
Explanatory document for the Nordic synchronous area proposal for frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

1. Introduction

The Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter “**SO Regulation**”) sets out rules on relevant subjects that should be coordinated between Transmission System Operators, as well as between TSOs and Distribution System Operators and with significant grid users, where applicable. The goal of SO Regulation is to ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities. In order to deliver these objectives, a number of steps are required.

One of these steps is to determine the frequency quality defining parameters and the frequency quality target parameter. Pursuant to Article 118(1)(c) of the SO Regulation, all Transmission System Operators in the Nordic Synchronous Area shall jointly develop common proposals for the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127 of the SO Regulation.

According to Article 6(3)(d)(i) of the SO Regulation the proposal for the frequency quality defining parameters and the frequency quality target parameter (hereafter referred to as “**Proposal**”) shall be submitted for approval by the relevant national regulatory authorities (hereinafter “NRAs”) no later than 14 September, 2018. The proposal is submitted for regulatory approval to all NRAs in the Nordic synchronous area. According to Article 6(6) of the SO Regulation the Proposal needs to be submitted to ACER as well, who may issue an opinion on the proposal if requested by the NRAs.

This document contains an explanation of the Proposal from all TSOs of the Nordic synchronous area (hereinafter “TSOs”).

It is structured as follows. The legal requirements for the Proposal are presented in Chapter 2. Chapter 3 starts with describing the objective of frequency quality. Chapter 4 provides an overview of the existing situation. The proposed frequency quality defining parameters and the frequency quality target parameter are described in Chapter 5. Chapter 6 describes the expected impact on the relevant objectives of the SO Regulation. Finally, Chapter 7 provides information about the implementation and Chapter 8 describes the public consultation.

2. Legal requirements and interpretation

2.1 Legal references and requirements

Several articles in the SO Regulation set out requirements which the Proposal must take into account. These are cited below.

- (1) Article 118(1)(c) and (2) of the SOGL constitutes the legal basis that the Proposal should take into account. Article 118 has the following content:

“1. By 12 months after entry into force of this Regulation, all TSOs of each synchronous area shall jointly develop common proposals for:[...]”

(c) the frequency quality defining parameters and the frequency quality target parameters in accordance with Article 127; [...]

2. All TSOs of each synchronous area shall submit the methodologies and conditions listed in Article 6(3)(d) for approval by all the regulatory authorities of the concerned synchronous area. Within 1 month after the approval of these methodologies and conditions, all TSOs of each synchronous area shall conclude a synchronous area operational agreement which shall enter into force within 3 months after the approval of the methodologies and conditions.”

- (2) Article 127 of the SOGL has the following content:

“Article 127: Frequency quality defining and target parameters

1. *The frequency quality defining parameters shall be:*
 - (a) *the nominal frequency for all synchronous areas;*
 - (b) *the standard frequency range for all synchronous areas;*
 - (c) *the maximum instantaneous frequency deviation for all synchronous areas;*
 - (d) *the maximum steady-state frequency deviation for all synchronous areas;*
 - (e) *the time to restore frequency for all synchronous areas;*
 - (f) *the time to recover frequency for the GB and IE/Ni synchronous areas;*
 - (g) *the frequency restoration range for the GB, IE/Ni and Nordic synchronous areas;*
 - (h) *the frequency recovery range for the GB and IE/Ni synchronous areas; and*
 - (i) *the alert state trigger time for all synchronous areas.*
2. *The nominal frequency shall be 50 Hz for all synchronous areas.*
3. *The default values of the frequency quality defining parameters listed in paragraph 1 are set out in Table 1 of Annex III.*
4. *The frequency quality target parameter shall be the maximum number of minutes outside the standard frequency range per year per synchronous area and its default value per synchronous area are set out in Table 2 of Annex III.*
5. *The values of the frequency quality defining parameters in Table 1 of Annex III and of the frequency quality target parameter in Table 2 of Annex III shall apply unless all TSOs of a synchronous area propose different values pursuant to paragraphs 6, 7 and 8.*
6. *All TSOs of CE and Nordic synchronous areas shall have the right to propose in the synchronous area operational agreement values different from those set out in Tables 1 and 2 of Annex III regarding:*
 - (a) *the alert state trigger time;*
 - (b) *the maximum number of minutes outside the standard frequency range.*
7. *All TSOs of the GB and IE/Ni synchronous areas shall have the right to propose in the synchronous area operational agreement values different from those set out in Tables 1 and 2 of Annex III regarding:*
 - (a) *time to restore frequency;*
 - (b) *the alert state trigger time; and*
 - (c) *the maximum number of minutes outside the standard frequency range.*
8. *The proposal for modification of the values pursuant to paragraph 6 and 7 shall be based on an assessment of the recorded values of the system frequency for a period of at least 1 year and the synchronous area development and it shall meet the following conditions:*
 - (a) *the proposed modification of the frequency quality defining parameters in Table 1 of Annex III or the frequency quality target parameter in Table 2 of Annex III takes into account:*
 - (i) *the system's size, based on the consumption and generation of the synchronous area and the inertia of the synchronous area;*
 - (ii) *the reference incident;*
 - (iii) *grid structure and/or network topology;*

(iv) load and generation behaviour;

(v) the number and response of power generating modules with limited frequency sensitive mode — over frequency and limited frequency sensitive mode — under frequency as defined in Article 13(2) and Article 15(2)(c) of Regulation (EU) 2016/631;

(vi) the number and response of demand units operating with activated demand response system frequency control or demand response very fast active power control as defined in Articles 29 and 30 of Regulation (EU) 2016/1388; and

(vii) the technical capabilities of power generating modules and demand units;

(b) all TSOs of the synchronous area shall conduct a public consultation concerning the impact on stakeholders of the proposed modification of the frequency quality defining parameters in Table 1 of Annex III or the frequency quality target parameter in Table 2 of Annex III.

9. All TSOs shall endeavour to comply with the values for the frequency quality defining parameters or for the frequency quality target parameter. All TSOs shall verify the fulfilment of the frequency quality target parameter at least annually.”

(3) Table 1 and Table 2 of Annex III of the SOGL have the following content:

Frequency quality defining parameters referred to in Article 127:

Table 1

Frequency quality defining parameters of the synchronous areas

	CE	GB	IE/NL	Nordic
standard frequency range	± 50 mHz	± 200 mHz	± 200 mHz	± 100 mHz
maximum instantaneous frequency deviation	800 mHz	800 mHz	1 000 mHz	1 000 mHz
maximum steady-state frequency deviation	200 mHz	500 mHz	500 mHz	500 mHz
time to recover frequency	not used	1 minute	1 minute	not used
frequency recovery range	not used	± 500 mHz	± 500 mHz	not used
time to restore frequency	15 minutes	15 minutes	15 minutes	15 minutes
frequency restoration range	not used	± 200 mHz	± 200 mHz	± 100 mHz
alert state trigger time	5 minutes	10 minutes	10 minutes	5 minutes

Frequency quality target parameters referred to in Article 127:

Table 2

Frequency quality target parameters of the synchronous areas

	CE	GB	IE/NL	Nordic
maximum number of minutes outside the standard frequency range	15 000	15 000	15 000	15 000

(4) Article 6(3)(d)(i) of the SO Regulation states:

“The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region, on which a Member State may provide an opinion to the concerned regulatory authority: [...]

(d) methodologies, conditions and values included in the synchronous area operational agreements in Article 118 concerning:

(i) the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127;

2.2 Interpretation and scope of the Proposal

This Proposal reflects the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127. The scope of this Proposal only includes these parameters. Although these parameters are related to security of supply, under different circumstances they may have different impact on the operational security of the Nordic synchronous area. I.e. although the frequency quality defining parameters apply for all hours of the year, the risk of a supply interruption due to the exhaustion of FCR will vary over the year, dependent on load, generation and generation mix, import and export. Furthermore, a frequency excursion outside the standard frequency range may have a differing impact on the risk of a supply interruption for different hours of the year. Article 131(2) of the SO Regulation requires that all TSOs of each synchronous area shall jointly develop common proposals for a methodology to assess the risk and the evolution of the risk of exhaustion of FCR of the synchronous area. This methodology will be described in a separate proposal and will address impact of different circumstances.

3. Objective of frequency quality

3.1 Main objective maintaining frequency quality

To maintain a good security of supply level, TSOs shall maintain the active power¹ balance between consumption and generation in the synchronous area. The system frequency is a direct indicator for the total active power balance in the whole synchronous area:

- If the active power generation exceeds the active power consumption, the system frequency will rise, and, vice versa,
- if the active power consumption exceeds the active power generation, the system frequency will fall

and will result in a deviation from the Nominal Frequency. The gradient (the speed) of the frequency deviation is determined by the amount of kinetic energy stored and released by the synchronously connected rotating masses (inertia) after a disturbance of the active power balance (there are also first attempts to obtain the same effect from non-synchronously connected generators via power electronics). The frequency deviation is in principle the same all over the synchronous area². Therefore, the system frequency and frequency quality shall be considered a ‘common good’ that affects all system users.

Since for technical reasons the operational range of generators is limited to a certain system frequency range, frequency deviations outside of this range would trigger the according automatic protection mechanisms leading to a disconnection of the generators in the whole synchronous area, immediately followed by a complete blackout.

To avoid the complete blackout, TSOs maintain the *frequency quality* by:

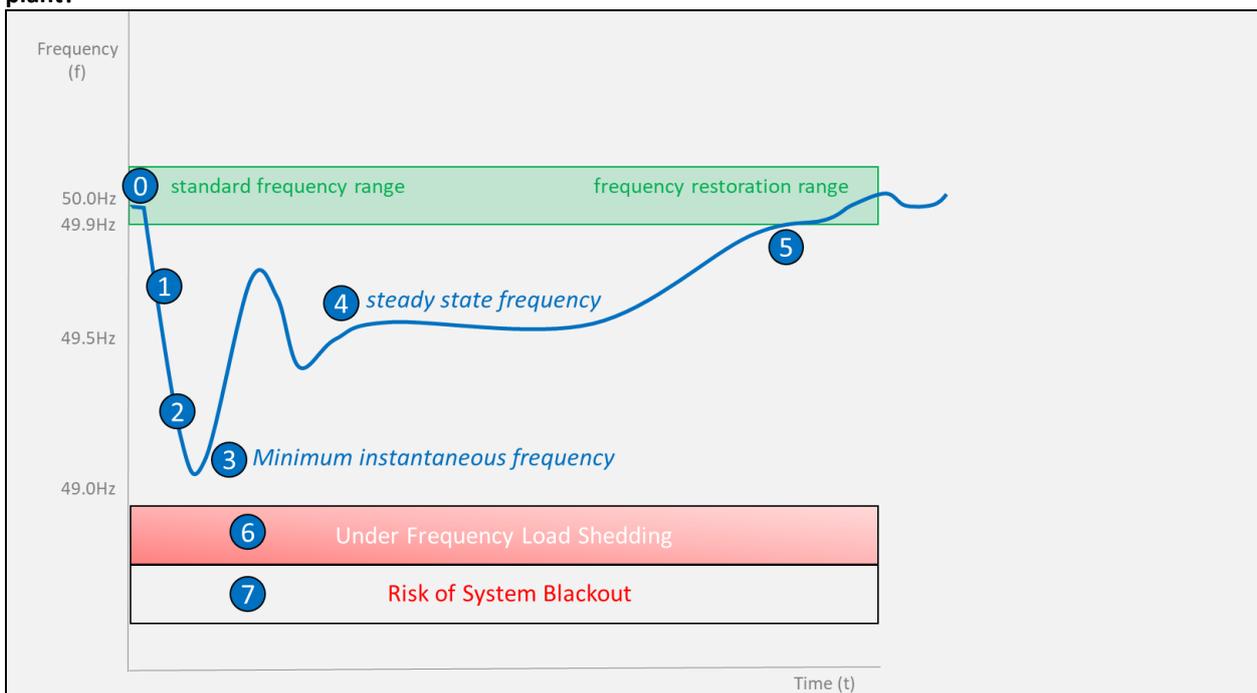
¹ Active power is defined as the real component of the apparent power at fundamental frequency, expressed in watts or multiples thereof such as kilowatts ('kW') or megawatts ('MW').

² See Figure 3 for an exception of this principle.

1. Keeping the *frequency* at times without large disturbances close enough to 50Hz;
2. Arrange sufficient and accurate measures (reserves, inertia) to limit the instantaneous and stationary *frequency deviation* after an incident;
3. Arrange *emergency measures* such as automatic Under Frequency Load Shedding (UFLS) to limit the impact of large events that are not addressed sufficiently by the measures mentioned under 2.

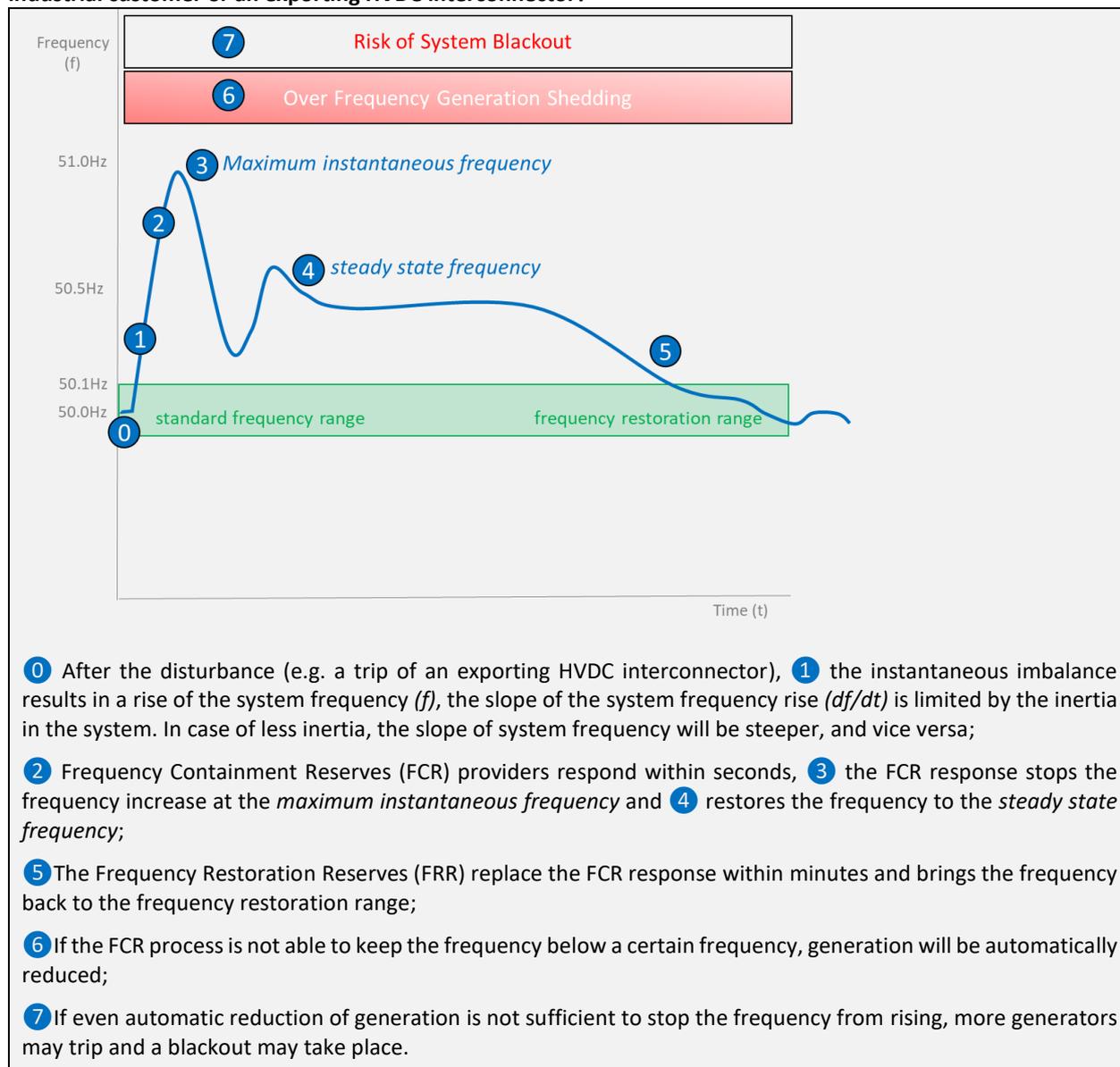
Textbox 1 explains what happens in case of a large instantaneous imbalance in (a) negative or (b) positive direction.

