Stage 02: Industry Consultation

Grid Code + Distribution Code

GC0048 Requirements for Generators EU Network Code implementation

GB proposals for Fault Ride Through requirement

What stage is this document at?

01	Workgroup Recommendation
02	Industry Consultation
03	Report to the Authority

This consultation sets out proposals formed by industry workgroup GC0048 to modify the Grid Code and Distribution Code to specify Fault Ride Through requirements as set out in the 'Requirements for Generators' EU Network Code. This is a requirement to ensure GB compliance with EU law

This document is open for Industry Consultation. Any interested party is able to make a response in line with the guidance set out in Section 5 of this document.

Published on:
Length of Consultation: **20 Working Days**
Responses by:

GC0048 workgroup recommends:

High Impact:
Developers of Transmission or Distribution connected generation schemes of ≥1MW in capacity;

Medium Impact:
The GB Transmission System Operator; GB Distribution Network Operators;

Low Impact:

Contents

About this document

This document outlines the information required for interested parties to form an understanding of a defect within the Grid Code. It seeks the views of interested parties in relation to the proposed solution(s) for this defect and any associated Grid Code legal text changes.

Document Control

Version	Date	Author	Change Reference
0.1	18 August 2016	National Grid; ENA	Draft Industry Consultation
1.0		National Grid; ENA	Final Industry Consultation

Any Questions?

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1 Executive Summary

1.1 The European Network Code 'Requirements for Generators' (RfG) applies technical requirements to new generators of 800 Watts (W) in capacity or greater, who procure their main plant items later than two years after the code 'Enters into Force'. In some cases existing power generating modules may be bound by RfG, for example if they undertake significant modernisation which necessitates substantial revisions to their connection agreement.

1.2 The joint Distribution Code/Grid Code workgroup GC0048 (T) have discussed the Fault Ride Through (FRT) proposals at length with meetings held between February – July 2016. Stakeholders have had the opportunity to comment on the high level proposals which are being presented in this document for wider industry consultation.

1.3 This consultation is the first of element of the Connection Codes that are anticipated to be necessary to implement the RfG into the GB framework. It is expected that FRT and other RfG issues will be consulted on separately over the course of 2016/17. Although legal text will be consulted on, it is also expected that there will need to be a final implementation consultation in late 2017 that ties all the previous RfG consultations together in a single set of legal text for implementation in 2019.

Comment [NG1]: Is this right - Should this be 2018?

1.4 Fault Ride Through is the ability of generating units and power park modules to ride through transmission system faults and disturbances whilst connected to a healthy system circuit. This is a fundamental requirement to maintain system security and avoid cascade tripping of generation causing wider system issues such as frequency collapse and potential system shut down.

1.5 Fault Ride Through was introduced to the GB Grid Code in June 2005 following Grid Code consultation H/04 (Changes to Incorporate New Generation Technologies and DC Inter-connectors H/04). At the time of this Grid Code modification, the new generation of power park modules (which includes wind farms) struggled to remain connected following a transmission system fault even if connected to a healthy circuit for normal protection operating times. To ensure consistency, fairness and non-discrimination, equivalent requirements were applied to both synchronous generating units and power park modules.

1.6 RfG specifies Fault Ride Through requirements for Type, B, C and D Power Generating Modules, whereas in GB the requirements are defined with respect to Large and Medium Power Stations only and their ability to remain connected and stable for a Transmission System fault operating at Supergrid Voltage (200kV or above). It is recognised that the intention behind the RfG Fault Ride Through requirements is the same as that in GB, but the way in which these requirements are defined is different.

1.7 The RfG requirements Entered into Force (EIF) on 17 May 2016. As European law takes priority over GB law (whilst recognising the recent vote to leave the European Union there still remains a desire for the UK to remain as part of the International Energy Market (IEM), the GB Codes need to be updated to ensure consistency with RfG within two years of Entry Into Force (17^{th} May 2018). The current GB requirements for Fault Ride Through are not consistent with RfG and therefore changes will have to be implemented to the GB Code.

1.8 Under CC.6.3.15 of the GB Grid Code, the Fault Ride Through requirements are defined in two parts. CC.6.3.15.1(a) defines the Fault Ride Through

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requirements for balanced and unbalanced transmission system faults which last up to 140ms in duration, whilst CC.6.3.15.1(b) refers to balanced faults and disturbances in excess of 140ms.

1.9 There is no current Distribution Code requirement for Fault Ride Through for transmission faults.

1.10 So far as Fault Ride Through is concerned, under RfG the requirements apply only to secured transmission faults (ie faults on the Transmission System cleared in up to 140ms). RfG makes no reference to longer duration faults cleared in protection operating times of 140ms or greater, or to faults on the Distribution System. The proposal is therefore to update the current GB Grid and Distribution Codes so that the Fault Ride Through requirements for balanced and unbalanced transmission faults up to 140ms in duration are consistent with RfG and the requirements for faults in excess of 140ms are retained as per current GB practice.

1.11 Unlike the GB Grid Code requirements for Fault Ride Through, which specifies a requirement for all Large and Medium Power Stations to remain connected and stable for a solid three phase balanced or unbalanced fault operating at Supergrid Transmission Voltage (ie 200kV or above) RfG specifies the requirement for a Generator to remain connected and stable with respect to a voltage against time profile at the Connection Point. The inference being that that the voltage-against-time curve reflects the conditions at that connection point for a transmission system fault.

1.12 The current GB Grid Code only specifies Fault Ride Through requirements for Large and Medium Power Stations (greater than 50MW in England and Wales, 30MW in SPT's Transmission Area and 10MW in Scottish Hydro Electricity Transmission's area). Under RfG, the requirements (depending upon Generator Type) would apply from 1MW or above but strictly in relation to Transmission faults. In addition the requirements will be consistent across GB which avoids the more complex issue of regional differences in Scotland.

1.13 RfG also provides further distinction in relation to the voltage against time curve at the generation connection point in relation to its type (ie Synchronous or asynchronous) or its category (ie Type A, B, C or D).

1.14 In addition, RfG also specifies the operating conditions that a Power Generating Module must be operating under when assessing Fault Ride Through capability (eg full active power output, maximum leading power factor, maximum and minimum short circuit levels etc). Many of these requirements will be specified by the Relevant System Operator and / or Transmission System Operator. As such this document contains a set of provisions which are believed to ensure consistency with RfG whilst also determining the national parameters required.

1.15 In summary this report provides the following:

- Interpretation of the RfG Fault Ride Through requirements
- Voltage against time curve parameters for Type B, C and D Power Generating Modules (both synchronous and asynchronous)
- Operating characteristics under which Fault Ride Through should be demonstrated
- Active Power recovery characteristics following fault clearance.
- Implications for GB stakeholders – for example the need to revise G59/3 Stage 2 under voltage protection settings.
- Proposed legal drafting.

1.16 This is the first consultation to be completed under RfG which includes proposed legal drafting. This consultation shall therefore seek to endorse the nominated approach taken for drafting these proposed FRT requirements.

1.17 The key steps when forming the Grid Code legal drafting for EU requirements are:

- Duplicate full Grid Code sections where we anticipate a change to be needed (eg Connection Conditions – CCs)
- To mark this new section as EU-specific
- Remove existing Grid Code text from this new section which is now superseded by the EU requirements
- Update the new section with the newly draft EU-specific requirements

1.18 The key steps when forming Distribution Code drafting for EU requirements are:

- The approach taken in forming the Distribution Code legal drafting is as follows
- For distribution connected generators it is currently proposed to replace the current ER G83 and ER G59 with two new documents of similar scope, ER G98 and ER G99. Both G98 and G99 will only apply to new connections.
- G59 and G83 will be retained as they will continue to apply to existing distribution connected generators.
- Make appropriate consequential amendments to the Distribution Code

1.19 This consultation includes draft legal text for the application of Fault Ride Through requirements to Type B power generating modules – see Appendix x. To aid understanding of the current proposed approach, the full draft text of ER G99 is included as Appendix x1.

1.20 It might be more appropriate, when the implications of all the EU Network Codes are better understood that the requirements on distribution connected generators are better incorporated into the body of the Distribution Code, rather than in the stand-alone documents G98 and G99. Stakeholders views on this would be welcome at any time, and particularly in response to this consultation.

1.21 Linkage between the Distribution Code and Grid Code requires some co-ordination but at a high level it is envisaged that that the requirements for Type A and B Embedded Generators would reside in the Distribution Code and all other requirements (Type C – D Embedded Generators and all Transmission Connected Generators (Type A - D) would reside in the Grid Code. Type D Power Generating Modules greater than 100MW would be caught by the provisions of CUSC and Grid Code and the provisions on C and D Power Generating Modules less than 100MW would be addressed by an approach similar to that for Licence Exempt Embedded Medium Power Stations (LEEMPS). The full details of this linkage will be developed over the coming months and introduced as part of the final implementation of the RfG

1.22 This consultation does not include the proposals for fast fault current injection which shall be the subject of a separate consultation.

1.23 The GC0048 WG believes these proposals are consistent with the RfG requirements and they provide adequate information for which Users can design their Plant and Apparatus.

1.24 The draft legal text in Annex 1 shows the proposed changes to the Grid Code Connection Conditions and the proposed format. Annex 2 highlights key points raised as part of the Grid Code legal text drafting.

1.25 The draft legal text in Annex 3 shows the proposed text to be adopted in Engineering Recommendation G99, to apply to Type B Power Generating Modules connected to distribution systems.

1.26 Based on the findings of the Workgroup discussions and Stakeholder engagement, the GC0048 WG recommends that the Grid Code is changed to include the modifications proposed in Annex 1 and Appendix 3 of this report.

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2 Why Change? Background to the Third Energy Package and Requirements for Generators (RfG) code

What is 'Requirements for Generators'?

2.1 RfG sets harmonised rules for grid connection across Europe of power generation modules of 800 Watts (W) in capacity or greater. It seeks to provide a clear legal framework for grid connections, facilitate Union-wide trade in electricity, ensure system security, facilitate the integration of renewable electricity sources, increase competition and allow more efficient use of the network and resources.

2.2 ENTSO-E web page for RfG, including code text: http://networkcodes.entsoe.eu/connection-codes/requirements-for-generators/

2.3 *ENTSO-E overview of the European Network Codes:* https://www.entsoe.eu/major-projects/network-code-development/Pages/default.aspx

How did it originate?

2.4 The European Third Energy Package was adopted in July 2009, and has been law since March 2011. It is a suite of legislation for both Electricity and Gas, and is a key step forward in developing a more harmonised European energy market.

2.5 As applied to the electricity supply industry, the Third Energy Package has three key outputs: enhancing sustainability and helping the European Union (EU) meet its decarbonisation obligations; ensuring security of supply in light of a changing generation mix; and creating a single European Market for Electricity.

2.6 As is common to all EU law, regulations apply directly to the member states, whereas directives require transcription into national law. In particular, Directive 2009/72/EC (concerning common rules for the internal market in electricity) was transcribed into GB Law via The Electricity and Gas (Internal Markets) Regulations 2011.

2.7 The Third Energy Package also delivered the formation of the European Network of Transmission System Operators for Electricity and Gas; ENTSO-E/ENTSO-G. ENTSO-E led the drafting of the RfG before the text was approved by EU Member States in June 2015.

When does it apply?

2.8 RfG 'Entered Into Force', the formal ratification of the legislation into the Official Journal of the European Union, on 17th May 2016. Member States then have two years to implement the code's requirements nationally.

2.9 However, there is a point two years after Entry Into Force where new power generating modules will either be bound by existing national requirements, or the new RfG requirements. If a power generating module developer has a legally binding contract to procure their main plant items dated before two years after Entry Into Force, then they are classed as existing and current national requirements will apply. After this date, the user is classed as 'New' and must comply with RfG.

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2.10 Brexit [RJW]

What were ENTSO-E's objectives when drafting RfG?

2.11 ENTSO-E's brief when drafting these codes was to realise the broad objectives of the Third Energy Package. ENTSO-E also considered the challenges additional renewable generation would present to the way Transmission Systems are designed and managed. In a world of increasing wind and solar generation, HVDC interconnection, and increasing reliance on solid state power conversion technologies, security of supply issues become an increasingly important consideration. Even if RfG was not mandating a need for change, it is expected that similar requirements would need to be introduced at a GB level alone simply to ensure the maintenance of a safe, secure, economic and flexible system.

2.12 From a systems engineering approach, ENTSO-E believe that Transmission Systems and their users (power generating modules, DSOs and demand facilities) should be considered as 'one system' comprehensively. They should cooperate closely during normal and disturbed operating conditions in order to preserve or restore system security.

Determining significance

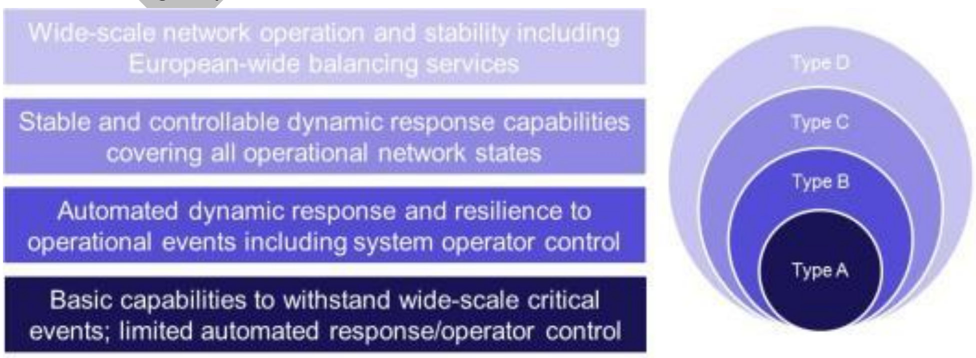
2.13 In particular, power generating modules are fundamental to the design and operational characteristics of the Transmission system, playing an important role by providing ancillary services for system balancing/frequency control, voltage control, resilience during disturbances and to assist with system restoration after blackouts

2.14 RfG therefore specifies power generating module capabilities in this 'system operability' context, and strives to be technology neutral and focuses primarily on capacity and connection.

2.15 Article 2 of RfG defines power generating modules and related terms as "either a synchronous power-generating module or a power park module".

Generator Banding

2.16 RfG uses four incremental types ('A' to 'D') which set a sliding scale of generator technical capabilities to support System Operators. The Transmission System Operation Guideline (TSOG) also uses the RfG banding thresholds to apply data exchange requirements on new *and* existing power generating modules (other EU codes may also refer to RfG banding too).



2.17 Each of the four RfG types has an associated connection voltage and installed unit capacity range (MW). For each European synchronous area, MW ceiling levels are set out in RfG. The code also describes the process each Member State needs to follow to set their own levels (whether this is the ceiling level itself, or values below). A full cost benefit analysis is not mandated as part of this activity.

2.18 Any banding level proposals must be justified, consulted on, and finally approved by the appropriate national regulatory authority (NRA). In the event that modifications to the approved levels are required in future, the same process can be re-run no sooner than 3 years later.

	Type A	**Type B**	**Type C**	**Type D**
Connection Voltage:	<110kV	<110kV	<110kV	≥110kV
	MW range for Power Generating Modules	**MW range for Power Generating Modules**	**MW range for Power Generating Modules**	**MW range for Power Generating Modules**
Continental Europe	800W-1 MW	1 MW-50MW	50 MW-75 MW	75 MW+
Great Britain	**800W-1 MW**	**1 MW-50MW**	**50 MW-75 MW**	**75 MW+**
Nordic	800W-1.5 MW	1.5 MW-10MW	10 MW-30 MW	30 MW+
Ireland and Northern Ireland	800W-0.1 MW	0.1 MW-5MW	5 MW-10 MW	10 MW+
Baltic	800W-0.5 MW	0.5 MW-10MW	10 MW-15 MW	15 MW+

2.19 For GB, there are two proposed options for the banding level which have been formed following industry consultation. Both options maintain the FRT requirement starting at 1MW. They then differ for the top end of Type B, as well as the Type C and Type D ranges. It is hoped that a report to the authority can be issued in Q3 2016 to confirm where these levels will be set:

Type	Option 1 - High	Option 2 - Medium
A	800W – 1MW	800W -1MW
B	1-50MW	1-30MW
C	50-75MW	30-50MW
D	75MW	50MW+

3 Why Change? Background to RfG Fault Ride Through technical requirement

3.1 The need for Fault Ride Through capability for faults on the Transmission System has been well documented in various literature. It is beyond the scope of this report to detail these requirements, however for further information the reader should refer to [1] and Appendix 2, section 5.1 of [2] in the references section.

3.2 Whilst the need and principles of a Fault Ride Through capability are well justified from a Transmission System perspective the purpose of this report is to understand and translate the RfG Fault Ride Through requirements into the GB Codes.

3.3 Under the GB Grid Code CC.6.3.15.1(a) (sometimes referred to as Mode A faults) are designed to cater for transmission system faults cleared in main protection operating times. This is illustrated below:

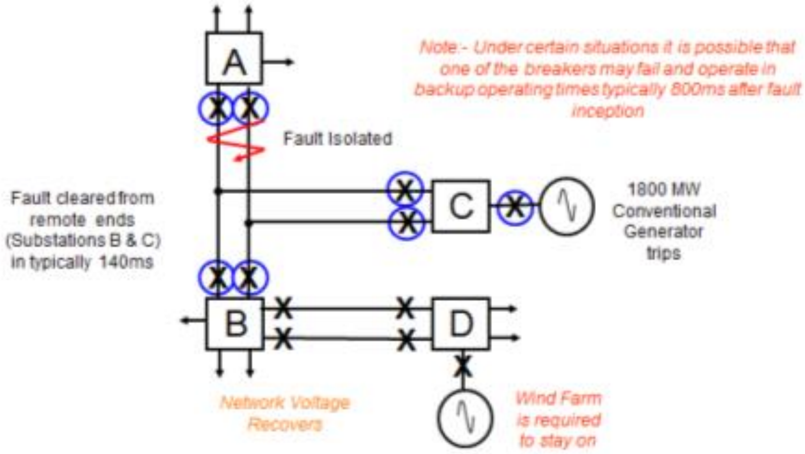


Figure 2.11

3.4 At 400kV, a fault applied at circuits adjacent to substation A would typically be cleared within 80ms. The remote end circuit breakers (at substations B and C) would also trip within 80ms for a unit protection scheme. For main protection schemes where intertripping is used to trip the remote end circuit breakers, they would typically trip within 60ms of the fault being cleared at the local end (total fault clearance time of 140ms). For a three ended circuit, the total fault clearance time (for Fault Ride Through purposes) is specified as 140ms.

3.5 The current GB Mode A Fault Ride Through requirements for Onshore Generating Units are detailed in CC.6.3.15.1(a). It is important to note that these requirements only apply to faults on the Transmission System operating at Supergrid Voltage (ie 200kV or above).

Background to the RfG Fault Ride Through Requirements

2.14 The RfG Fault Ride Through requirements for Power Generating Modules are detailed in Article 14(3), Article 16(3) and Article 17(3). Unlike the GB Grid Code, the RfG requirements segregate the requirements between Synchronous Plant and Asynchronous Plant. The requirements also differ dependent on Generator 'Type' (B – D) - with varying requirements applying between Type B/D Power Generating Modules and Type D Power Generating Modules connected at or above 110kV.

Comment [NG2]: RJW: Should we add verbatim as an appendix?

2.15 A further complication of the RfG structure is that the requirements are graded. For example, all the requirements applicable to Type C Power Generating Modules also include the requirements applicable to Type A and B Power Generating Modules

RfG Fault Ride Through Requirements

2.16 This section of the report details the GC0048 workgroup's understanding and interpretation of the RfG Fault Ride Through requirements.

2.17 The fundamental RfG Fault Ride Through principles are defined for Type B Power Generating Modules (Article 14 (3)). The requirements applicable to Type D Power Generating Modules connected at 110kV or above are simply an extension of the Type B requirements but with more onerous voltage against time parameters.

2.18 The Fault Ride Through requirement is assessed by a voltage against time profile which applies at the Power Generating Module Connection Point.

2.19 The voltage against time profile describes the conditions in which the power generating module must be capable of remaining connected to the network and continuing to operate stably after the power system has been disturbed by secured fault on the Transmission System.

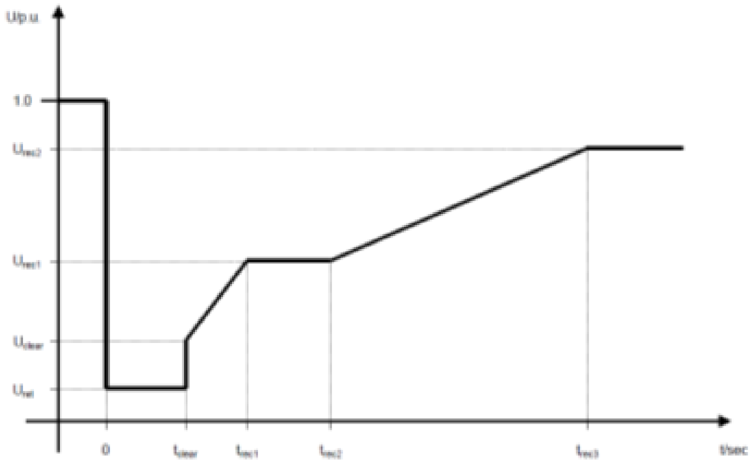


Figure 2.18 – Voltage Against Time Curve – Reproduction of RfG Fig 3

2.20 The Voltage against time curve is designed to express the lower limit of the actual phase to phase voltage at the Connection Point during a symmetrical fault, as a function of time before, during and after the fault.

Voltage against time curve for a Type D Synchronous Power Generating Module connected at or above 110kV

2.21 For a Type D Synchronous Power Generating Module, the range of voltage limits available for the TSO to select in accordance with Article 14(3)(a) – Figure 3 which is reproduced below as Table 2.21.

Voltage parameters (pu)		**Time parameters (seconds)**	
U_{ret}:	0	t_{clear}:	0,14-0,15 (or 0,14-0,25 if system protection and secure operation so require)
U_{clear}:	0,25	t_{rec1}:	t_{clear}-0,45
U_{rec1}:	0,5-0,7	t_{rec2}:	t_{rec1}-0,7
U_{rec2}:	0,85-0,9	t_{rec3}:	t_{rec2}-1,5

Table 2.21 – Extract of Table 7.1 from RfG

2.22 In accordance with the RfG requirements, each TSO is required to make publicly available the pre and post fault conditions for Fault Ride Through in terms of:-

- The pre-fault minimum short circuit capacity at the Connection Point expressed in MVA
- The pre-fault operating point of the power generating module expressed as active power output and reactive power output at the connection point and voltage at the Connection Point (ie Maximum MW output, Full MVAr lead and typical operating voltage).
- The post fault minimum short circuit capacity at the connection point expressed in MVA.

3.6 The relevant System Operator shall provide the pre-fault and postfault conditions for Fault Ride Through as a result of the calculations at the connection point as referenced in section A2.14 above.

- The prefault minimum short circuit capacity at each Connection Point expressed in MVA
- The pre- fault operating point of the power generating module expressed in active power output and reactive power output at the connection point and voltage at the Connection Point and
- The post fault minimum short circuit capacity at each connection point expressed in MVA.

3.7 It is envisaged that general maximum and minimum short circuit data would be included in the Electricity Ten Year Statement (ETYS) and the exact calculated figures would be specified in Appendix F of the Bilateral Connection Agreement.

3.8 For distribution connected Power Generating Modules it is envisaged that DNOs will publish appropriate typical figures (probably in the Long Term Development Statements) with more site specific values produced on request.

3.9 In addition Article 14(3) (vi) states the protection settings of the Power Generating Facility should not jeopardise Fault Ride Through performance which includes the under voltage protection at the Connection Point.

Implementation of RfG Fault Ride Through Requirements for Type D Synchronous Power Generating Modules connected at or above 110kV

3.10 As part of this drafting the approach, the principle adopted is that the GB Grid Code requirements would be expected to remain as they are unless there is a conflict with RfG.

3.11 To ensure the correct interpretation of the RfG Requirements, ENTSO-E have also produced a “Frequency asked Questions Document” Reference [3] which outlines the principles which TSO’s should consider when implementing the RfG. The examples which relate to Fault Ride Through are covered in Question 24.

3.12 The RfG Fault Ride Through requirements centre on the voltage against time curve. Based on Reference [3], the criteria would imply that the TSO should specify the pre and post fault short circuit level at the Connection Point and the pre fault operating conditions of the Generator (eg full MW output and maximum lead). A three phase solid short circuit fault should then be applied at the Connection Point and the Generator should remain connected and stable with the voltage profile remaining above the defined voltage against time curve set by the TSO.

3.13 A complexity with this approach is that the post fault voltage profile is dictated largely by the strength of the network and its topology rather than the Generation at the Connection Point. The Generator will have an impact on the voltage profile at the connection point but it is important to note that this is a more second order effect with pre and post fault system strength playing a more dominant role.

Determination of RfG Voltage against time parameters as applicable to Type D Synchronous Power Generating Modules connected at or above 110kV

3.14 The RfG requirements necessitate that the voltage against time curve (Figure 2.18 above) and parameters (Table 2.21) are to be derived at a National level. It is also specifically worth noting that the voltage against parameters for Type D Power Generating Modules connected at or above 110kV (RfG Tables 7.1 and 7.2) are different to those for Type D Power Generating Modules connected below 110kV (RfG Tables 3.1 and 3.2) , in which case the latter fall into the same range as values specified for Type B and C Power Generating Modules. It should further be noted that the parameter ranges vary depending upon the type of Power Generating Module (ie Synchronous Power Generating Modules or Power Park Modules).

3.15 Taking the extreme ends of these parameter ranges (Table 2.21 above), it is possible to plot a graph showing the parameter ranges available to TSO's at a National level. This is shown in Figure 2.32 below.

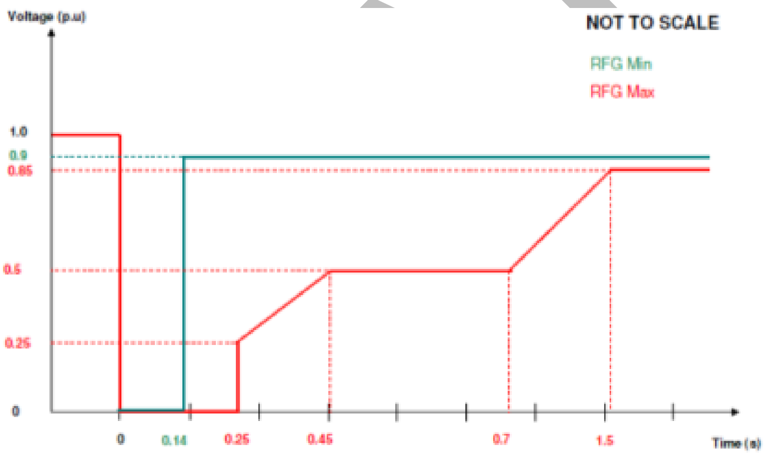


Figure 2.31 – Range of RfG Voltage Against Time Parameters available to TSO's

3.16 The green curve ('RFG Min') refers to the minimum voltage against time curve. Under this case, the post fault voltage profile would require a reasonably stiff system. The implication being that Generator tripping would be permitted under the least onerous of conditions. On the other hand, the red curve is the most onerous requiring the generating unit to remain connected and stable for quite severe post fault voltage recovery conditions.

3.17 At first glance and reading RfG, it would appear that the TSO should be able to select a voltage against time profile anywhere between the Green and Red line. In practice this is not strictly true as the range of parameters in Table 7.1 of RfG (Table 2.21) do limit the ability of the TSO to select certain values between these ranges. These restrictions are shown in Figure 2.33 below. This limitation was also reflected back to ENTSO-E but it is not believed it will cause an issue.

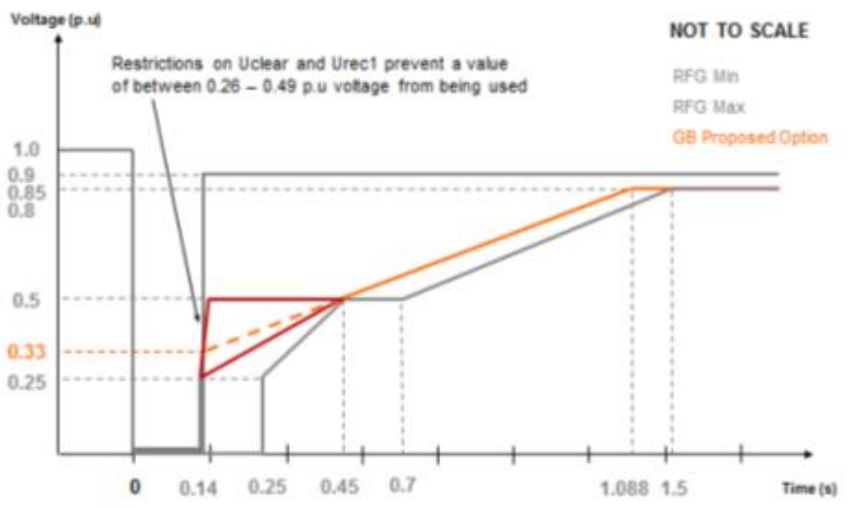


Figure 2.33 – Limitations on voltage against time curves

3.18 In summary a Generator has to ensure the post fault voltage profile is maintained above the defined voltage against time curve. The general understanding is that the post fault voltage profile will be dictated largely by the System rather than the performance of the Power Generating Module.

3.19 For the purposes of compliance, a 140ms three phase short circuit fault would be applied at the nearest Transmission System Connection Point of the Generator. Provided the Generator remains connected and stable and the post fault voltage profile remains above the defined voltage against time curve the Power Generating Module would be deemed compliant. In the event that the Generator were to pole slip, then the post fault voltage as seen from the Generator would result in oscillations beyond the defined voltage against time curve under which generator tripping would be permitted.

3.20 Under CC.6.3.15.1(a) of the GB Grid Code, a directly connected generator would be required to remain connected and stable for a solid three phase short circuit fault for up to 140ms in duration. In other words, the Generator could be exposed to zero volts for 140ms. Translating this into the RfG voltage against time curve therefore sets the value of U_{ret} to zero and t_{clear} to 0.14 seconds.

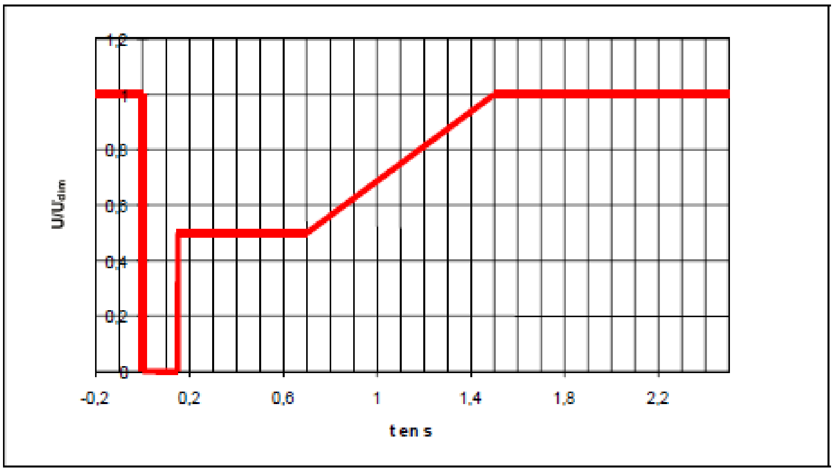
3.21 The subsequent points on the voltage against time curve are more complex to determine. In general, the post fault voltage profile is more a function of the pre and post fault short circuit level at the connection point rather than the characteristics of the Synchronous Power Generating Module itself. However, it is important that an achievable characteristic is set, which on one hand is not so onerous that it could result in the generator to pole slip whilst on the other that is so lenient that the generator would be permitted to trip for minor faults.

3.22 In practice, an assessment of stability will be made at the Transmission Connection application stage. The Transmission System Owner will design the Transmission Network in accordance with the requirements of the Security and Quality of Supply Standards (SQSS). During the application stage, stability studies will be run which will detail the specification of the excitation system (eg onload ceiling voltage and rise time). This specification being an important criterion upon which the stability requirements are assessed.

3.23 So far as the voltage against time curve is concerned, the curve needs to cater for credible system events but not those which would either be unduly pessimistic or beyond the requirements of the SQSS as these are covered under Mode B faults (ie faults in excess of 140ms). It is also vitally important that the Generator does not set its under-voltage protection settings to the same value as the voltage against time curve as this would result in premature tripping. As such, the voltage against time curve needs to consider credible voltage sags and dwells caused by high post fault MVAr demands.

3.24 Returning back to the derivation of the voltage against time curve, the value of U_{clear} is fixed at 0.25. As this marks the start of the voltage recovery (ie immediately on fault clearance) this point would also take place at 140ms, and therefore is set by t_{clear}.

3.25 The next stage is to consider the remaining parameters of the voltage against time curve, U_{rec1}, U_{rec2}, t_{rec1}, t_{rec2} and t_{rec3}. These are more complex due to the potential arbitrary nature of the points that can be selected for the voltage against time curve. Taking into account the effect of post fault voltage oscillations, particularly where there may be high MVAr demands and the analysis undertaken, the voltage against time curve needs to be robust enough to cater for system disturbances cleared in main protection operating times whilst ensuring it is not sufficiently onerous that the requirement is not achievable. An example of the current RTE voltage against time curve is shown in Figure 2.41. In summary this requires the generator to withstand a 100% voltage dip for a period of 150ms, a 50% voltage dip for a further 550ms (total 700ms) and restoration to 1.0pu volts a further 800ms (total 1500ms) later.



Gabarit de creux de tension pour les réseaux d'interconnexion

Figure 2.41 – French RTE Low Voltage Ride Through Voltage Against Time Curve

3.26 In deriving a GB voltage against time curve, there is always a concern under high MVAr demands the post fault voltage could struggle to return to 0.5 pu at 140ms instantaneously. On this basis and to take this effect into account the value of Urec1 was set at 0.5pu and trec1 set at 0.25s.

3.27 Should the voltage still struggle further to recover, then a plateau needs to be introduced but it becomes fairly straight forward to determine these values in terms of voltage and time. As a plateau is introduced the value of U_{rec1} remains at 0.5 pu and the time t_{rec1} would need to be at or less than the breaker fail operating time of typically 500ms.

3.28 Based on the fact that the Mode B Fault Ride Through requirements are considered separately from RfG and the study work conducted in Appendix 1 of [1], it was deemed a value of 450ms would be appropriate for $t_{rec2.}$ The last and final section is to consider the values of U_{rec2} and t_{rec3}. The RfG requirements only cover secured faults which would be cleared within 140ms.

3.29 As Mode B faults are designed to cover unsecured faults which could result in potentially small voltage deviations (say a voltage dip of 0.15pu (retained voltage 0.85pu) for a considerable length of time (eg 3 minutes) and based on the analysis conducted in Appendix 1 [1], it seems reasonable that the voltage against time curve should be set to a condition of 1.0pu at 1.5 seconds. This therefore sets the time t_{rec3}.

3.30 Based on the analysis completed and the approach adopted internationally, a value of 1.5s for t_{rec3} would not be seemed to be unreasonable. This is not however to be confused with compliance however where a solid three phase short circuit fault should be applied for 140ms with the post fault voltage returning to a value of between 1.0 pu - 0.9 pu with the specific value being specified in the Bilateral Agreement.

2.43 To summarise, the GB RfG Fault Ride Through Parameters are therefore shown in Table 2.43 and represented graphically in Figure 2.43.

Voltage Parameters [pu]		**Time Parameters [seconds]**	
U_{ret}:	0	t_{clear}:	0.14
U_{clear}:	0.25	t_{rec1}:	0.25
U_{rec1}:	0.5	t_{rec2}:	0.45
U_{rec2};	1.0	t_{rec3}:	1.5

Table 2.43 – Proposed GB Parameters for the Fault Ride Through Capability of a Type D Synchronous Power Generating Module connected at or above 110kV

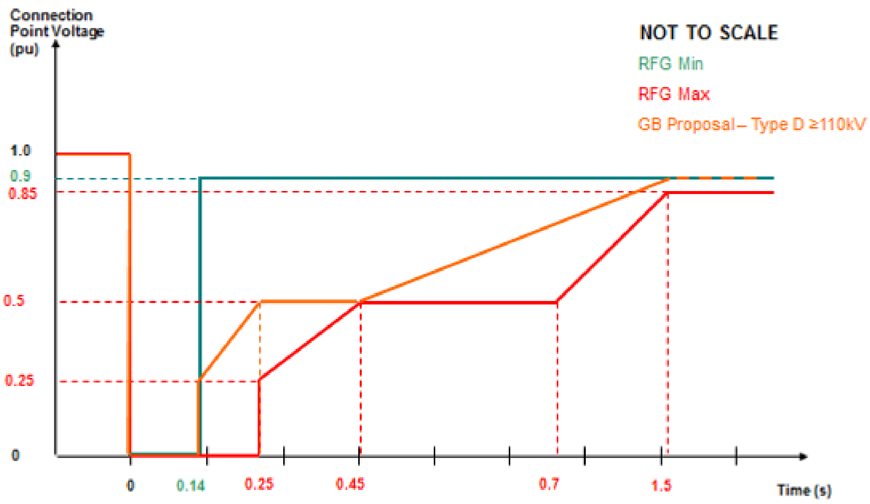


Figure 2.43 – Proposed GB Voltage against time curve for a Type D Synchronous Power Generating Module connected at or above 110kV

Determination of RfG Voltage against time parameters as applicable to Type C and D Synchronous Power Generating Modules connected below 110kV

3.31 The principles in deriving the voltage against time curve for Type C and D Synchronous Power Generating Modules connected below 110kV are broadly the same as those for Type D Synchronous Power Generating Modules connected at 110kV or above other than the parameter ranges specified in the RfG code.

3.32 Article 14(3)(a)(i) - Table 3.1defines the voltage against time parameter ranges for Type B, C and D Synchronous Power Generating Modules connected below 110kV which is reproduced below as Table 2.45.

Voltage parameters [pu]		Time parameters [seconds]	
U_{ret}	**0.05 – 0.3**	t_{clear}	**0.14 – 0.15** (or 0.14 – 0.25 if system protection and secure operation so require)
U_{clear}	**0.7 – 0.9**	t_{rec1}	t_{clear}
U_{rec1}	U_{clear}	t_{rec2}	t_{rec1} **– 0.7**
U_{rec2}	**0.85 – 0.9 and** $\geq U_{clear}$	t_{rec3}	t_{rec2} **– 1.5**

Table 2.45

Representing Table 2.45 in graphical format results in Figure 2.46.

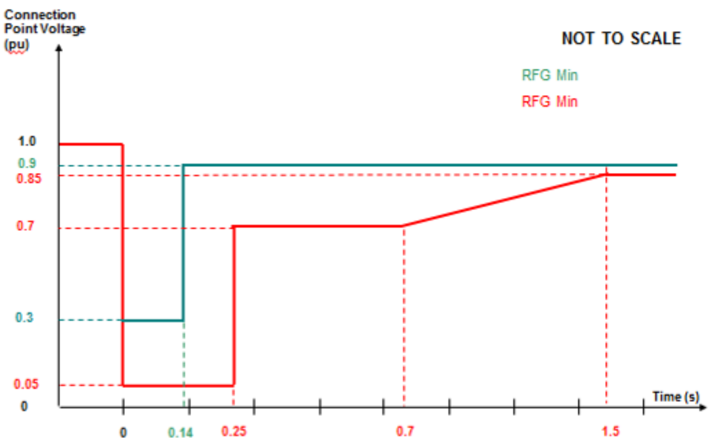


Figure 2.46 – Available range of voltage against time curves for Synchronous Power Generating Modules connected below 110kV

3.33 Determination of the paramters for Type C and D Synchronous Power Generating Modules follows a similar criteria for Type D Synchronous Power Generating Modules connected at or above 110kV. The following criteria has been used:-

t_{clear}	set at 140ms based on maximum protection operating times for a transmission system fault
U_{ret}	set at 0.15pu. This is set at the mid range value which is believed to be achievable for Synchronous Type C and D plant connected below 110kV

U_{clear} fixed to the lower of 0.7pu in line with RfG requirements. Based on system studies run under the GC0062 Work (Reference [1] this is believed to be achievable.

t_{rec2} set to 0.45s. System studies (GC0062 Workgroup Report – Ref [1]) demonstrated pole slipping would tend to occur for longer time durations than 450ms at 0.5pu).

U_{rec2} set to 0.9pu the upper limit based on steady state recovery voltages

t_{rec3} set to 1.5 seconds, based on protection having operated within this time, the ability of synchronous plant to withstand longer duration high impedance faults and study work demonstrated that synchronous plant does generally not have a problem for retained high voltages over a longer time frame.

3.34 Transposing the values defined in section 2.47 into a grahical form and plotting these between the maximum and minimum RfG values results in Figure 2.48 below.

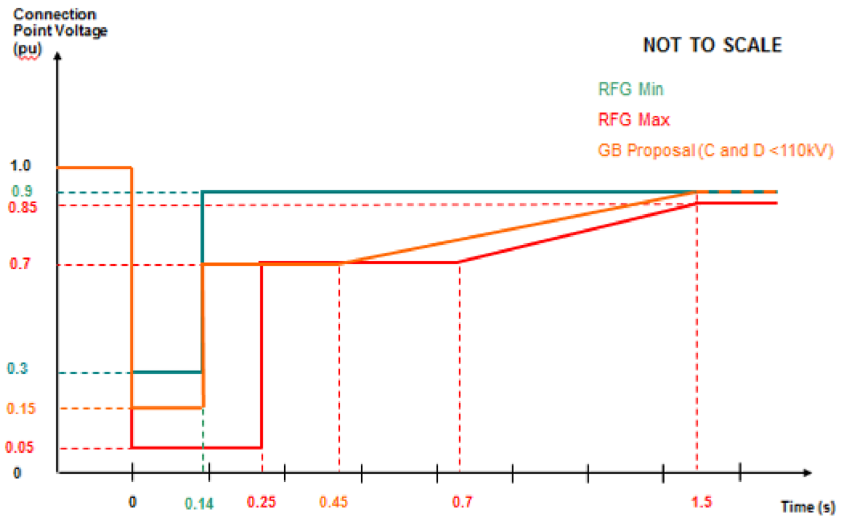


Figure 2.48 – Proposed voltage against time curve for Type, C and D Sychronous Power Generating Modules connected below 110kV.

Determination of RfG Voltage against time parameters as applicable to Type B Synchronous Power Generating Modules

3.35 The principles in deriving the voltage against time curve for Type B Synchronous Power Generating Modules are broadly the same as those for Type C and D Synchronous Power Generating Modules below 110kV.

3.36 The voltage against time parameters available to TSO's for Type B Synchronous Power Generating Modules are the same as those for Type C and D Synchronous Power Generating Modules connected below 110kV and as shown in Table 2.46 and Figure 2.47.

3.37 During the GC0048 Technical workgroup, AMPS members (ie representatives of Small Synchronous Generator manufacturers) identified that retained voltages dropping below 0.3pu would cause serious design issues and even then a Fault Ride Through compliant Type B Synchronous Power Generating Module would be exposed to significantly higher costs than a standard Generator (see Reference [5]).

Comment [NG3]: Should we include Chris Whitworth's paper in here

3.38 Other than the retained voltage (U_{ret}) being set at 0.3pu the other values would be set to the same values for Type C and D Synchronous Power Generating Modules as detailed in section 2.47 above. Plotting this in graphical format between the RfG maximum and minimum values results in Figure 2.53.

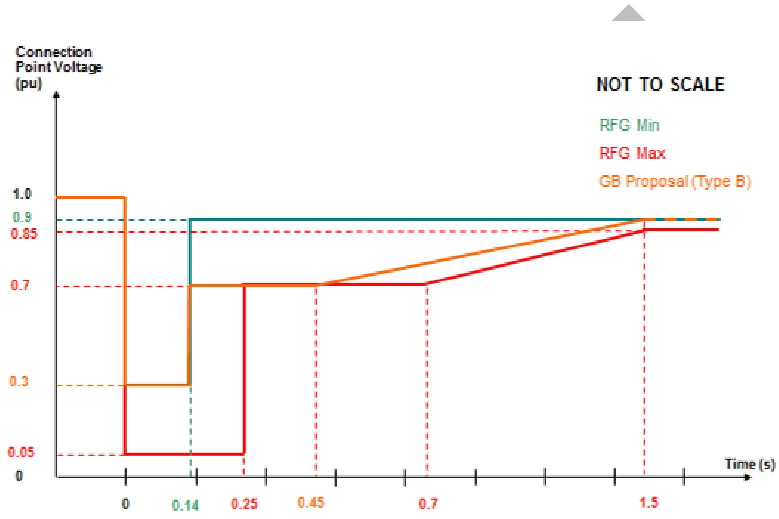


Figure 2.52 – Proposed voltage against time curve for Type, B Sychronous Power Generating Modules

Determination of RfG Voltage against time parameters as applicable to Type D Power Park Modules connected at or above 110kV

3.39 The voltage against time curve for Type D Power Park Modules connected at 110kV or above follow the same principles as defined above although the parameters available to TSO's are fundamentally different thereby resulting in a different shaped curve. This is shown by Table 2.53 and Figure 2.53 below.

Voltage parameters [pu]		Time parameters [seconds]	
U_{ret}	**0**	t_{clear}	**0.14 – 0.15** (or 0.14 – 0.25 if system protection and secure operation so require)
U_{clear}	U_{ret}	t_{rec1}	t_{clear}
U_{rec1}	U_{clear}	t_{rec2}	t_{rec1}
U_{rec2}	**0.85**	t_{rec3}	**1.5 – 3.0**

Table 2.53 – Range of voltage against time parameters for Type D Power Park Modules connected at or above 110kV (Reproduced from Table 7.2 of RfG Article 16(3)(a)(i)

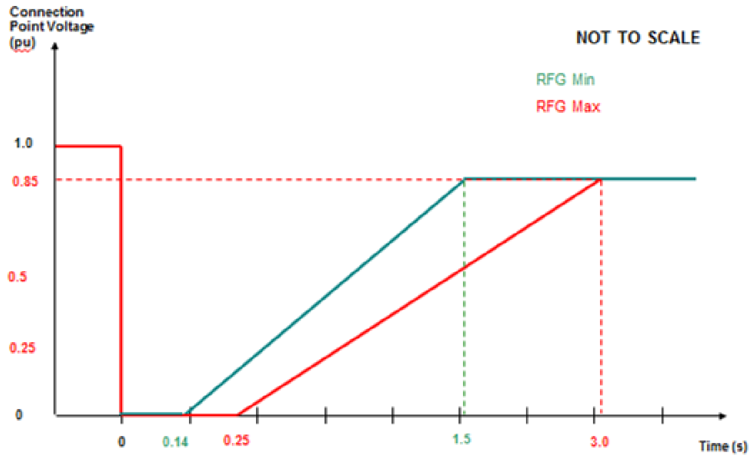


Figure 2.53 – Range of voltage against time parameters for Type D Power Park Modules connected at or above 110kV

3.40 Determination of the paramters for Type D Power Park Modules connected at or above 110kV follows a similar criteria for the Synchronous Generators above although it is noted that the parameter ranges available to the TSO as specified in the RfG restric the options avaiable. Values for each point on the voltage against time cureve have been set in the following way.

U_{ret}	Set to zero. This would equate to a solid three phase short circuot fault on the Transmission System which could be adjcent to a Power Generating Module.
t_{clear}	set to 140ms for protection operating times (as per synchronous power generating modules)
U, t	All other parameters (U_{clear}, U_{rec1}, t_{rec1} and t_{rec2}) are defined by RfG other than t_{rec3}.
U_{rec2}	Fixed at 0.85pu.

3.41 Under the SQSS an important value is a voltage of 0.9pu voltage at 2.2 seconds. It therefore seems appropriate to set t_{rec3} to 0.85pu at 2.086 seconds which is the interpolated value from 2.2 seconds at 0.9pu voltage. Under RfG Article 16(2)(a) – Tables 6.1 and 6.2 specify minimum voltages of 0.9pu. Therefore it seems reasonable that the Fault Ride Through Voltage against time curves should recover back to 0.9pu rather than 0.85pu hence the interpolated value as noted above.

3.42 Taking the above criteria into account results in the following voltage against time curve parameters which is shown in Table 2.56 and Figure 2.56.

Voltage parameters [pu]		Time parameters [seconds]	
U_{ret}	0	t_{clear}	0.14
U_{clear}	0	t_{rec1}	0.14
U_{rec1}	0	t_{rec2}	0.14
U_{rec2}	0.85	t_{rec3}	2.086

Table 2.56 – GB Voltage against time curve for Type D Power Park Modules connected at or above 110kV

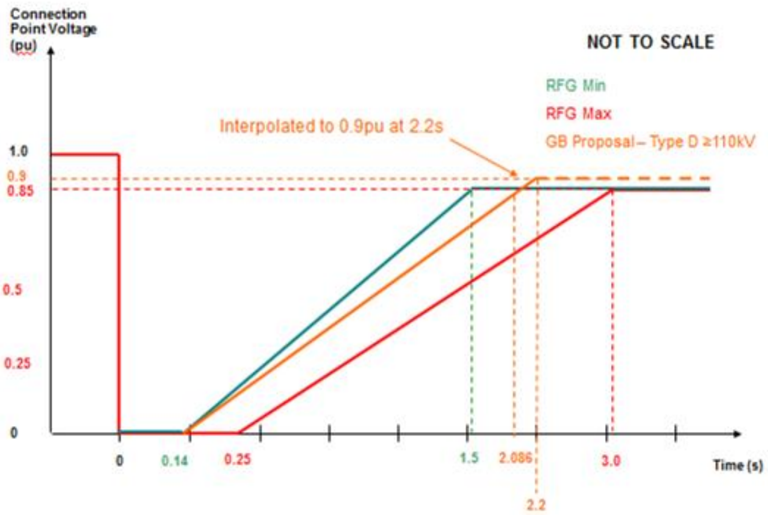


Figure 2.56 – Voltage against time curve for Type D Power Park Modules connected at or above 110kV

Determination of RfG Voltage against time parameters as applicable to Type B, C and D Power Park Modules connected below 110kV

3.43 The voltage against time curve for Type B, C and D Power Park Modules connected below 110kV follow the same principles as defined for Type D Power Park Modules connected at or above 110kV. Under RfG Article 14 (3)(a)(iii) the requirements of Table 3.2 applies which is reproduced here in Table 2.57 below. This is shown graphically in Figure 2.57.

Voltage parameters [pu]		Time parameters [seconds]	
U_{ret}	0.05 – 0.15	t_{clear}	**0.14 – 0.15** (or 0.14 – 0.25 if system protection and secure operation so require)
U_{clear}	U_{ret} – 0.15	t_{rec1}	t_{clear}
U_{rec1}	U_{clear}	t_{rec2}	t_{rec1}
U_{rec2}	0.85	t_{rec3}	1.5 – 3.0

Table 2.57 - Range of voltage against time parameters for Type B, C and D Power Park Modules connected below 110kV (Reproduced from Table 3.2 of RfG Article 14(3)(a)(iii)

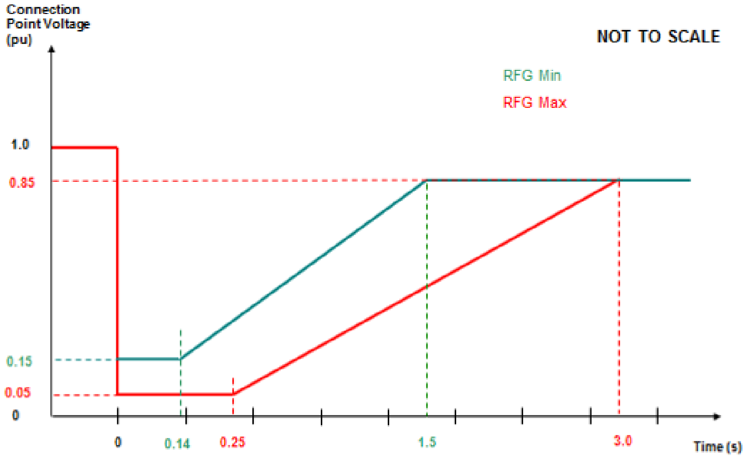


Figure 2.57 - Range of voltage against time parameters for Type B, C and D Power Park Modules connected below 110kV

3.44 Determination of the parameters for Type B, C and D Power Park Modules connected below 110kV follows a similar criteria for Type D Power Park Modules connected at or above 110kV.

t_{clear}	set at 0.14s – consistent with Transmission protection operating times and that required for Type D Power Park Modules connected at or above 110kV.
U_{ret}	set at 0.15pu. This was intially set at 0pu due to the low fault infeed depressing system voltage, especially with low levels of synchronous generation running but concern was expressed by Stakeholders (particulalry developers of DFIG dervied turbines) over stability concerns. Research conducted under H/04 showed the majority of wind turbines (even DFIG based machines) could withstand voltages down to 15% at the turbine terminals.
U_{rec2}	set at 0.85pu which is fixed by RfG. This simply marks the point on the votage against time curve but would need to be interpolated to 0.9pu to align with the SQSS and the minimum stready state operating voltage as defined in CC.6.1.4 (RfG) Article 16(2)(a) – Tables 6.1 and 6.2).
t_{rec3}	set at 2.063 seconds which is interpolated from a value of 2.2 seconds at 0.9pu voltage to satisfy requirements of SQSS.

3.45 Taking the above criteria into account results in the following voltage against time curve parameters which is shown in Table 2.59 and Figure 2.59.

Voltage parameters [pu]		Time parameters [seconds]	
U_{ret}	0.15	t_{clear}	0.14
U_{clear}	0.15	t_{rec1}	0.14
U_{rec1}	0.15	t_{rec2}	0.14
U_{rec2}	0.85	t_{rec3}	2.063

Table 2.59 – GB Voltage against time curve for Type B, C and D Power Park Modules connected below 110kV

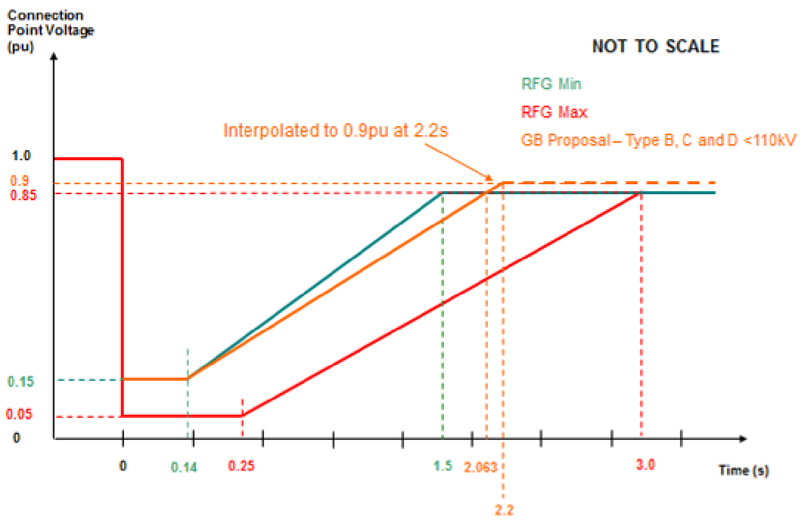


Figure 2.59 – GB Voltage against time curve for Type B, C and D Power Park Modules connected below 110kV

3.46 In all cases (Synchronous Power Generating Modules and Power Park Modules) the voltage against time curves end at U_{rec2} and t_{rec3}. The GB voltage against time curves therefore show the period after t_{rec3} as a dotted line which simply aim to reflect the fact that after the fault has cleared and the post fault voltage has been re-established, the voltage to which the Power Generating Module shall be somewhere between the voltage range specified in CC.6.1.4 and/or RfG Article 16(2)(a) – Tables 6.1 and 6.2.

