SONI submission of the general application of technical requirements in accordance with Articles 11 – 50 of the Commission Regulation (EU) 2016/1447 establishing a network code on high voltage direct current systems and direct current-connected power park modules

21 December 2018

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1. Introduction

On the 15 September 2016, the Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current (hereafter referred to as 'HVDC') entered in force.

The scope of this document is to seek approval from the National Regulatory Authority on SONI's submission for the general application of technical requirements in accordance with Articles 11- 50 of the Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current.

This submission document is produced by SONI Ltd in its role as the Transmission System Operator in Northern Ireland (hereafter referred to as 'TSO'). References in this document to the Relevant System Operator (hereafter referred to as 'RSO') mean the operator of the system to which the HVDC system is connected to, i.e. either TSO or DSO.

The requirements of the HVDC apply from three years after its publication as per Article 86. The requirements of the HVDC do not apply to:

- HVDC systems whose connection point is below 110 kV unless a cross-border impact is demonstrated by the relevant TSO.
- HVDC systems or DC-connected power park modules connected to the transmission system and distribution systems or to parts of the transmission system, or distribution systems, of islands of Member States of which the systems are not operated synchronously with either the Continental Europe, Great Britain, Nordic, Ireland and Northern Ireland or Baltic synchronous area.

In addition, Article 55 to 59, 69 to 74 and 84 shall not apply to HVDC systems within HVDC systems within one control area referred in points (c) and (d) of paragraph 1 of Article 3 where:

- The HVDC system has at least one HVDC converter station owned by the relevant TSO.
- The HVDC system is owned by an entity which exercises control over the relevant TSO.
- The HVDC system is owned by an entity directly or indirectly controlled by an entity which also exercises control over the relevant TSO.

With the exception of Articles 26, 31, 33 and 50, existing HVDC system and existing DC-connected power park modules are not subject to the requirements of this Regulation, unless:

(a) the HVDC system or DC-connected power park module has been modified to such an extent that its connection agreement must be substantially revised in accordance with the following procedure:
    i. the HVDC system or DC-connected power park module owners who intend to undertake the modernisation of a plant or replacement of equipment impacting the technical capabilities of the HVDC system or

DC-connected power park module shall notify their plans to the RSO in advance;

ii. if the RSO considers that the extent of the modernisation or replacement of equipment is such that a new connection agreement is required, the system operator shall notify the relevant regulatory authority or, where applicable, the Member State, and

iii. the relevant regulatory or, where applicable, the Member State decide if the existing connection agreement needs to be revised or a new connection agreement is required and which requirements of this Regulation shall apply; or

(b) a regulatory authority or, where applicable, a Member State decides to make an existing HVDC system or existing DC-connected power park module subject to all or some of the requirements of this Regulation, following a proposal from the relevant TSO.

For the purpose of this Regulation, an HVDC system or DC-connected power park module shall be considered to be existing if:

(a) it is already connected to the network on the date of entry into force of this Regulation; or

(b) the HVDC system owner or DC-connected power park module owner has concluded a final and binding contract for the purchase of the main generating plant or HVDC equipment by two years after the entry into force of the Regulation. The HVDC system owner or DC-connected power park owner must notify the relevant system operator and relevant TSO of conclusion of the contract within 30 months after the entry into force of the Regulation.
The notification submitted by the HVDC system owner or DC-connected power park module owner to the relevant system operator and to the relevant TSO shall at least indicate the contract title, its date of signature and date of entry into force and specifications of the main generating plant or HVDC equipment to be constructed, assembled or purchased.
A Member State may provide that in specified circumstances the regulatory authority may determine whether the HVDC system or DC-connected power park module is to be considered an existing or new HVDC system or DC-connected power park module.

Under Article 5 (4), the RSO or TSO is required to submit a proposal for requirements of general application for approval by the Utility Regulator within two years of entry into force of this regulation, i.e. 15 September 2018. The National Regulator then has six months to approve the proposal. While it was not a requirement to consult upon the proposal for all of the requirements of general application prior to submission to the Utility Regulator . However, the TSO issued a Consultation Document on the 9 November 2018 in the interest of transparency and to ensure that the TSO has the best information available to them to submit an appropriate set of recommendations to the Utility Regulator for the proposal of requirements of general application. The consultation was open for a period of four weeks and closed on the 7 December 2018. There were one submissions received during the consultation period.

Hence, the TSO is submitting its proposal for the general application of the non-mandatory requirements and non-exhaustive parameters in accordance with those set out in Title II Articles 11 - 50 of the HVDC for the UR approval

EirGrid Plc in its role as the Transmission System Operator in Ireland is submitting an equivalent proposal document to the Commission for Regulation of Utilities (CRU).

1.1. Associated documents

The TSO strongly recommends that all readers review the following documents:

- HVDC Network Code
- RfG Proposal Document.

All references to Article in this document refer to Articles set out in the HVDC unless otherwise specified.

1.2. Definitions and Interpretations

For the purposes of this submission document, terms used in this document shall have the meaning of the definitions included in Article 2 of HVDC.

In this submission document, unless the context requires otherwise:

a) the singular indicates the plural and vice versa;
b) the table of contents and headings are inserted for convenience only and do not affect the interpretation of this submission; and
c) any reference to legislation, regulations, directive, order, instrument, code or any other enactment shall include any modification, extension or re-enactment of it then in force.
d) Site specific:

   Where the term “Site specific” is used in the parameter proposal tables in section 4, it is intended to specify these parameters, taking consideration the following:

   - The appropriate system security studies
   - Consultation with the necessary users
   - Other locational factors deemed relevant by the TSO

1.3. Structure of this document

Sections 2 & 3 ‘Scope’ and ‘Background’ provide important information that guide the reader through the HVDC concepts and the principles underpinning this submission document.

Section 5 sets out the proposals that are being discussed in this submission document. It details the proposal, justification and applicability of parameter or requirement as appropriate.

In this document, the TSO has grouped parameters by technical theme, with a number of sub-themes discussed under each theme. Within each theme, the TSO goes into detail on which parameter or requirement applies to each DC- connection type. The themes are:

1. Frequency
2. Voltage
3. System Restoration
4. Instrumentation, simulation models and protection
5. General Issues

2. Scope

The scope of this submission is to seek the Utilities Regulator's approval of the TSO proposals for:

- making non-mandatory requirements mandatory;
- parameter selection for the non-exhaustive parameters; and
- non-exhaustive parameters for DC-connections which are providing certain system services, for example frequency response.

Note this submission does not seek on the Utilities Regulator's approval of the mandatory requirements or exhaustive parameters. These have been set by the Commission and cannot be changed.

Further information in the form of Implementation guidelines document is available online at:

- HVDC Implementation Guidelines

In some cases, exhaustive requirements are described in this document to provide context for relevant discussion points and this will be clearly indicated.

3. Background

The HVDC applies across the European Union. The HVDC recognises that the requirements of power systems in different synchronous areas can be different due to the differing sizes. For this reason, the HVDC provides that some of the requirements for general application are to be specified at National level, i.e. by the TSO, or RSO of the member state, rather than at EU level.

To give effect to this concept the HVDC contains requirements that are commonly described as either mandatory or non-mandatory and also requirements that are commonly described as exhaustive or non-exhaustive:

- A mandatory requirement must be applied by the TSO/ RSO as appropriate
- A non-mandatory requirement is one which the TSO/ RSO as appropriate may choose to apply
- An exhaustive parameter has a specified value or range in the HVDC which the TSO/ RSO as appropriate must apply
- A non-exhaustive parameter is one for which either:
    - The HVDC provides a range from which the TSO/ RSO as appropriate must select the applicable value for their region; or
    - The HVDC does not specify a value and the TSO/ RSO as appropriate must select the applicable value for their region.

As mandatory and exhaustive parameters are not at the discretion of the TSO/ RSO as appropriate to modify, they do not form part of this proposal document.

3.1 Principles underpinning the Proposals

Many of the requirements for general application exist in Northern Ireland today in the Grid Code.

Non-Mandatory Requirement Selection

In the majority of cases the following assumptions are made:

- where the requirement provided in the HVDC is an existing requirement in Northern Ireland, the requirement is made mandatory nationally under the HVDC;
- where the requirement provided in the HVDC is not an existing requirement in Northern Ireland, the requirement is not made mandatory nationally under the HVDC.

Non-Exhaustive Parameter Selection

There are two examples of non-exhaustive parameter selection under HVDC;

1. HVDC requests that the TSO/DSO/RSO selects the value from within a range or
2. HVDC does not specify a range and requests that the TSO/DSO/RSO specify a value.

In the majority of cases, the following assumptions are made:

- where the range for a non-exhaustive parameter provided in the HVDC includes the existing value applied in Northern Ireland, the existing value is proposed;
- where the range for a non-exhaustive parameter provided in the HVDC does not include the existing value applied in Northern Ireland then the value proposed represents the minimum amount of change possible;
- where the HVDC does not provide a value for a non-exhaustive parameter but requests that the RSO defines the value and it is an existing parameter in Northern Ireland, the existing value is proposed; and
- where the HVDC does not provide a value for a non-exhaustive parameter but requests that the RSO defines the value and it is not an existing parameter in Northern Ireland, a justification is given.

4. Consultation Update

SONI held a consultation our proposal for the general application of technical requirements in accordance with the Articles 11- 50 of the Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current. This consultation opened on 9 November 2018 for a period of four weeks until 7 December 2018.

4.1. Summary of submissions

The TSO received one individual submission on the consultation, which has been included in appendix of this submission document. This response is confidential as such will not be put into the public domain.

The respondent, Moyle Interconnector Limited ('Moyle') stated in their response that they agreed with the principles set out in the consultation document and offered no objection to the parameters proposed by SONI in the consultation document.

The full text of this submission is available in the Appendix of this document.

5. Derogation Requests

There are two instances where derogations from the HVDC Network Code are being sought:

1. Frequency Sensitive Mode, Active Power Range
2. Frequency Sensitive Mode, PPM Frequency Response Capability

Frequency Sensitive Mode, Active Power Range

Section 4.1.3.3, Article 39.8: FSM Parameter Selection

This article requires an active power range (ΔP/Pmax) to be defined by the TSO within the ranges of 1.5% to 10%. The TSO did not believe that an active power range value should be specified for continuous FSM operation as governor droop defines that amount of active power that is provided by the DC-connected PPM or HVDC system. The TSO consulted with the ENSTO-E Frequency Group in relation to FSM. This group confirmed that this parameter was included as an error and as such, it was not specified as part of this consultation.

ENSTO-E will be recommending that the requirement to specify this parameter will be removed in the next iteration of the Network Codes.

Proposed solution:

The TSO will prepare a class derogation request to the Utility Regulator to capture this error.

To this end, the TSO have not proposed a value for this parameter and feel that the derogation request will cover any implementation issues in this regard.

Section 4.1.3.3, Article 39.8: FSM with subject to fast action signal

The TSO has concerns in relation to a potential loss of frequency response from PPM units due to limitations set out in the Network Codes. The current requirements in the Grid Code required a 60% increase in Active Power within 5 seconds and 100% of expected increase (droop response) within 15 seconds of a frequency event. This requirement is core to the achievement of 40% RES-E target and the ability to operate the system at System Non Synchronous Penetration (SNSP) levels up to 75%. The HVDC range in Article 39.8 only allow us to specify a value for the change in power output relative to the Active Power output at the moment the frequency threshold was

reached (or the maximum capacity as defined by the TSO) between 1.5 – 10%, i.e. it does not allow us to specify the levels that currently exist in the Grid Code. However, to lose the capability provided for in today's Grid Code would be very damaging to the success of the DS3 program and ultimately to the integration of high levels of renewable energy into the power system. The TSO does not believe that the regulations intentionally undermine this capability.

Following discussions with ENTSO-E they have informed the TSO it is understood that the requirements of the Network Codes were not intended to reduce the capability of the fleet of generation connected to a power system. The understanding is that once a National Code was submitted to the National Regulatory Authority by 2012 that requirements of that code can be considered when implementing the RfG nationally.

Proposed Solution:

Therefore, the TSO is submitting a derogation request to the Utility Regulator in order to maintain the existing Grid Code requirements for Frequency Response of PPMs, including DC-connected PPMs.

6. Proposals

This section covers the submission proposals for the non-exhaustive parameter selection and non-mandatory requirement selection.

The document is laid out by theme, and in some cases further broken down into subthemes for clarity. The five main themes are:

5.1 Frequency
5.2 Voltage
5.3 System Restoration
5.4 Instrumentation, stimulation models and protection
5.5 General Issues

Each section includes the article number and the topic being discussed. A brief description of the requirement is provided alongside a table of the items being submitted. The tables contain:

- a description of the parameter or requirement;
- the HVDC allowable range or an indication that a parameter needs to be specified by the RSO;
- the submission proposal for the parameter or requirement;
- the HVDC Article reference;
- a list of the connection types that this applies to; and
- A justification code (see further below)

Justification Codes

The justification codes identify which of four assigned categories the proposed parameters falls into. For category 1, further rationale is only provided where it is felt it is required to aid understanding. If a proposal falls into category 2 or 3, an explanation is provided.

1. "In line with existing"
   The proposed parameter is in line with the existing Grid or Distribution Code requirements.
2. "As close as possible to the existing"
   The existing Grid or Distribution Code requirements do not fit within the allowable HVDC range. In this case the proposed parameter is as close to the existing Grid or Distribution Code requirements as is allowable under HVDC.
3. "New or Different"
   The requirement either does not exist in our Grid and Distribution Codes today and a rationale for the selection is provided. In some cases we have the requirement today but we are proposing a different value and a rationale is provided for this choice.
4. "N/A"

Please note that in some tables we have also shown mandatory and/or exhaustive parameters to provide context to the non-exhaustive or non-mandatory parameter.

These items are in greyed out cells and are not subject to submission, as the TSO does not have the right to change them.

6.1 Frequency Theme

The non-exhaustive and non-mandatory frequency parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Frequency Ranges
- Frequency Modes
- Active Power Control
- Synthetic Inertia

6.1.1 Frequency Modes Explanation

This section explains the difference between the frequency sensitive mode and limited frequency sensitive modes prior to defining the parameters.

Frequency Sensitive Mode:

The vast majority of synchronous generation units, which are currently in operation on the Transmission System today, operate in what is known in the Network Codes as Frequency Sensitive Mode (FSM). That is, generation units continuously respond to changes in the system frequency, in accordance with their governor droop characteristics for both increases and decreases in system frequency. This helps maintain the system frequency within the normal operating range.

