nationalgrid

Stage 01: Modification Proposal

Grid Code

GC0101

Mod Title:

EU Connection Codes GB Implementation – Mod 2

What stage is this document at?

01	Modification Proposal
02	Workgroup Report
03	Code Admin Consultation
04	Draft Final Modification Report
05	Report to the Authority

Purpose of Modification:

This modification (2/4) will set out within the Grid Code the following compliance obligations in the EU Connection Codes:

1. Set the Voltage & Reactive requirement in GB, as required in RfG and HVDC
2. Set the Frequency requirements in GB, as required in RfG and HVDC

The Proposer recommends that this modification should be: assessed by a Workgroup to form the final proposals for the mod and then proceed to Workgroup Consultation. *Grid Code issue GC0087* should also be **closed**, as this modification incorporates its scope and any progress against its ToR.

This modification was raised on 22nd May 2017 and will be presented by the Proposer to the Panel on 30th May 2017**.** The Panel will consider the Proposer's recommendation and determine the appropriate route.

	***High Impact:*** *Developers of: New generation schemes (800 Watts capacity and up), new HVDC schemes (including DC-connected Power Park Modules); GB NETSO; Distribution Network Operators;*
	***Medium Impact:*** *Transmission Owners (including OFTOs); Operators of existing generation, HVDC schemes considering modernisation;*
	***Low Impact:*** *None identified*

Contents

Any Questions?

Contact:

First Last

Code Administrator

christine.brown1@nationalgrid.com

01926 65 3328

Proposer:

Richard Woodward

National Grid (SO)

Timetable

The Code Administrator recommends the following timetable:

Workgroup Meeting 1	07 June 2017
Workgroup Meeting 2	July 2017
Workgroup Consultation (20 Working days)	20 July 2017
Workgroup Meeting 3 (Alternatives and vote)	September 2017
Workgroup Report presented to Panel	12 September 2017
Code Administration Consultation Report issued to the Industry (15 Working days)	14 September 2017
Draft Final Modification Report presented to Panel	10 October 2017
Panel Recommendation Vote	18 October 2017
Final Modification Report issued the Authority	27 October 2017
Implementation	13 November 2017

1 Summary

What

Full sections of the Grid Code, for example the Connection Conditions (CCs), will need to be extended to set out the new EU standards to which impacted users will need to comply with.

This will be a combination of completely new requirements inserted into the Grid Code, or adjustments/continuation of corresponding existing GB requirements to line up with equivalents in the new EU codes.

Why

Guidance from BEIS and Ofgem was to apply the new EU requirements within the existing GB regulatory frameworks. This would provide accessibility and familiarity to GB parties, as well as putting in place a robust governance route to apply the new requirements in a transparent and proportionate way.

This modification needs to be undertaken in timely manner to ensure impacted users are aware of their compliance obligations - particularly in relation to procurement of equipment, testing and operational requirements. This modification is also therefore, critical to facilitate/demonstrate Member State compliance to these three EU Network Codes.

How

With the support of the industry, we will use this modification to finalise proposals to apply the EU Connection Codes requirements, before consulting with the wider industry and submitting to Ofgem for a decision.

Previously, Grid Code and Distribution Code issue groups were formed (GC0048, GC0087, GC0090) to:
1. Comprehensively review the code to form a local interpretation of the requirements;
2. Undertake a mapping between the EU and GB codes to understand the extent for possible code changes;
3. Form proposals, which will now be taken forward as formal modifications.

2 Governance

Given the complexity and wide-ranging impact of the changes proposed in this mod, the proposer believes that self-governance or fast track governance arrangements are not appropriate in this case.

Instead, ‘Normal’ Grid Code governance processes should be followed.

3 Why Change?

This Proposal is one of a number of Proposals which seek to implement relevant provisions of a number of new EU Network Codes/Guidelines which have been introduced in order to enable progress towards a competitive and efficient internal market in electricity.