Textbox 1a: **What happens after a large instantaneous imbalance in a negative direction, e.g. a trip of a large power plant?**



- 0 After the disturbance (e.g. a trip of a large generator), 1 the instantaneous imbalance results in a fall of the system frequency (f), the slope of the system frequency fall (df/dt) is limited by the kinetic energy in the system (inertia). In case of less inertia, the slope of system frequency will be steeper, and vice versa;
- 2 Frequency Containment Reserves (FCR) providers respond within seconds, 3 the FCR response stops the frequency decrease at the *minimum instantaneous frequency* and 4 restores the frequency to the *steady state frequency*;
- 5 The Frequency Restoration Reserves (FRR) replace the FCR response within minutes and brings the frequency back to the frequency restoration range;
- 6 If the FCR process is not able to keep the frequency above the frequency at which automatic Under Frequency Load Shedding (UFLS) is triggered, automatic UFLS will trip part of the load in stages at different frequency levels until the frequency has stopped to decrease;
- 7 If even automatic UFLS is not sufficient to stop the frequency from falling, generators may trip and a blackout may take place.

Textbox 2b: What happens after an instantaneous imbalance in a positive direction, e.g. a trip of a very large industrial customer or an exporting HVDC interconnector?



The main objective of *maintaining frequency quality* is to limit the risk of supply interruptions caused by imbalances to acceptable levels. Following this main objective, the frequency quality determining parameters set the limits for frequency deviations for which the power system shall be capable to handle the so-called reference incidents³ without any interruptions of supply, i.e. without applying the emergency measures such as automatic UFLS. This means that after an occurrence of the reference incident while the system frequency

³ According to SO Regulation, article 3(2)(58) 'reference incident' means the maximum positive or negative power deviation occurring instantaneously between generation and demand in a synchronous area, considered in the FCR dimensioning. The Nordic proposal for 'the dimensioning rules for FCR' (in line with SO Regulation, article 118(1)(a)) further details the definition of reference incident for the Nordic situation.

is within the standard frequency range, the system frequency shall not reach the levels at which automatic UFLS will start to be applied.

3.2 Other objectives maintaining frequency quality

The requirements in the European Generator Connection Code and the Demand Connection Code⁴ describe that if the frequency is in between 49.0 and 51.0Hz, demand and generation shall be capable of remaining connected to the network and operating for unlimited time. If the frequency is outside this range, but inside 47.5-51.5Hz, demand and generation shall be capable of remaining connected to the network and operating for at least 30 minutes.

European Standard EN 50160 specifies the Voltage characteristics that shall be supplied by electricity distribution networks. In fact, this standard defines the minimum quality that end users may expect at their connection. With respect to system frequency, EN 50160 requires that - under normal operating conditions - the system frequency shall be within 49.5-50.5Hz for 95% of time⁵. Currently, the Nordic frequency quality is far better than required by this standard since excursions outside this frequency band are very rare and usually very short⁶.

Network equipment of TSOs and DSOs shall be able to operate safely and securely within the frequency range in which the power system is operated. Typically, power transformers may be vulnerable to a combination of high voltage and low frequency. In this situation, (over)flux may create intolerable heating of the core. Transformer design needs to take this into account.

4. The existing situation

4.1 Nominal Frequency and Standard Frequency range

The existing Nordic System Operation Agreement (SOA) describes the current requirements. Section 1.1 of appendix 3 of the SOA states that the highest permissible variation in the frequency during normal state is within the 49.90 to 50.10Hz band and that the goal of the Nordic TSOs is to maintain 50.00 Hz. The number of minutes with frequency outside 49.90 to 50.10Hz band shall be kept at a minimum.

4.2 Maximum steady-state frequency deviation

The main reason for keeping the frequency within the 49.90 to 50.10Hz band is that frequencies outside this band are reserved for disturbances. I.e. below 49.90Hz, Frequency Controlled Disturbance Reserves (FCR-D) will be activated. FCR-D will be fully activated and stabilises on a steady state frequency of 49.50Hz. FCR-D is dimensioned in such a way that it is sufficient to ensure that the biggest single incident in the system⁷ will not result in instantaneous frequencies that may trigger automatic Under Frequency Load Shedding (UFLS), which is the last barrier to prevent for frequencies that may trigger power plant outages and consequently a blackout. Furthermore, the frequency shall stabilise on a steady state value of not lower than 49.50Hz.

4.3 Maximum instantaneous frequency deviation

It shall be noted that apart from FCR-D also other system parameters (inertia, response of load to frequency, contribution of load trips etc.) affect the instantaneous frequency deviation after the reference incident. These parameters change continuously and accordingly affect the instantaneous frequency deviation after the reference incident. The SOA specifies that the first stage of automatic UFLS will be triggered at 48.80Hz.

⁴ Article 12 of Commission Regulation (EU) 2016/1388 of 17 August 2016.

⁵ To be more precise: based on 10s measurement intervals monitored over 1 week.

⁶ According to Fingrid's F-Report (report Frequency quality analysis for year 2015, Fingrid, 16.8.2016) between 2008 and 2015 on average 1 event per year with a duration of not more than 10.8s.

⁷ 'Dimensioning fault' according to the existing Nordic System Operation Agreement and the 'reference incident' in accordance with the terminology applied in the SO Regulation.

Even at unfavourable conditions such as low inertia levels, this should be below the minimum instantaneous frequency after the reference incident that took place at 49.90Hz.

4.4 Time to restore frequency and frequency restoration range

The Frequency Restoration Process restores FCR-D by activating Frequency Restoration Reserves (FRR). Currently, the TSOs apply mainly manual FRR (mFRR) and the full activation time of this mFRR has been set to 15 minutes. One of two main reasons for having a time limit of 15 minutes is that it is a good time span for starting up hydro power units and gas turbines. The second reason for it is that it takes approximately 15 minutes for an overloaded power line to start sagging dangerously⁸, which means that manual mFRR activation shall have mitigated the overloadings after imbalances within 15 minutes. In line with this, the current SOA states that after an N-1-fault the system shall be brought to a state where it can withstand any N-1-fault within 15 minutes, i.e. where the activated FCR-D is completely restored/replaced by FRR which shall be the case if the frequency is above 49.90Hz. Based on the above and in the terminology of the SO Regulation: the restoration range is 49.90 – 50.10Hz and the time to restore the frequency to this range is 15 minutes.

4.5 Maximum Number of Minutes outside the standard frequency range

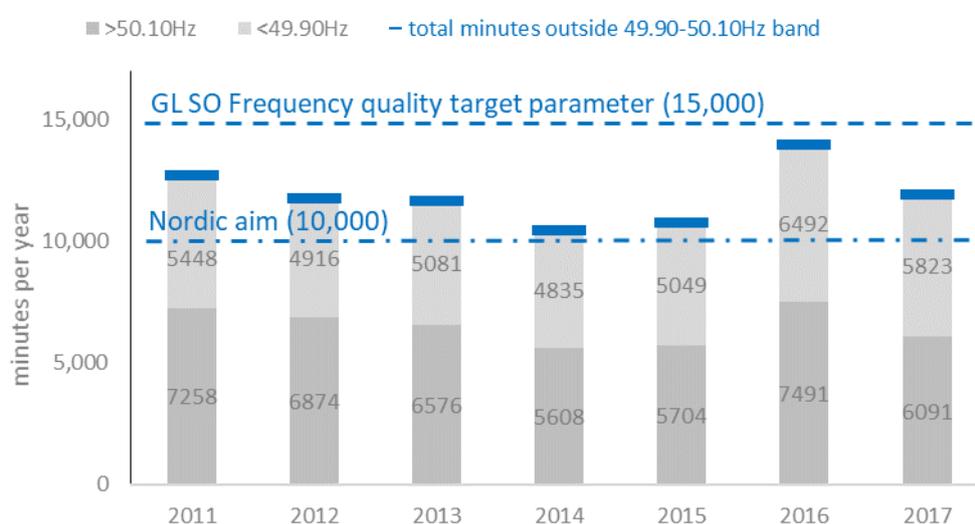


Figure 1: Number of minutes outside the standard frequency range per year⁹.

If the reference incident takes place at times that the frequency levels are below 49.90Hz, there is a risk that automatic UFLS takes place. For many years, the Nordic TSO apply the Minutes outside the standard frequency range per year as a proxy for this risk. The Nordic synchronous area faced an increasing number of minutes outside the standard frequency range in the first decade of this century. In order to stop this trend, the TSOs applied several measures and Figure 1 shows that the number of minutes outside the standard frequency was in the years 2011-2017 between 10,000 and 15,000.

The Nordic TSOs agreed that the aim for frequency deviations outside standard frequency range is not more than 10,000 min/year. This aim is considered when specifying the measures to keep frequency within the

⁸ Rule of thumb. Depends on loading before over loading occurs, and is also depending on chosen construction criteria of single lines.

⁹ The numbers are determined using the definition explained in Textbox 3 which is in accordance with the SO Regulation. The TSOs applied another definition before which means that the values from before 2011 are not completely comparable with the values in this figure.

standard frequency range. However, it should not be seen as an absolute ‘maximum’ for the number of minutes outside the standard frequency range, as mentioned in article 127 of the SO Regulation.

Textbox 3: Counting minutes/time outside the standard frequency range

SO Regulation article 131(a)(iv) requires that *“The frequency quality evaluation criteria shall comprise [...] for the instantaneous frequency data [...] the total time in which the absolute value of the instantaneous frequency deviation was larger than the standard frequency deviation[...]”*. Since SO Regulation article 3(2)(156) defines standard frequency deviation as *“the absolute value of the frequency deviation that limits the standard frequency range”*, this is in fact the time that the frequency is not within the *standard frequency range*. SO Regulation article 3(2)(131) defines *“instantaneous frequency data’ as “a set of data measurements of the overall system frequency for the synchronous area with a measurement period equal to or shorter than one second used for system frequency quality evaluation purposes;*

It may therefore be understood that the minutes outside the standard frequency range shall be determined by observing all frequency samples which should have a measurement period equal to or shorter than one second. If the value is outside the standard frequency range, $\frac{\text{measurement period in s}}{60\text{s}}$ shall be added to the number of minutes outside the standard frequency range.

5. Proposal for frequency quality defining parameters and the frequency quality target parameter

The frequency quality defining parameters represent the values which are used for the design of control processes and reserve dimensioning. Furthermore, they are aligned with emergency procedures and operation ranges for generators. The operation of synchronous area has been designed in such a way to guarantee that after a disturbance of the active power balance frequency deviations are kept within a certain range.

For the Nordic synchronous area this implies that large imbalances do not lead to frequency deviations that would trigger automatic under-frequency load-shedding (UFLS). The largest imbalance which by design shall not cause a violation of admissible system frequency ranges is named the reference incident (it also serves as input to the dimensioning of FCR). The reference incident for the Nordic synchronous area is defined in the methodology for dimensioning FCR¹⁰.

The frequency quality defining parameters define the acceptable ranges for system frequency before and after an occurrence of the reference incident (Figure 2). It is important to notice that the parameters do not only include ranges but also the time durations (time to restore frequency) in which the respective ranges should be reached.

¹⁰ Nordic synchronous area proposal for the dimensioning rules for FCR in accordance with Article 153 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

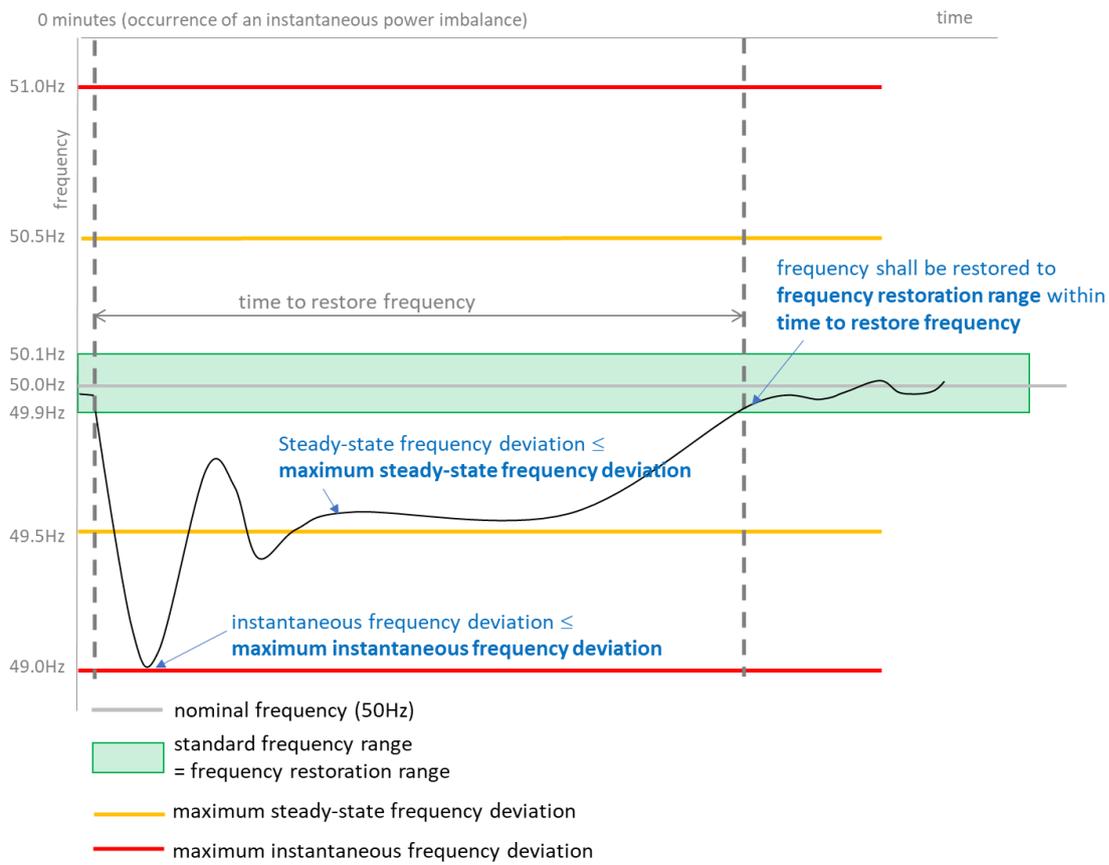


Figure 2: Frequency Quality Defining Parameters

The proposals set out below shall be considered as a continuation of the philosophy that has been applied in the years before this methodology came/comes into force (see section 4).

5.1 Nominal Frequency, Standard Frequency range and Maximum Number of Minutes outside the standard frequency range

The standard frequency range is defined by Article 3(2)(155) of the SO Regulation as the “*defined symmetrical interval around the nominal frequency within which the system frequency of a synchronous area is supposed to be operated.*” Article 127(2) and (3) of the SO Regulation define that the nominal frequency shall be 50Hz and that the default value for the standard frequency range is $\pm 100\text{mHz}$, which is the same as the “*highest permissible variation in the frequency during normal state*”¹¹ in the current Nordic System Operation Agreement (SOA).

The Nordic Frequency Containment Process (FCP) is divided in a ‘normal’ and ‘disturbance’ process¹² and applies different types of Frequency Containment Reserves (FCR) for these processes. The intention is that the FCR for normal operation (FCR-N) is used for normal continuous imbalances and that FCR-D is used for incidental disturbances. The activation of the two is linked to the definition of the standard frequency range, i.e. if the frequency is inside the $\pm 100\text{mHz}$ range, only FCR-N is activated, at $\pm 100\text{mHz}$ FCR-N reaches its maximum activation and if the frequency is outside the $\pm 100\text{mHz}$ range also FCR-D responds.