Voltage Ranges

3.47 Voltage range, Reactive Capability and Voltage Control will fall under the auspices of a separate consultation. There is however loose coupling between the steady state voltage ranges defined by RfG Article 16(a)(2) Tables 6.1 and 6.2 and the voltage against time curves which deserves a brief mention in this report.

3.48 RfG Article 16(a)(2) Tables 6.1 and 6.2 defines the steady state voltage operating range for Type D Power Generating Modules. CC.6.1.4 of the Grid Code however defines the steady state operating range of all User's connected to the Transmission System.

3.49 Following RfG would strictly create uncertainty between the steady state voltage requirements for a Type D Generator and Type A – C Generators.

Therefore it seems appropriate to adopt the same approach as defined in CC.6.1.4 of the GB Grid Code accepting that CC.6.1.4 will require minor changes to ensure consistency with the European Codes.

3.50 In general CC.6.1.4 and RfG Article 16(a)(2) Tables 6.1 and 6.2 are the same other than the GB Code requires the voltage range applicable to User's connected below 132kV should be within ±6% and RfG requires Type D Power Generating Modules connected between 132kV and 110kV to remain within the limits of ±10%. RfG also has flexibility on wider voltage ranges, minimum time periods and under voltage/ overfrequency or overvoltage /underfrequency but these issues will be addressed separately as part of the Voltage / Reactive consultation.

Unbalanced Faults

3.51 Article 14(3)(c) and Article 16(3)(c) of RfG define the Fault Ride Through capabilities in case of asymmetrical faults shall be specified by each TSO. There are potentially two separate options here these being either:-

3.51.1 Adopt the same principles as RfG using a voltage against time curve. In this case the Power Generating Module would need to ride through any balanced or unbalanced voltage where the phase to phase or phase to earth voltage is above the heavy black line shown in each of the voltage against time curves above; or

3.51.2 Retain the same approach as currently documented in the GB Grid Code – ie remain connected and stable for any unbalanced fault up to 140ms in duration.

3.52 This issue has been mentioned as part of the Workgroup but not in any level of detail. An unbalanced fault will always be less onerous to the Generator than a balanced fault. It considered that adopting the same approach to that defined under RfG for unbalanced faults would provide greater clarity to developers and manufacturers in addition to ensuring consistency of requirements. As such the proposed legal text covered in Annex X has been drafted on the basis of applying to balanced and unbalanced faults. A specific consultation question has also been raised on this issue to ensure Stakeholders are comfortable with this approach. It is also noted that in practice there is little difference between the RfG requirement and current GB practice – both requirements would necessitate the Power Generating Module to remain connected and stable for an unbalanced Transmission System fault for up to 140ms in duration.

Active Power Recovery

3.53 Article 17(3) – (Type B, C and D Synchronous Power Generating Modules) and Article 20(3) - (Type B, C and D Power Park Modules) define that the requirements for Active Power Recovery shall be specified by the relevant TSO.

3.54 The requirements for Power Park Modules are slightly more detailed than that for Synchronous Power Generating Modules but in general the requirements for Active Power Recovery would follow existing GB Grid Code practice which effectively states that following clearance of the fault, active power recovery shall be restored within 0.5seconds. The more detailed requirements applicable to active power recovery as applicable to Power Park Modules (RfG Article 20(3) will be covered as part of the Fast Fault current injection requirements which shall be addressed via a separate consultation.

Fast Fault Current Injection

3.55 Fast fault current injection is currently only loosely defined in the GB Grid Code which simply states that the Generating Unit or Power Park Module shall inject maximum fault current without exceeding the transient rating of the Generating Unit or Power Park Module.

3.56 RfG is silent on the fast fault current injection requirements for Synchronous Power Generating Modules, it is however a natural capability of this type of plant to naturally inject high fault currents when subject to a disturbance. This requirement is stipulated in the GB Grid Code and will remain so going forward.

3.57 So far as Power Park Modules are concerned Article 20(2)(b) defines the requirements for fast fault current injection. These requirements are far more specific than the current GB Grid Code requirements. Add to this the complexity of current converter technology when balanced against System need results in quite a challenge. As such, these issues and proposals will be addressed as part of a separate consultation.

Interaction between Voltage against time curves and G59 Protection

3.58 The proposed voltage against time curves for Type A – D Power Generating Modules are detailed above. For those Power Generating Modules which are connected to the Distribution Network, stakeholders noted that there would be a conflict with the G59 under voltage Stage 2 protection which is currently set at 0.8pu for 500ms. Whilst this was marginal in the case of the voltage against time curve for Synchronous Power Generating Modules it was more severe in the case of Power Park Modules where even the minimum RfG voltage against time criteria would have been incompatible with the current G59 Stage 2 Undervoltage protection settings. These issues are shown in Figures 2.73(a) and 2.73(b).

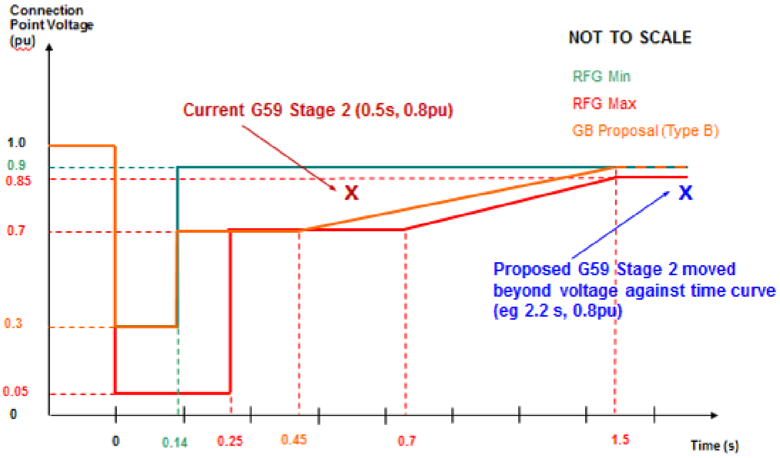


Figure 2.73(a) – GB Proposed Voltage Against Time Curve of a Type B Synchronous Power Generating Module showing the conflict with Stage 2 G59 Undervoltage Protection.

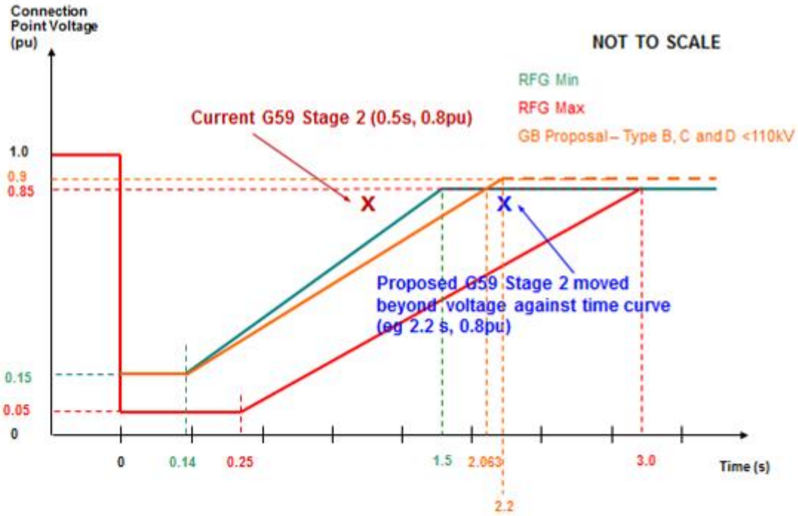


Figure 2.73(b) – GB Proposed Voltage Against Time Curve of a Type B, C or D Power Park Module connected below 110kV showing the conflict with Stage 2 G59 Undervoltage Protection.

3.59 The workgroup discussed this at length and agreed that the best policy would be to move the G59 Stage 2 Undervoltage protection to 0.8pu at 2.5s. This requirement would apply to all new Euro-compliant plant and would be equally applicable to Synchronous Power Generating Modules and Power Park Modules.

3.60 It is not believed that changing the G59 Stage 2 Undervoltage protection will cause a significant problem however it will be raised as a specific consultation question. GC0079 has been investigating the issue associated with changing RoCoF protection settings for distribution connected generators and has undertaken a risk assessment of distribution system protection requirements. The analysis has been performed for GC0079 (and GC0035) by the University of Strathclyde.

3.61 The University of Strathclyde were asked to comment on whether the proposed change to a single undervoltage protection would introduce any new risks. Their analysis pointed out that as the RfG only applies to new installations, it does not affect the risk profile for existing plant. For new installations there is the opportunity to assess any and all risks as part of the connection process, and in addition as the risk assessment is undertaken assuming a 3s window, a trip on undervoltage at 2.5s is within the expected bounds of fault situations, thus presenting no additional risk. For further information on the risk assessment techniques and assumptions see the GC0035 WG report Reference [5].

Fault Ride Through Requirements during single phase auto-reclosures or Delayed Auto Reclosures (DAR)

3.62 RfG Article 15(4)(c) states that “Power Generating Modules shall be capable of remaining connected to the network during single phase or three phase auto-reclosures on meshed network lines, if applicable to the network to which they are connected. The details of that capability shall be subject to co-ordination and agreements on protection schemes and settings as referred to in point (b) of Article 14(5)”.

3.63 In GB there is only place where a fast single phase auto reclose scheme is employed. In general, GB practice at a Transmission System level advocates the use of Delayed Auto Reclose Schemes (DAR) in which in the event of line is subject to a transient fault (eg lightning) the circuit will trip, the transient effects are allowed to decay away and the protection will automatically close the circuit breakers at the end of the line.

3.64 An example of a situation which could occur is shown in Figure 2.78 below. In this example, the double circuit between substations A, B and C is subject to a transient fault which recloses by DAR operation 15 - 20 seconds later. Under this scenario the Generator connected to substation C would be permitted to trip, however the Generator connected to substation B is still connected to a healthy circuit and would be expected to remain connected and stable during the DAR event.

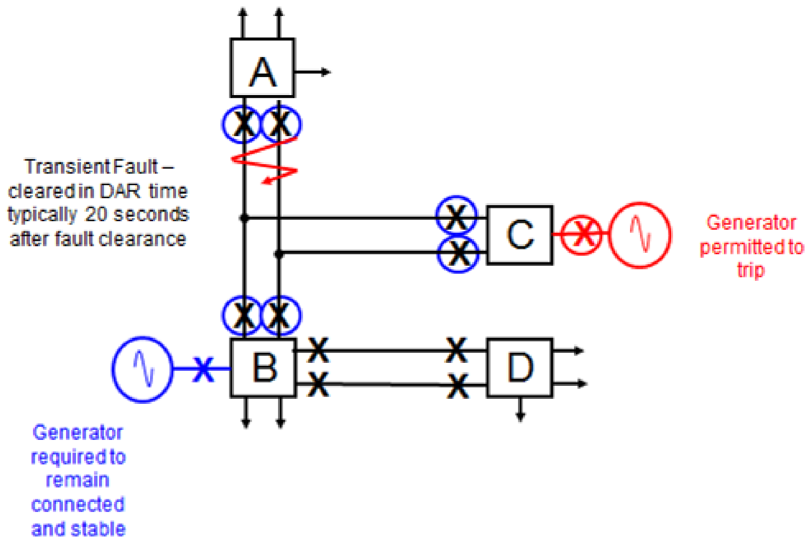


Figure 2.78 – Effect of DAR Operation and required Generator performance expected

3.65 As mentioned above, it is not standard practice for fast single phase auto reclosure schemes to be employed within GB, but if there were the requirements applicable to them would need to be considered on a case by case basis. In the case of Delayed Auto Reclose Schemes, the requirements of RfG Article 15(4)(c) would not apply where the Generator was connected to an unhealthy circuit (ie the Generator connected to substation C) but would be applicable where the Generator connected to a healthy circuit (ie the Generator connected to Substation B).

3.66 In GB there is no requirement to ride through autoreclose sequences on distribution systems.

Fault Ride Through requirements for Offshore Power Park Modules

3.67 RfG Article 26(2) states that the Fault Ride Through requirements laid down in point (a) of Article 14(3) and point (a) of Article 16(3) shall apply to AC Connected Offshore Power Park Modules.

3.68 GB is unique from the rest of Europe in that it has an Offshore Transmission regime. In summary this segregates the requirements from Offshore Transmission from Offshore Generation. Under the current GB Grid Code, Offshore Generators have the option of satisfying the Fault Ride Through requirements either at the Offshore Grid Entry Point or at the Interface Point (ie where the Offshore Transmission System connects to the Onshore Transmission System). It is further complicated by the fact that the Offshore Grid Entry Point (ie the point where the Offshore Generator connects to the Offshore Transmission System) can vary as agreed between the Offshore Generator and Offshore Transmission Licensee. The default position is generally accepted as the LV side of the Offshore Platform but this can vary as agreed between the parties to be anywhere on the platform.

3.69 It should also be noted that the RfG requirements apply only to Offshore Power Park Modules, not Offshore Synchronous Power Generating Modules. The GB Grid Code does require Fault Ride Through to apply to all types of Offshore Generation.

3.70 The concern raised at the GC0048 working group is that the current GB Grid Code enables Offshore Generators to satisfy the Fault Ride Through requirements either at the Offshore Grid Entry Point or the Interface Point. Unfortunately this option will no longer be available in a European Coded environment however it may have limited practical impact.

3.71 For a Type D Offshore Power Park Module connected at the LV side of the Offshore Platform which would typically have a connection voltage of 33kV the Offshore Power Park Module would have to meet the voltage against time curve for a Type B, C or D Power Park Module connected below 110kV. The retained voltage at the connection point would be 15% which broadly equates to the current requirement under CC.6.3.15.2 of the GB Grid Code.

3.72 There would still be a requirement for the OFTO network (referred to as OTSDUW Plant and Apparatus under the Grid Code) to satisfy the Fault Ride Through requirements at the Interface Point, the principle being it would be inappropriate for the Offshore Generation to have the capability of being stable and connected and the Offshore Transmission network to be susceptible of tripping.

Demonstration of RfG Fault Ride Through Compliance for a Transmission Connected Power Generating Module

3.73 This section of the consultation details how compliance should be assessed against RfG using a Type D Synchronous Power Generating Module connected at or above 110kV. Whilst not specifically discussed as part of the Workgroup the text below summaries the issues discussed as part of the GC0062 workgroup which will provide useful to readers as to how the requirements should be interpreted and also how compliance should be demonstrated. It is also felt that this information will be useful to the GC0048T Compliance Worksteam.

3.74 It should also be noted that RfG Articles 51(3), 51(4) (Type B and C Synchronous Power Generating Modules) and RfG Articles 53(3) (Type D Synchronous Power Generating Modules) define the simulation requirements for Fault Ride Through assessment. There is no requirement for actual tests to be completed on Synchronous Power Generating Modules to demonstrate compliance.

3.75 At the Generator application stage, National Grid will undertake a stability assessment to ensure compliance with the SQSS and determine the excitation parameters of the Generator. These studies would generally be undertaken during minimum demand conditions and would also identify if any reinforcement is necessary. The excitation performance requirements would then be reflected in the Bilateral Connection Agreement but it is assumed at this stage that the Generator is fully compliant with the requirements of the Grid Code. Any high level stability issues would generally be identified at this stage. The Bilateral Agreement would also specify the following information to enable the Generator to undertake the necessary compliance work:

- The Maximum and Minimum Pre Fault Short Circuit Level at the Connection Point

- The pre fault operating conditions of the Generator (eg Full MW output, maximum lead)
- The Maximum and Minimum Post Fault Short Circuit level at the Connection Point

3.76 With details of the Short Circuit levels and Generating Unit parameters available, the Generator should be in a position to run system studies to asses Compliance.

3.77 During the Workgroup, it was noted that the pre and post fault short circuit level would be very different as a result of the loss of the line and consequent change in system topology – see Figure 2.11 above. One suggestion was that NGET should provide an equivalent based on the representations shown in Figures 2.84(a) – (c).

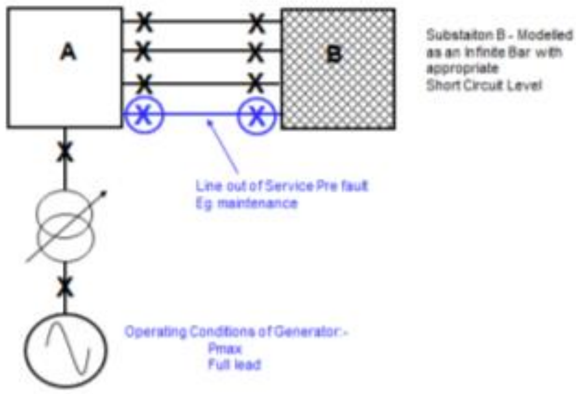


Figure 2.84(a) – Pre Fault Test Network Equivalent

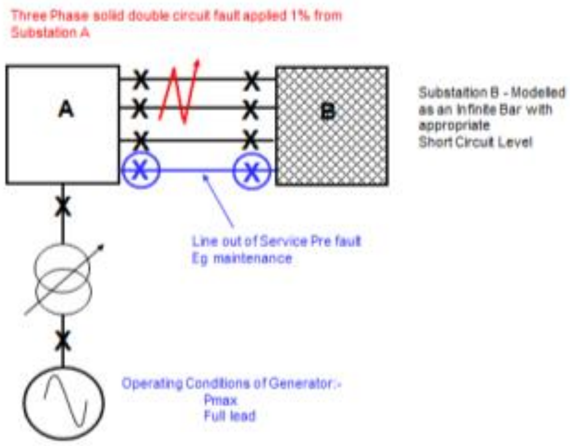


Figure 2.84(b) – Test Network Equivalent under Fault Conditions

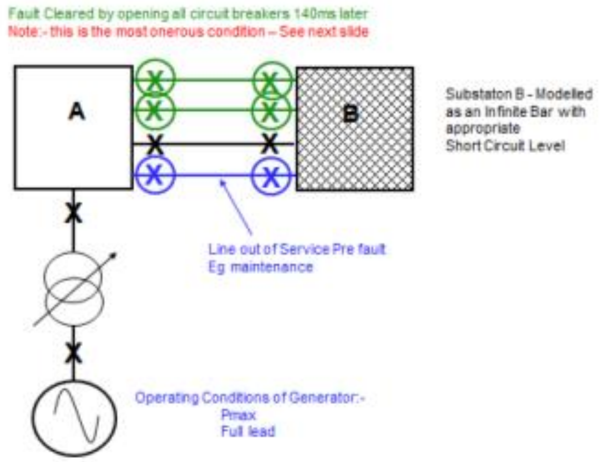


Figure 2.84(c) – Post Fault Network as an Equivalent

3.78 This approach is adopted by RTE of France as documented in Reference [4]. An example of the RTE model is shown in Figure 2.85 below.

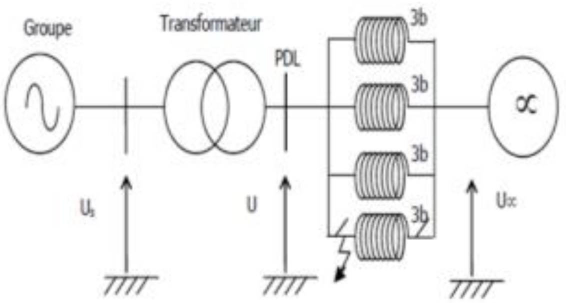


Figure 2.85 – RTE approach for Modelling Low Voltage Fault Ride Through

3.79 Following internal research and discussion with the National Grid System Design department, it was considered that it would be more straight forward to provide a simple model simply quoting the pre and post short circuit level. This simplifies the process and also reduces need to produce an equivalent. It also enables a fault level to be provided with is reflective of the number of Generators connected at a specific site.

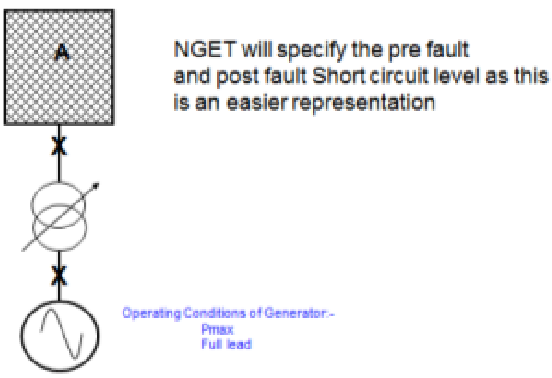


Figure 2.86 – Equivalent Network provided by NGET for Assessment of Fault Ride Through

3.80 Under this arrangement the Generator will need to model the infinite busbar reflecting the pre-fault short circuit level and the post fault short circuit level. As mentioned above both these values will be provided by National Grid.

3.81 For compliance purposes and to ensure adequate robustness of the Synchronous Power Generating Module, a 140ms 3 phase solid short circuit fault should be applied with simulation results showing the post fault voltage returning to between 1.0pu and 0.9pu the exact value being specified in the Bilateral Agreement.

3.82 To demonstrate this process, the following example is shown as to how compliance would be expected to be demonstrated. It needs to be noted that the Generator only needs to apply a fault for 140ms at the point of connection. Under these conditions the Synchronous Power Generating Module should remain connected and stable for a solid three phase balanced or unbalanced fault at the connection point, with active power being restored within 0.5 seconds of fault clearance.

Example – Compliance demonstration for a Type D Synchronous Power Generating Module connected at or above 110kV.

3.83 This section of the Appendix seeks to give an example of how a Generator would be expected to undertake Mode A Fault Ride Through compliance.

3.84 For the purposes of this example a 2082MVA Synchronous Generator seeks to connect to the Transmission System at 400kV. National Grid will provide the pre and post fault short circuit level to the Generator as part of the compliance process. This will enable the fault level to reflect different operating configurations in particular where there is more than one Generator connected at a specific site

3.85 The CUSC Contract requires the Generator to satisfy the requirements of the Connection and Use of System Code (CUSC) which in turns obligates them to satisfy the requirements of the Grid Code and Bilateral Agreement, the technical requirements being covered in Appendix F which would specify the excitation ceiling parameters. In this example a static excitation system has been assumed with an on load positive ceiling voltage of 2.0 pu, a rise time of 50ms and a negative ceiling level of no less than 1.6.pu and the installation of a Power System Stabiliser.

3.86 In order for the Generator to assess compliance, National Grid will provide the following data and model as shown in Figure 2.93 below.

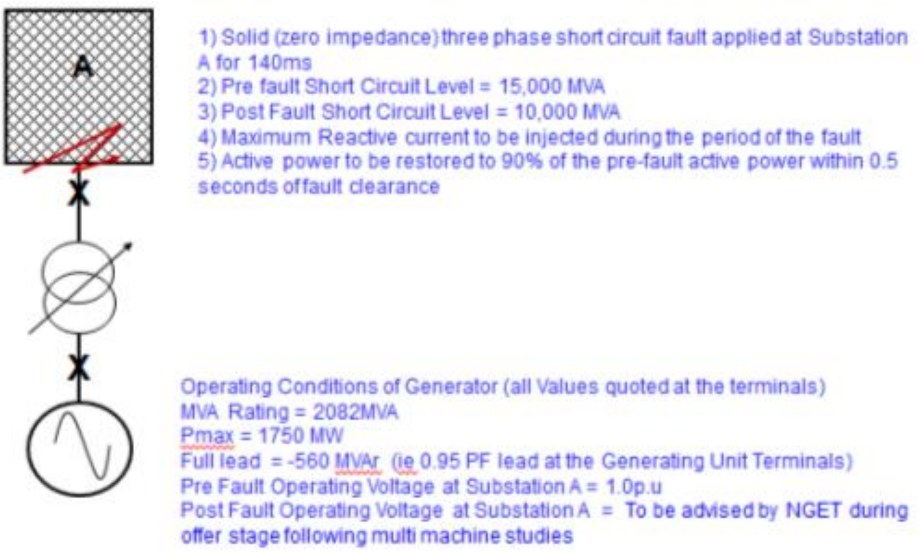
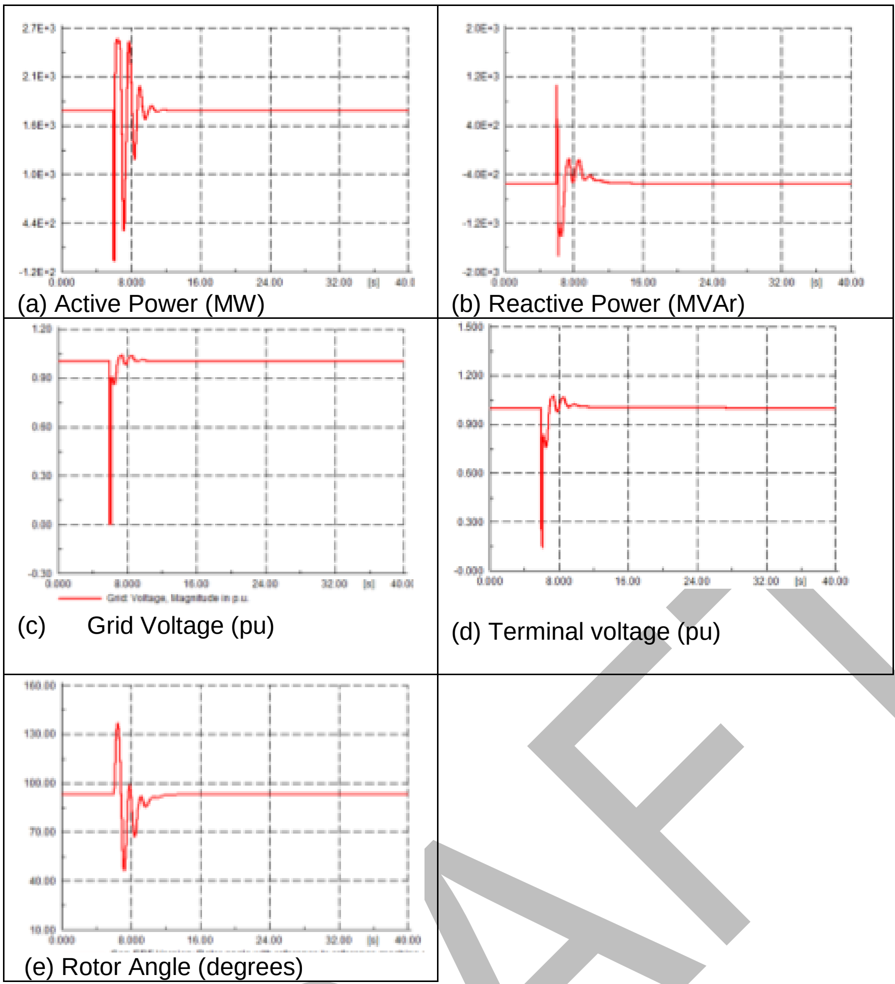


Figure 2.93 – Parameters and model issued by NGET for the Generator to undertake Mode A (RfG Compliant) Fault Ride Through Compliance Studies

3.87 The Generator will then be responsible for inserting their detailed Generating Unit model into the single machine equivalent. There is no restriction on the type of software modelling tool (eg Power Factory, PSS/E, Eurostag, EMTDC / PSCAD / Matlab) used so long as the Generator can supply traces of Active Power, Voltage, and rotor angle.

3.88 An example of a 140ms fault (based on a machine with parameters shown in Figure 2.93) with the post fault voltage returning to 1.0pu are shown in Figures 2.91 (a) – (e) below.



(a) Active Power (MW)
(b) Reactive Power (MVAr)
(c) Grid Voltage (pu)
(d) Terminal voltage (pu)
(e) Rotor Angle (degrees)

Figure 2.95 – Example of a 2082MVA machine subject to 140ms three phase fault with the post fault voltage returning to 1.0.pu

3.89 So far as the requirement to restore Active Power within 0.5 seconds of fault clearance is concerned, the existing GB Grid Code requirement would apply as detailed in CC.6.3.15.1(a)(ii) where the assessment is based on the total active energy during the period immediately after the fault. This requirement is necessary to account for the potential oscillatory nature of the post fault active power generated.

3.90 For Mode A faults, the initial stability assessment is carried out by NGET at the application stage which is then used to derive the excitation system requirements necessary. In extreme cases it may be necessary for other measures such as system reinforcement. There have and continue to be cases were an offer has been released showing stable results which when tested by the Generator have resulted in unstable conditions. These issues are generally down to modelling assumptions and under such circumstances NGET will work with the Generator to ensure consistency of models and results.

3.91 For the purposes of compliance simulation, studies will only be necessary. There will be no requirement to complete real tests or type tests. Under RfG, compliance simulations for Synchronous Power Generating Modules would be required as defined in Article 51 (3), 51 (4) and Article 53(3). In summary these simply refer to demonstration of compliance through simulation studies to demonstrate that the requirements of RfG Article 16 (3) and Article 17(3) can be demonstrated.

Insert Heading

Use this column in a Q&A style for explanations, in order to preserve the flow of the main text.

4 Legal Drafting Approach

Lessons Learned from implementation of Gas European Network Codes

4.1 Similarly to electricity, the European Third Energy Package as applied to the creation of a more harmonised European internal energy market for gas resulted in the development of a number of European Network Codes. The national implementation of these codes was taken forwards through an industry workgroup and resulted in a number of modifications to the GB Gas Uniform Network Code (UNC) in order to achieve legal compliance with the Codes. These took place between October 2013 and May 2016.

4.2 The Gas ENCs are as follows:

- Congestion Management Procedures (CMP)
- Capacity Allocation Mechanisms (CAM)
- Network Code on Gas Balancing of Transmission Networks (Balancing Code)
- Network Code on Interoperability and Data Exchange Rules
- More info here: http://www.gasgovernance.co.uk/euronetcodes

4.3 We have looked at how the gas implementation took place to see what lessons could be learned from this or what precedents could have been set.

4.4 Two key points have been highlighted:

4.4.1 The development of GB code modifications was carried out in manageable chunks that were consulted on and taken forwards individually. While this increased the need for coordination and careful planning, these issues were outweighed by the need to keep the work manageable and avoid consulting on too much material at once.

4.4.2 All of the UNC European Code provisions were put into a new section of the UNC, the European Interconnection Document (EID). This is a new document forming part of the Uniform Network Code (UNC) and sits alongside the other parts of the UNC, i.e. Transportation Principal Document (TPD), Offtake Arrangements Document, Independent Gas Transporter Document, (subject to approval of the Project Nexus modifications), Transition Document, Modification Rules and General Terms. This was done for reasons of clarity and also because some shippers only participating in domestic markets were not going to be subject to ENC provisions.

4.5 A legal roadmap on the development of the Gas European Code implementation giving more background was produced: http://www.gasgovernance.co.uk/sites/default/files/EU%20Codes%20Legal%20Roadmap.pdf

4.6 In conclusion, numerically there are four Gas ENCs compared to eight Electricity ENCs (counting TSOG as one rather than three); there is also only one GB gas code, the UNC, compared to five GB electricity codes (the CUSC, DCUSA, BSC, Grid Code and Distribution Code). The neatness of the single EID solution is therefore not as achievable for electricity but has been considered. The proposed solution for the connection codes (RfG, DCC, HVDC) in establishing a new European Connection Conditions (ECC) section of the Grid Code, and similar changes to the Distribution Code and its specific Engineering Recommendations, is however roughly analogous to this.

4.7 This consultation will invite responses from stakeholders on the structure of the solution being proposed and the options given. Please note however that in terms of what is achieved in the GB codes, since this facilitates implementation of European Law, the choice of format is presentational only; in terms of the technical content this will be the same for each.

Grid Code and Distribution Code legal drafting approach

4.8 For the purpose of the Grid Code it has been considered that the Connection Conditions (CC's) and other affected Grid Code sections should be duplicated in their entirety and updated to ensure consistency with the EU Code.

4.9 From a User's perspective it simply means that a new User can comply with the requirements of RfG by meeting the new EU sections of the GB Grid Code and existing Users meet the requirements of the code as currently drafted.

4.10 For distribution connected generators, the new requirements for Fault Ride Through have been drafted into a new document, ER G99, which will be introduced to replace ER G59. This will bear on Type B Power Generating Modules.

4.11 Linkage between the Distribution Code and Grid Code will require some co-ordination, but at a high level it is envisaged that that the requirements for Type A and B Embedded Generators would reside in the Distribution Code and all other requirements (Type C – D Embedded Generators and all Transmission Connected Generators (Type A- D) would reside in the Grid Code). The full details of this linkage will be developed over the coming months and introduced as part of the final implementation of the RfG

4.12 Type D Power Generating Modules greater than 100MW would be caught by the provisions of CUSC and Grid Code and provisions on C and D Power Generating Modules less than 100MW would be addressed by an approach similar to that for Licence Exempt Embedded Medium Power Stations.

4.13 For distribution connected generators it is currently proposed to replace the current ER G83 and ER G59 with two new documents of similar scope, ER G98 and ER G99. Both G98 and G99 will only apply to new connections.

4.14 This consultation includes draft legal text for the application of Fault Ride Through requirements to Type B power generating modules – see appendix x. To aid understanding of the current proposed approach, the full draft text of ER G99 is included as Appendix x1.

4.15 It might be more appropriate, when the implications of all the EU Network Codes are better understood that the requirements on distribution connected generators are better incorporated into the body of the Distribution Code, rather than in the stand-alone documents G98 and G99. Stakeholders views on this would be welcome at any time, and particularly in response to this consultation.

4.16 The Table below summarises how these requirements would apply.

Type	Network Connection	Applicable Industry Codes
A	Distribution	Distribution Code + G98/G99 (which replace G83/G59)
	Transmission	Grid Code , CUSC, BSC
B	Distribution	Distribution Code + G98/G99 (which replace G83/G59)
	Transmission	Grid Code , CUSC, BSC
C	Distribution	Distribution Code refers to Grid Code (sub 100MW via LEEMPS type arrangements) unless Type C Generator opts to be a BM party. If it opts for BM status it will need to meet the requirements of the Grid Code, CUSC and BSC in its own right.
	Transmission	Grid Code , CUSC, BSC
D	Distribution	Distribution Code plus Distribution Code refers to Grid Code (sub 100MW via LEEMPS type arrangements) unless Type D Generator opts to be a BM party and is less than 100MW. If it opts for BM status or greater than 100MW it will need to meet the requirements of the Grid Code, CUSC and BSC in its own right as well as the requirements of the Distribution Code.
	Transmission	Grid Code , CUSC, BSC

5 Impact & Assessment

Impact on the Grid Code

5.1 These modifications are necessary to ensure the Grid Code and Distribution Code are consistent with the Fault Ride Through requirements of the EU Network Code Requirements for Generators (RfG) document which entered into Force on 17th May 2016 and requires Member State Codes to be consistent with these requirements by 17th May 2018 at the latest.

5.2 These requirements apply only to new Power Generating Modules, the existing requirements as detailed in CC.6.3.15 and CC.A.4 will remain unchanged. To address this issue, it is therefore proposed to introduce a new section to the Grid Code (a duplicate of the Connection Conditions ECC's) which will apply to new User's (ie Users who are seeking a connection after 17th May 2018 or have not placed their contract for major plant items by 17th May 2018.

5.3 Under the Preface of the Grid Code section P.2 states "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.

5.4 The current Fault Ride Through requirements stipulated under CC.6.3.15 of the GB Grid Code are not consistent with RfG and therefore amendments to the GB Code will be a necessity to avoid contravention of European law.

5.5 The proposals have been discussed amongst the GC0048T workgroup and their comments have been taken into consideration which results in the proposals highlighted in this consultation.

5.6 In developing these proposals National Grid has attempted to develop a set of requirements which are consistent with the RfG requirements, strike the right balance between the needs of the Transmission System and Generator technology, without exposing them to excessive cost.

5.7 National Grid believe these proposed requirements deliver a set of GB parameters for implementation of the RfG Code into the GB Grid Code. It is however acknowledged that the Generation background continues to change with a trend towards smaller units connecting at distribution levels. It is therefore possible that a further review may be required in the future but such change would need to be progressed through the GB governance of the Grid Code Review Panel.

Impact on the Distribution Code

5.8 There are no historic Fault Ride Through requirements for distribution connected generators that were Small.

5.9 The RfG introduces new requirements for all generators that are Type B or larger

5.10 The parameters for Fault Ride Through for distribution connected generators have been developed jointly with those applicable to transmission connected generators in GC0048.

Timeline

Workgroup Meeting Dates

M1 - 01 January 2012
M2 - 01 January 2012
M3 - 01 January 2012
M4 - 01 January 2012
M5 - 01 January 2012

5.11 The new requirements have been drafted into a new document, ER G99, that will replace ER G59. ER G99, like ER G59 before it, will be cited in Annex 1 of the Distribution Code and there be governed, and binding on generators, as though it were itself part of the Code.

Impact on National Electricity Transmission System (NETS)

5.12 The proposed changes will provide greater clarity and certainly to Generators who are required to comply with the RfG requirements. The requirements will apply to future Users who own and operate Generating plant of 1MW or above compared to the current GB requirements which only apply to Large and Medium Power Stations. The proposed Fault Ride Through requirements also remove the regional differences criteria which are embodied within the current GB Grid Code.

Impact on Grid and Distribution Code Users

5.13 Users will have to comply with the revised Grid and Distribution Code requirements, but this will ensure compliance with EU and UK law.

Impact on Greenhouse Gas emissions

5.14 The proposed modification will have limited impact on green house emissions although for Generators and manufacturers of future sub 50MW Generation, there could be additional manufacturing and development costs in making the plant compliant with the RfG requirements, for example the development of a RfG Compliant Generator could drive the need for higher inertia's which would have an impact on Greenhouse Gas emissions during the construction phase.

Assessment against Grid Code Objectives

i. *To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity;*

ii. *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);*

The proposals will ensure the fault ride through requirements are consistent across GB and remove the need for regional differences.

iii. *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; and*

The proposal (as defined by RfG) applies to Power Generating Modules of 1MW and above. The current GB requirements only apply to Generating Units and Power Park Modules which form part of a Large or Medium Power Station. As this requirement now applies to a greater volume of Generating Plant this will contribute to the enhanced security of the Transmission System. It will also remove the issue of Regional Differences between England and Wales, Scotland and Offshore.

iv. *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.*

This requirement is driven by EU Commission Regulation **2016/631** and is therefore a mandatory change to ensure GB compliance with European law.

Assessment against Distribution Code Objectives

i. *to permit the development, maintenance and operation of an efficient, coordinated and economical system for the distribution of electricity;*

Condition 21 of the Distribution Licence requires the licensee to comply with any relevant legally binding decisions of the European Commission and/or the Agency. As such these proposals are necessary to ensure consistency with the European Commission Directive on Cross Border Trade.

ii. *to facilitate competition in the generation and supply of electricity*

The proposals will ensure the Fault Ride Through requirements are consistent across GB and remove the need for regional differences.

iii. 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.

This requirement is driven by European Directive XXXX and therefore a mandatory and necessary change.

Impact on core industry documents

5.15 The proposed modification will have an impact on the Grid Code and the Distribution Code.

Impact on other industry documents

5.16 The proposed modification will affect Engineering Recommendation documents G59 and G83, and replace them with G99 an dG98

Implementation

[RJW to provide]

6 Consultation Responses

Views are invited upon the proposals outlined in this consultation, which should be received by [Insert Date].

Your formal responses may be emailed to:
grid.code@nationalgrid.com or [ENA - TBC]

Responses are invited to the following questions:

1. Do you agree that the proposals outlined in the consultation reflect the correct interpretation of the RfG Fault Ride Through requirements? If not please state why.
2. Do you agree with the proposed voltage against time curves for Type B, C and D Power Generating Modules? If not please state why.
3. Do you support the principle that the RfG requirements as applied to balanced faults should also apply to unbalanced faults? If not please state why and if so do you believe the current GB requirements for unbalanced faults should be retained.
4. Do you support the active power recovery characteristics should be retained at 0.5 seconds following fault clearance as defined in the current GB Grid Code?

Transmission:

5. Do you support the requirement for faults and voltage dips in excess of 140ms apply only to Type C and D Power Generating Modules?
6. Do you agree that the requirements of RfG Article 15(4)(c) would not apply to Power Generating Modules isolated by a Transmission System Faults and connected to an unhealthy circuit event for Delayed Auto –Reclose time?

Distribution:

7. Do you support the proposed changes to the G59 Stage 2 Undervoltage protection settings of 0.8pu for 2.2 seconds? If not please state why.
8. Do you have any views on the implications for generators or networks of removing the two stage undervoltage protection for embedded Type B generators, ie reverting to a singly undervoltage tripping stage?

Legal Drafting:

9. Do you support the proposed legal drafting approach for Grid Code?
10. Do you have any views about the structure of the distribution documents, i.e. the scope of G98 and G99?
11. Do you think it is appropriate to maintain G98 and G99 as stand-alone documents, or do you think that as other EU Network Codes are implemented it might be more appropriate to include all the relevant requirements for both connection and ongoing operation in a single document? Or do you believe that such a decision should be made once further investigation of the effects of other EU Codes on the GB distribution documents has been undertaken?

Other:

12. Do you have any other comments you wish to make in relation to this consultation?

If you wish to submit a confidential response please note the following: Information provided in response to this consultation will be published on National Grid's website unless the response is clearly marked "Private & Confidential", we will contact you to establish the extent of the confidentiality. A response marked "Private and Confidential" will be disclosed to the Authority in full but, unless agreed otherwise, will not be shared with the Grid or Distribution Code Review Panels or the industry and may therefore not influence the debate to the same extent as a non-confidential response.

Please note an automatic confidentiality disclaimer generated by your IT System will not in itself, mean that your response is treated as if it had been marked "Private and Confidential".

Annex 1 - Proposed Grid Code Legal Text

This section contains the proposed legal text to give effect to the proposals. The proposed new text is in red and is based on Grid Code Issue X Revision XX.

Section 1 – Proposals for Grid Code Legal Text Changes

Key

1) Blue Text – From G Code
2) Black Text – Changes / Additional words
3) Orange/ Brown text – From RfG
4) Highlighted Green text – Questions for Stakeholders / Consultation
5) Highlighted yellow text – Nomenclature / Table / Figure numbers – to be finalised when more detail has been added

ECC.6.3.15 **FAULT RIDE THROUGH**

ECC.6.3.15.1 General Fault Ride Through requirements, principles and concepts applicable to **Type B, Type C** and **Type D Power Generating Modules** and **OTSDUW Plant and Apparatus** subject to faults up to 140ms in duration.

ECC.6.3.15.1.1 This section sets out the Fault Ride Through requirements on **Type B, Type C** and **Type D Synchronous Power Generating Modules, Type B, Type C and Type D Onshore Power Park Modules, Type B, Type C and Type D Offshore Power Park Modules** and **OTSDUW Plant and Apparatus.** For the avoidance of doubt, the Fault Ride Through requirements applicable to **Offshore Power Park Modules** includes both **AC Connected Power Park Modules** and **DC Connected Power Park Modules.**

ECC.6.3.15.1.2 Each **Synchronous Power Generating Module**, **Onshore Power Park Module**, **Offshore Power Park Module** and **OTSDUW Plant and Apparatus** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Connection Point** or (**Interface Point** in the case of **OTSDUW Plant and Apparatus**) remains on or above the heavy black line shown in sections ECC.6.3.15.4 – ECC.6.3.15.10 Figures below.

ECC.6.3.15.1.3 The voltage against time curves defined in ECC.6.3.15.2 – ECC.6.3.15.6 expresses the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase **Voltages** (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network **Voltage** level at the **Connection Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.

ECC.6.3.15.2 Voltage against time curve and parameters applicable to **Type B Synchronous Power Generating Modules**

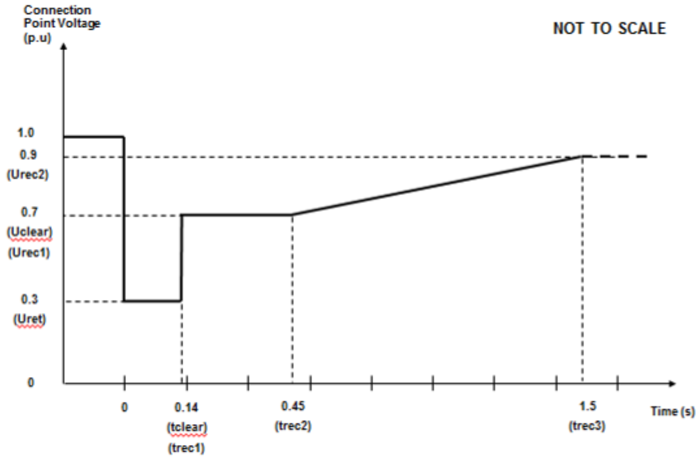


Figure X - Voltage against time curve applicable to **Type B Synchronous Power Generating Modules**

Voltage parameters (pu)		**Time parameters (seconds)**	
Uret	0.3	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

Table X Voltage against time parameters applicable to **Type B Synchronous Power Generating Modules**

ECC.6.3.15.3 Voltage against time curve and parameters applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

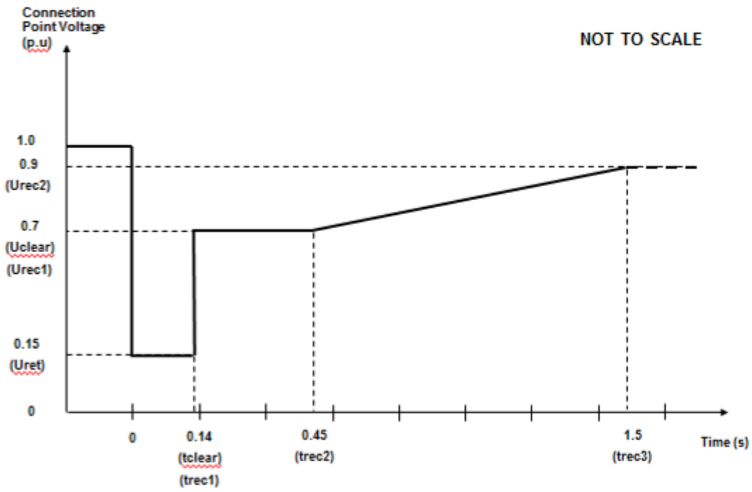


Figure X - Voltage against time curve applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

Voltage parameters (pu)		**Time parameters (seconds)**	
Uret	0.15	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

Table X Voltage against time parameters applicable to **Type C** and **D Synchronous Power Generating Modules** connected below 110kV

ECC.6.3.15.4 Voltage against time curve and parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

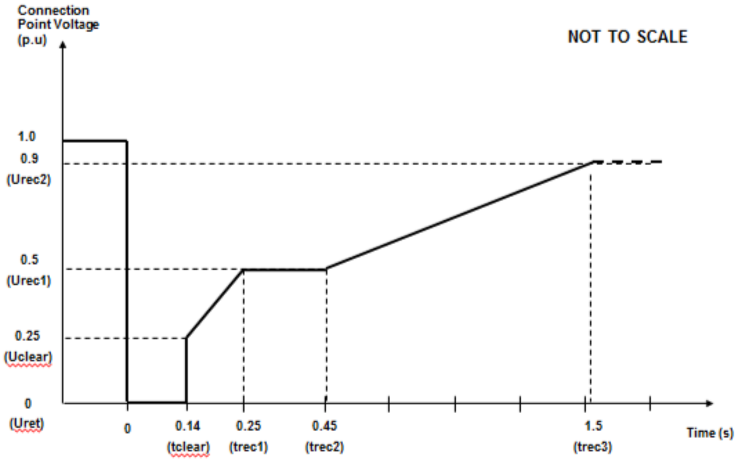


Figure X - Voltage against time curve applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.15	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

Table X Voltage against time parameters applicable to **Type D Synchronous Power Generating Modules** connected at or above 110kV

ECC.6.3.15.5 Voltage against time curve and parameters applicable to **Type B, C** and **D Power Park Modules** connected below 110kV

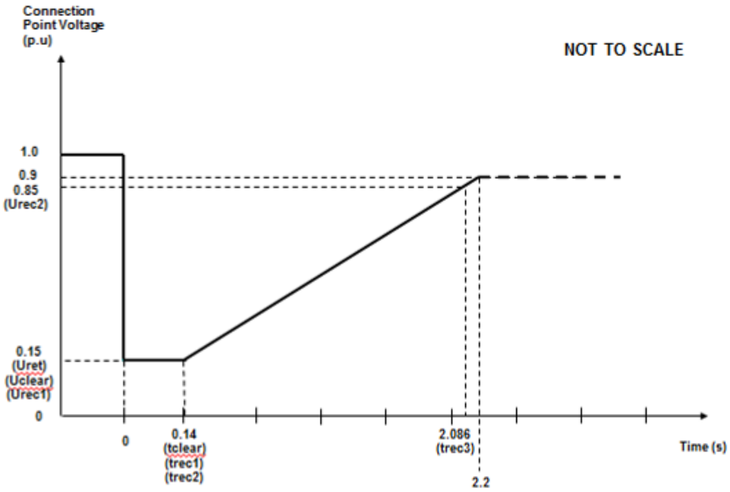


Figure X - Voltage against time curve applicable to **Type B, C and D Power Park Modules** connected below 110kV

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.15	tclear	0.14
Uclear	0.15	trec1	0.14
Urec1	0.15	trec2	0.14
Urec2	0.85	trec3	2.063

Table X Voltage against time parameters applicable to **Type B, C** and **D Power Park Modules** connected below 110kV

ECC.6.3.15.6 Voltage against time curve and parameters applicable to **Type D Power Park Modules** with a **Connection Point** at or above 110kV or **OTSDUW Plant and Apparatus** at the **Interface Point**.

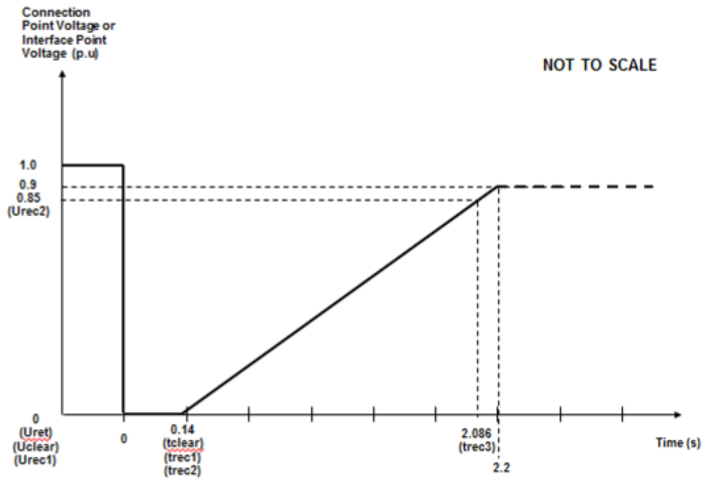


Figure X - Voltage against time curve applicable to **Type D Power Park Modules** with a **Connection Point** at or above 110kV or **OTSDUW Plant and Apparatus** at the **Interface Point**.

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0	tclear	0.14
Uclear	0	trec1	0.14
Urec1	0	trec2	0.14
Urec2	0.85	trec3	2.086

Table X Voltage against time parameters applicable to **Type D Power Park Modules** with a **Connection Point** at or above 110kV or **OTSDUW Plant and Apparatus** at the **Interface Point**.

ECC.6.3.15.1.7 In addition to the requirements in ECC.6.3.15.1 – ECC.6.3.15.6:

(i) Each **Power Generating Module** (or **OTSDUW Plant and Apparatus at the Interface Point**) shall be capable of satisfying the above requirements when operating at **Rated MW** output and maximum leading **Power Factor**.

(ii) **NGET** will specify the pre-fault and post fault short circuit capacity (in MVA) at the **Connection Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) in the **Bilateral Agreement**.

(iii) The pre-fault voltage shall be taken to be 1.0pu and the post fault voltage shall be 0.9pupu unless an a higher value is specified in the **Bilateral Agreement**.

(iv) To allow a **User** to model the Fault Ride Through performance of its **Power Generating Modules**, **NGET** will provide additional network data as may reasonably be required for the **User** to undertake such study work in accordance with PC.A.8. Alternatively, **NGET** may provide generic values derived from typical cases.

(v) **NGET** will publish fault level data under maximum and minimum demand conditions in the **Electricity Ten Year Statement**.

(v) Each **Power Generating Facility Owner** shall satisfy the requirements in ECC.6.3.15.1(i) – (v) unless the protection schemes and settings for internal electrical faults requires disconnection of the **Power Generating Module** (or **OTSDUW Plant and Apparatus**) from the network. The protection schemes and settings should not jeopardise Fault Ride Through performance as specified in ECC.6.3.15.1(i) – (v). The undervoltage protection at the **Connection Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) shall be set by the **Power Generating Facility Owner** (or **OTSDUA** in the case of **OTSDUW Plant and Apparatus**) according to the widest possible range unless **NGET** has agreed to narrower settings which shall be pursuant to the terms of the **Bilateral Agreement**. All protection settings associated with undervoltage protection shall be agreed between **NGET** and/or **Relevant Transmission Licensee's** and / or **Relevant Network Operators** (as applicable).

(vi) In addition to the requirements of ECC.6.3.15.1 – ECC.6.3.15.7 each **Type B, C** and **D Power Generating Module** and **OTSDUW Plant and Apparatus** at the **Interface Point** shall be designed such that upon clearance of the fault on the **Onshore Transmission System** and within 0.5 seconds of restoration of the voltage at the **Grid Entry Point** or **User System Entry Point** or **Interface Point** in the case of **OTSDUW Plant and Apparatus** to 90% of nominal voltage or greater, **Active Power** output (or **Active Power** transfer capability in the case of **OTSDW Plant and Apparatus**) shall be restored to at least 90% of the level immediately before the fault. Once **Active Power** output (or **Active Power** transfer capability in the case of **OTSDUW Plant and Apparatus**) has been restored to the required level, Active Power oscillations shall be acceptable provided that:

- The total Active Energy delivered during the period of the oscillations is at least that which would have been delivered if the Active Power was constant
- The oscillations are adequately damped.

For **Power Park Modules** ~~**Plant and Apparatus** installed on or after 1 December 2017,~~ comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

ECC.6.3.15.8 General Fault Ride Through requirements, principles and concepts applicable to **Type B** (30MW or greater), **Type C** and **Type D Power Generating Modules** and **OTDSUW Plant and Apparatus** subject to faults in excess of 140ms in duration.