Some EU Network Guidelines are still in development and these may in due course require a review of solutions developed for Codes that come into force beforehand. The full set of EU network guidelines are;

- Regulation 2015/1222 – Capacity Allocation and Congestion Management (CACM) which entered into force 14 August 2015
- Regulation 2016/1719 – Forward Capacity Allocation (FCA) which entered into force 17 October 2016
- ***Regulation 2016/631 - Requirements for Generators (RfG) which entered into force 17 May 2016***
- *Regulation 2016/1388 - Demand Connection Code (DCC) which entered into force 7 September 2016*
- ***Regulation 2016/1447 - High Voltage Direct Current (HVDC) which entered into force 28 September 2016***
- Transmission System Operation Guideline (TSOG) - entry into force anticipated Summer 2017
- Emergency and Restoration (E&R) Guideline - entry into force anticipated Autumn 2017

RfG, DCC and HVDC were drafted to facilitate greater connection of renewable generation; improve security of supply; and enhance competition to reduce costs for end consumers, across EU Member States.

These three codes specifically set harmonised technical standards for the connection of new equipment for generators, demand, and HVDC systems (including DC-Connected Power Park Modules respectively).

Significant work to progress GB understanding of the codes and consider the approach for implementation has been undertaken in Grid Code/Distribution Code issue groups **GC0048 (RfG), GC0087 (RfG Frequency)** and **GC0090 (HVDC)**.

This has been widely attended, including DNOs and smaller parties. Additional stakeholder holder engagement has been undertaken to ensure the impacts of the three EU codes is understood, as well as to provide an opportunity to feed into the approach.

The majority of the technical requirements involved in Mod 2 have been consulted on. No significant concern been registered yet from industry parties.

Through proposing these modifications under Open Governance, we will finalise our proposals; and undertake a final industry consultation to confirm they are appropriate, before submitting papers to Ofgem to request a decision.

4 Code Specific Matters

Technical Skillsets

- Understanding of the GB regulatory frameworks (particularly Grid Code and Distribution Code)
- High level understanding of the EU codes and their potential impact
- Operational/technical understanding of equipment which are bound by these codes
- Where appropriate, knowledge of the obligations and operational processes of GB Network Operators and the GB National Electricity Transmission System Operator

Reference Documents

Requirements for Generators legal text:
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0631&from=EN

High Voltage Direct Current legal text:
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1447&qid=1494236788524&from=EN

5 Solution

1. Set the Voltage & Reactive requirement in GB, as required in RfG and HVDC

Voltage Ranges

- RfG Article 16(2)(a) Tables 6.1 and 6.2 define the steady state voltage operating range for Type D Power Generating Modules
- CC.6.1.4 of the Grid Code currently defines the steady state operating range of *all* Users' connected to the Transmission System;
- CC.6.1.4 and RfG Article 16(2)(a) Tables 6.1 and 6.2 are similar, other than the GB Code requires the voltage range applicable to User's connected below 132kV should be within ±6% - RfG requires Type D Power Generating Modules connected between 132kV and 110kV to remain within the limits of ±10%
- It is not envisaged that this will have any significant impact on current GB practice as equipment rated at a nominal voltage of between 132kV and 110kV is generally not used.
- Therefore, it is proposed that the Voltage Range requirement as defined in Grid Code CC.6.1.4 is maintained (ensuring consistency with the requirements of the ESQCR), accepting that CC.6.1.4 will require minor changes to ensure consistency with the European Codes

Specification of Wider Ranges

- RfG Article 16 (2)(b) does permit the relevant System Operator in co-ordination with the Generator and relevant TSO to specify wider voltage ranges or longer minimum operating times if economically and technically feasible.
- In addition, Article 16(2)(c) states that the relevant System Operator in co-ordination with the Relevant TSO shall have the right to specify voltages at the connection point at which a Power Generating Module is capable of disconnection.

Operational conditions for simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency

- Article 16(2)(a)(ii) permits the Relevant TSO to specify shorter periods of time during which Type D Power Generating Modules shall be capable of remaining connected to the network in the event of simultaneous overvoltage and under-frequency or simultaneous under-voltage and over-frequency.
- Both Type C and Type D Power Generating Modules are subject to the same reactive capability, voltage and frequency range capability requirements. It therefore seems appropriate to apply the same voltage ranges (as per current GB practice) to Type A – C power generating modules too

Type B Synchronous Power Generating Modules - General Reactive Capability

- Reactive capability range of 0.95 Power Factor lag to 0.95 Power Factor lead at Rated MW output at the Connection Point, unless otherwise agreed with NGET or the relevant Distribution Network Operator.
- The value of 0.95 Power Factor Lead to 0.95 Power Factor lag at Rated MW output has been selected on the basis of DNO requirements, general plant capability and equitable treatment with Power Park Modules.

