
Parameters of Non-exhaustive Requirements

ENTSO-E Guidance document for national implementation for network codes on grid connection

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DESCRIPTION

Code(s) & Article(s) Network Codes (NCs) Requirements for Generators (RfG), Demand Connection Code (DCC) and High Voltage Direct Current (HVDC)

All articles with non-exhaustive requirements for which a national choice is expected to be requested (see indicative tables per code below)

Introduction

This is a general guidance document that provides a reference to all non-exhaustive parameters. It is aimed to provide the general considerations that are considered relevant in defining nationally these parameters and the principles of coordination between users and system operators to achieve this.

This IGD provides only guidance and could not be construed as binding for the implementation of the CNCs at the national level by Member States, NRAs, system operators and all other relevant stakeholders.

This general guidance also provides the most generic principles for determining all non-exhaustive parameters, and should be read in conjunction with the more specific guidance on major issues, clustered into the following separate IGDs:

- Parameters related to Voltage issues
- Parameters related to Frequency issues
- Restoration issues
- Active and reactive power control
- Instrumentation, simulation models and protection

For those clusters, general guidance in order to help the Transmission System Operators (TSOs) to define their own parameters has been provided in their own IGDs. Within these clusters, there are a number of requirements many of which have their own specific IGDs.

Those IGDs (found in [Active Library](#)) have been developed for specific non-exhaustive requirements and for some activities that have to be carried out for the national implementation (for example cost benefit analysis).

NC frame

The non-exhaustive topics are those for which the European level CNCs do not contain all the information or parameters necessary to apply the requirements immediately. These requirements are typically described in the CNC as “TSO / relevant system operator shall define” or “defined by / determined by / in coordination with the TSO / relevant TSO”.

Some of them need a choice at national level, but wider sharing and in some cases collaboration on the criteria can be necessary.

ENTSO-E understands that parameters for non-exhaustive requirements shall apply uniformly across different types of significant grid users, except where otherwise specified. For example, FRT capability parameters are different for synchronous power generating modules and power park modules and furthermore they vary between Type B/C and Type D power generating modules. However, different parameters of non-exhaustive requirements may be applied regionally. In cases of different applications, these parameters need to be justified by the relevant system operator, be harmonized with the network code and not lead to rules that would be incompatible with the network codes.

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| Further info | IGD Parameters related to frequency stability IGD Instrumentation simulation models and protection IGD Voltage-related parameters IGD System Restoration IGD Harmonisation IGD Making non-mandatory requirements at European level mandatory at national level IGD Reactive power control modes for PPM & HVDC |
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INTERDEPENDENCIES

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| Between the NCs | Several requirements exist in all three CNCs (RfG, DCC and HVDC). Many of these requirements need to be considered in aggregate in order to ensure that the overall functional requirements ensure a secure and operable system. Consistency in the national choices shall be ensured also through the NRA's monitoring/approval role on the national implementation. |
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| In other NCs | There are links to the national implementation of the codes applying the connection capabilities in both system and market operation (System Operation Committee and Market Committee topics) as far as the national documents are approved and released. In some cases these topics are expected to be at a national level contained in combined documents (e.g. broader content Grid Codes). Consistency needs to be maintained in these cases, i.e. it needs to be ensured that national connection code frequency capabilities are actually defined so that the settings that need to be applied can be developed through system and market operation codes. |
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| System characteristics | <p>System characteristics and its evolution have to be taken into consideration when defining requirements non-exhaustive requirements at national level.</p> <p>The choice of the non-exhaustive parameters when the NC enters in force needs to take into account the immediate and future system characteristics (for example RES penetration), including both the networks development. These are expected to change continuously and differently in each country. It is recommended to evaluate at national level the expected changes in system needs over the next 15-20 years, in order to define non-exhaustive parameters.</p> <p>Some choices will also be influenced by the proportion of the different types of generators within the country (type A/B versus C/D).</p> <p>In general, determining factors to be considered for the definition of the non-exhaustive requirements at national level, could be:</p> <ul style="list-style-type: none">- Maintaining existing requirements and performance, that are already foreseen from previous national regulations where their need and benefit is demonstrated by operational experience- Taking into consideration the evolution of national generation portfolio characteristics (e.g. level of penetration of power electronic interfaced renewable generation) |
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- Taking into consideration national system characteristics and needs and its future evolution (e.g. rural/urban conditions, density of load and generation)
- Ensuring that requirements needed for ensuring security of supply will be fulfilled at any time even considering the peculiarity of each electricity system (such as negative balance of each country)

Technology characteristics

Specification of non-exhaustive parameters for the functional requirements will typically be unaffected by the technology being used.

COLLABORATION

Methodology principles recommended for specifying non-exhaustive requirements

Step 1 - Identification of power system's needs taking into account different scenarios and potential studies

Step 2 - identification of technical options and limits to sustainably meet these needs

Step 3 - High level evaluation of adequacy to meet own and wider system needs (step 1) based on existing requirements and best practises including coordination as appropriate

Step 4 - matching the high level evaluation with network code requirements

TSO – TSO

In general parameters for non-exhaustive requirements should require co-ordination between TSOs in terms of criteria to be considered for the national implementation (please refer to column “proposer” of CNCs tables below).

Some requirements could require collaboration at synchronous area level while other requirements require collaboration between adjacent TSO, to ensure an efficient behaviour of the facilities connected near the border of these TSOs.

TSO – DSO

In general parameters for non-exhaustive requirements which affect TSO-DSO relationship should require co-ordination between the TSO and DSO (Distribution System Operator) (please refer to column “proposer” of CNCs tables below).

It is recommended to TSOs and DSOs to engage with each other at an early stage of national implementation to explore interdependencies and possible Impact of the requirements on transmission and distribution systems.

Relevant System Operator (RSO) – Grid User

In general parameters for non-exhaustive requirements should require co-ordination between the RSO (can be either TSO or DSO) and end user (please refer to column “proposer” of CNCs tables below).

It is recommended to system operators to engage with grid users at an early stage of national implementation to raise awareness on system engineering aspects and inform about system challenges. Early involvement supports transparency of the implementation processes and helps to mitigate concerns about discretionary decisions during the implementation process. It enables stakeholders to contribute actively to solutions and to make use of their expertise, e.g. manufacturers’ knowledge about technical capabilities and constraints of certain technologies. Factual discussions on technical / procedural challenges based on expertise and best practice are thus facilitated.

Annex I: Relationship between mandatory/non-mandatory, exhaustive/non-exhaustive and general/site requirements

Introductory definitions of applied acronyms

| | |
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| PGM: | Power-Generating Module |
| SPGM: | Synchronous Power-Generating Module |
| PPM: | Power Park Module |
| DF: | Demand Facility |
| DSO: | Distributed System Operator |
| CDSO: | Closed Distributed System Operator |
| DU: | Demand Unit |
| HVDC: | High-Voltage Direct Current |
| TSO: | Transmission System Operator |
| TC DF: | Transmission Connected Demand Facility |
| TC DS: | Transmission Connected Distribution System, including Transmission Connected Distribution Facilities |
| CDS: | Closed Distribution System |
| DRS: | Demand Response Services |
| PGFO: | Power Generating Facility Owner |
| Grid User: | Assets/facilities and their owners connected to transmission or distribution networks |

Other definitions:

| | |
|------------------------|---|
| Proposer: | An entity which determines value/range/specification of technical requirement. Typical proposers are TSO, DSO and RSO. An agreement between the involved parties in dependence of their relationship (please refer to column “proposer” of CNCs tables below). |
| Applicability: | A Grid User which shall apply value/range/specification of non-exhaustive technical requirement determined by Proposer. |
| Mandatory: | A requirement that shall be implemented by the Proposer in all EU Members States and other countries, which implement CNCs. |
| Non-mandatory: | Each Proposer in EU Member States and in other ENTSO-E member country, which implements CNCs can make a decision whether to introduce such a requirement. A non-mandatory requirement can be made mandatory in a specific country at any point in time after applicability of the relevant CNC. |
| Exhaustive: | A requirement that needs no further national specification (e.g. parameters, ranges, methodology) for its entire application since it's fully defined regarding capability, range and values. |
| Non-exhaustive: | A requirement needs further national specification (e.g. parameters, ranges, methodology) for its entire application in general on national level or as a site-specific choice. |
| General: | CNC demands the requirement to be implemented in National Implementation of CNC. In column XY in the following tables “G*” refers to Regulatory aspects in NC RfG, article 7(4), NC DC, article 6(4), NC HVDC, article 5(4). |
| Site specific: | CNC demands the requirement to be implemented in due time for plant design / |

commissioning at latest. In column XY in the following tables “S*” refers to Regulatory aspects in CNC: NC RfG, article 7(2), NC DC, article 6(2), NC HVDC, article 5(2).

