NIE Networks Generator Interface Protection Amendment Project

Distribution Code Consultation Document

18th July 2017

Northern Ireland Electricity Networks

1. INTRODUCTION

1.1 The purpose of this consultation paper is to seek the views of stakeholders on proposed amendments to the NIE Distribution-Code (D-Code) relating to amendments to Generator Interface Protection Settings needed to manage future operation of the All-Island Power System. This consultation paper follows on from discussions held at the Distribution Code Review Panel on 6th June 2017.

1.2 This consultation paper should be read in conjunction with the accompanying paper entitled 'NIE Networks' Generator Interface Protection Amendment Project: Supporting Document'. It provides a comprehensive overview of the need for the changes, the process followed in determining the implications of the amendments and the NIE Networks' recommendations.

2. BACKGROUND AND OVERVIEW

2.1 The Facilitation of Renewables (FOR) study, published in 2010 by Eirgrid and SONi, was a detailed technical study that considered levels of non-synchronous generation (wind and HVDC imports) up to 100% of system demand. The study has shown that during times of high wind generation following the loss of the single largest credible contingency, Rate of Change of Frequency (RoCoF) values of greater than 0.5 Hz/s could be experienced on the island power system. If system separation were to occur RoCoF values up to 2 Hz/s measured over a rolling 500ms could be experienced in Northern Ireland. Simulations show that for a voltage dip induced power imbalance in a system with significant volumes of wind farms, RoCoF values in excess of 2Hz/s can occur over short time periods.

2.2 Accordingly, the main outcome of the FOR study was that wind levels (Non-Synchronous generation) of up to about 75% of demand could be accommodated, but a series of mitigation measures would have to be carried out. One of these measures was the need to address the issue of RoCoF. This issue is the current binding limitation on operating the power system past a system non-synchronous penetration (SNSP) of 50%.

2.3 If, in the event of a large system contingency, system RoCoF in Northern Ireland may reach 2Hz/s, measured over 500ms. In such a scenario the interface protection currently employed by Distributed Generators (DG) connected to the NIE Networks' distribution system will operate disconnecting a large quantum of generation from the system. In an already turbulent scenario this would further exacerbate system instability.

2.4 In order to overcome this concern, enabling higher SNSP levels to be experienced on the system, NIE Networks were tasked with examining the current interface protection requirements employed by DG with the intention of relaxing them. Consequently, NIE Networks employed Strathclyde University to establish the most appropriate interface protection settings for DG connected to the NIE Networks' distribution system.

3. D-CODE CHANGES

3.1 This paper proposes the changes required to the D-Code to incorporate the new generator interface protection settings proposed in the ‘NIE Networks’ Generator Interface Protection Amendment Project: Supporting Document’. The proposed changes are included in the redline version in appendix 1 of this paper.

3.2 Non-Technical Changes

There are multiple paragraph reference corrections to section 7 of the D-Code Connection Conditions.

3.3 Technical Changes

CC7.10 is a new paragraph detailing the specific protection required for Power Stations.

CC7.11 is a new paragraph detailing the protection arrangements and settings applicable to all Power Stations ≥16Amps/phase. The settings vary on both size and date of connection of the Power Station to the system.

Appendix 4 is a new appendix giving guidance on risk assessment when using RoCoF LoM protection.

4. NEXT STEPS

4.1 This consultation will commence on **18/07/17** and will run for a period of 4 weeks. During this period stakeholders are invited to express a view on any aspect of the proposed generator interface protection amendments. Responses should be received by NIE Networks **by 17:00 on 15/08/17** and should be addressed to:

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4.2 During the consultation period, should any stakeholder have any specific queries on any aspect of this document they should contact Carl Hashim as set out above.

4.3 Stakeholders wishing to respond anonymously should state so in their response.

4.4 Following the end of the consultation period and receipt of responses from consultees, NIE Networks will send a report to the Utility Regulator on the outcome of its review which will include written representations from all electricity stakeholders responses received during the consultation process.

