Explanatory document for the amended Nordic synchronous area methodology 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

6 May 2022

DISCLAIMER

This document is released on behalf of all TSOs of Nordic synchronous area only for the purposes of the public consultation on 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. This version of the methodology for the additional properties of FCR does not in any case represent a firm, binding or definitive TSOs' position on the content.

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) shall be submitted for approval by the relevant national regulatory authorities (hereinafter "NRAs") no later than 14 September, 2018. The initial proposal¹ has been submitted for regulatory approval to all NRAs in the Nordic synchronous area by 14 September, 2018. In accordance with Article 6(6) of the SO Regulation the proposal has been submitted to ACER as well, who may issue an opinion on the proposal if requested by the NRAs. On 14 March 2019, the Nordic NRAs approved the proposal.

In accordance with article 153(2) of the SO Regulation, the Nordic TSOs need to implement FCR-D downwards. The additional properties of FCR-D downwards was not included in the initial version. The methodology was amended in 2020 where the additional properties of FCR-D downwards was added. The amended methodology has been approved by the NRAs on 21 September 2020.

This amended, third methodology (hereafter referred to as "**Methodology**") adds additional properties concerning dynamic performance and stability for FCR-N, FCR-D upwards and FCR-D downwards in accordance with Article 154(2) of the SO Regulation.

This document contains an explanation of the Methodology from all TSOs of the Nordic synchronous area (hereinafter "**TSOs**"). It is structured as follows. The legal requirements for the Methodology 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. Chapter 5 explains the background and proposed amendments. The proposed additional properties of FCR are described in Chapter 6. Chapter 7 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 Methodology 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 Methodology should take into account. Article 118 has the following content:

¹ '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', dated 10 September 2018.

"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 [2016/631 RfG] and Article 27 and 28 of Commission Regulation No [2016/1388 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 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

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	, CE GB I IRE NE	10 mHz 15 mHz 15 mHz 10 mHz
response insensitivity and possible intentiona frequency response dead band of the governor o the FCR providing units or FCR providing	GB F F NE	15 mHz 15 mHz 10 mHz
the FCR providing units or FCR providing	IRE NE	15 mHz 10 mHz
the set providing minto of sett providing	NE	10 mHz
groups.	4	
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

FCR technical minimum requirements referred to in Article 154:

 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 Methodology

The Nordic Frequency Containment Process (FCP) currently applies three products of Frequency Containment Reserves (FCR). FCR for normal operation (FCR-N) is used for continuous imbalances to stabilise the frequency within the \pm 100 mHz range. Within this range, the dynamic response from FCR-N shall as a minimum suppress variations in the frequency with periodicity of 10 seconds and slower, with an emphasis around period times of 70 seconds. The dynamic response from FCR-N shall be such that it contributes to maintaining the system frequency within the standard frequency range.

The purpose of FCR for disturbance situations (FCR-D) is to mitigate the impact of incidental disturbances once the frequency is below 49.90 Hz or above 50.10 Hz. FCR-D upwards shall be fully activated if the frequency stabilises at 49.50 Hz and FCR-D downwards shall be fully activated if the frequency stabilises at 50.50 Hz. FCR-D must limit the instantaneous frequency deviation and provide dynamic frequency control outside the standard frequency range.

In the event of a frequency drop to 49.50 Hz or a frequency increase to 50.50 Hz which is caused by a momentary power shortage or surplus, FCR-D shall be fully activated within 30 seconds, if the frequency deviation remains, and in addition as a minimum regulate up or down according to the power and energy requirement. It has to be noted that the *FCR full activation frequency deviation* of \pm 500 mHz and *FCR full activation frequency deviation* of \pm 500 mHz and *FCR full activation time* of 30 seconds that are specified in Annex V of the SO Regulation only apply to FCR-D. Consequently, the TSOs specify the required FCR-N response as additional properties in this Methodology. The other two requirements in Annex V of the SO 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 three products of FCR, section 4.1 addresses FCR-N, section 4.2 addresses FCR-D upwards and section 4.3 addresses FCR-D downwards.

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 - 50.10 Hz and which is activated automatically by the system frequency. Currently, FCR-N reserves shall be at least 600 MW at 50.00 Hz in the synchronous system. It shall be fully activated at f = 49.90/50.10 Hz ($\Delta f = \pm 0.10$ Hz). In conjunction with a rapid frequency change to 49.90/50.10 Hz, the reserve shall be up regulated/down regulated within 2-3 minutes.

