EirGrid and ESB Networks' proposal for the general application of technical requirements in accordance with Articles 13 – 28 of the Commission Regulation (EU) 2016/631 establishing a network code on requirements for grid connection of generators

20th December 2017

Updated with clarifications 17th January 2018

NETWORKS

Disclaimer

This consultation is published for general information purposes only. Neither EirGrid as the Transmission System Operator (TSO), ESB Networks DAC as the Distribution System Operator (DSO), nor ESB as the licensed owner of the Transmission and Distribution System:

(i) makes any warranty, representation or undertaking of any kind (express or implied) with respect to the information contained in this document (including its accuracy or completeness); or

(ii) shall under any circumstances be liable, whether in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise, for any loss or damage, direct or indirect, financial or otherwise, arising as a result of, or in connection with, the use of this document or any reliance on the information it contains. Any and all such liability is expressly excluded to the fullest extent permitted by law. The use of information contained within this consultation paper for any form of decision making is done at the user's sole risk.

Table of Contents

Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted: Default
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted
Formatted

Formatted: Default
Formatted: Default
Formatted: Default
Formatted: Default
Formatted: Default
Formatted: Default

1. Introduction

On the 17th May 2016 the Commission Regulation (EU) 2016/631 establishing a network code on requirements for grid connection of generators[1] (hereafter referred to as 'RfG') entered into force.

Field Code Changed

This public consultation document is produced jointly by EirGrid plc in its role as the Transmission System Operator in Ireland (hereafter referred to as the 'TSO') and ESB Networks in their role as the Distribution System Operator in Ireland (hereafter referred to as the 'DSO'). References in this document to the Relevant System Operator (hereafter referred to as the 'RSO') mean the operator of the system to which the generator is connected i.e. either the TSO or DSO.

The requirements of the RfG apply from three years after its publication as per Article 72. The requirements of RfG do not apply to existing Power Generating Modules (PGMs). A PGM is defined in Article 4 as existing if:

> (a) It is already connected to either the transmission or distribution network in Ireland by two years after entry into force of the RfG (17th May 2018); or
>
> (b) The power-generating facility owner has concluded a final and binding contract for the purchase of the main generating plant by two years after entry into force of the RfG (17th May 2018).

It should be noted that whilst the RfG does not apply to existing PGMs as per the above, should a PGM owner substantially modify their generation plant then certain requirements of the RfG will apply to that generation plant.

The requirements in RfG apply to generators with a Maximum Capacity[2] of 800 W or greater connecting to either the transmission or distribution networks in Ireland. These requirements cover different technical criteria and apply to generators based on their RfG Classification Type[3] (i.e. A, B, C and D).

Under Article 7 (4) the RSO or TSO is required to submit a proposal for requirements of general application for approval by the Commission for Regulation of Utilities (CRU) within two years of entry into force of this Regulation i.e. 17th May 2018. It is not a requirement of RfG to consult upon the proposal for requirements of general application prior to submission to the CRU. The TSO and DSO are issuing this consultation document in the interest of transparency and to ensure that the TSO and DSO have the best information available to them to submit an appropriate set of recommendations to the CRU for the proposal of requirements of general application.

The TSO and DSO are consulting on the non-mandatory requirements and non-exhaustive[4] parameters in accordance with the requirements set out in Title II, Articles 13-28 of the RfG. This consultation document seeks readers' views on new or changed technical requirements that may or will apply to generators.

[1] https://publications.europa.eu/en/publication-detail/-/publication/1267e3d1-0c3f-11e6-ba9a-01aa75ed71a1/language-en

Field Code Changed

[2] Refer to section 3.4 for more information on the definition of Maximum Capacity.
[3] Refer to section 3.2 for more information on the different types and bands within RfG
[4] Refer to section 3.1 for more information on non-exhaustive parameters and non-mandatory requirements.

An equivalent consultation is being run concurrently by SONI Ltd in its role as the Transmission System Operator in Northern Ireland and by Northern Ireland Electricity Networks in its role as the Distribution System Operator in Northern Ireland.

1.1. Associated documents

The TSO and DSO strongly recommend that all readers review the RfG Network Code, The RfG Consultation on Banding Thresholds in Ireland[5] and the RfG Banding Threshold Consultation Minded to Position in Ireland[6].

Field Code Changed
Field Code Changed
Field Code Changed

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

1.2. Definitions and Interpretations

For the purposes of this consultation document, terms used in this document shall have the meaning of the definitions included in Article 2 of RfG

In this consultation 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 consultation; 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.

1.3. Structure of this document

Sections 2 & 3 'Background' and 'Scope' provide important information that guide the reader through the RfG concepts and the principles underpinning this consultation document.

Section 4 sets out the proposals that are being discussed in this consultation document. It details the proposal, justification and applicability of parameter or requirement as applicable.

In this document we have grouped parameters by technical theme, with a number of sub-themes discussed under each theme. Within each theme we go into detail on which parameter or requirement applies to each generator type. The themes are:

1. Frequency
2. Voltage
3. System Restoration
4. Protection & Instrumentation

---

[5] http://www.eirgridgroup.com/site-files/library/EirGrid/RfG-Banding-Thresholds-Consultation-Ireland.pdf

Field Code Changed

[6] http://www.eirgridgroup.com/site-files/library/EirGrid/RfG-Banding-Thresholds-Consultation_Minded-To-Position_Ireland.pdf

Field Code Changed

2. Scope

The scope of this consultation is to seek your views on the TSO and DSO proposals for:

- making non-mandatory requirements mandatory; and
- parameter selection for the non-exhaustive parameters.

Note this consultation does not seek your views on the mandatory requirements or exhaustive parameters. These have been set by the Commission and cannot be changed. Further information on some of the background to these decisions is available in the ENTSO-E FAQ document[7].

Field Code Changed

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

[7] http://www.acer.europa.eu/Media/News/Documents/120626%20-%20NC%20RfG%20-%20Frequently%20Asked%20Questions%20(2).pdf

Field Code Changed

3. Background

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

To give effect to this concept the RfG 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/DSO/RSO as appropriate
- A non-mandatory requirement is one which the TSO/DSO/RSO as appropriate may choose to apply
- An exhaustive parameter has a specified value or range in the RfG which the TSO/DSO/RSO as appropriate must apply
- A non-exhaustive parameter is one for which either:
    - the RfG provides a range from which the TSO/DSO/RSO as appropriate must select the applicable value for their region.
    - Or the RfG does not specify a value and the TSO/DSO/RSO as appropriate must select the applicable value for their region

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

2.1. Principles underpinning the Proposals

Many of the requirements for general application exist in Ireland today in the Grid and/or Distribution Codes. Furthermore, many parameters and requirements in the Grid and Distribution Codes have been updated in recent years as a result of the work carried out under the DS3 Programme[8]. It is not intended to revisit this work.

Field Code Changed

Non-Mandatory Requirement Selection

In the majority of cases the following assumptions are made:

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

Non-Exhaustive Parameter Selection

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

[8] http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

Field Code Changed

1. RfG requests that the TSO/DSO/RSO selects the value from within a range or
2. RfG 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 RfG includes the existing value applied in Ireland, the existing value is proposed.
- where the range for a non-exhaustive parameter provided in the RfG does not include the existing value applied in Ireland then the value proposed represents the minimum amount of change possible.
- where the RfG 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 Ireland, the existing value is proposed.
- where the RfG 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 Ireland, a justification is given

2.2. Overview of Generator Types

Requirements for general application become increasing extensive as the size of the generator increases. RfG classifies all generators into one of four types A, B, C and D. Generator Types are primarily based on maximum capacity size. EirGrid's Minded to Position on Banding Threshold proposes the following:

Field Code Changed

- Type A units range from 800 W up to 0.09 MW
- Type B units range from 0.1MW up to 4.9 MW
- Type C units range from 5 MW to 9.9 MW
- Type D units are great then 10MW

Note all generation connected at 110 kV or higher is automatically considered as Type D.

It is important to note the definition of Maximum Capacity in the RfG:

> *'maximum capacity' or 'Pmax' means the maximum continuous active power which a power-generating module can produce, less any demand associated solely with facilitating the operation of that power-generating module and not fed into the network as specified in the connection agreement or as agreed between the relevant system operator and the power-generating facility owner;*

Current Grid Code requirements are applied based on Maximum Export Capacity (MEC) or Registered Capacity.

All generation subject to the RfG will be considered based on the actual installed capacity less house load. **This represents a fundamental change to how requirements are applied to generators and should be fully understood by users.**

The majority of the RfG, Articles 13-16, covers the requirements for power generating modules or PGMs.

There are additional articles detailing specific additional requirements for PGMs of different types. The three additional types are:

- Synchronous PGMs (SPGMs)
- Power Park Modules (PPMs)
- Offshore PPMs

Articles 17 – 19 cover additional requirements for synchronous PGMS or SPGMs.

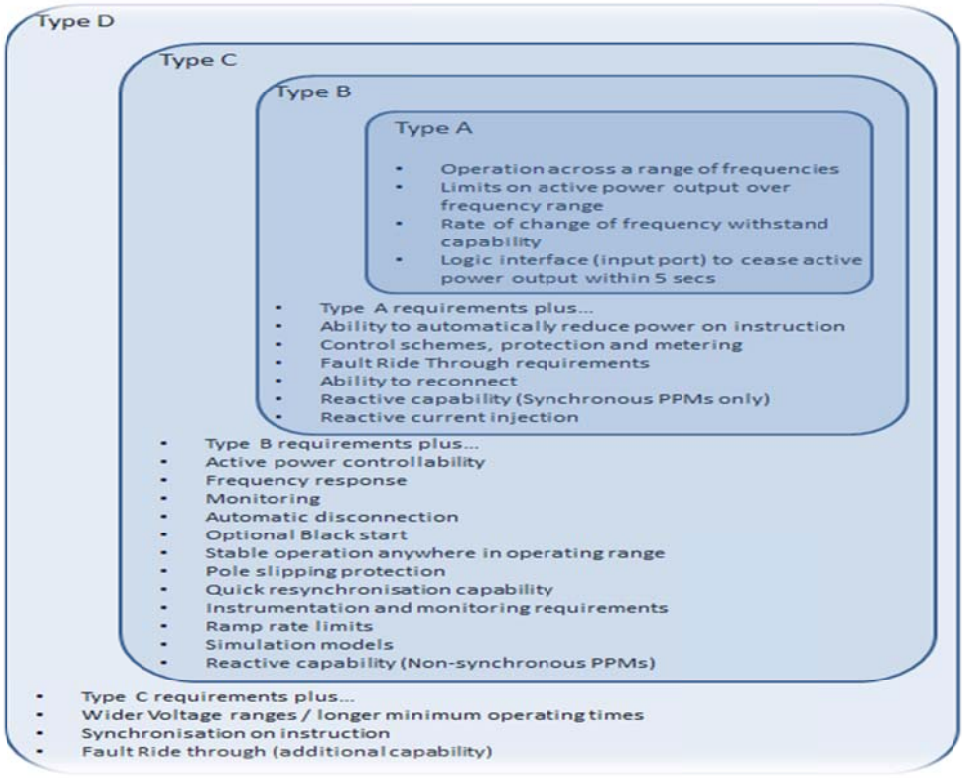
Articles 20 – 22 cover additional requirements for PPMs

Articles 23 – 28 cover additional requirements for Offshore PPMs

It should be noted that under the RfG the requirements for Offshore Power Park Modules depend on the location of the connection point.

- A PPM that is located offshore but has a **connection point onshore** shall be deemed to be an **onshore PPM**. Thus the requirements applicable to PPMs also apply to these units.
- A PPM that is located offshore and has a **connection point offshore** shall be deemed to be an **offshore PPM**. Thus the requirements applicable to offshore PPMs apply to these units .

An outline of the requirements of the RfG as applied to generators of each Type is shown below.



2.3. Overview of Topologies for Distribution Connected PGMs

Under the current Distribution Code, the applicability of different sections of the codes depends on the topology type. The current Distribution Code refers to Topology Types, types A, B, C, D, and E under section DCC11.1.3. Reconciliation of the newly defined RfG "Types" A, B, C , and D, with the pre-existing Distribution Code Types A, B, C, D, and E is required during the implementation of RfG.

Following the Banding Thresholds Consultation, ESBN and EirGrid minded to position paper states that ESBN and EirGrid are minded to re-name the existing Distribution Code Types A – E and adopt the newly named "Topologies 1-5". The definitions of these topologies will remain broadly as per the current ESBN Distribution Code

For the avoidance of doubt, where an RfG requirement is mandatory across a given RfG Type, this will be respected and applied to all topologies, and not only to a subset.

For the purpose of this consultation document, reference to 'type' is related to the RfG definition of type as per section 3.1, whilst reference to 'topology is a reference to the distribution 'types' as per the current Distribution Code.

Old Name	New Name
Type A	Topology 1
Type B	Topology 2
Type C	Topology 3
Type D	Topology 4
Type E	Topology 5

Table 1: Types Vs Topologies

4. Proposals

This section covers the consultation 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 subtheme for clarity. The four main themes are:

4.1 Frequency

4.2 Voltage including Fault Ride Through

4.3 System Restoration

4.4 Protection and Instrumentation

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 consulted on. The tables contain:

- A description of the parameter or requirement;
- The RfG allowable range or an indication that a parameter needs to be specified by the RSO;
- The consultation proposal for the parameter or requirement;
- The RfG Article reference;
- a list of the generator types that this applies to and
- a justification code.

Justification Codes

The justification codes identify which of three 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 RfG range. In this case the proposed parameter is as close to the existing grid or Distribution Code requirements as is allowable under RfG
3. "New of 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 consultation as we do not have the right to change them.

