY	MANDATORY
Calculation and monitoring of the Frequency Restoration Control Error	NA	MANDATORY	MANDATORY	MANDATORY
Frequency Restoration Process	NA	MANDATORY	MANDATORY	MANDATORY
Frequency Restoration Quality Target Parameters	NA	MANDATORY)	MANDATORY	MANDATORY
FRR Dimensioning	NA	NA	MANDATORY	MANDATORY
RR Dimensioning	NA	NA	MANDATORY	MANDATORY
Frequency Containment Process	NA	NA	NA	MANDATORY
FCR Dimensioning	NA	NA	NA	MANDATORY
Frequency Quality Target	NA	NA	NA	MANDATORY

When an area, whether it is a synchronous area, a LFC block, a LFC area or a monitoring area, is operated by more than one TSO, the TSOs involved shall define their cooperation with legally binding agreements. This agreement shall define responsibilities of each TSO with respect to the fulfilment of the LFC process obligations. For example, all TSOs of a synchronous area have to agree on issues related to the FCP, while all TSOs of the same LFC block have to agree on issues related to the FRP.

It has to be noted that some processes not listed in Table 1 are defined as optional from technical perspective of the SO Regulation, but may become mandatory according to provisions of another Network Code, such as Guideline on Electricity Balancing. Some of the not listed processes can also be mandatory for some TSOs if implementing them is a precondition for the fulfilment of the respective area process obligations: for example, if a TSO receives FRR from providers located in a different LFC area a cross-border FRR activation process is necessary and therefore mandatory for the involved TSOs. Following processes are defined as optional in the SO Regulation

- a replacement reserve process
- an imbalance netting process
- a cross-border FRR activation process
- a cross-border RR activation process
- a time control process for synchronous areas other than Continental Europe

The added value of different area types and area process obligations formulated in the SO Regulation can be summarized as follows:

- The different area process obligations provide clear responsibilities for TSOs operating different areas.
- The methodology of defining the area hierarchy and area process obligations is flexible and allows for a European harmonization of terms and procedures regardless of different physical characteristics of each synchronous area. At the same time, the best practices for the different synchronous areas within Europe are respected.
- The methodology allows flexibility with respect to changing requirements while providing strict principles.

Different area hierarchies are currently implemented in different synchronous areas (Figure 3). For example[2]:

- Great Britain (GB) and Ireland/North Ireland (IRE/NE) synchronous areas currently consist of exactly one LFC block and LFC area.
- Central-Europe (CE) currently consists of many LFC blocks as shown in Figure 3. Most of these LFC blocks consist of one LFC area, such as LFC blocks operated by RTE (France), ELIA (Belgium), TenneT NL (the Netherlands), and Terna (Italy) but there are also several examples of LFC blocks that consist of more than one LFC area such as:
    - The LFC block of Spain and Portugal with LFC areas operated by REN and REE; and
    - The German LFC block with four LFC areas operated by 50HzT, Amprion, TenneT Germany (including Energinet.dk) and TransnetBW.

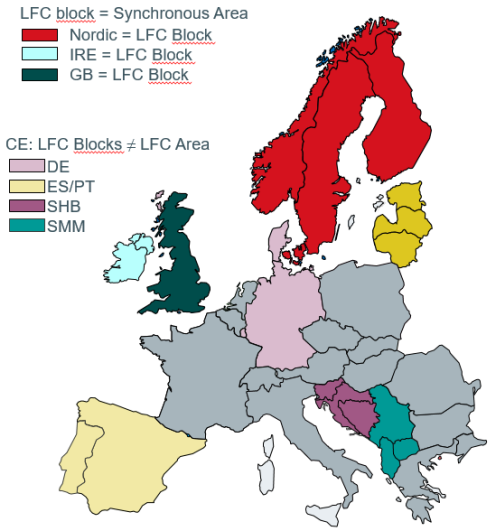

Figure 3. Currently applied European synchronous areas, LFC blocks and LFC areas. The LFC-block determination is not a term currently used in the existing Nordic configuration.

4. Description of the current LFC structure

Two of the Nordic TSOs, Svenska kraftnät and Statnett, have been given the task for taking actions[3] to balance Nordic power system whilst all Nordic TSOs are responsible to ensure sufficient upward and downward active power reserves to balance its control area. Each TSO is also responsible for operational security within its control area.