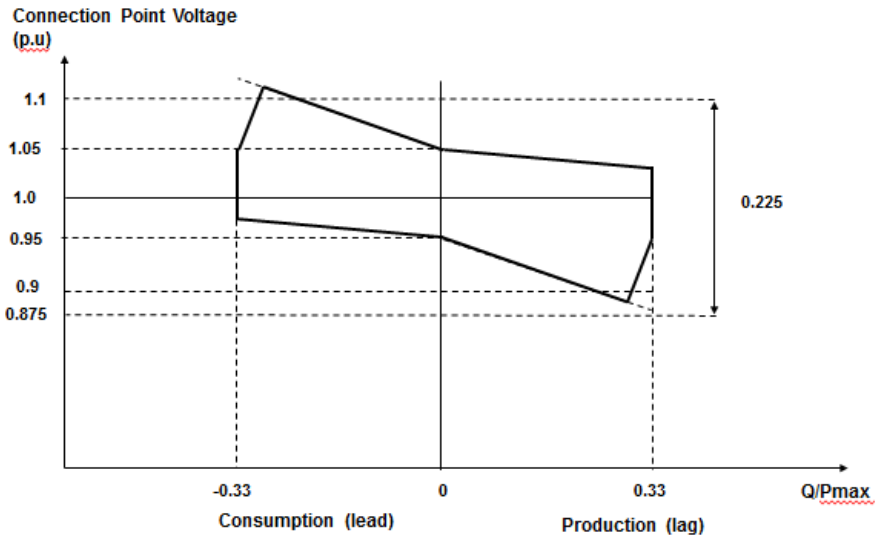
Type B Synchronous Power Generating Modules - Control Performance

- Article 17(2)(b) requires Type B Synchronous Power Generating Modules to be equipped with a permanent automatic excitation control system that can provide constant alternator terminal voltage at a selectable set point without instability over the entire operating range.
- In this context it is assumed that the entire operating range covers zero MW to Rated MW over the full reactive capability range (i.e. maximum lag (under-excited) to maximum lead (over-excited)
- Practical implementation of a scheme would be dependent upon the requirement specified at the Connection Point by the Relevant Network Operator which could be voltage control, power factor control or reactive power control.

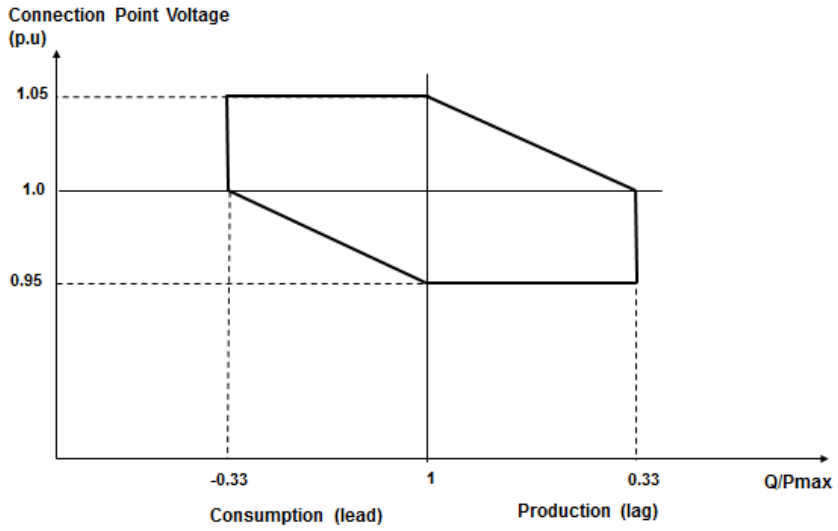
Type C and D Power Generating Modules - Reactive Power Capability

- When operating at maximum capacity, this is defined based on a U-Q/Pmax profile (i.e. a (voltage – reactive power)/Maximum Power Output profile) at the Connection Point.