4.1 Frequency Theme

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

- Frequency ranges
- Rate of Change of Frequency (RoCoF) withstand capability
- Automatic connection to the network
- Active Power Control
    - Admissible Active Power reduction from maximum output with falling frequency
    - Remote operation of facility to cease active power
    - Achieving Active Power Set-points
- Frequency Modes
    - Limited Frequency Sensitive Mode: Over-frequency (LFSM)-O
    - Limited Frequency Sensitive Mode: Under-frequency (LFSM)-U
    - Frequency Sensitive Mode (FSM)

4.1.1 Frequency ranges

4.1.1.1 Article 13.1 (a) (i): Frequency Ranges

Non-Exhaustive Parameter Selection

Applies to Type A, B, C, D PGMs and Offshore PPMs

Requirement

A power-generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in the table below. Please note that only the item in bold is a non-exhaustive parameter and therefore subject to consultation. The other parameters are provided for context.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency Ranges	*47,5 Hz-48,5 Hz for 90 minutes*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*
Frequency Ranges	48,5 Hz-49,0 Hz for a time to be specified by each TSO, but not less than 90 minutes	90 Minutes	13.1.a.(i)	*A, B, C, D PGMs and Offshore PPMs*	2
Frequency Ranges	*49,0 Hz-51,0 Hz for an unlimited time*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*
Frequency Ranges	*51,0 Hz-51,5 Hz for 90 minutes*	*Mandatory*	*13.1.a.(i)*	*A, B, C, D PGMs and Offshore PPMs*	*N/A*

Table 2 Frequency Withstand Time Periods

Justification

The RfG states that the operation time in the frequency range of 48.5 – 49.0 Hz shall be specified by the TSO but not less than 90 minutes. The current Grid Code requirement in this frequency range is 60 minutes. The proposed parameter of 90 minutes is the closest allowable to the current Grid Code requirement. Please note the Grid Code in Ireland also requires power-generating modules to remain connected to the network as follows

- between 47-47.5 Hz for 20 seconds
- and between 51.5 -52 Hz for 60 minutes

These requirements will remain in the Grid Code in addition to the RfG requirements in the table above.

4.1.2 Rate of Change of Frequency

4.1.2.1 Article 13.1 (b): RoCoF

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

With regard to the rate of change of frequency withstand capability, a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection.

Proposal: RoCoF Withstand Capability

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
The maximum RoCoF for which the Power Generating Module (PGM) shall stay connected	Not Specified	1 Hz/s over 500ms window	13.1.b	A, B, C and D PGMs & Offshore PPMs	1

Table 3 Rate-of-change-of-frequency-type loss of mains protection

Justification: RoCoF Withstand Capability

The proposal is to maintain the 'agreed in principal' Grid Code standard for RoCoF of 1 Hz/s over a 500 ms window. It is proposed to review the Ireland RoCoF requirement of 1 Hz/s as part of the three year review

Proposal: Loss of Mains Protection [Transmission Connected]

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
The proposal for loss of mains protection [Transmission Connected]	Not Specified	~~is~~ 1 Hz/s over 500ms window	13.1.b	D PGMs and Offshore PPMs	~~1~~3

Table 4 Rate-of-change-of-frequency-type loss of mains protection [Transmission Connected]

Justification: Loss of Mains Protection [Transmission Connected]

~~The proposal is to maintain the existing protection settings for transmission connected PGMs which is 1 Hz/s over a 500ms window.~~The proposal is to set the rate of change for loss of mains protection to 1 Hz/s over the 500 ms window.

This proposal is consistent with the -'agreed in principal' Grid Code standard for RoCoF of 1 Hz/s over a 500 ms window. It is proposed to review the Ireland RoCoF requirement of 1 Hz/s as part of the three year review.

Proposal: Loss of Mains Protection [Distribution Connected]

Parameter	Parameter in RfG	Consultation Proposal				Article Number	Type Applicability	Justification Code
		Positive and Negative RoCoF						
		Generator Category		Pick Up	Time Delay			
The proposal for loss of mains protection [Distribution Connected]	Not Specified	DFIG / Full Converter Generator		2 Hz/s	0.3s	13.1.b	A, B, C and D PGMs and Offshore PPMs	1
		Synchronous Generator / Directly Connected Induction Generator	H > 3 MWs /MVA	0.6 Hz/s	0.6s			
		Synchronous Generator / Directly Connected Induction Generator	H ≤ 3 MWs /MVA	1.0 Hz/s	0.6s			

Table 5 Rate-of-change-of-frequency-type loss of mains protection

Justification: RoCoF Protection settings [Distribution connected]

RoCoF settings were originally stated as 0.4 Hz/s in the 2003 *"Conditions Governing*[9]*"* document. In 2012 a newer version of the Conditions Governing document removed this value and advised that settings would be provided upon request to ESBN. Connection requests and witness testing have been based on revised settings since then. The basis for the revised settings was a study carried out by consultants for ESBN. This study looked at sensitivity to the detection of islanding. The outcome is that low inertia machines could have a setting consistent with the higher withstand capability and only high inertia (>3 MWs/MVA) synchronous machines would need a lower (0.6 Hz/s) setting. This would enable the majority of wind generators and small scale generators to comply with Distribution Code RoCoF withstand requirements of 1 Hz/s for 500ms.

The next version of the Conditions Governing document will have these values specifically included.

[9] *"Conditions Governing Connection to the Distribution System:*
• Connections at MV and 38kV
• Embedded Generators at LV, MV and 38kV"

4.1.3 Active Power Control

4.1.3.1 Article 13.4.a: Admissible reduction from maximum output with falling frequency

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

The relevant TSO shall specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 1 below.

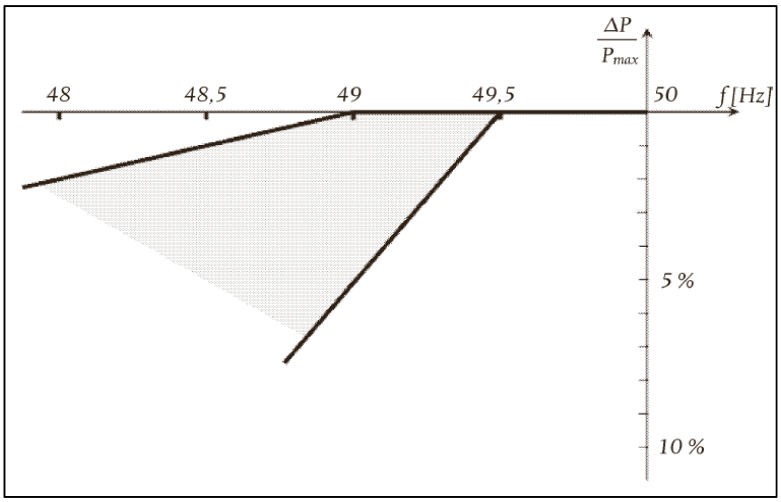


Figure 1 Maximum Power Capability Reduction with Falling Frequency

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Applicable Types	Justification Code
Admissible active power reduction from maximum output with falling frequency	below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50 Hz per 1 Hz frequency drop **or** below 49.5 Hz falling by a reduction rate of 10% of the maximum capacity at 50 Hz per 1 Hz frequency drop.	below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50 Hz per 1 Hz frequency drop	13.4 (a)	A, B, C and D PGMs and Offshore PPMs	3

Table 6 Admissible active power reduction from maximum output with falling frequency

Justification

As the system frequency decreases, it is essential that any reduction in generation output is minimised, in order to prevent the frequency from falling any further. The current proposal is to allow a maximum decrease in generation output of 2% when the frequency is below 49 Hz, and whilst this is the most arduous parameter allowable under the RfG, it lessens any further reduction in the system frequency by minimising the reduction in the generation MW output, which allows time for frequency response measures to be activated and ultimately the system frequency to stabilise.

4.1.3.2 *Article 13.5: Admissible reduction from maximum output with falling frequency taking Account of Technical Capabilities of PGMs*

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs

Requirement

The admissible active power reduction from maximum output shall: (a) clearly specify the ambient conditions applicable; (b) take account of the technical capabilities of power-generating modules.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Ambient Conditions	Not Specified	10°C, 70% relative humidity and 1013 hPa.	13.5	Gas-fired SPGMs (A, B, C and D).	3

Table 7 Admissible active power reduction from maximum output

Justification

The RfG allows the TSO to specify ambient conditions applicable. The current version of the Grid Code states, under the definition of registered capacity, that the standard ambient conditions for the measurement of registered capacity will be 10°C, 70 % relative humidity and 1013 hPa. As the RfG allows the TSO to specify the applicable ambient conditions, it is proposed to continue to use these ambient conditions requirements. The ENTSO-E guidance document for national implementation for network codes on grid connection (Implementation Guidelines Documents) highlights that the need for this requirement is driven by the characteristics of gas fired generation units. Other generation units should not require a reduction with falling frequency. For this reason it is proposed to limit the application of this clause to gas fired generation units.

4.1.3.3 Article 13.6: Remote operation of facility to cease active power output

Non-Mandatory Requirement being made Mandatory

Applies to Type A and B PGMs

Requirement

The power-generating module shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. The relevant system operator shall have the right to specify requirements for equipment to make this facility operable remotely.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Specify requirements for equipment to make this facility operable remotely for Type A	A right to specify	Maintain the right to specify for Type A only in due time for plant design (c/f Art 14 (2) (b) for Type B	13.6	A and B PGMs	1

Table 8 Specify requirements for equipment to make this facility operable remotely for Type A

Justification

The proposal is to maintain the right to specify the requirement for remote control equipment but to advise on a case by case basis, as necessary, taking into consideration that the specific requirements will be dependent on the plant design and compatibility requirements.

The intention of the phrase, 'in due time for plant design' is intended to mean during the connection offer phase.

4.1.3.4 Article 13.7: Automatic connection to the network

Non-Exhaustive Parameter Selection

Applies to Type A, B and C PGMs

Requirement

The relevant TSO shall specify the conditions under which a power-generating module is capable of connecting automatically to the network. Those conditions shall include:

(a) frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and

(b) maximum admissible gradient of increase in active power output.

Automatic connection is allowed unless specified otherwise by the relevant system operator in coordination with the relevant TSO.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency Ranges and Time Delay	Non-specific	49.8 Hz to 50.2 Hz with a five minute delay	13.7	A, B, and C PGMs	1
Maximum admissible gradient of increase in power	Non-specific	10% of Pmax per minute	13.7	A, B and C PGMs	3
Allowing automatic connection	A right to not allow	Allow	13.7	A, B and C PGMs	1

Table 9 Conditions under which a PGMs is capable of connecting automatically to the network

Justification: Frequency Ranges and Time Delay [Distribution Connected]

The values exist today for distribution connected generators, as stipulated in Conditions Governing[10]. The proposed frequency range and time delay are per the existing requirements in the Distribution Code.

Justification: Maximum admissible gradient of increase in power

The proposed maximum admissible gradient of increase in power of 3% of the PMax is not currently specified in the existing Distribution Code but it is consistent with the existing Grid Code requirement WFPS1.5.4.1 which states that deviations in the ramp rates will not exceed 3%.

[10] *"Conditions Governing Connection to the Distribution System: • Connections at MV and 38kV Embedded Generators at LV, MV and 38kV"*

4.1.3.5 Article 14.2.b: Remote operation of power output

Non-Mandatory Requirement being made Mandatory

Applies to Type B PGMs

Requirement

Type B PGMs shall fulfil the following requirements in relation to frequency stability:

> *(a) to control active power output, the power-generating module shall be equipped with an interface (input port) in order to be able to reduce active power output following an instruction at the input port; and*
>
> *(b) the relevant system operator shall have the right to specify the requirements for further equipment to allow active power output to be remotely operated*.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Right to specify the requirements for further equipment to allow active power output to be remotely operated	To specify or not to specify	RSO to specify for Type B generators with a maximum capacity 1 MW and above; in due time for plant design.	14.2 (b)	B PGMs	3

Table 10 Remote operation of Power Output

Justification

The TSO and DSO in Ireland have proposed a modification to the Distribution Code to reduce the threshold of controllability of generation units from 5 MW to 1 MW. This is being progressed through the Distribution Code Review Panel. This RfG proposal is in line with that proposal and ensures the DSO can specify equipment to allow active power output to be remotely operated.

4.1.3.6 Article 15.2.a: Achieving Active Power Set points

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs

Requirements

… power-generating modules shall fulfil the following requirements relating to frequency stability:

(a) with regard to active power controllability and control range, the power-generating module control system shall be capable of adjusting an active power set point in line with instructions given to the power-generating facility owner by the relevant system operator or the relevant TSO.

The relevant system operator or the relevant TSO shall establish the period within which the adjusted active power set point must be reached. The relevant TSO shall specify a tolerance (subject to the availability of the prime mover resource) applying to the new set point and the time within which it must be reached;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
The period within which the adjusted active power setpoint must be reached	No range provided	10 seconds response time plus the ramp rate for the unit. NB where wind turbines have to be turned on to achieve the set point then a maximum of 3 minutes response time is allowed.	15.2 (a)	C and D PGMs	1
Tolerance (subject to the availability of the prime mover resource) applying to the new setpoint and the time within which it must be reached	No Range Provided	For PGMs, the maximum of 1 MW or 1% of dispatch quantity is applied. For PPMs, the maximum of +/- 3% of registered capacity or +/- 0.5 MW.	15.2 (a)	C and D PGMs	3

Table 11: Achieving Active Power Set-points

Justification

The ramp rate referred to in this table is the Active Power Control Set-Point Ramp Rate as defined in the Grid Code and advised to the generator 120 business days in advance of commissioning.

The proposed Tolerance limits are as per the current operational and market monitoring tolerances. By aligning the tolerance for RfG with the current practices, it will ensure the monitoring and assessment of active power set point is consistent for all PGMs and PPMs.

Notes: In the context of paragraph (b) we interpret this section to apply to remotely controlled generation units where the set point is issued directly to the control system of the unit and does not apply to generation units where a dispatch instruction is issued from the TSO to an operator to implement. The Grid Code provides for both situations in section SDC2.4.2.12 for CDGUs and in Section WFPS1.5.2.1 for PPMs. The PPM requirement is that the unit starts to respond within 10 seconds of receiving the instruction hence the period within which the adjusted active power set point must be reached is 10 seconds plus the ramp rate.

4.1.4 Frequency Modes

4.1.4.1 Frequency Modes Explanation

This section explains the difference between 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 RfG as Frequency Sensitive Mode (FSM). That is, the 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 RfG parameters relating to the capability of units 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 normal 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 the maximum generation of the unit (or available active power for 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 active power control mode or when in wind following mode on curve 2. 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 system frequency. The calculation of the set points is based on a droop characteristics and time for delivery as specified in these FSM parameter settings.

Limited Frequency Sensitive Mode:

When a PGM is operating in Limited Frequency Sensitive Mode (LFSM), the generation unit does not provide any frequency response when the system frequency is within a specified dead band around the nominal frequency. The dead band for LFSM mode is much wider than that specified for FSM mode. FSM dead bands 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.

RfG 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 generators which act in LFSM mode today are PPMs when in wind following mode and curve 1.