The frequency quality target parameter defined by Article 127(4) the SO Regulation allows the frequency to be outside the standard frequency range for 15,000 minutes per year, which is 2.9% of the time. This number

¹¹ Nordic System Operation Agreement (SOA) of 20 September 2017, appendix 3, section 1.1 Quality standards

¹² There are differences in how FCR respond in the Nordic countries, mostly due to differences in technology used in the power plants (hydro, thermal).

of 15,000 minutes is the default parameter for frequency quality target parameter for all four synchronous areas that are addressed by the SO Regulation. The current aim of the Nordic TSO is 10,000 minutes per year. The aim of 10,000 minutes per year should be seen in the perspective of stopping the trend of increasing numbers of minutes outside the band of the first decade of the century (see section 4). When specifying measures to improve the frequency quality, the Nordic TSOs therefore apply 10,000 minutes per year.

5.2 Maximum instantaneous frequency deviation

The default value for *maximum instantaneous frequency deviation* is defined by the SO Regulation as 1000mHz and therefore allows an instantaneous frequency of up to 51.0Hz and down to 49.0Hz. For under frequency, this leaves 200mHz to the first trigger frequency of the automatic UFLS relays at 48.8Hz. This 200mHz buffer seems reasonable, and includes a margin for geographic variations in frequency and inaccuracies in models and measurements¹³. Figure 3 shows an example of the geographic variations in frequency after an instantaneous imbalance. The TSOs therefore propose applying the default value that is specified in table 1 of Annex 3 of the SO Regulation: 1000mHz.

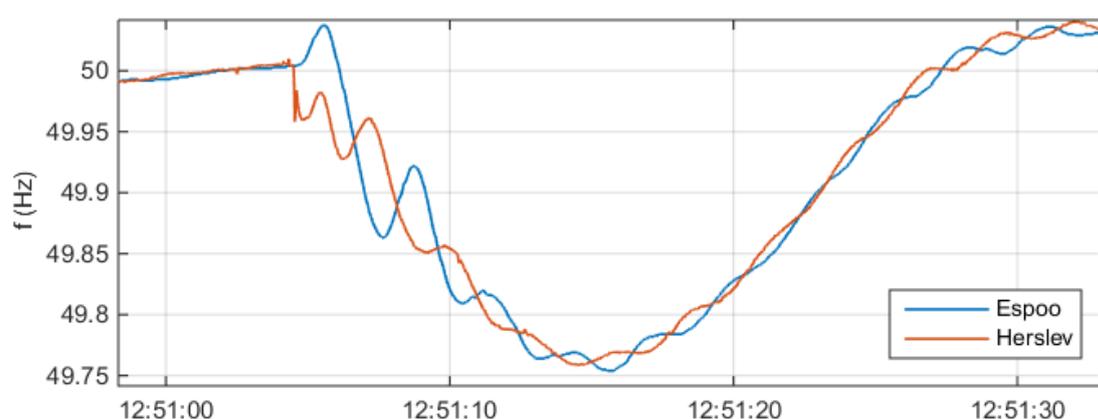


Figure 3: Frequency in Espoo (Southern Finland) and Herslev (Denmark) after a loss of 580MW

5.3 Maximum steady-state frequency deviation

The SO Regulation defines *steady state frequency deviation*¹⁴ as the “absolute value of frequency deviation after occurrence of an imbalance, once the system frequency has been stabilised. Since the Frequency Containment Process (FCP) has the objective to stabilise the frequency¹⁵, the steady state is implicitly defined as the situation after a disturbance in which the FCP has been completed and the Frequency Restoration Process (FRP) has to start. It shall be noted though that these periods may overlap, and that other imbalances may further impact the frequency. It is emphasized that the FCR response differs between the Nordic countries.

For the Nordic system, the *maximum steady-state frequency deviation* does not have a direct link to the UFLS risk. Hence, the *maximum steady-state frequency deviation* implicitly indicates the frequency range at which

¹³ A UCPTTE document from 1997 splits the 200mHz margin used in Continental Europe into four parts: 1) Possible stationary frequency deviation before the disturbance (50mHz), 2) insensitivities of the turbine governor (20mHz); 3) larger dynamic frequency deviation at the geographic location of the disturbance which is not taken into account by the simulation model (50mHz); and 4) other simulation model inaccuracies, approx. 10% (80mHz). The margin for a possible stationary frequency deviation before the disturbance (50mHz) is not applicable to the Nordic synchronous area since it is already assumed that the disturbance starts at 49.9Hz.

¹⁴ SO Regulation, article 3(2)(157)

¹⁵ SO Regulation, article 142

FCR shall be activated. The *Maximum steady-state frequency deviation* therefore directly links to the definition of FCR-D, which requires an increasing activation from 0% to 100% if the frequency reduces from 49.9 to 49.5Hz. For this reason, it is logical to keep the maximum steady-state frequency deviation to default value that is specified in table 1 of Annex 3 of the SO Regulation: 500mHz.

5.4 Time to restore frequency and frequency restoration range

'Time to restore frequency' is defined as the maximum expected time after the occurrence of a reference incident in which the System Frequency is restored inside a tolerance range which is named 'frequency restoration range'. Once the frequency is restored after a disturbance, the synchronous area should be able to handle the reference incident again without emergency measures such as automatic UFLS. Since this will only be feasible within the standard frequency range (49.90-50.10Hz), the 'frequency restoration range' is defined the same as the standard frequency range: 49.90-50.10Hz.

It shall be noted that during the 'Time to restore frequency' after a disturbance, a reference incident may result in emergency measures such as automatic UFLS. Consequently, the time to restore frequency shall be kept as short as possible. However, in order to restore the frequency, the Frequency Restoration Process (FRP) has to be completed. Especially if manual Frequency Restoration Reserves are involved that require starting up hydro power units or gas turbines, this may take up to 15 minutes.

For this reason, the default value of 15 minutes for time to restore frequency that is defined by the SO Regulation is reasonable and is proposed by the TSOs.

The impact of a 'time to restore frequency' of 15 minutes is that a) the power system may not be able to cater for a reference incident within 15 minutes after another incident; b) the specified duration of the full deployment of FCR must be at least 15 minutes and c) If the power system is operated in such a way that an instantaneous imbalance may lead to overloading a power line, it shall be possible to overload these lines for at least 15 minutes.

5.5 Alert state trigger time

Article 18 of the SO Regulation defines the system states, which are defined as the operational state of the transmission system in relation to the operational security limits which can be normal state, alert state, emergency state, blackout state and restoration state. This section 5.5 concentrates on the Alert state in relation to frequency and more specifically on the value for the Alert State Trigger Time. Since the definition of Alert State Trigger Time in the SO Regulation does not seem to be unambiguous, section 5.5.1 starts with a proposed interpretation of 'alert state trigger time' and 'steady state frequency'.

5.5.1 Definitions and proposed interpretation

Steady State frequency

According to article 18 of the SO Regulation, the alert state is triggered if the *steady state frequency* is outside a specified band for a certain time. SO Regulation art. 3(2)(157) define steady state frequency deviation as the absolute value of frequency deviation after occurrence of an imbalance, once the system frequency has been stabilised. Hence, article 18 seems to assume that the steady state frequency is continuously changing. Conversely, article 3(2)(157) suggests that for each disturbance, there is only one value of steady state frequency. It is therefore concluded that the definition in article 3(2)(157) cannot be applied to article 18.

As an alternative, the Nordic TSOs apply the *rolling average of the previous 60s period* as a proxy for the *steady state frequency* that triggers the alert state in accordance to article 18 of the SO Regulation. The main argument for choosing a 60s average is to cancel out the effect of the frequency oscillations in the Nordic system.

Alert State trigger time

The 'alert state trigger time' is defined as '*the time before alert state becomes active*' (SO Regulation art. 3(98)). Since the '*time before*' does have a starting point, the TSOs define the starting point as the time of

the disturbance: *Alert state trigger time means the time that has elapsed after the disturbance and during which the average system frequency deviation calculated over the previous 60s continuously exceeded 50% of the maximum steady state frequency deviation (250mHz).*

5.5.2 Impact of 'Alert State' and 'Alert State Trigger Time'

The definition of 'Alert State' and setting the 'Alert State Trigger Time' will have impact on the following requirements in the SO Regulation:

- When entering in Alert State, the synchronous area monitor will need to inform the other TSOs that the system is in Alert State (SO Regulation art. 152(3));
- When in Alert State, the 'common rules' (SO Regulation art. 152(6)) and 'operational procedures' (SO Regulation art. 152(10)) for the alert state will become active. These rules and procedures shall be defined by the TSOs in other methodologies;
- When in Alert State, the TSOs have the right to require changes in the active power production or consumption of power generating modules or demand units in order to reduce or to remove the violation of the requirements concerning active power reserve (SO Regulation art. 152(11));
- SO Regulation art. 156(9-10) defines the minimum activation period to be ensured by FCR providers: 'As of triggering the Alert State and during the alert state, each FCR provider shall ensure that its FCR providing units or groups with limited energy reservoirs are able to fully activate FCR continuously for a time period to be defined.' 'This period shall not be greater than 30 or smaller than 15 minutes.' Alert State Trigger Time determines after what time this functionality requirement for FCR becomes active. Note that this functionality requirement is only valid for Alert State.

5.5.3 Alert State Trigger Time

The default value for alert state trigger time is defined by the SO Regulation to 5 minutes. However, according to the SO Regulation, the TSOs shall have the right to propose alternative values in the synchronous area operational agreement¹⁶. The TSOs will not use this right.

5.6 Summary

Table 1 provides an overview of the proposed parameters of the Frequency Quality Defining Parameters. These are in accordance with the SO Regulation.

Table 1: **Frequency quality defining parameters for the Nordic synchronous area.**

Frequency quality defining parameters	
nominal frequency	50 Hz
standard frequency range	±100 mHz
maximum instantaneous frequency deviation	1000 mHz
maximum Steady-state frequency deviation	500 mHz
time to restore frequency	15 minutes
frequency restoration range	±100 mHz
alert state trigger time	5 minutes

¹⁶ SO Regulation, article 127(6)

The aim for frequency deviations outside the standard frequency range is not more than 10,000 min/year. However, Table 2 shows the frequency quality target parameter, which is considered as the absolute maximum of minutes outside the standard frequency range.

Table 2: **Frequency quality target parameter for the Nordic synchronous area.**

Frequency quality target parameter	
maximum number of minutes outside the standard frequency range	15,000

6. Expected impact of the Proposal on the relevant objectives of the SO Regulation

The Proposal generally contributes to and does not in any way hamper the achievement of the objectives of Article 4 of the SO Regulation. In particular, the Proposal serves the objectives to:

- Article 4(1)(c) determining common load-frequency control processes and control structures;
- Article 4(1)(d) ensuring the conditions for maintaining operational security throughout the Union;
- Article 4(1)(e) ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union; and
- Article 4(1)(h) contributing to the efficient operation and development of the electricity transmission system and electricity sector in the Union.

The Proposal contributes to these objectives by specifying the values for the frequency quality defining parameters and for the value of the frequency quality target parameter that the TSOs shall endeavour to comply with. The proposed values for the frequency quality defining parameters and for the value of the frequency quality target parameter intend to set efficient limits to the system frequency in different circumstances with the main objective to balance the operational security (risk for supply interruptions) and efficient operation of the electricity system (cost of load-frequency control measures to comply with the values). Furthermore, compliance with the proposed values ensures compliance with relevant international standards for user appliances.

7. Timescale for the implementation

The Proposal is based on the limits that are currently applied in the Nordic synchronous area. The Nordic synchronous area generally complies with the proposed frequency quality defining parameters and the frequency quality target parameter. Therefore, the TSOs shall implement the Proposal not later than when Nordic synchronous area operational agreement enters into force in accordance with Article 118 of the SO Regulation.

8. Public consultation

Article 11 of the SO Regulation states that: *“TSOs responsible for submitting proposals for terms and conditions or methodologies or their amendments in accordance with this Regulation shall consult stakeholders, including the relevant authorities of each Member State, on the draft proposals for terms and conditions or methodologies listed in Article 6(2) and (3). The consultation shall last for a period of not less than one month.”*

This proposal has been consulted in the period 1 June to 1 July 2018. The appendix to this document includes the views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the proposal.

Appendix: Results of Public Consultation

Article 11(3) of the SO Regulation states that: *”The TSOs responsible for developing the proposal for terms and conditions or methodologies shall duly take into account the views of stakeholders resulting from the consultations prior to its submission for regulatory approval. In all cases, a sound justification for including or not including the views resulting from the consultation shall be provided together with the submission of the proposal and published in a timely manner before, or simultaneously with the publication of the proposal for terms and conditions or methodologies.”*. Table 3 lists the views of stakeholders on this proposal resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

Table 3: Views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

no.	organisation	comment	response TSOs
2	Nordenergi	Nordenergi supports that the Nordic TSOs have agreed to take steps to ensure that the time period outside the frequency range will be limited to 10 000 minutes/year, and that this will be followed up on a quarterly basis.	Comment acknowledged and did not result in changes to the proposal. In addition, the TSOs note that 'time outside the standard frequency range' is one of the most important performance indicators that is followed-up by the TSOs on a weekly basis.
5	Fortum Oyj	Fortum is positive to the aim of frequency deviations outside the standard frequency range is not more than 10,000 minutes per year.	Comment acknowledged and did not result in changes to the proposal.

Explanatory document for the Nordic synchronous area proposal for additional properties of FCR in accordance with Article 154(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

1. Introduction

The Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter “**SO Regulation**”) sets out rules on relevant subjects that should be coordinated between Transmission System Operators, as well as between TSOs and Distribution System Operators and with significant grid users, where applicable. The goal of the SO Regulation is to ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities. In order to deliver these objectives, a number of steps are required.

One of these steps is to define the additional properties of Frequency Containment Reserves (FCR) for the Nordic synchronous area. Pursuant to Article 118(1)(b) of the SO Regulation, all Transmission System Operators in the Nordic Synchronous Area shall jointly develop common proposals for additional properties of FCR in accordance with Article 154(2) of the SO Regulation.

According to Article 6(3)(d)(iii) of the SO Regulation the proposal for additional properties of FCR in accordance with Article 154(2) (hereafter referred to as “**Proposal**”) shall be submitted for approval by the relevant national regulatory authorities (hereinafter “NRAs”) no later than 14 September, 2018. The Proposal is submitted for regulatory approval to all NRAs in the Nordic synchronous area. According to Article 6(6) of the SO Regulation the Proposal needs to be submitted to ACER as well, who may issue an opinion on the Proposal if requested by the NRAs.

This document contains an explanation of the Proposal from all TSOs of the Nordic synchronous area (hereinafter “**TSOs**”). It is structured as follows. The legal requirements for the Proposal are presented in Chapter 2. Chapter 3 starts with describing the objective of the additional properties of FCR. Chapter 4 provides an overview of the existing situation and Chapter 5 an outlook to future developments. The proposed additional properties of FCR are described in Chapter 6. Chapter 3 describes the expected impact on the relevant objectives of the SO Regulation. Finally, Chapter 8 provides the timeline for implementation and Chapter 9 describes the public consultation.

2. Legal requirements and interpretation

2.1 Legal references and requirements

Several articles in the SO Regulation set out requirements which the Proposal must take into account. These are cited below.

- (1) Article 118(1)(b) and (2) of the SO Regulation constitutes the legal basis that the Proposal should take into account. Article 118 has the following content:

“1. By 12 months after entry into force of this Regulation, all TSOs of each synchronous area shall jointly develop common proposals for:[...]

(b) additional properties of FCR in accordance with Article 154(2); [...]

2. All TSOs of each synchronous area shall submit the methodologies and conditions listed in Article 6(3)(d) for approval by all the regulatory authorities of the concerned synchronous area. Within 1 month after the approval of these methodologies and conditions, all TSOs of each synchronous area shall conclude a synchronous area operational agreement which shall enter into force within 3 months after the approval of the methodologies and conditions.”

- (2) Article 154(2) of the SO Regulation has the following content:

“ Article 154 FCR technical minimum requirements

[...]

2. All TSOs of a synchronous area shall have the right to specify, in the synchronous area operational agreement, common additional properties of the FCR required to ensure operational security in the synchronous area, by means of a set of technical parameters and within the ranges in Article 15(2)(d) of Commission Regulation No [000/2015 RfG] and Article 27 and 28 of Commission Regulation No [000/2015 DCC]. Those common additional properties of FCR shall take into account the installed capacity, structure and pattern of consumption and generation of the synchronous area. The TSOs shall apply a transitional period for the introduction of additional properties, defined in consultation with the affected FCR providers.