As the Nordic TSOs cooperate by using all available reserves in a region for 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 individual TSO's responsibility but contribute to a more efficient use of the regional resources. To balance the Nordic power system

[2] ENTSO-E: Supporting Document for the Network Code on Load-Frequency Control and Reserves, dated 28.06.2013 (https://electricity.network-codes.eu/network_codes/

[3] Nordic System Operation Agreement https://www.entsoe.eu/Documents/Publications/SOC/Nordic/System_Operation_Agreement_English_translation.pdf#search=Nordic%20system%20operation%20agreement

the TSOs are collaborating to minimize the cost of balancing by utilizing the most efficient resources when this is technically and financially appropriate.

5. Description of the selected approach

5.1 Options

Several options can be identified for LFC areas and LFC blocks in the Nordic synchronous area. These options can be evaluated against the objectives of the SO Regulation when selecting the best option for LFC structure. The two most relevant options for Nordic synchronous area have been presented in Table 2.

A LFC block can cover whole of the Nordic synchronous area or only part of it i.e. one, two or three countries. The Nordic TSO's prefer one Nordic LFC block and that is the main reason for presenting only two relevant options in Table 2.

Table 2. Most relevant options for LFC structure in Nordic synchronous area.

Option	Monitoring area	LFC area	LFC block
Option 1 (current)	bidding zone	synchronous area	synchronous area
Option 2 (proposal)	bidding zone	bidding zone	synchronous area

The level of coordination and harmonisation depends on how many LFC blocks there are within a synchronous area and how many LFC areas each LFC block is divided into.

The highest level of coordination and harmonisation is achieved with Option 1, where only one LFC block and one LFC area exist covering the entire Nordic synchronous area. In this option, the frequency control is managed by controlling frequency directly by up- or down-regulation within the LFC area and the same rules for LFC apply within and between all bidding zones in the Nordic synchronous area. This option, however, does not allow a direct connection of the LFC block of the Nordic synchronous area to the European platforms for the exchange of balancing energy without developing a separate centralized optimization function including a congestion check functionality for the Nordic synchronous area. Therefore, Option 1 is not considered to be viable anymore in the situation when the European platforms for the exchange of balancing energy have been implemented in accordance with Regulation (EU) 2017/2195 establishing a guideline on electricity balancing.

Option 2 allows a direct connection of the Nordic bidding zones corresponding to LFC areas to the European platforms. In addition, this option supports a safe and efficient transition of the Nordic power system towards containing an increased amount of intermittent renewable energy by better taking into account the flows between bidding zones in the context of LFC. A high level of coordination and harmonization in this option can be ensured by having one LFC block corresponding to the entire Nordic synchronous area and implementing methodologies for the sharing and exchange of reserves and the minimization of the amount of FRR counter activations between LFC areas through imbalance netting for activation between the LFC areas within the said LFC block of the Nordic synchronous area.

5.2 The LFC Proposal

Determination of LFC blocks and LFC areas is fundamental for functioning of markets for reserves needed for load-frequency control. When selecting the best option, it is important that

- well-functioning real-time market for LFC ensures cost efficiency and security of supply;
- flexibility resources are fully utilized in real-time market;
- there is available transparent and timely market information;
- the Nordic co-operation benefits the whole region.

The LFC Proposal will be based on Option 2 (Table 2), where

- monitoring area corresponds to a bidding zone;
- Bidding zones corresponds to LFC areas; and
- LFC block corresponds to the Nordic synchronous area.

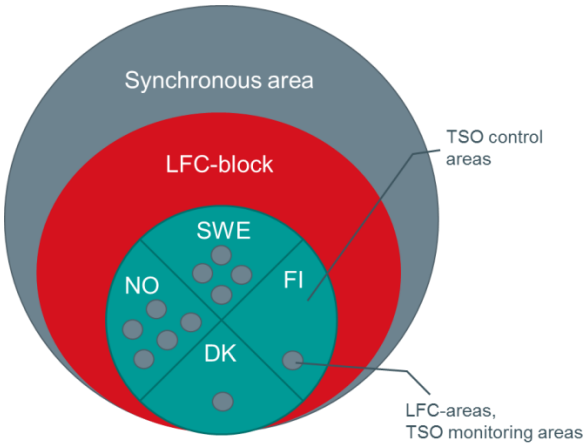

Figure 4. New LFC structure proposal in Nordic synchronous area

The LFC Proposal presented herein ensures the highest level of coordination and harmonization in LFC process and meets best the objectives set in the SO Regulation. This option also facilitates the goal of well-functioning real-time markets and issues addressed above. Especially, the LFC Proposal will deliver the following capabilities and benefits:

- A common dimensioning methodology for frequency restoration reserves (FRR). One LFC block facilities exchange and sharing of reserves to a higher degree than with multiple LFC blocks. This is regulated in the LFC Block agreement between the TSOs.
- In the proposed LFC block determination, where all the balancing actions are coordinated throughout synchronous area, TSOs are able to minimize the amount of counter activation of frequency restoration reserves (FRR) and aim to activate the most efficient reserve resources to balance the system.
- A common balancing market ensures transparency among all the balance service providers (BSPs) in a synchronous area and ensures market-based mechanisms in the widest possible extent.
- Each TSO in the Nordic synchronous area has responsibility to monitor and managing its operational security on its own control area.