At the moment, it is planned to continue to operate the majority of existing and future PGMs 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 RfG 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	PPM in wind following mode & curve 1	Not applicable in Ireland today
LFSM-U	Not applicable in Ireland today	Not applicable in Ireland today
FSM Normal	PPM in active power set point control mode & curve 1 or curve 2 PPM in wind following mode & curve 2	Normal governor regulation
FSM Frequency Step Change	As above	Operating Reserves

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 RfG section as they are not related the inherent capability of the unit.

4.1.4.2 Article 13.2.a: LFSM-O Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Type A, B, C and D PGMs and Offshore PPMs

Requirement

With regard to the limited frequency sensitive mode — over frequency (LFSM-O), the following shall apply, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas:

(a) *the power-generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and droop settings specified by the relevant TSO*;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency threshold	Between 50.2-50.5 Hz	50.2 Hz	13.2(a)	A, B, C and D PGMs & offshore PPMs	1
Droop settings	Between 2-12 %	Machines should be capable of operating in the range 2-12%. The default setting is 4%	13.2(a)	A, B, C and D PGMs & offshore PPMs	1

Table 12: LFSM-O Parameter Selection

Justification:

Frequency Threshold

CC.8.2.1 of the current Grid Code and DPC4.1.1 of the current Distribution Code states that the normal operating frequency range is between 49.8 Hz and 50.2 Hz. Under WFPS 1.5.3.2 and depending on operating mode active power response may not be required when the frequency is within this range. The RfG states that the frequency threshold shall be between 50.2 Hz and 50.5 Hz. Therefore, the existing frequency threshold of 50.2 Hz is allowable under the RfG and will be retained.

Droop Settings

Selected parameters are per our Grid Code today. The current Grid Code allows for a number of different droop ranges, depending on technology type. However, the default in all cases is a droop setting of 4%, regardless of technology type. By adopting a standard of 4%, as opposed to a default, it will ensure compliance with the RfG whilst maintaining a consistent droop setting to all generation types.

A droop parameter is a new requirement in the Distribution Code. The droop setting for distribution connected generators will align with the existing droop settings for transmission connected PGMs.

4.1.4.3 Article 13.2.b: LFSM-O: Automatic disconnection and reconnection

Non-Mandatory Requirement being made Mandatory

Applies to Type A PGM

Requirement

(b) instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power-generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the cooperation of power-generating facility owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Applicable Type	Justification Code
Automatic disconnection and reconnection of PGMs	Allow or do not allow	Do not allow	13.2 (b)	A PGMs	1

Table 13: LFSM-O Automatic Disconnection & Reconnection

Justification

It is not currently planned to invoke this non-mandatory proposal. However this should not be confused with additional protection settings applied in coordination with the RSO which are agreed on a case by case basis.

4.1.4.4 Article 13.2.f: LFSM-O: Actions at minimum regulating level

Non-Mandatory Requirement being made Mandatory

Applies to Type A, B, C and D PGMs and offshore PPMs

Requirement

The relevant TSO may require that upon reaching minimum regulating level, the power-generating module be capable of either:

(i) continuing operation at this level; or

(ii) further decreasing active power output;

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Actions in LFSM-O upon reaching minimum regulating level,	Choose between (i) continuing operation at this level; or (ii) further decreasing active power output	(i) continuing operation at this level	13.2 (f)	A, B, C and D PGMs & offshore PPMs	1

Table 14: LFSM-O Actions at Minimum Regulating Level

Justification

Under the current Grid Code and Distribution Code Minimum Load is defined as the minimum MW output a unit can maintain on a continuous basis, whilst providing system services. It is proposed to select option (i) which would maintain the requirements as defined in the current version of the Grid Code.

4.1.4.5 Article 15.2.c: LFSM-U Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs and offshore PPMs

Requirement

(i) *the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified by the relevant TSO in coordination with the TSOs of the same synchronous area as follows:*

– the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive;

– the droop settings specified by the TSO shall be in the range 2 – 12%.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Frequency threshold	between 49.8 Hz and 49.5 Hz inclusive	49.5 Hz	15.2 (c)	C and D PGMs & offshore PPMs	1
Droop settings	2-12%	Default is 4% unless otherwise specified by the TSO on a site specific basis	15.2 (c)	C and D PGMs & offshore PPMs	1

Table 15 LFSM-U Frequency Threshold & Droop Settings

Justification

Frequency Threshold:

Under the current version of the Grid Code, a Frequency Event occurs when the Transmission System Frequency deviates to a value below 49.5 Hz. The proposal is to retain the existing Grid Code requirements in relation to Frequency Events, by setting the frequency threshold to 49.5 Hz.

Droop Settings:

Selected parameters are per our Grid Code today. The current Grid Code allows for a number of different droop ranges, depending on technology type. However, the default in all cases is a droop setting of 4%, regardless of technology type. By adopting a default of 4%, as opposed to a range, it will ensure compliance with the RfG whilst maintaining a consistent droop setting to all generation types.

4.1.4.6 Article 15.2.d.(i) and (ii): FSM Parameter Selection

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and Offshore PPMs

Requirement

(i) *The power-generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4* (as given in the RfG*). In specifying those parameters, the relevant TSO shall take account of the following facts:*

- *In case of over frequency, the active power frequency response is limited by the minimum regulating level,*
- *In case of under frequency, the active power frequency response is limited by maximum capacity,*
- *The actual delivery of active power frequency response depends on the operating and ambient conditions of the power-generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources;*

(ii) *The frequency response dead band of frequency deviation and droop must be able to be reselected repeatedly;*

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Active Power Range (ΔP/Pmax)	1.5-10%	Not proposing a value at this time See note below	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	1
Frequency Response Insensitivity (Δf)	10-30 mHz	15mHz*	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	3
Frequency Response Insensitivity (Δf/f)	0.02-0.06%	0.03%	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	3
Frequency Response Deadband	0-500mHz	+/-15mHz*	15.2 (d) (i) and (ii)	C and D PGMs& offshore PPMs	3
Droop	2-12%	Depends on gen type – default is 4%	15.2 (d) (i) and (ii)	C and D PGMs & offshore PPMs	1

Table 16 FSM Parameter Selection

Justification

Active Power Range

The TSO have consulted with the ENTSO-E Frequency Expert Group in relation to FSM. ENTSO-E have 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 in Table 16.

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 PGM to be made intentionally unresponsive over any frequency interval.

Hence, it is proposed to retain the current 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.

*In addition to the individual requirements for Frequency Response Insensitivity (ΔF) and Frequency Response Deadband and as per Annex V of the System Operating Guidelines[11] (SOGL), the maximum combined effect of Frequency Response Insensitivity and Frequency Response Deadband cannot exceed a value of +/- 15 mHz

[11] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1485&from=EN

Field Code Changed

4.1.4.7 Article 15.2.d.(iii): FSM: Step Change in Frequency

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs and Offshore PPMs

Requirement

In the event of a frequency step change, the power-generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 (as given in the RfG) *in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power-generating module) within the ranges given in Table 5* (as given in the RfG) *. The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account;*

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Active power range	1.5-10%	5%	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Admissible initial time delay for activation of active power frequency response for PGMs	*2s*	*2s*	*15.2 (d) (iii)*	*C and D PGMs & offshore PPMs*	*N/A*
Admissible initial time delay for activation of active power frequency response for PPMs	Less than 2 seconds	0s No time delays other than those inherent in the design of the frequency response system	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Maximum admissible choice of full activation time	30 seconds	5s	15.2 (d) (iii)	C and D PGMs & offshore PPMs	3
Capability relating to the duration of provision of full active power frequency response	15-30 minutes	20min	15.2 (d) (v)	C and D PGMs & offshore PPMs	3

Table 17 Activating full active power frequency response

Justification

Active Power Range

SPGMs

As stated in the previous section, this is primarily based on the need to restore the system frequency as quickly as possible. Consider the example of a drop in frequency to 49.5 Hz. In theory, each PGM on the system should increase their output by ΔP (25%), assuming a 4% droop. However, as each PGM is increasing their output simultaneously, resulting in an increase in frequency, the governor control will reduce ΔP, effectively sharing the burden of restoring the frequency between all of the PGMs in FSM mode. As a result, the output of the PGM will not need to increase by the full ΔP of 25%.

Under the current Grid Code requirements, the same function is provided by Primary Operating Reserve (POR) and Secondary Operating Reserve (SOR). Both of which provide a ΔP of 5%. Hence, it is proposed that the active power range in the RfG will be set to 5%.

PPMs

The current requirements in the Grid Code require a 60% increase in Active Power within 5 seconds and 100% of expected increase (droop response) within 15 seconds of a . 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 RfG range in Article 15.2.d only allows us 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.

We do 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 RfG but respondents should understand that it is our intention to retain the Grid Code requirements for PPMs, in addition to the RfG requirements.

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

Current version of the Grid Code does not allow for any admissible initial time delays 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 RfG by setting the admissible initial time delay for the activation of active power frequency response for PPMs to 0 seconds.

Maximum admissible choice of full activation time

As stated above in the justification for the active power range, today the active power capability for FSM is provided by primary and secondary operating reserves (POR and SOR). Under the current requirements for POR and SOR, these reserves must be provided within 5 seconds. Hence, it is proposed to retain this requirement under the RfG by setting Maximum Admissible Choice of Full Activation time to 5 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 Ireland, the FCR equates to the 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 RfG Frequency Replacement Reserve Requirements.

4.1.5 Additional Non-Mandatory Frequency Requirements

There are a number of additional areas with non-mandatory requirements detailed in the RfG. Table 18 identifies the areas. In both cases, we do not intend to invoke these non-mandatory requirements at this time.

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability
Shorter initial FSM response delay for PGMs without inertia	Not specified	Not Mandatory – can be agreed on a case by case basis with System Services Contracts	15.2.d(iv)	Type A, B, C and D PGMs and offshore PPMs
Synthetic inertia capability for PPM	Not Specified	Not Mandatory – can be agreed on a case by case basis with System Services Contracts	21(2)	C and D PPMs

Table 18 - Areas with non-mandatory requirements detailed in the RfG

4.2 Voltage Theme

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

- Automatic disconnection
- Reactive Power capability
    - Type B PGM Requirements
    - At maximum capacity
    - Below maximum capacity
    - Supplementary requirements
    - Reactive power control modes
- Voltage Control System for Synchronous PGMs
- Fault Ride Through (FRT)
    - FRT capability for PGMs connected at voltages less than 110 kV
    - FRT capability for PGMS connected at voltages of 110 kV or more
    - Fast fault current injection for PPMs
    - Post fault active power recovery for PPMs
    - Priority to active or reactive current

4.2.1 Automatic Disconnection Due to Voltage Level

4.2.1.1 Article 15.3: Type C Automatic Disconnection Due to Voltage Level

Non-Exhaustive Parameter Selection

Applies to Type C PGMs

Requirement

With regard to voltage stability, type C power-generating modules shall be capable of automatic disconnection when voltage at the connection point reaches a minimum/maximum voltage level for a certain period of time. Table 19 specifies the voltage and duration settings.

Proposal

Parameter	Parameter in RfG	Consultation Proposal		Article Number	Type Applicability	Justification Code
		Voltage	Duration			
Minimum Voltage below which Module will automatic disconnect	Not specified	0.87 p.u.	3s	15.3	C (PPM)	1
	Not specified	0.8 p.u.	1.1s	15.3		1
	Not specified	0.87 p.u.	2.5s	15.3	C (SPGM)	1
	Not specified	0.8 p.u.	0.7s	15.3		1
Maximum Voltage above which Module will automatic disconnect	Not specified	1.12 p.u.	0.7s	15.3	C PGMs	1

Table 19: Parameters for Automatic Disconnection

Justification

The values are specified as stipulated in the Conditions Governing Connection to the Distribution System[9].

4.2.1.2 Article 16.2.c: Type D Automatic Disconnection Due to Voltage Level

Non-Exhaustive Parameter Selection

Applies to Type D PGMs

Requirement

With regard to voltage stability, *the relevant system operator in coordination with the relevant TSO shall have the right to specify voltages at the connection point at which a power-generating module is capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator and the power-generating facility owner*

Proposal: Automatic Disconnection Due to Voltage Level [Transmission Connected]

Table 20 specifies the voltage and duration settings.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Minimum Voltage below which Module will automatic disconnect	Not specified	Not Allowed	16.2.c	D PGMs	3
Maximum Voltage above which Module will automatic disconnect	Not specified	Not Allowed	16.2.c	D PGMs	3

Table 20: Type D Parameters for Automatic Disconnection

Justification: Automatic Disconnection Due to Voltage Level [Transmission Connected]

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.

Proposal: Automatic Disconnection Due to Voltage Level [Distribution Connected]

Table 21 specifies the voltage and duration settings.

Parameter	Parameter in RfG	Consultation Proposal		Article Number	Type Applicability	Justification Code
		Voltage	Duration			
Minimum Voltage below which Module will automatic disconnect	Not specified	0.87 p.u.	3s	15.3	D(PPM)	1
	Not specified	0.8 p.u.	1.1s	15.3		1
	Not specified	0.87 p.u.	2.5s	15.3	D (SPGM)	1
	Not specified	0.8 p.u.	0.7s	15.3		1
Maximum Voltage above which Module will automatic disconnect	Not specified	1.12 p.u.	0.7s	15.3	D PGMs	1

Table 21: Parameters for Automatic Disconnection

Justification: Automatic Disconnection Due to Voltage Level [Distribution Connected]

The values are specified as stipulated in the Conditions Governing Connection to the Distribution System[9].

4.2.2 Reactive Power Capability

The following sections discuss the reactive power capability requirements under RfG. Section 4.2.2.1 discusses the requirements at maximum capacity whilst section 4.2.2.3 discusses the requirements below maximum capacity. The requirements for synchronous power generating modules (SPGM) and Power Park Modules (PPMs) are discussed separately under each of these two sections.

It should be noted that the capabilities are different for different connections. The requirements are split out in the following sections to indicate this. The relevant elements of a connection for this discussion are:

1. Connection at 110 kV or more,
2. Connection at less than 110 kV,
3. Different topology connections at less than 110 kV.