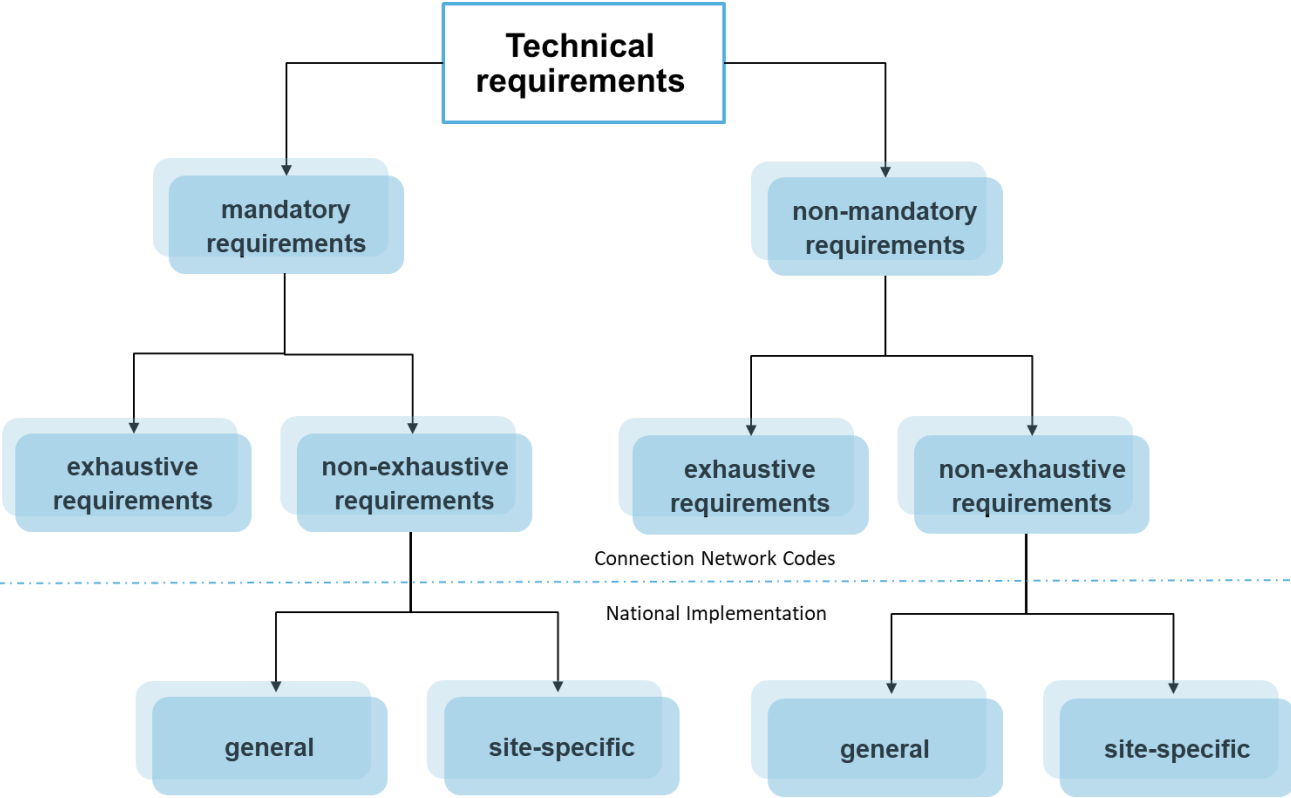


Table 1: RfG Non-Exhaustive Requirements

Table 1.1: RfG Non-Exhaustive Requirements – Frequency Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|------------------|-----|----------------------------|---------------------------|--------------------|---------------|--|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Frequency Issues | 1 | Frequency Ranges | - | 13(1)(a)(i) | A,B,C,D | Time period for: <ul style="list-style-type: none"> 47.5Hz-48.5Hz (SAs: CE, Baltic) 48.5Hz-49.0Hz (SAs: CE, Nordic, GB, IR, Baltic) 51.0Hz-51.5Hz (SAs: Baltic) | G | G (value) | TSO |
| | 2 | Frequency Ranges | X | 13(1)(a)(ii) | A,B,C,D | <ul style="list-style-type: none"> Potential wider frequency ranges Potential longer minimum times Specific requirements for frequency and voltage deviations | S | S (value) | Agreement between the RSO (DSO or TSO), in coordination with the TSO, and the PGFO |
| | 3 | RoCoF | - | 13(1)(b) | A,B,C,D | <ul style="list-style-type: none"> Max. RoCoF and measuring window for which PGM shall stay connected | G | G (value) | TSO |
| | 4 | RoCoF | - | 13(1)(b) | A,B,C,D | <ul style="list-style-type: none"> Specify RoCoF of the loss of main protection | S | S | RSO in coordination with the TSO |
| | 5 | LFSM-O | - | 13(2)(a) | A,B,C,D | <ul style="list-style-type: none"> Frequency threshold Droop settings | G | G (range) S (value before plant commissioning and to be reselected as appropriate using capabilities defined at CNC national implementation) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--------------------|---------------|---|---------------------|--|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 6 | LFSM-O | X | 13(2)(b) | A | <ul style="list-style-type: none"> Use of automatic disconnection and reconnection | G | G (value and criteria) | TSO |
| | 7 | LFSM-O | X | 13(2)(f) | A,B,C,D | <ul style="list-style-type: none"> Expected behaviour of the PGM once the regulating minimum level is reached | S | - | TSO |
| | 8 | Admissible Active Power Reduction | - | 13(4) | A,B,C,D | <ul style="list-style-type: none"> Admissible active power reduction from max. output with falling frequency | G | S (reviewed in due time for plant design) | TSO |
| | 9 | Admissible Active Power Reduction from maximum Output with falling Frequency | - | 13(5) | A,B,C,D | <ul style="list-style-type: none"> Definition of the ambient conditions applicable when defining the admissible active power reduction and take into account of the capabilities of PGM | G | S (reviewed in due time for plant design) | TSO |
| | 10 | Logic Interface (1) | X | 13(6) | A, B | <ul style="list-style-type: none"> Requirements for the additional equipment necessary to allow active power output to be remotely operable | S | - | RSO |
| | 11 | Automatic Connection to the Network | - | 13(7) | A,B,C | Conditions for automatic connection to the network regarding <ul style="list-style-type: none"> Frequency ranges Corresponding delay time Maximum admissible gradient of increase in active power output | G | G | TSO |

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--------------------------------|---------------------------|--------------------|---------------|---|---------------------|--|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 12 | Logic Interface (Z) | X | 14(2)(b) | B | <ul style="list-style-type: none"> Requirements for the equipment necessary to make the logic interface remotely operable (to cease active power output) | S | - | RSO |
| | 13 | Frequency Stability | - | 15(2)(a) | C,D | <ul style="list-style-type: none"> Time period to reach the adjusted active power set point Tolerance applying to the new set point Time period to reach tolerance applying to the new set point | G | G | TSO |
| | 14 | LFSM-U | - | 15(2) (c) | C,D | <ul style="list-style-type: none"> Frequency threshold Droop Definition of P_{ref} | G | G (range) S (adjustable setting in due time for plant design and to be reselected as appropriate using capabilities defined at CNC national implementation) | TSO |
| | 15 | Frequency Sensitive Mode | - | 15(2)(d)(i) | C,D | <ul style="list-style-type: none"> Active power range related to maximum capacity Frequency response insensitivity Frequency response dead band Droop | G | G (range) S (adjustable setting and to be reselected as appropriate using capabilities defined at CNC national implementation) | TSO |
| | 16 | Frequency Sensitive Mode (FSM) | - | 15(2)(d) (iii) | C,D | <ul style="list-style-type: none"> Maximum admissible full activation time | G | G | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--------------------|---------------|---|---------------------|--|----------------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 17 | Frequency Sensitive Mode (FSM) | X | 15(2)(d)(iv) | C,D | <ul style="list-style-type: none"> Maximum admissible initial delay for PGMs without inertia | G | S | TSO |
| | 18 | Frequency Sensitive Mode (FSM) | - | 15(2)(d)(v) | C,D | <ul style="list-style-type: none"> Time period for the provision of full active power frequency response | G | G | TSO |
| | 19 | Frequency Restoration Control | - | 15(2)(e) | C,D | <ul style="list-style-type: none"> Specifications of the frequency restoration control | G | G | TSO |
| | 20 | Real-Time Monitoring of FSM | - | 15(2)(g) | C,D | <ul style="list-style-type: none"> List of the necessary data which will be sent in real time Definition of additional signals | S | S | RSO (DSO or TSO) or TSO |
| | 21 | Rates of Change of Active Power Output | - | 15(6) | C,D | <p>Taking into consideration the specific characteristics of the prime mover technology:</p> <ul style="list-style-type: none"> Minimum limit of change of active power output in down direction Maximum limit of change of active power output in down direction Minimum limit of change of active power output in up direction Maximum limit of change of active power output in up direction | G | S (reviewed in due time for plant design) | RSO in coordination with the TSO |
| | 22 | Rates of Change of Active Power Output | - | 15(6)(d) | C,D | <ul style="list-style-type: none"> Additional devices for secure system operation | S | S | RSO in coordination with the TSO |

Table 1.2: RfG Non-Exhaustive Requirements – Voltage Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|----------------|-----|-------------------------------|---------------------------|---|---------------|--|---------------------|-----------------------------|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Voltage Issues | 1 | Fault Ride Through Capability | - | 14(3)(a)(i) (Voltage-against-time profile) | B,C,D | SPGM: <ul style="list-style-type: none"> ▪ U_{ret}, U_{clear}, U_{rec1}, U_{rec2} ▪ t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3} | G | G | TSO |
| | 2 | Fault Ride Through Capability | - | 14(3)(a)(i) (Voltage-against-time profile) | B,C,D | PPM: <ul style="list-style-type: none"> ▪ U_{ret}, U_{clear}, U_{rec1}, U_{rec2} ▪ t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3} | G | G | TSO |
| | 3 | Fault Ride Through Capability | - | 14(3)(a)(iv) | B,C,D | <ul style="list-style-type: none"> ▪ Pre-fault minimum short circuit capacity (MVA) at connection point ▪ Pre-fault active power output at connection point ▪ Pre-fault reactive power output at connection point ▪ Pre-fault voltage at connection point ▪ Post-fault minimum short circuit capacity (MVA) at connection point (only type D) | G | G | TSO |
| | 4 | Fault Ride Through Capability | - | 14(3)(b) (Voltage-against-time profile for asymmetric faults) | B,C,D | SPGM: <ul style="list-style-type: none"> ▪ U_{ret}, U_{clear}, U_{rec1}, U_{rec2} ▪ t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3} | G | G | TSO |
| | 5 | Fault Ride Through Capability | - | 14(3)(b) (Voltage-against-time profile for asymmetric faults) | B,C,D | PPM: <ul style="list-style-type: none"> ▪ U_{ret}, U_{clear}, U_{rec1}, U_{rec2} ▪ t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3} | G | G | TSO |
| | 6 | Fault Ride Through Capability | - | 16(3)(a)(i) (Voltage-against-time profile) | D | SPGM: <ul style="list-style-type: none"> ▪ U_{ret}, U_{clear}, U_{rec1}, U_{rec2} ▪ t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3} | G | G | TSO |