ECC.6.3.15.8.1 This section sets out the Fault Ride Through requirements on **Type B** (30MW or greater), **Type C** and **Type D** Synchronous Power **Generating Modules, Power Park Modules** and **OTSDUW Plant and Apparatus.**

(b) **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration

(1b) Requirements applicable to **Synchronous Power Generating** ~~**Units**~~ **Modules** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

In addition to the requirements of ECC.6.3.15.1 – ECC.6.3.15.7~~1 (a)~~ each **Synchronous Generating** **Module** ~~**Unit**, each with a **Completion Date** on or after **1 April 2005**~~ shall:

(i) remain transiently stable and connected to the **System** without tripping of any **Synchronous Power Generating Module** ~~**Unit**~~ for balanced **Supergrid Voltage** dips and associated durations on the **Onshore Transmission System** (which could be at the **Interface Point**) anywhere on or above the heavy black line shown in Figure X~~5a~~. Appendix X4A and Figures ECC.A.4A.3.2 (a), (b) and (c) provide an explanation and illustrations of Figure 5a; and,

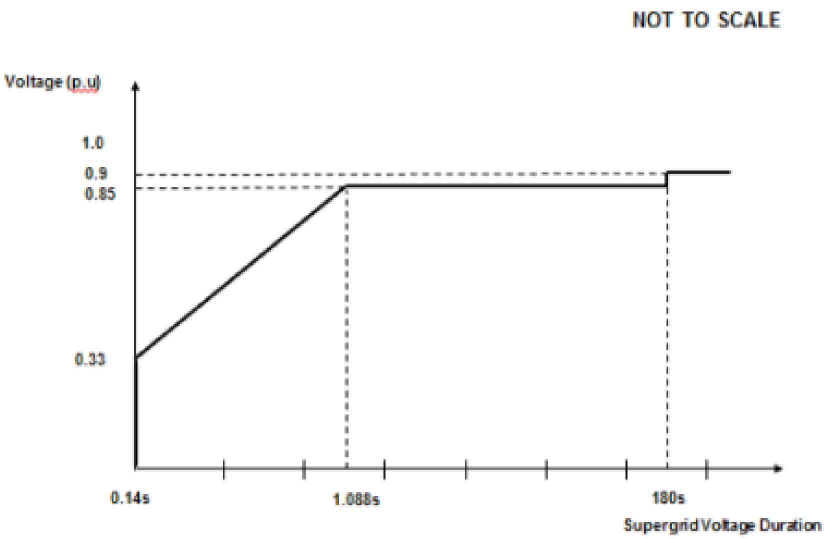


Figure 5a

(ii) provide **Active Power** output at the **Grid Entry Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5a, at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Synchronous Power Generating Modules** ~~**Units**~~) or **Interface Point** (for **Offshore Synchronous Power Generating Modules** ~~**Units**~~) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) and shall generate maximum reactive current (where the voltage at the **Grid Entry Point** is outside the limits specified in ECC.6.1.4) without exceeding the transient rating limits of the **Synchronous Power Generating Module** ~~**Unit**~~ and,

(iii) restore **Active Power** output following **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5a, within 1 second of restoration of the voltage to 1.0pu of the nominal voltage at the:

Onshore Grid Entry Point for directly connected **Onshore Synchronous Power Generating Modules** ~~**Units**~~ or,

Interface Point for **Offshore Synchronous Power Generating Modules** ~~**Units**~~ **or**,

User System Entry Point for **Embedded Onshore Synchronous Power Generating Modules** ~~**Units**~~ or,

~~**User System Entry Point** for **Embedded Medium Power Stations** not subject to a **Bilateral Agreement** which comprise **Synchronous Generating Units** and with an **Onshore User System Entry Point** (irrespective of whether they are located **Onshore** or **Offshore**)~~

to at least 90% of the level available immediately before the occurrence of the dip. Once the **Active Power** output has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- the total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- the oscillations are adequately damped.

For the avoidance of doubt a balanced **Onshore Transmission System Supergrid Voltage** meets the requirements of ECC.6.1.5 (b) and ECC.6.1.6.

(2b) Requirements applicable to **Type C** and **Type D** ~~**OTSDUW Plant and Apparatus** and~~ **Power Park Modules** and **OTSDUW Plant and Apparatus** and subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

In addition to the requirements of ECC.6.3.15.1 (a) each **OTSDUW Plant and Apparatus** or each **Power Park Module** and / or any constituent **Power Park Unit**, ~~each with a **Completion Date** on or after the 1 April 2005~~ shall:

(i) remain transiently stable and connected to the **System** without tripping of any **OTSDUW Plant and Apparatus**, or **Power Park Module** and / or any constituent **Power Park Unit**, for balanced **Supergrid Voltage** dips and associated durations on the **Onshore Transmission System** (which could be at the **Interface Point**) anywhere on or above the heavy black line shown in Figure 5b. Appendix 4A and Figures CC.A.4A.3.4 (a), (b) and (c) provide an explanation and illustrations of Figure 5b; and,

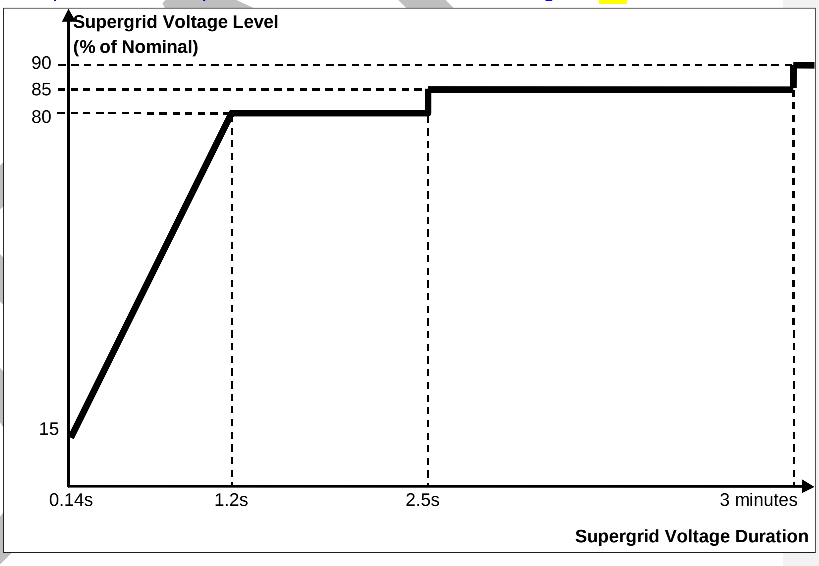


Figure 5b

(ii) provide **Active Power** output at the **Grid Entry Point** or in the case of an **OTSDUW**, **Active Power** transfer capability at the **Transmission Interface Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5b, at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Power Park Modules**) or **Interface Point** (for **OTSDUW Plant and Apparatus** and **Offshore Power Park Modules**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) except in the case of a **Non-Synchronous Generating Unit** or **OTSDUW Plant and Apparatus** or **Power Park Module** where there has been a reduction in the **Intermittent Power Source** or in the case of **OTSDUW Active Power** transfer capability in the time range in

Figure 5b that restricts the **Active Power** output or in the case of an **OTSDUW Active Power** transfer capability below this level and shall generate maximum reactive current (where the voltage at the **Grid Entry Point**, or in the case of an **OTSDUW Plant and Apparatus**, the **Interface Point** voltage, is outside the limits specified in ECC.6.1.4) without exceeding the transient rating limits of the **OTSDUW Plant and Apparatus** or **Power Park Module** and any constituent **Power Park Unit**; and,

(iii) restore **Active Power** output (or, in the case of **OTSDUW**, **Active Power** transfer capability), following **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5b, within 1 second of restoration of the voltage at the:

Onshore Grid Entry Point for directly connected **Onshore Power Park Modules** or,

Interface Point for **OTSDUW Plant and Apparatus** and **Offshore Power Park Modules** or,

User System Entry Point for **Embedded Onshore Power Park Modules** or,

~~**User System Entry Point** for **Embedded Medium Power Stations** which comprise **Power Park Modules** not subject to a **Bilateral Agreement** and with an **Onshore User System Entry Point** (irrespective of whether they are located **Onshore** or **Offshore**)~~

to the minimum levels specified in ECC.6.1.4 to at least 90% of the level available immediately before the occurrence of the dip except in the case of a **Non-Synchronous Generating Unit**, **OTSDUW Plant and Apparatus** or **Power Park Module** where there has been a reduction in the **Intermittent Power Source** in the time range in Figure 5b that restricts the **Active Power** output or, in the case of **OTSDUW**, **Active Power** transfer capability below this level. Once the **Active Power** output or, in the case of **OTSDUW**, **Active Power** transfer capability has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- the total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- the oscillations are adequately damped.

For the avoidance of doubt a balanced **Onshore Transmission System Supergrid Voltage** meets the requirements of ECC.6.1.5 (b) and ECC.6.1.6.

ECC.6.3.15.3 Other Fault Ride Through Requirements

(i) In the case of a **Power Park Module** ~~(comprising of wind-turbine generator units)~~, the requirements in ECC.6.3.15.X ~~and CC.6.3.15.2~~ do not apply when the **Power Park Module** is operating at less than 5% of its **Rated MW** or during very high primary energy source conditions ~~wind speed~~ conditions when more than 50% of the ~~wind turbine generator~~ **Power Park Units** in a **Power Park Module** have been shut down or disconnected under an emergency shutdown sequence to protect **User's Plant** and **Apparatus**.

(ii) In addition to meeting the conditions specified in ECC.6.1.5(b) and ECC.6.1.6, each **Non-Synchronous Generating Unit**, **OTSDUW Plant and Apparatus** or **Power Park Module** ~~with a **Completion Date** after 1 April 2005~~ and any constituent **Power Park Unit** thereof will be required to withstand, without tripping, the negative phase sequence loading incurred by clearance of a close-up phase-to-phase fault, by **System Back-Up Protection** on the **Onshore Transmission System** operating at **Supergrid Voltage**.

~~(iii) In the case of an **Onshore Power Park Module** in Scotland with a **Completion Date** before 1 January 2004 and a **Registered Capacity** less than 30MW the requirements in CC.6.3.15.1 (a) do not apply. In the case of an **Onshore Power Park Module** in Scotland with a **Completion Date** on or after 1 January 2004 and before 1 July 2005 and a **Registered Capacity** less than 30MW the requirements in CC.6.3.15.1 (a) are relaxed from the minimum **Onshore Transmission System Supergrid Voltage** of zero to a minimum **Onshore Transmission System Supergrid Voltage** of 15% of nominal. In the case of an **Onshore Power Park Module** in Scotland with a **Completion Date** before 1 January 2004 and a **Registered Capacity** of 30MW and above the requirements in CC.6.3.15.1 (a) are relaxed from the minimum **Onshore Transmission System Supergrid Voltage** of zero to a minimum **Onshore Transmission System Supergrid Voltage** of 15% of nominal.~~

(iii~~v~~) To avoid unwanted island operation, **Non-Synchronous Generating Units** in Scotland (and those directly connected to a **Scottish Offshore Transmission System**), **Power Park Modules** in Scotland (and those directly connected to a **Scottish Offshore Transmission System**) , or **OTSDUW Plant and Apparatus** with an **Interface Point** in Scotland shall be tripped for the following conditions:

(1) **Frequency** above 52Hz for more than 2 seconds

(2) **Frequency** below 47Hz for more than 2 seconds

(3) Voltage as measured at the **Onshore Connection Point** or **Onshore User System Entry Point** or **Offshore Grid Entry Point** or **Interface Point** in the case of **OTSDUW Plant and Apparatus** is below 80% for more than 2.5 seconds

(4) Voltage as measured at the **Onshore Connection Point** or **Onshore User System Entry Point** or **Offshore Grid Entry Point** or **Interface Point** in the case of **OTSDUW Plant and Apparatus** is above 120% (115% for 275kV) for more than 1 second.

The times in sections (1) and (2) are maximum trip times. Shorter times may be used to protect the **Non-Synchronous Generating Units**, or **OTSDUW Plant and Apparatus** or **Power Park Modules**.

(iv) For the avoidance of doubt the requirements specified in ECC.6.3.15.X – ECC.6.3.15.X do not apply to **Power Generating Modules** connected to an unhealthy circuit and islanded from the **Transmission System** even for delayed auto reclosure times.

ECC.4 - APPENDIX 4 - FAULT RIDE THROUGH REQUIREMENTS

FAULT RIDE THROUGH REQUIREMENTS FOR TYPE B, C AND D SYNCHRONOUS POWER GENERATING MODULES, ONSHORE POWER PARK MODULES, OFFSHORE POWER PARK MODULES (INCLUDING OFFSHORE POWER PARK MODULES WHICH ARE EITHER AC CONNECTED POWER PARK MODULES OR DC CONNECTED POWER PARK MODULES) AND OTSDUW PLANT AND APPARATUS

ECC.A.4A.1 Scope

The Fault Ride Through requirement is defined in ECC.6.3.15.1 - ECC.6.3.15.8~~(a), (b) and CC.6.3.15.3~~. This Appendix provides illustrations by way of examples only of ECC.6.3.15.1 – ECC.6.3.15.8 and further background and illustrations to ECC.6.3.15.1 – ECC.6.3.15.8 ~~and CC.6.3.15.1 (2b) (i)~~ and is not intended to show all possible permutations.

ECC.A.4A.2 Short Circuit Faults At Supergrid Voltage On The Onshore Transmission System Up To 140ms In Duration

For short circuit faults at **Supergrid Voltage** on the **Onshore Transmission System** (which could be at an **Interface Point**) up to 140ms in duration, the Fault Ride Through requirement is defined in ECC.6.3.15. In summary any **Power Generating Module** is required to remain connected and stable whilst connected to a healthy circuit. Figure ECC.A.4.A.2 illustrates this principle.

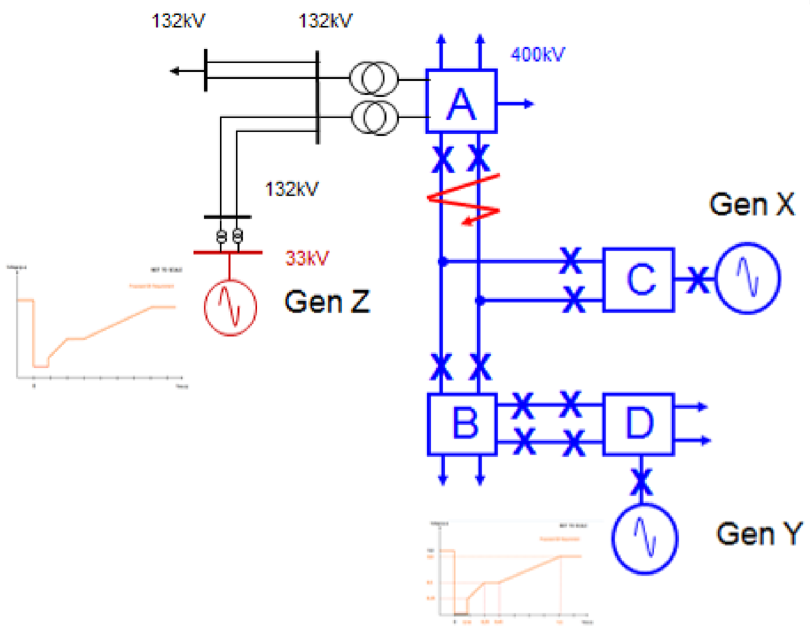


Figure ECC.A.4.A.2

In Figure ECC.A.4.A.2 a solid three phase short circuit fault is applied adjacent to substation A resulting in zero voltage at the point of fault. All circuit breakers on the faulty circuit (Lines ABC) will open within 140ms. The effect of this fault, due to the low impedance of the network, will be the observation of a low voltage at each substation node until the fault has been cleared. An indicative example of the Supergrid voltage before, during and after the fault is shown in Figure ECC.A.4.A.3.

Under this example, Generator X in Figure ECC.A.4.A.2, will trip as it is disconnected from the **Transmission System** by the clearance of the fault. Generator Y and Generator Z (an Embedded Generator) would need to remain connected and stable as both are still connected to the **Total System**.

The criteria for assessment is based on a voltage against time curve at each **Connection Point**. The voltage against time curve at the **Connection Point** varies for each different type and size of **Power Generating Module** as detailed in ECC.6.3.15.1.X – ECC.6.3.15.Y.

The voltage against time curve represents the voltage profile at a **Connection Point** that would be obtained by plotting the voltage at that **Connection Point** before during and after the fault. This is not to be confused with a voltage duration curve (as defined under ECC.6.3.15.X) which represents a voltage level and associated time duration.

The post fault voltage at a **Connection Point** is largely influenced by the topology of the network rather than the behaviour of the **Power Generating Module** itself. The **Power Generating Facility Owner** therefore needs to ensure each **Power Generating Module** remains connected and stable for a close up solid three phase short circuit fault for 140ms at the **Connection Point**.

Two examples are shown in Figure ECC.A.4.A.2.X and ECC.A.4.A.2.Y. In Figure ECC.A.4.A.2.X, the post fault profile is above the heavy black line. In this case the **Power Generating Module** must remain connected and stable. In Figure ECC.A.4.A.2.Y the post fault voltage dips below the heavy black line in which case the **Power Generating Module** is permitted to trip.

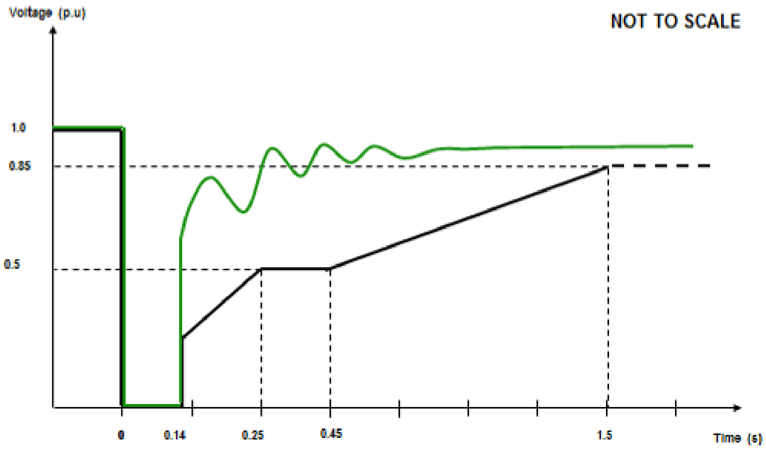


Figure ECC.A.4.A.2.X

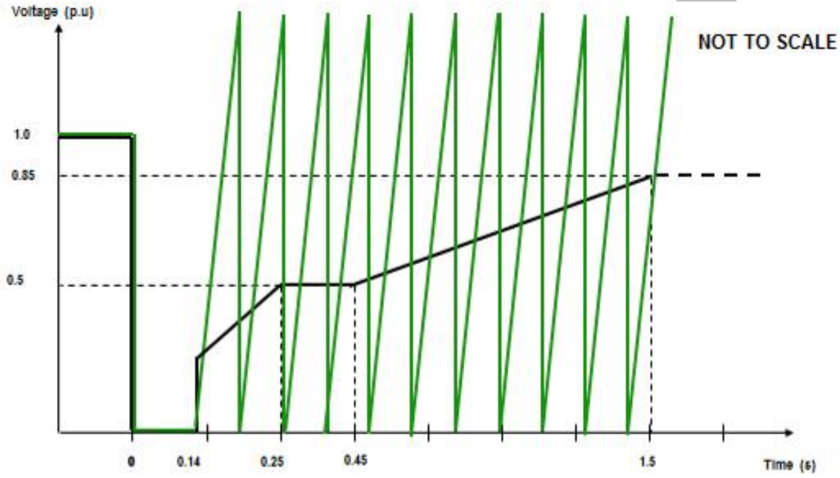


Figure ECC.A.4.A.2.Y

The process for demonstrating Fault Ride Through compliance against the requirements of ECC.6.3.15.X are detailed in ECP.A.3.5.

ECC.A.4A.3 Supergrid Voltage Dips On The Onshore Transmission System Greater Than 140ms In Duration

ECC.A.4A3.1 Requirements applicable to **Synchronous Power Generating Modules** ~~**Generating Units**~~ subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration.

For balanced **Supergrid Voltage** dips on the **Onshore Transmission System** having durations greater than 140ms and up to 3 minutes, the Fault Ride Through requirement is defined in ECC.6.3.15.1 (1b) and Figure 5a which is reproduced in this Appendix as Figure ECC.A.4A3.1 and termed the voltage–duration profile.

This profile is not a voltage-time response curve that would be obtained by plotting the transient voltage response at a point on the **Onshore Transmission System** (or **User System** if located **Onshore**) to a disturbance. Rather, each point on the profile (ie the heavy black line) represents a voltage level and an associated time duration which connected **Synchronous Power Generating Modules** ~~**Units**~~ must withstand or ride through.

Figures ECC.A.4A3.2 (a), (b) and (c) illustrate the meaning of the voltage-duration profile for voltage dips having durations greater than 140ms.

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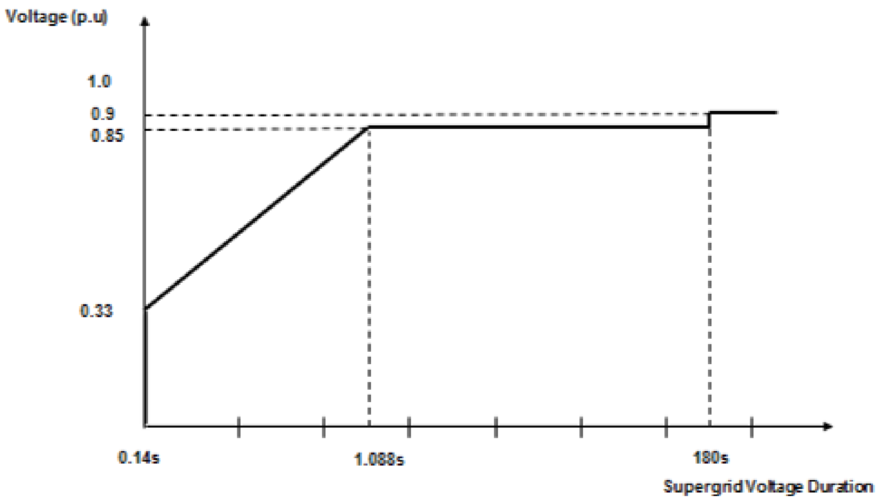

Figure ECC.A.4A3.1

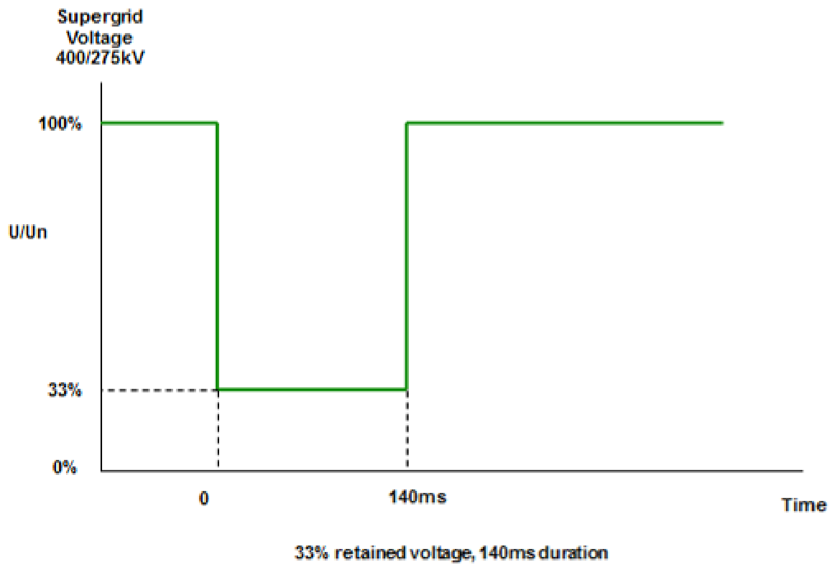

Figure ECC.A.4A3.2 (a)

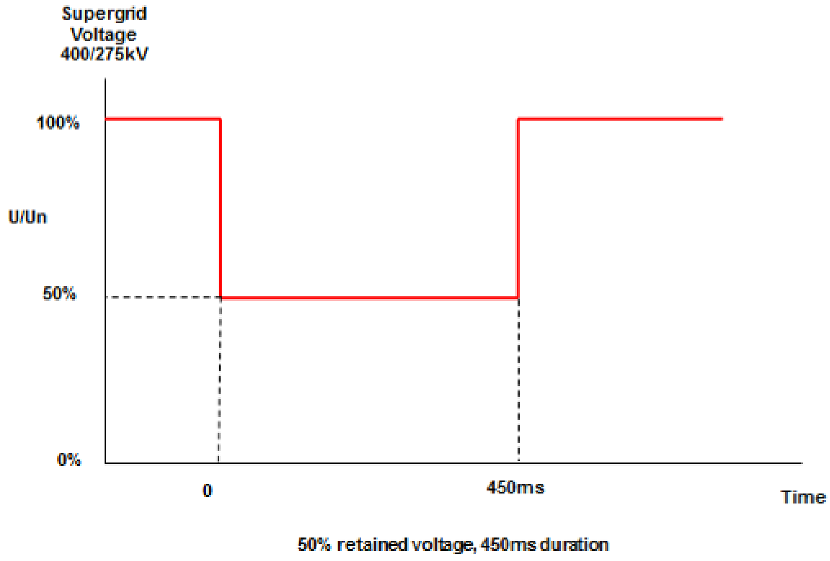

Figure ECC.A.4A3.2 (b)

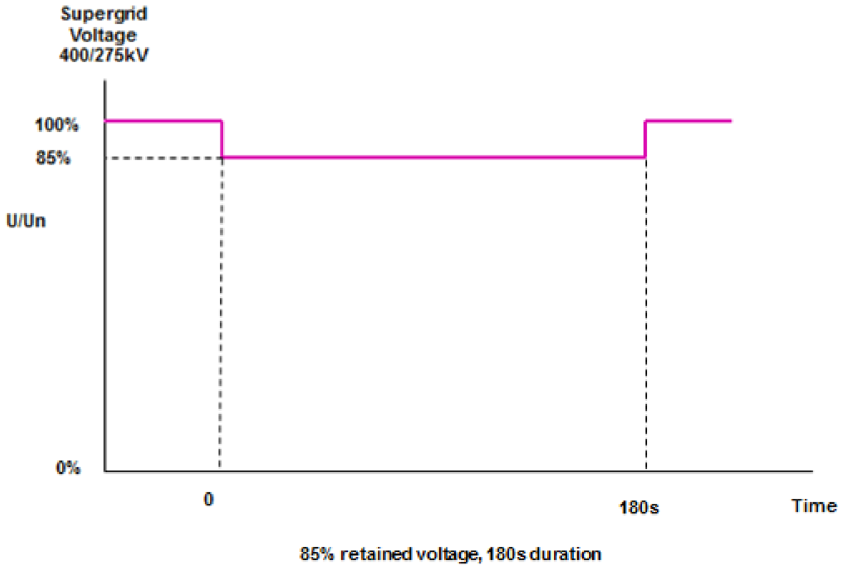

Figure ECC.A.4A3.2 (c)

ECC.A.4A3.2 Requirements applicable to **Power Park Modules** or **OTSDUW Plant and Apparatus** subject to **Supergrid Voltage** dips on the **Onshore Transmission System** greater than 140ms in duration

For balanced **Supergrid Voltage** dips on the **Onshore Transmission System** (which could be at an **Interface Point**) having durations greater than 140ms and up to 3 minutes the Fault Ride Through requirement is defined in ECC.6.3.15.1 (2b) and Figure 5b which is reproduced in this Appendix as Figure ECC.A.4A3.3 and termed the voltage–duration profile. This profile is not a voltage-time response curve that would be obtained by plotting the transient voltage response at a point on the **Onshore Transmission System** (or **User System** if located **Onshore**) to a disturbance. Rather, each point on the profile (ie the heavy black line) represents a voltage level and an associated time duration which connected **Power Park Modules** or **OTSDUW Plant and Apparatus** must withstand or ride through.

Figures ECC.A.4A.4 (a), (b) and (c) illustrate the meaning of the voltage-duration profile for voltage dips having durations greater than 140ms.

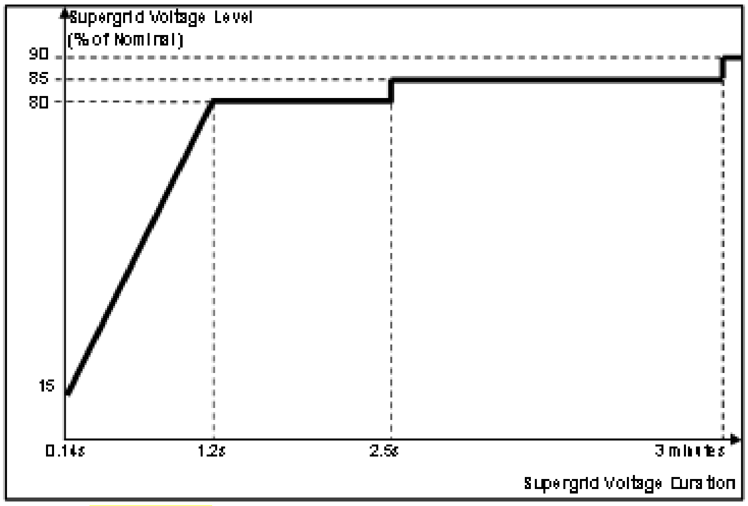

Figure ECC.A.4A3.3

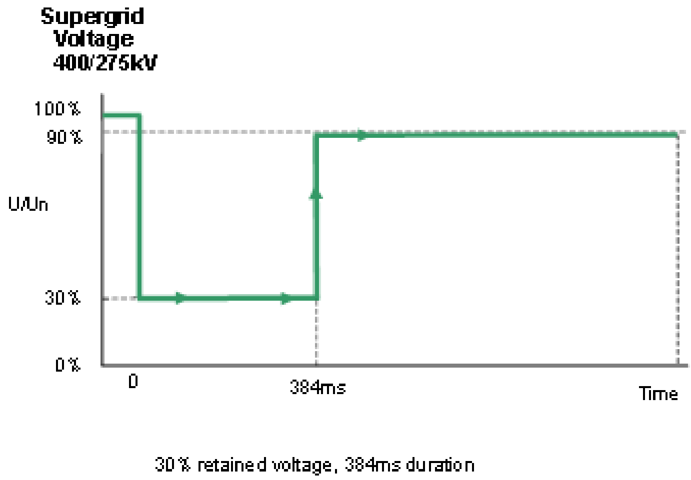

Figure ECC.A.4A3.4 (a)

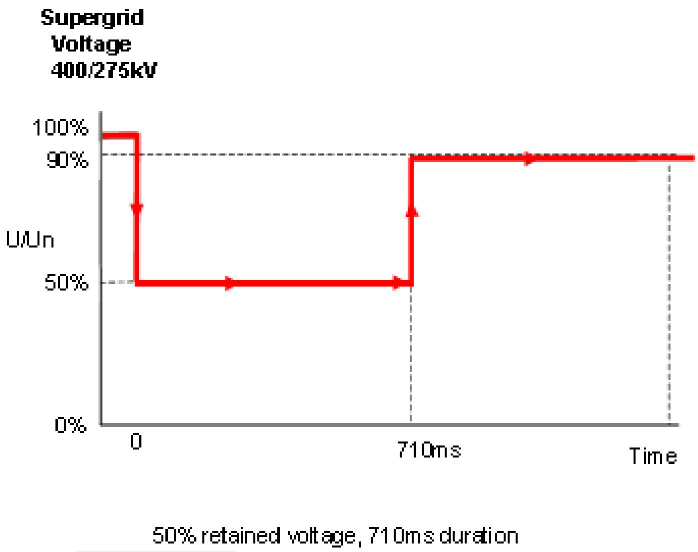

Figure ECC.A.4A3.4 (b)

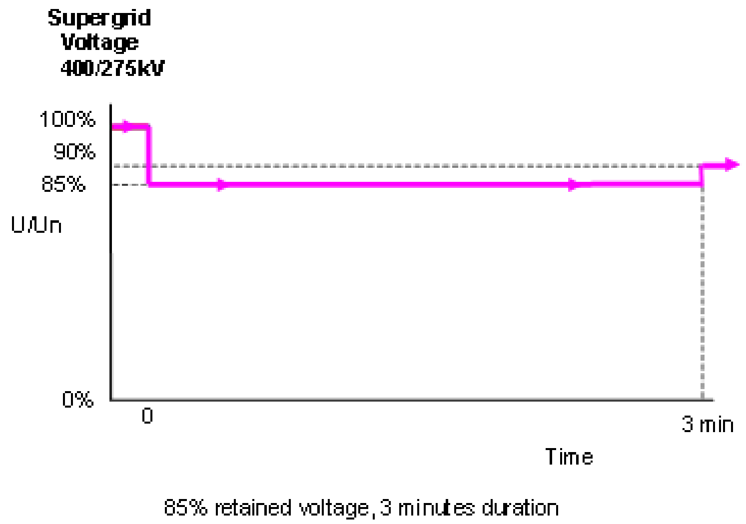

Figure ECC.A.4A3.4 (c)

Annex 2 – Grid Code – Proposed Legal Text Changes - Issues

RFG FAULT RIDE THROUGH – GRID CODE LEGAL TEXT ISSUES TABLE

No	Article	Issue	Comments
1	Art 14(3)(b)	Unbalanced Faults up to 140ms in duration	Should unbalanced faults be treated in the same way as balanced faults? At the present time the Fault Ride Through requirements in GB for unbalanced faults are fundamentally different to RFG's treatment of Balanced faults.
2	N/A	Offshore Power Park Modules – current drafting includes both AC and DC Connected Power Park Modules?	Fault Ride Through Requirements for AC and DC Connected Offshore Power Park Modules included within general Onshore Fault Ride Through requirements. We nedd to ensure Stakeholders are comfortable with this approach.
3	N/A	Fault Ride Through Requirements in excess of 140ms	Should these requirements only apply to Type C and D Power Generating Modules – ie as per current Grid Code?
4	N/A	Licence Exempt Embedded Medium Power Stations (LEEMPS)	Under the current Grid Code, LEEMPS are treated as Embedded Medium Power Stations not subject to a Bilateral Agreement. It is assumed these would be removed from the Code post RfG
5	CC.6.3.15.2	Fault Ride Through Offshore requirements	Is it acceptable to delete this section bearing in mind the Fault Ride Through requirement under RfG now applies at the Connection Point?
6	CC.6.3.15.2	Fault Ride Through Offshore requirements	A number of stake holders have advised they would like to see an option for meeting an onshore requirement or offshore requirement. Can this be facilitated under RfG?
7	CC.6.3.15.3	Fault Ride Through Protection requirements in Scotland	Discuss with Scottish TO's.

Draft G99 text applicable to Fault Ride Through

Purple text = from G59
Brown/Orange text = from RfG (June 2015)
Green text = from other EU documents referenced by RfG
Blue text = from Distribution Code
Black text = Changes/ additional words
Red text = Words that may/ will need changing

9.7 Fault Ride Through

9.7.1 Paragraphs 9.7.1 to 9.7.8 inclusive set out the fault ride through, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules** greater than 1 MW and less than 50MW (Type B), subject to disturbances from faults on the transmission system of up to 140ms in duration.

9.7.2 Each **Synchronous Power Generating Module** and **Power Park Module** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Connection Point** remains on or above the heavy black line shown in Figures 9.2 and 9.3 below.

9.7.3 The voltage against time curves defined in paragraphs 9.7.4 – 9.7.7 expresses the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at the **Connection Point** during a symmetrical or asymmetrical/unbalanced transmission fault, as a function of time before, during and after the fault.

9.7.4

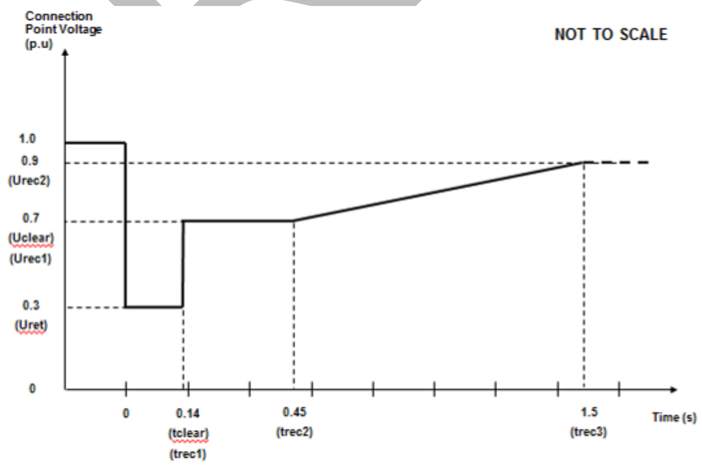

Figure 9.2 - Voltage against time curve applicable to **Synchronous Power Generating Modules** greater than 1 MW and less than 50MW (Type B)

9.7.5 Voltage against time parameters applicable to **Synchronous Power Generating Modules** greater than 1 MW and less than 50MW (Type B)

Insert Heading
Use this column in a Q&A style for explanations, in order to preserve the flow of the main text.

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.3	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

9.7.6

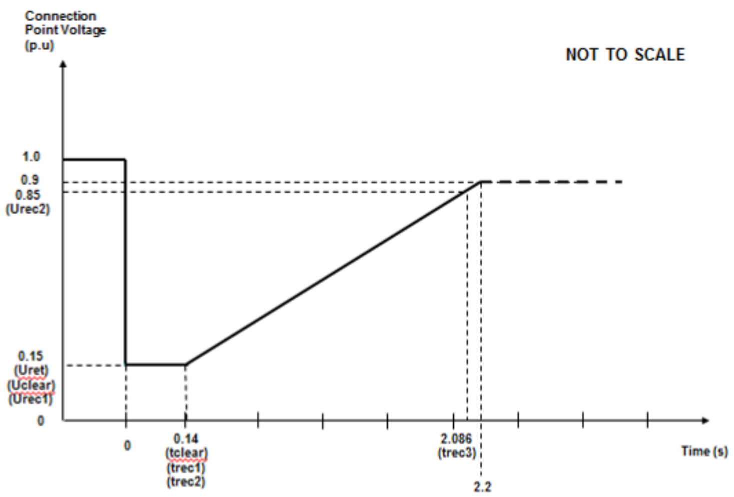

Figure 9.3 - Voltage against time curve applicable to **Power Park Modules** greater than 1 MW and less than 50MW (Type B)

9.7.7 Voltage against time parameters applicable to **Power Park Modules** greater than 1 MW and less than 50MW (Type B)

Voltage parameters (pu)		Time parameters (seconds)	
Uret	0.15	tclear	0.14
Uclear	0.7	trec1	0.14
Urec1	0.7	trec2	0.45
Urec2	0.9	trec3	1.5

9.7.8 In addition to the requirements in paragraphs 9.7.4 to 9.7.7:

(vii) Each **Power Generating Module** shall be capable of satisfying the above requirements when operating at **Rated MW** output and maximum leading **Power Factor.**

(viii) The pre-fault voltage shall be taken to be 1.0pu and the post fault voltage shall be 0.**9pu** unless a higher value is specified in the Connection Agreement.

(ix) **The DNO** will publish fault level data under maximum and minimum demand conditions in the Long Term Development Statements. To allow a **User** to model the fault ride through performance of its **Power Generating Modules**, **the DNO** will provide generic fault level values derived from typical cases. Where necessary, on reasonable request the DNO will specify the pre-fault and post fault short circuit capacity (in MVA) at the **Connection Point** and will provide additional network data as may reasonably be required for the **User** to undertake such study work.

(x) Each **Generator** shall satisfy the requirements in paragraphs 9.7.4 – 9.7.7 unless the protection schemes and settings for internal electrical faults requires disconnection of the **Power Generating Module** from the network. The protection schemes and settings should not jeopardise fault ride through performance as specified in paragraphs 9.7.4 – 9.7.7. The undervoltage protection at the **Connection Point** shall be set by the **Power Generating Facility Owner** according to the widest possible range unless **the DNO** has agreed to narrower settings which shall be pursuant to the terms of the **Connection Agreement**. All protection settings associated with undervoltage protection shall be agreed between the DNO and the Power Generating Facility Owner.

(xi) In addition to the requirements of paragraphs 9.7.4 – 9.7.8 each **Power Generating Module** shall be designed such within 0.5 seconds of restoration of the voltage at the **Connection Point** to 90% of nominal voltage or greater, **Active Power** output shall be restored to at least 90% of the level immediately before the fault. Once **Active Power** output has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- The total Active Energy delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant
- The oscillations are adequately damped.

For **Power Park Modules**, comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

9.7.9 In addition to paragraphs 9.7.1 – 9.7.8 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Power Generating Facility Owner** that the **Power Generating Facility** will contribute to the **DNO**'s **Distribution Network** security, may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO**'s main protection. The **DNO** will advise the **Embedded Power Generating Facility** in each case of the likely tripping time of the **DNO**'s protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time.

In the case of phase to phase faults on the **DNO**'s system that are cleared by **System** back-up **Protection** which will be within the **Plant** short time rating on the **DNO**'s **Distribution Network** the **DNO**, on request during the Connection Agreement process, will advise the Embedded Power Generating Facility Owner of the expected Phase Voltage Unbalance.

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10.5 Protection Settings

10.5.1 The following notes aim to explain the settings requirements as given in Section 10.5.7.1 below.

10.5.2 A LoM protection of RoCoF or vector shift type will generally be appropriate for **Type A and Type B Power Generating Modules**, but this type of LoM protection must not be installed for **Power Generating Facilities** at or above 50 MW. In those cases where the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping. See note in section 10.3.13 about the future long term unsuitability of RoCoF protection.

10.5.3 Under Voltage

In order to help maintain **Total System Stability**, the protection settings should be such as to facilitate transmission fault ride through capability. The overall aim is to ensure that **Power Generating Module** is not disconnected from the **Distribution Network** unless there is material disturbance on the **Distribution Network**, as disconnecting generation unnecessarily will tend to make an under voltage situation worse. To maximize the transmission fault ride through capability a single undervoltage setting of 13% with a time delay of 2.5s

10.5.4 Over Voltage

Over voltages are potentially more dangerous than under voltages and hence the acceptable excursions form the norm are smaller and time delays shorter, a 2-Stage over voltage protection[1] is to be applied as follows:

- Stage 1 (**LV**) should have a setting of +14% (ie the **LV** statutory upper voltage limit of +10%,with a further 4% permitted for voltage rise internal to the **Customer**'s installation and measurement errors),with a time delay of 1.0s (to avoid nuisance tripping for short duration excursions);

- Stage 2 (**LV**) should have a setting of +19% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion);

[1] Over Voltage Protection is not intended to maintain statutory voltages but to detect islanding

- Stage 1 (**HV**) should have a setting of +10% with a time delay of 1.0s (ie the **HV** statutory upper voltage limit of +6%,with a further 4% permitted for voltage rise internal to the **Customer's Installation** and measurement errors),, with a time delay of 1.0s to avoid nuisance tripping for short duration excursions);

- Stage 2 (**HV**) should have a setting of +13% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion).

To achieve high utilisation and **Distribution Network** efficiency, it is common for the **HV Distribution Network** to be normally operated near to the upper statutory voltage limits. The presence of **Power Generating Module** within such **Distribution Network** may increase the risk of the statutory limit being exceeded, eg when the **Distribution Network** is operating abnormally. In such cases the **DNO** may specify additional over voltage protection at the **Power Generating Module** connection point. This protection will typically have an operating time delay long enough to permit the correction of transient over voltages by automatic tap-changers.

10.5.5 Over Frequency

Power Generating Modules are required to stay connected to the **Total System** for frequencies up to 52 Hz for up to 15 minutes so as to provide the necessary regulation to control the **Total System** frequency to a satisfactory level. In order to prevent the unnecessary disconnection of a large volume of smaller **Power Generating Module** for all **LV** and **HV** connected **Power Generating Module** a single stage protection is to be applied that has a time delay of 0.5s and a setting of 52 Hz If the frequency rises to or above 52 Hz as the result of an undetected islanding condition, the **Power Generating Module** will be disconnected with a delay of 0.5s plus circuit breaker operating time.

10.5.6 Under Frequency

Section 9.3 requires **all Power Generating Facilities** to maintain connection unless the **Total System** frequency falls below 47.5 Hz for 20s or below 47 Hz.

For all **LV** and **HV** connected **Power Generating Module**, the following 2-stage under frequency protection should be applied:

- Stage 1 should have a setting of 47.5 Hz with a time delay of 20s;

- Stage 2 should have a setting of 47.0 Hz with a time delay of 0.5s;

- These settings are in line with the **Distribution Code** requirements.

10.5.7 Loss of Mains (LoM)

In order to avoid unnecessary disconnection of **Power Generating Module** during **Distribution Network** faults or switching events and the consequent disruption to **Generator**s and customers, as well as take into account the aggregate effect caused by multiple LoM operations on **Total System** Stability, consideration should be given to use of the appropriately sensitive settings which can be adjusted to take into account **Power Generating Module** type & rating and **Distribution Network** fault level. Example setting formulae are indicated in the notes below the Table 10.5.7.1.

10.5.7.1 Settings for Long-Term Parallel Operation

Prot Function	Type A and Type B Power Generating Modules				Type C and Type D Power Generating Modules	
	LV Protection(1)		**HV** Protection(1)			
	Setting	Time	Setting	Time	Setting	Time
U/V	Vφ-n† -13% = 200.1V	2.5s*	Vφ-φ‡ -13%	2.5s*	Vφ-φ‡- 20%	2.5s*
O/V st 1	Vφ-n† + 14% =262.2V	1.0s	Vφ-φ‡ + 10%	1.0s	Vφ-φ‡ + 10%	1.0s
O/V st 2	Vφ-n†+ 19% =273.7V$	0.5s	Vφ-φ‡ + 13%	0.5s		
U/F st 1	47.5Hz	20s	47.5Hz	20s	47.5Hz	20s
U/F st 2	47.0Hz	0.5s	47.0Hz	0.5s	47.0Hz	0.5s
O/F	52.0 Hz	0.5s	52.0Hz	0.5s	52.0Hz	0.5s
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees#		Intertripping expected	
LoM (RoCoF)	1 Hzs^{-1} time delay 0.5s		1 Hzs^{-1} time delay 0.5s		Intertripping expected	

(1) **HV** and **LV** Protection settings are to be applied according to the voltage at which the voltage related protection reference is measuring, eg:

- If the EREC G99 protection takes its voltage reference from an **LV** source then **LV** settings shall be applied. Except where a private none standard LV network exists, in this case the settings shall be calculated from **HV** settings values as indicated by paragraph 10.5.14;
- If the EREC G99 protection takes its voltage reference from an **HV** source then **HV** settings shall be applied.

†A value of 230V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network**

‡A value to suit the nominal voltage of the **HV** system connection point.

* Might need to be reduced if auto-reclose times are <3s. (see paragraph 10.1.7).

Intertripping may be considered as an alternative to the use of a LoM relay

$ For voltages greater than 230V +19% which are present for periods of<0.5s the **Power Generating Module** is permitted to reduce/cease exporting in order to protect the **Power Generating Module**.

(2) LOM constants

K1 = 1.0 (for low impedance networks) or 1.66 – 2.0 (for high impedance networks)

The LoM function shall be verified by confirming that the LoM tests specified in section 13.8 have been completed successfully

(3) Note that the times in the table are the time delays to be set on the appropriate relays. Total protection operating time from condition initiation to circuit breaker opening will be of the order of 100ms longer than the time delay settings in the above table with most circuit breakers, slower operation is acceptable in some cases.

The **Manufacturer** must ensure that the **Interface Protection** in a **Type Tested Power Generating Module** is capable of measuring voltage to an accuracy of ±1.5% of the nominal value and of measuring frequency to ± 0.2% of the nominal value across its operating range of voltage, frequency and temperature.

10.5.7.2 Settings for Infrequent Short-Term Parallel Operation

Prot Function	Type A and B **Power Generating Facility**			
	LV Protection		**HV** Protection	
	Setting	Time	Setting	Time
U/V	Vφ-n† -10% = 207V	0.5s	Vφ-φ‡ -6%	0.5s
O/V	Vφ-n† + 14% = 262.2V	0.5s	Vφ-φ‡ + 6%	0.5s
U/F	49.5Hz	0.5s	49.5Hz	0.5s
O/F	50.5Hz	0.5s	50.5Hz	0.5s

†A value of 230V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network**

‡A value to suit the voltage of the **HV** system connection point.

10.5.8 Over and Under voltage protection must operate independently for all three phases in all cases.

10.5.9 The settings in 10.5.7.1 should generally be applied to all **Power Generating Module**. In exceptional circumstances **Generators** have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Power Generating Module** may become unstable or suffer damage with the settings specified in 10.5.7.1. The agreed settings should be recorded in the **Connection Agreement**.

10.5.10 Once the settings and Operating Values of relays have been agreed between the **Generator** and the **DNO** they must not be altered without the written agreement of the **DNO**. Any revised settings should be recorded again in the amended **Connection Agreement.**

10.5.11 The under/over voltage and frequency protection may be duplicated to protect the **Power Generating Module** when operating in island mode although different settings may be required.

10.5.12 For **LV** connected **Power Generating Module** the voltage settings will be based on the 230V nominal system voltage. In some cases **Power Generating Module** may be connected to **LV systems** with non-standard operating voltages. Section 10.5.14 details how suitable settings can be calculated based upon the **HV** connected settings in table 10.5.7.1. Note that **Power Generating Modules** with non-standard **LV** protection settings need to be agreed by the **DNO** on a case by case basis.

10.5.13 Where an installation contains power factor correction equipment which has a variable susceptance controlled to meet the reactive power demands, the probability of sustained generation is increased. For **LV** installations, additional protective equipment provided by the **Generator**, is required as in the case of self-excited asynchronous machines.

10.5.14 Non-Standard private LV networks calculation of appropriate protection settings

The standard over and under voltage settings for **LV** connected **Power Generating Modules** have been developed based on a nominal **LV** voltage of 230V. Typical **DNO** practice is to purchase transformers with a transformer winding ratio of 11000:433, with off load tap changers allowing the nominal winding ratio to be changed over a range of plus or minus 5% and with delta connected **HV** windings. Where a **DNO** provides a connection at **HV** and the **Customer** uses transformers of the same nominal winding ratio and with the same tap selection as the **DNO** then the standard **LV** settings in table 10.5.7.1 can be used for **Power Generating Modules** connected to the **Customer's LV** network. Where a **DNO** provides a connection at **HV** and the **Customer's** transformers have different nominal winding ratios, and he chooses to take the protection reference measurements from the **LV** side of the transformer, then the **LV** settings stated in table 10.5.7.1 should not be used without the prior agreement of the **DNO**. Where the **DNO** does not consider the standard **LV** settings to be suitable, the following method shall be used to calculate the required **LV** settings based on the **HV** settings for Type A and B **Power Generating Facilities** stated in table 10.5.7.1.

Identify the value of the transformers nominal winding ratio and if using other than the nominal tap, increase or decrease this value to establish a **LV** system nominal value based on the transformer winding ratio and tap position and the **DNOs** declared **HV** system nominal voltage.

For example a **Customer** is using an 11,000V to 230/400V transformer and it is proposed to operate it on tap 1 representing an increase in the high voltage winding of +5% and the nominal HV voltage is 11,000V.

$V_{LVsys} = V_{LVnom} \times V_{HVnom}/V_{HVtap}$

V_{LVsys} = 230 x 11000/11550 = 219V

Where:

V_{LVsys} – LV system voltage

V_{LVnom} - LV system nominal voltage (230V)

V_{HVnom} - HV system nominal voltage (11,000V)

V_{HVtap} – HV tap position

The revised **LV** voltage settings required therefore would be;

OV stage 1 = 219x1.1 = 241V

OV stage 2 = 219x1.13 = 247.5V

UV = 219x0.8 = 175V

The time delays required for each stage are as stated in table 10.5.7.1.

Where **Power Generating Modules** are designed with balanced 3 phase outputs and no neutral is required then phase to phase voltages can be used instead of phase to neutral voltages.

This approach should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G99 would allow the **Power Generating Module** to be **Type Tested**, the **Manufacturer** may produce a declaration in a similar format to section 13.1 for presentation to the **DNO** by the **Installer**, stating that all **Power Generating Modules** produced for a particular **Power Generating Facility** comply with the revised over and under voltage settings. All other required data should be provided as for **Type Tested Power Generating Modules**. This declaration should make reference to a particular **Power Generating Facility** and its declared **LV System** voltage. These documents should not be registered on the ENA web site as they will not be of use to other **Installers** who will have to consult with the **Manufacturer** and **DNO** to agree settings for each particular **Power Generating Facility**.

10.5.15 The **Generator** shall provide a means of displaying the protection settings so that they can be inspected if required by the **DNO** to confirm that the correct settings have been applied. The **Manufacturer** needs to establish a secure way of displaying the settings in one of the following ways:

a) A display on a screen which can be read;
b) A display on an electronic device which can communicate with the **Power Generating Module** and confirm that it is the correct device by means of a Identification number / name permanently fixed to the device and visible on the electronic device screen at the same time as the settings;
c) Display of all settings including nominal voltage and current outputs, alongside the identification number / name of the device, permanently fixed to the **Power Generating Module**.

The provision of loose documents, documents attached by cable ties etc., a statement that the device conforms with a standard, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.

10.5.16 The protection arrangements (including changes to protection arrangements) for individual schemes will be agreed between the **Generator** and the **DNO** in accordance with this document.

The protection schemes and settings for internal electrical faults must not jeopardise the performance of a **power generating module**, in line with the requirements set out in this **EREC**. Electrical protection of the **power generating module** shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the **power generating module**.

10.5.17 The **Generator** shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest) for **power generating modules** with a **maximum capacity** of more than 1 MW (Type B and up):

(i) network and **power generating module** protection;

(ii) **synthetic inertia**, if applicable;

(iii) **frequency control** (**active power** adjustment);

(iv) power restriction; and

(v) power gradient constraint.

10.5.18 With regard to information exchange:

(i) Power Generating Facilities shall be capable of exchanging information with the relevant system operator and/or the TSO in real time or periodically with time stamping, as specified by the relevant system operator or the TSO;

(ii) the relevant system operator, in coordination with the TSO, shall specify the content of information exchanges including a precise list of data to be provided by the Power Generating Facility.

Annex 4 - Full G/99 Proposed Drafting

G99 Complied Draft
August 2016 v1.pdf

Annex 5 - References

[1] – GC0062 Fault Ride Through Consultation available at:- http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=45284

[2] - H/04- Changes to Incorporate New Generation Technologies and DC Inter-connectors (Generic Provisions):- available at:- http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=13419

[3] - ENTSO-E- Frequently asked questions document :- available at:_ https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/Network_Code_RfG/120626_-_NC_RfG_-_Frequently_Asked_Questions.pdf

[4] – RTE Documentation technique de reference, Article 4.3 – Stabilité, Installation raccordée au réseau d'interconnexion: http://clients.rte france.com/htm/fr/mediatheque/telecharge/reftech/01-09-14_complet.pdf available at:-https://clients.rte-france.com/htm/fr/mediatheque/telecharge/reftech/01-09-14_complet.pdf

[5] GC0035 - Frequency Changes during Large Disturbances and their effect on the total system - Phase – available at:- 1http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0035-GC0079/

Draft (work in progress) Engineering Recommendation G99 August 2016

To incorporate the EU Network Code Requirement for Generators (RfG) with existing GB documentation a number of new Engineering Recommendations are being drafted.

- G98-1 covers the connection procedure and technical requirements for Type Tested Generating Units up to 16 A per phase which are referred to as Micro-generators. (G83/2 single premises)
- G98-2 covers the connection procedure and technical requirements for (1) multiple Type Tested Micro-generating Plants in a Close Geographic Region and connected at Low Voltage and (2) Type Tested Generating Units above 16 A per phase but with a maximum capacity less than 50 kW. (G83/2 multiple premises and G59/3 <50kW).
- G99 covers the connection procedure and technical requirements for all non-Type Tested Generating Units that G59/3 covers at present.

The aim of this G99 document initially is to identify the sections that apply to non TT units, Type A and Type B Gens. It is intended to refer Type C and D generators to the Grid Code, work to fully consider this has yet to commence. As a consequence this present draft document has reference to small, medium and large power generating modules, which will be replaced with Types A, B, C, D as appropriate.

Definitions are listed first in this draft, but will be appropriately placed in the Terms and Definitions Section of the final document.

Some of the RfG requirements have yet to be fully drafted in conjunction with WG0048 and [ ] are used where parameters require finalising.