4.2.2.1 Reactive Power Capability for Type B PGMs

4.2.2.1.1 Article 17.2.a: Reactive Power capability for Type B SPGMs

Non-Mandatory Requirement being made Mandatory

Applies to Type B PGMs

Requirement

(a) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a synchronous power generating module to provide reactive power;

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
right to specify the capability of a synchronous power generating module to provide reactive power;	To specify or not to specify	Maintain existing reactive power requirements in the Distribution Code.	18.2.a	Type C and D SPGMs	1

Table 22: Right to specify reactive power capability for SPGMs

Justification

It is proposed to leave the existing reactive power requirements in the Distribution Code as is. These are further elaborated in Sections 4.2.2.1 and 4.2.2.3

4.2.2.1.2 Article 20.2.a: Reactive Power capability for Type B PPMs

Non-Mandatory Requirement being made Mandatory

Applies to Type B PPMs

Requirement

(b) with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a power park modules to provide reactive power;

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
right to specify the capability of a synchronous power generating module to provide reactive power;	To specify or not to specify	Maintain existing reactive power requirements in the Distribution Code.	18.2.a	Type C and D SPGMs	1

Table 23: Right to specify reactive power capability for PPMs

Justification

It is proposed to leave the existing reactive power requirements in the Distribution Code as is. These are further elaborated in Sections 4.2.2.1 and 4.2.2.3

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

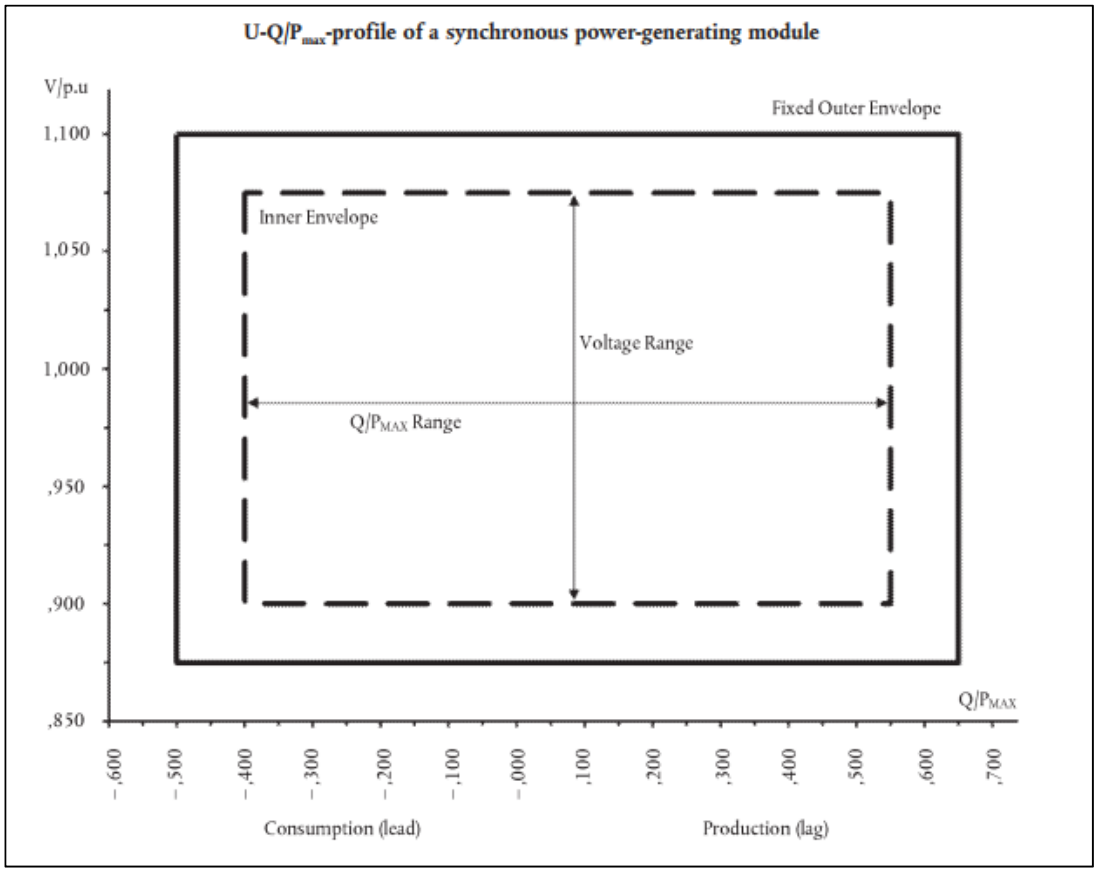
4.2.2.2.1 Article 18.2.b.(i): SPGM: Parameters required for U-Q/Pmax Profiles

Non-Exhaustive Parameter Selection

Applies to Type C and D SPGMs

Requirement

In relation to voltage stability, synchronous power-generating modules shall fulfil the requirements with regard to reactive power capability at maximum capacity. For that purpose a U-Q/P_{max}-profile is specified (inner envelope) within the boundaries of the fixed outer envelope of which the synchronous power-generating module shall be capable of providing reactive power at its maximum capacity (P_{max}).



U-Q/P_{max}-profile for synchronous Power-Generating Modules

The figure above represents boundaries of a U-Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the envelope are indicative. The dimensions of the inner envelope are limited by a maximum range of Q/P_{max} of 1.08p.u. and maximum range of steady state voltage level of 0.218p.u.

Proposal for SPGMs connected at a voltage level ≥ 110 kV

Table 24 lists the parameters which describe the U-Q/P_{max}-profile for SPGMs connected at a voltage level ≥ 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV	u_{min}	0.875 p.u.	0.9 p.u.	18.2.b (ii)	D SPGMs	1
	u_{max}	1.1 p.u.	1.1 p.u.			2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.5 p.u.			2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.52 p.u.			2
220 kV	u_{min}	0.875 p.u.	0.9 p.u.			2
	u_{max}	1.1 p.u.	1.1 p.u.			2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.5 p.u.			2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.52 p.u.			2
400 kV	u_{min}	0.875 p.u.	0.875 p.u.			1
	u_{max}	1.1 p.u.	1.05 p.u.			1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.5 p.u.			2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.52 p.u.			2

Table 24: Definition of U-Q/Pmax-profile at Maximum Capacity for SPGMs: connection @ ≥110 kV

Justification: SPGMs connected at a voltage level ≥ 110 kV

The RfG stipulates the reactive power capability as measured at the connection point. The Grid Code currently requests reactive power capability from SPGMs at the alternator terminals. Hence, the reactive power capability of synchronous power-generating modules, is projected onto the new measuring point the connection point.

The proposed reactive power capability parameters (Q_{min}/P_{max} (lead) and Q_{max}/P_{max} (lag)) of inner envelope has to take into account the supplementary reactive power which is compensated by the equipment connecting the alternator terminal and connection point in order to maintain the currently required reactive power capability. The voltage (u_{min} and u_{max}) ranges are aligned with the RfG voltage ranges within which the PGM shall stay connected to the network and operate normally.

It should be noted that the proposal for U_{max} has to be capped at 1.1p.u. which is a difference from our ranges today. Our current ranges are as follows for 110kV and 220kV

- 110kV: 1.118p.u. range today.
- 220kV: 1.111p.u. range today

Proposal for SPGMs connected at a voltage level < 110 kV

Table 25 below lists the parameters which describe the U-Q/P_{max}-profile for SPGMs connected at a voltage level < 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
10 kV and 20kV	u_{min}	0.875 p.u.	0.96 p.u.	18.2.b (ii)	C and D SPGMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	18.2.b (ii)	C and D SPGMs	2
	Q_{min}/P_{max} (import)	-0.5 p.u.	-0.33 p.u.	18.2.b (ii)	C and D SPGMs	2
	Q_{max}/P_{max} (Export)	0.65 p.u.	0 p.u.	18.2.b (ii)	C and D SPGMs	2
38 kV	u_{min}	0.875 p.u.	0.937 p.u.	18.2.b (ii)	C and D SPGMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	18.2.b (ii)	C and D SPGMs	1
	Q_{min}/P_{max} (Import)	-0.5 p.u.	-0.33 p.u.	18.2.b (ii)	C and D SPGMs	2
	Q_{max}/P_{max} (Export)	0.65 p.u.	0 p.u.	18.2.b (ii)	C and D SPGMs	2

Table 25: Definition of U-Q/Pmax-profile at Maximum Capacity for SPGMs: connection @ <110 kV

Justification: SPGMs connected at a voltage level <110 kV

Voltage

The current version of the Distribution Code does not explicitly graphically depict U-Q profiles. However, it does have table 6A (as per Distribution Code table numbering), which depicts a range of normal operating voltages.

TABLE 6A

Description	Nominal Voltage	Normal Operating Range [kV][5]	
		Lower bound	Upper bound
MV	10kV	9.6	11.3
MV	20kV	19.3	22.5
HV	38kV	35.6	43.8
110kV	110kV	99	123

In the current Distribution Code, for non-wind generators, no explicit linkage is made between the reactive power requirements and voltage ranges. RfG stipulates that such a requirement is specified.

It is proposed that for connections at voltages <110 kV, the power factor requirements stated for non-wind generators, will have to be maintained for the voltages in Table 6A (as per the Distribution Code table numbering) above.

There is a potential inconsistency that readers should be aware of, between the U-Q limits arising from this, and the Planning Standards used in the determination of connection methods for new generators

- When planning Distribution Generation connections, the max allowable Connection Point voltage, for dedicated circuits, is higher than would be the case for demand connections or load driven network
- This effectively sterilizes part of these circuits for use on demand connections
- ESBN has historically been minded to accept this risk, in the broader interests of connecting more generation and facilitating cheaper connections

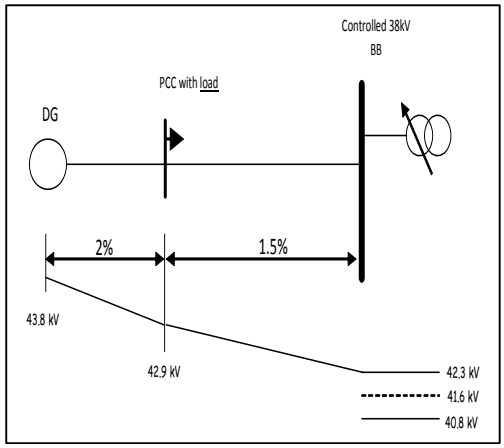


Figure 2 Example Connection Method - DSO

At this juncture, ESBN has no choice but to adopt to the RfG requirements in this regard. However, the reader should be aware that there are some potential consequences arising from this;

- ESBN may have to give consideration to reduction of max allowable Connection Point voltage to 1.1 p.u. for generators applying after Entry into Force of RfG
- This may have implications for costs of future connections

Q limits:

It is proposed to align the Q limits for the U-Q profile with the P-Q profile. The synchronous power-generating module shall be capable of moving to any operating point within its U-Q/P_{max} profile in appropriate timescales to target.

4.2.2.2.2 Article 18.2.b. (iv): SPGM: Time to Achieve Target Value within U-Q/Pmax Profile

Non-Exhaustive Parameter Selection

Applies to Type C and D SPGMs

Requirement

(iv) *the synchronous power-generating module shall be capable of moving to any operating point within its U-Q/Pmax profile in appropriate timescales to target values requested by the relevant system operator*;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time to achieve target value [transmission connected]	Not specified	Without undue delay but at least within 120 seconds	18.2.b (iv)	C and D SPGMs	1
Time to achieve target value [distribution connected]	Not specified	Without undue delay but at least within 120 seconds	18.2.b (iv)	C and D SPGMs	3

Table 26: Timescales to Achieve Target Values at Maximum Capacity

Justification: Transmission Connected

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.

Justification: Distribution Connected

The time to achieve the target value is a new parameter in the Distribution Code. The value chosen is to align with the current value for centrally dispatched generating units in the Grid Code. These units are being dispatched via EDIL; however the same time period will apply for units being dispatched via set point control.

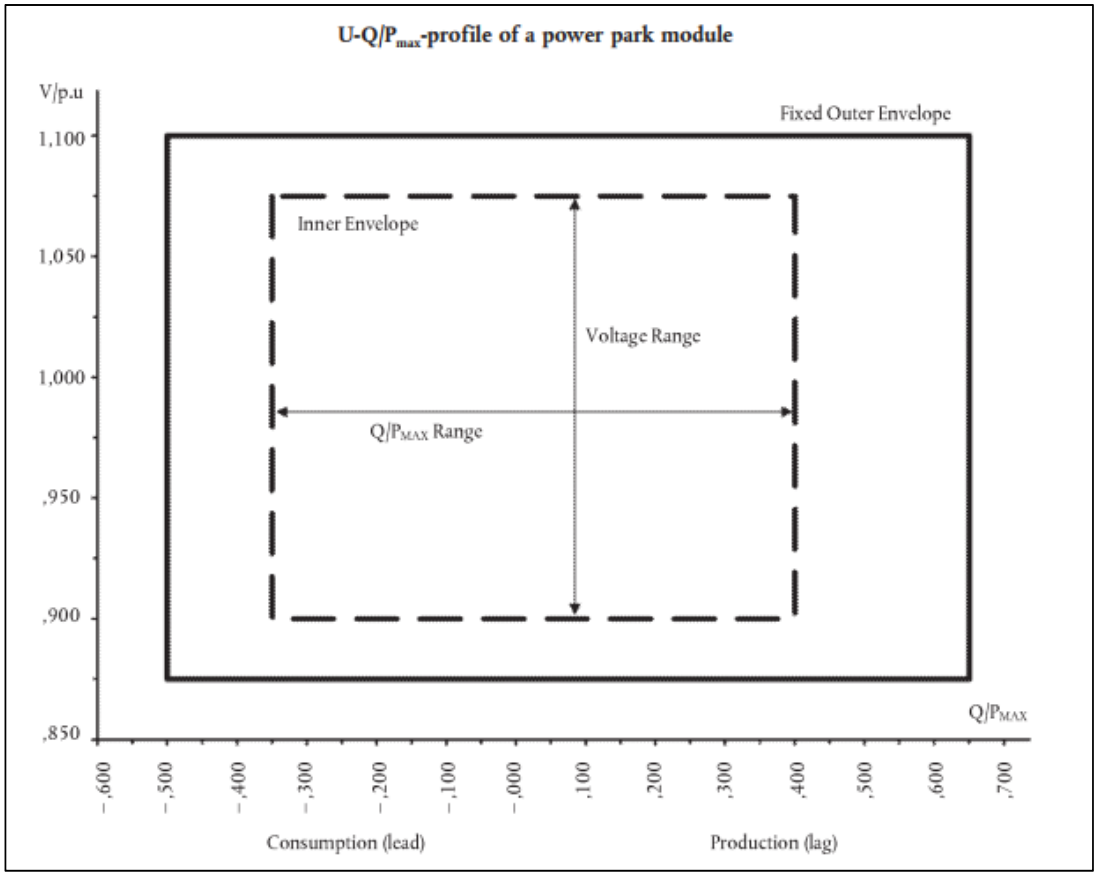
4.2.2.2.3 Article 21.3.b (i) and (ii) & Article 25.5: PPM: Parameters required for U-Q/Pmax Profiles

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs and Offshore PPMs

Requirement

Power Park modules shall fulfil requirements in relation to voltage stability with regard to reactive power capability at maximum capacity. For that purpose a U-Q/P_{max}-profile (inner envelope) is specified within the boundaries of the fixed outer envelope of which the Power Park Module shall be capable of providing reactive power at its maximum capacity (P_{max}).