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 7 | Fault Ride Through Capability | - | 16(3)(a)(i) (Voltage-against-time profile) | D | PPM: ▪ $U_{ret}, U_{clear}, U_{rec1}, U_{rec2}$ ▪ $t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3}$ | G | G | TSO |
| | 8 | Fault Ride Through Capability | - | 16(3)(c) (Voltage-against-time profile for asymmetric faults) | D | SPGM: ▪ $U_{ret}, U_{clear}, U_{rec1}, U_{rec2}$ ▪ $t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3}$ | G | G | TSO |
| | 9 | Fault Ride Through Capability | - | 16(3)(c) (Voltage-against-time profile for asymmetric faults) | D | PPM: ▪ $U_{ret}, U_{clear}, U_{rec1}, U_{rec2}$ $t_{ret}, t_{clear}, t_{rec1}, t_{rec2}, t_{rec3}$ | G | G | TSO |
| | 10 | Fault Ride Through Capability | - | 16(3)(b)(i) | D | ▪ Pre-fault minimum short circuit capacity (MVA) at connection point | G | G | TSO |
| | 11 | Fault Ride Through Capability | - | 16(3)(b)(iii) | D | ▪ Pre-fault active power output at connection point ▪ Pre-fault reactive power output at connection point ▪ Pre-fault voltage at connection point | G | G | TSO |
| | 12 | Fault Ride Through Capability | - | 16(3)(b)(iii) | D | ▪ Post-fault minimum short circuit capacity (MVA) at connection point | G | G | TSO |
| | 13 | Automatic Disconnection due to Voltage Level | - | 15(3) | C | ▪ Voltage criteria for automatic disconnection ▪ Settings for automatic disconnection | G | S (value) | RSO (DSO or TSO), in coordination with the TSO |
| | 14 | Voltage Ranges PGM U<300kV | - | 16(2)(a)(i) | D | Time period for operation: ▪ 1.118pu-1.15pu (SAs: CE) | G | G (value) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|---------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 15 | Voltage Ranges PGM U<300kV | X | 16(2)(a)(ii) | D | <ul style="list-style-type: none"> Shorter time period in the event of simultaneous overvoltage and under frequency Shorter time period in the event of simultaneous undervoltage and over frequency | G | S | TSO |
| | 16 | Voltage Ranges PGM U<300kV | - | 16(2)(b) | D | <ul style="list-style-type: none"> Wider voltage ranges for operation may be agreed by RSO, PGFO and TSO Longer minimum time periods for operation may be agreed by RSO, PGFO and TSO | S | S | Agreement between the RSO and the PGFO, in coordination with the TSO |
| | 17 | Voltage Ranges PGM 300kV < U < 400kV | - | 16(2)(a)(i) | D | Time period for operation <ul style="list-style-type: none"> 1.05pu-1.10pu (SAs: CE; Nordic) | G | S | TSO |
| | 18 | Voltage Ranges PGM 300kV < U < 400kV | X | 16(2)(a)(iii) | D | Time period for operation <ul style="list-style-type: none"> 1.05pu-1.0875pu in Spain may be specified as unlimited | G | G (value) | TSO |
| | 19 | Voltage Ranges PGM 300kV < U < 400kV | X | 16(2)(a)(v) | D | <ul style="list-style-type: none"> For Baltic voltage ranges and time period for operation may be in line with Continental Europe for facilities connected to the 400kV network. | G | G (value) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 20 | Voltage Ranges PGM 300kV < U < 400kV | X | 16(2)(a)(ii) | D | <ul style="list-style-type: none"> Shorter time period in the event of simultaneous overvoltage and under frequency Shorter time period in the event of simultaneous undervoltage and over frequency | G | S | TSO |
| | 21 | Voltage Ranges PGM 300kV < U < 400kV | - | 16(2)(b) | D | <ul style="list-style-type: none"> Wider voltage ranges for operation may be agreed by RSO, PGFO and TSO Longer minimum time periods for operation may be agreed by RSO, PGFO and TSO | S | S (value) | Agreement between the RSO and the PGFO, in coordination with the TSO |
| | 22 | Reactive Power Capability SPGM | X | 17(2)(a) | B | <ul style="list-style-type: none"> Capability to supply or absorb reactive power | G | G (range) | RSO |
| | 23 | Supplementary Reactive Power SPGM | X | 18(2)(a) | C,D | <ul style="list-style-type: none"> Definition of supplementary reactive power to compensate reactive power demand of the HV line or cable when connection point is not located at the HV side of the step-up transformer | G) | G (range) | RSO |
| | 24 | Reactive Power Capability SPGM at max. Capacity | - | 18(2)(b)(i) | C,D | <ul style="list-style-type: none"> U-Q/Pmax-profile at maximum capacity | G | G (range of capability) | RSO in coordination with the TSO |
| | 25 | Reactive Power Capability SPGM at max. Capacity | - | 18(2)(b)(iv) | C,D | <ul style="list-style-type: none"> Appropriate timescale to reach any operating point within U-Q/Pmax-profile | G | G (value) | RSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|-------------------------------|---------------------------|--------------------|---------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 26 | Voltage Control SPGM | - | 19(2)(a) | D | <ul style="list-style-type: none"> Parameters and settings of the components of the voltage control system Specifications of the automatic voltage regulator (AVR) | G | S (ranges) | Agreement between the PGFO and the RSO, in coordination with the TSO |
| | 27 | Voltage Stability SPGM | - | 19(2)(b)(v) | D | <ul style="list-style-type: none"> Power threshold above which PSS function must be specified | G | G (value) | TSO |
| | 28 | Reactive Power Capability PPM | X | 20(2)(a) | B,C,D | <ul style="list-style-type: none"> Capability to supply or absorb reactive power | G | G (range of capability) | RSO |
| | 29 | Fast Fault Current PPM | X | 20(2)(b)(ii) | B,C,D | <ul style="list-style-type: none"> How the voltage deviation is determined? When the voltage deviation is determined? Characteristics of fast fault current injection Timing of fast fault current injection which may include several stages Accuracy of fast fault current injection which may include several stages The end of the voltage deviation | G | G (values) | RSO in coordination with the TSO |
| | 30 | Fast Fault Current PPM | X | 20(2)(c) | B,C,D | <ul style="list-style-type: none"> Specification for asymmetrical current injection (in case of asymmetrical faults 1-phase/2-phase faults) | G | G (value) | RSO in coordination with the TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--|---------------|---|---------------------|-----------------------------|----------------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 31 | Supplementary Reactive Power PPM | X | 21(3)(a) | C,D | <ul style="list-style-type: none"> Definition of supplementary reactive power to compensate reactive power demand of the HV line or cable when connection point is not located at the HV side of the step-up transformer | G | G (range) | RSO |
| | 32 | Reactive Power PPM at max. Capacity | - | 21(3)(b) | C,D | <ul style="list-style-type: none"> U-Q/P_{max}-profile at maximum capacity | G | G (range of capability) | RSO in coordination with the TSO |
| | 33 | Reactive Power PPM below max. Capacity | - | 21(3)(c)(i) | C,D | <ul style="list-style-type: none"> U-Q/P_{max}-profile below maximum capacity | G | G (range of capability) | RSO in coordination with the TSO |
| | 34 | Reactive Power PPM below max. Capacity | - | 21(3)(c)(iv) | C,D | <ul style="list-style-type: none"> Appropriate timescale to reach any operating point within U-Q/P_{max}-profile | G | G (value) | RSO |
| | 35 | Reactive Power Control Modes PPM | - | 21(3)(d)(iv) (Voltage control mode) | C,D | <ul style="list-style-type: none"> t₁: time within which 90% of the change in reactive power is reached t₂: time within which 100% of the change in reactive power is reached | G | G (values) | RSO |
| | 36 | Reactive Power Control Modes PPM | - | 21(3)(d)(vi) (Power factor control mode) | C,D | <ul style="list-style-type: none"> Target power factor Time period to reach the set point Tolerance | G | G (ranges) | RSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--|---------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 37 | Reactive Power Modes PPM | - | 21(3)(d)(vii) (Specifications of the two reactive power control mode options) | C,D | <ul style="list-style-type: none"> Which reactive power control mode is chosen? Which associated set points are applied? Which further equipment is needed to make the relevant set point operable? | S | S | RSO, in coordination with the TSO and the PGFO |
| | 38 | Priority Active or Reactive Power Contribution PPM | - | 21(3)(e) (Provision of active power no later than 150ms from fault inception) | C,D | <ul style="list-style-type: none"> Priority for active or reactive power contribution during faults for which fault-ride-through capability is required | G | G | relevant TSO |
| | 39 | PPM Power oscillations damping | X | 21(3)(f) | C,D | <ul style="list-style-type: none"> Power oscillations damping by the power park module | G | S | relevant TSO |
| | 40 | Voltage Ranges Offshore PPM U<300kV | - | 25(1) | Offshore PPM | Time period for operation: <ul style="list-style-type: none"> 1.118pu-1.15pu (SAs: CE) | G | G (value) | TSOI |
| | 41 | Voltage Ranges Offshore PPM 300kV < U < 400kV | - | 25(1) | Offshore PPM | Time period for operation: <ul style="list-style-type: none"> 1.05pu-1.10pu (SAs: CE, Nordic) | G | G (value) | TSO |
| | 42 | Voltage Ranges Offshore PPM in Spain | X | 25(2) | Offshore PPM | Unlimited time period for operation: 1.05pu-1.0875pu (Spain) | G | G (value) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--------------------|---------------|--|---------------------|-----------------------------|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 43 | Voltage Ranges Offshore PPM in Baltic states | X | 25(3) | Offshore PPM | <ul style="list-style-type: none"> Time periods for operation and voltage ranges same as for SA CE for 400 kV | G | G | TSO |
| | 44 | Reactive Power Capability PPM Offshore at max.Capacity | - | 25(5) | Offshore PPM | <ul style="list-style-type: none"> U-Q/P_{max}-profile at P_{max} | G | G (range of capability) | TSO |