Purple text = from G59
Brown/Orange text = from RfG (June 2015)
Green text = from other EU documents referenced by RfG
Blue text = from Distribution Code
Black text = Changes/ additional words
Red text = Words that may/ will need changing

Term	Definition
Active Power	The product of voltage and the in-phase component of alternating current measured in units of watts, normally measured in kilowatts (kW) or megawatts (MW).
Apparatus	All Equipment in which electrical conductors are used, supported or of which they may form a part. [*needed for Plant*]
Apparent Power	The product of voltage and of alternating current measured in units of voltamperes and standard multiples thereof, ie: 1000 VA = 1 kVA 1000 kVA = 1 MVA
Authorised Certifier	An entity that issues **equipment certificate**s and **power generating module** documents and whose accreditation is given by the national affiliate of the European cooperation for Accreditation ('EA'), established in accordance with Regulation (EC) No 765/2008
Authority	The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000 The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000.
Automatic voltage regulator (AVR)	The continuously acting automatic equipment controlling the terminal voltage of a synchronous **power generating module** by comparing the actual terminal voltage with a reference value and controlling the output of an **excitation control system**

Black Start Capability	The capability of recovery of a **power generating module** from a total shutdown through a dedicated auxiliary power source without any electrical energy supply external to the **power generating facility**.
Connection Agreement	A contract between the **Distribution Network Operator** and the **User**, which includes the relevant site and specific technical requirements for the **Power Generating Facility**.
Connection Point	The interface at which the **Generating Unit** or demand facility is connected to a **Distribution Network**, as identified in the **connection agreement**.
Customer	**A** wholesale or final **customer** of electricity
Customer's Installation	The electrical installation on the **Customer**'s side of the supply terminals together with any equipment permanently connected or intended to be permanently connected thereto.
Direct Current or DC	The movement of electrical current flows in one constant direction, as opposed to Alternating Current or AC, in which the current constantly reverses direction.
Distribution Code	A code required to be prepared by a DNO pursuant to Standard Licence Condition 21 (Distribution Code) of a Distribution Licence and approved by the Authority as revised from time to time with the approval of, or by the direction of, the Authority.
Distribution Code Review Panel or Panel	The standing body established under the Distribution Code.
Distribution Licence	A distribution licence granted under Section 6(1)(c) of the Act.
Distribution Network	An electrical network, [including closed distribution networks], for the distribution of electrical power from and to third party[s] connected to it, a transmission or another Distribution Network.
Distribution Network Operator (DNO)	The person or legal entity named in Part 1 of a distribution licence and any permitted legal assigns or successors in title of the named party. A distribution licence is granted under Section 6(1)(c) of the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004).
Droop	The ratio of the steady-state change of **frequency**, referred to as nominal **frequency**, to the steady-state change in **active power** output, referred to as **maximum capacity**, expressed in percentage terms
DNOs Distribution Network	The **system** consisting (wholly or mainly) of electric lines owned or operated by the **DNO** and used for the distribution of electricity
Entry Point	The point at which a **User** connects to the **DNO's Distribution System** where power flows into the **DNO's Distribution System** under normal circumstances.
Equipment Certificate	A document issued by an **authorised certifier** for equipment used by a **power generating module**. The **equipment certificate** defines the scope of its validity at a national or other level at which a specific value is selected from the range allowed at a European level. For the purpose of replacing specific parts of the compliance process, the **equipment certificate** may include models that have been verified against actual test results
Excitation Control System	A feedback control system that includes the synchronous machine and its excitation system
Fault-ride Through	The capability of electrical devices to be able to remain connected to the **network** and operate through periods of low voltage at the **connection point** caused by secured faults
Frequency	The electric **frequency** of the **system** expressed in hertz that can be measured in all parts of the synchronous area under the assumption of a consistent value for the **system** in the time frame of seconds, with only minor differences between different measurement locations. It's nominal value is 50Hz.
Frequency Control	The capability of a **power generating module** to adjust its **active power** output in response to a measured deviation of system **frequency** from a **setpoint**, in order to maintain stable system **frequency**
Generating Unit	An indivisible set of installations which can generate electrical energy running independently and which can feed this energy into a **Distribution Network**.
Generator	A person who generates electricity under licence or exemption under the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act

	2004) or the Electricity (Northern Ireland) Order 1992 and whose Generating **Plant** is directly or indirectly connected to a **Distribution Network**. For avoidance of doubt, also covers any competent person or agent working on behalf of the **Generator**. Often referred to as a distributed or Embedded Generator. Also for the avoidance of doubt any **Customer** with generation connected to that **Customer's Installation** is a **Generator**.
Great Britain or GB	*The landmass of England & Wales and Scotland, including internal waters. USED IN RELATION TO SMALL < MED AND LARGE MAY NOT BE NEEDED*
Grid Code	The code which the **NETSO** is required to prepare under its Transmission Licence and have approved by the **Authority** as from time to time revised with the approval of, or by the direction of, the **Authority**.
High Voltage (HV)	A voltage exceeding 1000V AC or 1500V DC between conductors, or 600V AC or 900V DC between conductors and earth.
Installation document	A simple structured document containing information about a Type A **power generating module** and confirming its compliance with the relevant requirements.
Installer	A person who carries out the installation of **Generating Unit(s)** on behalf of a **Power Generating Facility Owner** and who carries out some of the functions required of a **Power Generating Facility Owner** during the installation and commissioning phases of a **Power Generating Facility**.
Instruction	Any command, within its authority, given by a **network operator** to a **power generating facility owner** in order to perform an action
Interface Protection	The electrical protection required to ensure that any **Generating Unit** is disconnected for any event that could impair the integrity or degrade the safety of the **Distribution Network.** The **interface protection** is typically not installed at the interface between the **DNO** and **Customer**'s **network**.
Inertia	The property of a rotating rigid body, such as an alternator, such that it maintains its state of uniform rotational motion and angular momentum unless an external torque is applied;
Limited Frequency Sensitive Mode - overfrequency (LFSM-O)	A **Micro-generator** operating mode which will result in **active power** output reduction in response to a change in **system frequency** above a certain value. In **GB** this value is 50.4Hz.
Low Voltage or LV	A voltage normally exceeding extra-low voltage (50V) but not exceeding 1000V AC or 1500V **DC** between conductors or 600V AC or 900V **DC** between conductors and earth.
Manufacturer	A person or organisation that manufactures **Power Generating Modules**
Maximum capacity	The maximum continuous **active power** which a **Micro-generator** can feed into the **network** as defined in the **connection agreement** or as agreed between the **DNO** and the **User**.
Minimum Regulating Level	The minimum **active power**, as defined in the **connection agreement** or as agreed between the relevant **network operator** and the **power generating facility owner**, down to which the **power generating module** can regulate
NETSO	National Grid Electricity Transmission (NGET) in its capacity as operator of the National Transmission System.
Network	A plant and apparatus connected together in order to transmit or distribute electricity.
Network Operator	The natural or legal person that operates a **network** and can be either a transmission system operator or a **Distribution Network Operator.**
Plant	Fixed and movable items used in the generation and/or supply and/or transmission of electricity other than Apparatus.
Point of Common Coupling	The point on a **Distribution Network**, electrically nearest the **Customer's Installation**, at which other **Customers** are, or may be, connected.
Point of Supply	The point of electrical connection between the apparatus owned by the **DNO** and the **User**.

Power Generating Module	Either a **synchronous power generating module** or a **power park module**;
Power Generating Facility	A facility that converts primary energy into electrical energy and which consists of one or more **power generating module**s connected to a **network** at one or more **connection point**s and may reasonably be considered as being managed as one **Power Generating Facility;**
Power Park Module (PPM)	A unit or ensemble of units generating electricity, which is either non-synchronously connected to the network or connected through power electronics, and that also has a single **connection point** to a transmission network, **distribution network**, closed distribution system or HVDC system
Power System Stabiliser (PSS)	An additional functionality of the AVR of a **synchronous power generating module** whose purpose is to damp power oscillations
Protection	The provisions for detecting abnormal conditions in a **System** and initiating fault clearance or actuating signals or indications.
Pump-Storage	A hydro unit in which water can be raised by means of pumps and stored to be used for the generation of electrical energy
Reactive Power	The imaginary component of the **apparent power** at fundamental **frequency**, usually expressed in kilovar ('kVAr') or megavar ('MVAr')
Setpoint	The target value for any parameter typically used in control schemes
Statement of Compliance	A document provided by the **power generating facility owner**, ***distribution system operator*** to the system operator stating the current status of compliance with the relevant specifications and requirements;
Step Voltage Change	Following system switching, a fault or a planned outage, the change from the initial voltage level to the resulting voltage level after all the **Generating Unit** automatic voltage regulator (AVR) and static VAR compensator (SVC) actions, and transient decay (typically 5 seconds after the fault clearance or system switching have taken place), but before any other automatic or manual tap-changing and switching actions have commenced.
Supplier	(a) A person supplying electricity under an Electricity Supply Licence; or (b) A person supplying electricity under exemption under the Electricity Act 1989 (as amended including by the Utilities Act 2000 and the Energy Act 2004)**;** in each case acting in its capacity as a **Supplier** of electricity to **Customers**.
Synthetic Inertia	The facility provided by a **power park module** to replace the effect of **inertia** of a **synchronous power generating module** to a prescribed level of performance
System	An electrical **network** running at various voltages.
System Stability	The ability of the **System,** for a given initial operating condition, to regain a state of operating equilibrium, after being subjected to a given system disturbance, with most **System** variables within acceptable limits so that practically the whole **System** remains intact.
Synchronous Compensation Operation	The operation of an alternator without prime mover to regulate voltage dynamically by production or absorption of reactive power
Synchronous Power Generating Module	An indivisible set of installations which can generate electrical energy such that the **frequency** of the generated voltage, the generator speed and the **network** voltage are in a constant ratio and thus in **synchronism**
Synchronism	The condition under which a **Power Generating Unit** or **System** is connected to another **System** so that the frequencies, voltage and phase relationships of that **Power Generating Unit** or **System**, as the case may be, and the **System** to which it is connected are similar within acceptable tolerances.
Total System	The integrated **System** of connected **Generating Unit**, Transmission System, **Distribution Networks** and associated electrical demand.
Transmission Licence	The licence granted under Section 6(1)(b) of the Electricity Act 1989 (as amended including by the Utilities Act 2000 and the Energy Act 2004)
Transmission System	A system of **High Voltage** lines and plant owned by the holder of a **Transmission Licence** and operated by the **NETSO**, which interconnects **Power Generating Facilities** and substations.

Transmission System Operator (TSO)	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other power systems, and for ensuring the long-term ability of the power system to meet reasonable demands for the transmission of electricity. CENELEC 50549-1
Type Tested	A **Micro-generator or Generating Unit** design which has been tested by an organization accredited in accordance with EC Regulation No 765/2008 to ensure that the design meets the requirements of this EREC G98-2, and for which the **Manufacturer** has declared that all products supplied will be constructed to the same standards, and with the same protection settings as the tested product.
User	The person with responsibility for the premises in which the **Generating Unit** is installed, normally referred to in other documentation as the **customer** / consumer / **network user**.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
	A3 (1), A4 (2a), covered		**Foreword** This Engineering Recommendation (EREC) is published by the Energy Networks Association (ENA) and comes into effect on x/x/xx for **Power Generating Modules** first installed on or after that date. It has been prepared and approved for publication under the authority of the **Great Britain Distribution Code Review Panel**. The approved abbreviated title of this engineering document is "EREC G99".	Y	Y	
1 1.1 1.2 1.3		1	**1 Purpose** 1.1 The purpose of this Engineering Recommendation (EREC) is to provide guidance on the connection of **Power Generating Facilities** to the **Distribution Networks** of licensed **Distribution Network Operators (DNOs)**. It is intended to address all aspects of the connection process from standards of functionality to site commissioning, such that **Customers, Manufacturers** and **Generators** are aware of the requirements that will be made by the local **DNO** before the **Power Generating Facility** will be accepted for connection to the **Distribution Network**. 1.2 The guidance given is designed to facilitate the connection of **Power Generating Module**(s) whilst maintaining the integrity of the **Distribution Network**, both in terms of safety and supply quality. It applies to all **Power Generating Module**(s) within the scope of Section 2, irrespective of the type of electrical machine and equipment used to convert any primary energy source into electrical energy. 1.3 This EREC is intended to provide guidance to **Generators** and **DNOs**. The mandatory requirements governing the connection of Distributed **Power Generating Modules** are generally set out in this document and in the Connection Conditions (CC) of the **Grid Code**. In the event of any conflict with this EREC, the provisions of the **Distribution Code** and **Grid Code** will prevail.	Y	Y	. DPC7 is currently dispersed amongst sections 8, 9 and 10 in this draft.
2		2	**2 Scope**			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
2.1		2.1	2.1 This EREC provides guidance on the technical requirements for the connection of **Power Generating Module**s to the **Distribution Networks** of licensed **DNO**s at < 110 kV with a **maximum capacity** of less than 50 MW (Type A and B). For the purposes of this EREC, a **Power Generating Module** is any source of electrical energy, irrespective of the prime mover and **Power Generating Module** type. This EREC applies to all **Power Generating Module**s connected at <110kV which is not in the scope of EREC G98 or is not compliant with EREC G98 requirements.	Y	Y	Text relating to TT removed 50MW to be confirmed once banding is agreed
2.2		2.2	2.2 This EREC does not provide advice for the design, specification, protection or operation of **Power Generating Module**s themselves. These matters are for the **Generator** to determine.			
2.3		2.3	2.3 Specific separate requirements apply to **Power Generating Facilities** comprising **Type Tested Power Generating Module**s less than or equal to 16A per phase or Type Tested **Generating Units** that are greater than 16A per phase but where the aggregate rated capacity is less than or equal to 50kW 3 phase (or 17 kW 1 phase) and these are covered in EREC G98. However, **Power Generating Module**s ≤16A per phase or where the aggregate rated capacity is less than or equal to 50kW 3 phase (or 17 kW 1 phase) that have not been **Type Tested** in accordance with EREC G98 should comply with the requirements set out in this document. Section 6 of this document provides more guidance on how to apply this document to **Power Generating Module**s that are below the 16A threshold but do not meet the requirements of EREC G98.			Reference to G98 annexes removed as included in EN 50438 Discussion: Do we need to maintain the 50kW limit?

New doc	RfG	G59	G59	<1MW	<50MW	Comments
2.4	A3 (2d) covered	2.4	2.4 The connection of mobile generation owned by the **DNO**, EREC G98 compliant **Power Generating Module**s, storage devices (except for **pump-storage power generating modules**), Offshore **power generating modules** or offshore **Transmission System**s containing generation are outside the scope of this Engineering Recommendation.			Offshore PGM not included for this draft. Discussion: Are these documents to include Storage devices?
2.5		2.5	2.5 This document applies to systems where the **Power Generating Facility** can be paralleled with a **Distribution Network** or where either the **Power Generating Facility** or a **Distribution Network** with a **Power Generating Facility** connected can be used as an alternative source of energy to supply the same electrical load.			
2.6		2.6	2.6 The generic requirements for all types of **Power Generating Facilities** within the scope of this document relate to the connection design requirements, connection application and notification process including confirmation of commissioning. The document does not attempt to describe in detail the overall process of connection from application, through agreement, construction and commissioning. It is recommended that the ENA publication entitled – "*Distributed Generation Connection Guide*" is consulted for more general guidance.			
2.7		2.7	2.7 **Power Generating Facilities** considered as **Medium and Large Power Generating Facilities** in **GB** are, in addition to the general requirements of this EREC, bound by the requirements of the **Grid Code**. In the case of **Large Power Generating Facilities**, the **Grid Code** will generally apply in full. For **Medium Power Generating Facilities**, only a subset of the **Grid Code** applies directly, and the relevant clauses are contained in this document (section 9.14).			Check once banding agreed, expect this can be removed

New doc	RfG	G59	G59	<1MW	<50MW	Comments
2.8		2.8	2.8 This EREC is written principally from the point of view of the requirements in **Great Britain**. There are some differences in the requirements in **Great Britain** and Northern Ireland, which are reflected in the separate Grid Codes for **Great Britain** and Northern Ireland, and the separate **Distribution Code** for Northern Ireland. These documents should be consulted where necessary, noting that the numbering of sections within these documents is not necessarily the same as in the **Distribution Code** for **Great Britain** and the **Grid Code** for **Great Britain**.			Check once clear on NIE direction. Note - they have different banding thresholds
2.9		2.9	2.9 The separate synchronous network operating in the Shetland Isles has specific technical challenges which are different to those of the **Great Britain** synchronous network. This EREC is not in itself sufficient to deal with these issues			
2.10	A6 (2)		**Pump-storage power generating modules** shall fulfil all the relevant requirements in both generating and pumping operation mode. **Synchronous compensation operation** of **pump-storage power generating modules** shall not be limited in time by the technical design of **power generating modules**. **Pump-storage** variable speed **power generating modules** shall fulfil the requirements applicable to **synchronous power generating modules** as well as those set out in Section 9.8.2 if they are going to be connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of more than 1 MW (Type B and up)			A20 (2) is included at the end of system stability under a new heading "Robustness". Consider transferring the tech refs here to another section/appendix

New doc	RfG	G59	G59	<1MW	<50MW	Comments
2.11	A6 (4)		Except for **Limited Frequency Sensitive Mode – Overfrequency** and the requirements under section CC 6.3.3 of the Grid Code relating to admissible **active power** reduction or where otherwise stated in the national framework, requirements of this EREC G99 relating to the capability to maintain constant **active power output** or to modulate **active power output** shall not apply to **power generating modules** of facilities for combined heat and power production embedded in the networks of industrial sites, where all of the following criteria are met: (a) the primary purpose of those facilities is to produce heat for production processes of the industrial site concerned; (b) heat and power generating is inextricably interlinked, that is to say any change of heat generation results inadvertently in a change of **active power** generating and vice versa;			All the PGM covered in this doc are A and B so point (c) is irrelevant
2.12	A6 (5)		Combined heat and power generating facilities shall be assessed on the basis of their electrical **maximum capacity**.			
2.13	A66 (1) covered		For **Power Generating Module** classified as emerging technology some clauses of this EREC G99 shall not apply. Details of emerging technology and their requirements are given in Appendix 13.X.			A list of the clauses to not be included will need to be included in an appendix. Review once emerging technology clear – may not need in this

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						document as well as G98
	A4 (2b)					The need for RfG A4 (2b) re applicability of docs and placing contracts is for discussion

New doc	RfG	G59	G59	<1MW	<50MW	Comments
3 3.1 3.2		3	**Normative references** The following referenced documents, in whole or part, are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. **3.1 <u>Statutory Requirements</u>** **Health and Safety at Work etc. Act (HASWA): 1974** The Health and Safety at Work etc. Act 1974 also referred to as HASAW or HSW, is the primary piece of legislation covering occupational health and safety in the United Kingdom. The Health and Safety Executive is responsible for enforcing the Act and a number of other Acts and Statutory Instruments relevant to the working environment. **Electricity Safety, Quality and Continuity Regulations (ESQCR): 2002** The Electricity Safety, Quality and Continuity Regulations 2002 (Amended 2006) - Statutory Instrument Number 2665 -HMSO ISBN 0-11-042920-6 abbreviated to ESQCR in this document. **Electricity at Work Regulations (EaWR): 1989** The Electricity at Work regulations 1989 abbreviated to EaWR in this document. **3.2 <u>Standards publications</u>** **BS 7671: 2008 Requirements for Electrical Installations** IEE Wiring Regulations: Seventeenth Edition. **BS 7430: 1999** Code of Practice for Earthing. **BS 7354**	Y	Y	

			Code of Practice for Design of Open Terminal Stations. **BS EN 61000 series*** Electromagnetic Compatibility (EMC). **BS EN 61508 series*** Functional safety of electrical/ electronic/ programmable electronic safety-related systems. **BS EN 60255 series*** Measuring relays and protection equipment. **BS EN 61810 series*** Electromechanical Elementary Relays. **BS EN 60947 series*** Low Voltage Switchgear and Controlgear. **BS EN 60044-1: 1999** Instrument Transformers. Current Transformers. **BS EN 60034-4:2008** Methods for determining synchronous machine quantities from tests. **BS EN 61400-12-1:2006** Wind turbines. Power performance measurements of electricity producing wind turbines. **IEC 60909 series*** Short-circuit currents in three-phase a.c. systems. Calculation of currents.			

			IEC TS 61000-6-5: 2001 Electromagnetic Immunity Part 6.5 Generic Standards. Immunity for Power Station and Substation Environments. **IEC 60364-7-712: 2002** Electrical installations of buildings – Special installations or locations – Solar photovoltaic (PV) power supply systems. **ENA Engineering Recommendation G5** Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution networks in the United Kingdom. **ENA Engineering Recommendation G74** Procedure to meet the requirements of IEC 909 for the calculation of short-circuit currents in three-phase AC power systems. **ENA Engineering Recommendation G83** Recommendations for connection of small-scale embedded Generators (up to 16 A per phase) in parallel with public low voltage distribution networks. ENA Engineering Recommendation G98 xxxx **ENA Engineering Recommendation P2** Security of Supply. **ENA Engineering Recommendation P18** Complexity of 132kV circuits.				

			ENA Engineering Recommendation P28 Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom. **ENA Engineering Recommendation P29** Planning limits for voltage unbalance in the UK for 132 kV and below. **ENA Technical Specification 41-24** Guidelines for the design, installation, testing and maintenance of main earthing systems in substations. **ENA Engineering Technical Report ETR 124** Guidelines for actively managing power flows associated with the connection of a single distributed generation plant. **ENA Engineering Technical report ETR 126** Guidelines for actively managing voltage levels associated with the connection of a single distributed generation plant. **ENA Engineering Technical report ETR 130** The application guide for assessing the capacity of networks containing distributed generation. * ***Where standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.***			
4		4	**2 Terms and definitions** For the purposes of this document, the following terms and definitions apply.	Y	Y	To be added later

			Note: Except where otherwise stated, the terms defined in this section shall have the same meaning as in the European Network Code Requirements for Generators, the **Grid Code** and the **Distribution Code**.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
5 5.1 5.2 5.3 5.4 5.5		5	**Legal Aspects** 5.1 The operation and design of the electricity system in **Great Britain** is defined principally by Directive 2009/72/EC, the Electricity Act (1989 as amended), the Electricity Safety Quality and Continuity Regulations (ESQCR) 2002, as well as general considerations under the Health and Safety at Work Act (HASWA) 1974 and the Electricity at Work Regulations (EaWR) 1989. A brief summary of the main statutory obligations on **DNO**s, **Generator**s and **Users** is included as Appendix 13.x. 5.2 Directive 2009/72/EC gives rise to a number of pieces of other EU law, the most relevant of which is Commission Regulation (EU) x/x, the Requirements for all Generators (RfG). This Code supersedes UK law, although it is not a complete set of requirements. This EREC has been written to comply fully with the requirements of the RfG, and to include other requirements required for connection to the GB power system. 5.3 Under section 21 of the Electricity Act, **Generator**s may be required to enter into a bespoke **Connection Agreement** with the **DNO**. Such a **Connection Agreement** will specify the terms and conditions including technical, operating, safety and other requirements under which **Power Generating Module**s are entitled to remain connected to the **Distribution Network**. It is usual to include site specific commercial issues, including recovery of costs associated with the connection, GDUoS (Generator Distribution Use of System) charges and the applicable energy loss adjustment factors, in **Connection Agreement**s. It is also common practice by some **DNO**s to collect the technical issues into a subordinate "Technical and Operating Agreement" which is given contractual force by the **Connection Agreement**. 5.4 **DNO**s are required by their licences to have in force and comply with the **Distribution Code**. **Generators** will be bound by their licences or by their **Connection Agreements**, or both, to comply with the **Distribution Code**. 5.5 In accordance with DPC5.4 of the **Distribution Code**, when details of the interface between a **Power Generating Facility** and the **Distribution Network** have been agreed a site responsibility schedule detailing ownership, maintenance, safety and control responsibilities will be drafted. The site responsibility schedule and operation drawing shall be displayed at the point of interconnection between the **DNO**'s and **Generator**'s systems, or as otherwise agreed.	Y	Y	New section to explain the impact of RfG DPC5 largely relates to load and is

New doc	RfG	G59	G59	<1MW	<50MW	Comments
5.6			5.6 The **DNO**s have statutory and licence obligations within which they have to offer the most economic, technically feasible option for connecting **Power Generating Facilities** to their **Distribution Network**s. The main general design obligations imposed on the **DNO**s are to: a. maintain supplies to their **Customers** within defined statutory voltage and frequency limits; b. ensure that the **Distribution Networks** at all voltage levels are adequately earthed; c. plan and develop their **Distribution Networks** to a standard not less than that set out in Engineering Recommendation P2 "Security of Supply" or EM7907 "Distribution Plannning Standards of voltage and security of supply" for the Scottish Hydro Electric Power Distribution Ltd licence area d. comply with the "Security of Supply" criteria defined in EREC P2; e. meet improving standards of supply in terms of customer minutes lost (CMLs) and the number of customer interruptions (CIs); f. facilitate competition in the connection, generation and supply of electricity.			suggested to be left in the DPC. .
5.7		5.6	5.7 Failure to meet any of the above obligations will incur legal or regulatory penalties. The first two criteria, amongst others, define the actions needed to allow islanded operation of the **Power Generating Facility** or to ensure that the **Power Generating Facility** is rapidly disconnected from the **Distribution Network** under islanded conditions. The next two criteria influence the type of connection that may be offered without jeopardising regulated standards.			
5.8		5.7	5.8 General conditions of supply to **Customer**s are also covered by Regulation 23 of the ESQCR 2002. Under Regulation 26 of the ESQCR 2002 no **DNO** is compelled to commence or continue a supply if the **Customer's Installation** may be dangerous or cause undue interference with the **Distribution Network** or the supply to other **Customer**s. The same regulation empowers the **DNO** to disconnect any part of the **Customer**'s **Installation** which does not comply with the requirements of Regulation 26. It should also be noted that each installation has to satisfy the requirements of the HASWA 1974 and the EaWR 1989.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
5.9	A3 (1)		5.9 The relevant **DNO** shall refuse to allow the connection of a **power generating module** which does not comply with the requirements set out in this EREC G99 and which is not covered by a derogation granted by the **Authority**.			
5.10		5.8	5.10 Regulations 21 and 22 of the ESQCR 2002 require installations that have alternative sources of energy to satisfy Regulation 21 in relation to switched alternative supplies, and Regulation 22 in the case of sources of energy running in parallel with the **Distribution Network**.			
5.11		5.9	5.11 Under Regulation 22 of the ESQCR 2002, no person may operate **Power Generating Modules** in parallel with a public **Distribution Network** without the agreement of the **DNO**.			
5.12		5.10	5.12 All **Generator**s have to comply with the appropriate parts of the ESQCR.			
		5.11				
5.13		5.12	5.13 It is important to note that both the **Distribution Code** and **Grid Code** use the terms **Large, Medium and Small** in relation to **Power Generating Facilities**. These terms are defined in the Codes and various parts of the Codes apply to different size **Power Generating Facilities**, with generally no **Grid Code** requirements applying to **Small Power Generating Facilities**. Any collection of **Power Generating Modules** under the control of one owner or operator in one installation is classed in the Codes as a **Power Generating Facility**.			Will need to review with NGET drafting
5.14		5.13	5.14 **Generators** with **Medium Power Generating Facilities** will have to comply with a few specific **Grid Code** clauses. The requirement for these clauses is contained in Section 9.14			This clause may not be needed in this document depending on banding thresholds

New doc	RfG	G59	G59	<1MW	<50MW	Comments
5.15		5.14	5.15 **Power Generating Facilities** that are to be connected to a **Distribution Network** and contain **Power Generating Module**s that trade in the wholesale market as Balancing Mechanism Units or have for other reasons become a party to the Balancing and Settlement Code and/or National Grid's Connection and Use of System Code, will then have to comply with the **Grid Code** requirements for **Power Generating Modules**.			For review with NGET
5.16		5.15	5.16 Information, which should assist **Generator**s wishing to connect to the **Distribution Network** at **High Voltage (HV)**, will be published by the **DNO** in accordance with condition 25 of the **Distribution Licence**. This is known as the Long Term Development Statement (LTDS). The general form and content of this statement is specified by Ofgem and covers the existing **Distribution Network** as well as authorised changes in future years on a rolling basis.			.
5.17		5.16	5.17 Under the terms of the Electricity Act 1989 (as amended), generation of electricity is a licensed activity, although the Secretary of State, may by order[1] grant exemptions. Broadly, generating stations of less than 50MW are automatically exempt from the need to hold a licence.			Subject to DECC review
		5.17	5			As per above clause no licence is required for Type A & B
5.18		5.18	5.18 **Generators** will need appropriate contracts in place for the purchase of any energy that is exported from the **Generator**s' **Power Generating Facilities**, and for any energy imported. For this purpose the **Generator** will need contracts with one or more **Supplier**s, and where the **Supplier** does not provide it, a meter operator agreement with the appropriate provider.			
5.19		5.19	5.19 **Generator**s wishing to trade ancillary services for National Grid purposes will need appropriate contracts in place with the National Grid Electricity Transmission in its role as **Great Britain** System Operator.			How likely it is that <50MW sets will be interested

[1] see http://www.opsi.gov.uk/si/si2001/20013270.htm

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						in these markets?

New doc	RfG	G59	G59	<1MW	<50MW	Comments
6 6.1		6	**Connection Application** **General** This document describes the processes that shall be adopted for both connection of single **Power Generating Modules** and installations that comprise of a number of **Power Generating Modules.** The process for the connection of single or multiple **Type Tested Power Generating Modules** in parallel with public Low Voltage Distribution Networks with an aggregate installed capacity of less than or equal to 16A per phase in a single premises is described in ERECG98-1. Those Power Generating Modules to be connected in parallel with a public Low Voltage Distribution Network with an aggregate rated capacity of less than 16A per phase in multiple premises or less than 17 kW single phase or 50 kW three phase, per customer installation, is described in EREC G98-2 The connection of other **Power Generating Modules** (ie **Power Generating Modules** outside the scope of EREC G98) is covered by this Engineering Recommendation. Where an installation comprises multiple asynchronous **Power Generating Modules** the application process and commissioning requirements should be based on the **Power Generating Facility** capacity (ie the aggregate capacity of all the asynchronous **Power Generating Modules** to be installed in any one installation), and whether the individual asynchronous **Power Generating Modules** are **Type Tested**. Where a new asynchronous **Power Generating Module** is to be connected to an existing installation then the table below will apply to the aggregate capacity of the complete installation irrespective of technology. Only the new **Power Generating Module** will be required to meet protection requirements of this Engineering Recommendation. Where an installation comprises multiple synchronous **Power Generating Modules** the application process and commissioning requirements should be based on the individual synchronous **Power Generating modules** capacity, and whether the individual synchronous **Power Generating Modules** are **Type Tested**.	Y	Y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Where a new synchronous **Power Generating Module** is to be connected to an existing installation then the table below will apply to the aggregate capacity of the complete installation irrespective of technology. Only the new **Power Generating Module** will be required to meet protection requirements of this Engineering Recommendation.			
6.1.1		6.1.1	6.1.1 The following table describes key differentiating features between **Power Generating Facility** capacity that influence the application, connection and commissioning process.	Y	Y	.

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>Power Generating Facility capacity
(as per the above clauses).</td><td>≤ 16A per phase (single premises)</td><td>≤ 16A per phase (multiple premises)
OR
≤ 50kW 3 phase
(or 17kW 1 phase)</td><td>All Capacities</td><td>All Capacities</td></tr>
<tr><td>Approval Status of individual Power Generating Modules</td><td>Type Tested Equipment and G98-1 compliant</td><td>Type Tested Equipment and G98-2 compliant</td><td>Type Tested Equipment but not G98-1 or G98-2 compliant</td><td>Not Type Tested Equipment</td></tr>
<tr><td>Consent required prior to connection. DNO to carry out impact assessment / electrical studies</td><td>NO (as G98-1)</td><td>YES (as G98-2)</td><td>YES (as G99)</td><td>YES (as G99)</td></tr>
<tr><td>Protection Requirements</td><td>As G98-1</td><td>As G98-2[1]</td><td>As G99</td><td>As G99</td></tr>
<tr><td>Commissioning Tests</td><td>As G98-1</td><td>As G98-2</td><td>As G99</td><td>As G99</td></tr>
<tr><td>Witness testing required by DNO</td><td>No[2]</td><td>As G98-2</td><td>At the discretion of the DNO[3]</td><td>YES – for HV, but at the discretion of the DNO for LV[4]</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>6.1.2</td><td></td><td>6.1.2</td><td>6.1.2 Power Generating Module(s) ≤ 16A per phase and EREC G98 compliant</td><td></td><td></td><td>Should be kept for clarity</td></tr>
</table>

[1] Note that some of the requirements only apply to generation that is >16A per phase but ≤ 50kW 3 phase (or 17kW 1 phase).

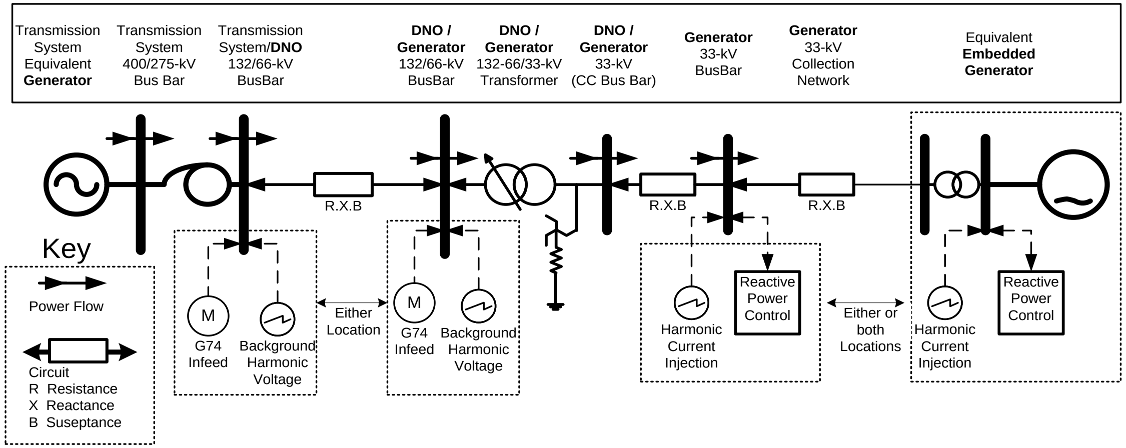
[2] **DNO**s may inspect selected installations, but without imposing a charge.

[3] The **DNO** shall charge the **Generator** for attendance of staff for witness testing at its own commercial rates.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			A connection procedure to facilitate the connection and operation of **Type Tested Power Generating Modules** with aggregate installed capacity of less than or equal to 16A per phase in parallel with public **Low Voltage Distribution Network** is given in EREC G98 and is not considered further in this document.			
6.1.3		6.1.3	6.1.3 **Power Generating Module(s) ≤ 16A per phase and not EREC G98 compliant** Where the **Power Generating Module** does not meet the requirements of EREC G98 because the **Power Generating Module** has not successfully been through the type testing process the connection process shall follow that for larger **Power Generating Modules** as described in this document.	Y	NOT >10MW	Should be kept for clarity
6.1.4		6.1.4	6.1.4 **Power Generating Module(s) > 16A per phase but ≤ 50kW 3 phase (or 17 kW 1 phase) and EREC G98 compliant.** A connection procedure to facilitate the connection and operation of **Type Tested Power Generating Modules** with aggregate installed capacity greater than 16 A per phase with an aggregate rated capacity of less than 17 kW per phase or 50 kW three phase, per customer installation, in parallel with public **Low Voltage Distribution Network** is given in EREC G98 and is not considered further in this document.			Should be kept for clarity and reference to G98 made. Words from 6.1.2 used as base.
6.1.5		6.1.5	6.1.5 **Power Generating Module(s)** not EREC G98 **Type Tested** or > than 50 kW 3 phase (or 17 kW 1 phase) The connection process for these **Power Generating Modules** is described in this document. When making a connection application for **Medium and Large Power Generating Facilities**, there are requirements that should be considered in addition to the general requirements identified in this document. **Medium and Large Power Generating Facilities** are bound by the requirements of the **Grid Code**. In the case of **Large Power Generating Facilities**, the **Grid Code** will generally apply in full. For **Medium Power Generating Facilities**, only a small subset of the **Grid Code** applies directly, and the relevant clauses are listed in DPC7 of the **Distribution Code**.	Y	Y	Needs review once banding and NGET approach to small , med and large decided

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Where **Grid Code** requirements apply, under the **Distribution Code** it is the **Generator**'s responsibility to comply with the **Grid Code** requirements.			
6.2		6.2	**Application for Connection**	Y	Y	TITLE ONLY
6.2.1		6.2.1	6.2.1 Information about the **Power Generating Module**(s) is needed by the **DNO** so that it can assess the effect that a **Power Generating Facility** may have on the **Distribution Network**. This document details the parameters to be supplied by a **User** wishing to connect **Power Generating Module(s)** that do not comply with EREC G98 to a **Distribution Network**. This document also enables the **DNO** to request more detailed information if required.			
6.2.2		6.2.2	6.2.2 Less than or equal to 16 A per phase and EREC G98 Compliant **Power Generating Module** The application process is described in EREC G98 and is not considered further in this document.			
6.2.3		6.2.3	6.2.3 Less than or equal to 16 A per phase and not EREC G98 compliant **Power Generating Module** The **Generator** should apply to the local **DNO** for connection using the **DNO**s standard application form (available from the **DNO**s website). On receipt of the application, the **DNO** will assess whether any **Distribution Network** studies are required and whether there is a requirement to witness the commissioning tests. In some cases studies to assess the impact on the **Distribution Network** may need to be undertaken before a firm quotation can be provided to the **Customer**. On acceptance of the quote, any works at the connection site and any associated facilitating works will need to be completed before the **Power Generating Module** can be commissioned. On successful completion of the commissioning tests, the **DNO** will sanction permanent energisation of the **Power Generating Module**.			
6.2.4		6.2.4	6.2.4 **Power Generating Facilities** >16A per phase but ≤ 50kW three phase (or 17kW single phase) and EREC G98 compliant, The application process is described in EREC G98 and is not considered further in this document			Words from 6.2.2 used as a base

New doc	RfG	G59	G59	<1MW	<50MW	Comments
6.2.5		6.2.5	6.2.5 **Power Generating Facilities** which include any non-**Type Tested Power Generating Modules** or any **Power Generating Facilities** > 50 kW three phase (or 17 kW single phase) The connection process is similar to that described in 6.2.3 above, although detailed system studies will almost certainly be required and consequently the **Generator** might need to provide additional information. The information should be provided using the standard application form (generally available from the **DNO**s website). The data that might be required is defined within this document			Currently DPC7 is dispersed in sections 8, 9 and 10. Suggestion is that DPC 8 will be transferred as a new section and DDRC schedules 5 transferred as appendix
6.3		6.3	**System Analysis for Connection Design**	Y	Y	TITLE ONLY
6.3.1		6.3.1	6.3.1 **DNO**s use a variety of modelling tools to undertake system analysis. Their exact needs for data and models will vary dependent on the voltage level, size, and location of the connection. Generally the **DNO** will seek the key information from the **Generator** via the application forms referred to in 6.2 above. Occasionally the **DNO** may also need additional data for modelling purposes and will seek this information in accordance with the requirements of this document.			
6.3.2		6.3.2	6.3.2 In the course of planning and designing a power system, it is often necessary to model a small section of the wider system in detail. This could be an embedded system at 132kV or less, which is connected to the **Transmission System** (400/275kV) via one or more step-down transformers.			
6.3.3		6.3.3	6.3.3 For plant connected at **HV**, it is generally necessary to build an equivalent model of the **Distribution Network**. An example is shown as Fig 6.1 below.			Revise diagram to remove 400/275 in

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			 Fig 6.1 Example equivalent **Total System** representation This model will typically include equivalent source representing existing **Power Generating Modules** fault level arising from asynchronous plant (EREC G74), interconnection impedances, loads, and possibly the **Generator**'s proposal for reactive compensation plant. The parameters of these elements will depend upon the selection of the boundary nodes between the equivalent and detailed networks in the model.			transmission reference
6.3.4		6.3.4	6.3.4 It may be beneficial to model some of the 'active' elements in full detail. Supergrid, grid primary and other transformers can be considered active for the purpose of determining voltage control limits. Knowledge of the voltage control set points, transformer tap changer deadbands, and control methods is often essential. Also a knowledge of which items of **Power Generating Modules** are mainly responsible for the range of fault contributions offered at the **connection point** by the **DNO** is a useful addition. Fault contribution may also arise from other rotating plant – shown here as an equivalent asynchronous motor (EREC G74).			
6.3.5		6.3.5	6.3.5 This equivalent **Total System** model will not accurately represent the fast dynamic (sub second) behaviour of the active elements within the Distribution and Transmission System.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
6.3.6		6.3.6	6.3.6 For synchronous machines, control systems for **Power Generating Module**s and prime movers have traditionally been provided and modelled in transparent transfer-function block diagram form. These models have been developed over many years and include lead/lag elements, gains, limiters and non-linear elements and may be tuned to obtain a satisfactory response for the particular **Power Generating Module** and grid connection. The requirement to submit models in this form for directly connected synchronous **Power Generating Module**s is written into the **Grid Code** and **this document**.			RfG only requires models to be submitted for Type C and D
6.3.7		6.3.7	6.3.7 For other generation technologies, the **Grid Code** includes the requirement to submit validated detailed models in respect of non-synchronous **Power Generating Module**s which are aggregated into a '**Power Park Module'** and where they are also classed as **Medium or Large Power Generating Facilities**.			Needs review once banding and NGET approach to small , med and large decided
6.3.8		6.3.8	6.3.8 This document has a similar requirement of the **Generator** where the **DNO deems** it necessary to ensure **System Stability** and security. The DDRC accepts models of both Synchronous/Asynchronous and Series Converter Connected **Power Generating Module**s.			
6.3.9		6.3.9	6.3.9 **DNO**s have a **Grid Code** obligation (CC 3.3) to ensure that validated detailed models are obtained in respect of **Medium Power Generating Facilities** embedded within their **Distribution Networks** unless they are connected at a voltage level below that of the lower voltage side of the relevant supergrid transformer. This requires the **Power Generating Module Manufacturer** to submit a **Power Generating Module** (Synchronous or Power Park) model in a format suitable for the **NETSO** usually in a documented block diagram format.			Possibly remove this clause once agreement on banding is reached.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
6.3.10		6.3.10	6.3.10 For the **DNO**s own purposes, should a model be required, it would normally be requested in a compiled form suitable for use with the particular variety of power system analysis software they use. Recently there is a move by **Manufacturer**s to create 'black-box' models of their **Power Generating Module**s. These are programmed for compatibility with industry standard power analysis modelling packages. This is in order to protect the **Manufacturer**s intellectual property and so lessen the need for confidentiality agreements between parties. There are potential advantages and disadvantages to this approach, but must be generally welcomed provided that the two main disadvantages of this approach, as described below, can be resolved: a. The model must not be software 'version' specific ie will work in all future versions, or has an assurance of future upgrades for a particular software package; b. The **Manufacturer** must provide assurance that the black box model correctly represents the performance of the **Power Generating Module** for load flow, fault level and transient analysis for the typical range of faults experienced by **DNO**s.			
6.4		DPC7.3	**Provision of Information** **Embedded Power Generating Facilities** can have a significant effect on the **DNO's Distribution Network** and as a result it's **Users**. To enable the **DNO** to assess the impact **Embedded Power Generating Modules** will have on the **DNO's Distribution Network,** the **Generator** will be required to supply information to the **DNO.** **Embedded Generator's** shall provide the following minimum information to the **DNO** during the connection application process or otherwise as requested by the **DNO**:- Relevant Sections: (a) **Power Generating Module** and site data for all **Embedded Power Generating Facilities** excluding the **OTSO.** — 6.4.1 and Schedule 5a of the DDRC (b) **Generation Set** data for all **Embedded Power Generating Modules** — 6.4.2 and Schedule 5b of the DDRC			Embedded Transmission System references deleted as not in scope Reference to subsequent DPC sections modified, DDRC location tbc

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(c) **Generation Set** data for specified types of **Embedded Power Generating Modules** — Schedules 5c of the DDRC 5c(i) Synchronous generators 5c(ii) Fixed speed induction generators 5c(iii) Double fed induction generators 5c(iv) Converter connected generators 5c(v) Transformers (d) **Generation Set** data for **Embedded Medium Power Generating Facilite**s — 6.4.3 and Schedules 5c of the DDRC When applying for connection to the **DNO's Distribution Network Embedded Power Generating Facilities** shall also refer to xxx. The **DNO** will use the information provided to model the **DNO's Distribution Network** and to decide what method of connection will need to be employed and the voltage level to which the connection should be made. If the **DNO** reasonably concludes that the nature of the proposed connection or changes to an existing connection requires more detailed consideration then further information may be requested. It is unlikely that more information than that specified in 6.4.1 will be required for **Embedded Power Generating Facilities** who are to be connected at **Low Voltage** and have less than 50kVA in capacity, or connected at other than **Low Voltage** and have less than 300kVA in capacity.			DPC 5 to be included in G99 in its entirety as a new section?
6.4.1		DPC7.3.1	**Information Required from all Embedded Power Generating Facilities** It will be necessary for each **Embedded Power Generating Facility** to provide to the **DNO** information on physical and electrical characteristics of the **Power Generating Facility** and site as a whole as set out in Schedule 5a of the **Distribution Data Registration Code** before entering into an agreement to connect any **Power Generating Module** onto the **DNO's Distribution Network:-** The information required includes:			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(a) Details of the proposed **connection point** (geographical and electrical) and connection voltage. (b) The number and types of **Power Generating Modules** and the total capacity of the **Power Generating Facility** and auxiliary supplies under various operating conditions. (c) Sketches of **System** Layout: **Operation Diagrams** showing the electrical circuitry of the existing and proposed main features within the **User's System** and showing as appropriate busbar arrangements, phasing arrangements, earthing arrangements, switching facilities and operating voltages. (d) Interface Arrangements (i) The means of synchronisation between the **DNO** and **User**; (ii) Details of arrangements for connecting with earth that part of the **Users System** directly connected to the **DNO's Distribution Network**. (iii) The means of connection and disconnection which are to be employed. (iv) Precautions to be taken to ensure the continuance of safe conditions should any earthed neutral point of the **Embedded Power Generating Facility's System** operated at **HV** become disconnected from earth. More or less detailed information than that contained above might need to be provided, subject to the type and size of generation or the point at which connection is to be made to the **DNO's Distribution Network**. This information will need to be provided by the **Embedded Power Generating Facility** at the reasonable request of the **DNO**.			
6.4.2		DPC7.3.2	**Additional Generation Set and Plant and Equipment Data Required from Embedded Power Generating Facilities.** The **Standard Planning Data** and **Detailed Planning Data** specified in Schedule 5b and Schedule 5c of the **Distribution Data Registration Code** may be requested by the **DNO** from the **User** before entering into an agreement to connect any **Power Generating Module** onto the **DNO's Distribution Network.**			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			The information specified in Schedule 5b of the **Distribution Data Registration Code** includes generic data for all **Embedded Generation Sets.** The information specified in Schedule 5c of the **Distribution Data Registration Code** includes the more detailed electrical parameters of individual **Generation Sets** and associated plant such as transformers, power factor correction equipment. The information required is classified as **Standard Planning Data** and **Detailed Planning Data** for each of the following categories of **Embedded Generation Module**: (i) Synchronous generators (ii) Fixed speed induction generators (iii) Doubly fed induction generators (iv) Series converter connected generators. (v) Transformers Under certain circumstances either more or less detailed information than that specified above might need to be provided and will be made available by the **Embedded Power Generating Facility** at the request of the **DNO.**			
6.4.3		DPC7.3.3	**Extra Information From Embedded Power Generating Facilities to be Provided to Meet Grid Code Requirements** (a) The **DNO** has an obligation under PC3.3 of the **Grid Code** to submit certain planning data relating to **Embedded Medium Power Generating Facilities** to **the TSO**. The relevant data requirements of the **Grid Code** are also listed in PC3.3 of the **Grid Code**. It is incumbent on **Embedded Medium Power Generating Facilities** to provide this data listed in PC3.3 of the **Grid Code** to the **DNO**. Where a **Generator** in respect of an **Embedded Power Generating Facility** is a party to the **CUSC** this DPC 7.3.3 will not apply. (b) In addition to supplying the **DNO** with details of **Embedded Power Generating Modules** there is a requirement to provide information to **the TSO** where it has been specifically requested by **the TSO** in the circumstances provided for under the **Grid Code**.			To be reviewed following NGET review of grid code

New doc	RfG	G59	G59	<1MW	<50MW	Comments
6.4.4		DPC7.3.4	**Information Provided by the DNO to Users** In accordance with Condition 4 and Condition 25 of its **Distribution Licence** the **DNO** is required to provide certain information to **Users** so that they have the opportunity to identify and evaluate opportunities to connect to the **DNO's Distribution Network** as set out in 9.1.9 and 9.1.10 Comprehensive information on the **DNO's Distribution Network** operating at 33kV and above is made available to **Users** through the Long Term Development Statements provided under Condition 25 of the **Distribution Licence.** Schedule 5d of the **Distribution Data Registration Code** is indicative of the type of network data the **DNOs** is required to provide to **Users** for identifying opportunities for connection of generation at voltages below 33kV. On the production of Schedule 5d data for a **User**, the **DNO** will update any relevant data that would otherwise be provided from the Long Term Development Statement.			This clause does not state any requirements, it is for info only. It could be removed

New doc	RfG	G59	G59	<1MW	<50MW	Comments
7 7.1		7	**CONNECTION ARRANGEMENTS** **Operating Modes** 7.1.1 **Power Generating Module** may be designed for one of three operating modes. These are termed long-term parallel operation, infrequent short-term parallel operation and switched alternative-only operation.	Y	Y	
7.2		7.2	**Long-Term Parallel Operation** 7.2.1 This refers to the frequent or long-term operation of **Power Generating Module** in parallel with the **Distribution Network**. Unless otherwise stated, all sections in this Engineering Recommendation are applicable to this mode of operation.	Y	Y	
7.3		7.3	**Infrequent Short-Term Parallel Operation**			
7.3.1		7.3.1	7.3.1 This mode of operation typically enables **Power Generating Module** to operate as a standby to the **DNO**s supply. A short-term parallel is required to maintain continuity of supply during changeover and to facilitate testing of the **Power Generating Module**.			
7.3.2		7.3.2	7.3.2 In this mode of operation, parallel operation of the **Power Generating Module** and the **Distribution Network** will be infrequent and brief and under such conditions, it is considered acceptable to relax certain design requirements, such as protection requirements, that would be applicable to long-term parallel operation.			
7.3.3	A3(2b)	7.3.3	7.3.3 As the design requirements for **Power Generating Module** operating in this mode are relaxed compared with those for long-term parallel operation, it is necessary for the **DNO** to specify a maximum frequency and duration of short-term parallel operation, to manage the risk associated with the relaxed design requirement. The **Power Generating Module** may be permitted to operate in parallel with the **DNO**s **Distribution Network** for no more than 5 minutes in any month, and no more frequently than once per week. Parallel operation during maintenance or commissioning tests of that **Power Generating Module** shall not count towards the five minute limit.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			If the duration of parallel connection exceeds this period, or this frequency, then the **Power Generating Module** must be considered as if it is, or can be, operated in Long-Term Parallel Operation mode. An alternative frequency and duration may be agreed between the **DNO** and the **Generator** taking account of particular site circumstances and **Power Generating Module** design. An electrical time interlock should be installed to ensure that the period of parallel operation does not exceed the agreed period. The timer should be a separate device from the changeover control system such that failure of the auto changeover system will not prevent the parallel being broken.			
7.3.4		7.3.4	7.3.4 The following design variations from those in the remainder of the document are appropriate for infrequent short-term parallel operation: a. Protection Requirements – Infrequent short-term parallel operation requires only under/over voltage and under/over frequency protection. This protection only needs to be in operation for the time the **Power Generating Module** is operating in parallel. A specific Loss of Mains (LoM) protection relay is not required, although many EREC G59/2 multifunction relays now have this function built in as standard. Similarly, additional requirements such as neutral voltage displacement, intertripping and reverse power are not required. This is based on the assumptions that as frequency and duration of paralleling during the year are such that the chance of a genuine LoM event coinciding with the parallel operation is unlikely. However, if a coincidence does occur, consideration must be given to the possibility of the **Power Generating Module** supporting an island of **Distribution Network** as under voltage or under frequency protection is only likely to disconnect the **Power Generating Module** if the load is greater than the **Power Generating Module** capacity. Consequently it is appropriate to apply different protection settings for short term parallel connection. As this **Power Generating Module** will not be expected to provide grid support or contribute to system security, more sensitive settings based on statutory limits would compensate for lack of LoM protection. Ultimately, if an island was established the situation would only persist for the duration of the parallel operation timer setting before generation was tripped. b. Connection with Earth – It is recommended that the **Power Generating Module**'s star points or neutrals are permanently connected to earth. In that way, the risks associated with switching are minimized and the undesirable effects of circulating currents and harmonics will be tolerable for the timescales associated with short-term paralleling.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			c. Fault Level – There is the need to consider the effect of the **Power Generating Module's** contribution to fault level. The risks associated with any overstressing during the short term paralleling will need to be individually assessed and the process for controlling this risk agreed with the **DNO**. d. Voltage rise / **Step Voltage Change** - Connections should be designed such that the operation of a **Power Generating Module** does not produce voltage rise in excess of statutory limits. In general this should not be an issue with most Short-Term Parallel Operation as at the time of synchronising with the mains most sites will normally be generating only sufficient output to match the site load. Therefore the power transfer on synchronising should be small, with the **Power Generating Module** ramping down to transfer site load to the mains. If the **Power Generating Module** tripped at this point it could introduce a larger **Step Voltage Change** than would normally be acceptable for loss of **Power Generating Module** operating under a long-term parallel arrangement but in this event it could be regarded as an infrequent event and a step change of up to 10% as explained in Section 9.5 would be acceptable. e. Out-of-phase capabilities - All newly installed switchgear should be specified for the duty it is to undertake. Where existing switchgear which might not have this capability is affected by short-term paralleling it is expected that it will not be warranted to replace it with gear specifically tested for out-of-phase duties, although the owner of each circuit breaker should specifically assess this. Clearly the synchronizing circuit breaker (owned by the **Generator**) must have this certified capability. For the avoidance of doubt it is a requirement of the Electricity at Work Regulations that "no electrical equipment shall be put into use where its strength and capability may be exceeded in such a way as may give rise to danger." Paragraph 9.4.6 below provides more information on the assessment of such situations.			
		7.3.5	7.3.5 Some manufacturers have developed fast acting automatic transfer switches. These are devices that only make a parallel connection for a very short period of time, typically 100 - 200ms. Under these conditions installing a conventional G59 protection with an operating time of 500ms is not appropriate when the parallel will normally be broken before the protection has a chance to operate. There is however the risk that the device will fail to operate correctly and therefore a timer should be installed to operate a conventional circuit breaker if the parallel remains on for more than 1s. The switch should be inhibited from making a transfer to the **DNO** network whilst voltage and frequency are outside expected limits.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
7.4 7.4.1		7.4	**7.4 Switched Alternative-Only Operation** 7.4.1 **General**			
7.4.1.1		7.4.1.1	7.4.1.1 Under this mode of operation it is not permissible to operate a **Power Generating Module** in parallel with the **Distribution Network**. Regulation 21 of the **ESQCR** states that it is the **Generator's** responsibility to ensure that all parts of the **Power Generating Module** have been disconnected from the **Distribution Network** and remain disconnected while the **Power Generating Module** is operational. The earthing, protection, instrumentation etc. for this mode of operation are the responsibility of the **Generator**, however where such **Power Generating Module** is to be installed, the **DNO** shall be given the opportunity to inspect the equipment and witness commissioning of any changeover equipment and interlocking.			
7.4.1.2		7.4.1.2	7.4.1.2 The changeover devices must be of a 'fail-safe' design so that one circuit controller cannot be closed if the other circuit controller in the changeover sequence is closed, even if the auxiliary supply to any electro-mechanical devices has failed. Changeover methods involving transfer of removable fuses or those having no integral means of preventing parallel connection with the **Distribution Network** are not acceptable. The equipment must not be installed in a manner which interferes with the **DNO**s cut-out, fusegear or circuit breaker installation, at the supply terminals or with any metering equipment.			
7.4.1.3		7.4.1.3	7.4.1.3 The direct operation of circuit-breakers or contactors must not result in the defeat of the interlocking system. For example, if a circuit-breaker can be closed mechanically, regardless of the state of any electrical interlocking, then it must have mechanical interlocking in addition to electrical interlocking. Where an automatic mains fail type of **Power Generating Module** is installed, a conspicuous warning notice should be displayed and securely fixed at the **Point of Supply**.			
7.4.1.4		7.4.1.4	7.4.1.4 The **Power Generating Facility** shall utilise an independent earth electrode from the **Distribution Network**.			
7.4.1.5		7.4.1.5	7.4.1.5 The switchgear that is used to separate the two **Systems** shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Facility**, from flowing into the **DNOs Distribution Network** when it operates as a switched alternative only supply			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
7.4.2		7.4.2	7.4.2 **Changeover Operated at HV**			
7.4.2.1		7.4.2.1	7.4.2.1 Where the changeover operates at **HV**, the following provisions may be considered by the **Generator** to meet the requirements of Regulation 21 of the **ESQCR**: a. An electrical interlock between the closing and tripping circuits of the changeover circuit breakers; b. A mechanical interlock between the operating mechanisms of the changeover circuit breakers; c. An electro-mechanical interlock in the mechanisms and in the control circuit of the changeover circuit breakers; d. Two separate contactors which are both mechanically and electrically interlocked. Electrically operated interlocking should meet the requirements of BS EN 61508.			
7.4.2.2			7.4.2.2 Although any one method may be considered to meet the minimum requirement, it is recommended that two methods of interlocking are used wherever possible. The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under **ESQCR**.			
7.4.3			7.4.3 **Changeover Operated at LV**			
7.4.3.1			7.4.3.1 Where the changeover operates at **LV**, the following provisions may be considered by the **Generator** to meet the requirements of Regulation 21 of the **ESQCR**: a. Manual break-before-make changeover switch; b. separate switches or fuse switches mechanically interlocked so that it is impossible for one to be moved when the other is in the closed position; c. An automatic break-before-make changeover contactor; d. Two separate contactors which are both mechanically and electrically interlocked;			