In the HVDC parameters relating to the capability of DC-connected PPMs to operate in FSM must be specified by the TSO and are broken down into two types of parameters – responses required in normal operation and responses required following a step change in frequency:

- In normal operation the parameters to be specified are the % droop and any associated frequency dead bands. There is no parameter relating to the time allowed to achieve the required response. These parameters are consistent with today's Grid Code requirements for free governor regulation.
- The parameters to be specified to assist with recovering the system frequency following a sudden imbalance and associated frequency step change are a specified % increase in active power relative to available active power for the DC-connected PPMs within a specified time period (usually seconds). This is similar to today's Grid Code Requirements for units to provide operating reserves.

These parameters also apply to PPMs. Under the existing Grid Code, PPMs are required to operate in FSM when in "% curtailed" mode. PPMs are not actually acting under the control of a traditional governor. Instead, they are moving to MW set points which are calculated in the control system based on measured changes in the system frequency. The calculation of the set point is based on the droop characteristics and time for delivery as specified in these FSM settings.

Limited Frequency Sensitive Mode:

When a unit is operating in Limited Frequency Sensitive Mode (LFSM), the unit does not provide any frequency response when the system frequency is within a specified deadband around the nominal frequency. The deadband for LFSM mode is much wider than that specified in FSM mode. FSM deadbands are very small and generally specified to reflect the technical inability of some units to respond to very small changes in frequency and/or to avoid generator hunting.

HVDC provides for different LFSM capabilities to be required for over and under frequency events. It should be noted that currently only a very small number of generation units operate in LFSM today. The only generation units which act in LFSM mode today are PPMs when in "emergency action" mode.

At the moment, it is planned to continue to operate the majority of existing and future units in FSM. However, as the transmission system evolves and new technology connects, the use of both FSM and LFSM will be assessed on a regular basis.

Summary

For clarity, the following table highlights the links between our current frequency control modes and the HVDC frequency control modes

RfG Frequency Control Mode	Equivalent Grid Code Frequency Control Mode for PPMs	Equivalent Grid Code Frequency Control Mode for SPGM
LFSM-O	Emergency Action Mode	Not applicable in Northern Ireland today
LFSM-U	Not applicable in Northern Ireland today	Not applicable in Northern Ireland today
FSM Normal	% Curtailed Mode	Free Governor Action
FSM Frequency Step Change	Same as above	Operating Reserves

Table 1 – Frequency modes

For the avoidance of doubt, relay activated response such as over and under frequency tripping of units or high frequency runback schemes are not covered by this HVDC section as they are not related the inherent capability of the unit.

6.1.2 Frequency Ranges

6.1.2.1. Frequency Range for HVDC systems

Article 11.1

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

An HVDC system shall be capable of staying connected to the network and remaining operable within the frequency ranges and time periods specified in Table 1, Annex I for the short circuit power range as specified in Article 32(2).

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency range	47.0 Hz – 47.5 Hz for 60 seconds	Mandatory	11.1	HVDC Systems	N/A
Frequency Range	47.5 Hz – 48.5 Hz for a time to specified by each TSO, but not longer than established times for generation and demand.	90 minutes	11.1	HVDC Systems	2
Frequency Range	48.5 Hz – 49.0 Hz for a time to be specified by each TSO, but not longer than established times for generation and demand	90 minutes	11.1	HVDC Systems	2
Frequency Ranges	49.0 Hz – 51.0 Hz for an unlimited time	Mandatory	11.1	HVDC Systems	N/A
Frequency Ranges	51.0 Hz – 51.5 Hz for a time to be specified by each TSO, but not longer than established times for generation and demand	90 minutes	11.1	HVDC Systems	2
Frequency Range	51.5 Hz – 52 Hz for a time to be specified by each TSO but longer than for DC-connected PPMs	60 minutes	11.1	HVDC Systems	1

Table 2- Frequency ranges for HVDC Systems

Justification:

1. Frequency Range: 47.5 Hz – 48.5 Hz for 90 minutes
   The proposal that a HVDC system must remain connected to the transmission system for a period of 90 minutes when the system frequency is in the range of 47.5 Hz -48.5 Hz aligns the proposal made for the same frequency range under the RfG. For system security reasons, it is essential that in the event of system emergency, all available generation and HVDC systems remain connected to the transmission system. The loss of further generation or HVDC systems during a system emergency would be contradictory to the return of the transmission system to a normal state. By aligning these frequency requirements, it will ensure that the maximum time allowable to restore the transmission system to a normal state is available.

2. Frequency Range: 48.5 Hz – 49.0 Hz for 90 minutes
   The proposal that a HVDC system must remain connected to the transmission system for a period of 90 minutes when the system frequency is in the range of 48.5 Hz – 49.0 Hz aligns the proposal made for the same frequency range under the RfG. For system security reasons, it is essential that in the event of system emergency, all available generation and HVDC systems remain connected to the transmission system. The loss of further generation or HVDC systems during a system emergency would be contradictory to the return of the transmission system to a normal state. By aligning these frequency requirements, it will ensure that the maximum time allowable to restore the transmission system to a normal state is available.

3. Frequency Range: 51.0 Hz – 51.5 Hz for 90 minutes
   The proposal that a HVDC system must remain connected to the transmission system for a period of 90 minutes when the system frequency is in the range of 51.0 Hz – 51.5 Hz aligns the proposal made for the same frequency range under the RfG. For system security reasons, it is essential that in the event of system emergency, all available generation and HVDC systems remain connected to the transmission system. The loss of further generation or HVDC systems during a system emergency would be contradictory to the return of the transmission system to a normal state. By aligning these frequency requirements, it will ensure that the maximum time allowable to restore the transmission system to a normal state is available.

4. Frequency Range: 51.5 Hz – 52.0 Hz for 60 minutes
   The proposal that a HVDC system must remain connected to the transmission system for a period of 60 minutes when the system frequency is in the range of 51.5 Hz – 52.0 Hz aligns the proposal made for the same frequency range under the RfG as well as the existing Grid Code Requirements.
   For system security reasons, it is essential that in the event of system emergency, all available generation and HVDC systems remain connected to the transmission system. The loss of further generation or HVDC systems during a system emergency would be contradictory to the return of the transmission system to a normal state. By aligning these frequency requirements, it will ensure that the

maximum time allowable to restore the transmission system to a normal state is available.

6.1.2.2. Frequency Range for remote-end HVDC converter stations

Article 47.1

Mandatory non - exhaustive parameter selection

Applies to Remote-end HVDC converter stations

Requirement:

Where a nominal frequency other than 50 Hz, or a frequency variable by design is used in the network connecting the DC-connected power park modules, subject to relevant TSO agreement, Article 11 shall apply to the remote-end HVDC converter station with the applicable frequency ranges and time periods specified by the relevant TSO, taking into account specificities of the system and the requirements laid down in Annex I.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency range	47.0 Hz – 47.5 Hz for 60 seconds	Mandatory	11.1	Remote end HVDC Converter stations	N/A
Frequency Range	47.5 Hz – 48.5 Hz for a time to specified by each TSO, but not longer than established times for generation and demand.	90 minutes	11.1	Remote end HVDC Converter stations	2
Frequency Range	48.5 Hz – 49.0 Hz for a time to be specified by each TSO, but not longer than established times for generation and demand	90 minutes	11.1	Remote end HVDC Converter stations	2
Frequency Ranges	49.0 Hz – 51.0 Hz for an unlimited time	Mandatory	11.1	HVDC System	N/A
Frequency Ranges	51.0 Hz – 51.5 Hz for a time to be specified by each TSO, but not longer than established times for generation and demand	90 minutes	11.1	Remote end HVDC Converter stations	2

Frequency Range	51.5 Hz – 52 Hz for a time to be specified by each TSO but longer than for DC-connected PPMs	60 minutes	11.1	Remote end HVDC Converter stations	1

Table 3 – Frequency ranges for remote-end converter stations

Justification:

The proposal for the frequency ranges of 47.5 Hz – 48.5 Hz, 48.5 Hz – 49.0 Hz, 51.0 Hz – 51.5 Hz and 51.5 Hz – 52.0 Hz and the associated time periods align with the proposal for the frequency requirements for HVDC systems under Article 11.1[1].

[1] Given past evaluation into the development of offshore Grids in Northern Ireland, it is likely that the offshore connections will evolve with AC converted to or paralleled with DC systems. This means that alignment with the RfG avoids the risk that earlier AC offshore generation is not compatible with subsequent DC-connected remote end converter capabilities.

6.1.2.3. Wider Frequency Ranges for HVDC Systems

Article 11.2

Non mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The relevant TSO and HVDC system owner may agree on wider frequency ranges or longer minimum times for operation if needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the HVDC system owner shall not unreasonably withhold consent.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Wider frequency ranges, longer minimum times for operation	To be agreed between the TSO and HVDC system owner	Site specific	11.2	HVDC systems	3

Table 4 – wider frequency ranges for HVDC systems

Justification:

This requirement will need to be implemented on a site specific basis due to:

- Varying station and/or HVDC system configurations
- Compatibility with existing equipment
- Operational constraints

6.1.2.4. Wider Frequency Ranges for DC-connected Power Park Modules

Article 39.2(b)

Non-mandatory being made mandatory

Applies to DC-Connected Power Park Modules

Requirement:

With regard to frequency ranges and response:

(a) wider frequency ranges or longer minimum times for operation can be agreed between the relevant TSO and the DC-connected power park module owner to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the DC-connected power park module owner shall not unreasonably withhold consent;

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Wider frequency ranges, longer minimum times for operation	To be agreed between the TSO and DC-connected Power Park module owner	Site specific	11.2	DC – Connected PPMs	3

Table 5 – Wider frequency ranges for DC-connected Power Park Modules

Justification:

This requirement will need to be implemented on a site specific basis due to:

- Varying station and/or DC system configurations
- Compatibility with existing equipment
- Operational constraints

6.1.2.5. Automatic disconnection of HVDC Systems

Article 11.3

Mandatory non- exhaustive parameter selection

Applies to HVDC Systems

Requirement:

Without prejudice to paragraph 1, an HVDC system shall be capable of automatic disconnection at frequencies specified by the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency for automatic disconnection	To be specified by the relevant TSO	Site - specific	11.3	HVDC systems	3

Table 6 - Automatic disconnection of HVDC systems

Justification:

These requirements will need to be implemented on a site specific basis due to:

- Varying station and/or HVDC system configurations
- Local transmission system strength
- Operational constraints

6.1.2.6. Automatic disconnection of DC-connected Power Park Modules at specified frequencies

Article 39.2(c)

Mandatory non- exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

With regard to frequency ranges and response:

(b) While respecting the provisions of point (a) of paragraph 2, a DC-connected power park module shall be capable of automatic disconnection at specified frequencies, if specified by the relevant TSO. Terms and settings for automatic disconnection shall be agreed between the relevant TSO and the DC-connected power park module.

Parameters:

Parameter	Parameter in HVDC	submission Proposal	Article Number	Type Applicability	Justification Code
Frequencies for disconnection	To be agreed between the TSO and the DC-connected power park module	Site specific	39.2(c)	DC-connected PPMs	3

Table 7 – automatic disconnection of DC-connected Power Park Modules

Justification:

The frequencies for the disconnection of DC-connected power park modules shall be specified on the site specific basis, due to:

(a) Varying station and/or HVDC system configuration and types;
(b) Compatibility with existing equipment; and
(c) Operational constraints.

6.1.2.7. Maximum admissible power output below 49 Hz

Article 11.4

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The relevant TSO may specify a maximum admissible active power output reduction from its operating point if the system frequency falls below 49 Hz.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Admissible active power reduction from maximum output with falling frequency	To be specified by the relevant TSO	Right to specify	11.4	HVDC Systems	3

Table 8- Maximum admissible power output below 49 Hz

Justification:

The TSO is proposing to invoke the right to specify the admissible active power reduction from maximum output with fall frequency.

The intention is to assess the need to allow active power reduction from maximum output with fall frequency on a case by case and where required, the TSO will specify the maximum active power reduction allowable.

6.1.2.8. Rate of Change of Frequency withstand capability for HVDC systems

Article 12

Mandatory exhaustive parameter selection

Applies to HVDC Systems

Requirement:

An HVDC system shall be capable of staying connected to the network and operable if the network frequency changes at a rate between – 2,5 and + 2,5 Hz/s (measured at any point in time as an average of the rate of change of frequency for the previous 1 s).

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Rate of change of frequency	-2.5 to + 2.5 Hz	-2.5 to + 2.5 Hz	12	HVDC systems	N/A

Table 9 – Rate of change of frequency withstand capability for HVDC systems

Note:

This has been included for information purposes only.

6.1.2.9. Rate of Change of Frequency withstand capability for DC-connected Power Park Modules

Article 39.3

Mandatory exhaustive parameter selection

Applies to DC – connected Power Park Modules

Requirement:

With regards to rate-of-change-of-frequency withstand capability, a DC-connected power park module shall be capable of staying connected to the remote-end HVDC converter station network and operable if the system frequency changes at a rate up to +/– 2 Hz/s (measured at any point in time as an average of the rate of change of frequency for the previous 1 second) at the HVDC interface point of the DC-connected power park module at the remote end HVDC converter station for the 50 Hz nominal system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Rate of change of frequency	-2.0 to + 2.0 Hz	-2.0 to + 2.0 Hz	39.3	DC-connected PPMs	N/A

Table 10 – Rate of change of frequency withstand capability for DC-connected Power Park Modules

Note:

This has been included for information purposes only.

6.1.2.10. Frequency signal requirement

Article 47.2

Mandatory exhaustive parameter selection

Applies to Remote – End HVDC converter station

Requirement:

With regards to frequency response, the remote-end HVDC converter station owner and the DC-connected power park module owner shall agree on the technical modalities of the fast signal communication in accordance with Article 39(1). Where the relevant TSO requires, the HVDC system shall be capable of providing the network frequency at the connection point as a signal. For an HVDC system, connecting a power park module the adjustment of active power frequency response shall be limited by the capability of the DC-connected power park modules.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Fast signal communication	0.1 seconds	TSO to specified the requirements for the provision of the network frequency at the connection point as a signal	47.2	Remote-end HVDC converter station	3

Table 11 – Frequency signal requirement

Justification:

The requirements for the provision of the network frequency signal at the connection point will be determined during implementation phase of the HVDC Network Code. Once determined, these requirements will be made publically available.

6.1.3 Frequency Modes

6.1.3.1. Frequency Sensitive Mode

Article 15

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

Requirements applying to frequency sensitive mode, limited frequency sensitive mode over-frequency and limited frequency sensitive mode under-frequency shall be as set out in Annex II.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency Deadband	0 -> +/- 500 mHz	+/- 15 mHz	15	HVDC Systems	3
Droop s_1 (upward regulation)	Minimum 0.1 %	0.1 – 12 %, with a default value of 4 %	15	HVDC Systems	3
Droop s_2 (upward regulation)	Minimum 0.1 %	0.1 – 12 %, with a default value of 4 %	15	HVDC Systems	3
Frequency Response insensitivity	Maximum of 30 mHz	15 mHz	15	HVDC Systems	3

Table 12 – Frequency Sensitive Mode

Justification:

Frequency Response Deadband and Frequency Response Insensitivity:

As was stated in the RfG consultation, the current version of the Grid Code does not distinguish between Frequency Response Insensitivity and Frequency Response Deadband.