U-Q/Pmax profile for a Type C or D Power Park Module with a Connection Point above 33kV:



Voltage/ Reactive Capability diagram for a Type C or D Power Park Module with a Connection Point <u>at or below 33kV</u> (NB most would be Distribution-connected)**:**



U-Q/Pmax profile for a Type C or D Power Park Module with a Connection Point <u>at or below 33kV</u> (NB most would be Distribution-connected):

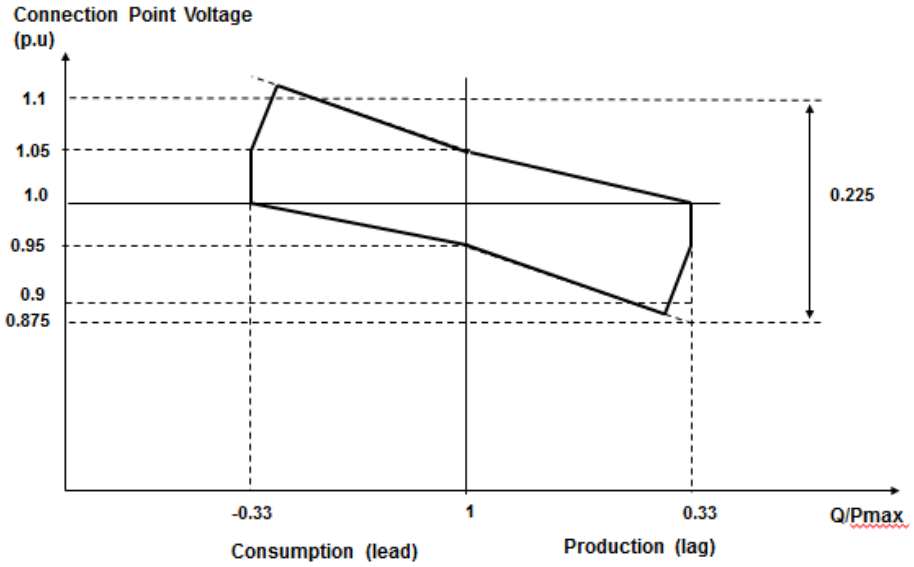
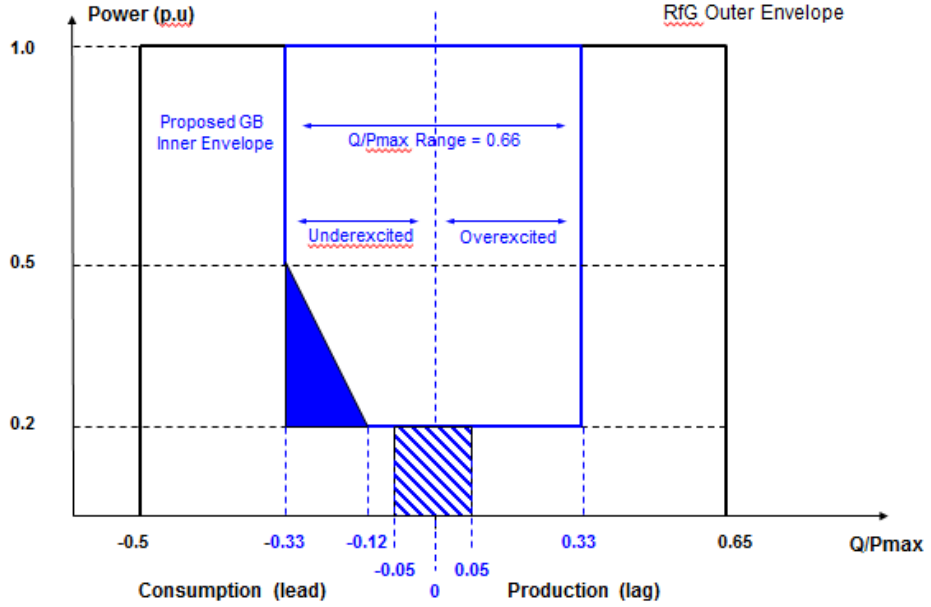