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

FCR-D upwards is the momentarily available active power available for frequency regulation in the range of 49.90–49.50 Hz, which is activated automatically by the system frequency.

FCR-D upwards shall be activated at 49.90 Hz and shall be fully activated at 49.50 Hz. It shall increase linearly or close to linearly within a frequency range of 49.90-49.50 Hz.

In the event of a frequency drop to 49.50 Hz:

- 50 % of the FCR-D upwards shall be regulated upwards within 5 seconds.
- 100 % of the FCR-D upwards shall be regulated upwards within 30 seconds.

4.3 Frequency Containment Reserves for downwards regulation in disturbance situations (FCR-D downwards)

FCR-D downwards is the momentarily available active power available for frequency regulation in the range of 50.1–50.5 Hz, which is activated automatically by the system frequency.

FCR-D downwards shall be activated at 50.10 Hz and shall be fully activated at 50.50 Hz. It shall increase linearly or close to linearly within a frequency range of 50.10-50.50 Hz.

In the event of a frequency change to 50.50 Hz:

- 50 % of the FCR-D downwards shall be regulated downwards within 5 seconds.
- 100 % of the FCR-D downwards shall be regulated downwards within 30 seconds.

5. Proposed amendments

5.1 Background

The Nordic power system is undergoing rapid changes. The currently implemented technical requirements of FCR are not sufficient for the Nordic system anymore. The TSOs have thus been working on developing new technical requirements and prequalification tests since 2014. Extensive analysis work has been performed to create requirements that answer to the needs of the power system. The proposed additional properties aim to secure sufficient response from FCR to both stochastic imbalances and sudden disturbances in varying inertia conditions. The currently implemented requirements have been designed for a system with higher inertia than what is observed in the power system today. With lower inertia the system frequency changes become more rapid, which increases the demands on dynamic performance of FCR.

The proposed additional properties for FCR-N and FCR-D have been designed to fulfil the purpose of the respective product. FCR-N shall be able to stabilise the frequency in case of stochastic imbalances that are too fast to be handled with FRR. FCR-N shall also contribute to dampening the slow frequency oscillations that frequently occur in the Nordic power system due to properties of the system. FCR-D shall act fast enough to contain the instantaneous frequency deviation in the reference incident and contribute to dampening the oscillations immediately after the incident. FCR-D shall also be capable of responding to the fast stochastic imbalances in case the FCR-N volume is saturated.

In the development of the new technical requirements the TSOs have also considered that the proposed solution shall be feasible from a market perspective. The TSOs have considered the impact of the new requirements on the prequalified FCR volume in each country, and the requirements have been set at a level that meets two objectives: system security and functioning FCR markets.

Stakeholders have been involved in several phases of the work. In the project "Revision of the Nordic Frequency Containment Process" (2014-2017) there was a Nordic reference group with members from FCR providers, manufacturers and universities. Proof of concept tests of the new requirements were also carried out in cooperation with FCR providers during this time. In later phases of the work there have been national stakeholder activities and stakeholders have been invited to comment on the draft requirements. During autumn and winter 2021/2022 all TSOs were conducting a pilot phase where a large number of providers tested the new requirements with different kinds of assets, including consumption, production and energy storages. In March 2022 the TSOs conducted a common Nordic stakeholder workshop to present the outcome of the pilot and the revisions to the proposed new requirements in response to the gained experiences.

5.1.1 Impact for the BSPs

The new requirements aim to fulfil the needs of the TSOs whilst being adapted to the needs of the BSPs in a balanced matter with regard to operational security and socio-economic benefit. All requirements are technology neutral, with generalised requirements on the response and reserve provision rather than specific methods or equipment to implement. The requirements are designed to work with the existing market and operational processes, which means that the new requirements do not change how BSPs bid and sell FCR, but merely changes the required response when the FCR is activated.