The Grid Cod definition of the Frequency Demand, which is set to +/- 15 mHz, whilst allowing for insensitivity in order to filter out noise, it does not allow for the HVDC Interconnector to be made intentionally unresponsive over any frequency interval.

Hence, it is proposed to retain the Grid Code requirement of +/- 15 mHz by setting a maximum absolute value of 15 mHz for both the Frequency Response Insensitivity and Frequency Response Deadband.

Droop s_1 (upward regulation) and Droop s_2 (upward regulation):

It is proposed to set this requirement of 0.1 % to 12% with a default value of 4% for HVDC systems for both the Droop s_1 (upward regulation) and Droop s_2 (down regulation). Please note that the default setting of 4% for both Droop s_1 (upward regulation) . the upper bound of 12 % for Droop aligns with the droop setting proposal for PGMs under RfG, while the lower boundary of 0.1 %, allows for maximum flexibility when selecting the droop settings. However, it is proposed 4 % would be used as the default value.

6.1.3.2. Frequency Control

Article 16.1

Non-madatory being made mandatory.

Applies to HVDC Systems

Requirement:

If specified by the relevant TSO, an HVDC system shall be equipped with an independent control mode to modulate the active power output of the HVDC converter station depending on the frequencies at all connection points of the HVDC system in order to maintain stable system frequencies.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Need for independent control mode to modulate active power output	To be specified by TSO	Site specific	16.1	HVDC Systems	3
Specify operating principle	To be specified by TSO	Site specific	16.1	HVDC Systems	3

Table 13 – Frequency Control

Justification:

The proposal is to specify both the need for independent control mode to modulate active power output and the associated operating principle on a site specific basis due to:

- System operational requirements
- HVDC System capacity
- Compatibility with existing equipment

6.1.3.3. FSM with subject to a fast signal response

Article 39.8

Mandatory non - exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

A capability for frequency sensitive mode for a DC-connected power park module shall be determined in accordance with Article 15(2)(d) of Regulation (EU) 2016/631, subject to a fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Active Power Range (∆P/PMax)	1.5 – 10 %	See note below 60 % in 5 seconds and 100 % in 15 seconds	39.8	DC – connected PPMs	1
Frequency response insensitivity (∆f)	10 – 30 mHz (as per the RfG)	15 mHz*	39.8	DC – connected PPMs	3
Frequency response insensitivity (∆f/f)	0.02 – 0.06 % (as per the RfG)	0.03%	39.8	DC – connected PPMs	3
Frequency Response Deadband	0 – 500 mHz (as per the RfG)	+/- 15 mHz*	39.8	DC – connected PPMs	3
Droop	2 – 12 % (as per the RfG)	Depends on generation type but 4% is proposed as a default	39.8	DC – connected PPMs	3
Admissible initial time delay for activation of active power frequency response	Less than 2 seconds (as per the RfG)	0s No time delays other than those inherent in the design of the frequency response system	39.8	DC – connected PPMs	3
Maximum admissible choice of full activation time	30 seconds (as per the RfG)	5 seconds	39.8	DC – connected PPMs	3
Capability relating to the	15 – 30 minutes	20 minutes	39.8	DC – connected	3

duration of provision of full active power frequency response	(as per the RfG)			PPMs	

Table 14 - FSM with subject to a fast signal response

Justification:

The proposal is in alignment with the proposal for the RfG .

Active Power Range

The TSO has consulted with the ENTSO-E Frequency Expert Group in relation to FSM. ENTSO-E has confirmed that this parameter was included in the above table as an error and as such will not be specified as part of this consultation.

For this reason, we are not proposing a value for active power range.

Frequency Response Insensitivity and Frequency Response Deadband

The current version of the Grid Code does not distinguish between Frequency Response Insensitivity and Frequency Response Deadband.

The Grid Code definition of the Frequency Deadband, which is set to +/- 15 mHz, whilst allowing for insensitivity in order to filter out noise, it does not allow for the frequency response of a PPM to be made intentionally unresponsive over any frequency interval.

Hence, it is proposed to retain the current Grid Code requirements of +/- 15 mHz by setting a maximum absolute value of 15 mHz for both the Frequency Response Insensitivity and Frequency Response Deadband.

*In addition to the individual requirements for Frequency Response Insensitivity (ΔF) and Frequency Response Deadband and as per Annex of the System Operating Guidelines (SOGL), the maximum combined effect of Frequency Response Insensitivity and Frequency Response Deadband cannot exceed a value of +/- 15 mHz.

Active Power Range:

The current requirement on the WPFS Settings Schedule requires a minimum of 60% of expected MW output change value based on droop characteristic within 5 seconds and 100% of expected MW Output value based on droop characteristic within 15 seconds. This requirement is core to the achievement of a 40% RES-E target and the ability to operate the system at System Non Synchronous Penetration (SNSP) levels up to 75%. The range in the HVDC only allows us to specify a value for the change in power output relative to the Active Power output at the moment the frequency threshold was reached (or the maximum capacity as defined by the TSO) between 1.5% - 10% i.e. it does not allow us to specify the levels that currently exist in the Grid Code. However, to lose the capability provided for in today's Grid Code would be very damaging to the success of

the DS3 program and ultimately to the integration of high levels of renewable energy into the power system.

The TSO does not believe that the regulations intentionally undermine this capability and therefore we are going to investigate options to retain todays Grid Code requirements for PPMs.

For the avoidance of doubt, in this consultation we have reflected the permissible ranges in the HVDC but respondents should understand that it is our intention to retain the Grid Code requirements for PPMs, in addition to the HVDC requirements.

Additional note:

Following the RfG Consultation earlier this year, the TSO engaged in further consultation with ENSTO-E and proposed the parameters for active power response in line with the current Grid Code requirements. The TSO will submit the necessary derogation request to the Utility Regulator with regard to these requirements in due course. Please see section 4 for further details.

Admissible initial time delay for activation of active power frequency response:

Current version of the Grid Code does not allow for any admissible initial time delay for the activation of active power frequency response, other than those which are inherent in the design of the Frequency Response System (WFPS1.5.3.9). It is proposed that the current requirement should be maintained under the HVDC by setting the admissible initial time delay for the activation of active power frequency response for PPMs to 0 seconds.

Capability relating to duration of provision of full active power frequency response:

The Frequency Containment Reserves (FCR) must remain in place until such time that the Frequency Replacement Reserves are available. In the case of Northern Ireland, the FCR equates to POR, SOR, TOR1 and TOR2 under the Grid Code. The existing Grid Code requires operating reserves to be in place for up to 20 minutes. Replacement reserves cover the period from 20 minutes to four hours after the event. By proposing a maximum admissible choice of full activation time of 20 minutes, this aligns the Grid Code Replacement Reserves requirements with the HVDC Frequency Replacement Reserve Requirements.

6.1.3.4. *Limited Frequency Sensitive Mode (LFSM-O) for DC-connected power park modules*

Article 39.4

Mandatory non - exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

DC-connected power park modules shall have limited frequency sensitive mode — overfrequency (LFSM-O) capability in accordance with Article 13(2) of Regulation (EU) 2016/631, subject to fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency Threshold	In accordance with Article 13(2) of Regulation (EU) 2016/631	50.2	39.4	DC-Connected PPMs	3
Droop Settings	In accordance with Article 13(2) of Regulation (EU) 2016/631	Should be capable of operating with a droop in the range of 2- 12 %. The default setting is 4 %.	39.4	DC-connected PPMs	3

Table 15 – Limited Frequency Sensitive Mode (LFSM) for DC-connected Power Park Module

Justification:

The above proposal aligns with the proposal for A, B, C and D PGMs and offshore PPMs under Article 13(2) of Regulation (EU) 2016/631[2].

It is not proposed to revisit this work at this time.

[2] Given past evaluation into the development of offshore Grids in Northern Ireland, it is likely that the offshore connections will evolve with AC converted to or paralleled with DC systems. This means that alignment with the RfG avoids the risk that earlier AC offshore generation is not compatible with subsequent DC-connected remote end converter capabilities.

6.1.3.5. LFSM - Constant power capability for DC-connected power park modules

Article 39.5

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

A capability for DC-connected power park modules to maintain constant power shall be determined in accordance with Article 13(3) of Regulation (EU) 2016/631 for the 50 Hz nominal system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Constant Power output	In accordance with Article 13(3) of Regulation (EU) 2016/631	In accordance with Article 13(3) of Regulation (EU) 2016/631	39.5	DC-Connected PPMs	3

Table 16 - LFSM constant power capability for DC-connected Power Park Modules

Justification:

The necessary parameters in the RfG were submitted to the Utility Regulator as part of the parameter proposal on the RfG in September 2018[3].

It is not planned to revisit this work at this time.

[3] Given past evaluation into the development of offshore Grids in Northern Ireland, it is likely that the offshore connections will evolve with AC converted to or paralleled with DC systems. This means that alignment with the RfG avoids the risk that earlier AC offshore generation is not compatible with subsequent DC-connected remote end converter capabilities.

6.1.3.6. LFSM-U for DC-connected Power Park Module

Article 39.7

Mandatory non - exhaustive parameter selection

Applies a DC-Connected Power park modules

Requirement:

A capability for limited frequency sensitive mode — under-frequency (LFSM-U) for a DC-connected power park module shall be determined in accordance with Article 15(2)(c) of Regulation (EU) 2016/631, subject to fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency threshold	In accordance with Article 15(2)(c) of Regulation (EU) 2016/631	49.5 Hz	39.7	a DC-connected PPMs	3
Droop Settings	In accordance with Article 15(2)(c) of Regulation (EU) 2016/631	Default is 4 % unless otherwise specified by the TSO on a site specific basis	39.7	a DC-connected PPMs	3

Table 17 – LFSM-U for DC-connected Power Park Module

Justification:

LFSM-U is not currently used as a mode of frequency response in Northern Ireland. However, looking to the future the introduction of new market conditions or system services may require LFSM-U for the provision of frequency restoration reserve (FRR), it is for this reason the above parameters for LFSM-U are specified.

In Article 15(c)(ii) of the RfG it deals with the delivery of active power response in LFSM-U mode taking into account ambient conditions. These ambient conditions are as described in paragraphs 4 and 5 of Article 15 of the RfG[4].

[4] Given past evaluation into the development of offshore Grids in Northern Ireland, it is likely that the offshore connections will evolve with AC converted to or paralleled with DC systems. This means that alignment with the RfG avoids the risk that earlier AC offshore generation is not compatible with subsequent DC-connected remote end converter capabilities.

6.1.4. Active Power Controllability

6.1.4.1. Active Power Controllability, Control Range and Ramping Rate

Article 13.1(a)

Non- Mandatory being made mandatory

Applies to HVDC Systems

Requirement:

With regard to the capability of controlling the transmitted active power:

(a) an HVDC system shall be capable of adjusting the transmitted active power up to its maximum HVDC active power transmission capacity in each direction following an instruction from the relevant TSO.

The relevant TSO:

(i) may specify a maximum and minimum power step size for adjusting the transmitted active power;

(ii) may specify a minimum HVDC active power transmission capacity for each direction, below which active power transmission capability is not requested; and

(iii) shall specify the maximum delay within which the HVDC system shall be capable of adjusting the transmitted active power upon receipt of request from the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum power Step	To be specified by TSO	To be specified on a case by case basis	13.1(a)(i)	HVDC systems	3
Minimum power step	To be specified by TSO	To be specified on a case by case basis	13.1(a)(i)	HVDC systems	3
Minimum active power transmission capacity	To be specified by TSO	Not greater than the lesser of 3 % of the HVDC system maximum capacity or 50 MW	13.1(a)(ii)	HVDC systems	3
Maximum delay	To be specified by TSO	10 seconds plus the HVDC system ramp rate	13.1(a)(iii)	HVDC systems	3

Table 18 – Active Power Controlability, Control Range and Ramping Rate

Justification:

Maximum power step:

To be specified on a case-by-case basis, depending on:

- interconnector capacity
- System capacity
- Equipment compatibility

Minimum power step:

To be specified on a case-by-case basis, depending on:

- interconnector capacity
- System capacity
- Equipment compatibility

Minimum active power transmission capacity:

It is proposed that the minimum active power capacity is not greater than the lesser of 3 % of the HVDC system maximum capacity or 50 MW.

Minimum delay:

The proposal of 10 seconds plus the HVDC system ramp rate is in line with the minimum delay for PGMs under the RfG proposals.

6.1.4.2. Modification of transmitted active power

Article 13.1(b)

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

With regard to the capability of controlling the transmitted active power:

(b) the relevant TSO shall specify how an HVDC system shall be capable of modifying the transmitted active power infeed in case of disturbances into one or more of the AC networks to which it is connected. If the initial delay prior to the start of the change is greater than 10 milliseconds from receiving the triggering signal sent by the relevant TSO, it shall be reasonably justified by the HVDC system owner to the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Modification of transmitted active power	To be specified by the relevant TSO	Site specific	13.1(b)	HVDC systems	3

Table 19 – Modication of transmiited active power

Justification:

The modification of the transmitted active power shall be specified on a site specific basis, due to:

- HVDC System capacity
- Compatibility with existing equipment
- Operational constraints

6.1.4.3. Fast active power reversal

Article 13.1(c)

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

With regard to the capability of controlling the transmitted active power:

(c) the relevant TSO may specify that an HVDC system be capable of fast active power reversal. The power reversal shall be possible from the maximum active power transmission capacity in one direction to the maximum active power transmission capacity in the other direction as fast as technically feasible and reasonably justified by the HVDC system owner to the relevant TSOs if greater than 2 seconds.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Fast active power reversal	To be specified by the relevant TSO	Site specific	13.1(c)	HVDC systems	3

Table 20 – Fast active power reversal

Justification:

Fast Active power reversal shall be specified on a site specific basis, due to:

- HVDC System capacity
- Compatibility with existing equipment
- Operational constraints

6.1.4.4. HVDC Systems Automatic remedial actions

Article 13.3

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

If specified by a relevant TSO, in coordination with adjacent TSOs, the control functions of an HVDC system shall be capable of taking remedial actions, including but not limited to, stopping the ramping and blocking FSM, LFSM-O, LFSM-U and frequency control. The triggering and block criteria shall be specified by the relevant TSO and subject to notification to regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Automatic remedial actions	Right to invoke	Right to specify	13.3	HVDC Systems	3

Table 21 – HVDC Automatic Remedial actions

Justification:

It is proposal to invoke the right to specify automatic remedial actions to be provided by HVDC systems. However, this requirement will be implemented on a site-specific basis where the need for such automatic remedial actions are identified by the relevant studies.