[...]"

- (3) Article 154(1) and Annex V of the SO GL Regulation specify the minimum technical requirements for FCR that shall be ensured by each reserve connecting TSO:

"Article 154 FCR technical minimum requirements

1. Each reserve connecting TSO shall ensure that the FCR fulfils the properties listed for its synchronous area in Table 1 of Annex V.

[...]"

ANNEX V

FCR technical minimum requirements referred to in Article 154:

Minimum accuracy of frequency measurement	CE, GB, IRE and NE	10 mHz or the industrial standard if better
Maximum combined effect of inherent frequency response insensitivity and possible intentional frequency response dead band of the governor of the FCR providing units or FCR providing groups.	CE	10 mHz
	GB	15 mHz
	IRE	15 mHz
	NE	10 mHz
FCR full activation time	CE	30 s
	GB	10 s
	IRE	15 s
	NE	30 s if system frequency is outside standard frequency range
FCR full activation frequency deviation.	CE	±200 mHz
	GB	±500 mHz
	IRE	Dynamic FCR ±500 mHz
		Static FCR ±1000 mHz
	NE	±500 mHz

Table 1 FCR properties in the different synchronous areas

- (4) Article 15(2)(d) of Regulation (EU) 2016/631 ("*network code on requirements for grid connection of generators*") provides a number of requirements (ranges) that shall be met by Type C and Type D power-generating modules "*when frequency sensitive mode ('FSM') is operating*". These include ranges of the "*Active power range related to maximum capacity*", "*Frequency response insensitivity*", "*Frequency response deadband*", "*Droop*", "*Active power*

frequency response capability”, “*initial activation of active power frequency response*” and the requirement that “(v) *the power-generating module shall be capable of providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO.*”. Furthermore, “(vi) *within the time limits laid down in point (v) of paragraph 2(d), active power control must not have any adverse impact on the active power frequency response of power-generating modules;*”.

- (5) Articles 27 and 28 of Regulation (EU) 2016/1388 (“*network code on demand connection*”) describe requirements for demand units to provide demand response services to system operators, including “*autonomously controlled demand response system frequency control*”. More specifically, Article 28 of Regulation (EU) 2016/1388 stipulates the “*specific provisions for demand units with demand response active power control, reactive power control and transmission constraint management*”. These provisions relate to operating capability across frequency ranges and voltage ranges, requirements related to receiving and executing instructions, controlling and adjusting power consumption, and requirements for maintaining the modification to power consumption.

- (6) Article 6(3)(d)(iii) of the SO Regulation states:

“The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region, on which a Member State may provide an opinion to the concerned regulatory authority: [...]

(d) methodologies, conditions and values included in the synchronous area operational agreements in Article 118 concerning:

(iii) additional properties of FCR in accordance with Article 154(2);

2.2 Interpretation and scope of the Proposal

The Nordic Frequency Containment Process (FCP) currently applies two types of Frequency Containment Reserves (FCR). FCR for normal operation (FCR-N) is used for continuous imbalances to keep the frequency within the $\pm 100\text{mHz}$ range. In conjunction with a rapid frequency change to 49.9/50.1 Hz, FCR-N shall be up regulated/down regulated within 2-3 minutes. FCR for disturbance situations (FCR-D) is only used in upward direction (upward FCR-D). The purpose of upward FCR-D is to mitigate the impact of incidental disturbances once the frequency is below 49.90Hz. Upward FCR-D shall be fully activated if the frequency stabilises at 49.50Hz. In the event of a frequency drop to 49.5 Hz caused by a momentary loss, FCR-D shall be fully activated within 30 seconds. It has to be noted that the *FCR full activation frequency deviation* of $\pm 500\text{mHz}$ and *FCR full activation time* of 30s that are specified in Annex V of the SO GL Regulation only apply to FCR-D. Consequently, the TSOs specify the required FCR-N response as additional properties in this proposal. The other two requirements in Annex V of the SO GL Regulation apply to both FCR-N and FCR-D.

3. Objective of additional properties of FCR

The objective of the additional properties of FCR is to complete the set of minimum requirements in Annex V of the SO Regulation for both FCR-N and FCR-D as required for secure operation of the Nordic synchronous area.

4. The existing situation

In this chapter, the existing requirements for FCR are presented. Since the Nordic TSOs apply two types of FCR, section 4.1 addresses FCR-N and section 4.2 addressed FCR-D.

4.1 Frequency Containment Reserves for normal operation (FCR-N)

FCR-N is the momentarily available active power available for frequency regulation in the range of 49.9 – 50.1Hz and which is activated automatically by the system frequency. Currently, FCR-N reserves shall be at least 600MW at 50.0Hz in the synchronous system. It shall be fully activated at $f = 49.9/50.1\text{Hz}$ ($\Delta f = \pm 0.1\text{Hz}$). In conjunction with a rapid frequency change to 49.9/50.1 Hz, the reserve shall be up regulated/down regulated within 2-3 minutes.

4.2 Frequency Containment Reserves for disturbance situations (FCR-D)

Currently, the TSOs only apply FCR-D in upward direction (upward FCR-D). Upward FCR-D is the momentarily available active power available for frequency regulation in the range of 49.9 – 49.5 Hz and which is activated automatically by the system frequency.

Upward FCR-D shall be activated at 49.9 Hz and shall be fully activated at 49.5 Hz. It shall increase virtually linearly within a frequency range of 49.9-49.5 Hz.

Agreed automatic load reduction could be delivered by e.g. industrial, district heating and electric boiler consumption. If load is reduced automatically when the frequency drops to 49.5 Hz it can be counted as part of the upward FCR-D. Load reduction can be used as upward FCR-D in the frequency range of 49.9 Hz to 49.5 Hz, when load reduction meets the same technical requirements set below for generators.

In the event of a frequency drop to 49.5 Hz:

- 50 % of the upward FCR-D frequency controlled disturbance reserve in each subsystem shall be regulated upwards within 5 seconds;
- 100 % of the upward FCR-D frequency controlled disturbance reserve shall be regulated upwards within 30 seconds.

5. Outlook

The TSOs foresee in the near future that changes and additions to the additional FCR properties are required. When the required changes are fully clear, the TSOs will start an amendment process. The following issues may be addressed:

- *Effectiveness of FCR:* After intensive analysis and measurement programs, the TSOs concluded that the existing requirements for both FCR-N and FCR-D do not necessarily meet the needs of the Nordic power system anymore. For this reason, the TSOs are in the process of defining more appropriate requirements that shall improve the effectiveness of both FCR-N and FCR-D.
- *Adding downward FCR-D:* Mainly caused by the increasing number of HVDC interconnectors to other synchronous areas, the Nordic synchronous area faces more and more large disturbances that result in an over frequency (i.e. generation surplus due to e.g. trip of an exporting HVDC interconnector). Since these incidents also affect the operational security, the TSOs will introduce downward FCR-D in accordance with the SO Regulation by 2021.

6. Proposal for additional FCR properties

Together with the requirements in Annex V of the SO Regulation, the proposed additional properties for FCR-N and upward FCR-D in section 6.1 and 6.2 form the same set of requirements as currently applied (see section 4.1 and 4.2). As discussed in chapter 5, these requirements do not necessarily meet the needs of the Nordic power system anymore and may need to be modified. Since the new requirements need to be defined carefully and in close cooperation with potential providers of FCR-N and upward FCR-D, the TSOs decided not to rush the implementation of new requirements. Furthermore, the TSOs did not opt for partly changing the requirements because that could mean that FCR providers should adapt their FCR providing units and/or FCR providing groups twice. For this reason, the additional properties for FCR-N and upward FCR-D below only include the existing requirements that are not covered by the requirements specified in the SO Regulation. It may be noted that the reasons for the existing requirements are largely historical and may – as suggested above – be outdated.

6.1 Additional FCR-N properties

As discussed in section 2.2, for FCR-N, Annex V of the SO GL Regulation specifies the *Minimum accuracy of frequency measurement* and the *Maximum combined effect of inherent frequency response insensitivity and possible intentional frequency response dead band of the governor of the FCR providing units or FCR providing groups*. Conversely, for FCR-N, SO GL Regulation does not specify the *FCR full activation frequency deviation* and the *FCR-N full activation time*. These two properties will be deducted from existing requirements in section 6.1.1 and 6.1.2.

6.1.1 FCR full activation frequency deviation

Since FCR-N is used for continuous imbalances to keep the frequency within the $\pm 100\text{mHz}$ range, FCR-N shall be fully activated at $f = 49.9/50.1\text{Hz}$ ($\Delta f = \pm 0.1\text{Hz}$). This implicitly means that the *FCR full activation frequency deviation* for FCR-N is $\pm 100\text{mHz}$, which is proposed in Article 3(1) of the Proposal.

6.1.2 FCR-N full activation time

FCR-N shall – in conjunction with a rapid frequency change to $49.9/50.1\text{ Hz}$ - be up regulated/down regulated within 3 minutes which is proposed in Article 3(2) of the Proposal.

Both the full activation frequency deviation and the full activation time are within the ranges in Article 15(2)(d) of Commission Regulation No [000/2015 RfG] and Article 27 and 28 of Commission Regulation No [000/2015 DCC].

6.2 Additional upward FCR-D properties

For FCR-D, Annex V of the SO GL Regulation specifies the *full activation frequency deviation* ($\pm 500\text{mHz}$) and the *full activation time* (30s). However, SO GL Regulation does not specify other requirements that are important for the Nordic synchronous area. These issues are addressed in section 6.2.1, 6.2.2 and 6.2.3.

6.2.1 virtual linear increase between 49.9 and 49.5Hz

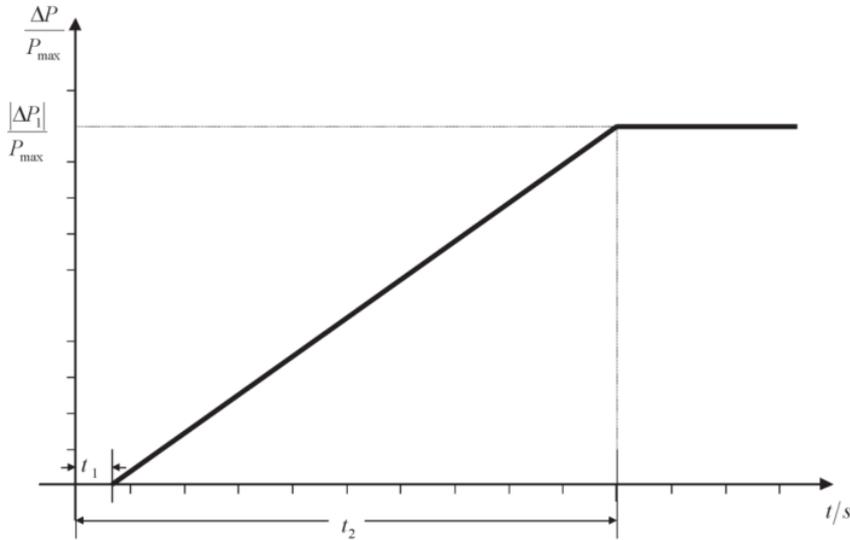
The existing rules for upward FCR-D include the requirement that activation shall increase virtually linearly within a system frequency range of $49.9\text{-}49.5\text{Hz}$. This should give the most stable control. This requirement is proposed in Article 4(1) of the Proposal.

6.2.2 50% of the FCR-D response shall be available within 5s

The existing rules for FCR-D require that in the event of a frequency drop to 49.5 Hz caused by a momentary loss of production 50 % of the upward FCR-D shall be regulated upwards within 5 seconds. This requires a faster response than required by Article 15(2)(d)(iii) of Commission Regulation No [000/2015 RfG] which states that “*in the event of a frequency step change, the power-generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 [..].*”.

Figure 6

Active power frequency response capability



This Figure 6 shows that it is only required to reach 50% of the activation far later than the current requirement of 50% within 5s. Since especially at times of low inertia in the Nordic synchronous area a fast FCR-D response is required¹, the TSOs consider relaxing the current requirement unacceptable for operational security reasons. For that reason, the TSOs propose keeping the existing requirement that “50% of the upward FCR-D in each subsystem shall be regulated upwards within 5 seconds;”. Article 4(2) of the Proposal reflects this position.

6.2.3 Load reduction can be used as upward FCR-D

In some cases, automatic load reduction is applied in the Nordic synchronous area as part of the upward FCR-D. This load reduction may be delivered by e.g. industrial load, district heating and electric boiler consumption. For upward FCR-D provided by load reduction in principle the same requirements apply as for upward FCR-D provided by generation units. This means that upward FCR-D provided by load reduction shall operate in the frequency range of 49.9 Hz to 49.5 Hz and that the same FCR full activation time and response requirements (see section 6.2.2) apply. This is reflected by article 4(3) of the Proposal.

6.3 Summary

The arguments in section 6.1 result in the additional properties for FCR-N in Article 3 of the Proposal:

1. FCR-N shall be fully activated at $f = 49.9/50.1\text{Hz}$ ($\Delta f = \pm 0.1\text{Hz}$). FCR full activation frequency deviation for FCR-N is $\pm 100\text{mHz}$.
2. In conjunction with a rapid system frequency change to 49.9/50.1 Hz, FCR-N shall be up regulated/ down regulated within 3 minutes.

The arguments in section 6.2 result in the additional properties for FCR-D in Article 4 of the Proposal:

1. Upward FCR-D shall be activated at 49.9 Hz and shall be fully activated at 49.5 Hz. It shall increase virtually linearly within a system frequency range of 49.9-49.5 Hz.

¹ to prevent for automatic Under Frequency Load Shedding in case of large instantaneous imbalances.

2. In the event of a system frequency drop to 49.5 Hz:
 - 50 % of the upward FCR-D shall be regulated upwards within 5 seconds;
 - 100 % of the upward FCR-D shall be regulated upwards within 30 seconds.
3. Agreed automatic load reduction in the event of frequency drops to 49.5 Hz can be counted as part of the upward FCR-D reserve. However: Load reduction can only be used as upward FCR-D in the frequency range of 49.9 Hz to 49.5 Hz, when load reduction meets the same technical requirements set under item 1 of this article.

7. Expected impact of the Proposal on the relevant objectives of the SO Regulation

The Proposal generally contributes to and does not in any way hamper the achievement of the objectives of Article 4 of the SO Regulation. In particular, the Proposal serves the objectives to:

- Article 4(1)(c) determining common load-frequency control processes and control structures;
- Article 4(1)(d) ensuring the conditions for maintaining operational security throughout the Union;
- Article 4(1)(e) ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union; and
- Article 4(1)(h) contributing to the efficient operation and development of the electricity transmission system and electricity sector in the Union.

The Proposal contributes to these objectives by specifying the additional rules for FCR-N and upward FCR-D, which are key reserves that are used in the common Nordic load-frequency control processes. The additional properties are required to maintain the operational security by reducing the risk for automatic Under Frequency Load Shedding (UFLS) and for system blackouts due to under or over frequency. The additional properties balance the impact of both cost for FCR and outage risk and therefore ensure efficient operation of the electricity transmission system.

8. Timescale for the implementation

For proposed additional properties for both FCR-N and FCR-D currently apply in the Nordic synchronous area. Therefore, the TSOs shall implement the proposed additional properties for both FCR-N and FCR-D not later than when Nordic synchronous area operational agreement enters into force in accordance with Article 118 of the SO Regulation.

9. Public consultation

Article 11 of the SO Regulation states that: *“TSOs responsible for submitting proposals for terms and conditions or methodologies or their amendments in accordance with this Regulation shall consult stakeholders, including the relevant authorities of each Member State, on the draft proposals for terms and conditions or methodologies listed in Article 6(2) and (3). The consultation shall last for a period of not less than one month.”*

This proposal has been consulted in the period 1 June to 1 July 2018. The appendix to this document includes the views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the proposal.