Table 1.3: RfG Non-Exhaustive Requirements – System Restoration Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|---------------------------|-----|--------------------------------|---------------------------|--------------------|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| System Restoration Issues | 1 | Reconnection Capability | - | 14(4)(a) | B,C,D | <ul style="list-style-type: none"> Conditions for reconnection to the network after an incidental disconnection caused by network disturbance | G | G | TSO |
| | 2 | Reconnection Capability | - | 14(4)(b) | B,C,D | <ul style="list-style-type: none"> Conditions for automatic reconnection | G | G | TSO |
| | 3 | Blackstart Capability | X | 15(5)(a)(ii) | C,D | <ul style="list-style-type: none"> Technical specifications for a quotation for black start capability | G (principle) | S | TSO |
| | 4 | Blackstart Capability | X | 15(5)(a)(iii) | C,D | <ul style="list-style-type: none"> Timeframe within which the PGM is capable of starting from shutdown without any external electrical energy supply | G | G (value) | RSO (DSO or TSO) in coordination with the TSO |
| | 5 | Blackstart Capability | X | 15(5)(a)(iv) | C,D | <ul style="list-style-type: none"> Voltage limits for synchronisation when article 16.2 does not apply | G | G (range) | RSO (DSO or TSO) |
| | 6 | Capability of Island Operation | X | 15(5)(b) | C,D | <ul style="list-style-type: none"> Capability of island operation | S | S | RSO (DSO or TSO) in coordination with the TSO |
| | 7 | Capability of Island Operation | X | 15(5)(b)(i) | C,D | <ul style="list-style-type: none"> Definition of quality of supply parameters | S | S | RSO (DSO or TSO) in coordination with the TSO |
| | 8 | Capability of Island Operation | X | 15(5)(b)(iii) | C,D | <ul style="list-style-type: none"> Methods and criteria for detecting island operation | S | S | Agreement between the PGFO and the RSO (DSO or TSO) in coordination with the TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RtG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 9 | Operation following Tripping to Houseload | X | 15(5)(c)(i) | C,D | <ul style="list-style-type: none"> Provision of simulation models | G | S | Agreement between the PGFO and the RSO (DSO or TSO) in coordination with the TSO |
| | 10 | Operation following Tripping to Houseload | - | 15(5)(c)(iii) | C,D | <ul style="list-style-type: none"> Minimum operation time within which the PGM is capable of operating after tripping | G | G (value) | RSO (DSO or TSO) in coordination with the TSO |
| | 11 | Operation following Tripping to Houseload | X | 15(5)(c)(iv) | C,D | <ul style="list-style-type: none"> Recordings of PGM performance | S | G/S | RSO (DSO or TSO) |
| | 12 | Operation following Tripping to Houseload | X | 15(6)(d) | C,D | <ul style="list-style-type: none"> Additional devices for secure system operation | S | S | Agreement between the PGFO and the RSO (DSO or TSO) |
| | 13 | Active Power Recovery SPGM | - | 17(3) | B,C,D | <ul style="list-style-type: none"> Definition of the magnitude and time for active power recovery | G | G (value) | TSO |
| | 14 | Post Fault Active Power Recovery PPM | - | 20(3)(a) | B,C,D | <ul style="list-style-type: none"> Specification when the post-fault active power recovery begins Specification of the max. allowed time for active power recovery Specification of magnitude and accuracy for active power recovery | G | G (value) | TSO |

Table 1.4: RfG Non-Exhaustive Requirements – Instrumentation, Simulation Models and Protections Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|---|-----|--|---------------------------|--------------------|---------------|--|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Instrumentation, Simulation Models and Protection | 1 | Control Scheme and Settings | - | 14(5)(a) | B,C,D | <ul style="list-style-type: none"> Control schemes of the control devices Control settings of the control devices | S | S (control schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | Agreement and coordination between the TSO, the RSO (TSO and DSO) and the PGFO |
| | 2 | Electrical Protection Schemes and Settings | - | 14(5)(b) | B,C,D | <ul style="list-style-type: none"> Electrical protection schemes Electrical protection settings | S | S (protection schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | Agreement and coordination between the RSO and the PGFO |
| | 3 | Information Exchanges | - | 14(5)(d) | B,C,D | <ul style="list-style-type: none"> Content of information exchange Precise list of data to be facilitated Precise time of data to be facilitated | G (principle) | S (value) | RSO (DSO or TSO) or TSO |
| | 4 | Manual, local Measures where the Automatic Remote Devices are out of Order | - | 15(2)(b) | C,D | <ul style="list-style-type: none"> Time period to reach the requested set point in cases where the automatic remote control devices are out of service Tolerance to reach the requested set point in cases where the automatic remote control devices are out of service | S | S (value) | RSO (DSO or TSO) or TSO |

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Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--------------------|---------------|--|---------------------|-----------------------------|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 5 | Loss of Angular Stability or Loss of Control | - | 15(6)(a) | C,D | <ul style="list-style-type: none"> Criteria to detect loss of angular stability or loss of control | S | S (value) | Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO |
| | 6 | Instrumentation | X | 15(6)(b)(i) | C,D | <ul style="list-style-type: none"> Definition of the quality of supply parameters | S | G/S | RSO |
| | 7 | Instrumentation | - | 15(6)(b)(ii) | C,D | <ul style="list-style-type: none"> Settings of the fault recording equipment Triggering criteria of the fault recording equipment Sampling rates of the fault recording equipment | S | S (value) | Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO |
| | 8 | Instrumentation | - | 15(6)(b)(iii) | C,D | <ul style="list-style-type: none"> Specifications of the oscillation trigger detecting poorly damped power oscillations | S | S (value) | RSO in coordination with the TSO |
| | 9 | Instrumentation | - | 15(6)(b)(iv) | C,D | <ul style="list-style-type: none"> Protocols for recorded data | S | S | Agreement between the PGFO, the RSO and the relevant TSO |
| | 10 | Simulation Models | X | 15(6)(c)(i) | C,D | <ul style="list-style-type: none"> Provision of simulation models | G | S | RSO in coordination with the TSO |
| | 11 | Simulation Models | X | 15(6)(c)(iii) | C,D | <ul style="list-style-type: none"> Specifications of the simulation models | G | G | RSO in coordination with the TSO |
| | 12 | Simulation Models | X | 15(6)(c)(iv) | C,D | <ul style="list-style-type: none"> Recordings of PGM performance | S | G/S | RSO in coordination with the TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | RfG NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|--------------------|---------------|--|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 13 | Installation of Devices for System Operations and Security | X | 15(6)(d) | C,D | <ul style="list-style-type: none"> Definitions of the devices needed for system operation and system security | S | S | RSO or TSO and PGFO |
| | 14 | Neutral Point at the Network Side of Step-Up Transformers | - | 15(6)(f) | C,D | <ul style="list-style-type: none"> Specifications of the earthing arrangement of the neutral point at the network side of the step-up transformers | G (principle) | S (value in due time for plant design and to be reselected as appropriate) | RSO |
| | 15 | Automatic Disconnection | X | 16(2)(c) | D | <ul style="list-style-type: none"> Definition of the threshold for automatic disconnection Definition of the parameters | S | S (value) | RSO in coordination with the TSO Agreement between the RSO and the PGFO |
| | 16 | Synchronisation | - | 16(4) | D | <ul style="list-style-type: none"> Settings of the synchronisation devices | G | G (range) S (value before plant commissioning and to be reselected as appropriate) | Agreement between the RSO and the PGFO |
| | 17 | Angular Stability | - | 19(3) | SPGM D | <ul style="list-style-type: none"> Agreement for technical capabilities of the PGM to aid angular stability | S | S | Agreement between the TSO and the PGFO |
| | 18 | Synthetic Inertia | X | 21(2) | PPM C,D | <ul style="list-style-type: none"> Definition of the operating principle of control systems to provide synthetic inertia Related performance parameters to provide synthetic inertia | G | S | TSO |

Table 2: DCC Non-Exhaustive Requirements

Table 2.1: DCC Non-Exhaustive Requirements – Frequency Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|------------------|-----|----------------------------|---------------------------|--------------------|-------------------------|--|---------------------|-----------------------------|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| FREQUENCY ISSUES | 1 | Frequency Ranges | - | 12(1) and Annex I | TC DF and TC DS | Time period for: <ul style="list-style-type: none"> 47.5Hz-48.5Hz (SAs: CE, Baltic) 48.5Hz-49.0Hz (SAs: CE, Nordic, GB, IR, Baltic) 51.0Hz-51.5Hz (SAs: Baltic) | G | G (value) | Relevant TSO |
| | 2 | Frequency Ranges | X | 12(2) and Annex I | TC DF and TC DS | <ul style="list-style-type: none"> Potential wider frequency ranges Potential longer minimum times Specific requirements for frequency and voltage deviations | S | S (value) | agreement between DSO, TC DF owner and TSO |
| | 3 | DRS | X | 28.(2)(k) | DF and CDS offering DRS | <ul style="list-style-type: none"> Rate of change of frequency withstand over a 500ms time period | G | G | relevant TSO |
| | 4 | DRS | X | 29.(2)(c) | DF and CDS offering DRS | for DU connected below 110 kV: <ul style="list-style-type: none"> Definition of the normal operating range | G | G (value) | relevant SO |
| | 5 | DRS | X | 29(2)(d) | DF and CDS offering DRS | <ul style="list-style-type: none"> Definition of the allowed frequency dead band | G | G (value) | relevant TSO, in consultation with TSOs of the synchronous area |
| | 6 | DRS | X | 29(2)(e) | DF and CDS offering DRS | <ul style="list-style-type: none"> Definition of the frequency ranges for DRS System Frequency Control (SFC) Definition of the maximum frequency deviation to respond | G | G (value) | relevant TSO, in consultation with TSOs of the synchronous area |

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|--------------------|-------------------------|---|---------------------|-----------------------------|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 8 | DRS | X | 29(2)(g) | DF and CDS offering DRS | <ul style="list-style-type: none"> Definition of the rapid detection of frequency system changes Definition of the response to frequency system changes | G | G | relevant TSO, in consultation with TSOs of the synchronous area |