6.1.4.5. Maximum loss of active power

Article 17.1

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

An HVDC system shall be configured in such a way that its loss of active power injection in a synchronous area shall be limited to a value specified by the relevant TSOs for their respective load frequency control area, based on the HVDC system's impact on the power system.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Limit for loss of active power injection	To be specified by the relevant TSO	Site specific	17.1	HVDC systems	3

Table 22 – Maximum loss of active power

Justification:

Limit for loss of active power injection shall be specified on a site specific basis, due to:

- HVDC System capacity
- Operational constraints
- Compatibility with existing equipment

6.1.4.6. Maximum loss of active power for a HVDC system connecting two control areas

Article 17.2

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems which connect two or more control areas

Requirement:

Where an HVDC system connects two or more control areas, the relevant TSO shall consult each other in order to set a coordinated value of the maximum loss of active power injection as referred to in paragraph 1, taking into account common mode failures.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Coordinate specified limit of active power injection	To be agreed between the relevant TSOs	To be agreed between the relevant TSOs on a case by case basis	17.2	HVDC Systems which connect two or more control areas	3

Table 23 – Maximum loss of active power for a HVDC system connecting two control areas

Justification:
It is proposed that the limit of active power injection for HVDC systems which connect two or more control areas will be agreed between the relevant TSOs on a case-by-case basis, taken into account the requirements and characteristics of each of the relevant control areas.

6.1.4.7. Active power capability for Power Park Module

Article 39.6

Mandatory non- exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

A capability for active power controllability of DC-connected power park modules shall be determined in accordance with Article 15(2)(a) of Regulation (EU) 2016/631 for the 50 Hz nominal system. Manual control shall be possible in the case that remote automatic control devices are out of service.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
The period within which the adjusted active power set point must be reached	To be specified in accordance with Article 15(2) of the Regulation (EU) 2016/631	The active power set point and the time to achieve this is determined by the TSO, however, following a shutdown, a PPM must commence active power export within 90 secs WFPS schedule 6.11	39.6	DC-connected PPMs	1
Tolerance applying to the new set point and the time within which it must be reached	To be specified in accordance with Article 15(2) of the Regulation (EU) 2016/631	Active power output to be within 3% of set point (based on RC) Time to achieve set point within ±10 seconds of target time. (See WFPS Settings schedule 6.1)	39.6	DC-connected PPMs	3

Table 24 – Active power capability for Power Park Modules

Justification:

The proposal is in alignment with the proposal for Article 15(2)(a) of Regulation (EU) 2016/631 for the 50 Hz nominal system.

The proposed period within which the adjusted active power set point must be achieved is as per the existing requirements under the WFPS settings schedule section 6.11.
The proposed parameters for the tolerance applying to a new DC-connected PPM are in alignment with the current Grid Code Requirements.

6.1.5 Synthetic Inertia

6.1.5.1. Synthetic Inertia

Article 14.1

Non-Mandatory non - exhaustive parameter

Applies to HVDC Systems

Requirement:

If specified by a relevant TSO, an HVDC system shall be capable of providing synthetic inertia in response to frequency changes, activated in low and/or high frequency regimes by rapidly adjusting the active power injected to or withdrawn from the AC network in order to limit the rate of change of frequency. The requirement shall at least take account of the results of the studies undertaken by TSOs to identify if there is a need to set out minimum inertia.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Provision of synthetic inertia	To specify or not to specify	Not invoking right to specify	14.1	HVDC systems	1

Table 25 – Synthetic Inertia

Justification:

SONI is not currently proposing to invoke the right to specify the provision of synthetic inertia response from HVDC systems to frequency changes. However, the need for the provision of synthetic inertia from HVDC system will reviewed on an regular basis. Hence, the TSO's right to specify the provision of synthetic inertia may be invoked at some point in the future.

6.1.5.2. Synthetic Inertia

Article 14.2

Non - Mandatory non- exhaustive parameter

Applies to HVDC Systems

Requirement:

The principle of this control system and the associated performance shall be agreed between the relevant TSO and the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Agreement of control system and associated parameters	To be agreed between the relevant TSO and the HVDC system owner	Not invoking right to specify	14.2	HVDC Systems	3

Table 26 – Synthetic Inertia

Justification:

SONI is not currently proposing to invoke the right to specify the provision of synthetic inertia response from HVDC systems to frequency changes. However, the need for the provision of synthetic inertia from HVDC system will reviewed on an regular basis. Hence, the TSO's right to specify the provision of synthetic inertia may be invoked at some point in the future.

6.2 Voltage Theme

The non-exhaustive and non-mandatory voltage parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Voltage ranges
- Reactive power capability
- Priority to active or reactive power
- Short-circuit requirements
- Fault-ride-through
- Power Quality

6.2.1. Voltage Ranges

6.2.1.1 Nominal Operational Voltage Range – Transmission System

Article 18.1:

Mandatory exhaustive parameter selection

Applies to HVDC converter stations

Requirement:

Without prejudice to Article 25, an HVDC converter station shall be capable of staying connected to the network and capable of operating at HVDC system maximum current, within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to reference 1 pu voltage, and the time periods specified in Tables 4 and 5, Annex III. The establishment of the reference 1 pu voltage shall be subject to coordination between the adjacent relevant system operators.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
110 kV	0.9 pu – 1.118 pu (unlimited)	0.9 pu – 1.118 pu (unlimited)	18.1 (Annex III Table 3)	HVDC Converter stations	1
275 kV	0.9 pu – 1.118 pu (unlimited)	0.9 pu – 1.118 pu (unlimited)	18.1 (Annex III Table 3)	HVDC Converter stations	1
400 kV	0.9 pu – 1.05 pu (unlimited)	0.9 pu – 1.05 pu (unlimited)	18.1 (Annex III Table 4)	HVDC Converter stations	1

Table 27 – Voltage ranges for HVDC Converter Stations

Justification:

Included for information purposes only.

6.2.1.2 Nominal Operational Voltage Range – DC-Connected PPM

Article 40.1(a):

Mandatory exhaustive parameter selection

Applies to DC – connected PPMs

Requirement:

With respect to voltage ranges:

(a) a DC-connected power park module shall be capable of staying connected to the remote-end HVDC converter station network and operating within the voltage ranges (per unit), for the time periods specified in Tables 9 and 10, Annex VII. The applicable voltage range and time periods specified are selected based on the reference 1 pu voltage

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
110 kV/ 275 kV	0.85 pu – 0.9 pu (60 minutes)	0.85 pu – 0.9 pu (60 minutes)	Article 40.1 (a) (ANNEX VII Table	DC-connected PPMs	3
	0.9 pu – 1.118 pu (unlimited)	0.9 pu – 1.118 pu (unlimited)		DC-connected PPMs	3
	1.118 pu – 1.15 pu (60 minutes)	Not allowed		DC-connected PPMs	3
400 kV	0.85 pu – 0.9 pu (60 minutes)	0.9 pu – 1.05 pu (unlimited)	Article 40.1 (a) (ANNEX VII Table 10)	DC-connected PPMs	3
	0.9 pu – 1.05 pu (unlimited)	0.9 pu – 1.05 pu (unlimited)		DC-connected PPMs	3
	1.05 pu – 1.15 pu (unlimited)	Not allowed		DC-connected PPMs	3

Table 28 –voltage ranges for DC-connected PPMs

Justification:

Included for information purposes only.

6.2.1.3 Nominal Operational Voltage Range – Transmission System

Article 48.1(a):

Mandatory exhaustive parameter selection

Applies to remote-end HVDC converter stations

Requirement:

With respect to voltage ranges:

(a) a remote-end HVDC converter station shall be capable of staying connected to the remote-end HVDC converter station network and operating within the voltage ranges (per unit) and time periods specified in Tables 12 and 13, Annex VIII. The applicable voltage range and time periods specified are selected based on the reference 1 pu voltage;

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
110 kV/ 275 kV	0.85 pu – 0.9 pu (60 minutes)	0.85 pu – 0.9 pu (60 minutes)	Article 40.1 (a) (ANNEX VII Table 9)	Remote end HVDC-Converter Stations	3
	0.9 pu – 1.10 pu (unlimited)	0.9 pu – 1.10 pu (unlimited)			3
	1.10 pu – 1.12 pu	Case by case			3
	1.12 pu – 1.15 pu	Not allowed			3
400 kV	0.85 pu – 1.05 pu (60 minutes)	0.85 pu – 0.9 pu (60 minutes)	Article 40.1 (a) (ANNEX VII Table 10)		3
	0.9 pu – 1.05 pu (unlimited)	0.9 pu – 1.05 pu (unlimited)			3
	1.05 pu – 1.15 pu	Not allowed			3

Table 29 – Voltage ranges for remote end HVDC converter stations

Justification:

The voltage capabilities of the remote end may be limited by the switchgear specification. It is therefore determined that voltage time scales above 1.10 pu shall be determined on a case-by-case basis.

6.2.1.4 Wider Operational Voltage Range and Longer Minimum Times for DC-Connected Power Park Modules

Article 40.1(b):

Non-Mandatory non-exhaustive parameter selection

Requirement:

With respect to voltage ranges:

(b) wider voltage ranges or longer minimum times for operation can be agreed between the relevant TSO and the DC-connected power park module owner to ensure the best use of the technical capabiliites of a DC-connected power park module if needed to preserve or to restore system security. If wider voltage ranges or longer minimum times for operation are economically and technically feasible, the DC-connected power park module owner shall not unreasonably without consent.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Wider voltage ranges and longer minimum times	Not specified	Site specific	40.1 (b)	DC connected PPMs	3

Table 30 – Wider Operational Voltage Range and Longer Minimum Times for DC-Connected Power Park Modules

Justification:

The specification of these parameters would occur in consultation with the DC connected power park module owner, during the connection application stage.

6.2.1.5 Wider Voltage Ranges or Longer Minimum Times

Article 48.1(b):

Non-Mandatory non-exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

With respect to voltage ranges:

(b) wider voltage ranges or longer minimum times for operation may be agreed between the relevant system operator, in coordination with the relevant TSO, and the DC-connected power park module owner in accordance with Article 40

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Wider Voltage Ranges and Longer Minimum Times	Not specified	Site specific	48.1 (b)	DC – Connected PPMs	3

Table 31 – Wider Voltage Ranges or Longer minimum times

Justification:

The specification of these parameters would require a relevant system operator to be in place. This would occur during the connection application stage.

6.2.1.6 Automatic Disconnection Due to Voltage Level

6.2.1.6.1 Automatic Disconnection Due to Voltage Level for HVDC Converter stations

Article 18.3:

Mandatory exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

An HVDC converter station shall be capable of automatic disconnection at connection point voltage specified by the relevant system operator, in coordination with the relevant TSO. The terms and settings for automatic disconnection shall be agreed between the relevant system operator, in coordination with the relevant TSO, and HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Minimum Voltage below which Module will automatic disconnect	Not specified	Not Allowed	18.3	HVDC Converter Stations	3
Maximum Voltage above which Module will automatic disconnect	Not specified	Not Allowed	18.3	HVDC Converter Stations	3

Table 32 – Automatic disconnection due to voltage level for HVDC Converter stations

Justification:

The current Grid Code does not stipulate voltage thresholds which allow for automatic disconnection. The TSO invokes the right to prohibit automatic disconnection from the Transmission System.

The HVDC converter station is not allowed to automatically disconnect from the system within the normal operating voltage range or fault ride through parameters. Beyond that, protection settings for undervoltage protection would be determined on a case by case.

6.2.1.6.2 Automatic Disconnection Due to Voltage Level – DC-connected PPM

Article 40.1(c):

Mandatory non-exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

With respect to voltage ranges:

(c) for DC-connected power park modules which have an HVDC interface point to the remote-end HVDC converter station network, the relevant system operator, in coordination with the relevant TSO may specify voltages at the HVDC interface point at which a DC-connected power park module shall be capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator, the relevant TSO and the DC-connected power park module owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Minimum Voltage below which Module will automatic disconnect	Not specified	Not allowed	40.1 c	DC-connected PPMs	3
Maximum Voltage above which Module will automatic disconnect	Not specified	Not allowed	40.1 c	DC-connected PPM s	3

Table 33 – Automatic disconnection due to voltage level for DC-Connected Power Park Modules

Justification:

This proposal is aligned with the RfG proposals.

The current Grid Code does not stipulate voltage thresholds which allow for automatic disconnection. The TSO invokes the right to prohibit automatic disconnection from the Transmission System.

6.2.2 Reactive power capability

6.2.2.1 Reactive power capability

6.2.2.1.1 Reactive Power Capability at Maximum Capacity: U-Q/P_{max} Profiles

Article 20.1:

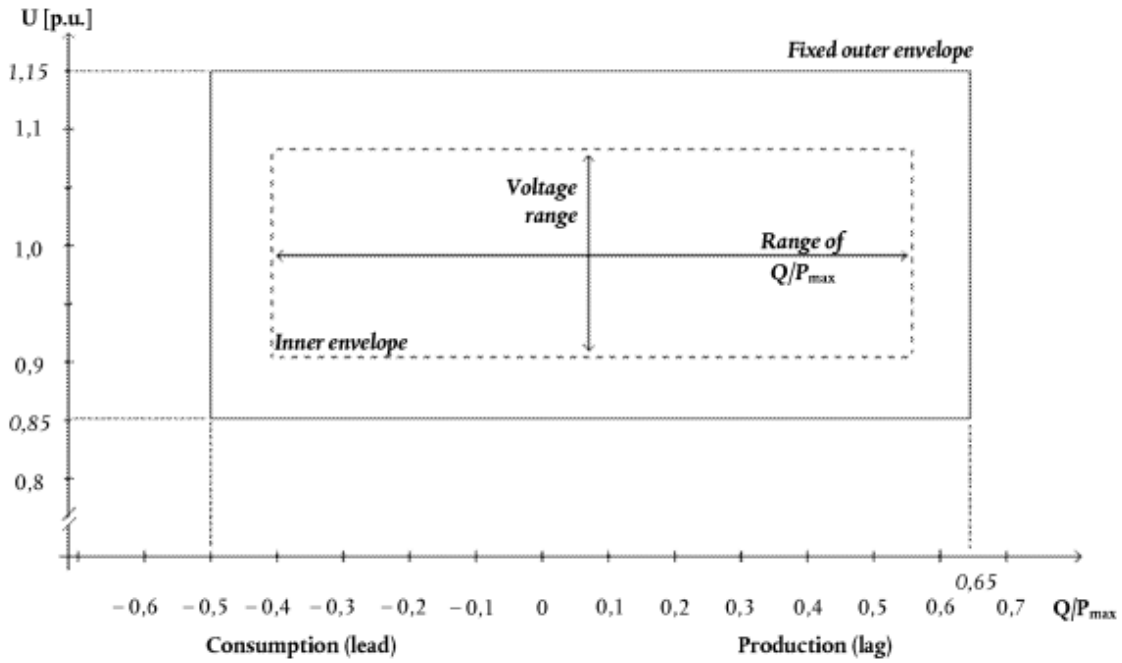
Mandatory non-exhaustive parameter selection

Applies to HVDC converter stations

Requirement:

The relevant system operator, in coordination with the relevant TSO, shall specify the reactive power capability requirements at the connection points, in the context of varying voltage. The proposal for those requirements shall include a U-Q/P_{max}-profile, within the boundary of which the HVDC converter station shall be capable of providing reactive power at both its maximum Import and maximum Export HVDC active power transmission capacity.