Because the needs of the power system are changing, the requirements will be stricter and thus harder to fulfil than the currently implemented ones. Some of the existing FCR providing units or groups will be unable to meet the new requirements, or the new requirements will lead to a reduction in the capacity that they can provide. The determining properties for being able to prequalify are the ability to activate close to linearly, respond quickly and to contribute to dampening of oscillations in the systems. This can be related to the physical properties of the entities. For example, some hydro power units may struggle due to penstock dynamics limiting the ability to respond quickly without being unstable. Similarly, some demand response may struggle with the ability to provide FCR linearly and to follow frequency variations. This is a consequence the TSOs find unavoidable, whilst as the requirements are technology neutral as described, equal treatment of stakeholders is ensured.

5.1.2 Prequalification documents for stakeholders

In addition to the new technical requirements, the TSOs have designed a set of prequalification requirements and tests to verify that all FCR providing units or groups comply with the technical requirements. All TSOs will implement the tests and evaluation criteria in their national prequalification processes according to Article 155(1). The TSOs have created a prequalification document for FCR providers and other relevant stakeholders. The document *Technical Requirements for Frequency Containment Reserve Provision in the Nordic Synchronous Area* describes both the technical requirements and the prequalification process on a detailed technical level. Draft versions of the above-mentioned document were published for stakeholder comments in 2017 and 2021 respectively. A third draft was prepared based on the experiences from the pilot phase, published for consultation prior to the Nordic stakeholder workshop in March 2022. The stakeholders had the possibility to discuss the draft during the workshop as well as provide comments afterwards.

5.2 Changes in the Methodology

This section outlines the amendments to the methodology of 18 June 2020 that has been approved by the NRAs based on the NRAs position paper of 21 September 2020. The amendments are described in detail in Section 6.

Section 5.3 describes the proposed amendments concerning additional properties for FCR-N in article 3 of the Methodology. Section 5.4 describes the proposed amendments concerning additional properties for FCR-D upwards in article 4 (Dynamic FCR-D upwards) and article 5 (Static FCR-D upwards) of the Methodology. Section 5.5 describes the proposed amendments concerning additional properties for FCR-D downwards in

article 6 (Dynamic FCR-D downwards, previously 4a) and article 7 (Static FCR-D upwards) of the Methodology.

The TSOs propose to add Article 8 on FCR providing entities with limited energy reservoirs as described in Section 5.6 and Article 9 on requirements on the measurements as described in Section 5.7. The aim is to complete the requirements as stated in Annex V and article 156 of the SO Regulation and to clarify the interpretation in relation to the different FCR products defined in this Methodology.

5.3 Changes in article 3 - Additional FCR-N properties

In accordance with Article 154(2) of the SO Regulation, all TSOs of a synchronous area shall have the right to specify common additional properties of the FCR required to ensure operational security in the synchronous area. Accordingly, the TSOs propose additional properties concerning dynamic performance and stability for FCR-N.

The additional requirements introduce a dynamic response requirement where FCR-N shall be tuned to suppress variations in the frequency with periodicity of 10 seconds and slower, with an emphasis around 70 second periods. The same behaviour shall apply for deactivation.

FCR-N shall be able to follow variations in the system frequency. As the system frequency is continuously varying, FCR-N must have a dynamic response that contributes to containing the frequency within the standard frequency range.

The additional requirements also introduce a stability term.

5.4 Changes in article 4 and 5 - Additional FCR-D upwards properties

In accordance with Article 154(2) of the SO Regulation, all TSOs of a synchronous area shall have the right to specify common additional properties of the FCR required to ensure operational security in the synchronous area. Accordingly, the TSOs propose additional properties concerning dynamic performance and stability for FCR-D.

The additional requirements introduce an energy and power requirement for activation of FCR-D upwards in addition to the full activation time.

FCR-D upwards shall be able to follow variations in the system frequency by activation and deactivation. FCR-D upwards must have a dynamic response that provides continuous frequency control when the frequency is below the standard frequency range. This is introduced in article 4 and is valid for Dynamic FCR-D upwards. Some units and groups are expected to not be able to fulfil this dynamic performance requirement. These units or groups will be covered by Static FCR-D upwards as introduced in article 5 of the Methodology

The additional requirements also introduce a stability term. The Dynamic FCR-D upwards response shall act such that it contributes to stabilisation and damping of system frequency oscillations, while Static FCR-D upwards response shall act such that it does not negatively affect stabilisation and damping of system frequency oscillations.