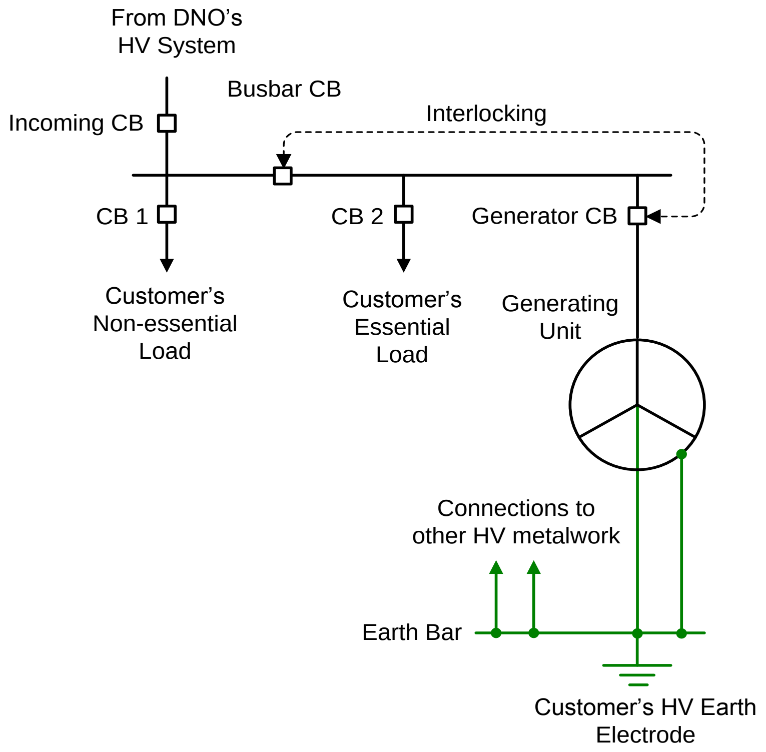
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			e. A system of locks with a single transferable key. Electrically operated interlocking should meet the requirements of BS EN 61508.			
7.4.3.2		7.4.3.2	7.4.3.2 The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under **ESQCR**.			
7.5		7.5	**7.5 Balance of Power Generating Module output at LV**			
7.5.1		7.5.1	7.5.1. EREC G98-1 allows the connection of **Type Tested Power Generating Modules** ≤16A per phase without consultation with the **DNO**. Connection of single phase **Type Tested Power Generating Modules** up to 17kW under EREC G98-2 is allowable, but this requires application to the **DNO** and may not be possible in many cases for technical reasons depending on point of connection and network design.			
7.5.2		7.5.2	7.5.2. A solution to these voltage issues and phase imbalance issues may be to utilise 3-phase **Power Generating Module**s (the same export power will result in lower voltage rises due to decreased line currents and a 3 phase connection will result in voltage rises of a sixth of those created by a single phase connection), or to use multiple single phase **Power Generating Module**s connected across three phases. If these individual **Power Generating Modules** are of differing ratings, current and voltage imbalance may occur. To maintain current and voltage imbalance within limits the **Installer** shall consider the phase that each **Power Generating Module** is connected to in an installation. In addition the **DNO** may define to an **Installer** the phases to which the **Power Generating Modules** in any given installation should be connected.			
7.5.3		7.5.3	7.5.3. An **Installer** should design an installation on a maximum unbalance output of 16A between the highest and lowest phase. Where there are a mixture of different technologies, or technologies which may be operational at different times (e.g.. wind and solar) **Power Generating Module**s shall be connected to give a total imbalance of less than 16A based on assumed worst case conditions, those being: a. One **Power Generating Module** at maximum output with the other(s) at zero output –all combinations to be considered. b. Both / all **Power Generating Modules** being at maximum output			

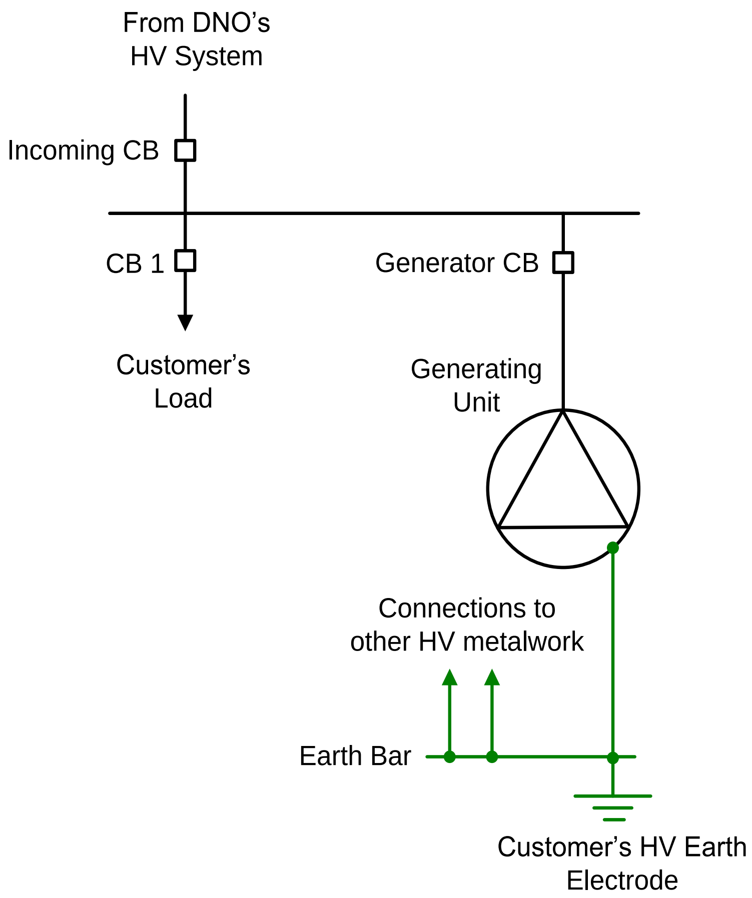
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			A **Power Generating Module** technology which operates at different times due to location e.g. east and west facing roofs for PV, must allow for the PV on one roof to be at full output and the PV on the other roof to be at zero output.			
7.5.4		7.5.4	7.5.4 In order to illustrate this requirement examples of acceptable and unacceptable connections have been given in Appendix 13.x.			
7.6		7.6	**7.6 Power Generating Module capacity for single and split LV phase supplies**			
7.6.1		7.6.1	7.6.1 The maximum aggregate capacity of **Generation Plant** that can be connected to a single phase supply is 17kW. The maximum aggregate capacity of **Generation Plant** that can be connected to a split single phase supply is 34kW.			
7.6.2		7.6.2	7.6.2 There is no requirement to provide intertripping between single phase inverters where these are installed on multi-phase supplies up to a limit of 17kW per phase (subject to balance of site output as per section 7.5). A single phase 17kW connection may result in an imbalance of up to 17kW following a **Distribution Network** or **Power Generating Module** outage. However the connection design should result in imbalance under normal operation to be below 16A between phases as noted above.			
7.6.3		7.6.3	7.6.3 **Power Generating Facilities** with a capacity above 17kW per phase are expected to comprise three phase units. The requirement to disconnect all phases following a fault in the **Customer's Installation** or a **Distribution Network** outage applies to three phase inverters only and will be tested as part of the type testing of the **Power Generating Module**. In some parts of the country where provision of three phase networks is costly then the **DNO** may be able to provide a solution using single or spilt phase networks for **Power Generating Facilities** above the normal limits as set out above.			
7.7		7.7	**7.7 Voltage Management Units in Customer's premises**			
7.7.1		7.7.1	7.7.1 Voltage Management Units are becoming more popular and use various methods, in most cases, to reduce the voltage supplied from the **DNO's Distribution Network** before it is used by the **Customer**. In some cases where the **DNO's Distribution Network** voltage is low they may increase the voltage supplied to the **Customer**. Some technologies are only designed to reduce voltage and cannot increase the voltage.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
7.7.2		7.7.2	7.7.2 The use of such equipment has the advantage to the **Customer** of running appliances at a lower voltage and in some cases this can reduce the energy consumption of the appliance. Some appliances when running at a lower voltage will result in higher current consumption as the device needs to take the same amount of energy from the system to carry out its task.			
7.7.3		7.7.3	7.7.3 If a Voltage Management Unit is installed between the **Entry Point** and the **Power Generating Module** in a **Customers Installation**, it may result in the voltage at the **Customer** side of the Voltage Management Unit remaining within the limits of the protection settings defined in section 10.5.7.1 while the voltage at the **Entry Point** side of the unit might be outside the limits of the protection settings. This would negate the effect of the protection settings. Therefore this connection arrangement is not acceptable and all **Power Generating Modules** connected to the **DNO's LV Distribution Network** under this Engineering Recommendation must be made on the **Entry Point** side of any Voltage Management Unit installed in a **Customer's Installation.**			
7.7.4		7.7.4	7.7.4 **Customers** should note that the overvoltage setting defined in section 10.5.7.1 is 4% above the maximum voltage allowed for the voltage from the **DNO's Distribution Network** under the **ESQCR** and that provided their **Installer** has designed their installation correctly there should be very little nuisance tripping of the **Power Generating Module**. Frequent nuisance tripping of a **Power Generating Module** may be due to a fault in the **Customer's Installation** or the operation of the **DNO's Distribution Network** at too high a voltage. **Customers** should satisfy themselves that their installation has been designed correctly and all **Power Generating Modules** are operating correctly before contacting the **DNO** if nuisance tripping continues. Under no circumstances should they resort to the use of Voltage Management Units installed between the **Entry Point** and the **Power Generating Module**.			
7.7.5	A13 (7) covered		The **connection point** on the **DNO's** side of the supply terminals must be within the **frequency** range [TBD] for at least [TBD] before the **Power Generating Module** is allowed to automatically connect to the **DNO's Distribution Network**. The maximum admissible gradient of increase in **active power** output when connecting is [TBD].			NGET to decide the frequency range and gradient of increase

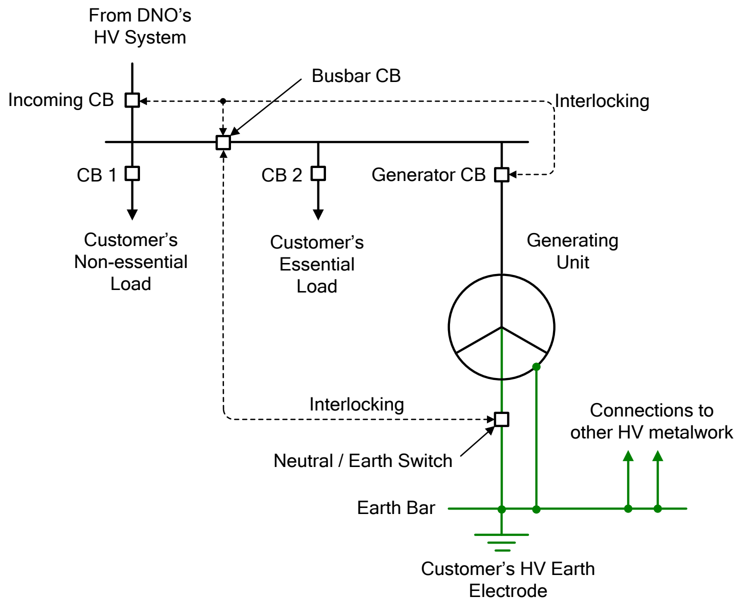
New doc	RfG	G59	G59	<1MW	<50MW	Comments
8		8	**8 EARTHING**			
8.1		8.1 DPC4.4.2	**8.1 General** 8.1.1 The earthing arrangements of the **Power Generating Module** and that part of the **User's System** that is connected to the **DNO's Distribution Network** shall satisfy the following requirements:. (a) The arrangements for connecting the **DNO's Distribution Network** with earth shall be designed to comply with the requirements of the **ESQCR** and relevant European and British Standards. Guidance as to the design of earthing systems is contained in **Electricity Supply Industry (ESI)** engineering publications, including Technical Specification 41-24**,** "Guidance for the design, installation, testing and maintenance of main earthing systems in substations" and Engineering Recommendation S.34, "A guide for assessing the rise of earth potential at substation sites". Additional requirements associated with **Power Generating Module** are given in this document. (b) The method of earthing of the **DNO's Distribution Network**, for example, whether it is connected solidly to earth or through an impedance, shall be advised by the **DNO**. The specification of associated **Equipment** shall meet the voltages which will be imposed on the **Equipment** as a result of the method of earthing. (c) Design practice for protective multiple earthing is detailed in the **Electricity Supply Industry (ESI)** engineering publications including Engineering Recommendation G12/4, "Application of protective multiple earthing to low voltage networks", and in the references contained in those publications. (d) **Users** shall take precautions to limit the occurrence and effects of circulating currents in respect of the neutral points of any interconnected system (eg where there is more than one source of energy.)			Words from DPC 6.4 included
8.2		8.2	**8.2 HV Power Generating Modules**			

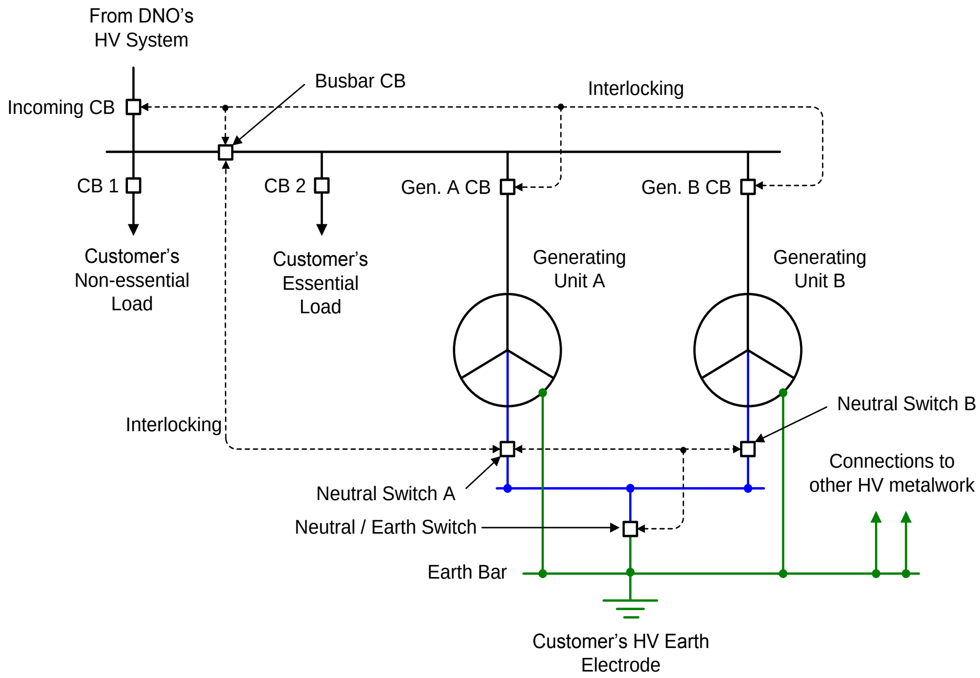
New doc	RfG	G59	G59	<1MW	<50MW	Comments
8.2.1		8.2.1	8.2.1 **HV Distribution Networks** may use direct, resistor, reactor or arc suppression coil methods of earthing the **Distribution Network** neutral. The magnitude and duration of fault current and voltage displacement during earth faults depend on which of these methods is used. The method of earthing therefore has an impact on the design and rating of earth electrode systems and the rating of plant and equipment.			
8.2.2		8.2.2	8.2.2 To ensure compatibility with the earthing on the **Distribution Network** the earthing arrangements of the **Power Generating Module** must be designed in consultation and formally agreed with the **DNO**. The actual earthing arrangements will also be dependent on the number of **Power Generating Module**s in use and the **Generators** system configuration and method of operation. The system earth connection shall have adequate electrical and mechanical capability for the duty.			
8.2.3		8.2.3	8.2.3 **HV Distribution Networks** operating at voltages below 132kV are generally designed for earthing at one point only and it is not normally acceptable for **HV Customers** or **HV Generator**s to connect additional **HV** earths when operating in parallel. One common exception to this rule is where the **Power Generating Module** uses an **HV** voltage transformer (VT) for protection, voltage control or instrumentation purposes and this VT requires an **HV** earth connection to function correctly. **HV Distribution Networks** operating at 132kV are generally designed for multiple earthing, and in such cases the earthing requirements should be agreed in writing with the **DNO**.			
8.2.4		8.2.4	8.2.4 In some cases the **DNO** may allow the **Generator** to earth the **Generator's HV System** when operating in parallel with the **Distribution Network**. The details of any such arrangements shall be agreed in writing between the relevant parties.			
8.2.5		8.2.5	8.2.5 **Generator**s must take adequate precautions to ensure their **Power Generating Module** is connected to earth via their own earth electrodes when operating in isolation from the **Distribution Network**.			
8.2.6			8.2.6 Typical earthing arrangements are given in figures 8.1 to 8.4.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
8.2.7		8.2.7	8.2.7 Earthing systems shall be designed, installed, tested and maintained in accordance with ENA TS 41-24, (Guidelines for the design, installation, testing and maintenance of main earthing systems in substations), BS7354 (Code of Practice for Design of Open Terminal Stations) ~~and~~ BS7430 (Code of Practice for Earthing) and Engineering Recommendation S.34 (A guide for assessing the rise of earth potential at substation sites). Precautions shall be taken to ensure hazardous step and touch potential do not arise when earth faults occur on **HV** systems. Where necessary, **HV** earth electrodes and **LV** earth electrodes shall be adequately segregated to prevent hazardous earth potentials being transferred into the **LV Distribution Network**.			
			Figure 8.1 - Typical Earthing Arrangement for an **HV Power Generating Module** Designed for Independent Operation (ie Standby Operation) Only  NOTE:			

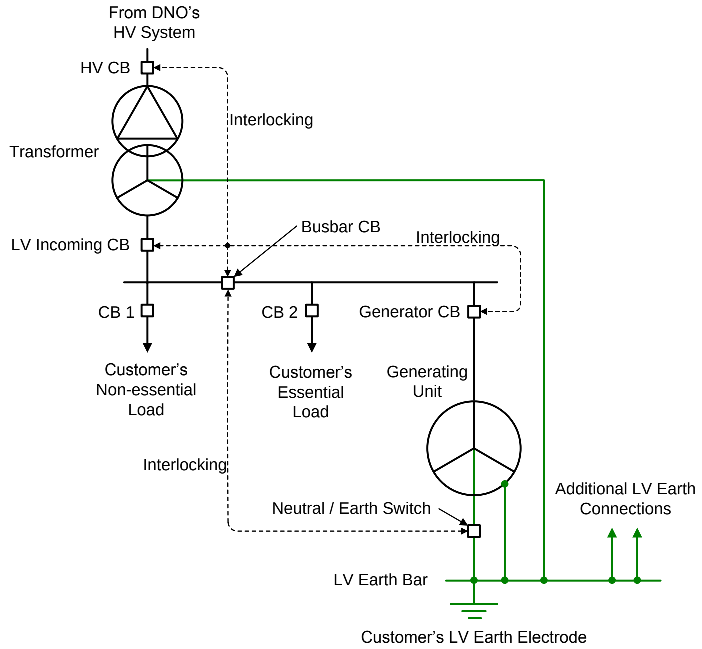
<table>
<tr><td>New doc</td><td>RfG</td><td>G59</td><td>G59</td><td><1MW</td><td><50MW</td><td>Comments</td></tr>
<tr><td></td><td></td><td></td><td>(1) Interlocking between busbar CB and Power Generating Facility CB is required to prevent parallel operation of the Power Generating Module and DNO’s Distribution Network</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Figure 8.2 - Typical Earthing Arrangement for a HV Power Generating Module Designed for Parallel Operation Only


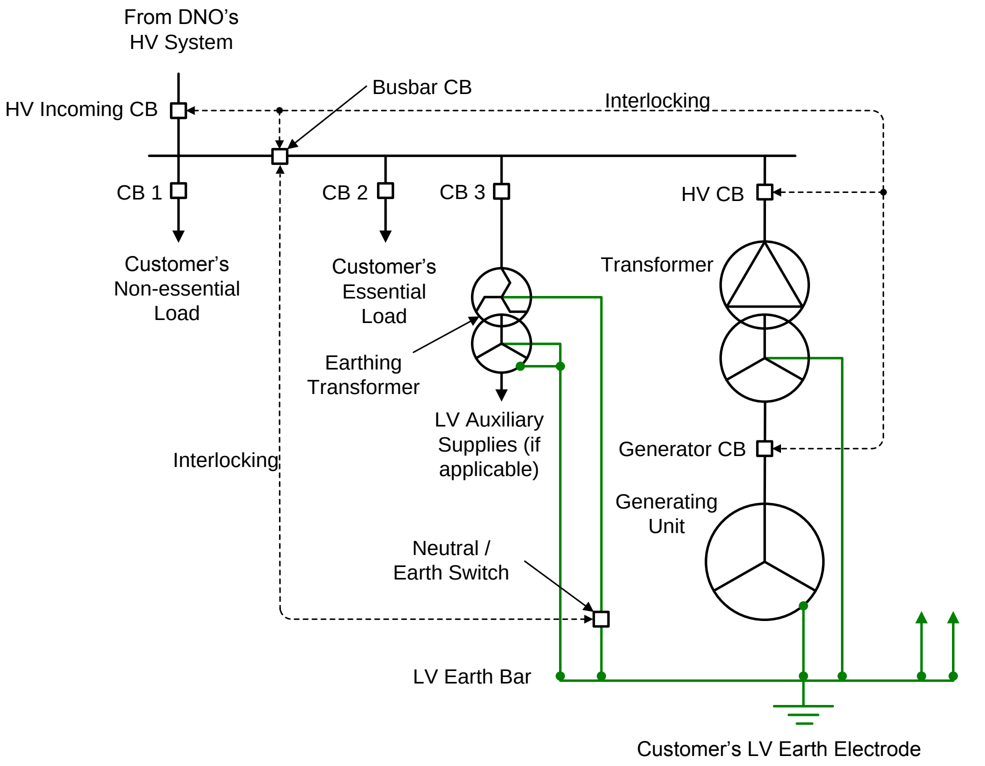
NOTE:</td><td></td><td></td><td></td></tr>
</table>

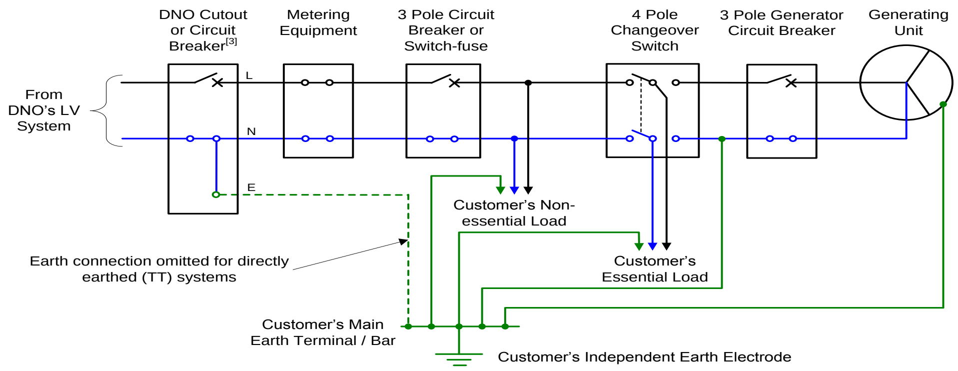
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(1) **Power Generating Module** winding is not connected to earth irrespective of whether it is star or delta connected			
			Figure 8.3 - Typical Earthing Arrangement for an **HV Power Generating Module** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation  NOTE: (1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network** (2) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral / earth switch is closed. (3) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.			
			Figure 8.4 - Typical Earthing Arrangement for two **HV Power Generating Modules** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation			

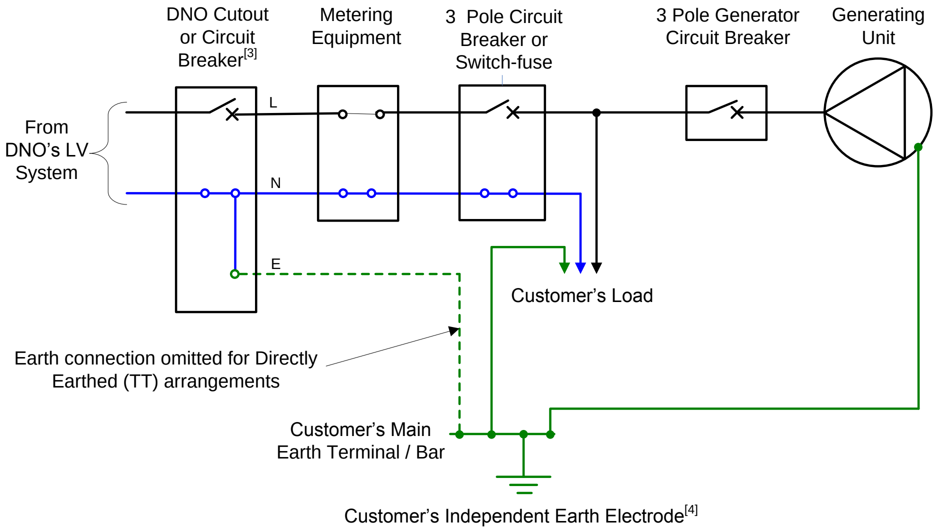
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			 NOTE: (1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Modules** operate independently from the **DNO's Distribution Network**. (2) If one **Power Generating Module** is operating independently from the **DNO's Distribution Network** (ie busbar CB is open) then its neutral switch is closed and the neutral / earth switch is closed. (3) If both **Power Generating Modules** are operating independently from the **DNO's Distribution Network** (ie busbar CB is open) then one neutral switch is closed and the neutral / earth switch is closed. (4) If one or both of the **Power Generating Modules** are operating in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) then both neutral switches and the neutral /earth switch are open.			

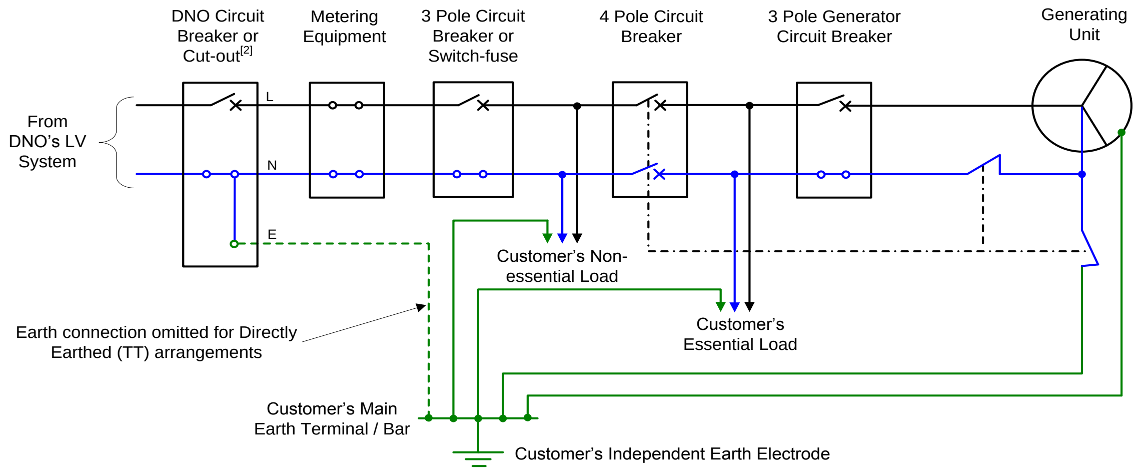
New doc	RfG	G59	G59	<1MW	<50MW	Comments
8.3		8.3	**8.3 LV Power Generating Modules**			
8.3.1		8.3.1	8.3.1 **LV Distribution Networks** are always solidly earthed, and the majority are multiple earthed. Design practice for protective multiple earthing is detailed in the **Electricity Supply Industry (ESI)** engineering publications including Engineering Recommendation G12/4, "Requirements for the application of protective multiple earthing to low voltage networks", and in the references contained in those publications.			
8.3.2		8.3.2 DPC7.4.6	8.3.2 The winding configuration and method of earthing connection shall be agreed with the **DNO.** In addition, where the **Power Generation Facility's Connection Point** is at **Low Voltage** the following shall apply (a) Where an earthing terminal is provided by the **DNO** it may be used by a **Power Generation Facility's** for earthing the **Power Generating Module**, provided the **DNO** earth connection is of adequate capacity. If the **Power Generating Module** is intended to operate independently of the **DNO's** supply, the **Power Generating Module** must include an earthing system which does not rely upon the **DNO's** earthing terminal. Where use of the **DNO's** earthing terminal is retained, it must be connected to the **Power Generating Modules** earthing system by means of a conductor at least equivalent in size to that required to connect the **DNO's** earthing terminal to the installation. (b) Where the **Power Generating Module** may be operated as a switched alternative only to the **DNO's System**, the **Power Generation Facility** shall provide an independent earth electrode. (c) Where it is intended to operate in parallel with the **DNO's Low Voltage System** with the star point connected to the neutral and/or earthing system, precautions will need to be taken to limit the effects of circulating harmonic currents. It is permissible to insert an impedance in the supply neutral of the **Power Generating Module** for this purpose, for those periods when it is paralleled with the **DNO's System**. However, if the **Power Generating Module** is operating in isolation from the **DNO's Distribution Network** it will be necessary to have the **Power Generating Module** directly earthed. (d) Where the **Power Generating Module** is designed to operate independently from the **DNO's Distribution Network** the switchgear that is used to separate			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			the two **Systems** shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Module**, from flowing into the **DNO's Distribution Network** when it operates as a switched alternative only supply			
8.3.3		8.3.3	8.3.3 The following diagrams 8.5 to 8.9 show typical installations.			
			Figure 8.5 - Typical Earthing Arrangement for an **LV Power Generating Module** Connected to the **DNO's Distribution Network** at **HV** and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation.  NOTE: (1) **HV** earthing is not shown.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network**. (3) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral earth switch is closed. (4) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.			
			Figure 8.6 - Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer HV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation  NOTE:			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(1) **HV** earthing is not shown. (2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Power Generating Module** operates independently from the **DNO's Distribution Network**. (3) When the **Power Generating Module** operates independently from the **DNO's Distribution Network** (ie busbar CB is open) the neutral / earth switch is closed. (4) When the **Power Generating Module** operates in parallel with the **DNO's Distribution Network** (ie busbar CB is closed) the neutral / earth switch is open.			
			Figure 8.7 - Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for Independent (ie Standby) Operation Only  NOTES (1) Only one phase of a three phase system is shown to aid clarity. (2) **Power Generating Module** is not designed to operate in parallel with the **DNO's Distribution Network**. (3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements. (4) The changeover switch must disconnect each phase and the neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			flowing through the part of the **Customer's Installation** that is not supported by the **Power Generating Module.** **Figure 8.8 -** Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for Parallel Operation Only  NOTES: (1) Only one phase of the three phase system is shown to aid clarity. (2) **Power Generating Module** is not designed to operate in standby mode. (3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(4) The **Customer**'s independent earth electrode is only required if the installation is Directly Earthed (TT).			
			Figure 8.9 - Typical Earthing Arrangement for an **LV Power Generating Module** Embedded within a **Customer LV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation**.**  NOTES: (1) Only one phase of a three phase system is shown to aid clarity. (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements. (3) When the **Power Generating Module** operates independently from the DNO's system, the switch that is used to isolate between these two systems must disconnect each phase and neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Customer's Installation** that is not supported by the			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Power Generating Module. This switch should also close the **Power Generating Module** neutral and earth switches during independent operation.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9 9.1		9	**NETWORK CONNECTION DESIGN AND OPERATION** **General Criteria**			
9.1.1		9.1.1	9.1.1 As outlined in Section 5, **DNO**s have to meet certain statutory and **Distribution Licence** obligations when designing and operating their **Distribution Networks**. These obligations will influence the options for connecting **Power Generating Modules**.			DPC4.1.1 covered
9.1.2		DPC4.1.2	The **DNO** has a duty to develop and maintain an efficient, secure and co-ordinated **Network** of electricity supply that is both economical and safe.			
9.1.3		DPC4.1.3	**This Section** sets out current principles and standards to be applied in the design of the **DNO's Distribution Network** and any **User** connections to that **Network.** Each scheme for reinforcement or modification of the **DNO's Distribution Network** is individually designed in the light of economic and technical features associated with the particular **System** limitations under consideration.			
9.1.4		DPC4.1.4	Nothing in this section is intended to inhibit design innovation**.** This Section is, therefore, based upon the performance requirements of the **DNO's Distribution Network** necessary to meet the above criteria.			
9.1.5		9.1.2	9.1.2 The technical and design criteria to be applied in the design of the **Distribution Network** and **Power Generating Module** connection are detailed in this document. The criteria are based upon the performance requirements of the **Distribution Network** necessary to meet the above obligations. These standards may be subject to revision from time to time in accordance with the provision of the **Distribution Licence**.			Words from DPC 4.1.5
9.1.6		9.1.3	9.1.3 The **Distribution Network**, and any **Power Generating Module** connection to that network, shall be designed, a. to comply with the obligations (to include security, frequency and voltage; voltage disturbances and harmonic distortion; auto reclosing and single phase protection operation).			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			b. according to design principles in relation to **Distribution Network**'s plant and equipment, earthing, voltage regulation and control, and protection as outlined in this section, subject to any modification to which the **DNO** may reasonably consent.			
9.1.7		9.1.4	9.1.4 **Power Generating Modules** should meet a set of technical requirements in relation to its performance with respect to frequency and voltage, control capabilities, protection coordination requirements, phase voltage unbalance requirements, neutral earthing provisions, islanding and **black start capability**. These requirements are listed in this section.			
9.1.8		9.1.5	9.1.5 There are additional performance requirements that are specified in the **Grid Code** for all embedded **Medium and Large Power Generating Facilities**. The requirements for **Medium Power Generating Facilities** are referenced in section 9.14, and are all listed in CC3.3 to CC3.5 of the **Grid Code**.			Review once terminology agreed
9.1.9		DPC4.5.1	In accordance with Condition 4 of its **Distribution Licence** the **DNO**, on the request of a **User,** will prepare a statement showing present and future circuit capacity, forecast power flows and loading on the part or parts of the **DNO's Distribution Network** specified in the request and **Fault Levels** at each distribution node covered by the request and containing: a) such further information as shall be reasonably necessary to enable such person to identify and evaluate the opportunities available when connecting to and making use of the part or parts of the licensee's distribution network specified in the request ;and b) if so requested, a commentary prepared by the licensee indicating the licensee's views as to the suitability of the part or parts of the licensee's distribution network specified in the request for new connections and the distribution of further quantities of electricity.. The **Distribution Licence** sets out conditions on the time scales and charges associated with providing such a statement			For discussion, this clause covers information contained in the D Licence, does it need re-iterating here? Comments
9.1.10		DPC4.5.2	In accordance with Condition 25 of its Distribution Licence the **DNO** will prepare on the request of the **Authority** a statement, also known as the Long Term Development Statement. The form and content of this statement will be specified by the **Authority** and will cover future years on a rolling basis. This statement gives information to assist any person who contemplates entering into distribution arrangements with the **DNO** to identify and evaluate the opportunities for doing so.			

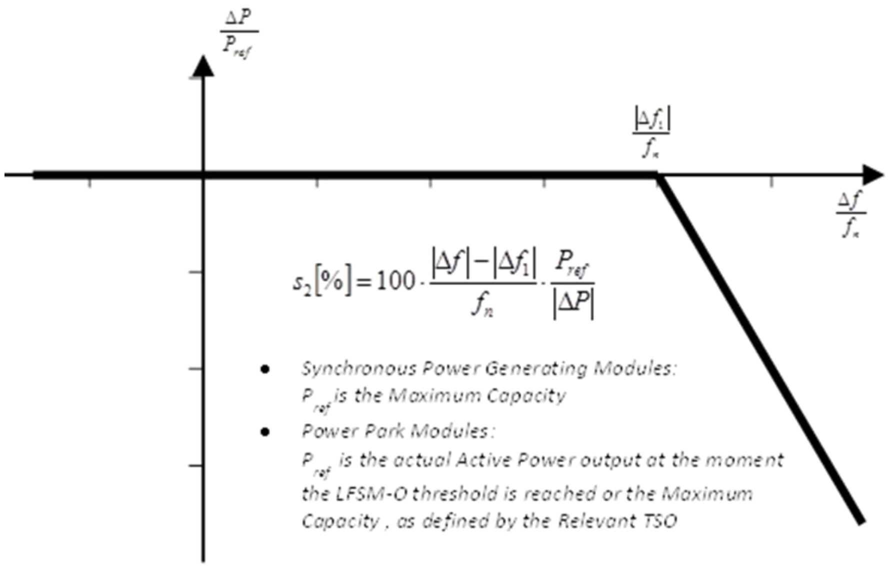
New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.2		9.2	**9.2 Network Connection Design for Power Generating Modules**			
9.2.1		9.2.1	9.2.1 The connection of new **Customer**s, including **Power Generating Facility Owner**s, to the **Distribution Network** should not generally increase the risk of interruption to existing **Customers**. For example, alterations to existing **Distribution Network** designs that cause hitherto normally closed circuits to have to run on open standby such that other **Customers** might become disconnected for the duration of the auto-switching times are deprecated.			
9.2.2		9.2.2	9.2.2 Connection of **Power Generating Modules** to **Distribution Networks** will be subject to rules for managing the complexity of circuits. For example EREC P18 sets out the normal limits of complexity of 132kV circuits by stipulating certain restrictions to be applied when they are designed e.g. the operation of protective gear for making dead any 132kV circuit shall not require the opening of more than seven circuit breakers and these circuit breakers shall not be located at more than four different sites. Each DNO will have similar policies for managing complexity of lower voltage circuits.			Clause rewritten to be generic for all distribution level voltages
9.2.3		9.2.3	9.2.3 The security requirements for the connection of **Power Generating Modules** are subject to economic consideration by the **DNO** and the **Power Generating Facility Owner.** A firm connection for **Power Generating Module** should allow the full MVA capacity to be exported via the **Distribution Network** at all times of year and after one outage on any one circuit of the **Distribution Network**. ETR 124 provides additional advice on the management of constraints and security.			
9.2.4		9.2.4	9.2.4 The decision as to whether or not a firm connection is required should be by agreement between the **DNO** and the **Power Generating Facility Owner**. The **DNO** should be able to provide an indication of the likely duration and magnitude of any constraints so that the **Power Generating Facility Owner** can make an informed decision. The **Power Generating Facility Owner** should consider the financial implications of a non-firm connection against the cost of a firm connection, associated **Distribution Network** reinforcement and the risk of any constraints due to **Distribution Network** restrictions.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.2.5		9.2.5	9.2.5 Where the **DNO** expects the **Power Generating Module** to contribute to system security, the provisions of EREC P2 and the guidance of ETR 130 will apply. In addition, the **Power Generating Module** should either remain synchronised and in parallel with the **Distribution Network** under the outage condition being considered or be capable of being resynchronised within the time period specified in EREC P2. There may be commercial issues to consider in addition to the connection cost and this may influence the technical method which is used to achieve a desired security of supply.			
9.2.6		9.2.6	9.2.6 When designing a scheme to connect **a Power Generating Module** , consideration must be given to the contribution which that **Power Generating Module** will make to short circuit current flows on the **Distribution Network**. The assessment of the fault level contribution from **a Power Generating Module** and the impact on the suitability of connected switchgear are discussed in Section 9.4.			
9.2.7		9.2.7	9.2.7 It is clearly important to avoid unwanted tripping of the **Power Generating Module** particularly where the **Power Generating Module** is providing **Distribution Network** or **Total System** security. The quality of supply and stability of **Power Generating Module** performance are dealt with in Sections 9.6 and 9.7 respectively.			
9.2.8		9.2.8	9.2.8 **Power Generating Modules** may be connected via existing circuits to which load and/or existing **Power Generating Modules are** also connected. The duty on such circuits, including load cycle, real and reactive power flows, and voltage implications on the **Distribution Network** will need to be carefully reviewed by the **DNO**, taking account of maximum and minimum load and generation export conditions during system intact conditions and for maintenance outages of both the **Distribution Network** and **Generation Plant**. In the event of network limitations, ETR 124 provides guidance to **DNO**s on overcoming such limitations using active management solutions.			
9.2.9		9.2.9	9.2.9 A **DNO** assessing a proposed connection of **a Power Generating Module** must also consider its effects on the **Distribution Network** voltage profile and voltage control employed on the **Distribution Network**. Voltage limits and control issues are discussed in Section 9.5.			
9.3		9.3	**9.3 Power Generating Module Performance and Control Requirements**			
9.3.1		DPC7.4.1.1	The requirements of this section do not apply to **Power Generation Facilities** that are designed and installed for infrequent short term parallel operation only.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.3.2	A14 (5a)		The design of and any changes to the schemes and settings of the different control devices of a **power generating module** with a **maximum capacity** of more than 1 MW (Type B and above) that are necessary for transmission **system stability** and for taking emergency action shall be coordinated and agreed between NGC, the **DNO operator** and the **power generating facility owner**.			
9.3.3		DPC7.4.1.2 9.3.1	For **Embedded Power Generating Modules,** which do not constitute or contain **BM Units** that are active (ie submitting bid-offer data) in the **Balancing Mechanism**, the electrical parameters required to be achieved at the **Generation Set** terminals are defined according to the connection method and will be specified by the **DNO** with the offer for connection. The rated power output of a **Power Generating Module** should not be affected by voltage changes within the statutory limits declared by the **DNO** in accordance with the **ESQCR** unless otherwise agreed with the **DNO**.			
9.3.4	A13 (6)		**Power generating modules** connected to the **DNO's Distribution Network** 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 **DNO** has the right to define requirements for equipment to make this facility operable remotely.			
9.3.5	A14 (2)		To control active power output, power generating modules connected to the **DNO's Distribution Network** below 110 kV and with a maximum capacity of more than 1 MW but less than 50 MW (Type B) shall also be equipped with an interface (input port) in order to be able to reduce **active power** output following an instruction at the input port. The **DNO** shall have the right to specify the requirements for further equipment to allow active power output to be remotely operated.			
9.3.6		9.3.5	Each item of a **Power Generating Module** and its associated control equipment must be designed for stable operation in parallel with the **Distribution Network**.			
9.3.7		DPC7.4.2.2	The **Power Generating Facility Owner** will notify, and keep notified, the **DNO** of the set points of the control scheme for voltage control or **Power Factor** control as appropriate and which have previously been agreed between the **Power Generating Facility Owner** and **DNO**. The information to be provided is detailed in Schedule 5a and Schedule 5b.			Keep under review with other EU op codes

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.3.8		9.3.6	Load flow and **System Stability** studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The **Connection Agreement** should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module** .			
			Frequency response			
9.4.1	A13 (3) A13 (2) A13 (4)		**Power generating modules** connected to the **DNO's Distribution Network** shall be capable of maintaining constant output at their target **active power** value regardless of changes in **frequency** between 49.5 Hz and [50.4 Hz].			Type A and B do not have LFSM-U and therefore the lower frequency response only starts at 49.5Hz. LFSM-O setting is the upper limit.
9.4.2	A13 Table 2	9.3.2	9.3.2 Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47Hz. In exceptional circumstances, the frequency of the **DNO's Distribution Network** could rise above 50.5 Hz. Therefore all embedded **Power Generating Facilities** should be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following: a. 47 Hz – 47.5 Hz Operation for a period of at least 20 seconds is required each time the frequency is within this range.			Modified in line with RfG. DPC7.4.1.3 covered here

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			b. 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. c. 49.0Hz – 51.0 Hz The PGM must remain connected in this range d. 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. e. 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.			
9.5	A13 (2)		**Limited Frequency Sensitive Mode – Overfrequency**			
9.5.1	A13 (2a)		The **power generating module** shall be capable of activating the provision of **active power frequency** response according to figure 9.1. The **GB** specific response is a **frequency** threshold of [50.4Hz] with a **droop** setting of [10% or less].			

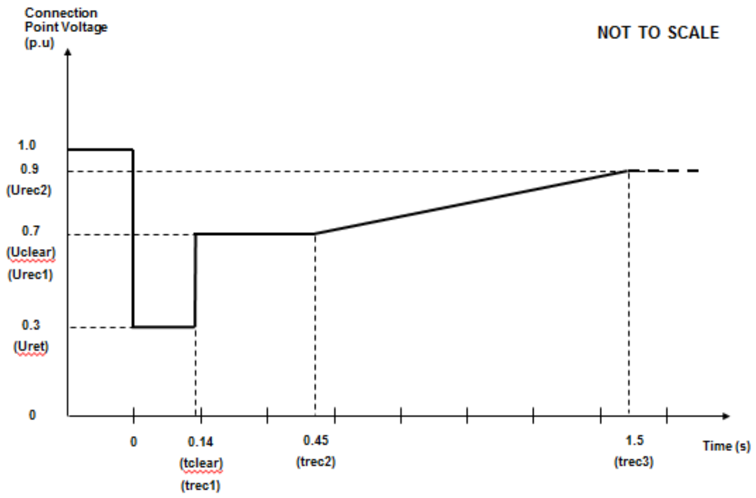
New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.5.2	A13 (2)		 Figure 9.1: **active power frequency** response capability of **power generating modules** in LFSM-O. Pref is the reference **active power** to which ΔP is related and may be defined differently for synchronous **power generating modules** and power park modules. ΔP is the change in **active power** output from the power generating module. fn is the nominal **frequency** (50 Hz) in the network and Δf is the **frequency** change in the network. At over frequencies where Δf is above Δf1, the **power generating module** has to provide a negative **active power** output change according to the **droop** S2.			
9.5.3	A13 (2b) A14 (1)		For **power generating modules** connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of less than 1 MW (Type A) automatic disconnection and reconnection at randomised frequencies may be allowed by **the relevant TSO** where it is able to demonstrate to the **Authority,** and with the cooperation of **power generating module** owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;			NGET need to decide if this will be allowed

New doc	RfG	G59	G59	<1MW	<50MW	Comments
	covered					
9.5.4	A13 (2e)		The **power generating module** shall be capable of activating a power **frequency** response with an initial delay that is as short as possible. If that delay is greater than two seconds, the **power generating facility owner** shall justify the delay, providing technical evidence to **the TSO;**			
9.5.5	A13 (2f)		**The 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**;			Decision from NGET necessary
9.5.6	A13 (2g)		The **power generating module** shall be capable of operating stably during LFSM-O operation. When LFSM-O is active, the LFSM-O **setpoint** will prevail over any other **active power setpoint**s.			
9.6		9.4.	**Fault Contributions and Switchgear Considerations**			
9.6.1		9.4.1	9.4.1 Under the **ESQCR** 2002 and the EaWR 1989 the **Power Generating Facility Owner** and the **DNO** have legal duties to ensure that their respective systems are capable of withstanding the short circuit currents associated with their own equipment and any infeed from any other connected system.			
9.6.1.1		DPC6.5.1	The short circuit rating of **User's Equipment** at the **Connection Point** should be not less than the design **Fault Level** of the **DNO's Distribution Network** to which it is connected. The choice of **Equipment** for connection at **Low Voltage** may take into account attenuation in the service lines as specified in Engineering Recommendation P25, "The short circuit characteristics of electricity board's low voltage distribution networks and the co-ordination of overcurrent protective devices on 230V single phase supplies up to 100 Amps" and Engineering Recommendation P26/1, "The estimation of the maximum prospective short circuit current for three phase 415V supplies". The **DNO** in the design of its **Network** will take into account the contribution to **Fault Level** of the **User's** connected **System** and **Apparatus**.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.6.1.2		DPC6.5.2	In order to permit these assessments to be carried out information should be exchanged on prospective fault power infeed and X/R ratios where appropriate at points of entry to and exit from the **DNO's Distribution Network.**			
9.6.2		9.4.2	9.4.2 The **Power Generating Facility Owner** may accept that protection installed on the **Distribution Network** can help discharge some of his legal obligations relating to fault clearance and, if requested, the **DNO** should consider allowing such faults on the **Power Generating Facility Owner's** system to be detected by **DNO** protection systems and cleared by the **DNO'**s circuit breaker. The **DNO** will not allow the **Power Generating Facility Owner** to close the **DNO'**s circuit breaker nor to synchronise using the **DNO'**s circuit breaker. In all such cases the exact nature of the protection afforded by the **DNO'**s equipment should be agreed and documented. The **DNO** may make a charge for the provision of this service.			
9.6.3		9.4.3	9.4.3 The design and safe operation of the **Power Generating Facility Owner**'s and the **DNO'**s installation's depend upon accurate assessment of the contribution to the short circuit current made by all the **Power Generating Modules** operating in parallel with the **Distribution Network** at the instant of fault and the **Power Generating Facility Owner** should discuss this with the **DNO** at the earliest possible stage.			
9.6.4		9.4.4	9.4.4 Short circuit current calculations should take account of the contributions from all synchronous and asynchronous infeeds including induction motors and the contribution from inverter connected **Power Generating Module**s. The prospective short circuit 'make' and 'break' duties on switchgear should be calculated to ensure that plant is not potentially over-stressed. The maximum short circuit duty might not occur under maximum generation conditions; it may occur during planned or automatic operations carried out either on the **Distribution Network** or **Transmission System**. Studies must therefore consider all credible **Distribution Network** running arrangements which are likely to increase **Distribution Network** short circuit levels. The level of load used in the assessment should reflect committed projects as well as the existing loads declared in the **DNO'**s Long Term Development Statement (LTDS). Guidance on short circuit calculations is given in EREC G74.			