The diagram below represents boundaries of the U-Q/P_{max}-profile with U being the voltage at the connection points expressed by the ratio of its actual value to its reference 1 pu value in per unit, and Q/P_{max} the ratio of the reactive power to the maximum HVDC active power transmission capacity. The figure below shows the reactive power requirement boundaries. The position, size and shape of the inner envelope are indicative.



The voltage range of the inner envelop is expressed by the minimal (u_{min}) and maximum (u_{max}) voltage in per unit. The Range of Q/P_{max} is expressed by the maximum import reactive power (Q_{min}/P_{max}) and the maximum export reactive power (Q_{max}/P_{max}) capability in per unit.

Parameters:

Parameter	Parameter in HVDC	Parameter in HVDC (outer envelope)	Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV to 300 kV	u_{min}	0.85 pu	0.9 pu	20.1 (Annex VII Table 9)	HVDC Converter stations	3
	u_{max}	1.15 pu	1.118 pu		HVDC Converter stations	3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	20.1 (Annex VII Figure 7)	HVDC Converter stations	3
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu		HVDC Converter stations	3
300 kV to 400 kV	u_{min}	0.85 pu	0.9 pu	20.1 (Annex VII Table 10)	HVDC Converter stations	3
	u_{max}	1.15 pu	1.05 pu		HVDC Converter stations	3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	20.1 (Annex VII Figure 7)	HVDC Converter stations	3
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu		HVDC Converter stations	3

Table 34 - Reactive Power Capability at Maximum Capacity: U-Q/Pmax Profiles

Justification:

The range of reactive power capability is as per the current Grid Code requirements for wind farm power stations and aligned with the proposed requirements for PPMs in the RfG consultation.

The voltage (u_{min} and u_{max}) ranges are aligned with the normal operating voltage ranges within which the HVDC converter station shall stay connected to the network and operate normally article 18.1 and Annex III Table 4 or Table 5).

6.2.2.1.2 Time to Achieve Target Value within P-Q/Pmax Profile

Article 20.3:

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

An HVDC system shall be capable of moving to any operating point within its U-Q/P_{max} profile in timescales specified by the relevant system operator in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Time to achieve target value	Not specified	Without undue delay but at least within 120 seconds	20.3	HVDC Systems	1

Table 35 – Time to achieve target value within P-Q/Pmax Profile

Justification:

The time to achieve the target value is as per the current requirement set out in the Scheduling and Dispatch Code Appendix B (SDC2.B.8) of the Grid Code for centrally dispatched generating units. These units are being dispatched via the TSO electronic interface program (EDIL); however, the same time period will apply for units being dispatched via set point control.

6.2.2.1.3 Reactive Power Capability below Maximum Capacity: P-Q/Pmax Profiles

Article 20.4:

Mandatory exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

When operating at an active power output in the range of maximum Import (P_{MIC}^{max})and maximum Export (P_{MEC}^{max}) HVDC active power transmission capacity, the HVDC converter station shall be capable of operating in every possible operating point, as specified by the relevant system operator in coordination with the relevant TSO and in accordance with the reactive power capability set out by the U-Q/P_{max} profile specified in Article 20 paragraphs 1 to 3 (see section 6.2.2.1.1 and 6.2.2.1.2).

Parameters:

Parameter	Parameter in HVDC	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
110 kV to 300 kV	p_{MIC}	1.0 p.u.	1.0 p.u	20.4	HVDC Converter Stations	3
	p_{MEC}	1.0 p.u.	1.0 p.u.	20.4	HVDC Converter Stations	3
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	20.4	HVDC Converter Stations	3
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	20.4	HVDC Converter Stations	3
300 kV to 400 kV	p_{MIC}	1.0 p.u.	1.0 p.u.	20.4	HVDC Converter Stations	3
	p_{MEC}	1.0 p.u.	1.0 p.u.	20.4	HVDC Converter Stations	3
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	20.4	HVDC Converter Stations	3
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	20.4	HVDC Converter Stations	3

Table 36 – Reactive Power Capability below Maximum Capacity: P-Q/Pmax Profiles

Justification:

HVDC is not included in the current SONI Grid Code. The reactive power parameters for $P_{MIC}<P<P_{MEC}$ are as per the current Northern Ireland Grid Code requirements.

6.2.2.1.4 Reactive Power Capability at Maximum Capacity: U-Q/Pmax Profiles

Article 40.2(b)(i):

Mandatory exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

With respect to reactive power capability for DC-connected power park modules:

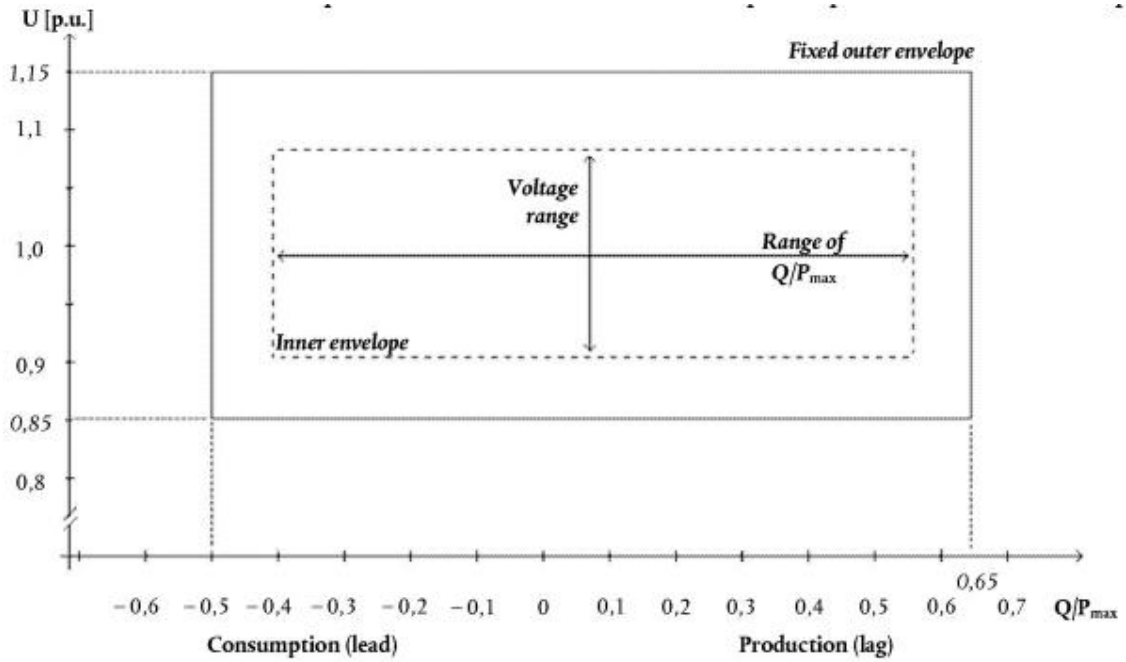
(b) DC-connected power park modules shall fulfil the following requirements relating to voltage stability either at the time of connection or subsequently, according to the agreement as referred to in point (a):

(i) with regard to reactive power capability at maximum HVDC active power transmission capacity, DC-connected power park modules shall meet the reactive power provision capability requirements specified by the relevant system operator, in coordination with the relevant TSO, in the context of varying voltage. The relevant system operator shall specify a U-Q/P_{max}-profile that may take any shape with ranges in accordance with Table 11, Annex VII, within which the DC-connected power park module shall be capable of providing reactive power at its maximum HVDC active power transmission capacity. The relevant system operator, in coordination with the relevant TSO, shall consider the long term development of the network when determining these ranges, as well as the potential costs for power park modules of delivering the capability of providing reactive power production at high voltages and reactive power consumption at low voltages.

If the Ten-Year Network Development Plan developed in accordance with Article 8 of Regulation (EC) No 714/2009 or a national plan developed and approved in accordance with Article 22 of Directive 2009/72/EC specifies that a DC-connected power park module will become AC-connected to the synchronous area, the relevant TSO may specify that either:

- the DC-connected power park module shall have the capabilities prescribed in Article 25(4) of Regulation (EU) 2016/631 for that synchronous area installed at the time of initial connection and commissioning of the DC-connected power park module to the AC-network; or
- the DC-connected power park module owner shall demonstrate to, and then reach agreement with, the relevant system operator and the relevant TSO on how the reactive power capability prescribed in Article 25(4) of Regulation (EU) 2016/631 for that synchronous area will be provided in the event that the DC-connected power park module becomes AC-connected to the synchronous area.

U-Q/Pmax-profile of a DC-connected power park module at the connection point. The diagram represents boundaries of a U-Q/Pmax-profile of the voltage at the connection point, expressed by the ratio of its actual value to its reference 1 pu value in per unit, against the ratio of the reactive power (Q) to the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.



The voltage range of the inner envelope is expressed by the minimal (u_{min}) and maximum (u_{max}) voltage in per unit. The Range of Q/P_{max} is expressed by the maximum import reactive power (Q_{min}/P_{max}) and the maximum export reactive power (Q_{max}/P_{max}) capability in per unit.

Parameters:

Parameter	Parameter in HVDC	Parameter in HVDC (outer envelope)	Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV to 300 kV	u_{min}	0.85 pu	0.9 pu	40.2 (b) (i) (Annex VII Table 9)	DC-connected PPMs	3
	u_{max}	1.15 pu	1.118 pu		DC-connected PPMs	3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	40.2 (b) (i) (Annex VII Figure 7)	DC-connected PPMs	3
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu		DC-connected PPMs	3
300 kV to 400 kV	u_{min}	0.85 pu	0.85 pu	40.2 (b) (i) (Annex VII Table 10)	DC-connected PPMs	3
	u_{max}	1.15 pu	1.05 pu		DC-connected PPMs	3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	40.2 (b) (i) (Annex VII	DC-connected	3

				Figure 7)	PPMs	
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu		DC-connected PPMs	3

Table 37 – Reactive Power Capability at Maximum Capacity – U-Q/Pmax Profiles

Justification:

The reactive power capability is aligned with the proposed PPM reactive power capability in the RfG. It is also aligned with the existing reactive power range specified by the Northern Ireland Grid Code for Interconnectors.

6.2.2.1.5 Reactive Power Capability at Maximum Capacity: U-Q/Pmax Profiles

Article 48.2(a) and (b):

Mandatory non- exhaustive parameter selection

Applies to HVDC converter stations

Requirement:

A remote-end HVDC converter station shall fulfil the following requirements referring to voltage stability, at the connection points with regard to reactive power capability:

(a) the relevant system operator, in coordination with the relevant TSO shall specify the reactive power provision capability requirements for various voltage levels. In doing so, the relevant system operator, in coordination with the relevant TSO shall specify a U-Q/Pmax-profile of any shape and within the boundaries of which the remote-end HVDC converter station shall be capable of providing reactive power at its maximum HVDC active power transmission capacity.

(b) the U-Q/Pmax-profile shall be specified by each relevant system operator, in coordination with the relevant TSO. The U-Q/Pmax-profile shall be within the range of Q/Pmax and steady-state voltage specified in Table 14, Annex VIII, and the position of the U-Q/Pmax-profile envelope shall lie within the limits of the fixed outer envelope specified in Annex IV. The relevant system operator, in coordination with the relevant TSO, shall consider the long term development of the network when determining these ranges.

Parameters:

Parameter	Parameter in HVDC	Parameter in HVDC (outer envelope)	Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV to 300 kV	u_{min}	0.85 pu	0.9 pu	40.2 (b) (i) (Annex VII Table 9)	DC-connected PPMs	3
	u_{max}	1.15 pu	1.118 pu			3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	40.2 (b) (i) (Annex VII Figure 7)		3
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu			3
300 kV to 400 kV	u_{min}	0.85 pu	0.85 pu	40.2 (b) (i) (Annex VII Table 10)		3

	u_{max}	1.15 pu	1.05 pu			3
	Q_{min}/P_{max} (lead)	-0.5 pu	-0.33 pu	40.2 (b) (i) (Annex VII Figure 7)		3
	Q_{max}/P_{max} (lag)	0.65 pu	0.33 pu			3

Table 38 - Reactive Power Capability at Maximum Capacity: U-Q/Pmax Profiles

Justification:

The reactive power capability is aligned with the proposed PPM reactive power capability in the RfG. It is also aligned with the existing reactive power range specified for Interconnectors in the Northern Ireland Grid Code.

6.2.2.2 Reactive Power Mode

6.2.2.2.1 Standard Reactive Power Control Mode for HVDC Converter Stations

Article 22.1:

Mandatory exhaustive parameter selection

Applies to HVDC converter stations

Requirement:

An HVDC converter station shall be capable of operating in one or more of the three following control modes, as specified by the relevant system operator in coordination with the relevant TSO:

a) voltage control mode;

b) reactive power control mode;

c) power factor control mode.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage	Not specified	Invoke the right to specify	Article 22.1	HVDC Converter stations	3
Reactive Power	Not specified	Invoke the right to specify	Article 22.1	HVDC Converter stations	3
Power Factor	Not specified	Invoke the right to specify	Article 22.1	HVDC Converter stations	3

Table 39 - Standard Reactive Power Control Mode for HVDC Converter Stations

Justification:

HVDC is not included in current draft of SONI Grid Code.

As much of the capacity of conventional generation becomes replaced by HVDC systems, the services that were previously provided by those generators, will need to be provided by the HVDC systems.