Table 2.2: DCC Non-Exhaustive Requirements – Voltage Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|----------------|-----|----------------------------|---------------------------|--------------------|--|---|---------------------|-----------------------------|--------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| VOLTAGE ISSUES | 1 | Voltage Ranges | - | 13(1) and Annex II | TC DF and TC DS in range 110 kV – 300 kV | Time period for: <ul style="list-style-type: none"> 1,05 pu – 1,10 pu (SAs: Nordic) 1,118 pu – 1,15 pu (SAs: CE, Baltic) | G | G (value) | TSO |
| | 2 | Voltage Ranges | - | 13(1) and Annex II | TC DF and TC DS 300 kV – 400 kV | Time period for: <ul style="list-style-type: none"> 1,05 pu – 1,10 pu (SAs: CE, Nordic, GB) 1,097 pu – 1,15 pu (SAs: Baltic) | G | G (value) | TSO |
| | 3 | Voltage Ranges | X | 13(4) and Annex II | TC DF and TC DS 300 kV – 400 kV | For Spain: <ul style="list-style-type: none"> Time period for operation in the voltage range 1,05 pu-1,0875 pu for facilities connected between 300kV and 400 kV may be specified as unlimited | G | G (value) | TSO in Spain |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|---|---|---------------------|-------------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 4 | Voltage Ranges | X | 13(5) and Annex II | TC DF and TC DS above 110kV | For Baltic <ul style="list-style-type: none"> Voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for 400 kV | G | G (value) | TSO in Baltic SA |
| | 5 | Automatic disconnection due to voltage level | - | 13(6) | TC DF and TC DS | <ul style="list-style-type: none"> Voltage criteria parameters at the connection point for automatic disconnection Technical parameters at the connection point for automatic disconnection | S | S (value) | agreement between relevant: TC DFO or TC DSO and TSO |
| | 6 | Voltage Ranges | | 13(7) | TC DS below 110 kV | <ul style="list-style-type: none"> Voltage range at the connection point that the TC DS shall be designed to withstand. | G | G | relevant TSO |
| | 7 | Reactive power capability for TC DF and TC DS | | 15.1.(a) | TC DF | <ul style="list-style-type: none"> Definition of the actual reactive power range for DF without onsite generation | G | S (value) | relevant TSO |
| | 8 | Reactive power capability for TC DF and TC DS | | 15.1.(b) | TC DF and TC DS at their connection point | <ul style="list-style-type: none"> Definition of the actual reactive power range for DF with onsite generation | G | S (value) | relevant TSO |
| | 9 | Reactive power capability for TC DF and TC DS | - | 15.1.(c) | TC DS | <ul style="list-style-type: none"> Definition of the scope of the analysis to find the optimal solution for reactive power | S | S (at connection application) | agreement between relevant TSO and TC DSO |
| | 10 | Reactive power capability for TC DF and TC DS | X | 15.1.(d) | TC DF and TC DS | <ul style="list-style-type: none"> Definition of other metrics than power factor | G | S (value) | relevant TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|-----------------|--|---------------------|-----------------------------|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 11 | Reactive power capability for TC DF and TC DS | X | 15(2) | TC DS | <ul style="list-style-type: none"> Reactive power capability for transmission connected distribution systems not to export reactive power at less than 25% of the maximum import capability | S | S | relevant TSO |
| | 12 | Reactive power capability for TC DF and TC DS | X | 15(3) | TC DS | <ul style="list-style-type: none"> Method to carry out active control the exchange of reactive power at the connection point | S | S | agreement between relevant TSO and TC DSO |
| | 13 | Reactive power capability for TC DF and TC DS | X | 15(4) | TC DS | <ul style="list-style-type: none"> Consideration of TC DS for reactive power management | S | S | TC DSO may require it from relevant TSO |
| | 14 | DRS | X | 28(2)(c) | DU offering DRS | For DF or CDS connected below 110 kV: <ul style="list-style-type: none"> Definition of the normal operating range | G | G (value) | RSO |
| | 15 | DRS | X | 28(2)(l) | DU offering DRS | <ul style="list-style-type: none"> Technical specifications to enable the transfer of information for DR LFDD and Low Voltage Demand Disconnection (LVDD), for DR Active Power Control (APC) and DR Reactive Power Control | G | G (value) | RSO |
| | 16 | DRS | X | 28(2)(f) | DU offering DRS | <ul style="list-style-type: none"> Definition of the time period to adjust the power consumption | G | G (value) | RSO or relevant TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|--------------------|---|---|---------------------|-----------------------------|---------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 17 | DRS | X | 28(2)(i) | DU offering DRS | <ul style="list-style-type: none"> Definition of the modalities of notification in case of a modification of the DR capability | G | G (value) | RSO or relevant TSO |
| | 18 | DRS | X | 28(2)(k) | DU offering DRS | <ul style="list-style-type: none"> Definition of the ROCOF maximum value | G | G (value) | relevant TSO |
| | 19 | Power quality | | 20 | TC DF and TC DS at the connection point | <ul style="list-style-type: none"> Allocated level of voltage distortion | G (principle) | S (value) | relevant TSO |

Table 2.3: DCC Non-Exhaustive Requirements – System Restoration Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|---------------------------|-----|----------------------------|---------------------------|--------------------|-----------------|---|---------------------|-----------------------------|-----------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| SYSTEM RESTORATION ISSUES | 1 | Short circuit requirements | - | 14(1) | TC DF and TC DS | <ul style="list-style-type: none"> Maximum short-circuit current at the connection point to be withstood | G | G (value) | relevant TSO |
| | 2 | Short circuit requirements | - | 14(2) | TC DF and TC DS | <ul style="list-style-type: none"> An estimate of the minimum and maximum short-circuit currents to be expected at the connection point as an equivalent of the network | G | G | relevant TSO |
| | 3 | Short circuit requirements | X | 14(3) | TC DF and TC DS | <ul style="list-style-type: none"> Unplanned events: threshold of the maximum short circuit current inducing an information from the TSO in case of a change above this threshold | G | S (value) ^a | relevant TSO |
| | 4 | Short circuit requirement | - | 14(5) | TC DF and TC DS | <ul style="list-style-type: none"> Planned events: threshold of the maximum short circuit current inducing an information from the TSO in case of a change above this threshold | G | S (value) | TC DF owner or TC DSO |
| | 5 | Short circuit requirement | - | 14(8) | TC DF and TC DS | <ul style="list-style-type: none"> Unplanned events: threshold of the maximum short circuit current inducing an information from the TC DF or TC DSO in case of a change above this threshold | G | S (value) | relevant TSO |
| | 6 | Short circuit requirements | - | 14(9) | TC DF and TC DS | <ul style="list-style-type: none"> Planned events: threshold of the maximum short circuit current inducing an information from the TC DF or TC DSO in case of a change above this threshold | G | S (value) | relevant TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|-----------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 7 | Demand disconnection for system defense | - | 19(1)(a) | TC DF and TC DS | <ul style="list-style-type: none"> Definition the capabilities of Low Frequency Demand Disconnection (LFDD) scheme | G (principle) | S | relevant TSO |
| | 8 | Demand disconnection for system defense | | 19(1)(c) | TC DF and TC DS | <ul style="list-style-type: none"> Frequency range: at least between 47-50 Hz, adjustable in steps of 0,05 Hz; Operating time: no more than 150 ms after triggering the frequency setpoint; Voltage lock-out: blocking of the functional capability shall be possible when the voltage is within a range of 30 to 90 % of reference 1 pu voltage; Provide the direction of active power flow at the point of disconnection; | G | G | RSO |
| | 9 | Demand disconnection for system defense | - | 19(2)(a) | TC DS | <ul style="list-style-type: none"> Definition of the LVDD scheme | G (principle) | S (value) | relevant TSO, in coordination with the TC DSO |
| | 10 | Demand disconnection for system defense | - | 19(2)(b) | TC DF | <ul style="list-style-type: none"> Definition of the LVDD scheme | G (principle) | S (value) | relevant TSO, in coordination with the TC DF owner |
| | 11 | Demand disconnection for system defense | X | 19(2)(c) | TC DS | <ul style="list-style-type: none"> Implementation of on load tap changer blocking and low voltage demand disconnection | S | S | relevant TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|--------------------|-----------------|--|---------------------|--|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 12 | Demand disconnection for system defense | | 19(2)(d) | TC DF and TC DS | <ul style="list-style-type: none"> Equipment for both on load tap changer blocking and low voltage demand disconnection coordination | S | S | relevant TSO |
| | 13 | Demand disconnection for system defense | X | 19(3)(a) | TC DF and TC DS | <ul style="list-style-type: none"> Requirement of automatic or manual on load tap changer blocking; | S | S | TSO |
| | 14 | Demand disconnection for system defense | - | 19(3)(b) | TC DS | <ul style="list-style-type: none"> Definition of the automatic on load tap changer blocking scheme | G (principle) | S (value) | TSO |
| | 15 | Demand disconnection for system defense | - | 19(4)(a) | TC DF and TC DS | <ul style="list-style-type: none"> Definition of the conditions for reconnection after a disconnection | G | G | relevant TSO |
| | 16 | Demand disconnection for system defense | - | 19(4)(b) | TC DF and TC DS | <ul style="list-style-type: none"> Settings of the synchronisation devices (including frequency, voltage, phase angle range and deviation of voltage and frequency) | S | S (value in due time for plant design and to be reselected as appropriate) | agreement between relevant TSO and TC DSO or TC DF owner |
| | 17 | Demand disconnection for system defense | X | 19(4)(c) | TC DF and TC DS | <ul style="list-style-type: none"> Definition of the automated disconnection equipment Time for remote disconnection | G | S (value) | relevant TSO |

Table 2.4: DCC Non-Exhaustive Requirements – Instrumentation, Simulation Models and Protections Issues

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|--|-----|---|---------------------------|--------------------|-----------------|---|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| INSTRUMENTATION SIMULATION MODELS AND PROTECTION | 1 | Electrical Protection Scheme and settings | - | 16(1) | TC DF and TC DS | <ul style="list-style-type: none"> Electrical protection schemes Electrical protection settings | S | S (protection schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | agreement between relevant TSO and TC DSO or TC DF owner |
| | 2 | Control Requirements | - | 17(1) | TC DF and TC DS | <ul style="list-style-type: none"> Control devices schemes Control devices settings | S | S (control schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | agreement between TSO and TC DSO or TC DF owner |
| | 3 | Information Exchanges | - | 18(1) | TC DF | <ul style="list-style-type: none"> Standards to exchange information and time stamping | G | G (value) | Relevant TSO |
| | 4 | Information Exchanges | - | 18(2) | TC DS | <ul style="list-style-type: none"> Standards to exchange information and time stamping | G | G (value) | Relevant TSO |
| | 5 | Information Exchanges | - | 18(3) | TC DF and TC DS | <ul style="list-style-type: none"> Make information exchange standards publicly available | G | G (value) | Relevant TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-exhaustive Requirement | Non mandatory Requirement | DCC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|--------------------|-----------------|---|---------------------|-----------------------------|---------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 6 | Simulation Models | - | 21(3) | TC-DF, TC-DS | <ul style="list-style-type: none"> Content and format of the simulation models or equivalent information | G | G (value) | TSO |
| | 7 | Simulation Models | - | 21(4) | TC DF and TC DS | <ul style="list-style-type: none"> Sub-models or equivalent information included in Art. 21.3. | G | G | TSO |
| | 8 | Simulation Models | - | 21(5) | TC DF and TC DS | <ul style="list-style-type: none"> Requirements for the recordings to be compared with the response of the model | G | S (value) | RSO or relevant TSO |