Appendix: Results of Public Consultation

Article 11(3) of the SO Regulation states that: *"The TSOs responsible for developing the proposal for terms and conditions or methodologies shall duly take into account the views of stakeholders resulting from the consultations prior to its submission for regulatory approval. In all cases, a sound justification for including or not including the views resulting from the consultation shall be provided together with the submission of the proposal and published in a timely manner before, or simultaneously with the publication of the proposal for terms and conditions or methodologies."* Table 1 lists the views of stakeholders on this proposal resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

Table 1: Views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

no.	organisation	comment	response TSOs
3	Nordenergi	<p>We have the following comments regarding the proposal for additional properties of FCR in accordance with Article 154(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017:</p> <p>In the explanatory document for Nordic FCR additional properties proposal it is raised that the existing additional FCR properties do not necessarily meet the needs of the Nordic power system anymore. The TSOs foresee in the near future that changes and additions to the additional FCR properties are required and it is stated that: "Since the new requirements need to be defined carefully and in close cooperation with potential providers of FCR-N and upward FCR-D, the TSOs decided not to rush the implementation of new requirements".</p> <p>Nordenergi regards that stronger efforts could have been made to address some of the issues raised by the TSOs already in the consulted proposal. We have the understanding that a separate consultation on downward FCR-D will be performed shortly and supports this effort to make the portfolio of reserves more complete.</p>	<p>Comment acknowledged and did not result in changes to the proposal. The TSOs recognise that some changes could have been included in the proposal. However - as stated in chapter 6 of the explanatory document - <i>'the TSOs did not opt for partly changing the requirements because that could mean that FCR providers should adapt their FCR providing units and/or FCR providing groups twice. For this reason, the additional properties for FCR-N and upward FCR-D below only include the existing requirements that are not covered by the requirements specified in the SO Regulation.'</i> The amendment process to this proposal will include a public consultation process.</p>
4	Nordenergi	<p>Given both the expected changes in the Nordic power system, the TSOs quarterly monitoring of the frequency quality and possible changes in product and settlement routines, it is crucial with deeper stakeholder involvement in the process going forward. In the monitoring process, it is important that new requirements are tested during a period to study/analyse any improvement to the frequency in the Nordic synchronous area before requirements enter into force on a permanent basis.</p> <p>Hence, new requirements etc. should be developed together with a</p>	<p>Comment acknowledged and did not result in a change of the proposal. Providers have already been involved in discussions and tests of new requirements and will also be involved in future.</p> <p>The focus in near future will be on the evaluation of the ability of providers to pre-qualify their assets. Furthermore, the need for the new FCR requirements from a system perspective will be analysed using simulation models. The TSOs will start the FCR implementation feasibility study shortly (proposed to be executed Q3'18-Q1'19). The TSOs will</p>

no.	organisation	comment	response TSOs
		reference group from the industry. We further encourage the TSOs to publish an implementation plan for the FCR in the Nordic region containing milestones like pre-qualifications, product roll-out, frequency monitoring periods and expected stakeholder involvement including future consultations.	share an implementation plan for the new FCR requirements with their stakeholders as soon as this plan has been agreed between the TSOs.
7	Fortum Oyj	<p>Given both the coming changes in the Nordic power system and possible changes in balancing products and settlement routines, it is crucial with deeper stakeholder involvement in the process going forward. In the monitoring process, it is important that new requirements are tested during a period to study/analyse any improvement to the frequency in the Nordic synchronous area before requirements enter into force on a permanent basis.</p> <p>Hence, new requirements etc. should be developed together with a reference group from the industry.</p>	Comment acknowledged, see response to comment no. 4
8	Fortum Oyj	We further encourage the TSOs to publish an implementation plan for the FCR in the Nordic region containing milestones like pre-qualifications, product roll-out, frequency monitoring periods and expected stakeholder involvement including future consultations.	Comment acknowledged, see response to comment no. 4
9	Fortum Oyj	Specifically the Article 4, – Upward FCR-D additional properties of the “Nordic synchronous area proposal for additional properties of FCR in accordance with Article 154(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation”, can be problematic given the fact that the frequency is too often below the standard frequency range, even with no major disturbance. It could be valuable to consider either to loosen the demand on virtual linearity or an introduction of a deadband (example: between 49,9 and 49,80) of the activation of FCR-D, or other measures to ensure FCR-D reserves are not used in vain.	Comment acknowledged and did not result in changes to the proposal. The TSOs recognise the issue that is raised by the respondent and aim for implementing resolutions in both the development of the new requirements for FCR and the new Nordic balancing model.

Explanatory document for the Nordic synchronous area Proposal for the dimensioning rules for FCR in accordance with Article 153 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

1. Introduction

The Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter “**SO Regulation**”) sets out rules on relevant subjects that should be coordinated between Transmission System Operators, as well as between TSOs and Distribution System Operators and with significant grid users, where applicable. The goal of SO Regulation is to ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities. In order to deliver these objectives, a number of steps are required.

One of these steps is to determine a methodology for dimensioning Frequency Containment Reserves (FCR) for the Nordic synchronous area. Pursuant to Article 118(1)(a) of the SO Regulation, all Transmission System Operators in the Nordic Synchronous Area shall jointly develop common proposals for dimensioning rules for FCR in accordance with Article 153 of the SO Regulation.

According to Article 6(3)(d)(ii) of the SO Regulation the proposal for the dimensioning rules for FCR in accordance with Article 153 (hereafter referred to as “**Proposal**”) shall be submitted for approval by the relevant national regulatory authorities (hereinafter “**NRAs**”) no later than 14 September, 2018. The Proposal is submitted for regulatory approval to all NRAs in the Nordic synchronous area. According to Article 6(6) of the SO Regulation the Proposal needs to be submitted to ACER as well, who may issue an opinion on the Proposal if requested by the NRAs.

This document contains an explanation of the Proposal from all TSOs of the Nordic synchronous area (hereinafter “**TSOs**”). It is structured as follows. The legal requirements for the Proposal are presented in Chapter 2. Chapter 3 starts with describing the objective of FCR. Chapter 4 provides an overview of the existing situation. The proposed dimensioning rules for FCR are described in Chapter 5. Chapter 6 describes the expected impact on the relevant objectives of the SO Regulation. Finally, Chapter 7 provides the timeline for implementation and Chapter 8 describes the public consultation.

2. Legal requirements and interpretation

2.1 Legal references and requirements

Several articles in the SO Regulation set out requirements which the Proposal must take into account. These are cited below.

- (1) Article 118(1)(c) and (2) of the SO Regulation constitutes the legal basis that the Proposal should take into account. Article 118 has the following content:

“1. By 12 months after entry into force of this Regulation, all TSOs of each synchronous area shall jointly develop common proposals for:[...]”

(a) the dimensioning rules for FCR in accordance with Article 153; [...]

2. All TSOs of each synchronous area shall submit the methodologies and conditions listed in Article 6(3)(d) for approval by all the regulatory authorities of the concerned synchronous area. Within 1 month after the approval of these methodologies and conditions, all TSOs of each synchronous area shall conclude a synchronous area operational agreement which shall enter into force within 3 months after the approval of the methodologies and conditions.”

- (2) Article 153 of the SO Regulation has the following content:

“Article 153 FCR dimensioning

1. All TSOs of each synchronous area shall determine, at least annually, the reserve capacity for FCR required for the synchronous area and the initial FCR obligation of each TSO in accordance with paragraph 2.

2. All TSOs of each synchronous area shall specify dimensioning rules in the synchronous area operational agreement in accordance with the following criteria:

(a) the reserve capacity for FCR required for the synchronous area shall cover at least the reference incident and, for the CE and Nordic synchronous areas, the results of the probabilistic dimensioning approach for FCR carried out pursuant to point (c);

(b) the size of the reference incident shall be determined in accordance with the following conditions:

(i) for the CE synchronous area, the reference incident shall be 3 000 MW in positive direction and 3 000 MW in negative direction;

(ii) for the GB, IE/NI, and Nordic synchronous areas, the reference incident shall be the largest imbalance that may result from an instantaneous change of active power such as that of a single power generating module, single demand facility, or single HVDC interconnector or from a tripping of an AC line, or it shall be the maximum instantaneous loss of active power consumption due to the tripping of one or two connection points. The reference incident shall be determined separately for positive and negative direction;

(c) for the CE and Nordic synchronous areas, all TSOs of the synchronous area shall have the right to define a probabilistic dimensioning approach for FCR taking into account the pattern of load, generation and inertia, including synthetic inertia as well as the available means to deploy minimum inertia in real-time in accordance with the methodology referred to in Article 39, with the aim of reducing the probability of insufficient FCR to below or equal to once in 20 years; and

(d) the shares of the reserve capacity on FCR required for each TSO as initial FCR obligation shall be based on the sum of the net generation and consumption of its control area divided by the sum of net generation and consumption of the synchronous area over a period of 1 year.”

(3) Article 3(2)(58) of the SO Regulation defines the ‘reference incident’ as the ‘*maximum positive or negative power deviation occurring instantaneously between generation and demand in a synchronous area, considered in the FCR dimensioning*’.

(4) Article 39(3)(b) of the SO Regulation explains “*The methodology referred to in Article 39* ” (as referred to in Article 153(c)):

”*Article 39 Dynamic stability management*

[..]

3. In relation to the requirements on minimum inertia which are relevant for frequency stability at the synchronous area level:

(a) all TSOs of that synchronous area shall conduct, not later than 2 years after entry into force of this Regulation, a common study per synchronous area to identify whether the minimum required inertia needs to be established, taking into account the costs and benefits as well as potential alternatives. All TSOs shall notify their studies to their regulatory authorities. All TSOs shall conduct a periodic review and shall update those studies every 2 years;

(b) where the studies referred to in point (a) demonstrate the need to define minimum required inertia, all TSOs from the concerned synchronous area shall jointly develop a methodology for the definition of minimum inertia required to maintain operational security and to prevent violation of stability limits. That methodology shall respect the principles of efficiency and proportionality, be developed within 6 months after the completion of the studies referred to in

point (a) and shall be updated within 6 months after the studies are updated and become available; and

(c) each TSO shall deploy in real-time operation the minimum inertia in its own control area, according to the methodology defined and the results obtained in accordance with paragraph (b).

(5) Article 6(3)(d)(ii) of the SO Regulation states:

“The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region, on which a Member State may provide an opinion to the concerned regulatory authority: [...]

(d) methodologies, conditions and values included in the synchronous area operational agreements in Article 118 concerning:

(ii) the dimensioning rules for FCR in accordance with Article 153;

2.2 Interpretation and scope of the Proposal

Article 153(2) of the SO Regulation includes two topics. Firstly, Article 153(2)(a)-(c) stipulates the dimensioning rules for FCR. Secondly, Article 153(2)(d) prescribes how the initial FCR obligation per TSO shall be calculated.

Where Article 153(2) only describes one type of FCR, the Nordic Frequency Containment Process (FCP) applies two types of FCR: FCR for normal operation (FCR-N) is used for continuous imbalances to keep the frequency within the ± 100 mHz range. For this reason, the purpose of FCR-N is not to mitigate the consequences of a disturbance such as a reference incident. The purpose of Frequency Containment Reserves for Disturbance situations (FCR-D) is to mitigate the impact of incidental disturbances, including the reference incident. Article 153(2)(b)(ii) of the SO Regulation refers to the “reference incident” which “shall be the largest imbalance that may result from an instantaneous change of active power such as that of a single power generating module, single demand facility, or single HVDC interconnector [...]”. This list clearly refers to incidents and therefore Article 153(2)(a)-(c) can only be applied to FCR-D. The scope of this Proposal with respect to Article 153(2)(a)-(c) shall therefore be limited to the dimensioning rules for FCR-D.

Article 153(2)(d) of the SO Regulation is about the initial FCR obligation per TSO. Also in this article there is no explicit differentiation between FCR-N and FCR-D. However, in the rules in Article 153(2)(d) can be applied to both FCR-N and FCR-D. For this reason, the TSOs consider Article 153(2)(d) of the SO Regulation applicable to both FCR-N and FCR-D.

The scope of this Proposal only includes the dimensioning rules for FCR-D on a Nordic level and the calculation of the initial distribution per TSO. It does not specify how each TSO shall fulfil its share. Procurement and settlement of FCR are not in the scope of the SO Regulation and this Proposal, but inside the scope of the 'Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing'.

3. Objective of FCR dimensioning

The Frequency Containment Process' (FCP) objective is to stop the frequency increase or decrease before the instantaneous frequency deviation reached the maximum instantaneous frequency deviation and consequently to stabilise the frequency deviation at a steady-state value not more than the permissible

Maximum Steady-State Frequency Deviation¹. The objective shall be met by a joint action of FCR within the whole synchronous area.

The objective of FCR-D dimensioning is to specify - for the situation that a reference incident takes place - the amount of FCR-D that is required to:

- limit the instantaneous frequency deviation to less than the maximum instantaneous frequency deviation (1000 mHz in accordance with Article 127 of the SO Regulation) and accordingly prevent for load shedding or generation shedding;
- limit the steady-state frequency deviation to less than the maximum steady-state frequency deviation (500 mHz in accordance with Article 127 of the SO Regulation).

4. The existing situation

In this chapter, the current procedure for the dimensioning of FCR is presented, together with the procedures for how the 'reference incidents' are being defined. Since the Nordic TSOs define two types of FCR, section 4.1 addresses FCR-N and section 4.2 addressed FCR-D.

4.1 Frequency Containment Reserves for Normal operation (FCR-N)

At the moment the volume for FCR-N is at least 600 MW for the synchronous system². The distribution between subsystems is revised each year before 1st March on the basis of annual consumption in the previous year (annual consumption is given in TWh at an accuracy of one decimal). The share of each subsystem is rounded to closest integer given in MW and this will enter into force on 1st April.

4.2 Frequency Containment Reserves for Disturbance situations (FCR-D)

At the moment the required FCR-D capacity is equal to the largest possible imbalance caused by the loss of individual major components (production units, lines, transformers, bus bars etc.) from all fault events that have been taken into account, deducted by 200 MW due to the estimated load frequency dependency (see Textbox 1). It should also be noticed that, at the moment, FCR-D is required only for low frequencies (49.5...49.9 Hz), which are caused by a loss of generation or import via an HVDC interconnector to another synchronous area.

The current dimensioning rules do not explicitly consider the additional network losses that may result from changing flows after a disturbance. E.g. if a nuclear plant in Sweden trips, the flows from both northern Sweden and Norway may increase which may increase the network losses which would result in a larger imbalance on a synchronous area level.

The current method for distribution of the requirements for FCR-D between the subsystems in Nordic power system is carried out in proportion to the largest possible imbalance caused by the loss of individual major components within the respective subsystem. Distribution of the requirement is updated once per week or more often if needed. Control centers of each Nordic TSO are responsible of defining the largest possible imbalance caused by the loss of individual major components on Thursday or Friday on previous week, separately for each hour. The TSO's Nordic Operational Information System NOIS automatically calculates the amount of needed FCR-D for each TSO.

¹ A more detailed explanation of what happens in case of an incident is included in textbox 1 of the 'Explanatory document for the Nordic synchronous area proposal for frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.'

² The value of ± 600 MW is based on historic assumptions of a load random variation of $\pm 1\%$ of 60 GW.

Textbox 1: Frequency dependency of load

Frequency dependency of load

Load in the synchronous area automatically and immediately reacts on an instantaneous change of the system frequency. This is called the 'frequency dependency of load' and means in practice that an imbalance is partly mitigated by the response of load.

Unfortunately, there is little actual knowledge about the impact of frequency dependency of load in the Nordic synchronous area. The latest TSO study is from 1995 and gives a figure for the frequency dependency of load 0.7 % / 0.5Hz for a low load situation. Currently, a large Nordic investigation on load modelling is being performed. The project started in 2015 and is expected to provide results by Q3 of 2019.

5. Proposal for dimensioning rules for FCR-D

Article 153(2)(a) of the SO Regulation states that *“the reserve capacity for FCR required for the synchronous area shall cover at least the reference incident and [...] the results of the probabilistic dimensioning approach for FCR carried out pursuant to point (c);”*. Section 5.1 explains how the required FCR-D will be dimensioned in order to cover the reference incident. Section 5.2 defines the reference incident. The TSOs will not apply *“a probabilistic dimensioning approach for FCR”*, which is explained in section 5.3.