6.2.2.2.2 Customised Reactive Power Control Mode for HVDC Converter Stations

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

Article 22.2:

An HVDC converter station shall be capable of operating in additional control modes specified by the relevant system operator in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Customised control mode	Not specified	Site specific	Article 22.2	HVDC Converter stations	3

Table 40 - Customised Reactive Power Control Mode for HVDC Converter stations

Justification:

During the connection offer process, additional reactive power control modes may be specified for the HVDC converter station in order to avoid limiting future opportunities. Hence, additional control modes are customised and therefore site-specific. HVDC converter station owner and the relevant system operator, in coordination with the relevant TSO, shall agree on the parameters and settings of additional control modes.

6.2.2.2.3 Voltage Control Mode

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

Article 22.3:

For the purposes of voltage control mode, each HVDC converter station shall be capable of contributing to voltage control at the connection point utilising its capabilities, while respecting Articles 20 and 21, in accordance with the following control characteristics:

(a) a set point voltage at the connection point shall be specified to cover a specific operation range, either continuously or in steps, by the relevant system operator, in coordination with the relevant TSO;

(b) the voltage control may be operated with or without a deadband around the set point selectable in a range from zero to +/– 5 % of reference 1 pu network voltage. The deadband shall be adjustable in steps as specified by the relevant system operator in coordination with the relevant TSO;

(c) following a step change in voltage, the HVDC converter station shall be capable of:

(i) achieving 90 % of the change in reactive power output within a time t_1 specified by the relevant system operator in coordination with the relevant TSO. The time t_1 shall be in the range of 0.1-10 seconds; and

(ii) settling at the value specified by the operating slope within a time t_2 specified by the relevant system operator in coordination with the relevant TSO. The time t_2 shall be in the range of 1-60 seconds, with a specified steady-state tolerance given in % of the maximum reactive power.

(d) voltage control mode shall include the capability to change reactive power output based on a combination of a modified set point voltage and an additional instructed reactive power component. The slope shall be specified by a range and step specified by the relevant system operator in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage set point	Not specified	continuous	22.3 (a)	HVDC Converter Stations	3
Steps to adjusted deadband	Not specified	Site specific	22.3 (b)	HVDC Converter Stations	3
t_1 = time within which 90% of the change in reactive power is reached	0,1 – 10 sec	1	22.3 (c) (i)	HVDC Converter Stations	3
t_2 = time within which 100% of the change in reactive power is reached	1 – 60 sec	5 (PPM requirements from RfG)	22.3 (c) (ii)	HVDC Converter Stations	3
Steady state tolerance	Not specified	5%	22.3 (c) (ii)	HVDC Converter Stations	3
Range and step of slope	Not specified	Site specific	22.3 (d)	HVDC Converter Stations	3

Table 41 - Voltage Control Mode

Justification:

The voltage set point shall be capable to cover continuously the normal operational voltage range (article 18.1 and Annex III Table 4 and Table 5).

The TSO invokes the right to specify the settings for a dead band during the connection offer process.

The time t_1 within which 90% of the change in reactive power is reached is set to 1 second. The proposed parameter for the Time t_1 is aligned with the existing requirements for an Interconnector within the Northern Ireland Grid Code.

The time t_2 to achieve 100% of the change in reactive power is set to 5 seconds. The proposed parameter is aligned with the proposal within the RfG for PPM.

6.2.2.2.4 Reactive Power Control Mode

Article 22.4:

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

With regard to reactive power control mode, the relevant system operator shall specify a reactive power range in MVAr or in % of maximum reactive power, as well as its associated accuracy at the connection point, using the capabilities of the HVDC system, while respecting Articles 20 and 21.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum Reactive Power Range	Not specified	Site specific	22.4	HVDC Systems	3
Accuracy of Reactive Power	Not specified	5%	22.4	HVDC Systems	3

Table 42 – Reactive Power Control Mode

Justification:

During the connection offer process any limits to reactive power exchange with the network at the connection point resulting from control of reactive power in reactive power control mode will be identified, and the associated required accuracy. The limits are dependent on the location of the connection of the HVDC converter station within the AC system and so are site specific.

6.2.2.2.5 Power Factor Control Mode

Article 22.5:

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

For the purposes of power factor control mode, the HVDC converter station shall be capable of controlling the power factor to a target at the connection point, while respecting Articles 20 and 21. The available set points shall be available in steps no greater than a maximum allowed step specified by the relevant system operator.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum Allowed Step Change in Power Factor	Not specified	Site specific	22.5	HVDC Converter stations	3
Maximum Set Point Steps	Not Specified	0.01 pu (PowerFactor)	22.5	HVDC Converter stations	3

Table 43 – Power Factor Control Mode

Justification:

Site specific, depending on the interaction of the HVDC converter station with the network at the connection point.

During the connection offer process any limits to the allowed step change in power factor will be identified. The limits are dependent on the location of the connection of the HVDC converter station within the AC system and so are site specific.

The maximum set point steps have been chosen to provide an acceptable resultant change in voltage at the connection point, regardless of where the connection point is on the AC network.

6.2.2.2.6 Equipment to Select Control Modes Remotely

Article 22.6:

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

The relevant system operator in coordination with the relevant TSO shall specify any equipment needed to enable the remote selection of control modes and relevant set points.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Equipment	Not specified	Site specific	22.6	HVDC Converter Stations	3

Table 44 – Equipment to select control mode remotely

Justification:

At this point in time we leave this as site specific as technology develops. This parameter may be further developed in future.

6.2.3 Reactive Power Exchanged with Network

6.2.3.1 Reactive Power Exchanged with the Network

Article 21.1:

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

The HVDC system owner shall ensure that the reactive power of its HVDC converter station exchanged with the network at the connection point is limited to values specified by the relevant system operator in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum Reactive Power Range	Not specified	Site specific	21.1	HVDC Converter Stations	3

Table 45 – Reactive Power Exchanged with Network

Justification:

During the connection offer process any limits to reactive power exchange with the network at the connection point will be identified. The limits are dependent on the location of the connection of the HVDC converter station within the AC system and so are site specific.

6.2.3.2 Maximum Tolerable Voltage Steps for Reactive Power Variation

Article 21.2:

Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

The reactive power variation caused by the reactive power control mode operation of the HVDC converter station, referred to in Article 22(1), shall not result in a voltage step ($|\Delta u|$) exceeding the allowed value at the connection point. The relevant system operator, in coordination with the relevant TSO, shall specify this maximum tolerable voltage step value.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum Tolerable Voltage Step	Not specified	As per TSSPS	21.2	HVDC Converter Stations	3

Table 46 – Maximum Tolerable Voltage Steps for Reactive Power Variation

Justification:

This will be equivalent to the switching of reactive power provider which depends on the frequency of the operation. The Transmission System Security and Planning Standards (TSSSPS) stipulates a limit for switching of 3%. However if frequent changes occur then the TSSPS states that ER P28 could apply and a general limit of 1%.

6.2.4 Reactive Power Consumption of extra high voltage lines

6.2.4.1. Reactive Power Capability

Article 40.2(b)(ii)

Mandatory non-exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

With respect to reactive power capability for DC-connected power park modules:

(b) DC-connected power park modules shall fulfil the following requirements relating to voltage stability either at the time of connection or subsequently, according to the agreement as referred to in point (a):

(ii) With regard to reactive power capability, the relevant system operator may specify supplementary reactive power to be provided if the connection point of a DC-connected power park module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power exchange of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the DC-connected power park module or its alternator terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Right to specify supplementary reactive power requirements when the connection point is remote	To specify or not to specify	TSOs reserve the right to specify	Article 40.2 (b) (ii)	DC-connected PPM	3

Table 47 – Reactive Power consumption of extra high voltage lines

Justification:

The TSO invoke the right to specify supplementary reactive power requirements for remote connection points in order to align with the supplementary reactive power requirements. Any supplementary reactive power compensation required to offset the reactive power demand of the line or cable between the connection point and HVDC converter station site will be identified during the connection offer process.

6.2.5 Priority to active or reactive power

6.2.5.1 Priority Given to Active or Reactive Power Contribution for HVDC Systems

Article 23:

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

Taking into account the capabilities of the HVDC system specified in accordance with this regulation, the relevant TSO shall determine whether active power contribution or reactive power contribution shall have priority during low or high voltage operation and during faults for which fault-ride-through capability is required. If priority is given to active power contribution, its provision shall be established within a time from the fault inception as specified by relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Prioritisation requirements during FRT	Active / Reactive	Active	23	HVDC Systems	3

Table 48 – Priority given to Active or Reactive Power Contribution for HVDC Systems

Justification:

The proposal for HVDC converter station aligns with the requirements for PPM in the current Grid Code which stipulates that priority shall always be given to the active power response during and after faults within the capabilities of the PPM.

6.2.5.2 Priority Given to Active or Reactive Power Contribution for DC-connection Power Park Modules

Article 40.3:

Mandatory non-exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

With regard to priority to active or reactive power contribution for DC-connected power park modules, the relevant system operator, in coordination with the relevant TSO shall specify whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required. If priority is given to active power contribution, its provision shall be established within a time from the fault inception as specified by the relevant system operator, in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Prioritisation requirements during FRT	Active/Reactive	Active	Article 40.3	DC-connected PPMs	3

Table 49 – Priority Given to Active or Reactive Power Contribution for DC-Connected Power Park modules

Justification:

The proposal aligns with the RfG consultation, which stipulated that priority should always be given to the active power response during, and after faults within the capabilities of the DC connected PPM.

6.2.6 Short-circuit requirements

6.2.6.1 Short Circuit – Fast Fault Current Injection for Symmetrical and Asymmetrical Faults

Articles 19.1, 19.2 and 19.3

Non-Mandatory non-exhaustive parameter selection, with the exception of Articles 19.2 and 19.3 which are being made mandatory

Applies to HVDC Systems

Requirement:

Article 19.1:

If specified by the relevant system operator, in coordination with the relevant TSO, an HVDC system shall have the capability to provide fast fault current at a connection point in case of symmetrical (3-phase) faults.

Article 19.2:

Where an HVDC system is required to have the capability referred to in paragraph 1, the relevant system operator, in coordination with the relevant TSO, shall specify the following:

(a) how and when a voltage deviation is to be determined as well as the end of the voltage deviation;

(b) the characteristics of the fast fault current;

(c) the timing and accuracy of the fast fault current, which may include several stages.

Article 19.3:

The relevant system operator, in coordination the relevant TSO, may specify a requirement for asymmetrical current injection in the case of asymmetrical (1-phase or 2-phase) faults.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage threshold for fast fault current injection	Not specified	During voltage dips i.e. when the voltage is below 0.9 p.u.	19.2 & 19.3	HVDC Systems	3
End of the voltage deviation	Not specified	Once the voltage has recovered to within normal operating voltage range	19.2 & 19.3	HVDC Systems	3
the characteristics of the fast fault current, including	Not specified	Reactive current should be provided for the duration of the	19.2 & 19.3	HVDC Systems	3

the time domain for measuring the voltage deviation and fast fault current		voltage deviation within the rating of the PPM			
the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance	Not specified	Rise Time no greater than 100ms and a Settling Time no greater than 300ms.	19.2 & 19.3	HVDC Systems	3

Table 50 – Short – circuit – Fast Fault Current Injection for Symmetrical and Asymmetrical Faults

Justification:

The fast fault current injection for symmetrical faults for HVDC converter station has been aligned with the fast fault current injection of PPM requirements according to RfG.

As proposed with the RfG, the fast fault current injection shall be provided during Transmission System voltage dips.

The parameters chosen above align with the parameters in the Northern Ireland.

6.2.7 Fault – ride – through capability

6.2.7.1 Fault Ride Through Capability for HVDC Converter Stations

Article 25.1

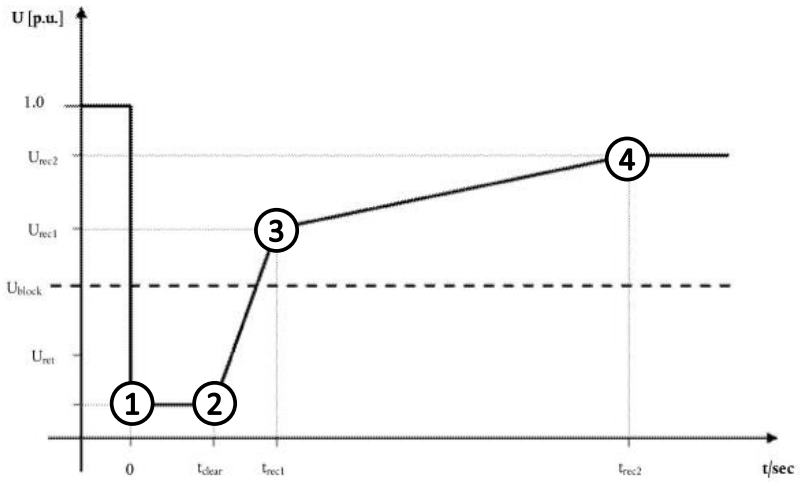
Mandatory non-exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

The relevant TSO shall specify, while respecting Article 18, a voltage-against time profile as set out in Annex V and having regard to the voltage-against-time-profile specified for power park modules according to Regulation (EU) 2016/631. This profile shall apply at connection points for fault conditions, under which the HVDC converter station shall be capable of staying connected to the network and continuing stable operation after the power system has recovered following fault clearance. The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before ($t < 0$), during ($0 \leq t \leq t_{clear}$) and after ($t_{clear} < t \leq t_{rec2}$) the fault. Any ride through period beyond t_{rec2} is in section or Article 18.

HVDC converter stations shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. That capability shall be in accordance with a voltage-against-time profile at the connection point for fault conditions in line the figure below.



Fault Ride Through Profile Example

The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical (Article 19.1) and asymmetrical (Article 19.3) fault, as a function of time before, during and after the fault. The voltage-against-time-profile is defined by the points 1 to 4 as follows:

Parameters:

Parameter	HVDC Parameter Range	Proposal	Article Number	Type Applicability	Justification Code
u_{ret}	0.00 – 0.3 pu	0.0 pu	25.1	HVDC Converter Stations	3
t_{clear}	0.14 – 0.25 s	0.15 s	25.1	HVDC Converter Stations	3
u_{rec1}	0.25 – 0.85 pu	0.85 pu	25.1	HVDC Converter Stations	3
t_{rec1}	1.5 – 2.5 s	2.5 s	25.1	HVDC Converter Stations	3
u_{rec2}	0.85 – 0.9 pu	0.9 pu	25.1	HVDC Converter Stations	3
t_{rec2}	t_{rec1} – 10.0 s	10.0 s	25.1	HVDC Converter Stations	3

Table 51 - Fault Ride Through Capability for HVDC Converter Stations

Justification:

The parameters chosen above are as closely aligned as possible within the range provided to the previous proposals for a Power Park Module (within the RfG).