Figure 8.16(c) –

Type C and Type D Power Park Modules – Reactive Capability below Maximum Capacity

- When operating below maximum capacity, the PPM is required to satisfy a Power – Reactive Power / Pmax (P – Q/Pmax) requirement
- The current reactive capability requirements of CC.6.3.2 can be mapped directly into RfG Article 21(3)(c) other than conversion of Power Factor into Q/Pmax. The proposed GB requirement is therefore shown below

P – Q Capability diagram of a Type C and Type D Power Park Module at the Connection Point



- For Type C and Type D Power Generating Modules which are distribution connected, and not subject to a Connection Agreement with National Grid, the Distribution Code is expected to obligate such Generators to meet the requirements of the Grid Code through similar arrangements adopted for LEEMPS

Type C and Type D Power Park Modules - Reactive Power Control Modes

- There are three principle ways in which reactive power can be controlled from a Power Generating Module –
  - voltage control;
  - reactive power control; or
  - power factor control
- Under RfG Article 21(3)(d)(vii) the relevant System Operator in co-ordination with the Relevant TSO shall specify which of the above three reactive power control modes applies.
- The table below provides a comparison between the current GB Grid Code requirements and those under RfG. As can be seen, the majority of the RfG requirements are consistent with current GB requirements

European Requirement	GB Requirement
Voltage Control settings – (Art 21(3)(d)(ii))	Steady State Control parameters covered in CC.A.7.2.2 – Parameters are consistent with RfG.
Setpoint / Deadband – (Art 21(3)(d)(iii))	Setpoint / Deadband – (CC.A.7.2.2.2) – No deadband would be set as per current GB Practice.
Transient voltage control – t_1 (1 – 5 seconds) and t_2 (5 – 60 seconds) to be specified – (Art 21(3)(iv))	Under GB Code t_1 is set at 1 second (CC.A.7.2.3.1(ii)) and t_2 is set at 2 seconds – (CC.A.7.2.3.1(iv). **The proposal would be to set t_2 to 5 seconds.**
Power Oscillation Damping – Art 21(3)(f)	As per CC.A.7.2.4

Type C and Type D Power Park Modules Reactive Power Control

- As described above, Reactive Power Control will not be required from Type C and Type D Power Park Modules unless otherwise specified in the Connection Agreement.
- Where a requirement for Reactive Power Control is specified, it would need to satisfy the requirements of RfG Article 21(3)(d)(v).

Type C and Type D Power Park Modules Power Factor Control

- Similar to Reactive Power Control, Power Factor control will not be required from Type C and Type D Power Park Modules unless otherwise specified in the Connection Agreement.
- Where a requirement for Power Factor Control is specified, it would need to satisfy the requirements of RfG Article 21(3)(d)(vi).

Type B Power Generating Modules General Reactive Capability requirements

- Only reactive capability as specified by the relevant System operator is required in RfG - Article 20(2)(a) states “with regard to reactive power capability, the relevant System Operator shall have the right to specify the capability of a power park module to provide reactive power”.

Type B Power Park Modules Reactive Capability requirements

- RfG effectively leaves this choice to the relevant System Operator. For a Transmission-connected Power Park Module, current GB Grid Code practice would be for a reactive capability of 0.95 Power Factor Lag to 0.95 Power Factor Lead at Rated MW output at the Connection Point.
- For a DNO connected Power Park Module which falls outside the remit of the Grid Code, the GB reactive capability requirements are specified in the Distribution Code and G59/3.
- To ensure the requirements therefore remain as flexible as possible, it is proposed that Type B Power Park Modules would be required to have a reactive capability range of 0.95 Power Factor lag to 0.95 Power Factor lead at Rated MW output at the Connection Point unless otherwise agreed with NGET or the relevant Distribution Network Operator.