5.1 FCR-D dimensioning based on reference incident (Article 153(2)(a))

In accordance with Article 153(2)(b)(ii) of the SO Regulation, *“the reference incident shall be determined separately for positive direction negative direction”*. The Nordic TSOs define the positive direction as a power surplus in the synchronous area, caused by e.g. tripping of a load or an exporting HVDC interconnector. The negative direction is defined by a power shortage and can be caused by e.g. tripping of a production unit or an importing HVDC interconnector. In accordance with Article 153(2)(a) of the SO Regulation, FCR-D shall cover at least the reference incident. This is interpreted as that downward FCR-D shall cover at least the reference incident in positive direction and that upward FCR-D shall cover at least the reference incident in negative direction. This is reflected by article 3(3) and 3(4) of the Proposal.

5.2 Definition of the reference incident (Article 153(2)(b)(ii))

This section 5.2 further elaborates on the definition of the reference incident as proposed in Article 3 of the Proposal in accordance with Article 153(2)(b)(ii) of the SO Regulation. In section 5.2.1, general guidance and reflections are given on the reference incident, in section 5.2.2-5.2.6 some detailed aspects for determining the size of 'reference incident' is presented, and in section 5.2.7 the daily process is presented.

5.2.1 'Reference incidents' considered for dimensioning of FCR-D

Article 153(2)(b)(ii) of the SO Regulation mentions that *the reference incident shall be the largest imbalance that may result from an instantaneous change of active power such as that of a single power generating module, single demand facility, or single HVDC interconnector or from a tripping of an AC line, or it shall be the maximum instantaneous loss of active power consumption due to the tripping of one or two connection points. The reference incident shall be determined separately for positive and negative direction;”*. The words *“such as”* in this article provide the TSOs with the task to define a more concrete list that shall be applicable to the Nordic system.

From the elements listed up in Article 153(2)(b)(ii), the following ones are considered in the FCR-D dimensioning process:

- *Single power generating module*³ - e.g. tripping of Oskarshamn 3, Sweden.

³ Power generating module: Either a Synchronous Power Generating Module or a Power Park Module.
Synchronous Power Generating module: An indivisible set of installations which can generate electrical energy such

- *Single demand facility* - e.g. tripping of one aluminum smelter hall in Norway.
- *Single HVDC interconnector*- e.g. tripping of Baltic Cable in import/export situation, Sweden.
- *Tripping of an AC-line*- e.g. tripping of line(s) Hasle-Halden resulting in system protection scheme (SPS) activation in Norway, and by this tripping of production units within the system protection scheme. Could also be tripping of one line resulting in loss of a regional part of the system.

The "the maximum instantaneous loss of active power consumption due to the tripping of one or two connection points" is considered to be much less relevant for the Nordic system. The TSOs concluded that it, at the time being, is not relevant to set a 'reference incident' based on tripping of *two* connection points. The reason for this is that the TSOs do not consider the probability for two simultaneous outages of demand facilities significant. Tripping of one connection point has already been covered by a *single power generating module* and a *single demand facility* which are listed above.

In addition to the list in Article 153(2)(b)(ii), the TSOs consider that tripping of *one busbar* shall be evaluated as a reasonable N-1 disturbance. This may be relevant during especially longer outages for maintenance on a busbar. See example in Figure 1. Per today, this scenario is considered in the normal outage planning within each of the Nordic TSOs to ensure that any planned outage does not result in too large installed production capacity connected to a single busbar. As such, - in practice - tripping of single bus bars will not likely have an impact on the dimensioning of FCR-D in the system.

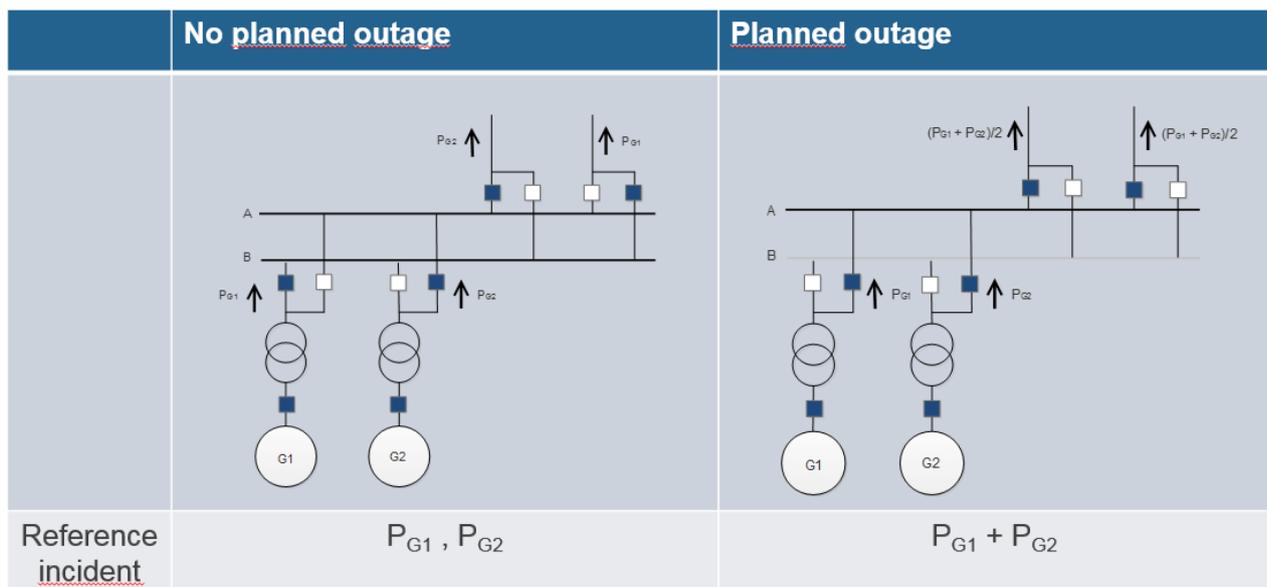


Figure 1: Left figure: 'incident considered' is the trip of busbar B, assuming $P_{G1} > P_{G2}$. Right: The 'incident considered' becomes the sum of P_{G1} and P_{G2}

5.2.2 House load/auxiliary systems to be considered

When assessing the instantaneous loss of active power generation for power generating modules, the real value for expected loss shall be taken into account. This means that for example, for thermal units with significant house load consumption (due to auxiliary systems), the total loss of active power as seen from the grid shall be used as basis for the definition of reference incident. This in turn means that the gross power

that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in synchronism.

generation of a unit should be taken into account. The reason for this can be seen in Figure 2. In this example the unit generator breaker is tripped instead of the breaker connecting to the main grid busbar.

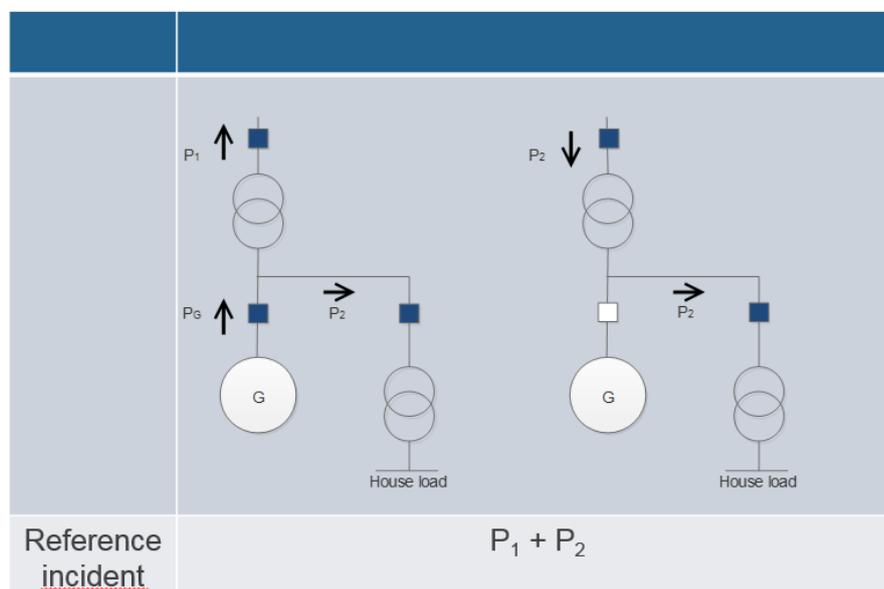


Figure 2: The 'incident considered' is the actual change of power after the trip of a generator unit. The house load shall be taken into account. 'Reference incident' equals the sum of $P_1 + P_2 (= P_G)$

5.2.3 Frequency dependency of load

Article 153(2) states that the FCR dimensioning rules (interpreted as applicable to FCR-D for the Nordic situation) shall be specified in accordance with a number of criteria. The first 'criterion' is that "the reserve capacity for FCR required for the synchronous area shall cover at least the reference incident [..]". Article 153(2)(ii) defines that "the reference incident shall be the largest imbalance that may result from an instantaneous change of active power such as that of a single power generating module [..]". The definition of the 'reference incident' in SO GL art. 3(2)⁴ implicitly suggests that the imbalance caused by the reference incident shall be seen on the synchronous area level and therefore implicitly take the frequency dependency of load into account. This approach is consistent with the existing approach (see section 4.2). However, as argued in Textbox 1, there is no actual knowledge on the size and variation of the frequency dependency of load since the latest TSOs study in 1995. For this reason, the TSOs will not take into account any frequency dependency of load in the dimensioning for FCR-D, at least until they have gained more knowledge on this. If sufficient evidence about the size and variation of the frequency dependency of load is provided, the TSOs may decide to correct the reference incident for the frequency dependency of load in the Nordic system at a later stage. A potential implementation of this correction, will require an amendment of the proposed methodology for FCR-D dimensioning.

⁴ "reference incident: the maximum positive or negative power deviation occurring instantaneously between generation and demand in a synchronous area, considered in the FCR dimensioning"

5.2.4 Change of losses due to flow changes after disturbances

The imbalance that is caused by large incident may also be influenced by the change in network losses due to changed flows (see section 4.2). This effect is however very much dependent on the specific situation, including the location of the incident, the location of the FCR-D providing units and the flows just before the incident. The effect can result in both increased or decreased network losses and can therefore both increase or decrease the resulting imbalance on a synchronous area level. The TSO will not include this effect either in the dimensioning of FCR-D.

5.2.5 Not considered for FCR-D dimensioning: Single disturbances with very low probability

Single failures with very low probability can occur in power system. This is the case for incidents leading to e.g. transmission tower collapse and certain less likely short circuits resulting in multiple bus bar tripping. These failures can in some cases lead to larger instantaneous imbalances than the incidents referred to in section 5.2.1.

However, taking these failures with very low probability into account would result in inefficient FCR-D dimensioning since the probability that the total amount of FCR-D would be activated is very small. Consequently, failures such as transmission tower collapse, trip of multiple bus bars etc. shall not set the 'reference incidents'.

5.2.6 Variation of active power output of a power generating module, HVDC facility

The size of the 'reference incident' depends on the actual operating point of a unit, which can differ from the nominal size of the unit. For example, a nuclear unit might

- run on "coast down" which mean reduced output in the end of its operational cycle;
- run with one generator synchronised to the main grid, in case outage on the other one (only applicable for two-turbine units like Ringhals nuclear power station).

The actual size depending on the actual operating point shall be the basis for FCR-D dimensioning in the Nordic system for each operational hour. The process for the continuous definition of 'reference incident' is defined in section 5.2.7.

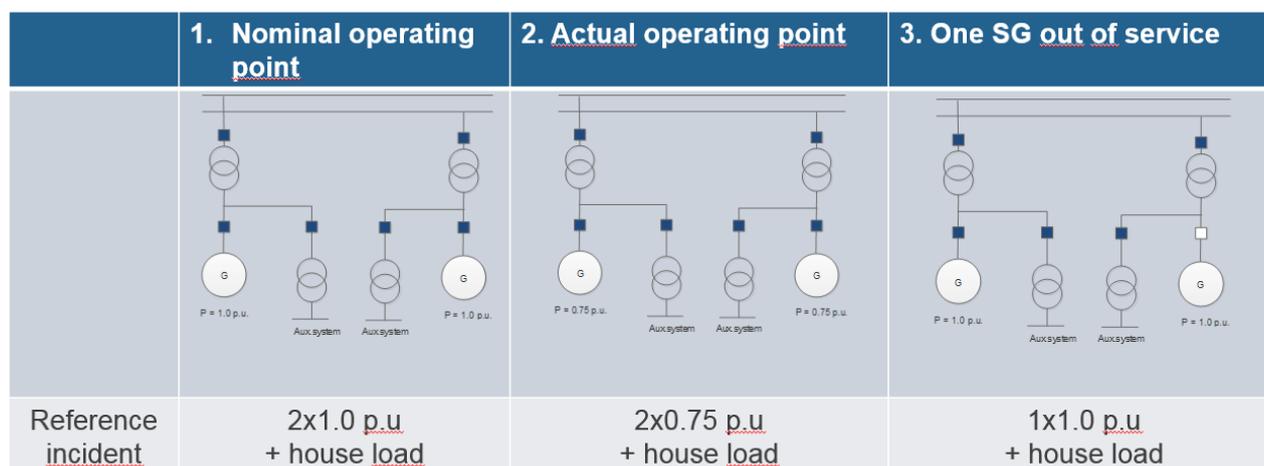


Figure 3: Size of 'reference incident' taking into account the actual operating point of a unit.

5.2.7 Daily process for defining 'reference incident'

The daily process to define the reference incident can utilize the already existing procedures. I.e. the continuous definition can be kept as a responsibility to control centers of each Nordic TSO. IT tool NOIS includes already now the possibility to define reference incident separately for each hour. However, NOIS does not, at the moment, include the possibility to define reference incident for both directions (up/down). This feature should be added to NOIS.

5.3 Probabilistic dimensioning approach for Frequency Containment Reserves (FCR) (Article 153.2(c))

Article 153.2(c) of the SO Regulation state that the “TSOs of the synchronous area shall have the right to define a probabilistic dimensioning approach for FCR [...]”

The TSOs conducted a joint project and have discussed a probabilistic methodology that can be used for a probabilistic dimensioning approach for FCR-D as mentioned in Article 153(2) of the SO Regulation. The methodology estimates the risk for insufficient FCR based on inputs including frequency distribution during normal situation, probability and size of faults, inertia in the system and amount of FCR-D. The results of the methodology provide an indication if in the considered situation the “probability of insufficient FCR of at most once in 20 years.”.

The TSOs however, together decided not using this methodology at the moment because the process for how to translate a certain risk level, inertia level, the actual probability for incidents and other inputs to a suitable measures, including FCR-D dimensioning needs to be further defined. For this reason, the TSOs do not use “the right to define a probabilistic dimensioning approach for FCR” in accordance with Article 153(2)(c) of the SO Regulation.

5.4 Calculation of the initial obligation per TSO (Article 153(2)(d))

In Article 153(2)(d) states that “the shares of the reserve capacity on FCR required for each TSO as initial FCR obligation shall be based on the sum of the net generation and consumption of its control area divided by the sum of net generation and consumption of the synchronous area over a period of 1 year.”

The share of FCR for TSO A is then

$$FCRshare_{TSO A} = \frac{Generation_{TSO A} + Consumption_{TSO A}}{\sum_{i=1}^4 (Generation_{TSO i} + Consumption_{TSO i})} \quad (eq.1)$$

The sharing key according to Article 153(2)(d) of the SO Regulation has been calculated for years 2013...2016 to get an understanding of its impact. The results are shown in Table 1. In this table, a comparison against 2016 values for FCR-D and FCR-N obligation is also included.

Table 1 The sharing key calculated with production and consumption data for 2013-2016. The column "SOA" reflects to the current obligation per country.

Country/%	Calculation according to SO GL					SOA FCR-D		SOA FCR-N	
	2013	2014	2015	2016	Avg.2013-2016	%	% change	%	% change
NO	36	37	37	38	37	29	26 %	35	6 %
SE	40	39	40	39	40	34	15 %	38	3 %
FI	21	20	20	20	20	22	-6 %	23	-12 %
DK2	3	3	3	3	3	15	-79 %	4	-18 %
sum	100	100	100	100	100	100		100	

As seen from the table the new sharing key seems quite constant between different years. In order to see if the sharing key would change between hours, hourly sharing keys were calculated with data for 2016. The results can be seen in Figure 4.