APPENDIX 1 - PROPOSED DISTRIBUTION CODE MODIFICATIONS (REDLINE)

Connection Conditions

7 Additional Technical Criteria for Generating Units

7.1 All **Power Stations** shall, in addition to the requirements of paragraph CC6, meet the technical design and operational criteria in this paragraph CC7, and the **Setting Schedules** insofar as each requirement is applicable to them, which contains more detailed requirements for **Power Stations** than those set out in paragraph CC6 and are intended to be complementary to paragraph CC6. However, in the event of any conflict between the requirements of paragraph CC6 and the requirements of this paragraph CC7 and the **Setting Schedules**, the provisions of the **Setting Schedules** shall prevail. Detailed information relating to a particular connection will, where indicated below, be made available by the **DNO** on request by the **Generator**.

7.2 Each connection between a **Power Station** and the **Distribution System**, unless specified otherwise in the **Connection Agreement**, must be controlled by a circuit breaker capable of interrupting the maximum short circuit current at the **Connection Point**. The short circuit current design values at a **Connection Point** will be set out in the **Connection Agreement**.

7.3 All **Power Stations** must comply with the requirements of NIE Engineering Recommendation G59/1/NI, Recommendations for the connection of embedded generating plant to Public distribution systems above 20kV G75/1 or with outputs over 5**MW**, and Engineering Recommendation G83/1, each as applicable and as amended, supplemented, varied or replaced from time to time and with all other relevant Engineering Recommendations and relevant regulations and the particular requirements of the **DNO** which will take account of the conditions prevailing on the **Distribution System** at the **Connection Point** at the relevant time. The **DNO** will notify its particular requirements to the **Generator** during the course of the **Generator's** application for connection to the **Distribution System**.

7.4 **Reactive Power** capability

7.4.1 Each **Power Station** must be capable of operating at its **Registered Capacity** in a stable manner as a minimum within the following power factor ranges:

	Range
Type A Generating Units	0.95 absorbing - 0.98 absorbing
Type B Generating Units	0.95 absorbing – 0.98 generating
Type C Power Stations	0.95 absorbing – 0.95 producing

7.4.2 In this paragraph CC7 **Type A Power Stations** means **Induction Generating Units**.

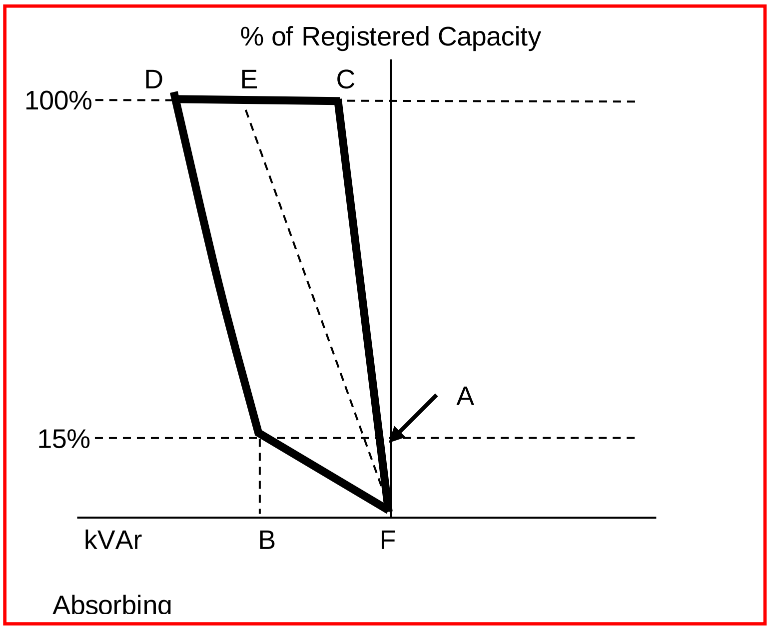
7.4.3 In this paragraph CC7 **Type B Power Stations** means:

(a) **Synchronous Generating Units**; with a **Registered Capacity** from 100 kW to under 5 MW;

(b) **Generating Units** of all types connected in part or in total through convertor technology with a **Registered Capacity** from 100kW; to under 5 MW

7.4.4 In this paragraph CC7 **Type C Power Stations** means **Power Stations** with a **Registered Capacity** of 5 MW and above

7.4.5 Each **Power Station with a Registered Capacity** of 100kW or more shall have a **Reactive Power** capab**ility at its Registered Capacity** as described in the following reactive power performance charts:-



Type A Reactive Power Performance

a) Point A is the minimum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage and power factor control modes);

b) Point B defines the maximum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control mode);