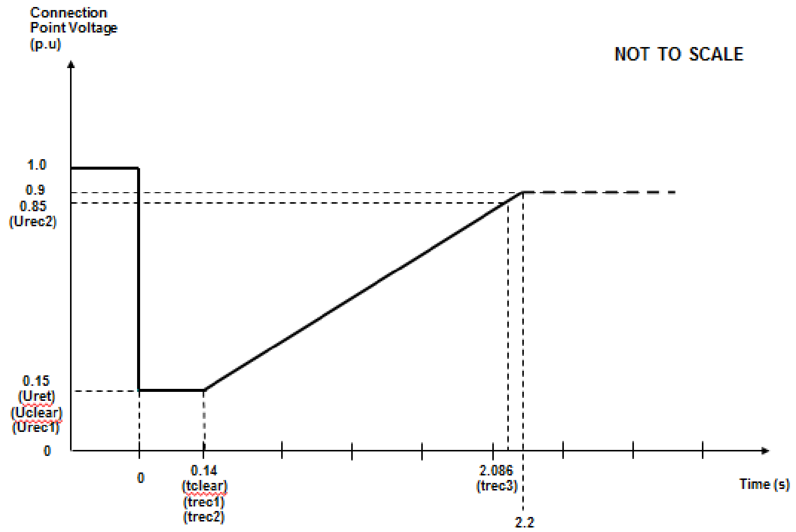
New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.6.5		9.4.5	9.4.5 The connection of **a Power Generating Module** can raise the **Distribution Network** reactance/resistance (X/R) ratio. In some cases, this will place a more onerous duty on switchgear by prolonging the duration of the DC component of fault current from fault inception. This can increase the proportion of the DC component of the fault current and delay the occurrence of current zeros with respect to voltage zeros during the interruption of fault current. The performance of connected switchgear must be assessed to ensure safe operation of the **Distribution Network**. The performance of protection may also be impaired by partial or complete saturation of current transformers resulting from an increase in **Distribution Network** X/R ratio.			
9.6.6		9.4.6	9.4.6 Newly installed protection systems and circuit breakers for **Power Generating Module** connections should be designed, specified and operated to account for the possibility of out-of-phase operation. It is expected that the **DNO'**s metering/interface circuit breaker will be specified for this duty, but in the case of existing circuit breakers on the **Distribution Network**, the **DNO** will need to establish the possibility or otherwise of the **DNO**s protection (or the **Power Generating Facility Owner**'s protection if arranged to trip the **DNO'**s circuit breaker) initiating a circuit breaker trip during a period when one of more **Power Generating Module**s might have lost **Synchronism** with the **Total System**. Where necessary, switchgear replacement, improved security arrangements and other control measures should be considered to mitigate this risk.			
9.6.7		9.4.7	9.4.7 When connection of **a Power Generating Module** is likely to increase short circuit currents above **Distribution Network** design ratings, consideration should be given to the installation of reactors, sectionalising networks, connecting the **Power Generating Module** to part of the **Distribution Network** operating at a higher voltage, changing the **Power Generating Module** specification or other means of limiting short circuit current infeed. If fault limiting measures are not cost effective or feasible or have a material detrimental effect on other users, **Distribution Network** plant with the potential to be subjected to short circuit currents in excess of its rating should be replaced or reference made to the relevant manufacturer to determine whether or not the existing plant rating(s) can be enhanced. In situations where **Distribution Network** design ratings would be exceeded in infrequent but credible **Distribution Network** configurations, then constraining the **Power Generating Module** off during periods of such **Distribution Network** configurations may provide a suitable solution. When assessing short circuit currents against **Distribution Network** design ratings, suitable safety margins should be allowed to cater for tolerances that exist in the **Distribution Network** data and **Power Generating Module** parameters used in system modelling programs. On request from a **Power Generating Facility Owner** the **DNO** will provide the rationale for determining the value of a specific margin being used in **Distribution Network** studies.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.6.8		9.4.8	9.4.8 For busbars with three or more direct connections to the rest of the **Total System**, consideration may be given to reducing fault levels by having one of the connections 'open' and on automatic standby. This arrangement will only be acceptable provided that the loss of one of the remaining circuits will not cause the group to come out of **Synchronism**, cause unacceptable voltage excursions or overloading of **Distribution Network** or **Transmission System** plant and equipment. The use of the proposed **Power Generating Module** to prevent overloading of **Distribution Network** plant and equipment should be considered with reference to EREC P2.			
9.6.9		9.4.9	9.4.9 Disconnection of **a Power Generating Module** must be achieved by the separation of mechanical contacts unless the disconnection is at **Low Voltage** and the equipment at the point of disconnection contains appropriate self monitoring of the point of disconnection, in which case an appropriate electronic means such as a suitably rated semiconductor switching device would be acceptable. The self monitoring facility shall incorporate fail safe monitoring to check the voltage level at the output stage. In the event that the solid state switching device fails to disconnect the **Power Generating Module**, the voltage on the output side of the switching device shall be reduced to a value below 50V within 0.5s. For the avoidance of doubt this disconnection is a means of providing LoM disconnection and not as a point of isolation to provide a safe system of work.			
9.6.10		DPC6.6	**Capacitive and Inductive Effects** The **User** shall, when applying to make a connection, provide the **DNO** with information as detailed in DPC8. Details will be required of capacitor banks and reactors connected at **HV** which could affect the **DNO's Distribution Network** and which it is proposed to connect if agreed by the **DNO**. When requested by the **DNO** details shall also be provided of distributed circuit capacitance and inductance. Sufficient detail is required for the following:- (a) To verify that controlling **Equipment** of the **DNO's Distribution Network** is suitably rated. (b) To show that the performance of the **DNO's Distribution Network** will not be impaired. (c) To ensure that arc suppression coils when used by the **DNO** for **System** earthing purposes are correctly installed and operated.			DPC8 suggested to be included in G99 as a new section?
9.7			**Fault Ride through**	n	y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.7.1	A14 (3)		Paragraphs 9.7.1 to 9.7.8 inclusive set out the fault ride through, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules** greater than 1 MW and less than 50MW (Type B), subject to faults up to 140ms in duration.	n	y	FRT for transmission faults - text generally follows NG drafting
9.7.2			Each **Synchronous Power Generating Module** and **Power Park Module** is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the **Connection Point** remains on or above the heavy black line shown in Figures 9.2 and 9.3 below.	n	y	
9.7.3			The voltage against time curves defined in 9.7.4 – 9.7.7 expresses the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at the **Connection Point** during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.	n	y	Decide if V is to be defined term
9.7.4			Figure 9.2 - Voltage against time curve applicable to **Synchronous Power Generating Modules** greater than 1 MW and less than 50MW (Type B)  	n	y	

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td>9.7.5</td><td></td><td></td><td>Table 9.1 - Voltage against time parameters applicable to Synchronous Power Generating Modules greater than 1 MW and less than 50MW (Type B)

<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (seconds)</th></tr>
<tr><td>Uret</td><td>0.3</td><td>tclear</td><td>0.14</td></tr>
<tr><td>Uclear</td><td>0.7</td><td>trec1</td><td>0.14</td></tr>
<tr><td>Urec1</td><td>0.7</td><td>trec2</td><td>0.45</td></tr>
<tr><td>Urec2</td><td>0.9</td><td>trec3</td><td>1.5</td></tr>
</table></td><td>n</td><td>y</td><td></td></tr>
<tr><td>9.7.6</td><td></td><td></td><td>Figure 9.3 - Voltage against time curve applicable to Power Park Modules greater than 1 MW and less than 50MW (Type B)


</td><td>n</td><td>y</td><td></td></tr>
<tr><td>9.7.7</td><td></td><td></td><td>Table 9.2 Voltage against time parameters applicable to Power Park Modules greater than 1 MW and less than 50MW (Type B)
<table>
<tr><th>Voltage parameters (pu)</th><th>Time parameters (seconds)</th></tr>
</table></td><td>n</td><td>y</td><td></td></tr>
</table>

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td><table>
<tr><td>Uret</td><td>0.15</td><td>tclear</td><td>0.14</td></tr>
<tr><td>Uclear</td><td>0.7</td><td>trec1</td><td>0.14</td></tr>
<tr><td>Urec1</td><td>0.7</td><td>trec2</td><td>0.45</td></tr>
<tr><td>Urec2</td><td>0.9</td><td>trec3</td><td>1.5</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>9.7.8</td><td>A17(3)</td><td></td><td>In addition to the requirements in 9.7.4 to 9.7.7:

(i) Each **Power Generating Module** shall be capable of satisfying the above requirements when operating at **Rated MW** output and maximum leading **Power Factor**.

(ii) The pre-fault voltage shall be taken to be 1.0pu and the post fault voltage shall be 0.9pu unless a higher value is specified in the Connection Agreement.

(iii) **The DNO** will publish fault level data under maximum and minimum demand conditions in the Long Term Development Statements. To allow a **User** to model the fault ride through performance of its **Power Generating Modules**, **the DNO** will provide generic fault level values derived from typical cases. Where necessary, on reasonable request the DNO will specify the pre-fault and post fault short circuit capacity (in MVA) at the **Connection Point** and will provide additional network data as may reasonably be required for the **User** to undertake such study work.

(iv) Each **Generator** shall satisfy the requirements in 9.7.4 – 9.7.7 unless the protection schemes and settings for internal electrical faults requires disconnection of the **Power Generating Module** from the network. The protection schemes and settings should not jeopardise fault ride through performance as specified in 9.7.4 – 9.7.7. The undervoltage protection at the **Connection Point** shall be set by the **Power Generating Facility Owner** according to the widest possible range unless **the DNO** has agreed to narrower settings which shall be pursuant to the terms of the **Connection Agreement**. All protection settings associated with undervoltage protection shall be agreed between the DNO and the Power Generating Facility Owner.

(v) In addition to the requirements of 9.7.4 – 9.7.8 each **Power Generating Module** shall be designed such within 0.5 seconds of restoration of the voltage at the **Connection Point** to 90% of nominal voltage or greater, **Active Power** output shall be restored to at least 90% of the level immediately before the fault. Once **Active Power** output has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:</td><td>n</td><td>y</td><td></td></tr>
</table>

New doc	RfG	G59	G59	<1MW	<50MW	Comments
	A14 (4)		- The total Active Energy delivered during the period of the oscillations is at least that which would have been delivered if **the Active Power** was constant - The oscillations are adequately damped. For **Power Park Modules~~,~~** comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.			
9.7.9		DPC7.4.4	In addition to paragraphs 9.7.1 – 9.7.8 any **Power Generating Module** or **Power Generating Facility** connected to the **DNO's Distribution Network**, where it has been agreed between the **DNO** and the **Power Generating Facility Owner** that the **Power Generating Facility** will contribute to the **DNO**'s **Distribution Network** security, may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault , in both cases cleared by the **DNO**'s main protection. The **DNO** will advise the **Embedded Power Generating Facility** in each case of the likely tripping time of the **DNO**'s protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time. In the case of phase to phase faults on the **DNO**'s system that are cleared by **System** back-up **Protection** which will be within the **Plant** short time rating on the **DNO**'s **Distribution Network** the **DNO**, on request during the Connection Agreement process, will advise the Embedded Power Generating Facility Owner of the expected Phase Voltage Unbalance.	y	y	This is close up fault rather than RfG transmission faults
9.8		9.5	**Voltage Limits and Control**			
9.8.1		9.5.1	Where **a Power Generating Module** is remote from a network voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the **DNO** should agree with the **Power Generating Facility Owner** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Power Generating Module** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.8.2		9.5.2	The connection of a **Power Generating Module** to the **Distribution Network** shall be designed in such a way that operation of the **Power Generating Module** does not adversely affect the voltage profile of and voltage control employed on the **Distribution Network**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **User.**			Words from DPC4.4.3 included
9.8.3	A17 (2a) and A20 (2a)	9.3.4	The DNO shall have the right to specify the capability of a power generating module connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of more than 1 MW but less than 50 MW (Type B) to provide reactive power. Following consultation with the **Power Generating Facility Owner** and dependent on **Distribution Network** voltage studies, a **DNO** will agree the reactive power and voltage control requirements for all **Power Generating Module**s that are connected to their **Distribution Network**s. It should be noted that the connection to the **Distribution Network** may impose restrictions on the capability of **Generation Plant** to operate in accordance with the assumptions of **Grid Code** CC6.3 and the **NETSO** should be advised of any restrictions in accordance with **Grid Code** BC1.6.1.			A17 and A20 are about type B but split into synchronous and PPM. Requirement same for both.
9.8.4		9.5.3	Where it is agreed that the **Generation Plant** should operate in voltage control (PV) mode or where there is a need to comply with **Grid Code** CCA7.2 when the **Power Generating Module** is required to operate to a '**setpoint** voltage' and 'slope', the **Power Generating Module** will have a specific role to control the **Distribution Network** voltage. The final responsibility for control of **Distribution Network** voltage does however remain with the **DNO**.			
9.8.5		9.5.4	Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution Network** operating at a higher voltage to parts of the **Distribution Network** operating at lower voltages. Export from **Power Generating Modules** in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side will not operate correctly without an import of reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of **Power Generating Modules** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.8.6		9.5.5	**Power Generating Modules** can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in active and reactive power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.			
9.8.7		9.5.6	An agreement between the **DNO** and the **Power Generating Facility Owner** may allow the use of voltage control techniques other than those previously mentioned. Such an agreement would normally be reached during the negotiating stage of the connection.			
9.8.8		9.5.7 DPC4.2.3.3	The **Step Voltage Change** caused by the connection and disconnection of **Power Generating Modules** from the **Distribution Network** must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other **Customers** connected to the **Distribution Network**. The magnitude of a **Step Voltage Change** depends on the method of voltage control, types of load connected and the presence of local generation. Typical limits for **Step Voltage Change** caused by the connection and disconnection of any **Customers** equipment to the **Distribution Network** should be ± 3% for infrequent planned switching events or outages in accordance with EREC P28. For unplanned outages such faults it will generally be acceptable to design to a **Step Voltage Change** of ±10%. A voltage step change should be considered to be the change from the initial voltage level to the resulting voltage level after all the **Power Generating Module automatic voltage regulator** and static VAR compensator actions, and transient decay (typically 5 seconds after the fault clearance or system switching) have taken place, but before any other automatic or manual tap-changing and switching actions have commenced			
9.8.9		9.5.8	The voltage depression arising from transformer magnetising inrush current is a short-time phenomenon not generally easily captured by the definition of **Step Voltage Change** used in this document. In addition the size of the depression is dependent on the point on wave of switching and the duration of the depression is relatively short in that the voltage recovers substantially in less than one second.			Dependant on P28 review outcomes

New doc	RfG	G59	G59	<1MW	<50MW	Comments
9.8.10		9.5.9	**Customer Installation**s should be designed such that transformer magnetising inrush current associated with normal routine switching operations does not cause voltage fluctuations outside those in EREC P28 (i.e. a maximum of ±3%). To achieve this it may be necessary to install switchgear so that sites containing multiple transformers can be energised in stages.			
9.8.11		9.5.10	Situations will arise from time to time when complete sites including a significant presence of transformers are energised as a result of post fault switching, post fault maintenance switching, carrying out commissioning tests on **Distribution Network** or on the **Customer**'s **Installation**. In these situations it will generally be acceptable to design to an expected depression of around 10% recognising that a worst case energisation might be a larger depression, on the basis that such events are considered to be rare and it is difficult to predict the exact depression because of the point on wave switching uncertainty. Should these switching events become more frequent than once per year then the design should revert to aiming to limit depressions to less than 3%.			
9.8.12		9.5.11	These threshold limits should be complied with at the **Point of Common Coupling** as required by EREC P28.			
9.9		DPC4.2.3.1	**Voltage Disturbances** Under fault and circuit switching conditions the rated **Frequency** component of voltage may fall or rise transiently. The fall or rise in voltage will be affected by the method of earthing of the neutral point of the **DNO's Distribution Network** and voltage may fall transiently to zero at the point of fault. BS EN 50160:2010 'Voltage Characteristics of Electricity Supplied by Public Distribution Systems', as amended from time to time, contains additional details of the variations and disturbances to the voltage which shall be taken into account in selecting **Equipment** from an appropriate specification for installation on or connected to the **System**.			
9.10			**Voltage Stability**			
9.10.1	A20 (2b)		The **DNO** in coordination with **NGET** shall have the right to specify that a **power park module** that is connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of more than 1 MW (Type B and up) be capable of providing **fast fault current** at the **connection point** in case of symmetrical (3-phase) faults, under the following conditions:			
9.10.2	A20 (2bi)		(i) the **power park module** shall be capable of activating the supply of **fast fault current** either by: – ensuring the supply of the **fast fault current** at the connection point; or			

			– measuring voltage deviations at the terminals of the individual units of the power park module and providing a **fast fault current** at the terminals of these units;			
9.10.3	A20 (2bii) A2		(ii) the **DNO** in coordination with **NGET** shall specify: – how and when a voltage deviation is to be determined as well as the end of the voltage deviation; – 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 following methods; • voltage measured as the root-mean-square value of the positive sequence phase-to-phase voltages at fundamental frequency; • current measured by the root-mean-square value of the positive sequence of the phase current at fundamental frequency. – the timing and accuracy of the **fast fault current**, which may include several stages during a fault and after its clearance;			Current and Voltage Definitions included here from Article 2
9.10.4	A20 (2c)		With regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the **DNO** in coordination with **NGC** shall have the right to specify a requirement for asymmetrical current injection.			
9.11			**Additional Requirements**			
9.11.1	A20 (3a)		**Power park modules** connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of more than 1 MW (Type B and up) shall fulfil the following additional requirements in relation to robustness: (a) providing post-fault **active power** recovery to meet **the TSO's** specification including: (i) when the post-fault **active power** recovery begins, based on a voltage criterion; (ii) a maximum allowed time for **active power** recovery; and (iii) a maximum allowed time for **active power** recovery.			Outcome of Mod 4 required
9.11.2	A20 (3b)		(b) the specifications shall be in accordance with the following principles: (i) interdependency between **fast fault current** requirements according to Paragraphs 9.10.3t o 9.10.5 and active power recovery; (ii) dependence between **active power** recovery times and duration of voltage deviations; (iii) a specified limit of the maximum allowed time for **active power** recovery; (iv) adequacy between the level of voltage recovery and the minimum magnitude for **active power** recovery; and (v) adequate damping of active power oscillations.			

9.12		9.6	**Power Quality**			
9. 12.1		9.6.1	Introduction The connection and operation of **Power Generating Modules** may cause a distortion of the **Distribution Network** voltage waveform resulting in voltage fluctuations, harmonics or phase voltage unbalance.			
9. 12.2		9.6.2	Flicker Where the input motive power of the **Power Generating Module** may vary rapidly, causing corresponding changes in the output power, flicker may result. The operation of **a Power Generating Module** including synchronisation, run-up and desynchronisation shall not result in flicker that breaches the limits for flicker in EREC P28. The fault level of the **Distribution Network** needs to be considered to ensure that the emissions produced by the **Power Generating Module** do not cause a problem on the **Distribution Network**. The **DNO** will use these declared figures to calculate the required maximum supply impedance required for the connection to comply with EREC P28. This calculation may show that the voltage fluctuations will be greater than those permitted and hence reinforcement of the **Distribution Network** may be required before the **Power Generating Module** can be connected.			TT considered in G98. Reference to BS EN removed as only applies to ≤75A
9. 12.2. 1		9.6.2. 1	For wind turbines, flicker testing should be carried out during the performance tests specified in BS EN 61400-12. Flicker data should be recorded from wind speeds of $1ms^{-1}$ below cut-in to 1.5 times 85% of the rated power. The wind speed range should be divided into contiguous bins of $1ms^{-1}$ centred on multiples of $1ms^{-1}$. The dataset shall be considered complete when each bin includes a minimum of 10 minutes of sampled data. The highest recorded values across the whole range of measurements should be used as inputs to the calculations described in BS EN 61000-3-11 to remove back ground flicker values. Then the required maximum supply impedance values can be calculated as described in 13.1. Note that occasional very high values may be due to faults on the associated HV network and may be discounted, though care should be taken to avoid discounting values which appear regularly.			Maximum supply impedance calculation from Appendix 13.1 to be inserted here or change reference to BS EN 61000-3-11?

9. 12.2		9.6.2. 2	For technologies other than wind, the controls or automatic programs used shall produce the most unfavourable sequence of voltage changes for the purposes of the test.			
9. 12.3		9.6.3	Harmonic Emissions Harmonic voltages and currents produced within the **Power Generating Facility Owner**'s system may cause excessive harmonic voltage distortion in the **Distribution Network**. The **Power Generating Facility Owner**'s installation must be designed and operated to comply with the planning criteria for harmonic voltage distortion as specified in EREC G5. EREC G5, like all planning standards referenced in this recommendation, is applicable at the time of connection of additional equipment to a **Customer**'s **Installation**. The **DNO** will use these declared figures to calculate the required maximum supply impedance required for the connection to comply with BS EN 61000-3-12 and will use this data in their design of the connection for the **Power Generating Module**. This standard requires a minimum ratio between source fault level and the size of the **Power Generating Module**, and connections in some cases may require the installation of a transformer between 2 and 4 times the rating of the **Power Generating Module** in order to accept the connection to a **DNO's Distribution Network.** Alternatively, if the harmonic emissions are low and they are shown to meet the requirements of BS EN 61000-3-2 then there will be no need to carry out the fault level to **Power Generating Module** size ratio check. **Power Generating Module**s meeting the requirements of BS EN 61000-3-2 will need no further assessment with regards to harmonics.			TT considered in G98. Reference to BS EN's removed as not applicable to this document
9. 12.4		9.6.4	Where the **Power Generating Module** is connected via a long cable circuit the likelihood of a resonant condition is greatly increased, especially at 132kV. This arises from the reaction of the transformer inductance with the cable capacitance. Resonance is likely in the low multiples of the fundamental frequency (8th-11th harmonic). The resonant frequency is also a function of the **Total System** fault level. If there is the possibility that this can change significantly eg by the connection of another **Power Generating Module** then a full harmonic study should be carried out.			
9. 12.5		9.6.5	Voltage imbalance			

			EREC P29 is a planning standard which sets the **Distribution Network** compatibility levels for voltage unbalance caused by uneven loading of three phase supply systems. **Power Generating Module**s should be capable of performing satisfactorily under the conditions it defines. The existing voltage unbalance on an urban **Distribution Network** rarely exceeds 0.5% but higher levels, in excess of 1%, may be experienced at times of high load and when outages occur at voltage levels above 11kV. 1% may exist continuously due to unbalance of the system impedance (common on remote rural networks). In addition account can be taken of the neutralising effect of rotating plant, particularly at 11 kV and below.			
9. 12.6		9.6.6	The level of voltage unbalance at the **Point of Common Coupling** should be no greater than 1.3% for systems with a nominal voltage below 33kV, or 1% for other systems with a nominal voltage no greater than 132kV. Overall, voltage unbalance should not exceed 2% when assessed over any one minute period. EREC P29, like all planning standards, is applicable at the time of connection.			
9. 12.6. 1		9.6.6. 1	For **Power Generating Facilities** of 50kW or less section 7.5 of this document specifies maximum unbalance of **Power Generating Modules**. Where these requirements are met then no further action is required by the **Power Generating Facility Owner**.			
9. 12.7		9.6.7	Power factor correction equipment is sometimes used with asynchronous **Power Generating Module**s to decrease reactive power flows on the **Distribution Network**. Where the power factor correction equipment is of a fixed output, stable operating conditions in the event of loss of the **DNO** supply are extremely unlikely to be maintained, and therefore no special protective actions are required in addition to the standard protection specified in this document.			
9. 12.8		9.6.8	DC Injection The effects of, and therefore limits for, DC currents injected into the **Distribution Network** is an area currently under investigation by **DNO**s. Until these investigations are concluded the limit for DC injection is less than 0.25% of the AC rating per **Power Generating Module**. The main source of these emissions are from transformer-less **Inverters**. Where necessary DC emission requirements can be satisfied by installing a transformer on the AC side of an **Inverter**.			
9.13		9.7	**System Stability**			

9.13.1		9.7.1	Instability in **Distribution Networks** may result in unacceptable quality of supply and tripping of **Customer**'s plant. In severe cases, instability may cascade across the **Distribution Network**, resulting in widespread tripping and loss of demand and generation. There is also a risk of damage to plant.			
9. 13.2		9.7.2	In general, **System Stability** is an important consideration in the design of **Power Generating Module** connections to the **Distribution Network** at 33kV and above. Stability considerations may also be appropriate for some **Power Generating Module** connections at lower voltages. The risks of instability generally increase as **Power Generating Module** capacity increases relative to the fault level infeed from the **Distribution Network** at the **Connection Point**.			DPC7.4.5.1 covered
9. 13.3		9.7.3	**System Stability** may be classified into several forms, according firstly to the main system variable in which instability can be observed, and secondly to the size of the system disturbance. In **Distribution Networks**, the forms of stability of interest are rotor angle stability and voltage stability. Rotor angle stability refers to the ability of synchronous machines in an interconnected system to remain in **Synchronism** after the system is subjected to a disturbance. Voltage stability refers to the ability of a system to maintain acceptable voltages throughout the system after being subjected to a disturbance.			
9. 13.4		9.7.4	Both rotor angle stability and voltage stability can be further classified according to the size of the disturbance. Small-disturbance stability refers to the ability of a system to maintain stability after being subjected to small disturbances such as small changes in load, operating points of **Power Generating Module**s, transformer tap-changing or other normal switching events. Large-disturbance stability refers to the ability of a system to maintain stability after being subjected to large disturbances such as short-circuit faults or sudden loss of circuits or **Power Generating Module**s.			
9. 13.5		9.7.5	Traditionally, large-disturbance rotor angle stability (also referred to as transient stability) has been the form of stability predominantly of interest in **Distribution Network**s with synchronous machines. However, it should be noted that the other forms of stability may also be important and may require consideration in some cases.			

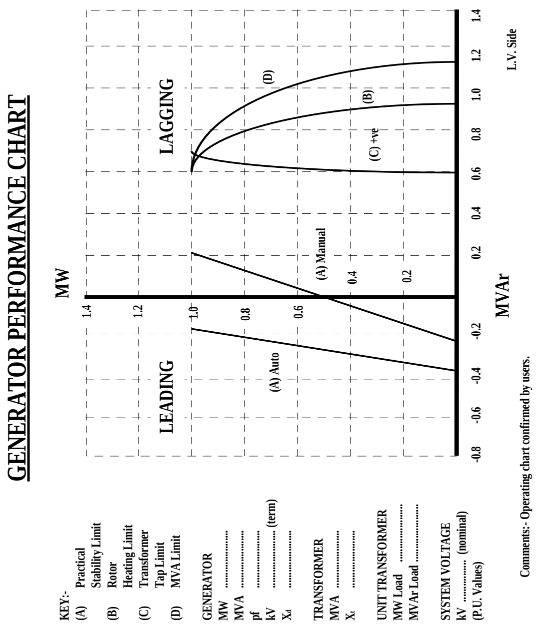
9. 13.6		9.7.6 DPC 7.4.5. 2	It is recommended that **a Power Generating Module** and its connection to the **Distribution Network** be designed to maintain stability of the **Distribution Network** for a defined range of initial operating conditions and a defined set of system disturbances. The range of initial operating conditions should be based on those which are reasonably likely to occur over a year of operation. Variables to consider include system loads, system voltages, system outages and configurations, and **Power Generating Module** operating conditions. The system disturbances for which stability should be maintained should be selected on the basis that they have a reasonably high probability of occurrence. It is recommended that these include short-circuit faults on single **Distribution Network** circuits (such as transformers, overhead lines and cables) and busbars, that are quickly cleared by main protection. With the **System** in its normal operating state, it is desirable that all **Power Generation Modules** remain connected and stable for any of the following credible fault outages, (a) any one single circuit overhead line, transformer feeder or cable circuit, independent of length, (b) any one transformer or reactor, (c) any single section of busbar at or nearest the point of connection where busbar protection with a total clearance time of less than 200ms is installed, (d) if demand is to be secured under a second circuit outage as required by ER P2/6, fault outages (a) or (b), overlapping with any pre-existing first circuit outage, usually for maintenance purposes. In this case the combination of circuit outages considered should be that causing the most onerous conditions for **System Stability**, taking account of the slowest combination of main protection, circuit breaker operating times and strength of the connections to the system remaining after the faulty circuit or circuits have been disconnected It should be noted that it is impractical and uneconomical to design for stability in all circumstances. This may include double circuit fault outages and faults that are cleared by slow protection. **Power Generating Module**s that become unstable following system disturbances should be disconnected as soon as possible.			
9. 13.7		DPC7 .4.5.3	Any **Generation Set** that causes the **System** to become unstable under fault conditions must be rapidly disconnected to reduce the risk of **Plant** damage and disturbance to the **System**.			

9. 13.8		9.7.7	Various measures may be used, where reasonably practicable, to prevent or mitigate system instability. These may include **Distribution Network** and **Power Generating Module** solutions, such as: • improved fault clearance times by means of faster protection; • improved performance of **Power Generating Module** control systems (excitation and governor/prime mover control systems; **Power System Stabilisers** to improve damping); • improved system voltage support (provision from either **Power Generating Module** or **Distribution Network** plant); • reduced plant reactance's (if possible); • Protection to identify pole-slipping; • increased fault level infeed from the **Distribution Network** at the **Connection Point**. In determining mitigation measures which are reasonably practicable, due consideration should be given to the cost of implementing the measures and the benefits to the **Distribution Network** and **Customers** in terms of reduced risk of system instability.			
9.14		9.8	**Island Mode**			
9. 14.1		9.8.1	A fault or planned outage, which results in the disconnection of a **Power Generating Module**, together with an associated section of **Distribution Network**, from the remainder of the **Total System**, creates the potential for island mode operation. It will be necessary for the **DNO** to decide, dependent on local network conditions, if it is desirable for the **Users** to continue to generate onto the islanded **DNO's Distribution Network**. The key potential advantage of operating in Island Mode is to maintain continuity of supply to the portion of the **Distribution Network** containing the **Power Generating Module**. The principles discussed in this section generally also apply where **Generation Plant** on a **Customer**'s site is designed to maintain supplies to that site in the event of a failure of the **DNO** supply.			Words from DPC 7.4.7 included.
9. 14.2		9.8.2	When considering whether **Power Generating Modules** can be permitted to operate in island mode, detailed studies need to be undertaken to ensure that the islanded system will remain stable and comply with all statutory obligations and relevant planning standards when separated from the remainder of the **Total System**. Before operation in island mode can be allowed, a contractual agreement between the **DNO** and **Power Generating Facility Owner** must be in place and the legal liabilities associated with such operation must be carefully considered by the **DNO** and the **Power Generating Facility Owner**. Consideration should be given to the following areas:			

			a. load flows, voltage regulation, frequency regulation, voltage unbalance, voltage flicker and harmonic voltage distortion; b. earthing arrangements; c. short circuit currents and the adequacy of protection arrangements; d. **System Stability**; e. resynchronisation to the **Total System**; f. safety of personnel.			
9. 14.3		9.8.3	Suitable equipment will need to be installed to detect that an island situation has occurred and an intertripping scheme is preferred to provide absolute discrimination at the time of the event. Confirmation that a section of **Distribution Network** is operating in island mode, and has been disconnected from the **Total System**, will need to be transmitted to the **Power Generating Module(s)** protection and control schemes.			
9. 14.4		9.8.4	The **ESQCR** requires that supplies to **Customers** are maintained within statutory limits at all times ie when they are supplied normally and when operating in island mode. Detailed system studies including the capability of the **Power Generating Module** and its control / protections systems will be required to determine the capability of the **Power Generating Module** to meet these requirements immediately as the island is created and for the duration of the island mode operation.			
9. 14.5		9.8.5	The ESQCR also require that **Distribution Networks** are earthed at all times. **Power Generating Facility Owner**s, who are not permitted to operate their installations and plant with an earthed star-point when in parallel with the **Distribution Network**, must provide an earthing transformer or switched star-point earth for the purpose of maintaining an earth on the system when islanding occurs. The design of the earthing system that will exist during island mode operation should be carefully considered to ensure statutory obligations are met and that safety of the **Distribution Network** to all users is maintained. Further details are provided in Section 8.			
9. 14.6		9.8.6	Detailed consideration must be given to ensure that protection arrangements are adequate to satisfactorily clear the full range of potential faults within the islanded system taking into account the reduced fault currents and potential longer clearance times that are likely to be associated with an islanded system.			

9. 14.7		9.8.7	Switchgear shall be rated to withstand the voltages which may exist across open contacts under islanded conditions. The **DNO** may require interlocking and isolation of its circuit breaker(s) to prevent out of phase voltages occurring across the open contacts of its switchgear. Intertripping or interlocking should be agreed between the **DNO** and the **Power Generating Facility Owner** where appropriate.			
9. 14.8		9.8.8	It will generally not be permissible to interrupt supplies to **DNO Customers** for the purposes of resynchronisation. The design of the islanded system must ensure that synchronising facilities are provided at the point of isolation between the islanded network and the **DNO** supply. Specific arrangements for this should be agreed and recorded in the **Connection Agreement** with the **DNO**. If no facilities exist for the subsequent resynchronisation with the rest of the **DNO's Distribution Network** then the **User** will under **DNO instruction**, ensure that the **Power Generating Module** is disconnected for re-synchronisation.			Words from DPC 7.4.7
9.15		DPC7 .4.8	**Black Start Capability** The National Electricity Transmission System will be equipped with Black Start Stations (in accordance with the Distribution Operating Code DOC 9). It will be necessary for each **User** to notify the **DNO** if its **Power Generating Module** has a restart capability without connection to an external power supply, unless the **User** shall have previously notified the **TSO** accordingly under the **Grid Code**. Such generation may be registered by the **TSO** as a Black Start Station.			
9.16		DPC7 .5	**Technical Requirements for Medium Power Stations** Where a **Generator** in respect of an **Embedded Power Statio**n is a party to the **CUSC** this section 9.14 will not apply.			DPC 7.5 included here in its entirety if banding requires it Medium power station to be reviewed. All references to Power Station to

						be reviewed
9.14.1.1		DPC7.5.2	In addition to the requirements in this document, the **DNO** has an obligation under CC 3.3 of the **Grid Code** to ensure that all relevant **Grid Code** Connection Condition requirements are met by **Medium Power Stations**. These requirements are summarised in CC 3.4 of the **Grid Code**. It is incumbent on **Medium Power Station** comply with the relevant **Grid Code** requirements listed in CC3.4 of the **Grid Code** as part of compliance with this **Distribution Code**. Note that a **DC Convertor** installation of capacity greater than 50MW and less than 100MW is considered to be a **Medium Power Station** for the purposes of **Grid Code** compliance.in this **Distribution code**			
9.14.1.2		DPC7.5.3	Where data is required by **NGC** from **Medium Power Station**s, nothing in the **Grid Code** or **Distribution Code** precludes the **Power Generating Facility Owner** from providing the information directly to **NGC** in accordance with **Grid Code** requirements. However, a copy of the information should always be provided in parallel to the **DNO**.			
9.14.2		DPC7.5.4.1	**Grid Code Connection Conditions Compliance** The technical designs and parameters of the **Embedded Medium Power Station**s will comply with the relevant Connection Conditions of the **Grid**. A statement to this effect, stating compliance with OC5.8 of the **Grid Code** is required to be presented to the **DNO** for onward transmission to **NGC**, before commissioning of the **Power Station**. Note that the statement might need to be resubmitted post commissioning when assumed values etc have been confirmed.			Statement of compliance is a defined RfG term. Need to review this once scope of doc clearer
9.14.2.1		DPC7.5.4.2	Should the **Power Generating Facility Owner** make any material change to such designs or parameters as will have any effect on the statement of compliance referred to in 9.14.2 the **Power Generating Facility Owner** must notify the change to the **DNO**, as soon as reasonably practicable, who will in turn notify **NGC**.			
9.14.2.2		DPC7.5.4.3	Tests to ensure **Grid Code** compliance may be specified by **NGC** in accordance with the **Grid Code**. It is the **Power Generating Facility Owner's** responsibility to carry out these tests.			

9.14.2.3		DPC7.5.4.4	Where **the TSO** can reasonably demonstrate that for **Total System** stability issues the **Medium Power Station** should be fitted with a **Power System Stabiliser**, **NGC** will notify the **DNO** who will then require it to be fitted for compliance with this section 9.14.2.3			
			FIGURE 1 			Would this figure be better located with Schedule 5a & 5b?
9.15		DPC4.4.1	**Specification of Equipment, Overhead Lines and Underground Cables** (a) The principles of design, manufacture, testing and installation of distribution **Equipment**, overhead lines and underground cables, including quality requirements, shall conform to applicable statutory obligations and shall comply with relevant **CENELEC** standards, **IEC** publications, European and British Standards. Further advice will be made available upon request to the **DNO**.			

			(b) The documents specified in paragraph (a) contain options for purchaser selection which together with other requirements that are necessary to meet **System** design needs, shall be specified so as to provide performances and ratings in line with **Electricity Supply Industry (ESI)** Technical Specifications (some of which are published as **Electricity Supply Industry (ESI)** Standards), British Electricity Board Specifications, Engineering Recommendations and Area Chief Engineers (ACE) Reports and Engineering Technical Reports and **Electricity Supply Industry (ESI)** documents as listed in Annex 1 of the **Distribution Code** or such other specifications as the **DNO** may adopt from time to time by agreement with the **Authority**. (c) The specifications of **Equipment**, overhead lines and cables shall be such as to permit **Operation** of the **DNO's Distribution Network** within the **Safety Management System** of the **DNO**, details of which will be made available by the **DNO** upon request. (d) **Equipment** shall be suitable for use at the operating **Frequency**, within the intended operating voltage range and at the design short-circuit rating of the **DNO's Distribution Network** to which it is connected having due regard to fault carrying capabilities and making and breaking duties. In appropriate circumstances, details of the **System** to which connection is to be made will be provided by the **DNO.** Guidance on the short circuit characteristics of the three phase **Low Voltage** system and associated supplies is provided in **Electricity Supply Industry** engineering publications, including Item 8 in DGD Annex 1 Engineering Recommendation P26/1, "The estimation of the maximum prospective short circuit current for three phase 415V supplies". (f) Cables**,** overhead lines transformers and other **Equipment** shall be operated within the thermal rating conditions contained in the appropriate standards, specifications, and other relevant publications, taking into account the intended use. Such information will be made available by the **DNO** upon request. (g) The standards, publications and specifications referred to in paragraphs (a) to (f) above are such standards, publications and specifications current at the time that the **Plant** and/or **Apparatus** was manufactured (and not commissioned) in the case of **Plant** and/or **Apparatus** on the **Total System**, or awaiting use or re-use. If any such **Plant/Apparatus** is subsequently moved to a new location or used in a different way, or for a different purpose, or is otherwise modified then such standards, publications and specifications current at the time that the **Plant** and/or **Apparatus** was manufactured (and not commissioned) will apply provided that in applying such standards, publications and specifications the **Plant** and/or **Apparatus** is reasonably fit for its intended purpose having due regard to the obligations of the **DNO** and the **User** under their respective licences. (h) All **Equipment** at the **Ownership Boundary** shall meet the design principles contained above. Connections for entry to and exit from the **DNO's Distribution Network** shall incorporate a means of disconnection of the **User's** installation by the **DNO**.			Remove clause (e) as 132kV Consider putting back re med incl

9.16		DPC6.7.1	**Communications and Telemetry Equipment** Where required by the **DNO** in order to ensure control of the **DNO's Distribution Network,** communications between **Users** and the **DNO** shall be established in accordance with the following. **Users** shall provide and maintain those parts of the communications equipment within their location. Provision of any necessary communications requirements shall be in accordance with the **Connection Agreement** for a specific connection.			
9.16.1		DPC6.7.2	**Primary Speech Facility** **Users** at their own cost shall provide and maintain equipment approved by the **DNO** by means of which routine and emergency communications may be established between the **User** and the **DNO**. Connection to the **DNO's** corporate telephone network and any circuit or circuits required to connect the **Users** with the point of connections shall be provided in accordance with the **Connection Agreement.** The facilities to be provided by the connection and the signalling and logical requirements for the interface between the **Users** equipment and the connection to the **DNO's** corporate telephone network will be specified in the **Connection Agreement.**			
9.16.2		DPC6.7.3	**Telemetry** The **User** shall provide such voltage, current, frequency, **Active Power** and **Reactive Power** pulses and outputs and status points from his **System** as are considered reasonable by the **DNO** to ensure adequate **System** monitoring. The telemetry outstation in such a situation will be provided, installed and maintained by the **DNO**.			
9.16.3		DPC6.7.4	**Telecontrol Outstation** If it is agreed between the parties that the **DNO** shall control the switchgear on the **User's System**, the **DNO** shall install the necessary telecontrol outstation. Notwithstanding the above, it shall be the responsibility of the **User** to provide the necessary control interface for the switchgear of the **User** which is to be controlled.			
9.16.4		DPC6.7.5	**Instructor Facilities** Where required by the **DNO**, the **User** shall provide accommodation for special instructor facilities specified by **DNO** for the receipt of operational messages.			

9.16.5		DPC6.7.6	**Data Entry Terminals** The **User** shall accommodate the **DNO's** data entry terminals for the purpose of information exchange.			
9.16.6		DPC6.7.7	**System Monitoring** Monitoring equipment is provided on the **DNO's Distribution Network** to enable the **DNO** to monitor dynamic performance conditions. Under the requirements of the **Grid Code**, **Generation Sets** and **Power Stations** will need to provide signals for monitoring purposes. Where this monitoring equipment requires input signals from the **User's** side of the **DNO/User Ownership Boundary**, the **User** shall be responsible for the provision of suitable signals in accordance with the **Connection Agreement.**			

#Purple text = from G59

Orange text = from RfG (June 2015)

Green text = from other EU documents referenced by RfG

Blue text = from Distribution Code

Black text = Changes/ additional words

Red text = Words that may/ will need changing

The aim of this document initially is to identify the sections that apply to non TT units, Type A and Type B Gens. This document presently considers small, medium and large power generating modules, depending on where the final B to C banding threshold falls (and the exact extent of this document). It may be that medium power generating modules are not needed in this document.

The document is broken down into a separate file for each section (or 2 sections if they are small) to make it more manageable for people to review and work upon.

Clauses from TS 505491 & 2, and the impact of these are not yet included in this document.

Please note this document uses the term “DNO”, this may be changed to DSO subject to discussion. The document also uses the terms Type A and Type B from RfG, but these may be removed if it is decided that these are not required.

Other Nomenclature proposed (eg Power Generating Module) is open for discussion and is outlined in the associated “Nomenclature Discussion” document.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10 10.1		10	**10 PROTECTION** **10.1 General**			
10.1.1		10.1.1	The main function of the protection systems and settings described in this document is to prevent the **Power Generating Module** supporting an islanded section of the **Distribution Network** when it would or could pose a hazard to the **Distribution Network** or **Customers** connected to it. The settings recognize the need to avoid nuisance tripping and therefore require a two stage approach where practicable, ie to have a long time delay for smaller excursions that may be experienced during normal **Distribution Network** operation, to avoid nuisance tripping, but with a faster trip, where possible, for greater excursions.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.1.2		10.1.2	In accordance with established practice it is for the **Generator** to install, own and maintain this protection. The **Generator** can therefore determine the approach, ie per **Power Generating Module** or per installation, and where in the installation the protection is sited. Where a common protection system is used to provide the protection function for multiple **Power Generating Module**s the complete installation cannot be considered to comprise **Type Tested Power Generating Module**s as the protection and connections are made up on site and so cannot be factory tested or **Type Tested**.			Clarifies what counts as TT and not TT,
10.1.3		10.1.3	In exceptional circumstances additional protection may be required by the **DNO** to protect the **Distribution Network** and its **Customers** from the **Power Generating Module**.			
10.1.4		DPC4.4.4	(a) The **DNO's Distribution Network** and the **System** of any **User** connected to the **DNO's Distribution Network** shall incorporate protective devices in accordance with the requirements of the **ESQCR**. (b) In order to ensure satisfactory operation of the **DNO's Distribution Network**, **Protection** systems, operating times, discrimination, and sensitivity across the **Ownership Boundary**, as well as testing and maintenance regimes, shall be agreed between the **DNO** and the **User** during the application for connection process, and may be reviewed from time to time by the **DNO**, with the concurrence of the **User.** (c) In order to cover a circuit breaker, or **Equipment** having a similar function, failing to operate correctly to interrupt fault current on a **HV System,** back-up protection by operation of other circuit breakers or **Equipment** having a similar function must normally be provided. The **DNO** will advise the **User** if the same is not required. If the **Equipment** providing the back-up protection is owned by the **DNO**, then this **Protection** may be limited to that needed to meet statutory requirements in respect of the **DNO's Distribution Network.** (d) Unless the **DNO** should advise otherwise, it is not acceptable for **Users** to limit the fault current infeed to the **DNO's Distribution Network** by the use of **Protection** and associated **Equipment** if the failure of that **Protection** and associated **Equipment** to operate as intended in the event of a fault, could cause **Equipment** owned by the **DNO** to operate outside its short-circuit rating.			DPC 4 relevant sections included for completeness and usability of document. For discussion. Option to make this specific to Power generating module (or term agreed) rather than User as was

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						needed in DCode
10.1.5		DPC6.3	**Protection** requirements vary widely depending on established practices and the needs of the particular **DNO's Distribution Network.** The basic requirement in all cases is that **Users'** arrangements for **Protection** at the **Ownership Boundary**, including types of **Equipment** and **Protection** settings, must be compatible with standards and practices on the **DNO's Distribution Network**, maintaining necessary operating times, sensitivity, discrimination and co-ordination, as specified by the **DNO** during the application for connection process and which may be reviewed from time to time and complied with by the **User**. In particular maximum fault clearance times (from fault current inception to arc extinction) must be within the limits established by the **DNO** in accordance with **Protection** and **Equipment** short circuit rating policy adopted for the **DNO's Distribution Network**.			(b) and (c) covered elsewhere
10.1.6		DPC4.2.4	**Auto-reclosing and Single Phase Protection Operation** In connecting to the **DNO's Distribution Network** the **User** should be aware that auto-reclosing or sequential switching features may be in use on the **DNO's Distribution Network**. The **DNO** will on request provide details of the auto-reclosing or sequential switching features in order that the **User** may take this into account in the design of the **User System**, including **Protection** arrangements. **Users** should be aware that the **Protection** arrangements on some **Distribution Networks** may cause disconnection of one phase or two phases only of a three phase supply for certain types of fault.			
10.1.7		DPC7.4.3.1	**Co-ordinating with Existing Protection** It will be necessary for the **Protection** associated with **Embedded Power Generating Modules** to co-ordinate with the **Protection** associated with the **DNO's Distribution network** as follows:- (a) For **Power Generating Modules directly** connected to the **DNO's Distribution Network** the **Embedded Power Generating Module** must meet the target clearance times for fault current interchange with the **DNO's Distribution Network** in order to reduce to a minimum the impact on the **DNO's Distribution Network** of faults on circuits owned by **Embedded Power Generating Modules**. The **DNO** will ensure that the **DNO Protection** settings meet its own target clearance times.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			The target clearance times are measured from fault current inception to arc extinction and will be specified by the **DNO** to meet the requirements of the relevant part of the **Distribution Network**. (b) The settings of any **Protection** controlling a circuit breaker or the operating values of any automatic switching device at any point of connection with the **DNOs Distribution Network**, as well as the **User's** maintenance and testing regime, shall be agreed between the **DNO** and the **User** in writing during the connection consultation process. (c) It will be necessary for the **Power Generating Module Protection** to co-ordinate with any auto-reclose policy specified by the **DNO**. In particular the **Power Generating Module Protection** should detect a loss of mains situation and disconnect the **Power Generating Module** in a time shorter than any auto reclose dead time. This should include an allowance for circuit breaker operation and generally a minimum of 0.5s should be allowed for this. For pole mounted auto-reclosers often set with a dead time of 1s, this implies a loss of mains response time of 0.5s. Similar response time is expected from under and over voltage relays.			Repetition removed from 10.5.10
10.1.8		DPC7.4.3.2	Specific **Protection** Required for **Embedded Power Generating Modules** In addition to any **Protection** installed by the **Generator** to meet his own requirements and statutory obligations on him, the **Generator** must install **Protection** to achieve the following objectives: i. For all **Power Generating Modules**: a. To disconnect the **Power Generating Module** from the **System** when a **System** abnormality occurs that results in an unacceptable deviation of the **Frequency** or voltage at the **Connection Point** ; b. To ensure the automatic disconnection of the **Power Generating Module**, or where there is constant supervision of an installation, the operation of an alarm with an audio and visual indication, in the event of any failure of supplies to the protective equipment that would inhibit its correct operation. ii. For polyphase **Power Generating Module**			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			a. To inhibit connexion of **Power Generating Modules** to the **System** unless all phases of the **DNO's Distribution Network** are present and within the agreed ranges of **Protection** settings; b. To disconnect the **Power Generating Module** from the **System** in the event of the loss of one or more phases of the **DNO's Distribution Network**; iii. For single phase **Power Generating Modules** a. To inhibit connexion of **Power Generating Modules** to the **System** unless that phase of the **DNO's Distribution Network** is present and within the agreed ranges of **Protection** settings; b. To disconnect the **Power Generating Module** from the **System** in the event of the loss of that phase of the **DNO's Distribution Network** ;			
10.2		10.2	**10.2 Protection Requirements**			
10.2.1		10.2.1 DPC7.4.3.3	Suitable **Protection** arrangements and settings will depend upon the particular **Power Generation Facility Owners** installation and the requirements of the **DNO's Distribution Network**. These individual requirements must be ascertained in discussions with the **DNO**. To achieve the objectives above, the **Protection** must include the detection of: . • UnderVoltage (1 stage); • OverVoltage (2 stage); • UnderFrequency (2 stage); • OverFrequency (1 stage); • Loss of Mains (LoM). The LoM protection will depend for its operation on the detection of some suitable parameter, for example, rate of change of frequency (RoCoF), phase angle change or unbalanced voltages. More details on LoM protection are given in Section 10.3.	Y	Y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			There are different **Protection** settings dependent upon the **System** voltage at which the **Power Generating Module** is connected (LV or HV). **Protection** settings for Type C and D **Generating Modules** and any connexion at 132kV must be considered on an individual basis and be consistent with **Grid Code** requirements. Loss of Mains protection will only be permitted at these sites if sanctioned by the **TSO**– see section 10.5.2 below. It is in the interest of **Generators**, **DNO**s and **NETSO** that **Power Generating Modules** remains synchronised to the **Distribution Network** during system disturbances, and conversely to disconnect reliably for true LoM situations. Frequency and voltage excursions less than the protection settings should not cause protection operation. As some forms of LoM protection might not readily achieve the required level of performance (eg under balanced load conditions), the preferred method for **Type C** and **Type D Power Generating Modules** is by means of intertripping. This does not preclude consideration of other methods that may be more appropriate for a particular connection.			
10.2.2		10.2.2	10.2.2 The protective equipment, provided by the **Generator**, to meet the requirements of this section must be installed in a suitable location that affords visual inspection of the protection settings and trip indicators and is secure from interference by unauthorised personnel.			
10.2.3	A14 (4b)	10.2.3	10.2.3 Installation of automatic reconnection systems shall be subject to prior authorisation by the **DNO**. If automatic resetting of the protective equipment is used, there must be a time delay to ensure that healthy supply conditions exist for a minimum continuous period of 20s. Reset times may need to be co-ordinated where more than one **Power Generating Module** is connected to the same feeder. The automatic reset must be inhibited for faults on the **Generator**'s installation.			
10.2.4		10.2.4	10.2.4 Protection equipment is required to function correctly within the environment in which it is placed and shall satisfy the following standards: • BS EN 61000 (Electromagnetic Standards) • BS EN 60255 (Electrical Relays); • BS EN 61810 (Electrical Elementary Relays); • BS EN 60947 (Low Voltage Switchgear and Control gear); • BS EN 60044 (Instrument Transformers).			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.			
10.2.5		DPC4.4.5	**Superimposed Signals** Where **Users** install mains borne signalling equipment it shall comply with BS EN50065 as amended from time to time. Where a **User** proposes to use such equipment to superimpose signals on the **DNO's Distribution Network**, the prior agreement of the **DNO** is required.			
10.2.6		10.2.5	10.2.5 Protection equipment and protection functions may be installed within, or form part of the **Power Generating Module** control equipment as long as: a. the control equipment satisfies all the requirements of Section 10 including the relevant standards specified in 10.2.4. b. the **Power Generating Module** shuts down in a controlled and safe manner should there be an equipment failure that affects both the protection and control functionality, for example a power supply failure or microprocessor failure. c. the equipment is designed and installed so that protection calibration and functional tests can be carried out easily and safely using secondary injection techniques (ie using separate low voltage test equipment).	Y	Y	Reference to TT not required.
10.3		10.3	**10.3 Loss of Mains (LoM)**			
10.3.1		10.3.1	10.3.1 To achieve the objectives of Section 10.1.1, in addition to protection installed by the **Generator** for his own purposes, the **Generator** must install protection to achieve (amongst other things) disconnection of the **Power Generating Module** from the **Distribution Network** in the event of loss of one or more phases of the **DNO**s supply. This LoM protection is required to ensure that the **Power Generating Module** is disconnected, to ensure that the requirements for **Distribution Network** earthing, and out-of-**Synchronism** closure are complied with and that **Customers** are not supplied with voltage and frequencies outside statutory limits.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.3.2		10.3.2	10.3.2 LoM is mandatory for all **Type A** and **Type B Power Generating Modules**. For **Type C** and **Typed C Power Generating Modules** the **DNO** will advise if LoM is required. The requirements of 10.5.2 apply to LoM protection for all **Power Generating Modules.**			
10.3.3		10.3.3	10.3.3 A problem can arise for **Generator**s who operate a **Power Generating Module** in parallel with the **Distribution Network** prior to a failure of the network supply because if their **Power Generating Module** continues to operate in some manner, even for a relatively short period of time, there is a risk that when the network supply is restored the **Power Generating Module** will be out of **Synchronism** with the **Total System** and suffer damage. LoM protection can be employed to disconnect the **Power Generating Module** immediately after the supply is lost, thereby avoiding damage to the **Power Generating Module**.			
10.3.4		10.3.4	10.3.4 Many **Customers** are connected to parts of **Distribution Networks** which will be automatically re-energised within a relatively short period following a fault; with dead times typically between 1s and 180s. The use of such schemes is likely to increase in the future as **DNO**s seek to improve supply availability by installing automatic switching equipment on their **Distribution Network**s.			
10.3.5		10.3.5	10.3.5 Where the amount of **Distribution Network** load that the **Power Generating Module** will attempt to pick up following a fault on the **Distribution Network** is significantly more than its capability the **Power Generating Module** will rapidly disconnect, or stall. However depending on the exact conditions at the time of the **Distribution Network** failure, there may or may not be a sufficient change of load on the **Power Generating Module** to be able to reliably detect the failure. The **Distribution Network** failure may result in one of the following load conditions being experienced by the **Power Generating Module** : a. The load may slightly increase or reduce, but remain within the capability of the **Power Generating Module**. There may even be no change of load; b. The load may increase above the capability of the prime mover, in which case the **Power Generating Module** will slow down, even though the alternator may maintain voltage and current within its capacity. This condition of speed/frequency reduction can be easily detected; or c. The load may increase to several times the capability of the **Power Generating Module** , in which case the following easily detectable conditions will occur:			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			• Overload and accompanying speed/frequency reduction • Over current and under voltage on the alternator			
10.3.6		10.3.6	10.3.6 Conditions (b) and (c) are easily detected by the under and over voltage and frequency protection required in this document. However Condition (a) presents most difficulty, particularly if the load change is extremely small and therefore there is a possibility that part of the **Distribution Network** supply being supplied by the **Power Generating Module** will be out of **Synchronism** with the **Total System**. LoM protection is designed to detect these conditions. In some particularly critical circumstances it may be necessary to improve the dependability of LoM detection by using at least two LoM techniques operating with different principles or by employing a LoM relay using active methods.			
10.3.7		10.3.7	10.3.7 LoM signals can also be provided by means of intertripping signals from circuit breakers that have operated in response to the **Distribution Network** fault.			
10.3.8		10.3.8	10.3.8 The LoM protection can utilise one or a combination of the passive protection principles such as reverse power flow, reverse reactive power, rate of change of frequency (RoCoF) and voltage vector phase shift. Alternatively, active methods such as reactive export error detection or frequency shifting may be employed. These may be arranged to trip the interface circuit breaker at the **DNO Generator** interface, thus, leaving the **Power Generating Module** available to satisfy the load requirements of the site or the **Power Generating Module** circuit breaker can be tripped, leaving the breaker at the interface closed and ready to resume supply when the **Distribution Network** supply is restored. The most appropriate arrangement is subject to agreement between the **DNO** and **Generator**.			
10.3.9		10.3.9	10.3.9 Protection based on measurement of reverse flow of real or reactive power can be used when circumstances permit and must be set to suit the **Power Generating Module** rating, the site load conditions and requirements for reactive power.			
10.3.10		10.3.10	10.3.10 Where the **Power Generating Module** capacity is such that the site will always import power from the **Distribution Network**, a reverse power relay may be used to detect failure of the supply. It will usually be appropriate to monitor all three phases for reverse power.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.3.11		10.3.11	10.3.11 However, where the **Power Generating Module**s normal mode of operation is to export power, it is not possible to use a reverse power relay and consequently failure of the supply cannot be detected by measurement of reverse power flow. The protection should then be specifically designed to detect loss of the mains connection using techniques to detect the rate of change of frequency or sudden phase shifts of voltage vector and/or power factor. All these techniques are susceptible to **Distribution Network** conditions and the changes that occur without islanding taking place. These relays must be set to prevent islanding but with the best possible immunity to unwanted nuisance operation.			
10.3.12		10.3.12	10.3.12 Both RoCoF and vector phase shift relays use a measurement of the period of the mains voltage cycle. The RoCoF technique measures the rate of change in frequency caused by any difference between prime mover power and electrical output power of the embedded **Power Generating Module** over a number of cycles. RoCoF relays should normally ignore the slow changes but respond to relatively rapid changes of frequency which occur when the **Generation Plant** becomes disconnected from the **Total System**. The voltage vector shift technique tries to detect the shift in the voltage vector caused by a sudden change in the output of **Power Generating Module** or load over one or two cycles (or half cycles). The main advantage of a vector shift relays is its speed and response to transient disturbances which are common to the onset of islanding but often difficult to quantify. Speed of response is also very important where high speed auto reclosing schemes are present.			
10.3.13		10.3.13	10.3.13 OIt is recognized that the steady evolution of the GB Transmission System, particularly with the displacement of traditional steam powered turbo alternators by renewable generation, the concomitant reduction in system inertia is leading to greater volatility of system frequency. This volatility and its implications for loss of mains protection systems is being kept under review by National Grid and the DNOs. Nevertheless the settings required in this current G99 document are believed to be appropriate for the long term.			TT discussion not required in G99 Review RoCoF