Table 3: HVDC Non-Exhaustive Requirements

Table 3.1: HVDC Non-Exhaustive Requirements – Frequency Issues

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|------------------|-----|---------------------------------|---------------------------|---------------------|---------------|---|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Frequency Issues | 1 | Frequency Ranges | - | 11(1) | HVDC System | Time period for: <ul style="list-style-type: none"> 47,5 Hz-48,5 Hz (SAs: CE, Baltic) 48,5 Hz-49,0 Hz (SAs: CE, Nordic, GB, IR, Baltic) 51,0 Hz-51,5 Hz (SAs: Baltic) 51,5 Hz-52,0 Hz (SAs: CE, Nordic, GB, IR, Baltic) | G | G (value) | RSO |
| | 2 | Wider Frequency Ranges | X | 11(2) | HVDC System | <ul style="list-style-type: none"> Potential wider frequency ranges Potential longer minimum times | S | S (value) | Agreement between TSO and HVDC System Operator |
| | 3 | Automatic Disconnection | - | 11(3) | HVDC System | <ul style="list-style-type: none"> Frequencies to disconnect | G | G (value and criteria) | TSO |
| | 4 | Maximum Admissible Power Output | X | 11(4) | HVDC System | <ul style="list-style-type: none"> Maximum admissible power output reduction below 49 Hz | G | S (reviewed in due time for plant design) | TSO |
| | 5 | Active Power Controllability | X | 13(1)(a) (i) | HVDC System | <ul style="list-style-type: none"> Maximum power step Minimum power step | G | G (value) | TSO |
| | 6 | Active Power Controllability | X | 13(1)(a) (ii) | HVDC System | <ul style="list-style-type: none"> Minimum active power transmission capacity | G | G (value) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|------------------------------|---------------------------|---------------------|---------------|---|---------------------|---|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 7 | Active Power Controllability | - | 13(1)(a)(iii) | HVDC System | <ul style="list-style-type: none"> Maximum delay | G | G (value) | TSO |
| | 8 | Active Power Controllability | - | 13(1)(b) | HVDC System | <ul style="list-style-type: none"> Modification of transmitted active power | G (principle) | S (value and adjustable setting in due time for plant design) | TSO |
| | 9 | Fast Active Power Reversal | X | 13(1)(c) | HVDC System | <ul style="list-style-type: none"> Capability or not fast active power reversal | G | G | TSO |
| | 10 | Automatic Remedial Action | X | 13(3) | HVDC System | <ul style="list-style-type: none"> Triggering criterion Blocking criterion | G (principle) | S (value in due time for plant design) | TSO |
| | 11 | Synthetic Inertia | X | 14(1) | HVDC System | <ul style="list-style-type: none"> Functionality | G | S | TSO |
| | 12 | Synthetic Inertia | - | 14(2) | HVDC System | <ul style="list-style-type: none"> Principle of control Performance parameters | G | S | Agreement between TSO and HVDC System Operator |
| | 13 | Frequency Sensitive Mode | - | Annex II A(1)(a) | HVDC System | <ul style="list-style-type: none"> Frequency response deadband Droop s1 (upward regulation) Droop s2 (downward regulation) Frequency response insensitivity | G | G (range) S (value in due time for plant design and to be reselected as appropriate using the capabilities defined at CNC national implementation) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|----------------------|---------------|---|---------------------|---|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 14 | Frequency Sensitive Mode | - | Annex II A(1)(d)(ii) | HVDC System | <ul style="list-style-type: none"> Initial delay t1 Time for full activation t2 | G | G | TSO |
| | 15 | LFSSM-O | - | Annex II B(1)(c) | HVDC System | <ul style="list-style-type: none"> Initial delay Time for full activation | G | G | TSO |
| | 16 | LFSSM-O | - | Annex II B(2) | HVDC System | <ul style="list-style-type: none"> Frequency threshold Droop s3 | G | G (range) S (value in due time for plant design and to be reselected as appropriate using the capabilities defined at CNC national implementation) | TSO |
| | 17 | LFSSM-U | - | Annex II C(1)(c) | HVDC System | <ul style="list-style-type: none"> Initial delay | G | G | TSO |
| | 18 | LFSSM-U | - | Annex II C(2) | HVDC System | <ul style="list-style-type: none"> Time for full activation Frequency threshold Droop s4 | G | G (range) S (value in due time for plant design and to be reselected as appropriate using the capabilities defined at CNC national implementation) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------------|---------------------------|---------------------|-------------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 19 | Frequency Control Mode | X | 16(1) | HVDC System | <ul style="list-style-type: none"> Need for independent control mode to modulate active power output | G (principle) | S | TSO |
| | 20 | Frequency Control Mode | X | 16(2) | HVDC System | <ul style="list-style-type: none"> Specify operating principle | S (principle) | S | TSO |
| | 21 | Max. Loss of Active Power | - | 17(1) | HVDC System | <ul style="list-style-type: none"> Specify limit for loss of active power injection | G | S | TSO |
| | 22 | Max. Loss of Active Power | - | 17(2) | HVDC System | <ul style="list-style-type: none"> Coordinate specified limit of active power injection | G | S | TSO |
| | 23 | Frequency Stability Requirements | - | 39(1)(b) | DC-connect ed PPM | <ul style="list-style-type: none"> Specify coordinated frequency control capabilities | G | S | TSO |
| | 24 | Frequency Ranges | - | 39(2)(a) | DC-connect ed PPM | <ul style="list-style-type: none"> The applicable frequency ranges and time periods at nominal frequencies other than 50 Hz | G | G | TSO |
| | 25 | Wider Frequency Ranges | X | 39(2)(b) | DC-connect ed PPM | <ul style="list-style-type: none"> Agreement on wider frequency ranges for operation Agreement on wider longer minimum times for operation | G | S (value) | Agreement between TSO and HVDC System Operator |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|------------------------------|---------------------------|---------------------|-------------------|--|---------------------|---|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 26 | Automatic Disconnection | - | 39(2)(c) | DC-connect ed PPM | <ul style="list-style-type: none"> Frequencies for automatic disconnection | G | S (value) | TSO |
| | 27 | LFSM-O | - | 39(4) | DC-connect ed PPM | <ul style="list-style-type: none"> Frequency threshold Droop settings | G | G (range) S (value in due time for plant design and to be reselected as appropriate using the capabilities defined at CNC national implementation) | TSO |
| | 28 | LFSM-O | - | 39(4) | DC-connect ed PPM | <ul style="list-style-type: none"> Definition of P_{ref} | G | G | TSO |
| | 29 | LFSM-O | X- | 39(4) | DC-connect ed PPM | <ul style="list-style-type: none"> Expected behaviour of the PGM once the minimum regulating level is reached | G | G | TSO |
| | 30 | Constant Power | - | 39(5) | DC-connect ed PPM | <ul style="list-style-type: none"> Specify capability of maintaining constant output at PPM target active power value regardless of changes in frequency | G | G (see RfG requirement in table 1) | TSO |
| | 31 | Active Power Controllability | - | 39(6) | DC-connect ed PPM | <ul style="list-style-type: none"> Specify tolerance (subject to the availability of the prime mover resource) applying to the new setpoint Specify the time within which the new setpoint must be reached | G | G (see RfG requirement in table 1) | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|-------------------|--|---------------------|---------------------------------------|-----------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 32 | LFSM-U | - | 39(7) | DC-connect ed PPM | <ul style="list-style-type: none"> Frequency threshold Droop | G | S (see RfG requirement in table 1) | TSO |
| | 33 | LFSM-U | - | 39(7) | DC-connect ed PPM | <ul style="list-style-type: none"> Definition of P_{ref} | G | G | TSO |
| | 34 | FSM with Subject to a Fast Signal Response | -/X | 39(8) | DC-connect ed PPM | <ul style="list-style-type: none"> Active power range related to maximum capacity Frequency response insensitivity Frequency response dead band Droop Maximum admissible full activation time Maximum admissible initial delay for PGMs without inertia Time period for the provision of full active power frequency response | See in Table1.1 | See in Table1.1 | See in Table1.1 |
| | 35 | Frequency Restoration | - | 39(9) | DC-connect ed PPM | <ul style="list-style-type: none"> Specifications of the frequency restoration control | G | G | TSO |
| | 36 | 39.3-39.9 For Frequencies Other than 50 Hz | - | 39(10) | DC-connect ed PPM | <ul style="list-style-type: none"> Frequency threshold (Frequency Other than 50 Hz) Frequency threshold (Frequency Other than 50 Hz) Definition of P_{ref} (Frequency Other than 50 Hz) | G/S | G/S | TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|---------------------|-----------------------------------|---|---------------------|-----------------------------|----------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 37 | Frequency Restoration | - | 47(1) | Remote-end HVDC Converter Station | <ul style="list-style-type: none"> Nominal frequencies other than 50 Hz will be provided accounting for Annex I requirements | G | S | TSO |
| | 38 | Frequency Restoration | X | 47(2) | Remote-end HVDC Converter Station | <ul style="list-style-type: none"> Provision of network frequency signal at the remote-end HVDC converter | S | S | TSO |