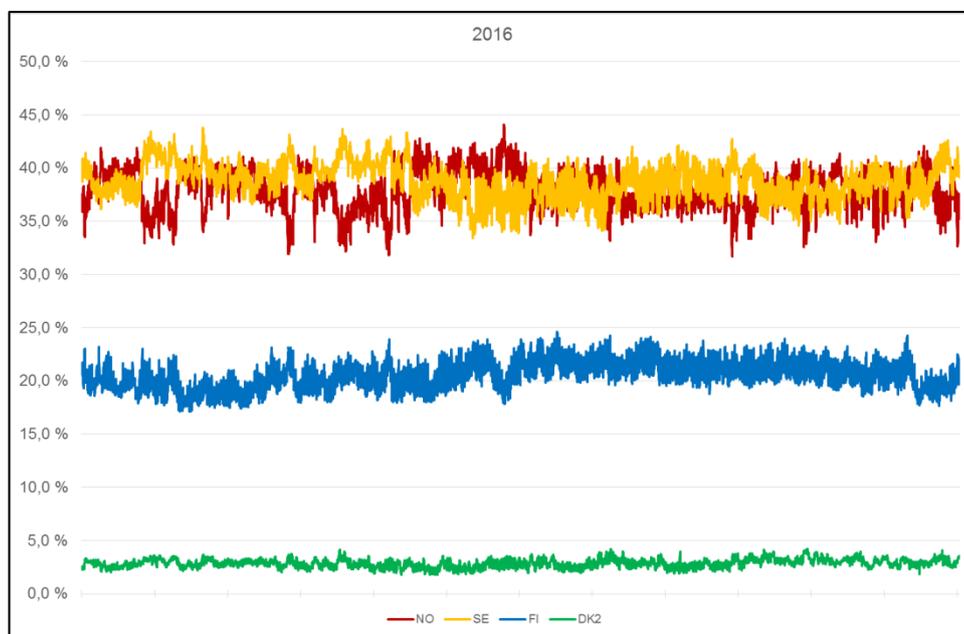


Figure 4 Calculation of sharing keys, based on hourly values, 2016.

The new sharing key seems to be stable also between hours during the year so the yearly value can be used for defining the share for each Nordic TSO.

The shares shall be revised each year before 1 October of year $y-1$ on the basis of net consumption and net generation in year $y-2$ and the new shares will enter into force on 1 January of year y .

5.5 Summary

The arguments in section 5.2 result in the rules for FCR-D dimensioning as included in Article 3 of the Proposal:

1. Following the dimensioning rules in this article, the Nordic TSOs will dimension FCR-D daily, separately for upward FCR-D and downward FCR-D.
2. The input to the dimensioning process of FCR-D shall be:
 - a. Planned network topology, considering maintenance of relevant network components;
 - b. Estimated (gross) generation of large generation modules;
 - c. Estimated demand of large connected consumers;
 - d. Estimated flows on HVDC interconnectors.
3. The total reserve capacity for upward FCR-D required for the Nordic synchronous area shall be dimensioned at least equally to the imbalance caused by the reference incident in negative direction.

4. The total reserve capacity for downward FCR-D required for the Nordic synchronous area shall be dimensioned at least equally to the imbalance caused by the reference incident in positive direction.
5. The reference incident shall be defined as the largest imbalance that may result from an instantaneous change of active power of:
 - a. *A single power generating module;*
 - b. *A single demand facility;*
 - c. *A single HVDC interconnector;*
 - d. *Tripping of an AC-line:* This may result in i) system protection scheme (SPS) activation which may trip one or more power generating units or ii) loss of a regional part of the system.
 - e. *Single failure on a busbar tripping more than one generation module or demand facility.*
6. The imbalance volume of the ‘instantaneous change of active power’ mentioned in item 5 of this article shall be determined by the net loss of active power as seen from the grid. I.e. it should be taken into account that auxiliaries load of the generation module may still consume power in the case that the unit generator breaker is tripped. Furthermore, the imbalance volume of the reference incident is determined by the maximum production, import, consumption or export that has been scheduled for the period for which the reference incident is determined.

The arguments in section 5.4 result in the rules for calculating the initial FCR-D Calculation the initial distribution as included in Article 4 of the Proposal:

1. In accordance with article 152(2)(d) of the SO Regulation, FCR-D and FCR-N shall be distributed to the TSOs pro-rata to the shares defined below.
2. The input to the calculation of the initial distribution are:
 - a. net generation per control area for calendar year $y-2$ in which net generation of a unit is defined as the generation level less than the total gross power generation of a unit, due to internal auxiliary power consumption of the unit;
 - b. net consumption per control area for calendar year $y-2$ in which ‘net’ means that the consumption of power plants’ auxiliaries is excluded, but network losses are included.
3. The shares of the reserve capacity on FCR required for each TSO as initial FCR obligation shall be based on the sum of the net generation and consumption of its control area divided by the sum of net generation and consumption of the synchronous area over a period of one year.

The shares shall be revised each year before 1 October of year $y-1$ and the new shares will enter into force on 1 January of year y .

6. Expected impact of the Proposal on the relevant objectives of the SO Regulation

The Proposal generally contributes to and does not in any way hamper the achievement of the objectives of Article 4 of the SO Regulation. In particular, the Proposal serves the objectives to:

- Article 4(1)(c) determining common load-frequency control processes and control structures;
- Article 4(1)(d) ensuring the conditions for maintaining operational security throughout the Union;
- Article 4(1)(e) ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union; and
- Article 4(1)(h) contributing to the efficient operation and development of the electricity transmission system and electricity sector in the Union.

The Proposal contributes to these objectives by specifying the dimensioning rules for FCR-D, which is one of the key reserves that is used in the common Nordic load-frequency control processes. Sufficient FCR-D guarantees the right frequency quality level and consequently maintains the operational security by reducing the risk for automatic Under Frequency Load Shedding (UFLS), automatic reduction of generation and for system blackouts due to under or over frequency. The dimensioning rules balance the impact of both cost for FCR-D and outage risk and therefore ensure efficient operation of the electricity transmission system.

7. Timescale for the implementation

For upward FCR-D, the Proposal (article 3(4)) is similar to the methodology that is currently applied in the Nordic synchronous area. Consequently, procedures, the IT systems, procurement mechanisms and cost-recovery mechanisms are in place for upward FCR-D. Therefore, the TSOs shall implement the dimensioning rules for upward FCR-D not later than when Nordic synchronous area operational agreement enters into force in accordance with Article 118 of the SO Regulation.

Also the rules for the initial distribution of FCR (article 4 of the Proposal) could be implemented by adapting existing processes. Therefore, the TSOs shall also implement rules for the initial distribution for FCR not later than when Nordic synchronous area operational agreement enters into force in accordance with Article 118 of the SO Regulation.

However, since downward FCR-D are currently not procured, the implementation of downward FCR-D requires an implementation project that includes tasks like product specification, prequalification, (IT) implementation at TSO and FCR-D provider, procurement mechanisms etc. The TSOs agreed that downward FCR-D in the Nordic synchronous area shall be implemented by 2021.

8. Public consultation

Article 11 of the SO Regulation states that: *“TSOs responsible for submitting proposals for terms and conditions or methodologies or their amendments in accordance with this Regulation shall consult stakeholders, including the relevant authorities of each Member State, on the draft proposals for terms and conditions or methodologies listed in Article 6(2) and (3). The consultation shall last for a period of not less than one month.”*

This proposal has been consulted in the period 1 June to 1 July 2018. The appendix to this document includes the views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the proposal.

Appendix: Results of Public Consultation

Article 11(3) of the SO Regulation states that: *"The TSOs responsible for developing the proposal for terms and conditions or methodologies shall duly take into account the views of stakeholders resulting from the consultations prior to its submission for regulatory approval. In all cases, a sound justification for including or not including the views resulting from the consultation shall be provided together with the submission of the proposal and published in a timely manner before, or simultaneously with the publication of the proposal for terms and conditions or methodologies."* Table 1 lists the views of stakeholders on this proposal resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

Table 1: Views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

no.	organisation	comment	response TSOs
6	Fortum Oyj	We think that a separate consultation on downward FCR-D should be performed and support efforts to make the portfolio of reserves more complete. We further encourage the Nordic TSOs to take a decision on the FCR-D downward development timetable.	Comment acknowledged and resulted in a change of Article 5(2) of the proposal. The last two sentences are replaced by <i>'The TSOs agreed that downward FCR-D in the Nordic synchronous area shall be implemented by 2021. The dimensioning rules for downward FCR-D (article 3(4) of this Proposal) will therefore be implemented by 2021.'</i> Chapter 7 of the Explanatory document has been updated accordingly.
11	Ørsted A/S	1. TSOs should be obliged to publish information on future FCR demand on a daily basis. Financial and operational decisions by market participants depend on the access to open, transparent and timely information from TSOs. The current proposal does not contain any obligations on TSOs to publish information on demand for FCR-N and FCR-D to market participants in a transparent and timely manner.	Comment acknowledged and did result the following addition to section 2.2 of the explanatory document: <i>"The scope of this proposal only includes the dimensioning rules for FCR-D on a Nordic level and the calculation of the initial distribution per TSO. It does not specify how each TSO shall fulfil its share. Procurement and settlement of FCR are not in the scope of the SO Regulation and this proposal, but inside the scope of the 'Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing'."</i>
12	Ørsted A/S	2. Network losses should be included in new dimensioning rules for FCR-D. We support the new methodology for daily FCR-D dimensioning based on planned network topology; estimated (gross) generation of large generation modules; estimated demand of large connected consumers; and estimated flows on HVDC interconnectors. Additionally, we would recommend that TSOs include network losses in the methodology in order to properly reflect these in the final dimensioning.	Comment acknowledged and did not result in changes to the proposal. Section 5.2.4 of the explanatory document discusses why the TSOs do not take into account the changes in network losses in the dimensioning of FCR-D: <i>'The imbalance that is caused by large incident may also be influenced by the change in network losses due to changed flows (see section 4.2). This effect is however very much dependent on the specific situation, including the location of the incident, the location of the FCR-D providing units and the flows just before the incident. The effect can result in both increased or decreased network losses and can therefore both increase or decrease the resulting imbalance on a synchronous area level. The TSO will not include this effect either in the dimensioning of FCR-D.'</i>

13	Ørsted A/S	<p>3. The initial FCR-N and FCR-D obligations should be distributed between TSOs in a fair, transparent and analytically well-founded manner. The current distribution key results in a 79 % reduction in FCR-D requirements for DK2 – reducing the obligation to 3 % from 15 %. Furthermore, the proposal seeks to exempt East Denmark from the obligation to hold at least two-thirds of its initial FCR obligation in its own control area. This exemption is unfounded and has no basis on SOGL or other European rules. Together, the combination of the reduction in initial obligation and the exemption for control area capacity in East Denmark creates high insecurity about the future demand for FCR in East Denmark. Not having a local demand in DK2, danish FCR providers are discriminated compared to other Nordic providers which we find highly unacceptable.</p>	<p>Comment acknowledged and did not result in a change of the proposal. The TSOs understand the respondent's concern. However, the proposed distribution key literally implements article 152(2)(d) as required by the SO Regulation. Furthermore, in the FCR Exchange limits proposal the TSOs proposed as few as possible limitations to the market as possible. The TSOs note that the limitations specified in Article 3 and Article 4 of the FCR Exchange limits proposal is only required for Finland, Norway and Sweden and not for East Denmark (DK2) due to the size of East Denmark (DK2).</p>
14	Ørsted A/S	<p>4. The proposal may negatively impact the provision of FCR from East Denmark. In addition to the concerns about local demand stated above, the proposal also raises concerns about future access to a common Nordic market for FCR providers in East Denmark. Changes in the dimensioning and distribution, combined with continued access to 125MW FCR from Nordic-CE HVDC interconnections (Kontiskan and Kontek), may limit the possibility of FCR exports from East Denmark to southern Sweden, thus undermining a currently well-functioning market. We urge TSOs to perform an impact assessment of the proposed changes and openly share the results with stakeholders.</p>	<p>Comment acknowledged and did not result in a change of the proposal. We refer to answer to item 13. Sharing/exchange of FCR between synchronous areas is currently being discussed between the TSOs of the Nordic and CE synchronous area.</p>
15	Ørsted A/S	<p>5. Overcoming the descrimination of Danish FCR providers. To overcome the unacceptable discrimination of Danish FCR providers in the TSO proposal we request the following addendum of a new bullet 5. In "Article 3 - Limits for the exchange of FCR-N" and "Article 4 - Limits for the exchange of FCR-D" in "Nordic synchronous area Porposal for limits for the exchange of FCR between the TSOs in accordonce..." .</p> <p>This addendum ensures that FCR providers from East Denmark and Sweden are equal regarding covering the 2/3 demand of the sum of the 2 areas. As the TSO's has not detected any problems regarding the TRM on the interconnector between East Denmark and Sweden regarding their proposal, this proposed addendum should not be a problem neither.</p>	<p>We refer to answer to 13 and 14. Procurement of FCR is not part of the scope of the SO Regulation. The TSOs note that a common Danish – Swedish FCR market was implemented in 2012, given full access for Danish and Swedish providers to a common market as requested, with the same limitations as proposed in the FCR Exchange limits proposal.</p>

	<p>The proposal:</p> <p>Proposed new Bullet 5 in Article 3. The FCR-N demand for East Denmark (3%) and Sweden (40%) is regarded as one total demand (43%) which FCR-N providers from both Sweden and East Denmark can deliver without being regarded as imported capacity.</p> <p>Proposed new Bullet 5 in Article 4. The FCR-D demand for East Denmark (3%) and Sweden (40%) is regarded as one total demand (43%) which FCR-D providers from both Sweden and East Denmark can deliver without being regarded as imported capacity.</p>	
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Explanatory document for the Nordic synchronous area proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

1. Introduction

The Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter “**SO Regulation**”) sets out rules on relevant subjects that should be coordinated between Transmission System Operators, as well as between TSOs and Distribution System Operators and with significant grid users, where applicable. The goal of SO Regulation is to ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities. In order to deliver these objectives, a number of steps are required.

One of these steps is to determine the limits for the exchange of FCR between the TSOs. Pursuant to Article 118(1)(t) of the SO Regulation, all Transmission System Operators in the Nordic Synchronous Area shall jointly develop common proposals for, if applicable, [...], limits for the exchange of FCR between the TSOs in accordance with Article 163(2).

According to Article 6(3)(d)(vii) of the SO Regulation the proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2) (hereafter referred to as “**Proposal**”) shall be submitted for approval by the relevant national regulatory authorities (hereinafter “NRAs”) no later than 14 September, 2018. The Proposal is submitted for regulatory approval to all NRAs in the Nordic synchronous area. According to Article 6(6) of the SO Regulation the Proposal needs to be submitted to ACER as well, who may issue an opinion on the Proposal if requested by the NRAs.

This document contains an explanation of the Proposal from all TSOs of the Nordic synchronous area (hereinafter “**TSOs**”). It is structured as follows. The legal requirements for the Proposal and the interpretation of the scope are presented in Chapter 2. Chapter 3 describes the objective of the limits for the exchange of FCR. Chapter 4 provides an overview of the existing situation. The proposed limits for the exchange of FCR are described in Chapter 5. Chapter 6 describes the expected impact on the relevant objectives of the SO Regulation. Finally, Chapter 7 provides the timeline for implementation and Chapter 8 describes the public consultation.

2. Legal requirements and interpretation

2.1 Legal references and requirements

Several articles in the SO Regulation set out requirements which the Proposal must take into account. These are cited below.

- (1) Article 118(1)(t) and (2) of the SO Regulation constitutes the legal basis that the Proposal should take into account. Article 118 has the following content:

“1. By 12 months after entry into force of this Regulation, all TSOs of each synchronous area shall jointly develop common proposals for:[...]”