Type B Power Park Modules Control Performance requirements

- RfG does not specify any form of reactive power control mode (e.g. voltage control, reactive power control or power factor control) from a Type B Power Park Module.
- Voltage control would be the preferred choice for both Transmission-connected and Distribution-connected generation

Configuration, Voltage Range, Reactive Capability and Control performance requirements for AC Connected Offshore Power Park Modules

<u>Configuration</u>

- RfG Article 23 defines the requirements for AC connected Power Park Modules. These are classified into two categories:
    - Configuration 1:- AC connection to a single onshore Grid interconnection point whereby one or more Offshore Power Park Modules that are interconnected offshore to form an Offshore AC System are connected to the Onshore System

- Configuration 2:- Meshed AC connections whereby a number of Offshore Power Park Modules are interconnected Offshore to form an Offshore AC System and the Offshore AC System is connected to the Onshore System at two or more Grid Interconnection Points.
- For any Power Park Module which is connected to an HVDC System, the requirements of the HVDC Network Code shall apply.

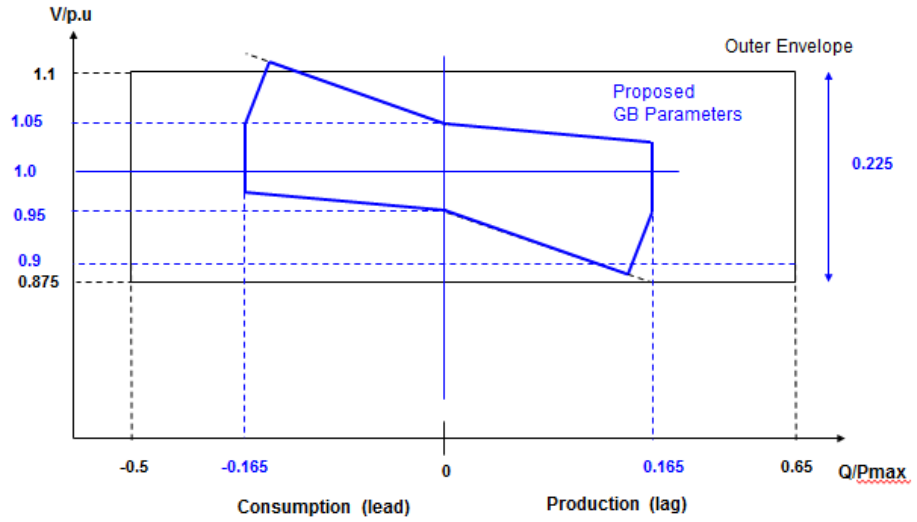
Offshore Voltage Range

- RfG Article 25(1) defines the steady state voltage operating range for AC Connected Offshore Power Park Modules
- CC.6.1.4 of the Grid Code currently defines the steady state operating range of all User's connected to the Transmission System which includes Offshore Generating Units and Offshore Power Park Modules connected to Offshore Transmission Systems
- CC.6.1.4 and RfG Article 25(1) are similar, however the GB Code requires the voltage range applicable to User's connected below 132kV should be within ±6% and RfG requires AC Connected Offshore Power Generating Modules connected between 132kV and 110kV to remain within the limits of ±10%.
- It is not envisaged that this will have any significant impact on current GB practice where equipment rated at a nominal voltage of between 132kV and 110kV are generally used
- All other requirements relating to voltage range are the same as the onshore requirements

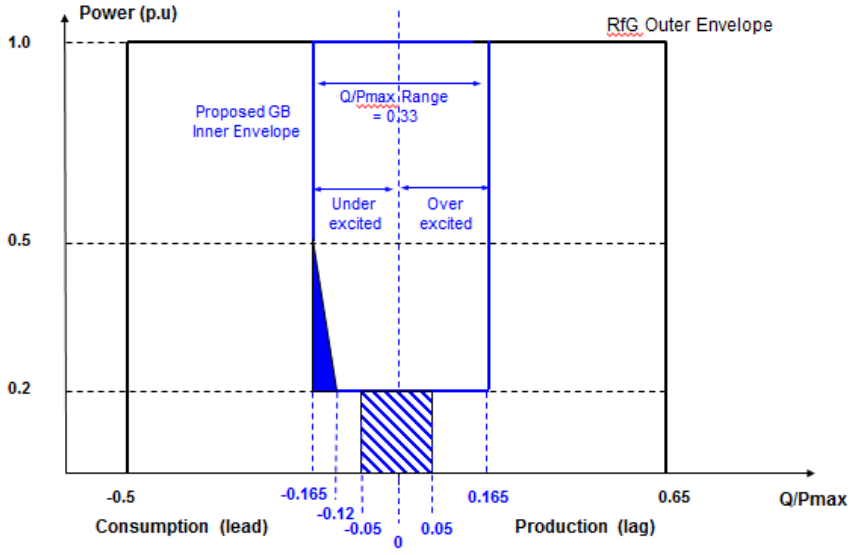
Offshore AC Connected Power Park Modules Reactive Capability requirements