Table 3.2: HVDC Non-Exhaustive Requirements – Voltage Issues

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|----------------|-----|--|---------------------------|---------------------|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Voltage Issues | 1 | Voltage Ranges $110 \text{ kV} \leq U < 300 \text{ kV}$ | - | Annex III Table 4 | HVDC System | Time period for: <ul style="list-style-type: none"> 1,118 pu - 1,15 pu (SAs: CE) | G | G | TSO |
| | 2 | Voltage Ranges $300 \text{ kV} < U \leq 400 \text{ kV}$ | - | Annex III Table 5 | HVDC System | Time period for: <ul style="list-style-type: none"> 1,05 pu - 1,0875 pu (SAs: CE) 1,05 pu - 1,10 pu (SAs: Nordic) | G | G | TSO |
| | 3 | Agreement on Wider Voltage Ranges or Longer Min. Times | X | 18(2) | HVDC System | <ul style="list-style-type: none"> Wider voltage ranges for operation Longer minimum time periods for operation | S | S | Agreement between TSO and HVDC System Operator |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|------------------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 4 | Automatic Disconnection | - | 18(3) | HVDC System | <ul style="list-style-type: none"> Voltage criteria at the connection point for automatic disconnection Technical parameters at the connection point for automatic disconnection | G | S (value) | Agreement between TSO and HVDC System Operator |
| | 5 | Voltage Ranges | - | 18(4) | HVDC System | <ul style="list-style-type: none"> Specify 1 pu applicable requirements at connection points | G | S | RSO with TSOs |
| | 6 | Voltage Ranges | X | 18(5) | HVDC System | <ul style="list-style-type: none"> Decision on use continental Europe voltage ranges | G | G | Baltic TSOs |
| | 7 | Short Circuit Contribution during Faults | X | 19(2)(a) | HVDC System | <ul style="list-style-type: none"> Specifications on voltage deviation | G | S (value) | TSO |
| | 8 | Short Circuit Contribution during Faults | X | 19(2)(b) | HVDC System | <ul style="list-style-type: none"> Characteristics of fast fault current | G | S | TSO |
| | 9 | Short Circuit Contribution during Faults | X | 19(2)(c) | HVDC System | <ul style="list-style-type: none"> Timing and accuracy of fast fault current | G | S (value) | TSO |
| | 10 | Short Circuit Contribution during Faults | X | 19(3) | HVDC System | <ul style="list-style-type: none"> Specify asymmetrical current injection for 1-phase faults Specify asymmetrical current injection for 2-phase faults | G | S (value) | RSO with TSO |
| | 11 | Reactive Power Capability | - | 20(1) | HVDC Converter station | <ul style="list-style-type: none"> U-Q/P_{max} profile at maximum capacity | G | G (range) | RSO with TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|---------------------|------------------------|---|---------------------|-----------------------------|--------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 12 | Reactive Power Capability | - | 20(3) | HVDC Converter station | <ul style="list-style-type: none"> Provide timescale to move within U-Q/P_{max} profile | G | G (value) | RSO with TSO |
| | 13 | Reactive Power Exchanged with the Network | - | 21(2) | HVDC Converter station | <ul style="list-style-type: none"> Specify maximum tolerable voltage step value | G | S | TSO |
| | 14 | Reactive Power Control Mode | - | 22(1) | HVDC Converter station | <ul style="list-style-type: none"> Define which of the control modes are required | G | S | TSO |
| | 15 | Reactive Power Control Mode | - | 22(2) | HVDC Converter station | <ul style="list-style-type: none"> Define of any other control modes are required and if so what are they | G | S | TSO |
| | 16 | Reactive Power Control Mode | - | 22(3)(b) | HVDC Converter station | <ul style="list-style-type: none"> For voltage control mode definition of adjustment steps required for dead band | G | S (value) | RSO with TSO |
| | 17 | Reactive Power Control Mode | - | 22(3)(c) | HVDC Converter station | <ul style="list-style-type: none"> In voltage control mode time within which 90% of the change in reactive power is reached within 0,1 seconds -10,0 seconds In voltage control mode t_2 = time within which 100% of the change in reactive power is reached within 1 seconds - 60 seconds | G | S (value) | RSO with TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|---------------------|------------------------|---|---------------------|--|--------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 18 | Reactive Power Control Mode | - | 22(3)(d) | HVDC Converter station | <ul style="list-style-type: none"> Voltage control slope specified by range and step | G | G (range and value) | RSO with TSO |
| | 19 | Reactive Power Control Mode | - | 22(4) | HVDC System | <ul style="list-style-type: none"> Reactive power range in Mvar or % | G | G (value) | RSO |
| | 20 | Reactive Power Control Mode | - | 22(5) | HVDC System | <ul style="list-style-type: none"> Maximum allowable step size of set point | G | G (value) | RSO |
| | 21 | Reactive Power Control Mode | - | 22(6) | HVDC System | <ul style="list-style-type: none"> Equipment specification to enable remote control of control modes and set points | G | S | RSO with TSO |
| | 22 | Priority to Active or Reactive Power Contribution | - | 23 | HVDC System | <ul style="list-style-type: none"> TSO decide active or reactive power has priority during low and high voltage operation and during faults | G | S (value in due time for plant design and to be reselected as appropriate using the capabilities defined at CNC national implementation) | TSO |
| | 23 | Fault Ride Through | - | 25(1) | HVDC System | Specify: <ul style="list-style-type: none"> 3-phase fault: U_{ret} 3-phase fault: U_{rec1} 3-phase fault: U_{rec2} 3-phase fault: t_{clear} 3-phase fault: t_{rec1} 3-phase fault: t_{rec2} | G | S | TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|----------------------------|---------------------------|---------------------|---------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 24 | Fault Ride Through | X | 25(2)(a) | HVDC System | <ul style="list-style-type: none"> Pre-fault minimum short circuit capacity (MVA) at connection point | G | S | RSO |
| | 25 | Fault Ride Through | X | 25(2)(b) | HVDC System | <ul style="list-style-type: none"> Pre-fault voltage at connection point | G | S | RSO |
| | 26 | Fault Ride Through | X | 25(2)(c) | HVDC System | <ul style="list-style-type: none"> Post-fault minimum short circuit capacity (MVA) at connection point | G | S | RSO |
| | 27 | Fault Ride Through | X | 25(4) | HVDC System | <ul style="list-style-type: none"> Voltages where HVDC system can block, U_{block} | G | S | Agreement between TSO and HVDC System Operator |
| | 28 | Fault Ride Through | - | 25(5) | HVDC System | <ul style="list-style-type: none"> Acceptance of narrower settings on under voltage protection Narrower settings on under voltage protection | G | S (value) | Agreement between TSO and HVDC System Operator |
| | 29 | Fault Ride Through | - | 25(6) | HVDC System | Specify: <ul style="list-style-type: none"> 1-phase fault: U_{ret} 1-phase fault: U_{rec1} 1-phase fault: U_{rec2} 1-phase fault: t_{clear} 1-phase fault: t_{rec1} 1-phase fault: t_{rec2} 2-phase fault: U_{ret} 2-phase fault: U_{rec1} 2-phase fault: U_{rec2} 2-phase fault: t_{clear} 2-phase fault: t_{rec1} 2-phase fault: t_{rec2} | G | S | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|------------------------------------|---|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 30 | Power Quality | - | 24 | HVDC System | <ul style="list-style-type: none"> Specify voltage fluctuation limits Specify voltage distortion limits | G (principle) | S (value) | TSO |
| | 31 | Power Quality | - | 44 | DC-connected Power Park Modules | <ul style="list-style-type: none"> Specify voltage fluctuation limits Specify voltage distortion limits | G (principle) | S (value) | RSO in coordination with TSO |
| | 32 | Power Quality | - | 50 | Remote-end HVDC converter stations | <ul style="list-style-type: none"> Specify voltage fluctuation limits Specify voltage distortion limits | G (principle) | S (value) | RSO in coordination with TSO |
| | 33 | Post Fault Active Power Recovery | - | 26 | HVDC System | <ul style="list-style-type: none"> Active power recovery magnitude profile Active power recovery time profile | G | G | TSO |
| | 34 | Voltage Ranges 110 kV ≤ U < 300 kV | - | Annex VII Table 9 | DC-connected Power Park Modules | Time period for: <ul style="list-style-type: none"> 1,10 pu - 1,118 pu (SAs: CE, Nordic, GB, IR, Baltic) 1,118 pu - 1,15 pu (SAs: CE, Nordic, GB, IR, Baltic) | G | G | RSO in coordination with TSO |
| | 35 | Voltage Ranges 300 kV < U ≤ 400 kV | - | Annex VII Table 10 | DC-connected Power Park Modules | Time period for: <ul style="list-style-type: none"> 1,05 pu - 1,15 pu (SAs: CE, Nordic, GB, IR, Baltic) | G | G | RSO in coordination with TSO |
| | 36 | Agreement on Wider Voltage Ranges or Longer Min. Times | X | 40(1)(b) | DC-connected Power Park Modules | <ul style="list-style-type: none"> Wider voltage ranges for operation Longer minimum time periods for operation | S | S (value) | Agreement between TSO and HVDC System Operator |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|----------------------------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 37 | Automatic Disconnection | X | 40(1)(c) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Voltage criteria at the connection point for automatic disconnection Technical parameters at the connection point for automatic disconnection | S | S (value) | Agreement between TSO and HVDC System Operator |
| | 38 | Voltage Ranges for Other AC Voltages | - | 40(1)(d) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> The voltage ranges that are not included in the scope of Annex VII for DC connected PPM Time periods for operation in the voltage range for DC connected PPM | G | G (value) | TSO |
| | 39 | Agreement How to Meet Reactive Power Requirements | - | 40(1)(e) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Voltage ranges (frequencies other than nominal 50 Hz) Time periods (frequencies other than nominal 50 Hz) The range of Q/P_{max} (frequencies other than nominal 50 Hz) The range of steady-state voltage (frequencies other than nominal 50 Hz) | S | G | RSO in coordination with TSO |
| | 40 | Reactive Power Capability | - | 40(2)(b) (i) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Reactive power range within profile in Table 11 of Annex VII and if applicable Reactive power range from Article 25(4) of the RfG | See Table 1.2 | See Table 1.2 | See Table 1.2 |
| | 41 | Reactive Power Consumption of High Voltage Line or Cable | X | 40(2)(b) (ii) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Supplementary reactive power requirements at connection point | G | G (range) | RSO in coordination with TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|---------------------|------------------------------------|---|---------------------|---|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 42 | Priority to Active or Reactive Power Contribution | - | 40(3) | DC-connected Power Park Modules | <ul style="list-style-type: none"> RSO decide active or reactive power has priority | G | S (adjustable setting in due time for plant design) | RSO in coordination with TSO |
| | 43 | Voltage Ranges $110 \text{ kV} \leq U < 300 \text{ kV}$ | - | Annex VII Table 12 | Remote-end HVDC converter stations | Time period for: <ul style="list-style-type: none"> 1,10 pu - 1,118 pu (SAs: CE, Nordic, GB, IR, Baltic) 1,118 pu - 1,15 pu (SAs: CE, Nordic, GB, IR, Baltic) | G | G (value) | TSO |
| | 44 | Voltage Ranges $300 \text{ kV} < U \leq 400 \text{ kV}$ | - | Annex VII Table 13 | Remote-end HVDC converter stations | Time period for: <ul style="list-style-type: none"> 1,05 pu - 1,15 pu (SAs: CE, Nordic, GB, IR, Baltic) | G | G (value) | TSO |
| | 45 | Agreement on Wider Voltage Ranges or Longer Min. Times | X | 48(1)(b) | Remote-end HVDC converter stations | <ul style="list-style-type: none"> Wider voltage ranges for operation Longer minimum time periods for operation | S | S | Agreement between RSO, TSO and remote end converter owner |
| | 46 | Voltage Ranges for Other AC Voltages | - | 48(1)(c) | Remote-end HVDC converter stations | <ul style="list-style-type: none"> The voltage ranges that are not included in the scope of Annex VII for remote-end HVDC converter station Time periods for operation in the voltage range for remote-end HVDC converter station | G | G (value) | RSO in coordination with TSO |
| | 47 | Reactive Power Provision | - | 48(2)(a) | Remote-end HVDC converter stations | <ul style="list-style-type: none"> Specify the reactive power provision capability requirements for various voltage levels | G | G (range) | RSO in coordination with TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|------------------------------|---------------------------|---------------------|------------------------------------|---|---------------------|-----------------------------|------------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 48 | U-Q/P _{max} Profile | - | 48(2)(a) | Remote-end HVDC converter stations | <ul style="list-style-type: none"> Specify the maximum range of Q/P_{max} Specify the maximum range of steady-state voltage level in pu | G | G (range) | RSO in coordination with TSO |