U-Q/P_{max}-profile for Power Park Modules

The figure above represents boundaries of a U-Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1 p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.

The dimensions of the inner envelope are limited by a maximum range of Q/P_{max} of 0.66 and maximum range of steady state voltage level of 0.218 p.u.

Proposal for PPMs connection at a voltage level ≥ 110 kV

Table 27 lists the parameters which describe the U-Q/P_{max}-profile for PPMs connected at a voltage level ≥ 110 kV.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
110 kV	u_{min}	0.875 p.u.	0.9 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
220 kV	u_{min}	0.875 p.u.	0.9 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	2
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	Q_{max}/P_{max} (lead)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
400 kV	u_{min}	0.875 p.u.	0.875 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	u_{max}	1.1 p.u.	1.05 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	D PPMs and Offshore PPMs	1

Table 27: Definition of a U-Q/Pmax-profile at Maximum Capacity PPMs: connected @ 110 kV or more

Justification: PPMs connected at a voltage level ≥110 kV:

The reactive power parameters are as per the current Grid Code requirements.

The voltage ranges for the reactive power capability are aligned with the voltages specified for the synchronous power-generating modules in Table 24 in section 4.2.2.2.1.

It should be noted that the proposal for U_{max} has to be capped at 1.1p.u. which is a difference from our ranges today. Our current ranges are as follows for 110kV and 220kV

- 110kV: 1.118p.u. range today.
- 220kV: 1.111p.u. range today

Proposal for PPMs connected at a voltage level < 110 kV

Table 28 lists the parameters which describe the U-Q/Pmax-profile lists the parameters which describe the revised U-Q/P_{max}-profile for PPMs connected a voltage level < 110 kV and in Topology 2[12].

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
10 kV and 20kV	u_{min}	0.875 p.u.	0.96 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	2
38 kV	u_{min}	0.875 p.u.	0.937 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.b (ii)	C and D PPM and offshore PPMs	2

Table 28: Definition of a U-Q/Pmax-profile at Maximum Capacity PPMs connected @ <110 kV and in Topology 2

[12] See section 3.3 for a detailed description of the topologies.

Table 29 lists the parameters which describe the U-Q/Pmax-profile lists the parameters which describe the revised U-Q/P_{max}-profile for PPMs connected a voltage level < 110 kV and in all other Topologies.

Connection Voltage	Parameter	Parameter in RfG (outer envelope)	Consultation Proposal (Inner Envelope)	Article Number	Type Applicability	Justification Code
10 kV & 20kV	u_{min}	0.875 p.u.	0.96 p.u.	21.3.b (ii)	C and D PPM	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	C and D PPM	2
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.42 p.u.	21.3.b (ii)	C and D PPM	2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0 p.u.	21.3.b (ii)	C and D PPM	2
38 kV	u_{min}	0.875 p.u.	0.937 p.u.	21.3.b (ii)	C and D PPM	1
	u_{max}	1.1 p.u.	1.1 p.u.	21.3.b (ii)	C and D PPM	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.42 p.u.	21.3.b (ii)	C and D PPM	2
	Q_{max}/P_{max} (lag)	0.65 p.u.	0 p.u.	21.3.b (ii)	C and D PPM	2

Table 29: Definition of a U-Q/Pmax-profile at Maximum Capacity for PPMs connected @ <110 kV & all other Topologies

Justification: PPMs connected at a voltage level <110 kV

Voltage

The current version of the Distribution Code does not explicitly graphically depict U-Q profiles. However, it does have Table 6A, which depicts a range of normal operating voltages.

TABLE 6A

Description	Nominal Voltage	Normal Operating Range [kV][5]	
		Lower bound	Upper bound
MV	10kV	9.6	11.3
MV	20kV	19.3	22.5
HV	38kV	35.6	43.8
110kV	110kV	99	123

Linkage between Reactive Power requirements and voltage ranges:

DCC 11.4.3, which covers existing Types [Topologies][13] B [<5 MW], C, D and E, does not contain any explicit reference to having the P-Q capability across specific voltage ranges.

DCC 11.4.5, which covers existing Types [Topologies] A and B [>5 MW], does explicitly state that the P-Q capability must be maintained across the voltage ranges is Table 6A.

It is proposed that for connections at voltages <110 kV, the power factor requirements stated for non-wind generators, will have to be maintained for the voltages in Table 6A.

Figure 3 below depicts the DCC 11.4.5 requirement graphically.

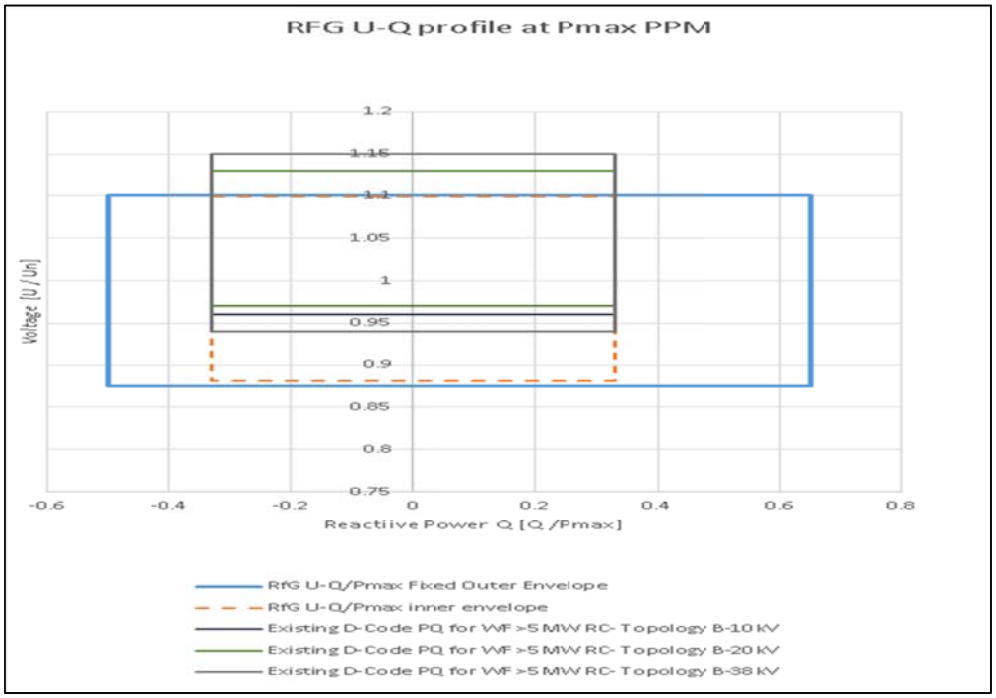
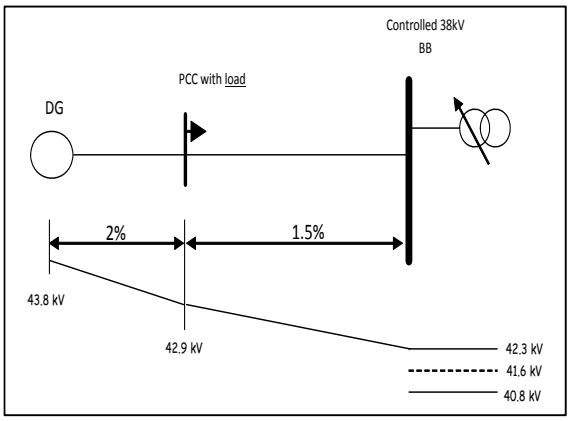


Figure 3: PPM U-Q Profile @ Pmax connected at a voltage level <110 kV

[13] See section 3.3 for a detailed description of the topologies."

Clearly these are currently outside the allowable limits specified in RfG. A reader might well ask how this came about.



- When planning Distribution Generation connections, the max allowable Connection Point voltage, for dedicated circuits, is higher than would be the case for demand connections or load driven network
- This effectively sterilizes part of these circuits for use on demand connections
- ESBN has historically been minded to accept this risk, in the broader interests of connecting more generation and facilitating cheaper connections

At this juncture, ESBN has no choice but to adapt to the RfG requirements in this regard. However, the reader should be aware that there are some potential consequences arising from this;

- For Generator connections where the Connection Point voltage regularly exceeds 1.1 p.u. of nominal voltage, the effectiveness and ability to use reactive power capability of the generator will be severely compromised
- For [RoI] Topology 2 connections, ability to ultimately participate in SSRP or DRP provision may be in doubt
- ESBN may have to give consideration to reduction of max allowable Connection Point voltage to 1.1 p.u. for generators applying after Entry into Force of RfG
- This may have implications for costs of future connections

Q limits:
RfG states that for the U-Q profile, Q limits maximum must also be stipulated. This range must not exceed 0.66 Q/Pmax in total. Hence the existing and new requirements are aligned.

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

4.2.2.3.1 Article 21.3.c.(i), (ii) and (iv): PPM: Parameters required for P-Q/Pmax Profiles

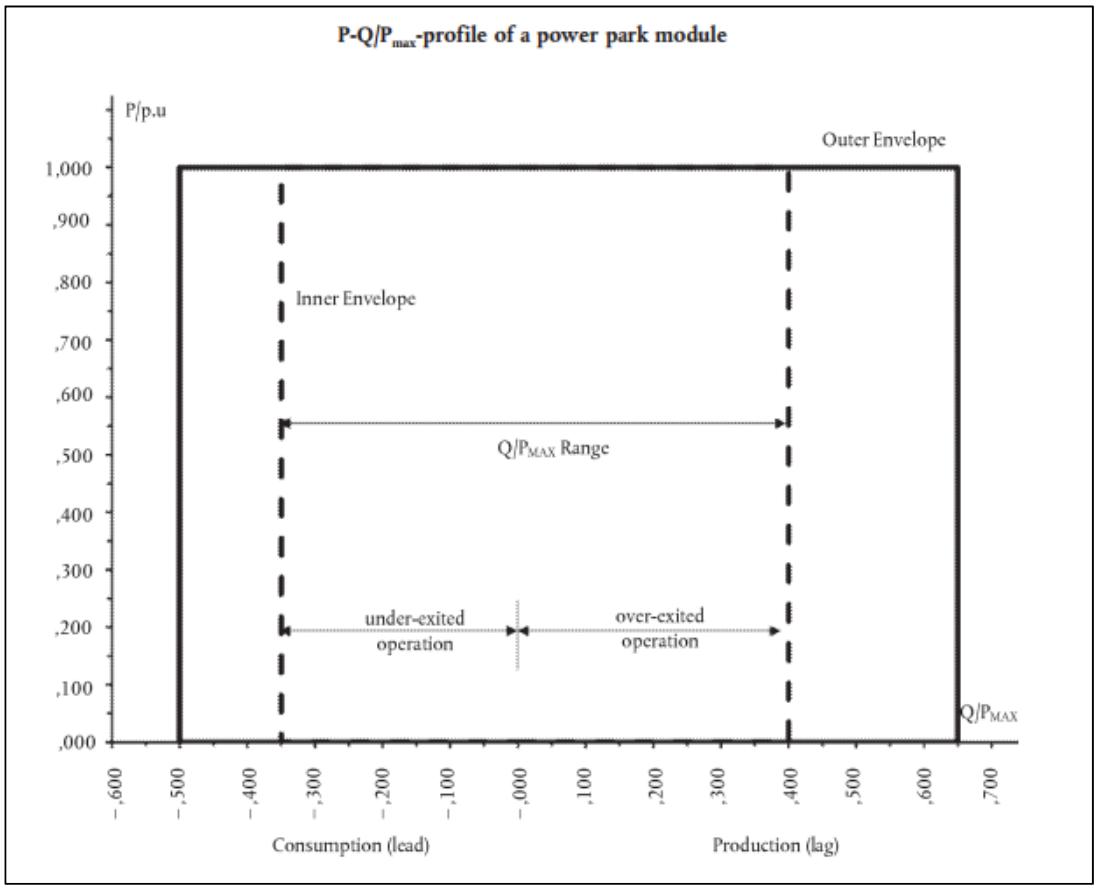
Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

Power park modules shall fulfil the following additional requirements in relation to voltage stability with regard to reactive power capability below maximum capacity. For that purpose a P- Q/P_{max}-profile is specified within the boundaries of which the power park module shall be capable of providing reactive power below maximum capacity (P < P_{max}).

The figure below represents boundaries of a P- Q/P_{max}-profile by the voltage at the connection point, expressed by the ratio of its actual value and the reference 1 p.u. value, against the ratio of the reactive power (Q) and the maximum capacity (P_{max}). The position, size and shape of the inner envelope are indicative.



The diagram represents boundaries of a P-Q/P_{max}-profile at the connection point by the fixed outer envelope.

Proposal PPMs connected at a voltage level ≥ 110 kV

Table 30 lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level ≥110 kV.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
110 to 400 kV	p_{min}	0.0 p.u.	0.12 p.u.	21.3.c (ii)	D PPMs	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	D PPMs	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.c (ii)	D PPMs	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.c (ii)	D PPMs	1

Table 30: P-Q/Pmax-profile below Maximum Capacity PPMs: connection @ voltage level ≥110 kV~~@ > 110 kVTimescales to Achieve Target Values at Maximum Capacity~~

Justification: PPMs connected at a voltage level ≥ 110 kV

The reactive power capability requirements are as per the current Grid Code requirements stipulated in WFPS.1.6.3.1.

Proposal PPMs connected at a voltage level < 110 kV

The reactive power requirements for wind generators in the existing Distribution Code are consistent with the P-Q inner and outer envelopes stipulated by RfG and **hence no change is required**. This is depicted diagrammatically in Figure 4 below. For consistency, these diagrams are shown in a tabular format in the following pages.