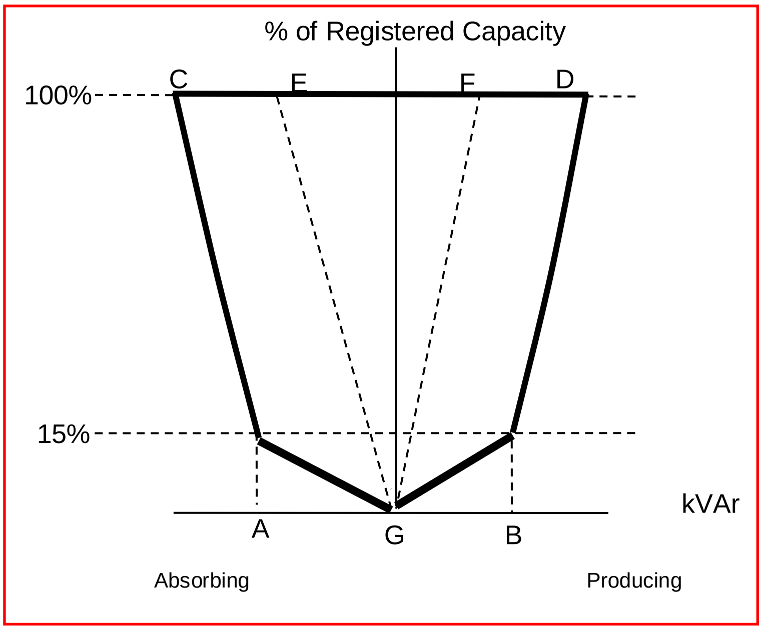
c) Point C is the minimum absorbing **Reactive Power** capability at 100% **Registered Capacity** and power factor limit of 0.98 absorbing either in power factor or voltage control modes;

d) Point D is the maximum absorbing capability at 100% **Registered Capacity** (voltage control mode);

e) Point E is the power factor limit of 0.95 absorbing at 100% **Registered Capacity** (power factor control mode);

f) Points A,B & D i.e. reactive capabilities are defined by the capability declared by the **Generator** during the application process; and

g) Point ‘F’ is the kVAr capability below 15% of **Registered Capacity** which may not be zero.



Type B Reactive Power Performance

a) Point A is the maximum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

b) Point B is the maximum producing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

c) Point C is the maximum absorbing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

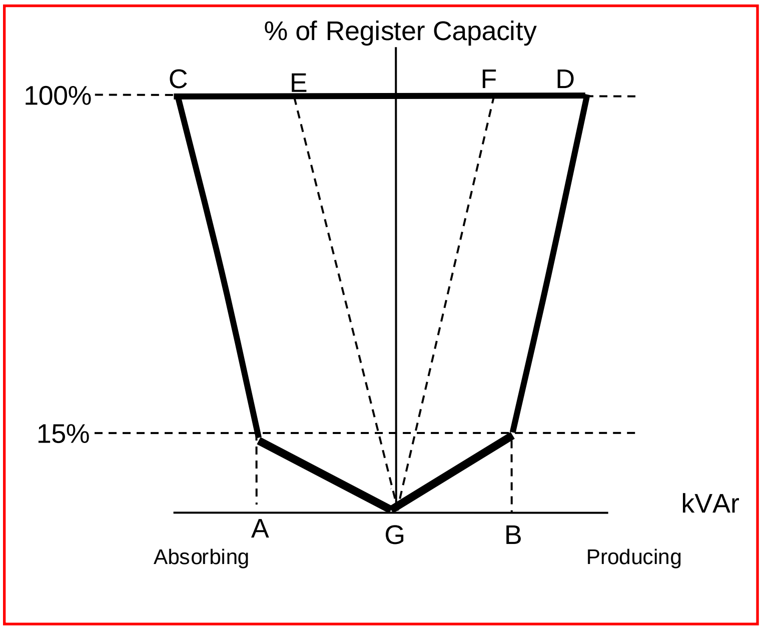
d) Point D is the maximum producing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

e) Point E is the power factor limit of 0.95 absorbing at 100% **Registered Capacity**;

f) Point F is the power factor limit of 0.98 producing at 100% **Registered Capacity**;

g) Point G is the kVAr capability, which may not be zero, at zero kW output; and

h) Points A,B,C & D i.e. reactive capabilities are defined by the capability declared by the **Generator** during the application process.