Table 3.3: HVDC Non-Exhaustive Requirements – System Restoration

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|--------------------|-----|---|---------------------------|---------------------|------------------------|--|---------------------|-----------------------------|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| System Restoration | 1 | Energisation and Synchronisation of HVDC Converter Stations | X | 28 | HVDC Converter Station | <ul style="list-style-type: none"> ▪ Limits of any voltage change to a steady-state level (<5% pre-synchronisation voltage) ▪ Maximum magnitude of the voltage transients ▪ Duration of the voltage transients | G | S | RSO with TSO |
| | 2 | Power Oscillation Damping Capability | - | 30 | HVDC System | <ul style="list-style-type: none"> ▪ Frequency range of oscillations ▪ The network conditions when oscillations occur ▪ Agree control parameter settings | G | S | TSO, Agreement between TSO and HVDC System Operator |
| | 3 | Power Oscillation Damping Capability | - | 31(2) | HVDC System | <ul style="list-style-type: none"> ▪ Specifications of extent of SSTI ▪ Input parameters | G | S | TSO |
| | 4 | Power Oscillation Damping Capability | - | 31(3) | HVDC System | <ul style="list-style-type: none"> ▪ Identify all parties relevant at a connection point | G | S | TSO |
| | 5 | Black Starts | X | 37(1) | HVDC System | <ul style="list-style-type: none"> ▪ Obtain quote for black start | S | S | TSO |

Parameters of Non-exhaustive requirements

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|---------------------------------|--|---------------------|-----------------------------|--|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 6 | Black Starts | - | 37(2) | HVDC System | <ul style="list-style-type: none"> Specify timeframe after shut down of the HVDC system Wider frequency ranges than Article 11 as required Wider voltage ranges than Article 18 as required | G | S | TSO |
| | 7 | Black Starts | - | 37(3) | HVDC System | <ul style="list-style-type: none"> Capacity of black start Availability of black start | S | S | Agreement with TSO and HVDC System Owner |
| | 8 | Stable Operation with Min & Max SC Power | - | 42(b) | DC connected Power Park Modules | <ul style="list-style-type: none"> The minimum of short circuit power The maximum of short circuit power Network characteristics of the HVDC interface point | G | G (range) | RSO in coordination with TSO |

Table 3.4: HVDC Non-Exhaustive Requirements – Simulation Issues

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------------------|-----|---|---------------------------|---------------------|------------------------|---|---------------------|-----------------------------|-------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| Simulation Issues | 1 | Interaction Between HVDC and Other Plants/Equipment | X | 29(1) | HVDC Converter Station | <ul style="list-style-type: none"> Requesting studies on HVDC systems interaction | S | S | TSO |
| | 2 | Interaction Between HVDC and Other Plants/Equipment | - | 29(2) | HVDC Converter Station | <ul style="list-style-type: none"> Specify study required to examine interaction with adjacent equipment | S | S | TSO |
| | 3 | Interaction Between HVDC and Other Plants/Equipment | - | 29(3) | HVDC Converter Station | <ul style="list-style-type: none"> Specify all other relevant parties to the study | S | S | TSO |
| | 4 | Interaction Between HVDC and Other Plants/Equipment | X | 29(5) | TSO | <ul style="list-style-type: none"> Models/information for use in studies | G | S | Interacting 3rd Parties |
| | 5 | Interaction Between HVDC and Other Plants/Equipment | X | 29(7) | HVDC System | <ul style="list-style-type: none"> Specify transient levels of performance | S | S | TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|---------------|--|---------------------|--|--------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 6 | Network Characteristics | - | 32(1) | HVDC System | <ul style="list-style-type: none"> Method for calculation Pre-fault conditions for minimum short circuit power Pre-fault conditions for maximum short circuit power Post fault conditions for minimum short circuit power Post fault conditions for maximum short circuit power | G (criteria) | G | TSO |
| | 7 | HVDC System Robustness | - | 33(1) | HVDC System | <ul style="list-style-type: none"> Specify changes in system conditions for HVDC system to remain stable | G | S (at time of change) | TSO |
| | 8 | Electrical Protection Schemes and Settings | - | 34(1) | HVDC System | <ul style="list-style-type: none"> The protection schemes for internal electrical faults The protection settings for internal electrical faults | S | S (control schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | TSO with RSO |
| | 9 | Electrical Protection Schemes and Settings | - | 34(3) | HVDC System | <ul style="list-style-type: none"> Acceptance of changes by owner to protection | S | S | TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|--|---------------------------|---------------------|---------------|--|---------------------|---|---|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 10 | Electrical Protection Schemes and Settings | - | 35(1) | HVDC System | <ul style="list-style-type: none"> Control modes for a control scheme Parameters for a control scheme | S | S (control schemes in due time for plant design and setting values before plant commissioning and to be reselected as appropriate) | Agreement with RSO, TSO and HVDC System Owner |
| | 11 | Electrical Protection Schemes and Settings | X | 35(2) | HVDC System | <ul style="list-style-type: none"> Specify priority order of protection and control devices | S | S | TSO |
| | 12 | Changes to Protection and Control Schemes and Settings | X | 36(1) | HVDC System | <ul style="list-style-type: none"> Changes to control modes Changes to protections settings | S | S (at time of change) | TSO |
| | 13 | Changes to Protection and Control Schemes and Settings | - | 36(2) | HVDC System | <ul style="list-style-type: none"> Coordination of changes and agreement | S | S (at time of change) | Agreement with RSO, TSO and HVDC System Owner |
| | 14 | Changes to Protection and Control Schemes and Settings | X | 36(3) | HVDC System | <ul style="list-style-type: none"> Equipment specification to enable remote control of control modes and associated setpoints | S | S (at time of change) | TSO |

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|-------|-----|---|---------------------------|---------------------|----------------------------------|--|---------------------|-----------------------------|------------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| | 15 | Synchronization | - | 41(1) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Limits of any voltage change to a steady-state level (<5% pre-synchronisation voltage) Maximum magnitude of the voltage transients Duration of the voltage transients | G | S (value) | RSO in coordination with TSO |
| | 16 | Output Signals | - | 41(2) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Specify required output signals | G | G (value) | RSO in coordination with TSO |
| | 17 | Method of Pre-Fault and Post-Fault Conditions | - | 42(a) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Method for calculation Pre-fault conditions for minimum short circuit power Pre-fault conditions for maximum short circuit power Post fault conditions for minimum short circuit power Post fault conditions for maximum short circuit power | S (criteria) | S | RSO in coordination with TSO |
| | 18 | Equivalents Representing the Collection Grid | - | 42(c) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Provide network equivalent for harmonic studies | S | S | RSO in coordination with TSO |
| | 19 | Electrical Protection Schemes | - | 43(1) | DC-connect ed Power Park Modules | <ul style="list-style-type: none"> Electrical protection schemes Electrical protection settings | S | S | RSO in coordination with TSO |

Table 3.5: HVDC Non-Exhaustive Requirements – General Issues

| Issue | FCN | Non-Exhaustive Requirement | Non-Mandatory Requirement | HVDC NC Article No. | Applicability | Parameters/ Ranges/Values | Timing of Proposal | | Proposer |
|----------------|-----|----------------------------|---------------------------|---------------------|------------------------------------|---|--------------------------------------|--------------------------------------|--------------------------------------|
| | | | | | | | Requirement as such | Values/Range of Requirement | |
| General Issues | 1 | Scope | - | 38 | DC-connected Power Park Modules | <ul style="list-style-type: none"> Non-exhaustive requirements of Articles 13 to 22 of the Network Code RfG will apply | See in Tables 1.1, 1.2, 1.3, and 1.4 | See in Tables 1.1, 1.2, 1.3, and 1.4 | See in Tables 1.1, 1.2, 1.3, and 1.4 |
| | 2 | Scope | - | 46 | Remote-end HVDC converter stations | <ul style="list-style-type: none"> Non-exhaustive requirements of Articles 11 to 39 will apply | See requirements for HVDC system | See requirements for HVDC system | See requirements for HVDC system |