5.5 Changes in article 6 and 7 - Additional FCR-D downwards properties

In accordance with Article 154(2) of the SO Regulation, all TSOs of a synchronous area shall have the right to specify common additional properties of the FCR required to ensure operational security in the synchronous area. Accordingly, the TSOs propose additional properties concerning dynamic performance and stability for FCR-D.

The proposed requirements for FCR-D downwards mirror the proposed requirements for FCR-D upwards (see section 5.4 and 6.2).

5.6 New article 8 – Additional properties of FCR providing units and groups with Limited Energy Reservoirs

In accordance with Article 154(2) of the SO Regulation, all TSOs of a synchronous area shall have the right to specify common additional properties of the FCR required to ensure operational security in the synchronous area. Accordingly, the TSOs propose additional properties concerning entities with Limited Energy Reservoirs.

The additional properties clarify how the requirements in Article 156 of the SO Regulation shall be interpreted for the three FCR products defined within this Methodology as well as additional properties of the FCR provision necessary to ensure operational security of the Nordic synchronous area.

5.7 New article 9 – Additional requirements on minimum accuracy and resolution of measurements

In accordance with Article 154(2) of the SO Regulation, all TSOs of a synchronous area shall have the right to specify common additional properties of the FCR required to ensure operational security in the synchronous area. Accordingly, the TSOs propose additional properties concerning minimum accuracy and resolution on measurements.

The proposed additional properties complete the statements on minimum accuracy of measurements as specified in Annex V of the SO Regulation and constitutes of requirements on the FCR capabilities necessary to ensure operational security of the Nordic synchronous area.

6. Proposal for additional FCR properties

Together with the requirements in Annex V of the SO Regulation, the proposed additional properties for FCR-N, FCR-D upwards and FCR-D downwards in sections 6.1, 6.2 and 6.3 respectively, the proposed additional properties for entities with limited energy reservoirs in section 6.4, and the proposed additional properties for the measurement system in section 6.5, form a new set of requirements to meet the needs of the Nordic power system today and in the future.

6.1 Additional FCR-N properties

As discussed in section 2.2, for FCR-N, Annex V of the SO 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 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. Further, the SO Regulation does not specify other properties that are important for the Nordic power system. Hence, requirements on the dynamic properties of FCR-N are proposed as specified in 6.1.3. Section 6.1.4 describes the relation of the additional properties and the FCR prequalification process specified in Article 155 of the SO Regulation.

6.1.1 FCR full activation frequency deviation and proportional activation

Since FCR-N is used for continuous imbalances to stabilise the frequency within the \pm 100 mHz range, FCR-N shall be fully activated in the upward direction at f = 49.90 Hz and fully activated in the downward direction at f = 50.10 Hz. This means that the *FCR full activation frequency deviation* for FCR-N is \pm 100 mHz, which is proposed in Article 3(1) of the Methodology. Within the interval 49.9 to 50.1 Hz the activation shall be close to proportional to the frequency deviation.

The full activation frequency deviation is within the ranges in Article 15(2)(d) of Commission Regulation No [2016/631 RfG] and Article 27 and 28 of Commission Regulation No [2016/1388 DCC].

6.1.2 FCR-N activation and deactivation response

The FCR-N response is proposed in Article 3(2) of the Methodology. The response from FCR-N shall be tuned to suppress variations in the frequency with periodicity of 10 seconds and slower, with an emphasis around of 70 second periods. This means that FCR-N shall activate approximately 63% of the final value in 60 seconds and approximately 95% of the final value in 3 minutes in response to a step change of ± 100 mHz from 50.0 Hz in the system frequency.

The full activation time is within the ranges in Article 15(2)(d) of Commission Regulation No [2016/631 RfG] and Article 27 and 28 of Commission Regulation No [2016/1388 DCC].

In Article 3(3) of the Methodology it is proposed that the above mentioned response applies also for deactivation, i.e. the same requirements shall be fulfilled if the 100 mHz frequency change is from 49.9 to 50.0 Hz or 50.1 Hz to 50.0 Hz.

In case of a frequency deviation smaller than 100 mHz, the FCR-N response shall be activated by applying the same dynamic behaviour as for full activation and deactivation. This is proposed in Article 3(5) of the Methodology.