Type C Reactive Power Performance

a) Point A is the maximum absorbing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

b) Point B is the maximum producing **Reactive Power** capability at 15% **Registered Capacity** (voltage control);

c) Point C is the maximum absorbing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

d) Point D is the maximum producing **Reactive Power** capability at 100% **Registered Capacity** (voltage control);

e) Point E is the power factor limit of 0.95 absorbing at 100% **Registered Capacity**;

f) Point F is the power factor limit of 0.95 producing at 100% **Registered Capacity**;

g) Point G is the kVAr capability, which may not be zero, at zero kW output; and

h) Points A,B,C & D i.e. reactive capability are defined by the capability declared by the **Generator** during the application process.

7.5 A **Power Station** shall maintain the voltage at the **Connection Point** within its reactive capability power limits as outlined in paragraph CC7.4, the appropriate **Setting Schedules** and the statutory voltage limits as described in paragraph CC5.3.

7.6 All **Power Stations** connecting to the **Distribution System** shall be capable of providing the following **Reactive Power** control modes. All **Power Stations** shall operate in the control mode instructed by the **DNO**.

7.6.1 **Power Stations** with a **Register Capacity** of 5 MW and above shall be capable of providing three control modes**,** Power Factor Control, Voltage Control and VAr Control.

7.6.1.1. Whilst the **Power Station** is operating in Power Factor control mode its reactive capability is described by the envelope EFG within the Type C reactive power performance chart of paragraph CC7.4.5.

7.6.1.2. Whilst the **Power Station** is operating in Voltage Control Mode, the minimum reactive capability is described by the envelope ACDBG within the Type C reactive power performance chart of paragraph CC7.4.5.

7.6.1.3. Whilst the **Power Station** is operating in VAr Control Mode the **Power Station** must be capable of importing or exporting VArs within the envelope described by ACDBG within the Type C reactive power performance chart of paragraph CC7.4.5.

7.6.2 **Power Stations** with a **Registered Capacity** of less than 5 MW shall be capable of providing two control modes, Power Factor Control and Voltage Control.

7.6.2.1. Whilst the **Power Station** is operating in Power Factor control mode its reactive capability is described by the envelope ACE within the Type A and EGF for Type B within their associated reactive power performance charts of paragraph CC7.4.5.

7.6.2.2. Whilst the **Power Station** is operating in Voltage Control mode its reactive capability is described by the envelope ACDB for Type A and ACDBG for Type B within their associated reactive power performance chart of paragraph CC7.4.5.

7.7 The short circuit ratio for each **Power Station** shall not be less than 0.5.

7.8 For the avoidance of doubt, all **Power Stations** must be capable of delivering **Reactive Power** performance at the **Connection Point**. However, where complex **User Systems** involve **Generating Units** and **Load**, the **User** may submit calculations to support compliance.

7.9 Co-ordination with existing **Protection**

7.9.1 Each **Generator** must meet, in relation to each of its **Power Stations**, the target clearance times for fault current interchange with the **Distribution System** in order to reduce to a minimum the impact on the **Distribution System** of faults on circuits owned by a **Generator**. 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 System**. A **Generator** may obtain relevant details specific to its **Power Stations** pursuant to paragraph CC6.4. The **DNO** shall ensure that (subject to any necessary discrimination) the same target fault clearance times can be achieved by its own **Apparatus** at each **Connection Point**.

7.9.2 Unless otherwise agreed, the fault clearance times required by the **Connection Agreement** shall not be faster than 120 ms but, if otherwise agreed, nothing in this paragraph CC7.9.2~~7.5.2~~ shall prevent a **Power Station** or the **DNO's Apparatus** at the **Connection Point** from having faster clearance times (subject to necessary discrimination being maintained). The times specified in the **Connection Agreement** will reflect the **DNO's** view of the requirements of the **Distribution System**, and the **User's System**, for the expected life time of the **Protection** (for example, 15 years). The probability that the fault clearance times stated in the **Connection Agreement** will be exceeded by any given fault must be less than 2%.

7.9.3 To cover for failure of the above **Protection** systems to meet the above fault clearance times, the **Generator** may be required to provide back up **Protection**. The back up **Protection** shall be required to discriminate with other **Protections** fitted on the **Distribution System**. Relevant details will be made available to a **Generator** upon request pursuant to paragraph CC7.1.