6.2.7.2 Voltage level the HVDC Converter Station Blocks

Article 25.4:

Non-Mandatory non- exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant TSO may specify voltages (U_{block}) at the connection points under specific network conditions whereby the HVDC system is allowed to block. Blocking means remaining connected to the network with no active and reactive power contribution for a time frame that shall be as short as technically feasible and which shall be agreed between the relevant TSOs and the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
ublock	Not specified	Site specific	Article 25.4	HVDC Systems	3

Table 52 – Voltage Level the HVDC Converter Station Blocks

Justification:

The allowed blocking voltage would be determined following a set of system studies, pertaining to the proposed connection point. Furthermore, evaluating this on a case-by-case basis will allow advances to be incorporated.

6.2.7.3 Fault Ride Through Capability in case of asymmetrical faults

Article 25.6:

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant TSO shall specify fault-ride-through capabilities in case of asymmetrical faults.

Parameters:

Parameter	HVDC Parameter Range	Proposal	Article Number	Type Applicability	Justification Code
u_{ret}	0.00 – 0.3 pu	0.0 pu	25.1	HVDC systems	3
t_{clear}	0.14 – 0.25 s	0.15 s	25.1		
u_{rec1}	0.25 – 0.85 pu	0.85 pu	25.1		
t_{rec1}	1.5 – 2.5 s	2.5 s	25.1		
u_{rec2}	0.85 – 0.9 pu	0.9 pu	25.1		
t_{rec2}	t_{rec1} – 10.0 s	10.0 s	25.1		

Table 53 – Fault Ride Through Capability in case of asymmetrical faults

Justification:

The parameters chosen above are as closely aligned as possible within the range provided to the previous proposals for a Power Park Module (within the RfG).

6.2.7.4 Post Fault Active Power Recovery

Article 26:

Mandatory exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant TSO shall specify the magnitude and time profile of active power recovery that the HVDC system shall be capable of providing, in accordance with Article 25

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
when the post-fault active power recovery begins, based on a voltage criterion	Not specified	u_n< 0.9 pu	26	HVDC Systems	3
maximum allowed time for active power recovery	Not specified	500ms/1s	26	HVDC Systems	3
magnitude and accuracy for active power recovery	Not specified	90%	26	HVDC systems	3

Table 54 – Post Fault Active Power Recovery

Justification:

The proposals are aligned with the proposed Active Power Recovery for PPMs within the RfG. These were in turn aligned to the existing requirements for WFPS within the SONI Grid Code.

6.2.8 Power Quality

6.2.8.1 Power Quality for HVDC Systems

Article 24:

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

An HVDC system owner shall ensure that its HVDC system connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level specified by the relevant system operator in coordination with the relevant TSO. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Level of voltage distortion or fluctuation of the supply voltage at the connection point	Not specified	ER G5/4-1 Harmonics ER P28 Voltage fluctuation	24	HVDC Systems	3

Table 55 – Power Quality for HVDC Systems

Justification:

These are the limits as established by the Transmission System Security and Planning Standards and align with the limits set in the Requirement for Generators and Demand Connection Codes.

6.2.8.2 Power Quality for DC-connected PPMs

Article 44

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

DC-connected power park modules owners shall ensure that their connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level specified by the relevant system operator, in coordination with the relevant TSO. The necessary contribution from grid users to associated studies, including, but not limited to, existing DC-connected power park modules and existing HVDC systems, shall not be unreasonably withheld. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage and distortion limits	To be specified by the relevant TSO	To be site specific	44	DC-connected PPMs	3

Table 56 – voltage and distortion limits

Justification:

This requirement will need to be implemented on a site specific basis due to:

- Varying station and/or HVDC system configurations
- Compatibility with existing equipment
- Operational constraints

6.2.8.3 Power Quality for remote-end HVDC Converter Stations

Article 50

Mandatory exhaustive parameter selection

Applies to Remote-end HVDC Converter stations

Requirement:

Remote-end HVDC converter station owners shall ensure that their connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level allocated to them by the relevant system operator, in coordination with the relevant TSO. The necessary contribution from grid users to the associated studies shall not be unreasonably withheld, including from, but not limited to, existing DC-connected power park modules and existing HVDC systems. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented shall be in accordance with the process provided for in Article 29.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage and distortion limits	To be specified by the relevant TSO	To be site specific	50	Remote-end HVDC Convertor stations	3

Table 57 – Power Quality for remote-end HVDC Converter Stations

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types;
(b) Localised short circuit level
(c) Local modes of Oscillation
(d) Compatibility with existing equipment

6.3 System Restoration

The non-exhaustive and non-mandatory frequency parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Power Oscillation Damping Capability
- System Restoration

6.3.1 Power Oscillation Damping Capability

6.3.1.1 Frequency range for oscillations

Article 30

Applies to HVDC Systems

Mandatory non - exhaustive parameter selection

Requirement:

The HVDC system shall be capable of contributing to the damping of power oscillations in connected AC networks. The control system of the HVDC system shall not reduce the damping of power oscillations. The relevant TSO shall specify a frequency range of oscillations that the control scheme shall positively damp and the network conditions when this occurs, at least accounting for any dynamic stability assessment studies undertaken by TSOs to identify the stability limits and potential stability problems in their transmission systems. The selection of the control parameter settings shall be agreed between the relevant TSO and the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Frequency range for oscillations	To be specified by the TSO	Site specific	30	HVDC System	3

Table 58 – Frequency range for oscillations

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(e) Varying station and/or HVDC system configuration and types;
(f) Localised short circuit level
(g) Local modes of Oscillation
(h) Compatibility with existing equipment

6.3.1.2 SSTI Study requirements

Article 31.2

Mandatory non- exhaustive parameter selection

Applies HVDC Systems

Requirement:

The relevant TSO shall specify the necessary extent of SSTI studies and provide input parameters, to the extent available, related to the equipment and relevant system conditions in its network. The SSTI studies shall be provided by the HVDC system owner. The studies shall identify the conditions, if any, where SSTI exists and propose any necessary mitigation procedure. Member States may provide that the responsibility for undertaking the studies in accordance with this Article lies with the TSO. All parties shall be informed of the results of the studies.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Specification of extent of SSTI and parameters	To be specified by the TSO in due for plant design	To be specified on a case by case	31.2	HVDC System Owners	3

Table 59 – SSTI Study Requirements

Justification:

The proposal is to specify these requirements on the case – by – case basis, taking into considering:

- The proximity of HVDC converter to power generation modules
- The electrical characteristics of the local network
- The torsional modes of existing generation in the vicinity
- The characteristics of the HVDC converter

6.3.1.3 Relevant parties at a connection point

Article 31.3

Mandatory non-exhaustive parameter selection

Applies to relevant parties

Requirement:

All parties identified by the relevant TSO as relevant to each connection point, including the relevant TSO, shall contribute to the studies and shall provide all relevant data and models as reasonably required to meet the purposes of the studies. The relevant TSO shall collect this input and, where applicable, pass it onto the party responsible for the studies in accordance with article 10.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Identify all parties relevant at the connection point	In due time for plant design	Develop necessary process for the management of date during the implementation phase	31.3	All parties relevant parties at the connection point	3

Table 60 – Relevant parties at a connection point

Justification:

It is proposed to develop the necessary process for the collection of the necessary inputs and the management of this data during the implementation phase of the HVDC.

6.3.2 Blackstart

6.3.2.1 Procurement of Blackstart

Article 37.1

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The relevant TSO may obtain a quote for black start capability from an HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Obtain quote for black start	TSO to obtain	Retain the existing services process	37.1	HVDC Systems	1

Table 61 – Procurement of Blackstart services

Justification:

The TSO currently has a procedure in place for the obtaining of services, such as black start. It is proposed to retain the existing process.

6.3.2.2 Time frame and voltage limits to energise an AC busbar during blackstart

Article 37.2:

Non-mandatory being made mandatory

Applies to HVDC Systems with Black start capabilities

Requirement:

An HVDC system with black start capability shall be able, in case one converter station is energised, to energise the busbar of the AC-substation to which another converter station is connected, within a timeframe after shut down of limits set out in Article 11 and within the voltage limits specified by the relevant TSO or as provided for in Article 18, where applicable. Wider frequency and voltage ranges can be specified by the relevant TSO where needed in order to restore system security.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Time frame and voltage limits to energise the AC busbar with start, with wider frequency and voltage ranges	In due time for plant design	Site Specific	37.2	HVDC system with black start capabilities	3

Table 62 – Time frame and voltage limits to energise an AC busbar during blackstart

Justification:
The proposal to specify this requirement as site – specific is to allow for a number of factors to be taken into consideration:

- Varying nature blackstart situation
- Availability of plant, including transmission plant during blackstart situation
- Availability of staff during a blackstart situation

These elements are included as part of to the System Restoration plan.

6.3.2.3 Capacity and availability of black start capability

Article 37.3:

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The relevant TSO and HVDC system owner shall agree on the capacity and availability of the black start capability and the operational procedure.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Capacity and availability of black start	To be agreed between the TSO and the HVDC system owners	To be agreed on a case by case basis	37.3	HVDC systems	1

Table 63 – Capacity and availability of blackstart capability

Justification:

The TSO is proposing to retain the current process of agreeing the capacity and availability of the black start capability and the operational procedure on a case by case basis, as this allows both the system needs and the HVDC system characteristics to be taken into consideration.

6.4 Instrumentation, simulation models and protection

The non-exhaustive and non-mandatory frequency parameters cover a number of different requirements. The following sub-themes are discussed in the next sections:

- Interaction between HVDC Systems and other plant / equipment
- Electrical Protection Schemes and settings
- Synchronisation
- Network characteristics
- Output signals
- Power Oscillations and damping capability
- HVDC Robustness
- Power Quality

6.4.1 Interaction between HVDC Systems and other plant / equipment

6.4.1.1 Interaction between HVDC Systems and other plant / equipment

Article 29.2

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The studies shall be carried out by connecting the HVDC system owner with the participation of all other parties identified by the TSOs as relevant to each connection point. Member States may provide that the responsibility for undertaking the studies in accordance with this Article lies with the TSO. All parties shall be informed of the results of the studies.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Specify study required to examine interaction with adjacent equipment	TO be specified by TSO	Grid Code Appendix A – Planning Data requirements for Users (other than the DNO) connected to the transmission system only to be modified to include the relevant study requirements and parameters for HVDC System	29.2	HVDC Systems	3

Table 64 – Interaction between HVDC Systems and other plant / equipment

Justification:

Currently, Appendix A – Planning Data Requirements for Users (other than DNO) connected to the transmission system only does not contain any data requirements or parameters for HVDC system. It is proposed to modify the Appendix A to include the necessary requirements and parameters including these required for purpose of system and other studies.

6.4.1.2 Identification of all parties relevant to studies

Article 29.3

Mandatory non- exhaustive parameter selection

Applies to relevant parties

Requirement:

All parties identified by the relevant TSO as relevant to each connection point, including the relevant TSO, shall contribute to the studies and shall provide all relevant data and models as reasonably required to meet the purposes of the studies. The relevant TSO shall connect this input and, where applicable, pass it on to the party responsible for the studies in accordance with Article 10.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
All relevant parties to studies	Specify all other relevant parties to the study	TSO to develop process for identification of all relevant parties during the implementation phase.	29.3	All parties relevant to studies	3

Table 65 – Identification of all parties relevant to studies

Justification:

As part of the implementation phase, the TSO will develop a process for the identification of all relevant parties, who must contribute to the study and provide all relevant information, including all necessary models.

6.4.1.3 Models and information requirements

Article 29.4

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant TSO shall assess the result of the studies based on their scope and extent as specified in accordance with paragraph 1. If necessary for the assessment, the relevant TSO may request the HVDC system owner to perform further studies in line with the scope and extent specified in accordance with paragraph 1.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Model / information for in studies	To be specified by the TSO	Case by case basis	29.4	HVDC System Owner	3

Table 66 – Models and information requirements

Justification:

The need for any further studies, in addition to those required under Article 29.2 and 29.3, will be determined on a case-by-case basis.

6.4.2 Electrical protection schemes and settings

6.4.2.1 Specification of Electrical protection schemes and settings

Article 34.1

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant system operator shall specify, in coordination with the relevant TSO, the schemes and settings necessary to protect the network taking into account the characteristics of the HVDC system. Protection schemes relevant for the HVDC system and the network, and settings relevant for the HVDC system, shall be coordinated and agreed between the relevant system operator, the relevant TSO and the HVDC system owner. The protection schemes and settings for internal electrical faults shall be designed so as not to jeopardise the performance of the HVDC system in accordance with this Regulation.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Specification of protection schemes and settings	To be specified by TSO	Site specific	34.1	HVDC Systems	3

Table 67 – Specification of electrical protection schemes and settings

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types; and
(b) Compatibility with existing equipment
(c) Need for Special Protection Schemes

6.4.2.2 Agreement of Electrical protection schemes and settings

Article 34.3

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

Any changes to the protection schemes or their settings relevant to the HVDC system and the network shall be agreed between the system operator, the relevant TSO and the HVDC system owner before being implemented by the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Agreement of protection schemes and settings	To be agreed between the relevant TSO and the HVDC system owner	Necessary process to be developed during implementation phase.	34.3	HVDC Systems	3

Table 68 – Agreement of Electrical protection schemes and settings

Justification:

The business process for the agreement of the necessary protection schemes and settings between the TSO and aHVDC system owner will be developed as part of the implementation phase of the HVDC code.

6.4.2.3 Agreement of Control schemes, including the necessary settings

Article 35.1

Mandatory non - exhaustive parameter selection

Applies to HVDC Systems

Requirement:

A control scheme, specified by the HVDC system owner consisting of different control modes, including the settings of the specific parameters, shall be coordinated and agreed between the relevant TSO, the relevant system operator and the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Control scheme, including settings to be agree between the relevant TSO and HVDC system owner.	To be agreed between the relevant TSO and the HVDC system owner	It will be necessary to develop a process during the implementation phase.	34.3	HVDC Systems	3

Table 69 – Agreement of Control schemes

Justification:

The business process for the agreement of the necessary protection schemes and settings between the TSO and the HVDC system owner will be developed as part of the implementation phase of the HVDC.

6.4.2.4 Priority rating of protection and control for HVDC systems

Article 35.2

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

With regard to priority rating of protection and control, the HVDC system owner shall organise its protection and control devices in compliance with the following priority ranking, listed in decreasing order of importance, unless otherwise specified by the relevant TSOs, in coordination with the relevant system operator:

(a) Network system and HVDC system protection;
(b) Active power control for emergency assistance;
(c) Synthetic inertia, if applicable;
(d) Automatic remedial actions as specified in Article 13(3);
(e) LFSM;
(f) FSM and frequency control; and
(g) Power gradient constraint.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Priority rating of protection and control for HVDC systems	Change to priority order of protection and control	Process to be developed during implementation phase.	35.2	HVDC Systems	3

Table 70 – priority rating of protection and control for HVDC systems

Justification:

The business process for the reprioitisation of the protection and control of HVDC systems, inlcuding the agreement of any repriorisation between the TSO and the HVDC System owner, will be developed as part of the implementation phase of the HVDC code.