6.1.3 FCR-N dynamic properties

In addition to the activation and deactivation response in section 6.1.2, FCR-N shall be able to follow variations in the system frequency. As the system frequency is continuously varying, FCR-N must have a dynamic response that contributes to contain the frequency within the standard frequency range. This is proposed in Article 3(4) of the Methodology.

To ensure frequency stability of the Nordic power system, the properties of the dynamic FCR-N response shall act such that it contributes to stabilisation and damping of system frequency oscillations. This is proposed in Article 3(6) of the Methodology.

6.1.4 Confirmation of compliance

According to article 155(1) of the SO Regulation the prequalification process is a responsibility of each individual TSO. It is therefore proposed in Article 3(7) of the Methodology that compliance with the abovementioned requirements is confirmed in the FCR prequalification process.

The TSOs have developed common Nordic prequalification documents which contain tests and evaluation criteria to be implemented by each TSO in the national prequalification process.

6.2 Additional FCR-D upwards properties

For FCR-D, Annex V of the SO Regulation specifies the *full activation frequency deviation* (\pm 500 mHz) and the *full activation time* (30 seconds). However, the SO 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. Section 6.2.4 describes the relation of the additional properties and the FCR prequalification process specified in Article 155 of the SO Regulation.

6.2.1 Activation between 49.90 and 49.50 Hz

FCR-D upwards is activated in the interval 49.9-49.5 Hz. Full activation at 49.5 Hz corresponds to the *full activation frequency deviation* of Annex V of the SO Regulation. The activation starts at 49.9 Hz, i.e. outside the standard frequency range where FCR-N is fully activated. The FCR-D upwards activation within the interval 49.9 to 49.5 Hz must be close to proportional to the frequency deviation. These properties are proposed in Article 4(1) of the Methodology.

6.2.2 Additional requirements on activation time

Additional requirements on the full activation time are proposed in Article 4(2) of the Methodology, for Dynamic FCR-D, and in Article 5(2), for Static FCR-D. In conjunction with a system frequency change from 49.9 Hz to 49.0 Hz with a slope of -0.24 Hz/s, FCR-D upwards shall be regulated upwards as follows:

- 1. $|\Delta P_{7.5s}| \ge 0.86 \cdot |\Delta P_{ss}|$
- 2. $|E_{7.5s}| \ge 3.2s \cdot |\Delta P_{ss}|$

In the equations above,

 $\Delta P_{7.5s}$ (MW) is the activated power 7.5 seconds after the start of a system frequency change

 ΔP_{ss} (MW) is the steady state FCR-D upwards activation at a frequency deviation of -500mHz

 $E_{7.5s}$ (MWs) is the activated net energy during the first 7.5 seconds of a system frequency change.

In addition, for Static FCR-D the delay before the response is initiated shall not exceed 2.5 seconds as described in Article 5(2).

In case of an instantaneous frequency deviation different to that stated in Article 4(2) and 5(2) respectively, the FCR-D upwards response shall be activated by applying the same dynamic behaviour as for full activation. This is proposed in Article 4(4) and 5(3) respectively, of the Methodology.

Compliance with Article 15(2)(d)(iii) of Commission Regulation No [2016/631 RfG] requires full activation linearly within 30 seconds. Especially at times of low inertia in the Nordic synchronous area a faster FCR-D response is required². The TSOs consider it critical to implement requirements that ensure this response is delivered.

6.2.3 FCR-D upwards dynamic properties

The FCR-D upwards has two objectives: to limit the instantaneous frequency deviation and to provide dynamic frequency control outside the standard frequency range. The first objective is ensured when all of the dimensioned FCR-D upwards activates according to the requirements stated in section 6.2.2. The second objective can be met when a large enough share of the dimensioned FCR-D capacity has dynamic properties that allow continuous following of the system frequency variations equal to the requirements for Dynamic FCR-D. The TSOs consider it necessary to ensure dynamic activation and deactivation on a system level. However, the TSOs also consider it important to efficiently use technologies with different inherent properties, including such where the dynamic properties are lacking. This position is reflected in the introduction of Dynamic and Static Version of FCR-D in Article 4 and 5 respectively of the Methodology. The dimensioning of Dynamic and Static FCR-D will be handled in such a way that enough of the dynamic capabilities are ensured on a system level. The requirements for this are defined in the separate methodology for Dimensioning of FCR per article 153 of the SO regulation, and further elaborated on in the corresponding explanatory document.