- The Reactive Capability requirements for AC connected Offshore Power Park Modules are broadly the same as those for Type C and Type D Onshore Power Park Modules as defined in Article 21(3), other than in respect of the parameters which are redefined in Table 11 of RfG
- For Configuration 1 Offshore AC Connected Power Park Modules the maximum range of Q/Pmax is set to zero (i.e. unity power factor) and for Configuration 2 Offshore AC Connected Power Park Modules the maximum range of Q/Pmax is set to 0.33.
- Both Configuration 1 and Configuration 2 have a maximum steady state voltage range of 0.225pu
- The voltage range remains unchanged at 0.225pu. The following requirements for Configuration 2 AC connected Power Park Modules are shown below

Configuration 2 - AC connected Offshore Power Park Module U-Q/Pmax Profile



Configuration 2 - AC connected Offshore Power Park Module P-Q/Pmax Profile



- For Configuration 1 AC connected Power Park Modules the Reactive Capability at the Offshore connection point is fixed at unity power factor i.e. zero transfer of reactive power.
- There does not appear to be any tolerance (e.g. ±5%) on the tolerance of reactive power imported or exported to the transmission system
- Notwithstanding this, Article 21(3)(d)(v) defines the requirements for Reactive Power control which states where reactive power control is employed, reactive power should be controlled with an accuracy of ±5 MVAr or ±5% of the full reactive power).
- Interpretation of this requirement would therefore imply that this tolerance should also apply to Configuration 1 AC connected Offshore Power Park Modules

2. Set the Frequency requirements in GB, as required in RfG and HVDC

RfG – Type A and up;

RfG Article	Requirement	Range		Suggested GB Value		Interactions	Policy Req'd? (e.g. Non-compatibility to be defined)	Code Change req'd?
13.1(a)	Frequency Ranges	47 – 47.5Hz	20 seconds	47 – 47.5Hz	20 seconds	DCC;	No	No
		47.5 – 48.5Hz	90 minutes	47.5 – 49.0Hz	90 minutes	RfG Voltage & Reactive		
		48.5 – 49.0Hz	TSO defined (not less than 90mins)	49.0 – 51Hz	Continuous			
		49.0 – 51.0Hz	Unlimited					
		51.0 – 51.5Hz	90 minutes	51.0 – 51.5Hz	90 minutes			
		51.5 – 52Hz	15 minutes	51.5 – 52Hz	15 minutes			
13.2	LFSM-O	Frequency threshold	50.2 – 50.5Hz	Frequency threshold	50.4Hz	HVDC;	To define activation time in GC	?
						DCC		
		Droop	2 – 12%	Droop	10% (2%/0.1Hz)			
		Activation delay	<2 s	Activation delay	<2s			
- 13.2(f)		DMOL						Y
13.3	Maintenance of Constant Active Power	49.5 – 50.5 Hz? – By interpretation		49.5 – 50.4Hz				Y
13.4-13.5	Power Output with Falling Frequency	Below 49Hz falling by a reduction rate of 2% of the Max Capacity at 50Hz/1Hz Freq. drop; Below 49.5Hz by a reduction rate of 10% of the Max Capacity at 50Hz per 1Hz Freq drop		Power Output should not drop by more than pro-rata with frequency (i.e. max permitted requirement is 100% power at 49.5Hz falling linearly to 95% at 47.0Hz)				Y