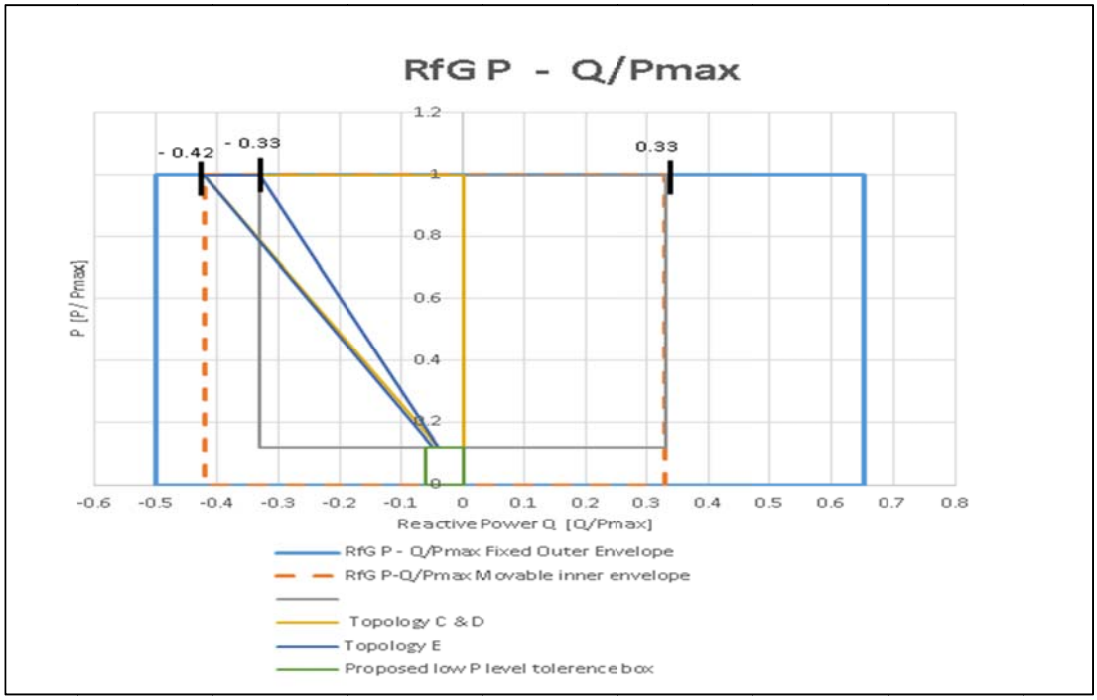


Figure 4: Reactive power capability of PPM connected to distribution system

Table 31 lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level <110 kV and in Topology 2.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Connection voltages at 10kV, 20kV or 38kV.	**p_{min}**	0.0 p.u.	0.12 p.u.	21.3.c (ii)	C and D PPM	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	C and D PPM	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	-0.33 p.u.	21.3.c (ii)	C and D PPM	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	0.33 p.u.	21.3.c (ii)	C and D PPM	1

Table 31: P-Q/Pmax-profile below Maximum Capacity PPMs: connection @ <110 kV & in Topology 2

Table 32 lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level <110 kV and in Topologies 3 and 4.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Connection voltages at 10kV, 20kV or 38kV.	**p_{min}**	0.0 p.u.	0.12 p.u.	21.3.c (ii)	C and D PPM	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	C and D PPM	1

	Q_{min}/P_{max} (lead)	-0.5 p.u.	Power factor range from 0.92 [-0.42 Q / Pmax] to unity [0 Q/Pmax]	21.3.c (ii)	C and D PPM	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	Power factor range from 0.92 [-0.42 Q / Pmax] to unity [0 Q/Pmax]	21.3.c (ii)	C and D PPM	1

Table 32: P-Q/Pmax-profile below Maximum Capacity PPMs connection@<110 kV & Topologies 3 & 4

Table 33 lists the parameters which describe the P-Q/P_{max}-profile for PPMs connected at a voltage level <110 kV and in Topology 5.

Connection Voltage	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Connection voltages at 10kV, 20kV or 38kV.	**p_{min}**	0.0 p.u.	0.12 p.u.	21.3.c (ii)	C and D PPM	1
	p_{max}	1.0 p.u.	1.0 p.u.	21.3.c (ii)	C and D PPM	1
	Q_{min}/P_{max} (lead)	-0.5 p.u.	Power factor range from 0.92 [-0.42 Q / Pmax] to 0.95 [-0.33 Q/Pmax]	21.3.c (ii)	C and D PPM	1
	Q_{max}/P_{max} (lag)	0.65 p.u.	Power factor range from 0.92 [-0.42 Q / Pmax] to 0.95 [-0.33 Q/Pmax]	21.3.c (ii)	C and D PPM	1

Table 33: P-Q/Pmax-profile below Maximum Capacity for PPMs: connection @ <110 kV & Topology 5

Justification: PPMs connected at a voltage level <110 kV

Proposal is as per current Distribution Code requirements.

4.2.2.3.2 Article 21.3.c.(iv): PPM: Time to Achieve Target Value within P-Q/Pmax Profile

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

(v) the power park module shall be capable of moving to any operating point within its P- Q/P_{max}-profile in appropriate timescales to target values requested by the relevant system operator .

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time to achieve target value [transmission connected]	Not specified	Without delay but within 20 seconds	21.3.c.(iv)	~~C and~~ D PPMs	1
Time to achieve target value [distribution connected]	Not specified	Without delay but within 20 seconds	21.3.c.(iv)	C and D PPMs	1

Table 34: Timescales to Achieve Target Values at Maximum Capacity

Justification

This aligns with the current Grid Code requirements in WFPS.1.6.2 and current Distribution Code requirements in DCC11.5.2.3 which stipulates that a change in set-point shall be implemented within 20 seconds of receipt of the appreciate signal from the TSO.

4.2.2.4 Supplementary Reactive Power Requirements

4.2.2.4.1 Article 18.2.a: SPGM: Supplementary reactive power requirements

Non-Mandatory Requirement being made Mandatory

Applies to Type C and D SPGMs

Requirement

The *relevant system operator may specify supplementary reactive power to be provided if the connection point of a synchronous power-generating 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 demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power-generating 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*.

Proposal

Requirement	Requirement in RfG	Consultation 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	RSOs reserve the right to specify	18.2.a	Type C and D SPGMs	1

Table 35: Right to Specify Supplementary Reactive Power Requirements for SPGMs

Justification

The TSO and DSO invoke the right to specify supplementary reactive power requirements for remote connection points in order to align with the supplementary reactive power requirements. This is not a new requirement. Currently the TSO and DSO have the right to specify supplementary reactive power requirements during the connection offer process and this will continue.

4.2.2.4.2 Article 21.3.a: PPM: Supplementary reactive power requirements

Non-Mandatory Requirement being made Mandatory

Applies to Type C and D PPMs

Requirement

The relevant system operator may specify supplementary reactive power to be provided if the connection point of a 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 convertor terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high- voltage line or cable between the high-voltage terminals of the step-up transformer of the power park module or its convertor terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.

Proposal

Requirement	Requirement in RfG	Consultation 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	RSOs reserve the right to specify	21.3.a	Type C and D PPMs	1

Table 36: Right to Specify Supplementary Reactive Power Requirements for PPMs

Justification

The TSO and DSO invoke the right to specify supplementary reactive power requirements for remote connection points in order to align with the supplementary reactive power requirements. This is not a new requirement. Currently the TSO and DSO have the right to specify supplementary reactive power requirements during the connection offer process and this will continue.

4.2.2.5 Reactive Power Control Modes for PPMs

4.2.2.5.1 Article 21.3.d.(iv)- Voltage Control Mode

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs

Requirement

Following a step change in voltage, the power park module shall be capable of achieving 90% of the change in reactive power output within a time t_1 and must settle at the value specified by the slope within a time t_2 with a steady-state reactive tolerance no greater than 5% of the maximum reactive power.

Proposal

The proposed times are listed in Table 37.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
t_1 = time within which 90% of the change in reactive power is reached	1 – 5 sec	1	21.3.d.(iv)	C and D ~~PGMs~~PPMs	1
t_2 = time within which 100% of the change in reactive power is reached	5 – 60 sec	5	21.3.d.(iv)	C and D ~~PGMs~~PPMs	3

Table 37: Parameters for Voltage Control Mode

Justification

The time t_1 within which 90% of the change in reactive power is reached is set to 1 second as per the current requirements in WFPS1.6.2.4 of the Grid Code

The time t_2 to achieve 100% of the change in reactive power is set to 5 seconds which is currently a requirement in SONI WFPS Setting Schedule. This is a new requirement ~~that is not currently set~~ in the Grid Code.

4.2.2.5.2 Article 21.3.d (vi) - Power Factor Control Mode

Non-Exhaustive Parameter Selection

Applies to Type C and D PGMs

Requirement

For the purpose of power factor control mode, the power park module shall be capable of controlling the power factor at the connection point within the required reactive power range with a target power factor in steps no greater than 0,01.

Proposal

The target power factor value, its tolerance and the period of time to achieve the target power factor following a sudden change of active power output are specified in Table 38.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Target power factor	Not specified	site-specific	21.3.d.(vi)	C and D ~~PGMs~~PPMs	3
Time period to reach the set point	Not specified	site-specific	21.3.d.(vi)	C and D ~~PGMs~~PPMs	3
Tolerance	Not specified	site-specific	21.3.d.(vi)	C and D ~~PGMs~~PPMs	3

Table 38: Parameters for Power Factor Control Mode

Justification

The reactive power requirements are determined by local factors and depend highly on the subset of generators and loads connected to local transmission/distribution system and the supplementary reactive power consumption of overhead lines and cables. To meet the local needs in terms of reactive power requirement in power factor control mode the parameters are proposed to be site-specific.

4.2.3 Voltage Control System for SPGM

4.2.3.1 Article 19.2.a and 19.2.b.(v)

Non-Exhaustive Parameter Selection

Applies to Type D SPGMs

Requirement

In relation to voltage stability, power-generating facility owner and the relevant system operator, in coordination with the relevant TSO, shall agree on the parameters and settings of the components of the voltage control system. The agreement shall cover the specifications and performance of an automatic voltage regulator ('AVR') with regard to steady-state voltage and transient voltage control (site-specific non-exhaustive Parameter). Further the specifications and performance of the excitation control system of an automatic voltage regulator shall include a Power System Stabilizer (PSS) function to attenuate power oscillations, among other, if the synchronous power-generating modules size is above the value proposed by the TSO.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Power Threshold	Not specified	All Type D PGMs	19.2.b.(v)	D SPGMs	2

Table 39: Power Threshold above which PSS Function is required

Justification

Due to the increasing complexity of the transmission system, along with the increasing levels of non-synchronous generation, it is likely the frequency and intensity of oscillations will increase. In order manage this going forward and to maintain the security and safety of the transmission system, PSSs will be required on all type D PGMs.

4.2.4 Fault Ride Through Capability

The following sections discuss the fault ride through (FRT) capability requirements under RfG. The requirements for SPGM and PPMs are discussed separately under each of these two sections.

It should be noted that the capabilities are different for different connection types. The requirements are split out in the following sections to indicate this. The relevant elements of a connection for this discussion are:

1. Connection at 110 kV or more
2. Connection at less than 110 kV
3. Different topology connections at less than 110 kV.

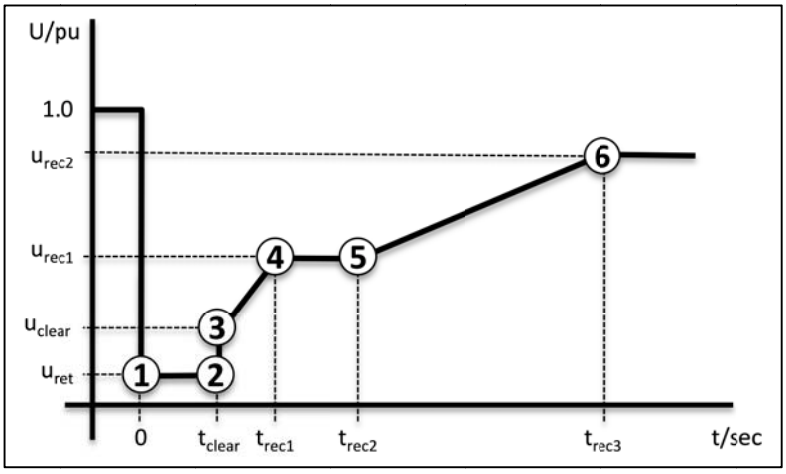
4.2.4.1 Article 14.3.a & 16.3.a: FRT Capability for PGMs connected at voltage level <110 kV

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PGMs and offshore PPMs

Requirement

Power-generating modules 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 with the figure below:



Fault Ride Through Profile of a Power-Generating Module

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, during and after the fault.

That lower limit is specified for synchronous power-generating modules and power park modules connected below the 110 kV level in the following subsections.

Proposal: SPGMs connected at a voltage level < 110 kV

Table 40 lists the parameters which describe the FRT capability parameters for SPGMs connection at a voltage level < 110 kV.

No. on Graph	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
1	u_{ret}	0.05 – 0.3 p.u.	0.05 p.u.	14.3.a (i)	B,C, and D SPGMs	2
2	u_{ret}	0.05 – 0.3 p.u.	0.05 p.u.			
	t_{clear}	140 – 250 ms	150 ms			
3	u_{clear}	0.7 – 0.9 p.u.	0.7 p.u.			
	t_{clear}	140 – 250 ms	150 ms			
4	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec1}	t_{clear}	t_{clear}			
5	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec2}	t_{rec1} – 700 ms	450 ms			
6	u_{rec2}	0.85 – 0.9 p.u.	0.9 p.u.			
	t_{rec3}	t_{rec2} – 1.5 s	t_{rec2}			

Table 40: Definition of FRT parameters for SPGMS connected @ <110 kV

Justification: SPGMs connected at a voltage level <110 kV

A change is needed here to comply with RfG. The points (150ms, 0.5 p.u.) and (450 ms, 0.5 p.u.) have to move to (150 ms, 0.7 p.u.) and (450 ms, 0.9 p.u.), respectively in order to come within the stipulated envelope.

Figure 5 shows the fault ride through capabilities including for completeness, the under-voltage protection settings (UV trip area) and RfG boundaries.