In addition to the full activation time in section 6.2.2, Dynamic FCR-D upwards response shall be able to continuously follow the dynamic frequency variations in the system frequency as introduced in Article 4(3). No corresponding requirement to continuously follow the dynamic frequency variations in the system frequency variations in the system frequency exists for Static FCR-D upwards.

To ensure frequency stability of the Nordic power system, the dynamic properties of the Dynamic FCR-D upwards response shall act such that it contributes to stabilisation and damping of system frequency oscillations. This is proposed in Article 4(5) of the Methodology. For Static FCR-D upwards, the dynamic

² to prevent for automatic Low Frequency Demand Disconnection in case of large instantaneous imbalances.

properties of the response shall act such that it does not negatively affect stabilisation and damping of system frequency oscillations as proposed in Article 5(4).

6.2.4 Confirmation of compliance

According to article 155(1) of the SO Regulation the prequalification process is a responsibility of each individual TSO. It is therefore proposed in Article 4(6) and 5(5) of the Methodology that compliance with the above-mentioned requirements is confirmed in the FCR prequalification process.

The TSOs have developed common Nordic prequalification documents which contain tests and evaluation criteria to be implemented by each TSO in the national prequalification process.

6.3 Additional FCR-D downwards properties

Reference incidents in positive direction have similar but opposite effects on the system frequency as reference incidents in negative direction. For that reason, the proposed requirements for FCR-D downwards mirror the proposed requirements for FCR-D upwards (see section 6.2).

6.4 Additional properties on FCR providing units or groups with limited energy reservoirs

This section is intended to complement the provisions in Article 156 of the SO Regulation as well as provide guidance towards how that article shall be interpreted for the different FCR products defined within this Methodology.

6.4.1 Common properties for all FCR products provided from limited energy reservoirs

An FCR providing unit or group with an energy reservoir that limits its capability to provide FCR shall activate its FCR for as long as the frequency deviation persists, unless its energy reservoir is exhausted in either the positive or negative direction. This statement corresponds to Article 156(8) of the SO Regulation and is implemented in Article 8(1) of the Methodology.

If the FCR providing unit or group has started a process to recover its energy reservoir, and a new disturbance occurs during the recovery process, the FCR providing unit or group shall be able to stop the recovery process and start activation of the reserve with the available energy. The FCR response shall thus not be hindered by the activation of a recovery process. This is reflected in Article 8(5) of the Methodology.

6.4.2 Properties for all FCR products on energy management functions

FCR providing units or groups with an energy reservoir that limits its endurance for full activation to less than two hours must implement a Normal state Energy Management function (NEM) to limit the risk of a reservoir depletion, and an Alert state Energy Management scheme (AEM) to limit the consequences of a reservoir depletion. This is introduced in article 8(6) of the Methodology. FCR providing entities with an energy reservoir where the endurance for full activation exceeds two hours may implement the same energy management functions, or during prequalification propose other solutions of similar effect, to be approved by the reserve connecting TSO. FCR providing entities classified as LER which have an energy reservoir that is not replenished from the power grid may also suggest an alternative energy management solution with similar effect, to be approved by the TSO.

As described in article 8(7), the FCR providing unit or group shall activate the Normal state Energy Management function when the reservoir level has drifted from the nominal level such that an increased risk of depletion has occurred. The Normal state Energy Management function shall be used to restore the reservoir level to the nominal value.

During provision from an FCR providing unit or group with a Normal state Energy Management function, active power and energy shall be reserved from the unit or group to ensure proper functioning of the Normal

state Energy Management function, in addition to the active power needed to ensure full availability of FCR provision itself. This is reflected in Article 8(9) of the Methodology.

The FCR providing entity shall activate the Alert state Energy Management function when the reservoir level has drifted from the nominal level such that a severe risk of depletion has occurred. The Alert state Energy Management function shall be used to ensure that the FCR response does not fully and suddenly cease in accordance with Article 8(8) of the Methodology.

Further, if the FCR providing unit or group is applying any form of energy management functions during operation those shall not interfere with the ability to provide FCR. This is stated in Article 8(10) of the Methodology.