(t) if applicable, for synchronous areas other than CE, limits for the exchange of FCR between the TSOs in accordance with Article 163(2); [...]

2. All TSOs of each synchronous area shall submit the methodologies and conditions listed in Article 6(3)(d) for approval by all the regulatory authorities of the concerned synchronous area. Within 1 month after the approval of these methodologies and conditions, all TSOs of each synchronous area shall conclude a synchronous area operational agreement which shall enter into force within 3 months after the approval of the methodologies and conditions.”

- (2) Article 163(2) of the SO Regulation has the following content:

“ Article 163

Exchange of FCR within a synchronous area

[..].

2. All TSOs involved in the exchange of FCR within a synchronous area shall respect the limits and requirements for the exchange of FCR within the synchronous area specified in the Table of Annex VI.”

- (3) The table of Annex VI of the SO Regulation (as referred to in Article 163(2)) has the following content:

Table
Limits and requirements for the exchange of FCR

Synchronous area	Exchange of FCR allowed between:	Limits for the exchange of FCR
CE synchronous area	TSOs of adjacent LFC blocks	<ul style="list-style-type: none"> — the TSOs of an LFC block shall ensure that at least 30 % of their total combined initial FCR obligations, is physically provided inside their LFC block; and — the amount of reserve capacity on FCR, physically located in an LFC block as a result of the exchange of FCR with other LFC blocks, shall be limited to the maximum of: <ul style="list-style-type: none"> — 30 % of the total combined initial FCR obligations of the TSOs of the LFC block to which the reserve capacity on FCR is physically connected; and — 100 MW of reserve capacity on FCR.
	TSOs of the LFC areas of the same LFC block	<ul style="list-style-type: none"> — the TSOs of the LFC areas constituting a LFC block shall have the right to specify in the LFC block operational agreement internal limits for the exchange of FCR between the LFC areas of the same LFC block in order to: <ul style="list-style-type: none"> — avoid internal congestions in case of the activation of FCR; — ensure an even distribution of reserve capacity on FCR for the case of network splitting; and — avoid that the stability of the FCP or the operational security is affected.
Other synchronous areas	TSOs of the synchronous area	<ul style="list-style-type: none"> — The TSOs of the synchronous area shall have the right to specify in the synchronous area operational agreement limits for the exchange of FCR in order to: <ul style="list-style-type: none"> — avoid internal congestions in case of the activation of FCR; — ensure an even distribution of FCR in case of network splitting; and — avoid that the stability of the FCP or the operational security is affected.

- (4) Article 39(4) of Regulation (EU) 2017/2195 (hereafter: “**EB Regulation**”) includes a relevant restriction to the exchange of FCR: “Cross-zonal capacity allocated for the exchange of balancing capacity or sharing of reserves shall be used exclusively for frequency restoration reserves with manual activation, for frequency restoration reserves with automatic activation and for replacement reserves. The reliability margin calculated pursuant to Regulation (EU) 2015/1222 shall be used for operating and exchanging frequency containment reserves, except on Direct Current (‘DC’) interconnectors for which cross-zonal capacity for operating and

exchanging frequency containment reserves may also be allocated in accordance with paragraph 1.”.

(5) Article 6(3)(d)(vii) of the SO Regulation states:

“The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region, on which a Member State may provide an opinion to the concerned regulatory authority: [...]

(d) methodologies, conditions and values included in the synchronous area operational agreements in Article 118 concerning: [...]

(vii) for synchronous areas other than CE and if applicable, the limits for the exchange of FCR between TSOs in accordance with Article 163(2);

2.2 Interpretation and scope of the Proposal

The dimensioning rules for FCR in accordance with Article 153 of the SO Regulation result in the total required amount of FCR for a synchronous area. Article 153(2)(d) of the SO Regulation specifies how this required amount of FCR shall be initially distributed over the TSOs of the synchronous area. Article 163 sets out the rules for deviating from this initial distribution by exchanging FCR between the TSOs within a synchronous area. Within this context, Article 163(2) and the table of Annex VI of the SO Regulation provide the TSOs with the right to specify the limits for the exchange of FCR which is the scope of this Proposal.

Article 39(4) of the EB Regulation includes the condition that only the reliability margin shall be used for exchanging frequency containment reserves between the TSOs of one synchronous area.

Where Article 163(2) only describes one type of FCR, the Nordic Frequency Containment Process (FCP) applies two types of FCR: FCR for normal operation (FCR-N) is used for continuous imbalances to keep the frequency within the $\pm 100\text{mHz}$ range. The purpose of Frequency Containment Reserves for Disturbance situations (FCR-D) is to mitigate the impact of incidental disturbances. This Proposal addresses both types of FCR.

3. Objective of limits for the exchange of FCR

FCR exchange contributes to the efficient operation of the electricity system by allocating FCR more efficiently. However, for maintaining operational security, it is required to maintain a certain distribution of FCR in the Nordic synchronous area. The objective of the limits for the exchange of FCR is to guarantee that the FCR distribution after exchange will be operationally secure.

4. The existing situation

This chapter describes the existing limits for the exchange of FCR. Since the Nordic TSOs define two types of FCR, section 4.1 addresses FCR-N and section 4.2 addresses FCR-D.

4.1 Frequency Containment Reserves for Normal operation (FCR-N)

The existing Nordic System Operation Agreement requires that ‘Each subsystem shall have at least 2/3 of the frequency controlled normal operation reserve¹ in its own system for potential splitting up and island operation.’. In practice the TSOs consider this rule mainly relevant for limiting congestion caused by activation of FCR-N.

¹ The existing System Operation Agreement refers to FCR-N as ‘frequency controlled normal operation reserve’.

4.2 Frequency Containment Reserves for Disturbance situations (FCR-D)

The existing Nordic System Operation Agreement requires that ‘The activation of the frequency controlled disturbance reserve² 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. Each subsystem shall have at least 2/3 of the frequency controlled disturbance reserve in its own system for potential splitting up and island operation.’ The 2/3 rule is in practice mainly relevant for avoiding that operational security is affected.

5. Proposal for limits for the exchange of FCR

Article 163(2) and the table of Annex VI of the SO Regulation provide the TSOs with the right to specify in the synchronous area operational agreement the limits for the exchange of FCR in order to:

- avoid internal congestions in case of the activation of FCR;
- ensure an even distribution of FCR in case of network splitting; and
- avoid that the stability of the FCP or the operational security is affected.

The TSOs make use of the right to specify limits for the exchange of FCR-N in order to avoid internal congestions in case of the activation of FCR-N. For FCR-D, the TSOs make use of this right in order to avoid that operational security is affected. Below the impact on exchanging FCR is discussed.

FCR activation is triggered by frequency deviations which are caused by the net imbalance in the synchronous area. Both imbalances and FCR activation are distributed over the synchronous area and consequently result in additional flows in the transmission network, superimposed on the scheduled flows and flows resulting from the Frequency Restoration Process.

Article 39(4) of the EB Regulation requires that exchange of FCR must be within the reliability margin. With the intention to maximise the allowed exchange of energy to the day ahead and intraday markets, the reliability margins (TRMs) in the Nordic synchronous are generally kept very small which in some cases may lead to non-optimal operational procedures, e.g. for congestion management. The implications are that redistribution of FCR (due to e.g. FCR exchange) must be carefully considered to reduce the risk for overload in the grid caused by FCR activations. The reliability margins will to a large extent be used by activations of FCR-N.

The Nordic TSOs have estimated the additional flows that are supposed to use TRM³. From their studies, the TSOs concluded that the impact of the use of the TRM on interconnectors between the TSOs’ control areas is limited if at least 2/3 of the FCR-N is located in the TSO’s control area. For this reason, the TSOs propose that each TSO shall have at least 2/3 of their initial FCR-N obligation in its own control area. Increased flows due to FCR-D activations are however allowed beyond the use of the reliability margin for a limited period. Furthermore, since the SO Regulation specifies different products for upward FCR-D and downward FCR-D on most borders sufficient cross zonal capacity will be available to exchange at least one of these products, dependent on the direction of the scheduled flow on the border. Hence, the TSOs will allow exchanging upward and downward FCR-D outside the reliability margin for a limited period, but only if FCR-D exchange shall not cause the situation that the activation of the FCR-D may affect operational security. Based on their experience with the existing rules, the TSOs consider that this condition shall be fulfilled if each TSO shall have at least 2/3 of their initial FCR-D obligation in its own control area.

² The existing System Operation Agreement refers to FCR-D as ‘frequency controlled disturbance reserve’.

³ The input to the estimations were historical figures from 2016 (imbalances, FCR distributions etc.) and have therefore been compared to the TRM (Transmission Reliability Margin) and not yet with the reliability margin as used in the Electricity Balancing Guideline.

In case the TSOs decide to exchange or share FCR with one or more TSOs of other one or more synchronous areas (in accordance with Article 173 and 174 of the SO Regulation), the FCR provided by the TSO in the other synchronous area may be considered as delivered in the importing TSO's 'own control area'. The related rules will be set in the methodologies for frequency coupling, exchange and sharing of FCR (in accordance with Article 172 of the SO Regulation).

Because of the small initial obligation of East Denmark (DK2) (approx. 3% of the Nordic FCR capacity), shifting the entire initial FCR-N obligation of East Denmark (DK2) to other Nordic countries will only have a very small impact on the use of TRM on East Denmark (DK2)'s interconnector with Sweden. Consequently, the TSOs propose that the requirement that at least 2/3 of their initial FCR obligation shall be in the TSO's own control area shall not apply to East Denmark (DK2).

5.1 Summary

The arguments above result in the limits for the exchange of FCR as included in Article 3 and Article 4 of the Proposal:

Article 3 – Limits for the exchange of FCR-N

1. Each TSO shall have at least 2/3 of their initial FCR-N obligation (determined in accordance with Article 153(2)(d) of the SO Regulation) in its own control area;
2. The 2/3 obligation in paragraph 1 can be partly fulfilled by guaranteed FCR-N provision from another synchronous area;
3. In case of FCR-N capacity shortage in certain areas, affected TSOs may agree on a temporary exception to paragraph 1 and 2;
4. Because of the small initial FCR-N obligation of East Denmark (DK2), paragraph 1 shall not apply to East Denmark (DK2).

Article 4 – Limits for the exchange of FCR-D

1. Each TSO shall have at least 2/3 of their initial FCR-D obligation (determined in accordance with Article 153 of the SO Regulation) in its own control area;
2. The 2/3 obligation in paragraph 1 can be partly fulfilled by guaranteed FCR-D provision from another synchronous area;
3. In case of FCR-D capacity shortage in certain areas, affected TSOs may agree on a temporary exception to paragraph 1 and 2;
4. Because of the small initial FCR-D obligation of East Denmark (DK2), paragraph 1 shall not apply to East Denmark (DK2).

6. Expected impact of the Proposal on the relevant objectives of the SO Regulation

The Proposal generally contributes to and does not in any way hamper the achievement of the objectives of Article 4 of the SO Regulation. In particular, the Proposal serves the objectives to:

- Article 4(1)(d) ensuring the conditions for maintaining operational security throughout the Union; and
- Article 4(1)(h) contributing to the efficient operation and development of the electricity transmission system and electricity sector in the Union.

Where the objective of maintaining operational security (article 4(1)(d) may require stricter limits, operational efficiency may increase with limits that are less strict. The proposed limits for the exchange of FCR balance the objectives of ensuring the conditions for maintaining operational security and efficient operation of the electricity system.

7. Timescale for the implementation

The proposed limits for the exchange of FCR are similar to the rules that are currently applied in the Nordic synchronous area. Therefore, the TSOs shall implement the Proposal not later than when Nordic synchronous area operational agreement enters into force in accordance with Article 118 of the SO Regulation.

8. Public consultation

Article 11 of the SO Regulation states that: *“TSOs responsible for submitting proposals for terms and conditions or methodologies or their amendments in accordance with this Regulation shall consult stakeholders, including the relevant authorities of each Member State, on the draft proposals for terms and conditions or methodologies listed in Article 6(2) and (3). The consultation shall last for a period of not less than one month.”*

This proposal has been consulted in the period 1 June to 1 July 2018. The appendix to this document includes the views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the proposal.

Appendix: Results of Public Consultation

Article 11(3) of the SO Regulation states that: *"The TSOs responsible for developing the proposal for terms and conditions or methodologies shall duly take into account the views of stakeholders resulting from the consultations prior to its submission for regulatory approval. In all cases, a sound justification for including or not including the views resulting from the consultation shall be provided together with the submission of the proposal and published in a timely manner before, or simultaneously with the publication of the proposal for terms and conditions or methodologies."* Table 1 lists the views of stakeholders on this proposal resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

Table 1: Views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Proposal.

no.	organisation	comment	response TSOs
13	Ørsted A/S	3. The initial FCR-N and FCR-D obligations should be distributed between TSOs in a fair, transparent and analytically well-founded manner. The current distribution key results in a 79 % reduction in FCR-D requirements for DK2 – reducing the obligation to 3 % from 15 %. Furthermore, the proposal seeks to exempt East Denmark from the obligation to hold at least two-thirds of its initial FCR obligation in its own control area. This exemption is unfounded and has no basis on SOGL or other European rules. Together, the combination of the reduction in initial obligation and the exemption for control area capacity in East Denmark creates high insecurity about the future demand for FCR in East Denmark. Not having a local demand in DK2, danish FCR providers are discriminated compared to other Nordic providers which we find highly unacceptable.	Comment acknowledged and did not result in a change of the proposal. The TSOs understand the respondent's concern. However, in the FRC dimensioning proposal the proposed distribution key literally implements article 152(2)(d) as required by the SO Regulation. Furthermore, in the FCR Exchange limits proposal the TSOs proposed as few as possible limitations to the market as possible. The TSOs note that the limitations specified in Article 3 and Article 4 of the FCR Exchange limits proposal is only required for Finland, Norway and Sweden and not for East Denmark (DK2) due to the size of East Denmark (DK2).
14	Ørsted A/S	4. The proposal may negatively impact the provision of FCR from East Denmark. In addition to the concerns about local demand stated above, the proposal also raises concerns about future access to a common Nordic market for FCR providers in East Denmark. Changes in the dimensioning and distribution, combined with continued access to 125MW FCR from Nordic-CE HVDC interconnections (Kontiskan and Kontek), may limit the possibility of FCR exports from East Denmark to southern Sweden, thus undermining a currently well-functioning market. We urge TSOs to perform an impact assessment of the proposed changes and openly share the results with stakeholders.	Comment acknowledged and did not result in a change of the proposal. We refer to answer to item 13. Sharing/exchange of FCR between synchronous areas is currently being discussed between the TSOs of the Nordic and CE synchronous area.
15	Ørsted A/S	5. Overcoming the discrimination of Danish FCR providers. To overcome the unacceptable discrimination of Danish FCR providers in the TSO proposal we request the following addendum of a new bullet 5. In "Article 3 - Limits for the exchange of FCR-N" and "Article 4 - Limits for the exchange of FCR-D" in "Nordic synchronous area Proposal for	We refer to answer to 13 and 14. Procurement of FCR is not part of the scope of the SO Regulation. The TSOs note that a common Danish – Swedish FCR market was implemented in 2012, given full access for Danish and Swedish providers to a common market as requested, with the same limitations

	<p>limits for the exchange of FCR between the TSOs in accordance...” .</p> <p>This addendum ensures that FCR providers from East Denmark and Sweden are equal regarding covering the 2/3 demand of the sum of the 2 areas. As the TSO’s has not detected any problems regarding the TRM on the interconnector between East Denmark and Sweden regarding their proposal, this proposed addendum should not be a problem neither.</p> <p>The proposal:</p> <p>Proposed new Bullet 5 in Article 3. The FCR-N demand for East Denmark (3%) and Sweden (40%) is regarded as one total demand (43%) which FCR-N providers from both Sweden and East Denmark can deliver without being regarded as imported capacity.</p> <p>Proposed new Bullet 5 in Article 4. The FCR-D demand for East Denmark (3%) and Sweden (40%) is regarded as one total demand (43%) which FCR-D providers from both Sweden and East Denmark can deliver without being regarded as imported capacity.</p>	<p>as proposed in Article 3 and Article 4 of the FCR Exchange limits proposal.</p>
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