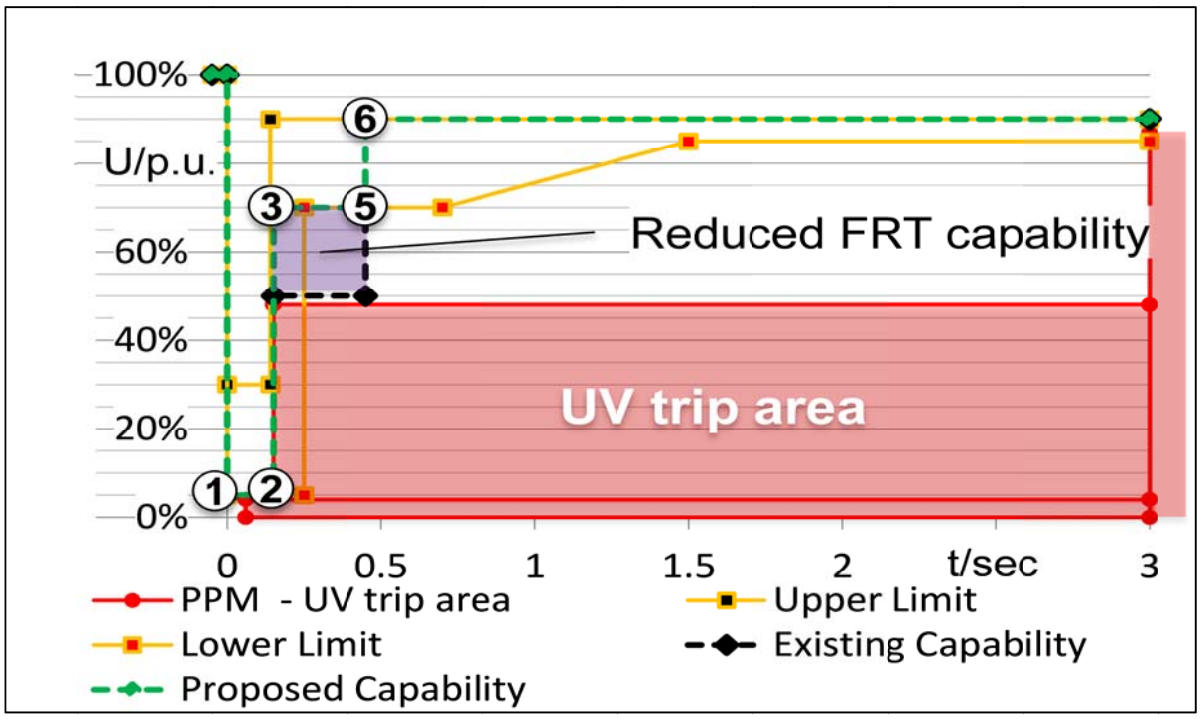


Figure 5: FRT capability for SPGMS connected @ <110 kV

Proposal: PPMs connected at a voltage level < 110 kV

Table 41 lists the parameters which describe the FRT capability parameters for ~~SPGMs~~ PPMs connection at a voltage level < 110 kV.

No. on Graph	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
1	u_{ret}	0.05 – 0.15 p.u.	0.15 p.u.	14.3.a (i)	B,C and D PPMs	2
2	u_{ret}	0.05 – 0.15 p.u.	0.15 p.u.			
	t_{clear}	140 – 250 ms	250 ms			
3	u_{clear}	u_{ret} – 0.15 p.u.	u_{ret}			
	t_{clear}	t_{clear}	t_{clear}			
4	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec1}	t_{clear}	t_{clear}			
5	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec2}	t_{rec1}	t_{rec1}			
6	u_{rec2}	0.85 p.u.	0.85 p.u.			
	t_{rec3}	1.5 – 3.0 s	2.9 s			

Table 41: Definition of FRT parameters for PPMs connected @ <110 kV

Justification: PPMs connected at a voltage level <110 kV

Fault ride through capability changes slightly. Point (2) to (5) at (625 ms, 0.15 p.u.) moved to (250 ms, 0.15 p.u.). This will give a greater margin between this point and the under-voltage setting of 0.13 p.u. for 0.5s. Figure 6 shows the fault ride through capabilities including for completeness, the under-voltage protection settings (UV trip area) and RfG boundaries.

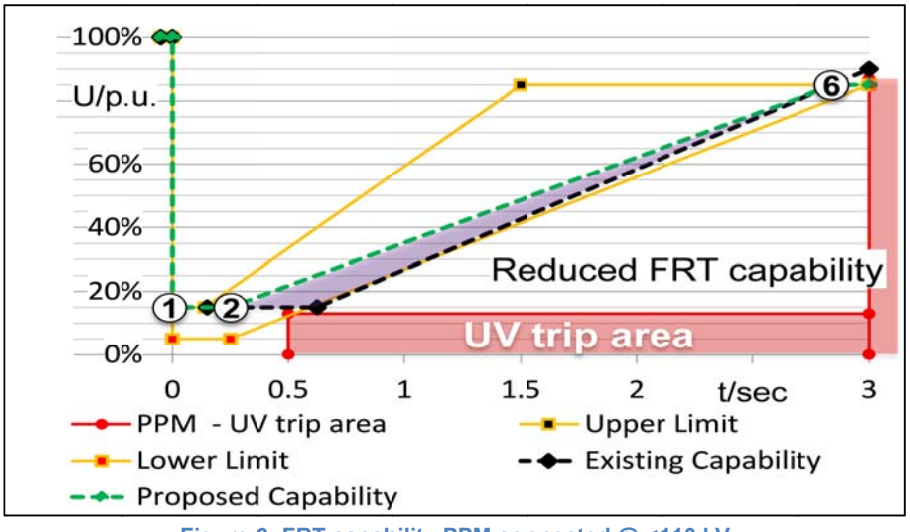


Figure 6: FRT capability PPM connected @ <110 kV

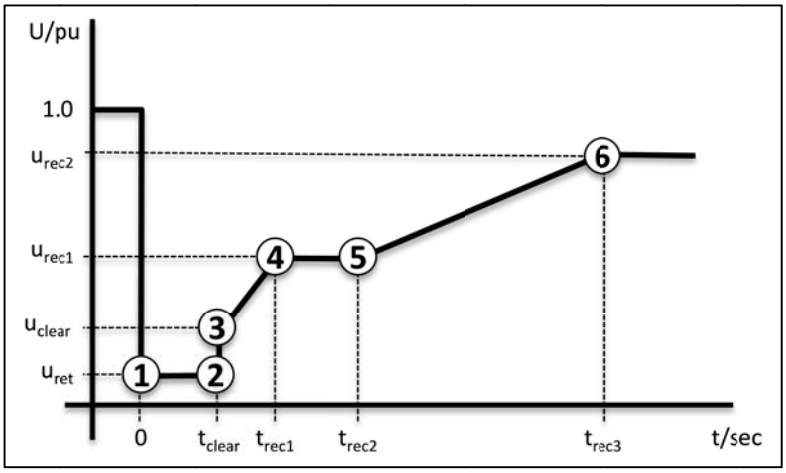
4.2.4.2 Article 16.3.a FRT Capability for PGMs connected at voltage level ≥110 kV

Non-Exhaustive Parameter Selection

Applies to Type D PGMs and offshore PPMs

Requirement

Power-generating modules 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 of a Power-Generating Module

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, during and after the fault.

That lower limit is specified for synchronous power-generating modules and power park modules connected at or above 110 kV in the following subsections.

Proposal: SPGMs connected at a voltage level ≥ 110 kV

Table 42 lists the parameters which describe the FRT capability parameters for SPGMs connection at a voltage level ≥ 110 kV.

No. on Graph	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
1	u_{ret}	0 p.u.	0	16.3.a (i)	D SPGMs	2
2	u_{ret}	0 p.u.	0			
	t_{clear}	140 – 250 ms	150 ms			
3	u_{clear}	0.25 p.u.	0.25 p.u.			
	t_{clear}	140 – 250 ms	150 ms			
4	u_{rec1}	0.5 – 0.7 p.u.	0.5 p.u.			
	t_{rec1}	t_{clear} – 450 ms	450 ms			
5	u_{rec1}	0.5 – 0.7 p.u.	0.5 p.u.			
	t_{rec2}	t_{rec1} – 700 ms	450 ms			
6	u_{rec2}	0.85 – 0.9 p.u.	0.9 p.u.			
	t_{rec3}	t_{rec2} – 900 ms	450 ms			

Table 42: Definition of FRT parameters for SPGMs connected @ □110 kV

Justification: SPGMs connected at a voltage level ≥110 kV

According to the RfG parameters, the retained voltage (u_{ret}) is stipulated to be 0.0 p.u. The recovery voltage has been capped to the upper bound of u_{rec2} of 0.9 p.u. Figure 7 shows the fault ride through capabilities including for completeness, the RfG boundaries.

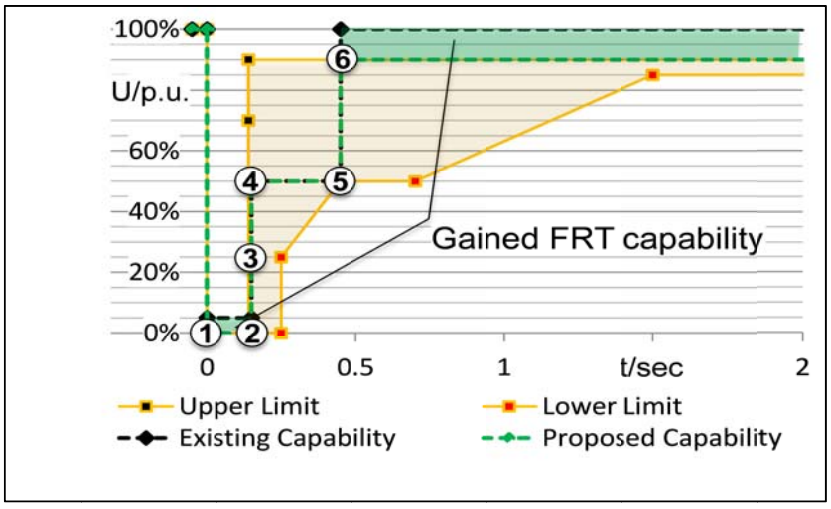


Figure 7: FRT capability of SPGMs connected at ≤ 110 kV

Proposal: PPMs connected at a voltage level ≥ 110 kV

Table 43 lists the parameters which describe the FRT capability parameters for ~~SPGMs~~ PPMs connection at a voltage level < 110 kV.

No. on Graph	Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
1	u_{ret}	0 p.u.	0	16.3.a (i)	D PPMs	2
2	u_{ret}	0 p.u.	0			
	t_{clear}	140 – 250 ms	150 ms			
3	u_{clear}	u_{ret}	u_{ret}			
	t_{clear}	t_{clear}	t_{clear}			
4	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec1}	t_{clear}	t_{clear}			
5	u_{rec1}	u_{clear}	u_{clear}			
	t_{rec2}	t_{rec1}	t_{rec1}			
6	u_{rec2}	0.85 p.u.	0.85 p.u.			
	t_{rec3}	1.5 – 3.0 s	2.9 s			

Table 43: Definition of FRT parameters for PPMs connected @ ≥ 110 kV

Justification: PPMs connected at a voltage level ≥110 kV

According to the RfG parameters, the retained voltage (u_{ret}) is stipulated to be 0.0 p.u. Figure 8 shows the fault ride through capabilities including for completeness, the under-voltage settings in the distribution system and the RfG boundaries.

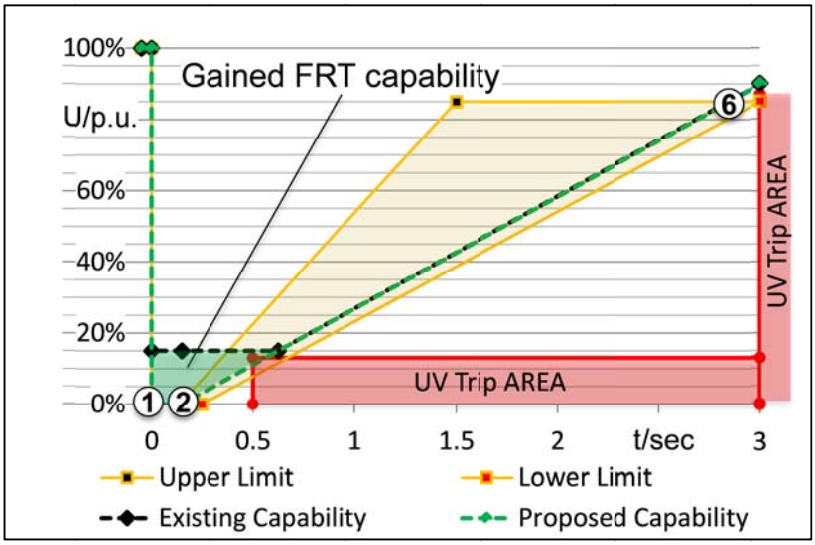


Figure 8: FRT capability of PPMs connected at ≤ 110 kV

It is noted that these proposed FRT capability requirements, conflict with the current protection settings for under voltage relays. However in the future, these protection settings may change and the FRT capability needs to remain.

4.2.4.3 Fast Fault Current Injection

4.2.4.3.1 Article 20.2.b Fast Fault Current Injection for Symmetrical Faults

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

the relevant system operator in coordination with the relevant TSO shall have the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults, under the following conditions

(i) the power park module shall be capable of activating the supply of fast fault current either by:
   a. ensuring the supply of the fast fault current at the connection point, or
   b. measuring voltage deviations at the terminals of the individual units of the PPM and providing a fast fault current at the terminals of these units;

(ii) the relevant system operator in coordination with the relevant TSO shall specify:
   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, including the time domain for measuring the voltage deviation and fast fault current, for which current and voltage may be measured differently from the method specified in Article 2,
   c. the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance;

Proposal

Parameter	Parameter in RfG	Consultation 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.	20.2.b	B, C and D PPMs	1
End of the voltage deviation	Not specified	Once the voltage has recovered to within normal operating voltage range	20.2.b	B, C and D PPMs	1
the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current	Not specified	Reactive current should be provided for the duration of the voltage deviation within the rating of the PPM	20.2.b	B, C and D PPMs	1
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.	20.2.b	B, C and D PPMs	~~2~~1

Table 44: Fast Fault Current Injection - Symmetrical Faults

Justification:

As per the current Grid Code requirements, the fast fault current injection shall be provided during transmission system voltage dips. Voltage dips can occur following a transmission fault, or more generally, where bus voltages and terminal voltage of less than 90% nominal voltage on any or all phases occur. CC.8.3.2 specifies the transmission system disturbance voltages following transmission faults.

According to WFPS1.4.2, the provision of reactive current shall continue until the transmission system voltage recovers to within the normal operational range as specified in CC8.3.1, or for at least 500 ms, whichever is sooner. The reactive current response shall be supplied within the rating of PPM, with a Rise Time no greater than 100ms and a Settling Time no greater than 300ms.