6.4.3 Properties of FCR-N provided from limited energy reservoirs

FCR-N provision from an FCR providing unit or group with limited energy reservoirs (LER) shall be continuously available during the whole contractually agreed delivery period. This is a clarification towards Article 156(9) of the SO Regulation where it is stated that each FCR provider shall ensure that the FCR from its FCR providing units or groups with limited energy reservoirs are continuously available during normal state. Since FCR-N is fully activated within the bounds of normal state it follows that FCR-N has to be continuously available throughout the contractually agreed delivery period, to allow secure operation of the Nordic synchronous area. This position is reflected in Article 8(2) of the Methodology.

6.4.4 Properties of FCR-D upwards and FCR-D downwards provided from limited energy reservoirs FCR-D upwards is active in the system frequency band 49.5-49.9 Hz, while FCR-D downwards is active in the band 50.1-50.5 Hz. Both of these bands can correspond to both normal state and alert state, depending on the amount of time within each respective frequency range. FCR-D may also be active in emergency state, which for the purpose of Article 8 of the Methodology shall be treated equally to alert state.

During operation in normal state FCR-D provision from units or groups with limited energy reservoirs (LER) shall be continuously available. From the point in time of triggering of alert state and during the alert state, FCR-D providing units or groups with limited energy reservoirs shall be able to fully activate FCR continuously for a time period in accordance with the methodology per article 156(10) of the SO Regulation. This position corresponds to Article 156(9) of the SO Regulation and is reflected in Article 8(3) of the Methodology.

Further, FCR-D providing units or groups with partially or fully depleted energy reservoirs shall restore full nominal capacity within 120 minutes of the allowed start of recovery. The recovery process shall be initiated and completed as soon as possible. This requirement is an adaptation of Article 156(13)(b) of the SO Regulation and includes a clarification that the article shall be applied for FCR-D only, as FCR-N shall be continuously available per Article 6(2) of the Methodology. This position is reflected in Article 8(4) of the Methodology.

6.4.5 Confirmation of compliance

According to article 155(1) of the SO Regulation the prequalification process is a responsibility of each individual TSO. It is therefore proposed in Article 8(11) of the Methodology that compliance with the abovementioned requirements is confirmed in the FCR prequalification process.

The TSOs have developed common Nordic prequalification documents which contain tests and evaluation criteria to be implemented by each TSO in the national prequalification process.

6.5 Additional requirements on FCR minimum accuracy and resolution of measurements

As discussed in section 2.2, Annex V of the SO 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, Annex V of the SO Regulation does not specify the necessary resolution of frequency measurement nor corresponding values for the active power measurement of FCR providing units or groups. These are properties that are important for the Nordic power system to ensure the effectiveness of the other requirements defined within this Methodology. Hence, Article 9 of the Methodology introduces additional properties on measurements to complete the specification of Annex V.

6.5.1 FCR minimum accuracy of measurements

The measurement accuracy for active power and frequency shall achieve the values stated in the below table, or better. The value shall include the total inaccuracy of instrument (measurement) transformer, measurement transducer and any other equipment in the measurement system. The requirements for minimum accuracy for active power measurements are divided into three categories as responses from larger units or groups need to have a better accuracy for the regulation to be effective. Conversely, for smaller units or groups a slightly worse accuracy can be accepted since some of the inaccuracy can be expected to even out on a system scale. This position is reflected in Article 9(1) of the Methodology.

Measured quantity	Category	Rated power	Accuracy
Active power	A	< 1.5 MW	± 5%
	В	1.5 – 10 MW	±1%
	C+D	> 10 MW	± 0.5 %
System frequency	N/A	N/A	\pm 10 mHz

The TSOs have after consultations with the FCR providers concluded that it is necessary for some of the existing units and groups of category C+D to be allowed to transition into the above requirements as the measurement accuracy per today is not always fulfilled. The TSOs hence propose that FCR providing units or groups of category C+D, which have been prequalified for the first time prior to the end of 2023, will be evaluated towards the accuracy requirements for category B in the above table. This exemption shall continue to apply only until the next substantial change of the equipment. This position is introduced in article 9(2) of the Methodology

6.5.2 FCR minimum resolution of measurements

The measurement resolution for active power and frequency shall achieve the values stated in the below table, or better. This requirement is introduced in Article 9(3) of the Methodology.