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.3.14		10.3.14	10.3.14 The LoM relay that operates on the principle of voltage vector shift can achieve fast disconnection for close up **Distribution Network** faults and power surges, and under appropriate conditions can also detect islanding when normally a large step change in generation occurs. The relay measures the period for each half cycle in degrees and compares it with the previous one to determine if this exceeds its setting. A typical setting is 6 degrees, which is normally appropriate to avoid operation for most normal vector changes in low impedance **Distribution Network**s. This equates to a constant rate of change of frequency of about 1.67 $Hzs^{-1}$and hence the relay is insensitive to slow rates of change of frequency. When vector shift relays are used in higher impedance **Distribution Network** s, and especially on rural **Distribution Network** s where auto-reclosing systems are used, a higher setting may be required to prevent nuisance tripping. Typically this is between 10 and 12 degrees.			TT discussion not required in G99
		10.3.15				Not needed as covered in 10.5.2 of this document
10.3.15		10.3.16	10.3.16 Raising settings on any relay to avoid spurious operation may reduce a relay's capability to detect islanding and it is important to evaluate fully such changes. Appendix 13.x provides some guidance for assessments, which assume that during a short period of islanding the trapped load is unchanged. In some circumstances it may be necessary to employ a different technique, or a combination of techniques to satisfy the conflicting requirements of safety and avoidance of nuisance tripping. In those cases where the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping.			TT discussion not required in G99
10.3.16		10.3.17	10.3.17 For a radial or simple **Distribution Network** controlled by circuit breakers that would clearly disconnect the entire circuit and associated **Power Generating Module**, for a LoM event an intertripping scheme can be easy to design and install. For meshed or ring **Distribution Network**s, it can be difficult to define which circuit breakers may need to be incorporated in an intertripping scheme to detect a LoM event and the inherent risks associated with a complex system should be considered alongside those associated with a using simple, but potentially less discriminatory LoM relay.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.3.17		10.3.18	10.3.18 It is the responsibility of the **Generator** to incorporate the most appropriate technique or combination of techniques to detect a LoM event in his protection systems. This will be based on knowledge of the **Power Generating Module,** site and network load conditions. The **DNO** will assist in the decision making process by providing information on the **Distribution Network** and its loads. The settings applied must be biased to ensure detection of islanding under all practical operating conditions.			
10.4		10.4	**10.4 Additional DNO Protection** Following the **DNO** connection study, the risk presented to the **Distribution Network** by the connection of a **Power Generating Module** may require additional protection to be installed and may include the detection of: • Neutral Voltage Displacement (NVD); • Over Current; • Earth Fault; • Reverse Power. This protection will normally be installed on equipment owned by the **DNO** unless otherwise agreed between the **DNO** and **Generator**. This additional protection may be installed and arranged to operate the **DNO** interface circuit breaker or any other circuit breakers, subject to the agreement of the **DNO** and the **Generator**. The requirement for additional protection will be determined by each **DNO** according to size of **Power Generating Module**, point of connection, network design and planning policy. This is outside the scope of this document. When intertripping is considered to be a practical alternative, for detecting a LoM event, to using discriminating protection relays, the intertripping equipment would be installed by the **DNO**.	Y	Y	
10.4.1		10.4.1	10.4.1 Neutral Voltage Displacement (NVD) Protection Section 9.9.6 states that the **DNO** will undertake detailed consideration to ensure that protection arrangements are adequate to satisfactorily clear the full range of potential faults within an islanded system.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Section 10.3 describes LoM protection which the **Generator** must install to achieve (amongst other things) disconnection of the **Power Generating Module** from the **Distribution Network** in the event of loss of one or more phases of the **DNO**s supply. Where a **Power Generating Module** inadvertently operates in island mode, and where there is an earth fault existing on the **DNO**'s **HV Distribution Network** NVD protection fitted on the **DNO**s **HV** switchgear will detect the earth fault, and disconnect the **HV** system from the island. **DNO**s need to consider specific investigation of the need for NVD protection when, downstream of the same prospective island boundary, there are one or more **Power Generating Module**s (with an output greater than 200kVA per unit) having the enabled capacity to dynamically alter real and reactive power output in order to maintain voltage profiles, and where such aggregate embedded generation output exceeds 50% of prospective island minimum demand.			
10.4.2		10.4.2	10.4.2 As a general rule for generation installations connected at 20kV or lower voltages **DNO**s will not require NVD protection for the following circumstances: • Single new **Power Generating Module** connection, of any type with an output less than 200kVA; • Multiple new **Power Generating Module** connections, of any type, on a single site, with an aggregated output less than 200kVA; • Single or multiple new **Power Generating Module** connections, of any type, where the voltage control is disabled or not fitted, on a single site, and where the aggregate output is greater than 200kVA ; • Single or multiple new **Power Generating Module** connections, of any type, and where the voltage control is enabled, on a single site, where the aggregate output is greater than 200kVA, but where the aggregate output is less than 50% of the prospective island minimum demand. It should be noted that above is a "general rule"; each **DNO** will have differing network designs and so the decision will be made by the **DNO** according to size of **Power Generating Module**, point of connection, network design and planning policy. This is outside the scope of this document.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.4.3		10.4.3	10.4.3 If the assessed minimum load on a prospective island is less than twice the maximum combined output of new **Power Generating Module** consideration should be given to use of NVD protection as a part of the **Interface Protection**. The consideration should include an assessment of: a. The specification of capability of the LoM protection, including the provision of multiple independent detection techniques; b. The influence of activation of pre-existing NVD protection already present elsewhere on the same prospective island; c. The opportunity arising from asset change/addition associated with the proposed new Power Generating Module connection eg the margin of additional cost associated with NVD protection.	Y	Y	
10.5 10.5.1		10.5	**10.5 Protection Settings** The following notes aim to explain the settings requirements as given in Section 10.5.7.1 below.			
						Removed as superceeded by RfG requirements
10.5.2		10.5.2	10.5.2 A LoM protection of RoCoF or vector shift type will generally be appropriate for **Type A and Type B Power Generating Modules**, but this type of LoM protection must not be installed for **Power Generating Facilities** at or above 50 MW. In those cases where the **DNO** requires LoM protection this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping. See note in section 10.3.13 about the future long term unsuitability of RoCoF protection.			DPC7.4.3.8
10.5.3		10.5.3	10.5.3 Under Voltage			No FRT requireme

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			In order to help maintain **Total System Stability**, the protection settings should be such as to facilitate transmission fault ride through capability). The overall aim is to ensure that **Power Generating Module** is not disconnected from the **Distribution Network** unless there is material disturbance on the **Distribution Network**, as disconnecting generation unnecessarily will tend to make an under voltage situation worse. To maximize the transmission fault ride through capability a single undervoltage setting of 13% with a time delay of 2.5s [			nt in RfG on Type A gen so keep GB words for FRT for Type A gen. The FRT WG is looking into changing the Gcode to come in line with RfG. Some Type B gen requirements apply to some Large PS in SHETL and SPT
10.5.4		10.5.4	10.5.4 Over Voltage			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Over voltages are potentially more dangerous than under voltages and hence the acceptable excursions form the norm are smaller and time delays shorter, a 2-Stage over voltage protection[1] is to be applied as follows: • Stage 1 (**LV**) should have a setting of +14% (ie the **LV** statutory upper voltage limit of +10%,with a further 4% permitted for voltage rise internal to the **Customer**'s installation and measurement errors),with a time delay of 1.0s (to avoid nuisance tripping for short duration excursions); • Stage 2 (**LV**) should have a setting of +19% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion); • Stage 1 (**HV**) should have a setting of +10% with a time delay of 1.0s (ie the **HV** statutory upper voltage limit of +6%,with a further 4% permitted for voltage rise internal to the **Customer's Installation** and measurement errors),, with a time delay of 1.0s to avoid nuisance tripping for short duration excursions); • Stage 2 (**HV**) should have a setting of +13% with a time delay of 0.5s (ie recognising the need to disconnect quickly for a material excursion). To achieve high utilisation and **Distribution Network** efficiency, it is common for the **HV Distribution Network** to be normally operated near to the upper statutory voltage limits. The presence of **Power Generating Module** within such **Distribution Network** may increase the risk of the statutory limit being exceeded, eg when the **Distribution Network** is operating abnormally. In such cases the **DNO** may specify additional over voltage protection at the **Power Generating Module** connection point. This protection will typically have an operating time delay long enough to permit the correction of transient over voltages by automatic tap-changers.			
10.5.5		10.5.5	10.5.5 Over Frequency			RfG requirement is for 51.5Hz – 52Hz

[1] Over Voltage Protection is not intended to maintain statutory voltages but to detect islanding

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td>Power Generating Modules are required to stay connected to the Total System for frequencies up to 52 Hz for up to 15 minutes so as to provide the necessary regulation to control the Total System frequency to a satisfactory level. . In order to prevent the unnecessary disconnection of a large volume of smaller Power Generating Module for all LV and HV connected Power Generating Module a single stage protection is to be applied that has a time delay of 0.5s and a setting of 52 Hz If the frequency rises to or above 52 Hz as the result of an undetected islanding condition, the Power Generating Module will be disconnected with a delay of 0.5s plus circuit breaker operating time.</td><td></td><td></td><td>withstand of 15 minutes</td></tr>
<tr><td>10.5.6</td><td></td><td>10.5.6</td><td>10.5.6 Under Frequency

Section 9.3 requires all Power Generating Facilities to maintain connection unless the Total System frequency falls below 47.5 Hz for 20s or below 47 Hz.

For all LV and HV connected Power Generating Module , the following 2-stage under frequency protection should be applied:

• Stage 1 should have a setting of 47.5 Hz with a time delay of 20s;

• Stage 2 should have a setting of 47.0 Hz with a time delay of 0.5s;

• These settings are in line with the Distribution Code requirements.</td><td></td><td></td><td>Time delay to avoid nuisance trips</td></tr>
<tr><td>10.5.7</td><td></td><td>10.5.7</td><td>10.5.7 Loss of Mains (LoM)

In order to avoid unnecessary disconnection of Power Generating Module during Distribution Network faults or switching events and the consequent disruption to Generators and customers, as well as take into account the aggregate effect caused by multiple LoM operations on Total System Stability, consideration should be given to use of the appropriately sensitive settings which can be adjusted to take into account Power Generating Module type & rating and Distribution Network fault level. Example setting formulae are indicated in the notes below the Table 10.5.7.1.</td><td></td><td></td><td></td></tr>
<tr><td>10.5.7.1</td><td></td><td>10.5.7.1</td><td>10.5.7.1 Settings for Long-Term Parallel Operation
<table><tr><th></th><th>Type A and Type B Power Generating Modules</th><th>Type C and Type D PGMs</th></tr></table></td><td>Y</td><td>Y</td><td>RfG has 15 min withstand requireme</td></tr>
</table>

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th rowspan="2">Prot Function</th><th colspan="2">LV Protection(1)</th><th colspan="2">HV Protection(1)</th><th colspan="2"></th></tr>
<tr><th>Setting</th><th>Time</th><th>Setting</th><th>Time</th><th>Setting</th><th>Time</th></tr>
<tr><td>U/V</td><td>Vφ-n† -13% = 200.1V</td><td>2.5s*</td><td>Vφ-φ‡ -13%</td><td>2.5s*</td><td>Vφ-φ‡- 20%</td><td>2.5s*</td></tr>
<tr><td>O/V st 1</td><td>Vφ-n† + 14% =262.2V</td><td>1.0s</td><td>Vφ-φ‡ + 10%</td><td>1.0s</td><td>Vφ-φ‡ + 10%</td><td>1.0s</td></tr>
<tr><td>O/V st 2</td><td>Vφ-n†+ 19% =273.7V$</td><td>0.5s</td><td>Vφ-φ‡ + 13%</td><td>0.5s</td><td></td><td></td></tr>
<tr><td>U/F st 1</td><td>47.5Hz</td><td>20s</td><td>47.5Hz</td><td>20s</td><td>47.5Hz</td><td>20s</td></tr>
<tr><td>U/F st 2</td><td>47.0Hz</td><td>0.5s</td><td>47.0Hz</td><td>0.5s</td><td>47.0Hz</td><td>0.5s</td></tr>
<tr><td>O/F</td><td>52.0 Hz</td><td>0.5s</td><td>52.0Hz</td><td>0.5s</td><td>52.0Hz</td><td>0.5s</td></tr>
<tr><td>LoM (Vector Shift)</td><td colspan="2">K1 x 6 degrees</td><td colspan="2">K1 x 6 degrees#</td><td colspan="2">Intertripping expected</td></tr>
<tr><td>LoM (RoCoF)</td><td colspan="2">1 Hzs^{-1} time delay 0.5s</td><td colspan="2">1 Hzs^{-1} time delay 0.5s</td><td colspan="2">Intertripping expected</td></tr>
</table>
(1) HV and LV Protection settings are to be applied according to the voltage at which the voltage related protection reference is measuring, eg:
• If the EREC G99 protection takes its voltage reference from an LV source then LV settings shall be applied. Except where a private none standard LV network exists, in this case the settings shall be calculated from HV settings values as indicated by section 10.5.16;
• If the EREC G99 protection takes its voltage reference from an HV source then HV settings shall be applied.
†A value of 230V shall be used in all cases for Power Generating Facilities connected to a DNO's LV Distribution Network
‡A value to suit the nominal voltage of the HV system connection point.
* Might need to be reduced if auto-reclose times are <3s. (see 10.5.13).
# Intertripping may be considered as an alternative to the use of a LoM relay
$ For voltages greater than 230V +19% which are present for periods of<0.5s the Power Generating Module is permitted to reduce/cease exporting in order to protect the Power Generating Module.
(2) LOM constants
K1 = 1.0 (for low impedance networks) or 1.66 – 2.0 (for high impedance networks)
</td><td></td><td></td><td>nt for 51.5-52Hz. 52Hz trip in 0.5s is beyond requirement of RfG. Medium PGF requirements will probably be removed following final banding decision.

DPC7.4.3.4

Asynchronous FRT requirements conflict with G59 settings for stage 2 undervoltage protection.</td></tr>
</table>

<table>
<tr><th>New doc</th><th>RfG</th><th>G59</th><th>G59</th><th><1MW</th><th><50MW</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td>
The LoM function shall be verified by confirming that the LoM tests specified in 13.8 have been completed successfully
(3) Note that the times in the table are the time delays to be set on the appropriate relays. Total protection operating time from condition initiation to circuit breaker opening will be of the order of 100ms longer than the time delay settings in the above table with most circuit breakers, slower operation is acceptable in some cases.
The Manufacturer must ensure that the Interface Protection in a Type Tested Power Generating Module is capable of measuring voltage to an accuracy of ±1.5% of the nominal value and of measuring frequency to ± 0.2% of the nominal value across its operating range of voltage, frequency and temperature.
</td><td></td><td></td><td></td></tr>
<tr><td>10.5.7.2</td><td></td><td>10.5.7.2</td><td>
10. 5.7.2 – Settings for Infrequent Short-Term Parallel Operation
<table>
<tr><th rowspan="3">Prot Function</th><th colspan="4">Small Power Generating Facility</th></tr>
<tr><th colspan="2">LV Protection</th><th colspan="2">HV Protection</th></tr>
<tr><th>Setting</th><th>Time</th><th>Setting</th><th>Time</th></tr>
<tr><td>U/V</td><td>Vφ-n† -10%
= 207V</td><td>0.5s</td><td>Vφ-φ‡ -6%</td><td>0.5s</td></tr>
<tr><td>O/V</td><td>Vφ-n† + 14%
= 262.2V</td><td>0.5s</td><td>Vφ-φ‡ + 6%</td><td>0.5s</td></tr>
<tr><td>U/F</td><td>49.5Hz</td><td>0.5s</td><td>49.5Hz</td><td>0.5s</td></tr>
<tr><td>O/F</td><td>50.5Hz</td><td>0.5s</td><td>50.5Hz</td><td>0.5s</td></tr>
</table>
†A value of 230V shall be used in all cases for Power Generating Facilities connected to a DNO’s LV Distribution Network
‡A value to suit the voltage of the HV system connection point.
</td><td></td><td></td><td>DPC7.4.3.9</td></tr>
</table>

New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.5.8		10.5.8	10.5.8 Over and Under voltage protection must operate independently for all three phases in all cases.			DPC7.4.3.5
10.5.9		10.5.9	10.5.9 The settings in 10.5.7.1 should generally be applied to all **Power Generating Module**. In exceptional circumstances **Generator**s have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Power Generating Module** may become unstable or suffer damage with the settings specified in 10.5.7.1. The agreed settings should be recorded in the **Connection Agreement**.			DPC7.4.3.6
10.5.10		10.5.10	10.5.10 Once the settings and Operating Values of relays have been agreed between the **Generator** and the **DNO** they must not be altered without the written agreement of the **DNO**. Any revised settings should be recorded again in the amended **Connection Agreement**.			DPC7.4.3.6
10.5.11		10.5.11	10.5.11 The under/over voltage and frequency protection may be duplicated to protect the **Power Generating Module** when operating in island mode although different settings may be required.			
10.5.12		10.5.12	10.5.12 For **LV** connected **Power Generating Module** the voltage settings will be based on the 230V nominal system voltage. In some cases **Power Generating Module** may be connected to **LV systems** with non-standard operating voltages. Section 10.5.16 details how suitable settings can be calculated based upon the **HV** connected settings in table 10.5.7.1. Note that **Power Generating Modules** with non-standard **LV** protection settings need to be agreed by the **DNO** on a case by case basis.			
		10.5.13				Requirements now in section 10.1.7
		10.5.14				Duplication of 10.2.3,
10.5.14		10.5.15	10.5.15 Where an installation contains power factor correction equipment which has a variable susceptance controlled to meet the reactive power demands, the probability of sustained generation is increased. For **LV** installations, additional protective equipment provided by the **Generator**, is required as in the case of self-excited asynchronous machines.			

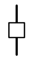
New doc	RfG	G59	G59	<1MW	<50MW	Comments
10.5.15		10.5.16	10.5.16 Non-Standard private LV networks calculation of appropriate protection settings The standard over and under voltage settings for **LV** connected **Power Generating Modules** have been developed based on a nominal **LV** voltage of 230V. Typical **DNO** practice is to purchase transformers with a transformer winding ratio of 11000:433, with off load tap changers allowing the nominal winding ratio to be changed over a range of plus or minus 5% and with delta connected **HV** windings. Where a **DNO** provides a connection at **HV** and the **Customer** uses transformers of the same nominal winding ratio and with the same tap selection as the **DNO** then the standard **LV** settings in table 10.5.7.1 can be used for **Power Generating Modules** connected to the **Customer's LV** network. Where a **DNO** provides a connection at **HV** and the **Customer's** transformers have different nominal winding ratios, and he chooses to take the protection reference measurements from the **LV** side of the transformer, then the **LV** settings stated in table 10.5.7.1 should not be used without the prior agreement of the **DNO**. Where the **DNO** does not consider the standard **LV** settings to be suitable, the following method shall be used to calculate the required **LV** settings based on the **HV** settings for **Small Power Generating Facilities** stated in table 10.5.7.1. Identify the value of the transformers nominal winding ratio and if using other than the nominal tap, increase or decrease this value to establish a **LV** system nominal value based on the transformer winding ratio and tap position and the **DNO**s declared **HV** system nominal voltage. For example a **Customer** is using an 11,000V to 230/400V transformer and it is proposed to operate it on tap 1 representing an increase in the high voltage winding of +5% and the nominal HV voltage is 11,000V. $V_{LVsys} = V_{LVnom} \times V_{HVnom}/V_{HVtap}$ V_{LVsys} = 230 x 11000/11550 = 219V Where: V_{LVsys} – LV system voltage V_{LVnom} - LV system nominal voltage (230V)			

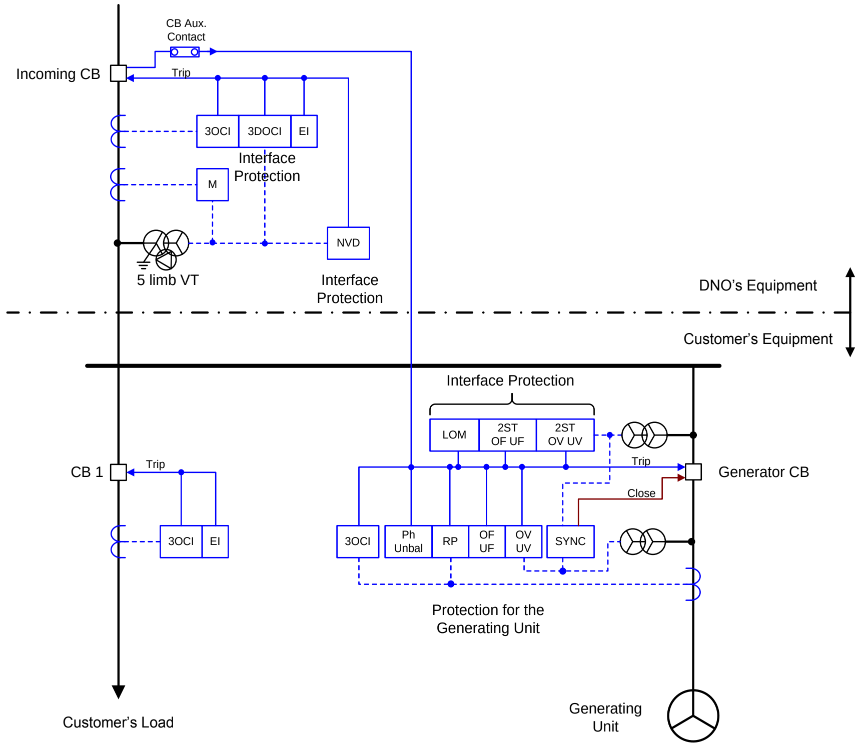
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			V_{HVnom} - HV system nominal voltage (11,000V) V_{HVtap} – HV tap position The revised **LV** voltage settings required therefore would be; OV stage 1 = 219x1.1 = 241V OV stage 2 = 219x1.13 = 247.5V UV = 219x0.8 = 175V The time delays required for each stage are as stated in table 10.5.7.1. Where **Power Generating Modules** are designed with balanced 3 phase outputs and no neutral is required then phase to phase voltages can be used instead of phase to neutral voltages. This approach should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G99 would allow the **Power Generating Module** to be **Type Tested**, the **Manufacturer** may produce a declaration in a similar format to section 13.1 for presentation to the **DNO** by the **Installer**, stating that all **Power Generating Modules** produced for a particular **Power Generating Facility** comply with the revised over and under voltage settings. All other required data should be provided as for **Type Tested Power Generating Module**s. This declaration should make reference to a particular **Power Generating Facility** and its declared **LV System** voltage. These documents should not be registered on the ENA web site as they will not be of use to other **Installer**s who will have to consult with the **Manufacturer** and **DNO** to agree settings for each particular **Power Generating Facility**.			
10.5.16		10.5.17	10.5.17 The **Generator** shall provide a means of displaying the protection settings so that they can be inspected if required by the **DNO** to confirm that the correct settings have been applied. The **Manufacturer** needs to establish a secure way of displaying the settings in one of the following ways: a. A display on a screen which can be read;			

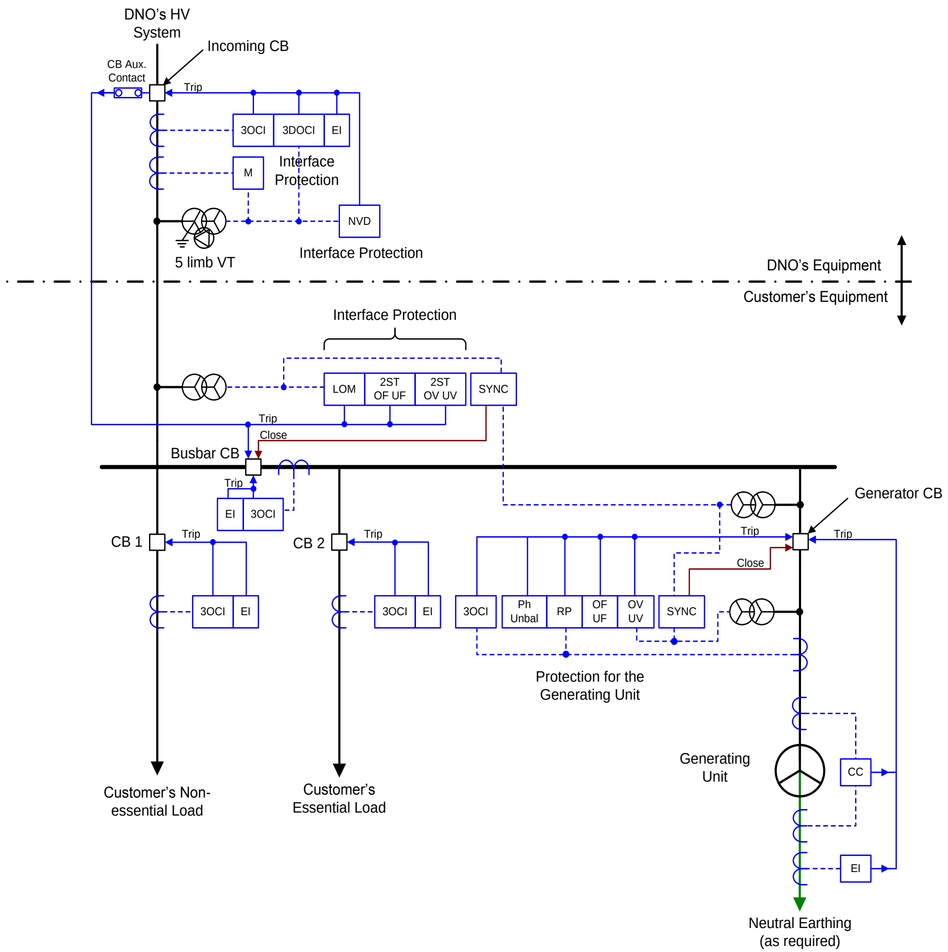
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			b. A display on an electronic device which can communicate with the **Power Generating Module** and confirm that it is the correct device by means of a Identification number / name permanently fixed to the device and visible on the electronic device screen at the same time as the settings; c. Display of all settings including nominal voltage and current outputs, alongside the identification number / name of the device, permanently fixed to the **Power Generating Module**. The provision of loose documents, documents attached by cable ties etc., a statement that the device conforms with a standard, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.			
10.5.17	A14 (5b) A14 (5bi) covered A14 (5biv) covered		The protection arrangements (including changes to protection arrangements) for individual schemes will be agreed between the **Generator** and the **DNO** in accordance with this document. The protection schemes and settings for internal electrical faults must not jeopardise the performance of a **power generating module**, in line with the requirements set out in this **EREC**. Electrical protection of the **power generating module** shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the **power generating module**.			Moved from 10.6
10.5.18	A14 (5c)		The **Generator** shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest) for **power generating modules** with a **maximum capacity** of more than 1 MW (Type B and up): (i) network and **power generating module** protection; (ii) **synthetic inertia**, if applicable; (iii) **frequency control** (**active power** adjustment); (iv) power restriction; and (v) power gradient constraint.			
10.5.19	A14 (5d)		With regard to information exchange:			For discussion – where does this best fit

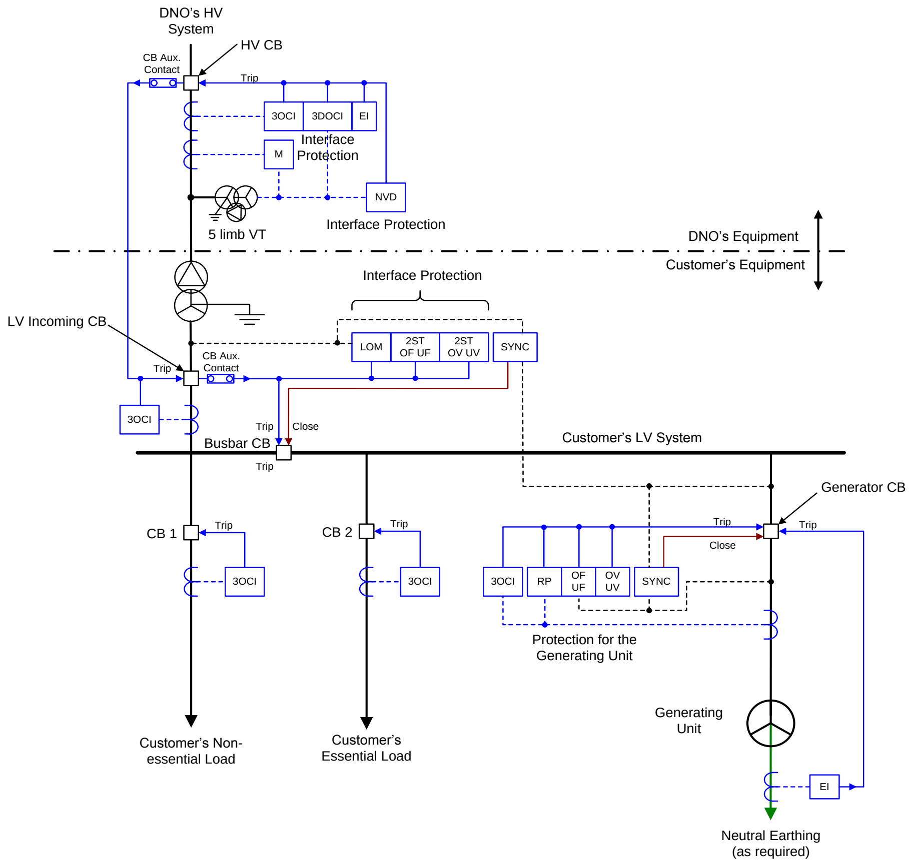
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(i) Power Generating Facilities shall be capable of exchanging information with the relevant system operator or the TSO in real time or periodically with time stamping, as specified by the relevant system operator or the TSO; (ii) the relevant system operator, in coordination with the TSO, shall specify the content of information exchanges including a precise list of data to be provided by the Power Generating Facility.			within this document? We have defined data provision in the DRC which is suggested to be transferred into this document, suggest it would fit well there.
10.6		10.6	**10.6 Typical Protection Application Diagrams** This Section provides some typical protection application diagrams in relation to parallel operation of **Power Generating Module** within **DNO Distribution Networks**. The diagrams only relate to **DNO** requirements in respect of the connection to the **Distribution Network** and do not necessarily cover the safety of the **Generator**'s installation. The diagrams are intended to illustrate typical installations. Figure 10.1 - List of Symbols used in Figures 10.2 to 10.6. Figure 10.2 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for Parallel Operation Only Figure 10.3 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation Figure 10.4 - Typical Protection Arrangement for an **LV Power Generating Module** Connected to a **DNO's HV Distribution Network** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation Figure 10.5 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for Parallel Operation Only	Y	Y	

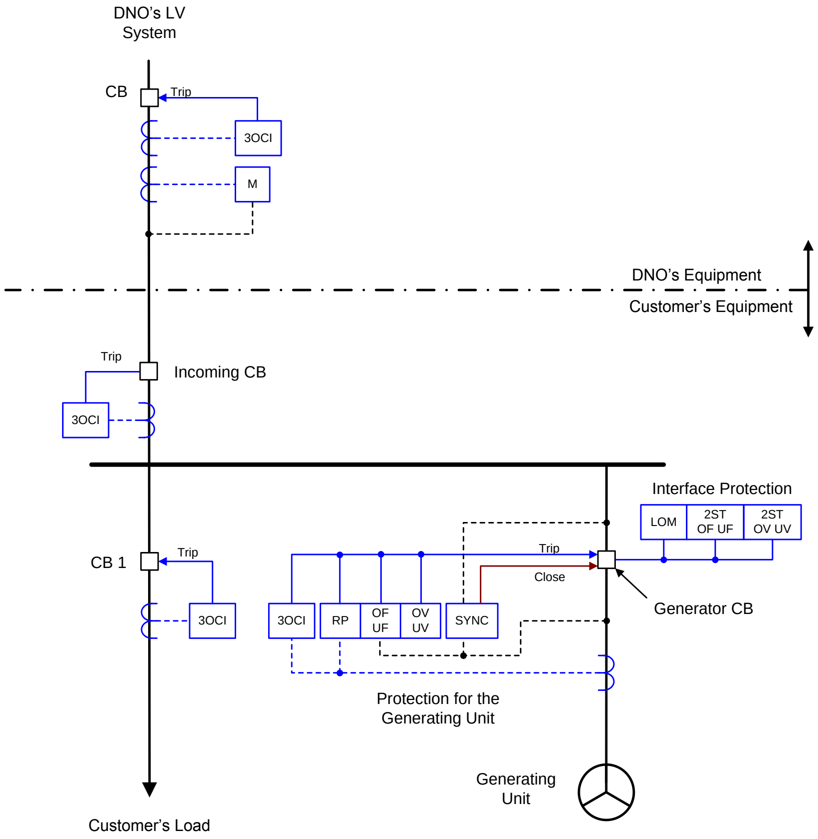
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Figure 10.6 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation			
			Diagram Notes: a. Neutral Voltage Displacement Protection With arc suppression coil systems, the NVD relay should be arranged to provide an alarm only. b. Reverse Power Protection Reverse power protection may be either a standard three phase reverse power relay set to operate at above the agreed level of export into the **Distribution Network**, or a more sensitive relay if no export is permitted. c. Directional Protection In some cases overcurrent protection may afford adequate back-up protection to the **Distribution Network** during system faults. However, where increased sensitivity is required, three phase directional overcurrent IDMT relays, or alternative voltage based protection may be used. d Load Limitation Relay Three phase definite time overcurrent relays, in addition to providing overload protection, could be arranged to detect phase unbalance. This condition may be due to pulled joints or broken jumpers on the incoming **DNO** underground or overhead **HV** supply. NB Items (c) and (d) are alternatives and may be provided as additional protection. e. Phase Unbalance Protection Three phase thermal relays for detecting phase unbalance on the incoming **DNO HV** supply, eg pulled joints, broken jumpers or uncleared unbalanced faults. f. Supply Healthy Protection Some form of monitoring or protection is required to ensure that the **DNO**s supply is healthy before synchronizing is attempted. This could be simply under and over voltage monitoring of all phases on the **DNO** side of the synchronising circuit breaker. Alternatively automatic under and over voltage monitoring, applied across all three phases, together with synchronising equipment designed such that closing of the synchronising circuit breaker cannot occur unless all three phases of the supply have frequency and voltages within statutory limits and have a voltage phase balance within the limits in EREC P29.	Y	Y	
			Figure 10.1 - List of Symbols in Figures 10.2 – 10.6	Y	Y	

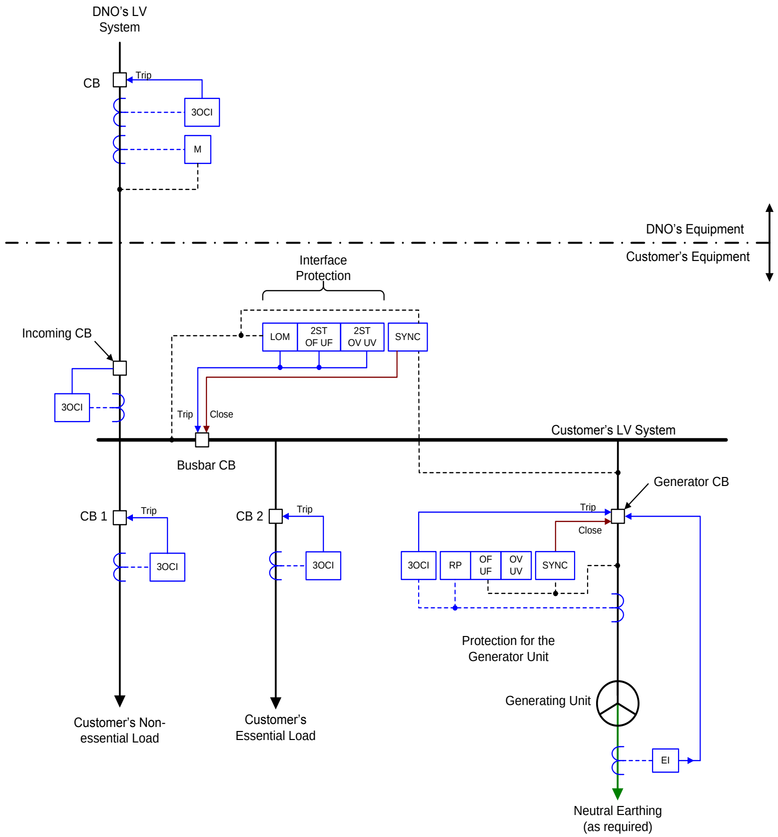
New doc	RfG	G59	G59	<1MW	<50MW	Comments
			BEF — Balanced Earth Fault CC — Circulating Current 3DOCI — 3 Pole Directional Overcurrent (IDMT) EI — Earth Fault (IDMT) LOM — Loss of Mains M — Metering NVD — Neutral Voltage Displacement 3OCI — 3 Pole Overcurrent (IDMT) OF UF — Single Stage Over Frequency & Single Stage Under Frequency OV UV — Single Stage Over Voltage & Single Stage Under Voltage Ph Unbal — Phase Unbalance RP — Reverse Power 2ST OF UF — 2 Stage Over Frequency & 2 Stage Under Frequency 2ST OV UV — 2 Stage Over Voltage & 2 Stage Under Voltage SYNC — Synchronising  Circuit Beaker			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Figure 10.2 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for Parallel Operation Only 	Y	Y	
			Figure 10.3 - Typical Protection Arrangement for an **HV Power Generating Module** Connected to a **DNO's HV Distribution Network** Designed for both Independent Operation (ie Standby	Y	Y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Operation) and Parallel Operation 			
			Figure 10.4 - Typical Protection Arrangement for an **LV Power Generating Module** Connected to a **DNO's HV Distribution Network** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation..	Y	Y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Figure 10.5 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for Parallel Operation Only 	Y	Y	
			Figure 10.6 - Figure 10.6 - Typical Protection Diagram for an **LV Power Generating Module** Connected to a **DNO's LV Distribution Network** Designed for both Independent Operation	Y	Y	

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(ie Standby Operation) and Parallel Operation 			

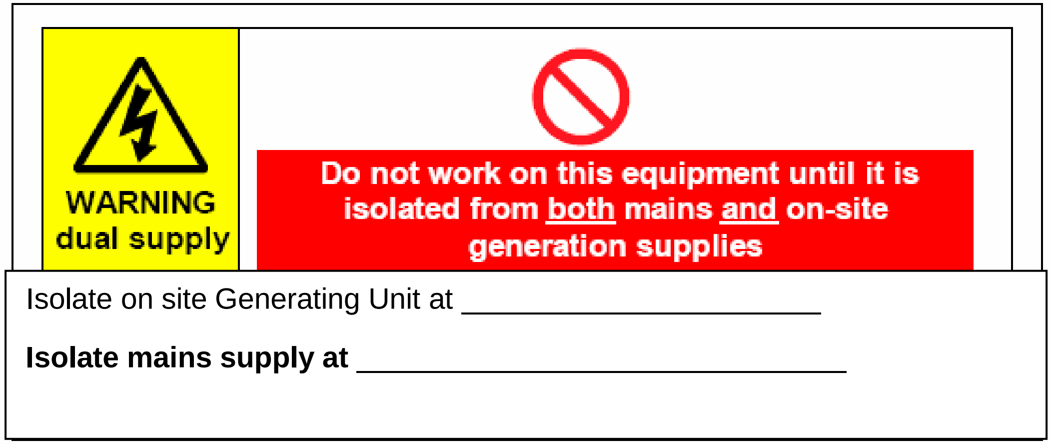
New doc	RfG	G59	G59	<1MW	<50MW	Comments
11 11.1		11 11.1	**11 INSTALLATION, OPERATION AND CONTROL INTERFACE** **11.1 General**			
11.1.1		11.1.1	11.1.1 Installations should be carried out by competent persons, who have sufficient skills and training to apply safe methods of work to install the **Power Generating Module** in compliance with this EREC. Ideally they should have recognised and approved qualifications relating to the fuel / energy sources and general electrical installations[1].			
11.1.2		11.1.2	11.1.2 Notwithstanding the requirements of this EREC, the installation should be carried out to the standards required in the **Manufacturer**'s installation instructions.			
11.1.3		11.1.3	11.1.3 The **Generator** and **DNO** must give due regard to these requirements and ensure that all personnel are competent in that they have adequate knowledge and sufficient judgement to take the correct action when dealing with an emergency. Failure to take correct action may jeopardise the **Generator**'s equipment or the **Distribution Network** and give rise to danger.			
		11.1.4				Applies to TT only
11.1.4		11.1.5	11.1.5 The **DNO** and the **Generator** must agree in writing the salient technical requirements of the interface between their two systems. These requirements will generally be contained in the Site Responsibility Schedule and/or the **Connection Agreement.** In particular it is expected that the agreement will include: a. the means of synchronisation between the **Generator**'s system and the **Distribution Network**, where appropriate;			

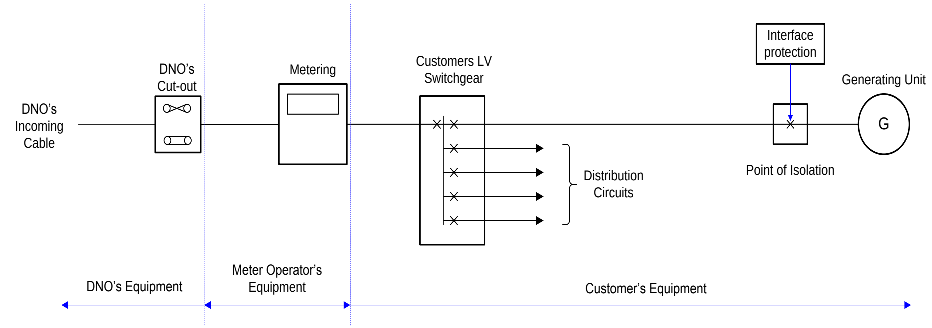
[1] The Installers can choose to be approved under the 'Microgeneration Certification Scheme (MCS) supported by Department of Energy and Climate Change. This certification scheme for microgeneration products and Installers provides an ongoing, independent, third party assessment of Installers of microgeneration systems and technologies to ensure that the requirements of the appropriate standards are met and maintained. The scope of MCS scheme includes the supply, design, installation, set to work and commissioning of a range of microgeneration technologies. For more details, see http://www.greenbooklive.com/page.jsp?id=4

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			b. the responsibility for plant, equipment and protection systems maintenance, and recording failures; c. the means of connection and disconnection between the **DNO**s and **Generator**'s systems; d. key technical data eg import and export capacities, operating power factor range, **Interface Protection** settings; e. the competency of all persons carrying out operations on their systems; f. details of arrangements that will ensure an adequate and reliable means of communication between the **DNO** and **Generator**; g. the obligation to inform each other of any condition, occurrence or incident which could affect the safety of the other's personnel, or the maintenance of equipment and to keep records of the communication of such information; h. the names of designated persons with authority to act and communicate on their behalf and their appropriate contact details.			
11.1.5		11.1.6	11.1.6 **Generator**s should be aware that many **DNO**s apply auto-reclose systems to **High Voltage** overhead line circuits. This may affect the operations of directly connected **HV Power Generating Module**s and also **Power Generating Module**s connected to **LV Distribution Networks** supplied indirectly by **HV** overhead lines.	Y	Y	
11.1.6		DPC7.2.1	**Embedded Power Generating Facilities** connected to the **DNOs Distribution Network** will comply with the requirements of this document.			
11.2		11.2	**11.2 Isolation and Safety Labelling**			
11.2.1		11.2.1	11.2.1 Every installation or system which includes **Power Generating Modules** operating in parallel with the **Distribution Network** must include a means of isolation capable of disconnecting			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			the whole of the **Power Generating Module** [2] infeed to the **Distribution Network.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.			
		DPC7.2.5	The disconnection of a **Power Generation Module** must be achieved by the physical separation of mechanical contacts unless the disconnection is at **Low Voltage** and the equipment for achieving the disconnection contain appropriate self-monitoring of the point of disconnection, in which case an appropriate electronic means such as a suitably rated semiconductor switching device would be acceptable.			
11.2.2		11.2.2 DPC7.2.3	11.2.2 The **Generator** must grant the **DNO** rights of access to the means of isolation without undue delay and the **DNO** must have the right to isolate the **Power Generation Modules** infeed at any time should such disconnection become necessary for safety reasons and in order to comply with statutory obligations. The **Isolating Device** should normally be installed at the **Connection Point**, but may be positioned elsewhere with the **DNO's** agreement..			
11.2.3		11.2.3	11.2.3 To ensure that **DNO** staff and that of the User and their contractors are aware of the presence of **a Power Generating Module** , appropriate warning labels should be used.			DPC7.2.4
11.2.4		11.2.4	11.2.4 Where the installation is connected to the **DNO LV Distribution Network** the **Generator** should generally provide labelling at the **Point of Supply** (Fused Cut-Out), meter position, consumer unit and at all points of isolation within the customer's premises to indicate the presence of **a Power Generating Module .** The labelling should be sufficiently robust and if necessary fixed in place to ensure that it remains legible and secure for the lifetime of the installation. The Health and Safety (Safety Signs & Signals) Regulations 1996 stipulates that labels should display the prescribed triangular shape, and size, using black on yellow colouring. A typical label, for both size and content, is shown below in figure 11.1.			DPC7.2.4

[2] Where the Power Generating Module is designed to support part of the customer's system independently from the DNO system, the switch that is used to separate the independent part of the customer's system from the DNO system must disconnect each phase and neutral. This prevents generator neutral current from inadvertently flowing through the part of the system that is not supported by the Power Generating Module . See also Figure 8.7 and 8.9

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			 **Figure 11.1 Warning label**			
11.2.5		11.2.5	11.2.5 Where the installation is connected to the **DNO's HV Distribution Network** the **Generator** should give consideration to the labelling requirements. In some installations eg a complex CHP installation, extensive labelling may be required, but in others eg a wind farm connection, it is likely to be clear that **Power Generating Module**s are installed on site and labelling may not be required. Any labels should comply with The Health and Safety (Safety Signs & Signals) Regulations 1996 which stipulates that labels should display the prescribed triangular shape, and size, using black on yellow colouring.	Y	Y	
11.3		11.3	**11.3 Site Responsibility Schedule**			
11.3.1		11.3.1	11.3.1 In order to comply with the Distribution Planning and Connection Code DPC5.4.3 of the **Distribution Code** a Site Responsibility Schedule (SRS) should be prepared by the **DNO** in conjunction with the **Generator.** The SRS should clearly indicate the ownership, operational and maintenance responsibility of each item of equipment at the interface between the **Distribution Network** and the **Power Generating Module**, and should include an operational diagram so that all persons working at the interface have sufficient information so that they can undertake their duties safely and to minimise the risk of inadvertently interrupting supplies. The SRS should also record the agreed method of communication between the **DNO** and the **Generator**.			
11.3.2		11.3.2	11.3.2 The operational diagram should be readily available to those persons requiring access to the information contained on it. For example, this could be achieved by displaying a paper copy at the **Point of Supply**, or alternatively provided as part of a computer based information			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			system to which all site staff has access. The most appropriate form for this information to be made available should be agreed as part of the connection application process.			
11.3.3		11.3.3	11.3.3 In the case of a **LV** connected **Power Generating Module,** a simple diagram located at the **Point of Supply** may be sufficient. The scope of the diagram should cover the **Distribution Network**, **Customer**'s **installation** and the **Power Generating Module** as shown below in Fig 11.2, however the location of any metering devices, consumer unit and circuit protective devices (together with their settings) within the **Customer**'s **installation** should also be shown.  **Fig 11.2 – Example of an Operational Diagram**	Y	Y	
11.3.4		11.3.4	11.3.4 In the case of an **HV** connected **Power Generating Module** the diagram is likely to be more complex and contain more detailed information.			
11.3.5		11.3.5	11.3.5 In addition to preparing the diagram as part of the connection process, there are obligations on the **DNO** and the **Generator** to ensure that the Site Responsibility Schedule including the operational diagram are updated to reflect any changes on site. To facilitate this, the **Generator** must contact the **DNO** when any relevant changes are being considered.			
11.4		11.4	**11.4 Operational and Safety Aspects**			
11.4.1		11.4.1	11.4.1 Where the **Point of Supply** provided by the **DNO** for parallel operation is at **HV**, in addition to the provisions of DOC 8, the **Generator** must ensure: a. that a person with authority, or his staff, is available at all times to receive communications from the **DNO** Control Engineer so that emergencies, requiring urgent action by the **Generator**, can be dealt with adequately. Where required by the **DNO**, it will also be a duty of the **Generator**'s staff to advise the **DNO** Control Engineer of any abnormalities that occur on the **Power Generating**			DPC7.2.6

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			Module which have caused, or might cause, disturbance to the **Distribution Network**, for example earth faults; b. Where in the case that it is necessary for the **Generator's** staff to operate the **DNO**s equipment, they must first have been appropriately trained and designated as a **DNO** 'Authorised Person' for this purpose. The names of the **Generators** authorised persons should be included on the Site Responsibility Schedule. All operation of **DNO** equipment must be carried out to the specific instructions of the **DNO** Control Engineer in accordance with the **DNO**s safety rules.			
11.4.2		11.4.2	11.4.2 For certain **Power Generating Module** connections to an **HV Point of Supply**, the **Generator** and the **DNO** may have mutually agreed to schedule the real and / or reactive power outputs to the **Distribution Network** to ensure stability of the local **Distribution Network**. The **DNO** may require agreement on specific written procedures to control the bringing on and taking off of such **Power Generating Module**. The action within these procedures will normally be controlled by the **DNO**s Control Engineer.	Y	Y	
11.4.3		11.4.3	11.4.3 Where the **Point of Supply** provided by the **DNO** for parallel operation is at **LV**, the **DNO**, depending upon local circumstances, may require a similar communications procedure as outlined in sub-paragraph 11.4.1(a) above.			
11.5		11.5	**11.5 Synchronizing and Operational Control**			
11.5.1		11.5.1	11.5.1 Before connecting two energised electrical systems, for example a **Distribution Network** and **Power Generating Module**, it is necessary to synchronise them by minimising their voltage, frequency and phase differences.			
11.5.2		11.5.2	11.5.2 Operational switching, for example synchronising, needs to take account of **Step Voltage Changes** as detailed in Section 9.5.			
11.5.3		11.5.3	11.5.3 Automatic synchronising equipment will be the norm which, by control of the **Power Generating Module**'s field system (**Automatic Voltage Regulator**) and governor, brings the incoming unit within the acceptable operating conditions of voltage and speed (frequency), and closes the synchronising circuit breaker. Manual synchronising can only be done with the specific agreement of the **DNO**.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
		DPC7.2.7				
11.5.4		11.5.4	11.5.4 The facility to use the **DNO**s interface circuit breaker for synchronizing can only be used with the specific agreement of the **DNO**.			DPC7.2.8
						11.5.5 does not exist in G59/3
11.5.5		11.5.6	11.5.6 The synchronising voltage supply may, with **DNO** agreement, be provided from a **DNO** owned voltage transformer. Where so provided, the voltage supplies should be separately fused at the voltage transformer.			
11.5.6		11.5.7	11.5.7 Where the **Generator**'s system comprises ring connections with normal open points, it may not be economic to provide synchronising at all such locations. In such cases mechanical key interlocking may be applied to prevent closure unless one side of the ring is electrically dead. A circuit breaker or breakers will still, however, require synchronising facilities to achieve paralleling between the **Generator** and the **DNO** supply.	Y	Y	
11.5.7		11.5.8	11.5.8 The conditions to be met in order to allow automatic reconnection when the **DNO** supply is restored are defined in Section 10. Where a **Power Generating Facility Owner** requires his **Power Generating Module** to continue to supply a temporarily disconnected section of the **Distribution Network** in island mode**,** the special arrangements necessary will need to be discussed with the **DNO**.			
11.5.8	A40 (3)		The **Generator** shall notify the **DNO** of any operational incidents or failures of a **Power Generating Module** that affect its compliance with the requirements of this Regulation, without undue delay, after the occurrence of those incidents.			Included here for completeness, but suggest it is more appropriately adopted into DOC 7

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						(Operational Liaison)

New doc	RfG	G59	G59	<1MW	<50MW	Comments
12 12.1		12 12.1	**12 TESTING AND COMMISSIONING** **12.1 General**			
		DPC7.4.9.1	Where **Power Generating Modules** require connection to the **DNO's Distribution Network** in advance of the commissioning date, for the purposes of testing, the **Embedded Power Generating Facility** must comply with the requirements of the **Connection Agreement**. The **Embedded Power Generating Facility** shall provide the **DNO** with a commissioning programme, approved by the **DNO** if reasonable in the circumstances, to allow commissioning tests to be co-ordinated.			
	A41 (2)	DPC7.4.9.2	The **Generator** will demonstrate all the commissioning tests performed on his **Power Generating Module** in order to discharge the requirements of this document. In general the **DNO** will witness these tests for **Power Generating Modules** connected to the **DNO's Distribution Network** at **HV**. For **Power Generating Modules** connected to the **DNO's Distribution Network** at **Low Voltage** it is expected that the **DNO** will not witness the commissioning tests in the majority of cases. The **DNO** shall have the right to request that the **Generator** carry out compliance tests and simulations as set out in this section according to a repeat plan or general scheme or after any failure, modification or replacement of any equipment that may have an impact on the **power generating module's** compliance with the requirements of this EREC G99. The **Generator** shall be informed of the outcome of those compliance tests and simulations.			
12.1.1		12.1.1	12.1.1 A brief summary of generic requirements related to connection application, notification of commissioning and commissioning test requirements for **Power Generating Facilities** and **Power Generating Module**s are given in Section 6.1. This section provides further details on the testing, commissioning and witnessing requirements.			
12.1.2		12.1.2	12.1.2 General procedural issues, including the requirements for witnessing the commissioning tests and checks are described in Section 12.2.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
12.1.3	A41 (3)		A list of information and documents to be provided as well as the requirements to be fulfilled by the **Generator** within the framework of the compliance process is provided in the Data Registration Code.			
12.1.4		12.1.3	12.1.3 The requirements for the commissioning tests and checks are shown in section 12.3.			G99 is all non-TT
12.1.5		12.1.4	12.1.4 It is the responsibility of the **Installer** to undertake these commissioning tests / checks and to ensure the **Power Generating Facility** and **Power Generating Module**s meet all the relevant requirements.			
12.1.6		12.1.5	12.1.5 In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the **Manufacturer**, **Supplier** or **Installer** of the **Power Generating Module**s or may be required to satisfy legislation and other standards.	Y	Y	This does not read well
12.2		12.2	**12.2 Procedures and Witnessing Requirements**			
12.2.1		12.2.1	12.2.1 The **DNO** may decide to witness the **Power Generating Facility** and **Power Generating Module** commissioning tests and checks. The table in Section 6.1 provides information on when the **DNO** may wish to witness the testing and whether the **DNO** may charge for doing so.			
12.2.2		12.2.3	12.2.3 The **DNO** will normally decide to witness the commissioning checks and tests for the Power Generating Modules and Power Generating Facilities within the scope of this document. In such cases the Installer shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.			Modifications to reflect G99 scope
12.2.3		12.2.4	12.2.4 Where commissioning tests and checks are to be witnessed the **Installer** shall discuss and agree the scope of these tests with the **DNO** at an early stage of the project. The **Installer** shall submit the scope, date and time of the commissioning tests at least 15 days before the proposed commissioning date.	Y	Y	
12.3		12.3	**12.3 Commissioning Tests / Checks required at all Power Generating Facilities**			
12.3.1	A40 (1)		For **power generating modules** connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of less than 1 MW (Type A), the **Generator** may rely upon **equipment certificates**, issued as per Regulation (EC) No 765/2008, to show compliance with this EREC G99.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
12.3.2		12.3.1	12.3.1 The following tests and checks shall be carried out by the **Installer** at all **Power Generating Facilities** and on all **Power Generating Module**s: a. Inspect the **Power Generating Facility** to check compliance with BS7671. Checks should consider: (i) Protection (ii) Earthing and bonding (iii) Selection and installation of equipment b. Check that suitable lockable points of isolation have been provided between the **Power Generating Module**s and the rest of the installation. c. Check that safety labels have been installed in accordance with clause 11.2 of EREC G99; d. Check interlocking operates as required. Interlocking should prevent **Power Generating Module**s being connected to the **DNO** system without being synchronised; e. Check that the correct protection settings have been applied (in accordance with EREC G99 clause 10.5.7.1); f. Complete functional tests to ensure each **Power Generating Module** synchronises with, and disconnects from, the **DNO'**s **Distribution Network** successfully and that it operates without tripping under normal conditions; g. Carry out a functional test to confirm that the **Interface Protection** operates and trips each **Power Generating Module** when all phases are disconnected between the **Power Generating Module** and the **DNO**s **Distribution Network**. This test is carried out by opening a suitably rated switch between the **Power Generating Module** and the **DNO'**s **Point of Supply** and checking that the **Power Generating Module** disconnect quickly (e.g. within 1s); h. Check that once the phases are restored following the functional test described in (g) at least 20s elapses before the **Power Generating Module**s re-connect.	Y	Y	Words copied from 12.4.1

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			The results of these tests shall be recorded in the schedule provided in Appendix 13.x using the relevant sections for **HV** and **LV** protection along with any additional test results required.			
12.3.3	A40 (4)	12.4.1	Protection commissioning tests are also required and the following describes how these should be carried out for the standard range of protection required. Where additional protection is fitted then this should also be tested, additional test requirements are to be agreed between the **DNO** and **Generator**. The **Generator** shall notify the **DNO** of the planned test schedules and procedures to be followed for verifying the compliance of a **power generating module** with the requirements of this EREC G99, in due time and prior to their launch. The **DNO** shall approve in advance the planned test schedules and procedures. Such approval by the **DNO** shall be provided in a timely manner and shall not be unreasonably withheld. The results of these tests shall be recorded in the schedule provided in Appendix 13.x and 13.x using the relevant sections for **HV** and **LV** protection along with any additional test results required. a) Calibration and stability tests shall be carried out on the over voltage and under voltage protection <u>for each phase</u>, as described below: (i) The operating voltage shall checked by applying nominal voltage to the protection (so that it resets) and then slowly increasing this voltage (for over voltage protection or reducing it (for under voltage protection) until the protection picks up. The voltage at which the protection picks up shall be recorded. Where the test equipment increases / decreases the voltage in distinct steps, these shall be no greater than 0.5% of the voltage setting. Each pickup value shall be within 1.5% of the required setting value. (ii) Timing tests shall be carried out by stepping the voltage from the nominal voltage to a value 4V above the setting voltage (for overvoltage protection) and 4V below the setting (for under voltage protection) and recording the operating time of the protection. The operating time of the protection shall be no shorter than the setting and no greater than the setting + 100ms. (iii) Stability tests (no-trip tests) shall also be carried out at the voltages and for the durations defined in Appendix 13.x. The protection must not trip during these tests. b) Calibration and stability tests shall be carried out on the over frequency and under frequency protection as described below:			Moved from section 12.4 as all tests are applicable.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(i) The operating frequency shall be checked by applying nominal frequency to the protection (so that it resets) and then slowly increasing this frequency (for over frequency protection) or reducing it (for under frequency protection) until the protection picks up. The frequency at which the protection picks up shall be recorded. Where the test equipment increases / decreases the frequency in distinct steps, these shall be no greater than 0.1% of the frequency setting. Each pick up value shall be within 0.2% (i.e. 0.1Hz) of the setting value. (ii) Timing tests shall be carried out by stepping the frequency from 50Hz to a value 0.2Hz above the setting frequency (for over frequency protection) and 0.2Hz below the setting (for under frequency protection) and recording the operating time of the protection. The operating time of the protection shall be no shorter than the setting and no greater than the setting + 100ms or the setting + 1% of the setting, whichever gives the longer time. (iii) Stability tests (no-trip tests) shall also be carried out at the frequencies and for the durations defined in the commissioning test record, Appendix 13.x. The protection must not trip during these tests. c) Calibration tests for rate of change of frequency protection, where used, shall be carried out as follows: (i) Rate of change of frequency shall be checked by first applying a voltage with a frequency of 50.5Hz to the protection and then ramping this frequency down at $0.1Hzs^{-1}$ until a frequency reaches 49.5Hz. This test is repeated at increasing values of rate of change of frequency (in increments of $0.05Hzs^{-1}$) until the protection operates. The test shall be repeated for rising frequency but this time each tests shall be start at 49.5Hz and end at 50.5Hz. The operating values should be within 0.05Hz per second of the required setting. (ii) Timing tests shall be carried out by applying a falling and a rising frequency at rate of $0.1Hzs^{-1}$ above the setting value. The protection operating times shall be no longer than 0.5s. d) Calibration for vector shift protection, where used, shall be carried out as follows: (i) The tests shall be carried out at nominal voltage. An instantaneous shift in the voltage vector shall be applied using an appropriate test set. A vector shift below the setting value shall applied initially (e.g. starting at 8 degrees). The test shall be repeated with increasing vector shift values (in increments of 1 degree) until the pickup value is determined. The tests shall be carried out for both leading and lagging shifts in the voltage vector.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
			(ii) Timing tests shall be carried out by applying a vector shift of 2 degrees above the setting and recording the operating time of the protection. Test shall be carried out for both a leading and a lagging shift in voltage. e) RoCoF and vector shift stability checks shall be performed on all loss of mains protection in accordance with Appendix 13.3 irrespective of the type of loss of mains protection employed for a particular **Power Generating Module** or **Power Generating Facility**. f) In addition to the 3 phase disconnection test specified in 12.3.2 (g) the installer shall carry out an additional functional check of the LoM protection by removing one phase of the supply to the **Power Generating Module** and confirming that the protection operates to disconnect the **Power Generating Module** from the **Distribution Network**. This test is applicable to all **Power Generating Module**s where **LV** protection settings are applied (i.e. not applicable if protection voltage reference is at **HV**), and should be repeated for all phases. i. Disconnection of a voltage sensing feed from a voltage monitoring relay does not accurately replicate the conditions arising from the loss of an incoming phase and is not an acceptable test method. i. Manufacturers and installers should be encouraged to incorporate disconnection points into the design of all **LV Power Generating Module**s or installations in order to facilitate this test. i. Where this test is considered to be impractical due to network arrangement or safety concerns, it may be replaced by an injection test to prove the operation of current unbalance protection, provided that such protection is installed and is set at an appropriately sensitive level. (For example, according to BS EN 60034-1, this should be <8%, 20s for a salient pole **Power Generating Module**). It should be noted that experience of current imbalance protection in this application can be problematic once in service, and has led to nuisance tripping due to load and network voltage imbalance.			