Frequency Requirements – Type C and up

Article	Requirement	Range		Suggested GB Value		Interactions	Policy Req'd? (e.g. non-compatibility to be defined)?	Code Change Req'd?
15.2(c)	LFSM-U	Frequency Threshold	49.8–49.5Hz	Frequency Threshold	49.5Hz			
		Droop	2 – 12%	Droop	10%		Y	Y
		Initial Delay	<2s	Initial Delay	<2s			
15.2(d)	FSM	Active Power range	1.5 – 10%	Active Power range $\lvert\Delta P_1\rvert/P_{max}$	10%			
		Frequency Insensitivity	10 – 30mHz	Frequency Insensitivity $\lvert\Delta f_i\rvert$	±15mHz		Y	Y
		Frequency Insensitivity	0.02–0.06%	Frequency Insensitivity $\lvert\Delta f_i\rvert / f_n$	±0.03%			
		Deadband	0-500mHz	Deadband	0			
		Droop	2 – 12%	Droop	3 – 5%			
		Maximum admissible initial delay t_1 for Generation with Inertia	2s	Maximum admissible initial delay t_1 for Generation with Inertia	2s			
		Maximum admissible initial delay t_1 for Generation without Inertia	TSO defined	Maximum initial admissible delay t_1 for Generation without Inertia	1s			
		Full activation time t_2	30s	Full activation time t_2	10s			
15.2(g)	ASBMON	Status Signal (on/off)		Status Signal (on/off)				
		Scheduled Active Power output		Scheduled Active Power output				
		Actual value of Active Power output		Actual value of Active Power output				
		Actual parameter settings for Active Power Frequency Response		Actual parameter settings for Active Power Frequency Response			Y	Y
		Droop and deadband		Droop and deadband				
13.1(b)	RoCoF withstand	To be defined by the TSO		+/-1Hzs^{-1}		DCC	Y	Y

6 Impacts and Other Considerations

i. *The Grid Code and Distribution Code will bear the primary impact of the EU Connection Code mods. Some consequential changes are anticipated in the STC code especially from HVDC (primarily Section K - Technical, Design And Operational Criteria And Performance Requirements For Offshore Transmission Systems)*

ii. *The Transmission/Distributions connections and compliance processes will need to be slightly altered to ensure they accommodate the new EU requirements as set out in the modified Grid Code and Distribution Codes.*

iii. *No system changes are anticipated as a result of implementing the EU Connection Codes*

iv. *Existing Grid Code issue GC0087 should be closed down, with this modification incorporating its recommendations and outcomes into a broader package or work.*

Does this modification impact a Significant Code Review (SCR) or other significant industry change projects, if so, how?

The EU Network Code implementation is being undertaken as a significant programme of work within the GB industry. This mod forms part of that programme, but is not part of an on-going SCR.

Consumer Impacts

This modification facilitates the implementation of consistent technical standards across the EU for the connection of new Generation or HVDC equipment.

7 Relevant Objectives

Impact of the modification on the Relevant Objectives:	
Relevant Objective	**Identified impact**
To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity	**Positive**
To facilitate competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity)	**Positive**
Subject to sub-paragraphs (i) and (ii), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national electricity transmission system operator area taken as a whole	**Positive**
To efficiently discharge the obligations imposed upon the licensee by this license and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency; and	**Positive**
To promote efficiency in the implementation and administration of the Grid Code arrangements	**Neutral**

The EU Connection Codes derive from the Third Energy Package legislation which is focused on delivering security of supply; supporting the connection of new renewable plant; and increasing competition to lower end consumer costs. It therefore directly supports the first three Grid Code objectives.

Furthermore, this modification is to ensure GB compliance of EU legislation in a timely manner, which positively supports the fourth Grid Code applicable objective.

8 Implementation

This modification must be in place to ensure the requirements of the EU Connection Codes are set out in the GB codes *by* two years from the respective Entry Into Force dates (set out earlier in this paper).

It is therefore crucial that this work is concluded swiftly to allow the industry the maximum amount of time to consider what they need to do to arrange compliance.

9 Legal Text

Not yet agreed

10 Recommendations

Panel is asked to:

- Approval ‘normal’ code governance procedures be used
- Approve the closure of Grid Code issue GC0087
- Refer this proposal to a Workgroup for continuing the formation of proposals