Measured quantity	Resolution
Active power	0.01 MW or 0.025%
System frequency	5 mHz

6.5.3 Confirmation of compliance

According to article 155(1) of the SO Regulation the prequalification process is a responsibility of each individual TSO. It is therefore proposed in Article 7(3) of the Methodology that compliance with the abovementioned requirements is confirmed in the FCR prequalification process.

The TSOs have developed common Nordic prequalification documents which contain tests and evaluation criteria to be implemented by each TSO in the national prequalification process.

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

The Methodology 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 Methodology 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 Methodology contributes to these objectives by specifying the additional rules for FCR-N and 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 Low Frequency Demand Disconnection (LFDD) 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

Additional properties for FCR-N, FCR-D upwards and FCR-D downwards - as approved by the Nordic NRAs on 21 September 2020 - have been implemented in the Nordic synchronous area. This section describes how the TSOs propose that the transition from the existing additional properties to the properties as described in this Methodology shall occur.

This part of the Methodology has been developed in consultation with affected providers in accordance with article 154(2) of the SO Regulation. The providers have commented that implementing the new requirements will require a significant amount of time and effort for existing units and groups that provide FCR.

As stated in Article 10(3) of the Methodology the TSOs shall start to implement the FCR additional properties as specified in the Methodology immediately after all of the following has concluded:

- a. the approval by all NRAs of the Synchronous Area
- b. the TSOs have finalised the prequalification procedures

This section of the Methodology is intended to ensure that the TSOs as well as the providers have a suitable preparation time prior to the proposed requirements entering into force. The time for reaching point b is limited to one year from the date of NRA approval as stated in Article 10(3) of the Methodology.

The transitional period for the implementation of additional properties of FCR by the existing affected FCR providers shall be five years counted from the date of approval by the NRAs of the Synchronous Area: maximum one year for the TSOs to adapt their national processes and a total maximum of five years for the FCR providers to implement the FCR additional properties. This statement is intended to ensure that the

existing providers are given at least four years to transition to the new technical requirements. In case the adaptation of the national processes for one or several of the TSOs conclude earlier than after one year, the providers will be given additional time to transition such that the end date of the transition always occur at a total maximum of five years after NRA approval. This statement is reflected in Article 10(3) of the Methodology.

The TSOs intend to keep their respective prequalification teams on high-alert for at least the first year after national implementations to ensure the efficiency of the prequalification procedures, and if needed introduce any necessary updates to the prequalification procedures. The TSOs will also monitor the effects of the implementation of the requirements as stated in this Methodology. Since the TSOs propose that the implementation into national processes shall take maximum one year from the date of approval, Article 10(3) thus includes the statement that the TSOs shall review the requirements of this Methodology within two years from the date of approval by the NRAs of the Synchronous Area, and evaluate if the experience from the implementation necessitates any adjustments to the requirements within this Methodology.

New FCR providing units and groups shall apply the new requirements immediately after implementation in the national processes. The specific date will be communicated in advance by the relevant TSO. This position is introduced in Article 10(4) of the Methodology.

Existing FCR providing units and groups shall have transitioned within a maximum of five years counted from the date of approval by NRAs of the Synchronous Area. Existing units and groups that at that date haven't already transitioned to the new requirements will then be re-evaluated towards the new requirements in accordance with article 155(6)(b) of the SO Regulation. This requirement is implemented in Article 10(5).

In case of an already existing prequalification which is re-evaluated in accordance with article 155(6) of the SO Regulation the evaluation shall be made towards the new requirements as stated in this Methodology§. This is reflected in Article 10(6) of the Methodology.

The reserve connecting TSO shall be allowed to extend existing prequalifications to ensure a smooth transition from the existing requirements to the new requirements. The extension shall be based on successful auditing based on the existing requirements. The extension shall end at the latest within a maximum of five years after NRA approval of this Methodology. For some of the TSOs behind this Methodology many providers are up for reassessment in accordance with article 155(6) with many units at the same time, often at the beginning of the above described transitional period. This will for example happen at five years after entry into force of the SO Regulation in September 2023, where many previously not time-limited prequalifications now end. The intent of Article 8(8) of the Methodology is hence to allow the transition of the existing units and groups to the new requirements to be able to be spread out within the full extent of the proposed transitional period.

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 Methodology has been consulted in the period xxx to xxx. 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 Methodology.

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 Methodology.

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

no.	Organisation	Comment	response TSOs