6.4.2.5 Changes to protection and control schemes and settings

Article 36.1

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The parameters of the different control modes and the protection settings of the HVDC system shall be able to be amended or changed in the HVDC converter station, if required by the relevant system operator or the relevant TSO, and in accordance with paragraph 3.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Changes to the control modes of HVDC Systems	Changes to the control modes of HVDC Systems, if required by the TSO	Process to be developed during the implementation phase	36.1	HVDC systems	3

Table 71 – Changes to protection and control schemes and settings

Justification:

The process for the changing of the control mode of a HVDC system will be developed as part of the implementation phase of the HVDC code.

6.4.2.6 *Coordination and agreement of changes to schemes and settings of a HVDC System Control modes*

Article 36.2

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

Any change to the schemes or settings of parameters of the different control modes and protection of the HVDC system, including the procedure, shall be coordinated and agreed between the relevant system operator, the relevant TSO and the HVDC system owner.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Coordination and agreement of changes	Coordination and agreement between the TSO and HVDC owner for changes to the schemes or settings of parameters of the different control modes and protection of the HVDC system, including the necessary procedure	Process to be developed during the implementation phase	36.2	HVDC Systems	3

Table 72 – Coordination and agreement of changes to schemes and settings of HVDC System Control Modes

Justification:

The process for the coordination and agreement between the TSO and HVDC owner for changes to the schemes or settings of parameters of the different control modes and protection of the HVDC system, including the necessary procedure, will be developed as part of the implementation phase of the HVDC.

6.4.2.7 *Equipment specification for remote control of control modes and set points*

Article 36.3

Non-mandatory being made mandatory

Applies to HVDC Systems

Requirement:

The control modes and associated set points of the HVDC system shall be capable of being changed remotely, as specified by the relevant system operator, in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Equipment specification to enable remote control of control modes and set points	To be specified by the relevant system operator	Site specific	36.3	HVDC systems	3

Table 73 – Equipment specification for remote control of control modes and set points

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types; and

(b) Compatibility with existing equipment

6.4.2.8 Provision of protection requirements

Article 43.1

Mandatory non-exhaustive parameter selection

Applies to DC – connected Power Park Modules

Requirement:

Electrical protection schemes and settings of DC-connected power park modules shall be determined in accordance with Article 14(5)(b) of Regulation (EU) 2016/631, where the network refers to the synchronous area network. The protection schemes have to be designed taking into account the system performance, grid specificities as well as technical specificities of the power park module technology and agreed with the relevant system operator, in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Provision of protection requirements	To be agreed with the RSO, in coordination with the TSO	Site specific	43.1	DC-Connected PPMs	1

Table 74 – provision of protection requirements

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types;
(b) Compatibility with existing equipment; and
(c) Operational constraints which may drive the need for special protection schemes.

6.4.3 Network Characteristics

6.4.3.1 Minimum and maximum short circuit power at the connection point

Article 32.1

Mandatory non-exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The relevant system operator shall specify and make publicly available the method and the pre-fault and post-fault conditions for the calculation of at least the minimum and maximum short circuit power at the connection point.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Minimum and maximum short circuit power at the connection point	RSO shall make publically available	The TSO also make the short circuit levels for all existing transmission stations publically available as part of the ten year transmission forecast statement	32.1	HVDC Systems	1

Table 75 – minimum and maximum short circuit power at the connection point

Justification:

The necessary short – circuit levels are already currently available on an individual transmission station level in the Ten Year Transmission Forecast Statement.

6.4.3.2 Publication of method for calculation of minimum and maximum short circuit power

Article 42(a)

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

Article 42(a):

With regard to the network characteristics, the following shall apply for the DC-connected power park modules:

(a) each relevant system operator shall specify and make publicly available the method and the pre-fault and post-fault conditions for the calculation of minimum and maximum short circuit power at the HVDC interface point

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Calculation of minimum and maximum short circuit power	RSO to specify and publish method for the calculation of minimum and maximum short circuit power	To be published during implementation phase of the HVDC network code	42(b)	DC-connected PPMs	3

Table 76 – Publication of method for calculation of minimum and maximum short circuit power

Justification:

As part of the implementation phase of the TSO will specify and publish to their website the method and the pre-fault and post-fault conditions for the calculation of minimum and maximum short circuit power at the HVDC interface points.

6.4.3.3 Maximum to minimum short circuit range

Article 42(b)

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

With regard to the network characteristics, the following shall apply for the DC-connected power park modules:

(b) the DC-connected power park module shall be capable of stable operation within the minimum to maximum range of short circuit power and network characteristics of the HVDC interface point specified by the relevant system operator, in coordination with the relevant TSO

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Maximum to minimum short circuit range	To be specified by the relevant system operator, in coordination with the relevant TSO.	Site specific	42(b)	DC-connected PPMs	1

Table 77 – Maximum to minimum short circuit range

Justification:

This requirement will need to be implemented on a site specific basis due to:

- Varying station and/or HVDC system configurations
- Compatibility with existing equipment

6.4.3.4 Provision of network equivalent

Article 42(c)

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

Article 42(c):

With regard to the network characteristics, the following shall apply for the DC-connected power park modules:

(a) each relevant system operator and HVDC system owner shall provide the DC-connected power park module owner with network equivalents representing the system, enabling the DC-connected power park module owners to design their system with regard to harmonics

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Provision of network equivalent for harmonic studies	In due time for plant design	In due time for plant design	42(c)	DC-connected PPMs	3

Table 78 – Provision of network equivalent

Justification:

The relevant network equivalents representing the system will be provide in due time for the plant design.

6.4.4 HVDC Robustness

Article 33.1

Mandatory exhaustive parameter selection

Applies to HVDC Systems

Requirement:

The HVDC system shall be capable of finding stable operation points with a minimum change in active power flow and voltage level, during and after any planned or unplanned change in the HVDC system or AC system to which it is connected. The relevant TSO shall specify the changes in the system conditions for which the HVDC systems shall remain in stable operation.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
The changes in the system conditions for which the HVDC systems shall remain in stable operation	To be specified by TSO	Frequency and voltage requirements as per sections 5.1 and 5.2 above. Short circuit levels will be site specific.	33.1	HVDC Systems	2

Table 79 – HVDC Robustness

Justification:

The changes to the system frequency and voltages shall be as proposed in sections 5.1 and 5.2 above for Articles 11 and 18 of the HVDC.

In relation to the changes to short – circuit levels, these changes shall be specified on the site specific basis, due to:

(a) Varying station and/or HVDC system configuration and types; and
(b) Compatibility with existing equipment

6.4.5 Power Quality

6.4.5.1 Voltage and distortion limits

Article 44

Mandatory exhaustive parameter selection

Applies to DC-connected Power Park Modules

Requirement:

DC-connected power park modules owners shall ensure that their connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level specified by the relevant system operator, in coordination with the relevant TSO. The necessary contribution from grid users to associated studies, including, but not limited to, existing DC-connected power park modules and existing HVDC systems, shall not be unreasonably withheld. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Voltage and distortion limits	To be specified by the relevant TSO	To be site specific	44	DC-connected power park modules	3

Table 80 – voltage and distortion limits

Justification:

This requirement will need to be implemented on a site specific basis due to:

- Varying station and/or HVDC system configurations
- Compatibility with existing equipment
- Operational constraints

6.4.6 Output signals for DC-connected Power Park Modules

Article 41.2

Mandatory non - exhaustive parameter selection

Applies to DC-Connected Power Park Modules

Requirement:

The DC-connected power park module owner shall provide output signals as specified by the relevant system operator, in coordination with the relevant TSO.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Output signals	Specify required output signals	Site-specific	41.2	DC-connected PPMs	3

Table 81 – Output signals for DC-connected Power Park Modules

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types;
(b) Varying need and use of control and protection schemes, including SPSs; and
(c) Compatibility with existing equipment;

6.4.7 Power Oscillation and Damping during the synchronisation of a HVDC converter station

Article 28

Non- Mandatory non-exhaustive parameter selection

Applies to HVDC Converter stations

Requirement:

Unless otherwise instructed by the relevant system operator, during the energisation or synchronisation of an HVDC converter station to the AC network or during the connection of an energised HVDC converter station to an HVDC system, the HVDC converter station shall have the capability to limit any voltage changes to a steady-state level specified by the relevant system operator in coordination with the relevant TSO. The level specified shall not exceed 5 per cent of the pre-synchronisation voltage. The relevant system operator, in coordination with the relevant TSO, shall specify the maximum magnitude, duration and measurement window of the voltage transients.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Limits (including transient max. magnitude, duration and measurement window) of any voltage change to steady-state level	Not greater than 5 % of pre-synchronisation voltage	Site specific but not greater than 5 % of pre-synchronisation voltage	28	HVDC converter stations	3

Table 82- Power Oscillation and damping during the synchronisation of a HVDC converter station

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types;
(b) Compatibility with existing equipment;

6.4.8 Power Oscillation and Damping during the synchronisation of a DC-connected Power Park Module

Article 41.1

Mandatory non- exhaustive parameter selection

Applies to HVDC Converter Stations

Requirement:

During the synchronisation of a DC-connected power park module to the AC collection network, the DC-connected power park module shall have the capability to limit any voltage changes to a steady-state level specified by the relevant system operator, in coordination with the relevant TSO. The level specified shall not exceed 5 per cent of the pre-synchronisation voltage. The relevant system operator, in coordination with the relevant TSO, shall specify the maximum magnitude, duration and measurement window of the voltage transients.

Parameters:

Parameter	Parameter in HVDC	Submission Proposal	Article Number	Type Applicability	Justification Code
Limits (including transient max. magnitude, duration and measurement window) of any voltage change to steady-state level	Not greater than 5 % of pre-synchronisation voltage	Site specific but not greater than 5 % of pre-synchronisation voltage	41.1	HVDC converter station	3

Table 83 – Power Oscillation and Damping during the synchronisation of a DC-connected Power Park Module

Justification:

This requirement will need to be implemented on a site-specific basis due to:

(a) Varying station and/or HVDC system configuration and types; and

(b) Compatibility with existing equipment;

6.5 General Issues

The non-exhaustive and non-mandatory frequency parameters cover a number of different requirements.

6.5.1 Scope for offshore power park modules

Article 38:

Mandatory exhaustive parameter selection

Requirement:

The requirements applicable to offshore power park modules under Article 13 to 22 of Regulation (EU) 2016/631 shall apply to DC-connected power park modules subject to specific requirements provided for in Article 41 to 45 of this Regulation. These - requirements shall apply at the HVDC interface points of the DC-connected power park module and the HVDC systems. The categorisation in Article 5 of Regulation (EU) 2016/631 shall apply to DC-connected power park modules.

Note:

Included for information purposes.

6.5.2 Scope for offshore power park modules

Article 38:

Mandatory exhaustive parameter selection

Requirement:

The requirements applicable to offshore power park modules under Article 13 to 22 of Regulation (EU) 2016/631 shall apply to DC-connected power park modules subject to specific requirements provided for in Article 41 to 45 of this Regulation. These - requirements shall apply at the HVDC interface points of the DC-connected power park module and the HVDC systems. The categorisation in Article 5 of Regulation (EU) 2016/631 shall apply to DC-connected power park modules.

Note:

Included for information purposes.

6.5.3 General System Management Requirements Applicable to DC-Connected Power Park Modules

Article 45

Mandatory exhaustive parameter selection

Requirement:

With regard to general system management requirements, Articles 14(5), 15(6) and 16(4) of Regulation (EU) 2016/631 shall apply to any DC-connected power park module.

Note:

Included for information purposes.

6.5.4 Scope for remote-end HVDC converter stations

Article 46:

Mandatory exhaustive parameter selection

Requirement:

The requirements of Articles 11 to 39 apply to remote-end HVDC converter stations, subject to specific requirements provided for in Articles 47 to 50.

Note:

Included for information purposes.

7. Conclusion

This concludes SONI's submission to the commission for the Utilities Regulator of the proposal for the general application of technical requirements in accordance with Articles 11- 50 of the Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current.

SONI would now like to request the approval of the Utilities Regulator for each of the requirements proposed in this document.

8. Appendix

The following appendix holds the submission from industry in relation to the Consultation on the proposals within this document.

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SONI
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7th December 2018

Re: SONI proposal for the general application of technical requirements in accordance with Articles 11 – 50 of the Commission Regulation (EU) 2016/1447 establishing a network code on high voltage direct current systems and direct current-connected power park modules

Moyle Interconnector Limited ('Moyle') welcomes the opportunity to respond to this SONI consultation on Northern Ireland parameters to be applied for technical requirements under Commission Regulation 2016/1447 (the HVDC network code, 'the HVDC'). Moyle's response is from the perspective of an existing HVDC interconnector owner.

In general Moyle agrees with the principles set out in the consultation document (section 3.1):

- where the requirement provided in the HVDC is an existing requirement in Northern Ireland to make the requirement mandatory under the HVDC; and
- where the requirement in the HVDC is not an existing requirement in Northern Ireland the requirement is not made mandatory under the HVDC.

And where the value of a parameter needs to be set:

- to apply the existing Northern Ireland parameter value where possible;
- where application of the existing Northern Ireland parameter is not permitted, to apply a value as close as permissible;
- where the HVDC does not specify a parameter value and a parameter value exists in Northern Ireland, to use the existing Northern Ireland value; and
- where the HVDC does not specify a parameter value and no parameter value exists in Northern Ireland the SO provides justification for selection of the value.

Such an approach minimises the burden of implementation of and satisfactory compliance with the HVDC. Alignment of certain parameters with the RfG should help to ensure a consistent approach across the transmission system.

Moyle notes that, with the exception of articles 26, 31, 33 and 50, the HVDC does not apply to existing HVDC systems[i], such as Moyle. With this in mind, Moyle offers no objection to the parameters proposed by SONI under any article.

Moyle notes that the requirements SONI has proposed under many articles are 'to be site-specific' or 'to be specified on a case by case basis'. This is an appropriate approach since HVDC units are likely to be of large capacity relative to the AC system but small in number, therefore implying that a bespoke treatment is in proportionate to ensure compatibility of the HVDC and AC systems.

In the event that Moyle in the future undertakes such significant modifications that its connection agreement must be substantially revised[ii], Moyle welcomes SONI's position on these articles. In such

a situation Moyle would further welcome timely engagement between the SO and the HVDC system owner to ensure early selection of appropriate parameters.

[i] Article 4.
[ii] Article 4.