4.2.4.3.2 Article 20.2.c Fast Fault Current Injection for Asymmetrical Faults

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

(iii) with regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the relevant system operator in coordination with the relevant TSO shall have the right to specify a requirement for asymmetrical current injection

Proposal

Parameter	Parameter in RfG	Consultation 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.	20.2.~~b~~c	B, C and D PPMs	1
End of the voltage deviation	Not specified	Once the voltage has recovered to within normal operating voltage range	20.2.c	B, C and D PPMs	1
the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current	Not specified	Reactive current should be provided for the duration of the voltage deviation within the rating of the PPM	20.2.~~b~~c	B, C and D PPMs	1
the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance	Not specified	Accuracy within the rating of PPM; Rise Time no greater than 100ms and a Settling Time no greater than 300ms.	20.2.~~b~~c	B, C and D PPMs	~~2~~1

Table 45: Fast Fault Current Injection - Asymmetrical Faults

Justification:

As per the current Grid Code requirements, the fast fault current injection shall be provided during transmission system voltage dips. Voltage dips can occur following a transmission fault, or more generally, where bus voltages and terminal voltage of less than 90% nominal voltage on any or all phases occur. CC.8.3.2 specifies the transmission system disturbance voltages following transmission faults.

According to WFPS1.4.2, the provision of reactive current shall continue until the transmission system voltage recovers to within the normal operational range as specified in CC8.3.1, or for at least 500 ms, whichever is sooner. The reactive current response shall be supplied within the rating of PPM, with a Rise Time no greater than 100ms and a Settling Time no greater than 300ms.

4.2.4.4 *Article 20.3.a Post-Fault Active Power Recovery for PPMs*

Non-Exhaustive Parameter Selection

Applies to Type B, C and D PPM

Requirement

(a) the relevant TSO shall specify the post-fault active power recovery that the power park module is capable of providing and shall specify certain parameters

Proposal

Table 46 details the specification of post fault active power recovery capability that power park module shall be capable of providing.

Parameter	Parameter in RfG	Consultation 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 p.u.	20.3.a	B, C and D PPMs	**1**
maximum allowed time for active power recovery	Not specified	500ms/1s	20.3.a	B, C and D PPMs	**1**
magnitude and accuracy for active power recovery	Not specified	90%	20.3.a	B, C and D PPMs	**1**

Table 46: Post-Fault Active Power Recovery for PPMs

Justification

These proposals are as per the current Grid Code WFPS.1.4.2 b) of the current Grid Code. The maximum allowed time for active power recovery differs between fault clearance within 140 ms of 500 ms and for longer clearance times of 1 second.

4.2.4.5 *Article 21.3.e Priority Given to Active or Reactive Power Contribution for PPMs*

Non-Exhaustive Parameter Selection

Applies to Type C and D PPMs

Requirement

With regard to prioritising active or reactive power contribution, 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, this provision has to be established no later than 150 ms from the fault inception;

Proposal

Table 47 specifies the priority to power contribution during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception.

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Prioritisation requirements during FRT	Active/Reactive	Active	21.3.e	C and D PPMs	1

Table 47: Priority given to Active or Reactive Power Contribution

Justification

The proposal aligns with WFPS.1.4.2 of the 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.

4.2.5 Additional Non-Mandatory Voltage Requirements

There is one remaining non-mandatory requirements detailed in the RfG. Table 48 below identifies the area. We do not intend to invoke this non-mandatory requirement at this time.

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability
Simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency	Do we want to expertise the right to specify this non-mandatory RfG?	Not invoking at this time.	16(02)(a)(ii)	Type ~~A, B, C and~~ D PGMs

Table 48: List of Non-Mandatory and not invoked Requirements for Generators

4.3 System Restoration Theme

There is only one article in RfG with a non-exhaustive parameter under the system restoration theme. The sub theme is on:

- Operation of PGM following tripping to house load.

4.3.1 Article 15.5.c.(iii) Operation following tripping to house load

Non- Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

A power-generating module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on the system operator's switchgear position signals. Power-generating modules shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Operation Following Tripping to House Load	Not Specified	4 hours	15.5.c.iii	C and D PGMs and offshore PPMs with a minimum re-synchronisation time greater than 15 minutes*	2/3

Table 49: Operation Following Tripping to House Load

Justification

The Grid Code currently requires generators with a startup time in excess of 20 minutes to be capable of tripping to house load and remain there indefinitely. The RfG requirements are stated differently. Firstly, the requirement applies to Type C & D PGMs with a minimum re-synchronisation time greater than 15 minutes and secondly the time to remain in the mode must be specified by the TSO. For the purpose of this consultation the only item being consulted on is the operation time following tripping to house load. The TSO proposes 4 hours which is aligned to the time to during which units may be without external supply under the Power System Restoration Plan. The Power System Restoration Plan envisages the system being re-synchronised within 4 hours.

4.4 Protection and Instrumentation Theme

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

- Manual Local Measures where the automatic remote devices are out of service
- Instrumentation
- Dynamic system behaviour monitoring
- Simulations
- Neutral Earthing
- Synthetic Inertia

4.4.1 Article 15.2.b: Manual, local measures

Non- Exhaustive Parameter Selection

Applies to Types B, C and D PGMs

Requirement

Manual local measures shall be allowed in cases where the automatic remote control devices are out of service.

The relevant system operator or the relevant TSO shall notify the regulatory authority of the time required to reach the set point together with the tolerance for the active power.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Time required to achieve setpoint when automatic remote devices are unavailable	Not Specified	1 hour	15(2)(b)	B, C and D PGMs	3

Table 50: Time required to Achieve Set point when Automatic Remote Devices are Unavailable

Justification:

While this is a new requirement for PGMs in terms of the Grid Code, it is an existing requirement under the Distribution Code (DCC.11.5.2.6.2) which states that for PPMs, a responsible operator shall be present at the connection point within one hour and shall be capable of taking the required appropriate actions.

The proposed value of 1 hour as the time required to achieve set point when automatic remote devices are unavailable is intended to allow the operator a reasonable time to reach the site, while also ensuring consistency between the Grid Code and Distribution Code.

4.4.2 Article 15.6.b (i): Instrumentation: Quality of Supplies

Non-Mandatory Requirement being made Mandatory

Applies to Types C and D PGMs and offshore PPMs

Requirement

Power-generating facilities shall be equipped with a facility to provide fault recording and monitoring of dynamic system behaviour. This facility shall record the following parameters:

- Voltage,
- Active power,
- Reactive power, and
- Frequency

The relevant system operator shall have the right to specify quality of supply parameters to be complied with on condition that reasonable prior notice is given.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Quality of supplies parameters to be recorded.	Not Specified	Site Specific	15(6)(b)(i)	C and D PGMs and offshore PPMs	3

Table 51: Quality of Supplies Parameters to be Recorded

Justification:

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

- Varying station and/or generation unit configurations and generation types.
- Compatibility with existing equipment

4.4.3 Article 15.6.b.(iii): Dynamic System Behaviour Monitoring

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

The dynamic system behaviour monitoring shall include an oscillation trigger specified by the relevant system operator in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations;

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
oscillation trigger detecting poorly damped power oscillations.	Not Specified	Site Specific	15(6)(b)(iii)	C and D PGMs and offshore PPMs	3

Table 52: Oscillation Trigger Detecting Poorly Damped Power Oscillations

Justification

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

- Varying station and/or generation unit configurations and generation types.
- Compatibility with existing equipment

4.4.4 Article 15.6.c.(iii) Simulation Model Provision

Non-Mandatory Requirement being made Mandatory

Applies to Types C and D PGMs and offshore PPMs

Requirement

The request by the relevant system operator referred to in point (i) shall be coordinated with the relevant TSO. It shall include:

- The format in which models are provided,
- The provision of documentation on a model's structure and block diagrams,
- An estimate of the minimum and maximum short circuit capacity at the connection point, expressed in MVA, as an equivalent of the network.

Proposal

Requirement	Requirement in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Model Provision	Not Specified	Retain the existing model provision requirements with the inclusion of min and max short circuit levels as part of Grid Code Planning Code Appendix Generator Data Requirements	15(6)(c)(iii)	C and D PGMs and offshore PPMs	3

Table 53: Simulation Model Provision

Justification

Grid Code PC.A4 to PC.A8 defines the format of the models to provided, along with details of the supporting documentation. Any information that is required to be provided to the customer will be provided through the current pre-energisation process. This will be provided to the user up to two years in advance of connection, along with the minimum short circuit level as a per unit value.

The proposal is to retain the existing PCA but with the inclusion of additional fields for the provision of the min and max short circuit levels in MVA.

4.4.5 Article 15.6.f.: Neutral-point at the network side of step transformers

Non-Exhaustive Parameter Selection

Applies to Types C and D PGMs and offshore PPMs

Requirement

Earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.

Proposal

Parameter	Parameter in RfG	Consultation Proposal	Article Number	Type Applicability	Justification Code
Earthing arrangement of the neutral-point	Not Specified	400 kV – solidly earthed 220 kV – site specific 110 kV – site specific	15(6)(f)	C and D PGMs and offshore PPMs	1

Table 54: Neutral-point at the Network Side of Step Transformers

Justification:

The proposal is to maintain the proposed Grid Code standard as defined in CC.7.2.5.3.2 and CC.7.2.5.3.3. for 220 kV and 400 kV transformers respectively.

For 110 kV transformers, a modification to the existing text in the Grid Code was proposed at the GCRP, this has been further modified to specifically relate to demand customers and generator customers rather than the DSO. This proposal will be presented to the next GCRP meeting. The revised text of modification proposal (MPID 272), states:

*"The **TSO** will consider on a case by case basis the required treatment of the 110 kV neutral connection of these **Transformer**s. A 110 kV Neutral Earth Switch may be required to be installed in specific instances and **Demand Customers** or **Generators,** as applicable, will be advised of this at the time of the **Connection Offer**. The **TSO** will be responsible for the status of the 110 kV Neutral Earth Switch on these **Transformer**s."*

It is already stated in the Distribution Code clauses listed below, that the neutral point of the HV side of a customer step-up transformer, at the connection point shall not under any circumstance, be earthed by the customer. The relevant existing Distribution Code clauses are: DCC6.3.4, DCC9.3.4, DCC11.4.4

4.2.6 Additional Non-Mandatory Protection & Instrumentation Requirements

There are a number of additional areas with non-exhaustive parameters detailed in the RfG. Table 55 below identifies the areas. In all cases these requirements will be highly dependent on the type of PGM, the location of the connection, etc. As such, these requirements must be dealt with on a case by case basis and do not form part of this consultation.

Parameter	Parameters in RfG	Article Number	Type Applicability
Control Scheme and Settings: Agreement and coordination between the TSO, the RSO (TSO and DSO) and the power generating facility owner (PGFO)	Control schemes and settings of the control devices	14.5.a	B,C and D PGMs and offshore PPMs
Electrical Protection Schemes and settings: Agreement and coordination between the RSO and the PGFO	Protection schemes and settings	14.5.b	B,C and D PGMs and offshore PPMs
Loss of angular stability or loss of control: Agreement between PGFO and the RSO (DSO or TSO), in coordination with the TSO	Criteria to detect loss of angular stability or loss of control	15.6.a	C and D PGMs and offshore PPMs
Instrumentation: Settings of the fault recording equipment, including triggering criteria and sampling rate **Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO.**	Settings of the fault recording equipment, including triggering criteria and sampling rate	15.6.b(ii)	C and D PGMs and offshore PPMs
Instrumentation: Protocols for recorded data **Agreement between PGFO, the RSO and the relevant TSO**	Protocols for recorded data	15.6.b(iv)	C and D PGMs and offshore PPMs
Installation of devices for system operations and system security: Agreement between RSO or TSO and PGFO	Definition of the devices needed for system operation and system security	15.6.d	C and D PGMs and offshore PPMs
Synchronisation: Agreement between the RSO and the PGFO	Settings of the synchronisation devices	16.4	D PGMs and offshore PPMs
Angular stability under fault conditions: Agreement between the TSO and PGFO	Agreement for technical capabilities of the power generating module to aid angular stability.	19.3	D SPGM

Table 55: Parameters to be agreed on a Case by Case basis

5. Consultation Process

5.1. Webinar

To facilitate public engagement on the proposed RfG parameters the TSO and the DSO will host an industry webinar during the consultation process. This webinar, scheduled for the 16th of January 2018, will provide an opportunity for discussion on the proposed RfG parameters as specified in this consultation document.

5.2. Consultation Responses

The TSO and DSO welcome feedback on the proposals set out in Section 4 of this paper. A template has been provided to facilitate this feedback.

Whilst we welcome any feedback on the proposals included in this document, in particular we would like your views on the following:

- Do you agree with the proposed values for each of the specific parameters as set out in this paper
- Do you think that other parameters should have been selected for any of the parameters?
- If yes, please explain what values you would have proposed for the specific parameters.
- If yes, please explain why you would have proposed the value including any costs/benefits/saving you believe will materialise from your proposal.
- Do you believe that any non-exhaustive parameters have been excluded from this document incorrectly
- If yes, please detail the RfG reference
- Do you please that any non-mandatory requirements have been excluded from this document incorrectly?
- If yes please detail the RfG reference

The consultation period ends on 9th February 2018.

Responses should be submitted to EirGrid at gridcode@eirgrid.com before 5pm on **9th February 2018**.

Field Code Changed

6. Next Steps

Following the closure of the consultation period the TSO and DSO shall consider any comments received and shall submit a proposal to the CRU.

After the CRU has approved the proposal the TSO and DSO shall implement the approved RfG parameters into the Ireland Grid Code and Ireland Distribution Code.

Page 4: [1] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [1] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [2] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [2] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [3] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [3] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [4] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [4] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [5] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [5] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [6] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [6] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [7] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [7] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [8] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [8] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [9] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [9] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [10] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [10] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [11] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [11] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [12] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [12] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [13] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [13] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [14] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [14] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [15] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [15] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [16] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [16] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [17] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [17] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [18] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [18] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [19] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [19] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [20] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [20] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [21] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [21] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [22] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [22] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [23] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [23] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [24] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [24] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [25] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [25] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [26] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [26] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [27] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [27] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [28] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [28] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [29] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [29] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [30] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [30] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [31] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font

Page 4: [31] Formatted	McMullan,Lisa	26/01/2018 12:43:00

Default Paragraph Font