- Each TSO shall operate its control area with sufficient upward and downward active power reserves, which may include shared or exchanged reserves in accordance with the LFC block agreement, to face imbalances between demand and supply within its control area as stated in Article 152(1) of the SO Regulation.

As the Nordic synchronous area, LFC block and LFC area as well are operated by more than one TSO, the TSOs involved shall specify the allocation of responsibilities on frequency containment and frequency restoration processes in accordance with Article 141(8), 141(9) and 141(10) of the SO Regulation. In addition, when a LFC area consists of more than one monitoring area, all TSOs of the LFC area shall establish a LFC area operational agreement in accordance with Article 120 of the SO Regulation.

6. Description of the expected impact of the LFC Proposal on the relevant objectives of the SO Regulation

The LFC Proposal contributes to the achievement of the objectives of Article 4 of the SO Regulation. The main purpose of LFC Proposal is to determine the configuration for LFC blocks and LFC areas aiming at common load-frequency control processes and control structure on a synchronous area level. Control processes and structures can be achieved by a range of configurations of LFC blocks and areas. The Nordic TSOs concluded that one LFC block and bidding zones corresponding LFC areas and monitoring areas is most appropriate for the Nordic synchronous area.

In regard of the aim of the SO Regulation to ensure the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union, the LFC Proposal has through the determination of LFC blocks, LFC areas and monitoring areas requested relevant TSOs to specify the allocation of responsibilities on frequency containment and frequency restoration processes. In addition, these TSOs define for configuration set in LFC Proposal the frequency quality defining parameters and the frequency quality target parameters for monitoring the frequency quality level of Nordic synchronous area.

The LFC Proposal ensures and enhances the transparency and reliability of information on transmission system operation by specifying each bidding zone as a LFC area and a monitoring area. This configuration ensures that TSOs will continuously calculate and monitor the real-time active power exchange between the bidding zones. The LFC Proposal ensures transparency for all BSPs in the Nordic synchronous area by establishing a common balancing market and ensuring the application of market-based mechanisms in the widest possible extent.

The LFC Proposal contributes to the efficient operation and development of the electricity transmission system and electricity sector in the Union. This is the outcome of the proposal facilitating the sharing and exchange of FRR reserves and the minimization of the amount of FRR counter activations between LFC areas through imbalance netting for activation to be agreed in the LFC block operational agreement.

The LFC Proposal facilitates the application of the principle of optimization between the highest overall efficiency and lowest total cost for all parties involved, by making use of common based market mechanisms while ensuring operational security and by having a common Nordic balancing market for the activation of the most efficient resources to balance the system. This is a result having one LFC block in the Nordic synchronous area.

The LFC Proposal ensures that the TSOs make use of the market-based mechanisms as far as possible to ensure network security and stability through a common balancing market ensuring application of market based mechanisms in the widest possible extent.

Finally, the LFC Proposal respects the responsibility assigned to the TSOs in order to ensure system security, including as required by national legislation. This implies that each TSO in Nordic synchronous area has responsibility to monitor and manage operational security on its own control area.. Furthermore, each TSO shall operate its control area with the sufficient upward and downward active power reserves, which may include shared or exchanged reserves in accordance with the LFC block agreement to face imbalances between demand and supply within its control area consisting of one or more bidding zones and as agreed between the TSOs of the LFC block of the Nordic synchronous area. This is a result of a bidding zone corresponding to a LFC area.

7. Timescale for the implementation

The LCF Proposal shall enter into force immediately after it has been approved by the relevant NRAs and it shall be implemented when Nordic synchronous area operational agreement concluded in accordance with Article 118 of the SO Regulation, LFC block operational agreement in accordance with Article 119 of the SO Regulation and LFC area operational agreement in accordance with Article 120 of the SO Regulation have been implemented.

The LFC configuration of the LFC Proposal shall be the basis according to which the Nordic synchronous area operational agreement in accordance to Article 118 of the SO Regulation, LFC block operational agreement in accordance to Article 119 of the SO Regulation, and LFC area operational agreement in accordance to Article 120 of the SO Regulation shall be concluded. These agreements shall include implementation plans for when the LFC configuration of the LFC Proposal shall be implemented and a description how the transition from the current LFC structure to the proposed LFC structure shall be made.