New doc	RfG	G59	G59	<1MW	<50MW	Comments
12.3.4		12.4.2	12.4.2 It may be necessary to undertake ad-hoc testing to determine[1], for example: a. the voltage dip on synchronising; b. the harmonic voltage distortion; c. the voltage levels as a result of the connection of the **Power Generating Facilities** and to confirm that they remain within the statutory limits.			
12.3.5		12.3.2	12.3.2 The tests and checks shall be carried out once the installation is complete, or, in the case of a phased installation (i.e. where **Power Generating Modules** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the **installation document** or Power Generating Module Document (as applicable) included in Appendix 13.x. The **Installer** or **Generator**, as appropriate, shall complete the declaration at the bottom of the form, sign and date it and provide a copy to the **DNO** at the time of commissioning (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed).			
12.3.6	A30 (1)		Separate **installation documents** shall be provided for each **power generating module** connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of less than 1 MW (Type A) within the **power generating facility**. Each **DNO** shall ensure that the required information can be submitted by third parties on behalf of the **Generator**.			
12.3.7	A32 (1) A32 (2) covered		For each new **power generating module** connected to the **DNO's Distribution Network** below 110 kV and with a **maximum capacity** of more than 1 MW (Type B plus), a **power generating module document ('PGMD')** shall be provided by the **Generator** to the **DNO** and shall include a **statement of compliance**. For each **power generating module** within the **power generating facility**, separate independent **PGMD**s shall be provided. Details of the data required to be included in each **PGMD** is provided in the Data Registration Code.			The data registration code needs to be updated in line with the RfG.
12.4		12.5	**12.4 Periodic Testing**			
12.4.1		12.5.1	12.5.1 The **Interface Protection** shall be tested by the **Generator** at intervals to be agreed with the **DNO.**			

[1] Such periodic testing may be required due to system changes, **DNO** protection changes, fault investigations etc.

New doc	RfG	G59	G59	<1MW	<50MW	Comments
12.5		12.6	**12.5 Changes at the Installation**	Y	Y	
12.5.1	A40 (2) covered	12.6.1	12.6.1 If during the lifetime of the **Power Generating Modules** it is necessary to replace a major component of a **Power Generating Module** or its protection system, that may affect its compliance with the requirements applicable under this Regulation, the DNO should be notified before initiating that modification.			
12.5.2	A30 (3)	12.6.2	12.6.2 In the event that **Power Generating Module** is to be decommissioned and will no longer operate as a source of electrical energy in parallel with the **Distribution Network**, the **Generator** or third parties (including aggregators) shall notify the **DNO** by providing the information as detailed in Appendix 13.x. Where the presence of **Power Generating Modules** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.			
12.5.3		12.6.3	12.6.3 Where one or more **Power Generating Module**s are to be added or replaced at an existing **Power Generating Facility** installed under EREC G59, EREC G83 or an earlier version of the **Distribution Code**, it is not necessary to modify the other existing **Power Generating Modules** to comply with the latest versions of the these documents unless these documents explicitly include retrospective changes. For the avoidance of doubt, this also applies where the changes increase the capacity of the **Power Generating Facility** above the 16A per phase threshold. For example, if a new 3kW one phase **Power Generating Module** is added to an existing **Power Generating Facility** comprising an existing 3kW 1 phase **Power Generating Module** complying with EREC G83/1-1, this increases the capacity of the **Power Generating Facility** from 3kW (13.04A per phase) to 6kW (26.08A per phase). In this case the new **Power Generating Module** will either have to comply with EREC G99 or EREC G98(as amended) but the existing **Power Generating Module** will not need to be modified.			
12.5.4			12.6.4 If a **Power Generating Module** is changed at a **Power Generating Facility** the replacement must comply with the current version of EREC G99 or EREC G98, as applicable.	Y	Y	

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<td>Y</td>
<td>Y</td>
<td>Appendices for TT PGF are removed. Discussion on removal of 13.10 required.</td>
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<tr><td>13.9</td><td></td><td></td><td>Emerging technology exceptions</td><td></td><td></td><td></td></tr>
<tr><td></td><td>A66 (1)</td><td></td><td>For power generating modules classified as an emerging technology at the time of their connection to a network, in accordance with the procedures set out in Title VI of EU Network Code on Requirements for Grid Connection of Generators the following sections of this document do not apply.</td><td></td><td></td><td>May not need this here (it is in G98). Review and complete as necessary one emerging</td></tr>
</table>

New doc	RfG	G59	G59	<1MW	<50MW	Comments
						technologies defined

13.2 Power Generating Module Installation and Commissioning Confirmation

Commissioning Confirmation Form for all Installations	
To ABC electricity distribution 99 West St, Imaginary Town, ZZ99 9AA	DNO or IDNO abced@wxyz.com
Installer or Power Generation Facility Owner Details :	
Installer	
Accreditation/Qualification	
Address	
Post Code	
Contact person	
Telephone Number	
E-mail address	
Installation Details	
Site Contact Details	
Address	
Post Code	
Site Telephone Number	
MPAN(s)	
Location within Customer's Installation	
Location of Lockable Isolation Switch	

Details of Power Generation Module(s) - where applicable

Manufacturer / Reference	Date of Installation	Technology Type	G83 / G59	Type Test Ref No.	Power Generation Module installed capacity in kW				
					3-Phase Units	Single Phase Units			Power Factor
						PH1	PH2	PH3	

Information to be enclosed	
Description	Confirmation

Final copy of circuit diagram	Yes / No*
Power Generation Module Type Test Reference Number, or for **Power Generation Modules** not yet listed on the ENA web site a completed **Power Generation Module** Type Test Sheet	Yes / No*
Schedule of protection settings (may be included in circuit diagram)	Yes / No*
Commissioning Checks	
Installation satisfies the requirements of BS7671 (IET Wiring Regulations).	Yes / No*
Suitable lockable points of isolation have been provided between the **Power Generation Modules** and the rest of the installation.	Yes / No*
Labels have been installed at all points of isolation in accordance with EREC G59.	Yes / No*
Interlocking that prevents **Power Generation Module**s being connected in parallel with the **DNO** system (without synchronising) is in place and operates correctly.	Yes / No*
The **Interface Protection** settings have been checked and comply with EREC G59	Yes / No*
Power Generation Modules successfully synchronise with the **DNO** system without causing significant voltage disturbance.	Yes / No*
Power Generation Modules successfully run in parallel with the DNO system without tripping and without causing significant voltage disturbances.	Yes / No*
Power Generation Modules successfully disconnect without causing a significant voltage disturbance, when they are shut down.	Yes / No*
Interface Protection operates and disconnects the **Power Generation Module**s quickly (within 1s) when a suitably rated switch, located between the **Power Generation Modules** and the **DNO**s incoming connection, is opened.	Yes / No*
Power Generation Module(s) remain disconnected for at least 20s after switch is reclosed.	Yes / No*
Loss of tripping and auxiliary supplies Where applicable, loss of supplies to tripping and protection relays results in either **Power Generation Module** lockout or an alarm to a 24hr manned control centre.	Yes / No*
Balance of Multiple Single Phase Power Generation Modules Confirm that design of the complete installation has been carried out to limit output power imbalance to below 16A/phase, as required by section 7.5 of EREC G59	Yes / No*
Additional Comments / Observations:	
Declaration – to be completed by Installer for Power Generating Facilities under 50kW or by the Generator for Power Generating Facilities above 50kW	
I declare that the **Power Generation Module**s and the installation which together form a **Power Generating Facility** at the above address, comply with the requirements of EREC G59/3 and the commissioning checks have been successfully completed. *The **Power Generating Facility** comprises only **Power Generation Modules Type Tested** to EREC G59 or EREC G83/2 or later, or *part or all of this **Power Generating Facility** contains **Power Generation Modules** not **Type Tested** to EREC G59 or EREC G83 and the **Power Generating Module** Installation and Commissioning tests form (Appendix 13.3) has been completed in addition to this form.	
* Delete the part which does not apply.	
Signature:	Date:

* Circle as appropriate. If "No" is selected the **Power Generating Facility** is deemed to have failed the commissioning tests and the **Power Generation Modules** shall not be put in service.

13.3 Power Generating Module Installation and Protection Commissioning Test

Requirements for Power Generation Modules in addition to those required in Appendix 13.2

Over and Under Voltage Protection Tests LV											
Calibration and Accuracy Tests											
Phase	Setting	Time Delay	**Pickup Voltage**				**Time Delay** Setting plus or minus 4V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/Fail					Pass/Fail
L2 - N	**262.2V** 230V system	**1.0s**	*258.75*		*265.65*	Pass/Fail	266.2	*1.0s*		*1.1s*	Pass/Fail
L3 - N						Pass/Fail					Pass/Fail
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/Fail					Pass/Fail
L2 - N	**273.7V** 230V system	0.5s	*270.25*		*277.15*	Pass/Fail	277.7	*0.5s*		*0.6s*	Pass/Fail
L3 - N						Pass/Fail					Pass/Fail
Stage 1 Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/Fail					Pass/Fail
L2 - N	**200.1V** 230V system	2.5s	*196.65*		*203.55*	Pass/Fail	196.1	*2.5s*		*2.6s*	Pass/Fail
L3 - N						Pass/Fail					Pass/Fail
Stage 2 Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N						Pass/Fail					Pass/Fail
L2 - N	**184.0V** 230V system	0.5s	*180.55*		*187.45*	Pass/Fail	180	*0.5s*		*0.6s*	Pass/Fail
L3 - N						Pass/Fail					Pass/Fail

Over and Under Voltage Protection Tests LV							
Stability Tests							
Test Description	Setting	Time Delay	Test Condition (3-Phase Value)	Test Voltage all phases ph-n	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OV Stage 1	258.2V	5.00s		Pass/Fail
Stage 1 Over Voltage	**262.2V**	**1.0s**	> OV Stage 1	269.7V	0.95s		Pass/Fail
Stage 2 Over Voltage	**273.7V**	**0.5s**	> OV Stage 2	277.7V	0.45s		Pass/Fail
Inside Normal band	---------	---------	> UV Stage 1	204.1V	5.00s		Pass/Fail
Stage 1 Under Voltage	**200.1V**	**2.5s**	< UV Stage 1	188V	2.45s		Pass/Fail
Stage 2 Under Voltage	**184.0V**	**0.5s**	< UV Stage 2	180V	0.45s		Pass/Fail
Additional Comments / Observations::							

Over and Under Voltage Protection Tests HV referenced to 110V ph-ph VT output											
Calibration and Accuracy Tests											
Phase	Setting	Time Delay	**Pickup Voltage**				**Time Delay** measured value plus or minus 2V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/Fail					Pass/Fail
L2 - L3	**121V** 110V VT secondary	**1.0s**	*119.35*		*122.65*	Pass/Fail	Measured value plus 2V	*1.0s*		*1.1s*	Pass/Fail
L3 - L1						Pass/Fail					Pass/Fail
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/Fail					Pass/Fail
L2 - L3	**124.3V** 110V VT secondary	0.5s	*122.65*		*125.95*	Pass/Fail	Measured value plus 2V	*0.5s*		*0.6s*	Pass/Fail
L3 - L1						Pass/Fail					Pass/Fail
Stage 1 Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/Fail					Pass/Fail
L2 - L3	**95.70V** 110V VT secondary	2.5s	*94.05*		*97.35*	Pass/Fail	Measured value minus 2V	*2.5s*		*2.6s*	Pass/Fail
L3 - L1						Pass/Fail					Pass/Fail
Stage 2 Under Voltage			Lower Limit	Measured Value	Upper Limit		Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2						Pass/Fail					Pass/Fail
L2 - L3	**88.00V** 110V VT secondary	0.5s	*86.35*		*89.65*	Pass/Fail	Measured value minus 2V	*0.5s*		*0.6s*	Pass/Fail
L3 - L1						Pass/Fail					Pass/Fail

Over and Under Voltage Protection Tests HV
referenced to 110V ph-ph VT output

Stability Tests							
Test Description	Setting	Time Delay	Test Condition (3-Phase Value)	Test Voltage All phases ph-ph	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OV Stage 1	119V	5.00s		Pass/Fail
Stage 1 Over Voltage	**121V**	**1.0s**	> OV Stage 1	122.3V	0.95s		Pass/Fail
Stage 2 Over Voltage	**124.3V**	**0.5s**	> OV Stage 2	126.3V	0.45s		Pass/Fail
Inside Normal band	---------	---------	> UV Stage 1	97.7V	5.00s		Pass/Fail
Stage 1 Under Voltage	**95.7V**	**2.5s**	< UV Stage 1	90V	2.45s		Pass/Fail
Stage 2 Under Voltage	**88V**	**0.5s**	< UV Stage 2	86V	0.45s		Pass/Fail

Additional Comments / Observations:

Over and Under Frequency Protection Tests

Calibration and Accuracy Tests

Setting	Time Delay	Pickup Frequency				Time Delay				
Stage 1 Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52Hz	0.5s	*51.90*		*52.10*	51.2-51.8Hz	51.7-52.3Hz	*0.50s*		*0.60s*	Pass/Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit		Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5Hz	20s	*47.40*		*47.60*	51.2-51.8Hz	47.8-47.2Hz	*20.0s*		*20.2s*	Pass/Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit		Freq step	Lower Limit	Measured Value	Upper Limit	Result
47Hz	0.5s	*46.90*		*47.1*	51.2-51.8Hz	47.3-46.7Hz	*0.50s*		*0.60s*	Pass/Fail

Stability Tests

Test Description	Setting	Time Delay	Test Condition	Test Frequency	Test Duration	Confirm No Trip	Result
Inside Normal band	---------	---------	< OF Stage 1	51.3Hz	120s		Pass/Fail
Stage 1 Over Frequency	52Hz	0.5s	> OF Stage 2	52.2Hz	0.45s		Pass/Fail
Inside Normal band	---------	---------	> UF Stage 1	47.7Hz	30s		Pass/Fail
Stage 1 Under Frequency	47.5Hz	20s	< UF Stage 1	47.3Hz	19.5s		Pass/Fail
Stage 2 Under Frequency	47Hz	0.5s	< UF Stage 2	46.8Hz	0.45s		Pass/Fail

Additional Comments / Observations:

Loss-of-Mains (LOM) Protection Tests – RoCoF (Pending outcome of working group)

Calibration and Accuracy Tests

Ramp in range 49.5-50.5Hz	**Pickup** (+ / -0.005Hzs^{-1})				**Time Delay** RoCoF= $\pm$**0.05Hz/s** above setting			
Setting = 0.125 / 0.20 Hzs^{-1}	Lower Limit	Measured Value	Upper Limit	Result	Test Condition	Measured Value	Upper Limit	Result
Increasing Frequency	*0.120* *0.195*		*0.130* *0.205*	Pass/Fail	0.175 Hzs^{-1} 0.25 Hzs^{-1}		*<0.5s*	Pass/Fail
Reducing Frequency	*0.120* *0.195*		*0.130* *0.205*	Pass/Fail	0.175 Hzs^{-1} 0.25 Hzs^{-1}		*<0.5s*	Pass/Fail

Stability Tests					
Ramp in range 49.5-50.5Hz	Test Condition	Test frequency ramp	Test Duration	Confirm No Trip	Result
Inside Normal band	< RoCoF (increasing f)	Higher of 0.12 Hzs^{-1} or ROCOF - 0.01 Hzs^{-1}) = ____________	5.0s		Pass/Fail
Inside Normal band	< RoCoF (reducing f)		5.0s		Pass/Fail
Additional Comments / Observations:					

Limited Frequency Sensitive Mode Tests								

Loss-of-Mains (LOM) Protection Tests - Vector Shift								
Calibration and Accuracy Tests								
Vector Shift	**Pickup** (± 0.5 degree)				**Time Delay** Vector shift = 2 deg above setting			
Setting = 6 / 12 degrees	Lower Limit	Measured Value	Upper Limit	Result	Test Condition	Measured Value	Upper Limit	Result
Vector Shift : Lagging Angle	*5.5* *11.5*		*6.5* *12.5*	Pass/Fail	8 deg 14 deg		*<0.5s*	Pass/Fail
Vector Shift : Leading Angle	*5.5* *11.5*		*6.5* *12.5*	Pass/Fail	8 deg 14 deg		*<0.5s*	Pass/Fail

Stability Tests					
Test Description	Test Condition	Test vector shift	Test Duration	Confirm No Trip	Result
Inside Normal band	< Vector Shift (Lagging f)	Higher of 5 degrees or vector shift -1 degree =______________			Pass/Fail
Inside Normal band	< Vector Shift (Leading f)				Pass/Fail

Additional Comments / Observations:

Insert here any additional tests which have been carried out

Declaration – to be completed by Generator or Generators Appointed Technical Representative.	
I declare that the **Power Generating Module** and the installation comply with the requirements of G~~5~~99~~/3~~ and the additional commissioning checks noted above have been successfully completed in addition to those required for all **Power Generating Module** installations (see Appendix 13.2)	
Signature:	Date:
Position.	

Declaration – to be completed by DNO Witnessing Representative	
I confirm that I have witnessed the tests in this document on behalf of ______________________________ and that the results are an accurate record of the tests	
Signature:	Date:

13.4 Power Generating Facility Decommissioning Confirmation

Confirmation of the decommissioning of a **Power Generating Facility** connected in parallel with the public **Distribution Network** – in accordance with Engineering Recommendation G59/3.

Site Details	
Site Address (inc. post code)	
Telephone number	
MPAN(s)	
Distribution Network Operator (DNO)	
Power Generating Module Details	
Manufacturer and model type	
Serial number of each **Power Generation Module**	
Rating (kVA)	
Type of prime mover and fuel source	

Decommissioning Agent Details		
Name		
Accreditation/Qualification:		
Address (incl post code)		
Contact person		
Telephone Number		
Fax Number		
E-mail address		
Name:	Signature:	Date:

13.6 Additional Information Relating to System Stability Studies

13.6.1 System Stability

Stability is an important issue for secure and reliable power system operation. Consequently **System Stability** considerations deserve attention when developing **Power Generating Facility** connection design and operating criteria. Power **System Stability** is defined as the ability of a power system to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after it has been subjected to a disturbance. When subjected to a disturbance, the stability of the system depends on the initial system operating condition as well as the severity of the disturbance (e.g. small or large). Small disturbances in the form of load changes or operational network switching occur continually; the stable system must be able to adjust to the changing conditions and operate satisfactorily. The system must also be able to survive more severe disturbances, such as a short circuit or loss of a large **Power Generating Facility.** If following a disturbance the system is unstable, it will usually experience a progressive increase in angular separation of synchronous **Power Generation Module** rotors from the system, or an uncontrolled increase in the speed of asynchronous **Power Generation Module** rotors, or a progressive decrease in system voltages. An unstable system condition could also lead to cascading outages and ultimately to a system blackout.

The loss of **System Stability** is often related to inability of synchronous **Power Generation Modules'** to remain in **Synchronism** after being subjected to a disturbance, either small or large. Loss of **Synchronism** can occur between one synchronous **Power Generation Modules'** and the rest of the system, or between groups of synchronous **Power Generation Modules'**, with **Synchronism** being maintained within each group after separating from each other. Small disturbances arise frequently as a result of normal load variations and switching operations. Such disturbances cause electro-mechanical rotor oscillations, which are generally damped out by the inertia of the **Power Generation Modules'**, system impedance and loads connected to the **Distribution Network**. Where damping is inadequate, **Power System Stabilisers** (PSSs) may offer a solution**.**

Undamped oscillations which result in sustained voltage and power swings, and even loss of **Synchronism** between synchronous **Power Generation Modules'**, can arise following a small disturbance if either

- the transfer capability of the interconnecting **Distribution Network** is insufficient; or
- the control and load characteristics either singly or in combination are such that inadequate or negative damping, or reduced synchronising torque occurs.

Large disturbances, such as a 3-phase short circuit fault or circuit outage, can result in large excursions of synchronous **Power Generation Modules'** rotor angles (i.e. angular separation) due to insufficient synchronising torque. The associated stability problem is then concerned with the ability of the system to maintain **Synchronism** when subjected to such a disturbance. Normally the most arduous case occurs when the summer minimum demand coincides with the maximum power output of the synchronous **Power Generating Module**.

During a fault the electrical output of each synchronous **Power Generation Modules'** may be substantially less than the mechanical input power from its prime mover and the excess energy will cause the rotor to accelerate and increase the electrical angle relative to the power system. Provided that the fault is disconnected quickly, the synchronous **Power Generation Module** controls respond rapidly and with adequate **Distribution Network** connections remaining post-fault, the acceleration will be contained and stability maintained. Pole slipping could occur and if the acceleration is not contained, this will cause large cyclic exchanges of power between the synchronous **Power Generation Module** and the **Distribution Network**. These may damage synchronous **Power Generation Modules**, cause maloperation of **Distribution Network** protection and produce unacceptable voltage depressions in supply systems.

In the case of some types of asynchronous **Power Generating Module**, the voltage depression on the local **Distribution Network** will cause acceleration of the rotor (increasing slip), with subsequent increased reactive demand. For prolonged faults this may cause the asynchronous **Power Generation Module** to go past its breakaway torque point and result in loss of stable operation and subsequent **Power Generating Module** disconnection

In the case of doubly fed asynchronous **Power Generating Modules** and series converter connected **Power Generating Modules**, a voltage depression on the local **Distribution Network** may cause the AC-DC-AC converter to rapidly disconnect, with subsequent fast disconnection of the machine leading to a potential loss of **System Stability.**

In the case of embedded **Medium** and **Large Power Generating Facilitie**s the capability to ride through certain **Transmission System** faults is critical to **Distribution Network** and **Total System** stability. The **Grid Code** “fault ride through” requirements CC.6.3.15 apply to these **Power Generating Facilities.**

Where larger synchronous **Power Generating Module**s are installed consideration should be given by the **Generator** and the **DNO** (in conjunction with **NETSO** where necessary) for the need to provide pole-slipping protection. The ‘reach’ (i.e. impedance locus) of any settings applied to such a protection should be agreed between the **Generator** and the **DNO**. The settings should be optimised, with the aim of rapidly disconnecting generation in the event of pole-slipping, whilst maintaining stability of the protection against other disturbances such as load changes.

Stability investigations for new **Power Generating Module**s will initially need to use data that has been estimated from Manufacturer’s designs. On occasions, the machine size and/or equipment dynamic parameters change, and the studies may need to be repeated later during the project.

13.6.2 Clearance times

A **Distribution Network** can be subjected to a wide range of faults of which the location and fault type cannot be predicted. The **System Stability** should therefore be assessed for the fault type and location producing the most onerous conditions. It is recommended that three phase faults be considered.

The operating times of the equipment that have to detect and remove a fault from the system are critical to **System Stability**. Worst case situations for credible fault conditions will need to be studied, the fault locations selected for examination being dependent upon protection fault clearance times. Stability will normally be assessed on the basis of the slowest combination of the operating times of main protection signalling equipment and circuit breakers. Fault clearance times therefore need to include the operating times of protection relays, signalling, trip relays and circuit breakers.

Faster clearance times may become necessary where studies indicate that the risk to **System Stability** is unacceptable. Single phase to earth fault clearance times can be protracted but their effects on the **System Stability** are likely to be less disruptive than a three-phase fault. Each case to be studied should be considered on an individual basis in order to determine acceptable fault clearance times.

13.6.3 Power System Stabilizers

In general, **Power System Stabiliser**s should provide positive system damping of oscillations in the frequency range from 0 to 5Hz. The gain of the **Power System Stabiliser** shall be such that an increase in the gain by a factor of at least 2 shall not cause instability. **Power Generation Module**s in embedded **Medium** and **Large Power Generating Facilitie**s will need to be studied in the context of the **Total System**, in conjunction with **NETSO**, and will need to satisfy the requirements of the **Grid Code**.

Voltage fluctuations resulting from inadequate damping of control systems require study at the **Point of Common Coupling** (PCC) and must be compliant with ER P28.

13.7 Loss of Mains (LoM) Protection Analysis

The following analysis for LoM protection includes the results of practical measurements. The attached analysis of the problem demonstrates the speed with which a **Power Generation Module** can move out of **Synchronism** and the consequences for the unit of a reclosure on the **Distribution Network**.

13.7.1 Prime Mover Characteristics

A Modern **Power Generation Module** can be of four types:-

1. Synchronous **Power Generation Module**: Where the stator frequency defined by the rotational speed of the applied dc magnetic field in the rotor winding. The two being magnetically locked together, with the rotor magnetic field being at a slight advance (10-20 electrical degrees) of the Stator in order to generate. When connected to a large electrical network both will track the applied frequency. The electrical inertia constant H of the generator will be in the order of 3-5 seconds (time to decrease the frequency by 50% for a 100% increase in load).

2. Asynchronous **Power Generation Module**: Where the stator frequency is determined by the large electrical network it is connected to. The rotating stator field then induces a rotating magnetic field in the rotor winding. To generate, this winding will be rotating at a marginally faster speed to this induced rotating frequency (-1 to -2% slip) in order to generate. The electrical inertia constant H of the generator will be in the order of 4-5 seconds.

3. Doubly Fed Induction **Power Generation Module** (DFIG): Similar to the Asynchronous generator and usually found in wind turbines. Here the rotor is directly energised by a back to back voltage source converter (VSC). This creates in the rotor a variable frequency, in magnitude and phase, which allows the generator rotor to operate over a wider speed range than the 1-2% of an Asynchronous generator. Typically +/-20% speed range is possible. The electrical inertia of the generator is less clearly defined as the rotor is effectively decoupled from the stator, but typically it is given as 4 to 5 seconds before the secondary control systems can react in a similar time period.

4. Converter Connected **Power Generation Module** (CCGU): Whilst the DFIG is partly coupled to the network through the stator, here the power source is completely hidden behind the converter and the generator is fully decoupled from the network. The electrical inertia of the generator is theoretically zero unless a degree of ‘virtual inertia’ is introduced into the converter control scheme, to make the generator behave as if it were closely coupled to the network.

LoM protection systems follow two interrelated principles:

- Rate of Change of Frequency or RoCoF (of voltage)
- Vector Shift or Vector Surge (of voltage)

Both situations can arise from an imbalance between the power applied to the prime mover (and hence generator) and the power thus sent out into the network to supply load. There is a presumption, with both types of relays, that an unbalance in load always exists when a generator is disconnected (Islanded) from the large electrical network. And this is then of sufficient magnitude to cause the generator to accelerate or de-accelerate (depending on its electrical inertia constant H) so changing the frequency of the generated voltage at a sufficient rate to be detected. This is assumed to be in the order of 10%.

Even if the generator remains connected, sudden changes to the impedance of the distribution network, caused by switching, or a sudden load change, can have a similar but smaller effect until a new stable operating point is achieved. This is quite common, especially on weak (low fault level) overhead networks. This is not a LoM event, but is known to cause mal-operation of LoM relays unless properly accounted for.

Generally RoCoF detection is able to discriminate better between true and false LoM events than Vector Shift is. The latter can be fooled by a sudden network impedance change and is therefore best suited to firm urban networks where remote circuit switching has minimal effects on the system fault level. Hence the need for the k factors in the protection table in section 10.5.7.1.

The initial change in frequency following the change in load is essentially a function of the inertia constant H of the combination of the **Power Generation Module** and its Prime Mover. The derivation of the transient frequency response is given in section 2 below.

Note that these equations only truly apply to generator types 1 and 2 and to the initial (1-2 second) response for type 3. For type 4 generators discussions with the generator manufacturer may be required to determine if any form of LoM relay would provide effective protection.

13.7.2 Analysis of Dynamic Behaviour of Power Generation Module Following Load Change

The kinetic energy of a rotating **Power Generation Module** and its prime mover is given by the equation

$$K = 5.48 \times 10^{-6} \times J \times N^2 \qquad \text{equation 1}$$

where K = kinetic energy in kJ

J = moment of inertia in kgm^2

N = machine in speed in rpm

From equation 1, the inertia constant (H) of the machine can be calculated using the expression,

$$H = \frac{K^1}{G} \qquad \text{equation 2}$$

Where K^1 = Kinetic energy at rated speed and frequency (F_r)

G = kVA capacity of the **Power Generation Module**

Hence at any frequency, F, the kinetic energy, K, can be expressed as

$$K = \left(\frac{F}{F_r}\right)^2 \times H \times G \qquad \text{equation 3}$$

Now the immediate effect of any change in the power, P_C, being supplied by the **Power Generation Module** is to initiate a change in the kinetic energy of the machine. In fact P_C is the differential of the kinetic energy with respect to time, thus

$$P_c = \frac{dK}{dt} \qquad \text{equation 4}$$

Rewriting

$$P_c = \frac{dK}{dF} \times \frac{dF}{dt} \qquad \text{equation 5}$$

Differentiating equation 3 gives

$$\frac{dK}{dF} = \frac{2FHG}{F_r^2} \qquad \text{equation 6}$$

Substituting in equation 5

$$P_c = \frac{2FHG}{F_r^2} \times \frac{dF}{dt}$$

Re-arranging

$$\frac{dF}{dt} = \frac{P_c F_r^2}{2HGF} \qquad \text{equation 7}$$

Worked Example

Consider a 200kW generator where 100% of the load is suddenly applied. The resulting rate of change of frequency can be calculated from equation 7 above. It is necessary to evaluate the kinetic energy at rated speed and frequency from equation 1.

Now J = moment of inertia = 80kgm^2; and

N = 750 rpm

Hence K = HG = 5.48 x 10^{-6} x 80 x 750^2

= 247 kJ

Therefore $\frac{dF}{dt} = \frac{200 \times 50^2}{2 \times 247 \times 52.5} = 19.3$ Hz s^{-1}

13.7.3 Assessment of Practical Results -

Island Mode

The diagram below shows an example of generator types 1, 2, and 3 connected to a common high fault level **DNO** network busbar. In each case the **Power Generation Module** is rated at approximately 2.5MVA with parameters typical for these types of generator. They are each supplying 2MW at unity power factor at the busbar after power factor correction (Gen types 2 and 3). For the DFIG an operating point of -5% slip is assumed (some energy is then exported through the voltage sourced converters via the rotor). Voltage is in per unit; voltage angle in degrees; frequency change is in per unit (1pu = 50Hz).

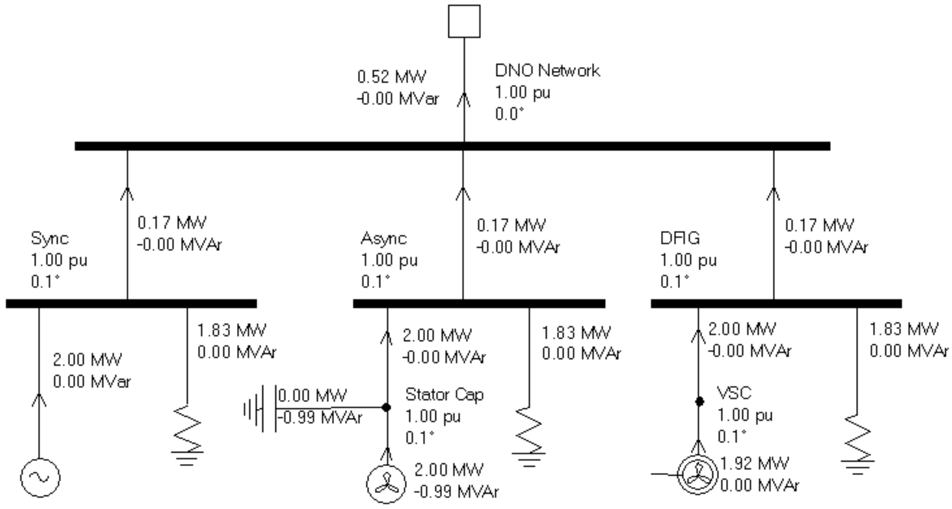

Figure 1 - Three Power Generating Module types

Transient Study

At t=0.1 seconds the network connections are broken leaving each generator in an islanded condition supplying 90% of its original load. Each type of generator will behave differently depending on its inertia constant and its electrical characteristics.

The following three figures show how each performs in the first couple of seconds. This assumes that no internal protection or control systems intervene and any fault ride through system is inactive.

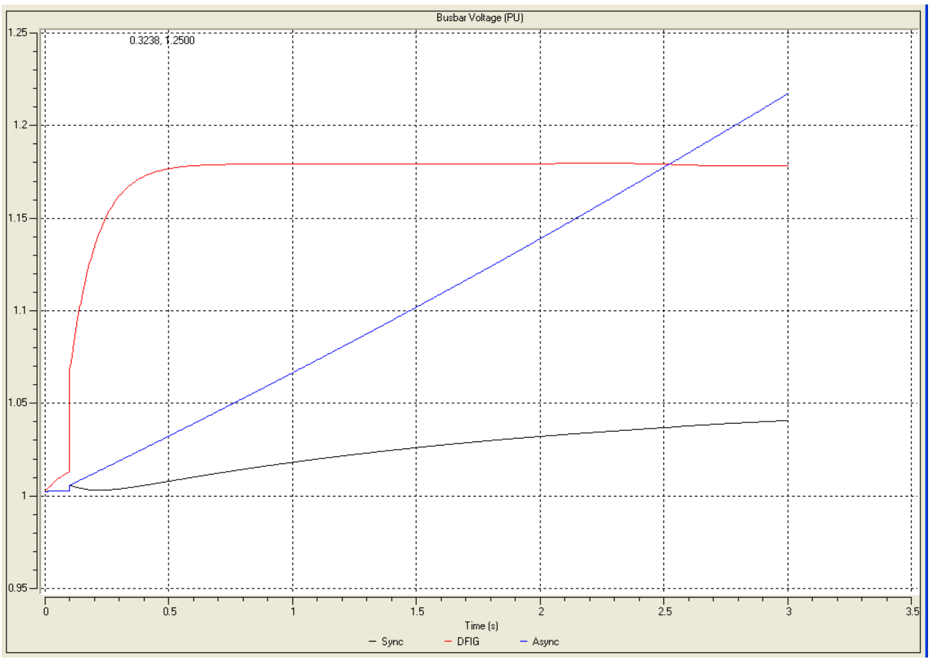

Figure 2 - Voltage Profile

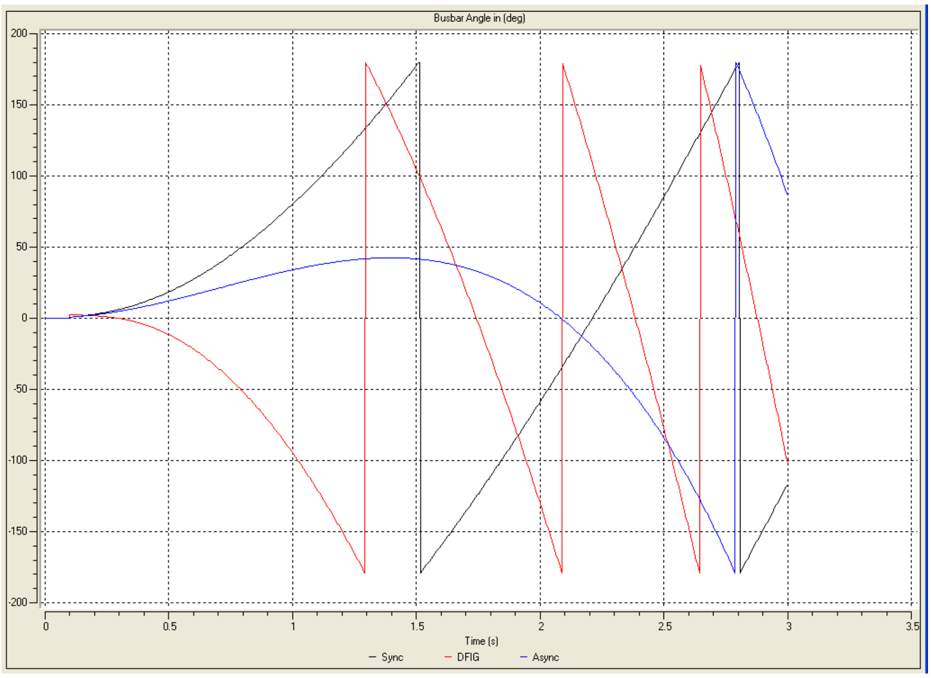

Figure 3 Voltage Angle (flips at +/- 180 Deg)

Note that it shows:

Synchronous Generator**:** Speed Increase, slow voltage rise

Asynchronous Generator: Initial increase then fall (as voltage climbs)

DFIG Generator**:** Speed Decreasing (as terminal voltage has jumped up)

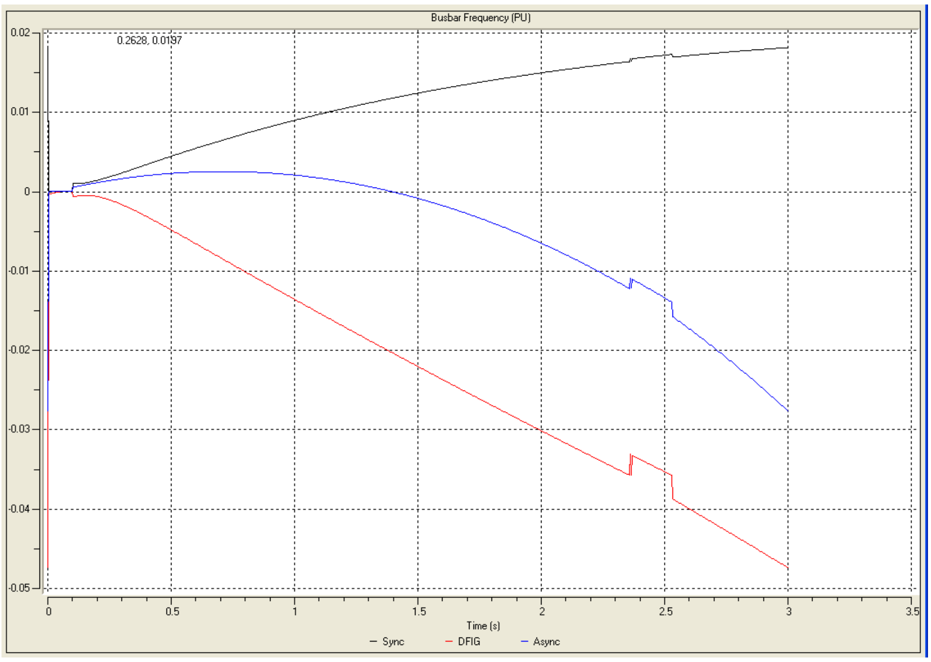

Figure 4 Voltage Frequency Change (PU)

Results

Considering the settings in 10.5.7.1 with a K1 and K2=1

Prot Function	Small Power Generating Facility			
	LV Connected		HV Connected	
	Setting	Time	Setting	Time
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees#	
LoM (RoCoF)	K2 x 0.125 Hz s^{-1}		K2 x 0.125 Hz s^{-1} #	

From inspection of the above graphs the following detection (pick up) times would have resulted:-

Prot Function	Power Generating Module Type		
	Synchronous	Asynchronous	DFIG
	Pick Up Time	Pick Up Time	Pick Up Time
LoM (Vector Shift)	0.20 s	0.23 s	0.32 s
LoM (RoCoF)	0.22 s	0.36 s	0.24 s

Actual tripping time would be determined by the relay sampling method

Circuit Impedance Change – High to Low Fault Level

The diagram below shows an example of same generator types 1, 2, and 3 connected to a common high fault level **DNO** network busbar. In this case each is connected via a low (Z) and a high impedance circuit (10 x Z). All three export 2MW at unity pf, primarily via the low impedance circuit. However should the low impedance circuit fault, the generation remains connected via the high impedance circuit.

In this scenario, the low Z circuit trips at 0.1 seconds and we see the machine responses to the sudden impedance change. As before, voltage is in per unit; voltage angle in degrees; frequency change is in per unit (1pu=50Hz).

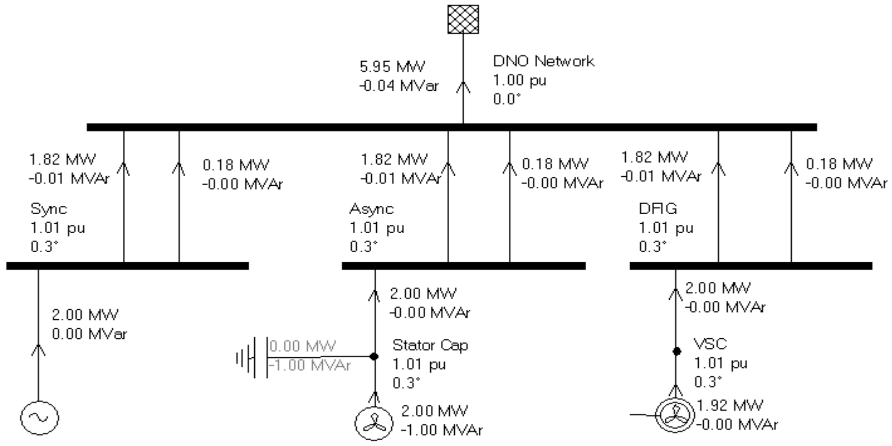

Figure 5 - Impedance Step Change Network

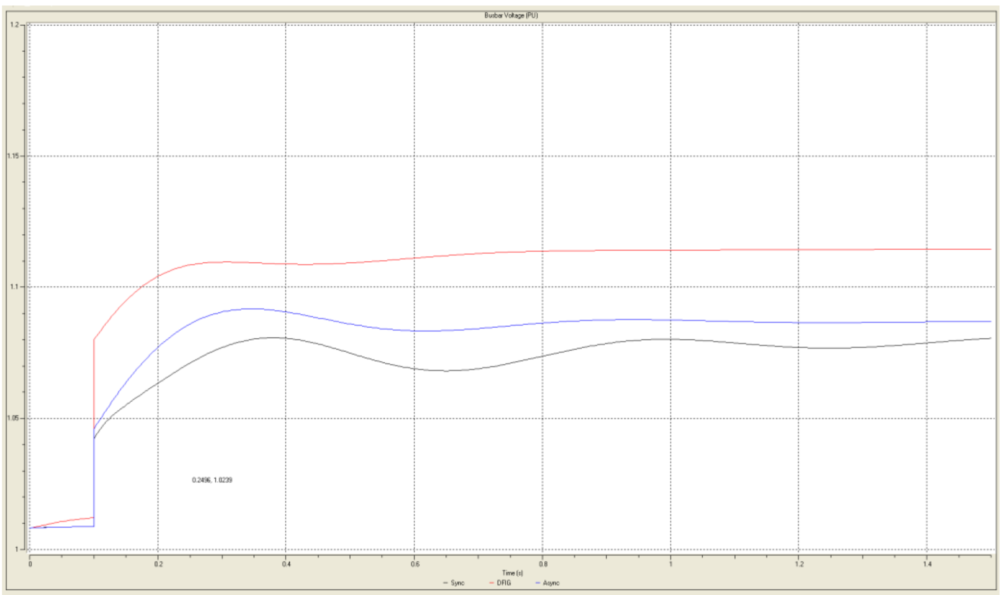

Figure 6 - Voltage Response

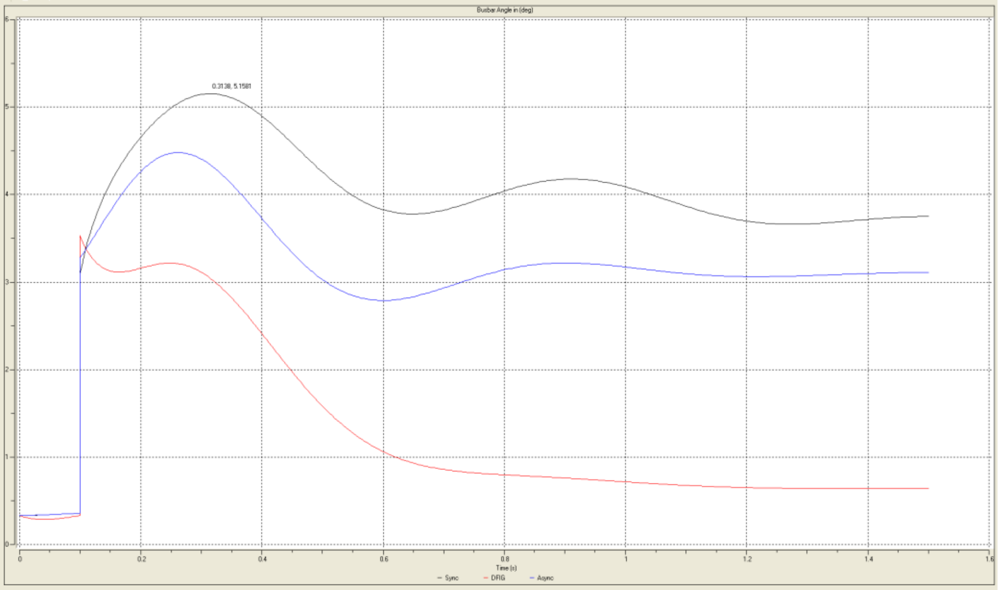

Figure 7 - Voltage Angle

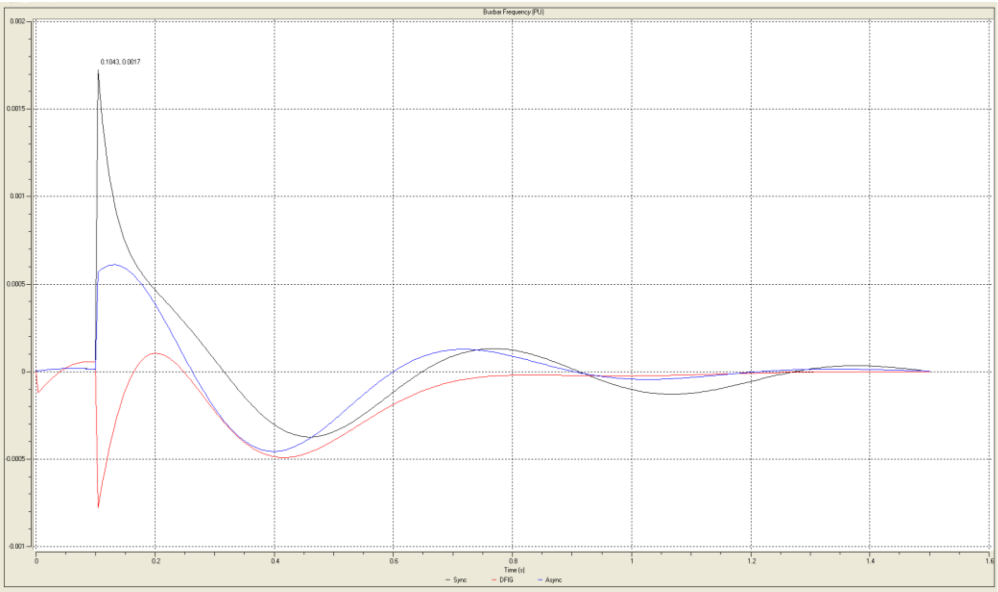

Figure 8 - Voltage Frequency Change (PU)

Results

Considering the settings in 10.5.7.1 with a K1 and K2=1

Prot Function	Small Power Generating Facility			
	LV Connected		HV Connected	
	Setting	Time	Setting	Time
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees#	
LoM (RoCoF)	K2 x 0.125 Hz s^{-1}		K2 x 0.125 Hz s^{-1} #	

From inspection of the above graphs the following detection (pick up) times would have resulted:-

Prot Function	Power Generating Module Type		
	Synchronous	Asynchronous	DFIG
	Pick Up Time	Pick Up Time	Pick Up Time
LoM (Vector Shift)	No Trip (5.15 Deg)	No Trip (4.5 Deg)	No Trip (3.5 Deg)
LoM (RoCoF)	No Trip (0.085 Hz s^{-1})	No Trip (0.03 Hz s^{-1})	No Trip (0.04 Hz s^{-1})

Actual tripping time would be determined by the relay sampling method, and in this case, it is highly unlikely that the RoCoF relay would have acted as the change in frequency was transient and oscillatory.

It can also be seen that the vector shift relay was quite close to pick-up, and there will be circumstances where the K factor will need to be raised to prevent mal-operation.

On the voltage response graph for the DFIG Generator would indicate that it would have exceeded the over voltage protection setting (+10%) after 1 second and tripped