7.9.4 The setting of any **Protection** controlling a circuit breaker or the operating values of any automatic switching device at any **Connection Point** shall have been agreed between the **DNO** and the **User** during the course of the application for a **Connection Agreement**. The settings and operating values will only be changed if both the **DNO** and the **User** agree provided that neither the **DNO** nor the **User** shall unreasonably withhold their consent.

7.9.5 If in the opinion of the **DNO** following an overall review of **Distribution System Protection** requirements improvements to any **Power Station Protection** scheme are necessary, the relevant provisions of the **Connection Agreement** shall be followed.

7.9.6 The Power Station Protection must co-ordinate with any auto reclose policy specified by the DNO.

7.10 Specific **Protection** Required for **Power Stations**

In addition to any **Protection** installed by the **Generator** to meet its own requirements and statutory obligations, the **Generator** must install **Protection** to achieve the following objectives:

i. For all **Power Stations**:

a. To disconnect the **Power Station** 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 Station**, 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 Stations:**

a. To inhibit connection of **Power Station** to the **System** unless all phases of the **DNO's Distribution System** are present and within the agreed ranges of **Protection** settings;

b. To disconnect the **Power Station** from the **System** in the event of the loss of one or more phases of the **DNO's Distribution System**;

iii. For single phase **Power Stations:**

a. To inhibit connection of **Power Station** to the **System** unless that phase of the **DNO's Distribution System** is present and within the agreed ranges of **Protection** settings;

b. To disconnect the **Power Station** from the **System** in the event of the loss of that phase of the **DNO's Distribution System**;

7.11 Suitable **Protection** arrangements and settings will depend upon the particular **Generator**'s installation and the requirements of the **Distribution System**. These individual requirements must be ascertained in discussions with the **DNO**. To achieve the objectives above, the **Protection** must include the detection of:

a. Over Voltage (O/V)

b. Under Voltage (U/V)

c. Over **Frequency** (O/F)

d. Under **Frequency** (U/F)

e. Loss of Mains (LoM)

There are different Protection settings dependent upon size of the **Power Station.**

Protection Function	Power Stations ≥ 16A/phase and <5MW		Power Stations >5MW	
	Setting	Time Delay	Setting	Time Delay
U/V stage 1	0.9pu$	0.5s	0.85pu$	3.0s
U/V stage 2	N/A	N/A	0.6pu$	2.0s
O/V	1.1pu$	0.5s	1.1pu$	0.5s
U/F	48Hz	0.5s	48Hz	0.5s
O/F	50.5Hz	0.5s	52Hz#	1.0s
LoM(RoCoF)¥	0.125 – 0 .4Hz/s$	0s	1.5Hz/s	0.3s∝

Notes: ∝ The required protection requirement is expressed in Hertz per second (Hz/s). The time delay should begin when the measured rate exceeds the threshold expressed in Hz/s and be reset if it falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in Hz/s continuously for 300ms. Setting the number of cycles on the relay used to calculate the RoCoF is not an acceptable implementation of the time delay since the relay would trip in less than 300ms if the rate was significantly higher than the threshold.

$ 0.125Hz/s is the preferred setting, 0.4Hz/s can be accepted where the **Generator's** studies indicate that nuisance tripping could occur at the lower setting. All **Protection** settings will be agreed between NIE Networks and the **Generator** during the connection process.

¥ RoCoF – Rate of Change of Frequency.

$ Base unit is defined as the nominal voltage at the **Connection Point.** This applies to phase-phase and phase-neutral voltages.

A default setting of 52Hz will apply unless a lower setting is requested by the **DNO**.

7.11.1 For each of the **Protection** functions, the CB opening should occur with no inherent time delay following a protection trip operation from the relay.

7.11.2 All **Power Stations** with an output ≥16A/phase and connected to the **System** on or after 1st October 2017 must apply protection settings as per paragraph CC7.11. For the avoidance of doubt, **Power Stations** with an output ≥16Amps/phase and connected on or after 1st October 2017 shall not employ vector shift as a LoM technique.

7.11.3 All **Power Stations** ≥16Amps/phase and <5MW connected to the **System** prior to 1st October 2017 shall maintain the protection settings as outlined in their **Connection Agreement.**

7.11.4 **All Power Stations ≥5MW** connected to the system prior to 1st October 2017 shall ensure that the **Protection** settings as per paragraph CC7.11 are applied by 31st December 2017.

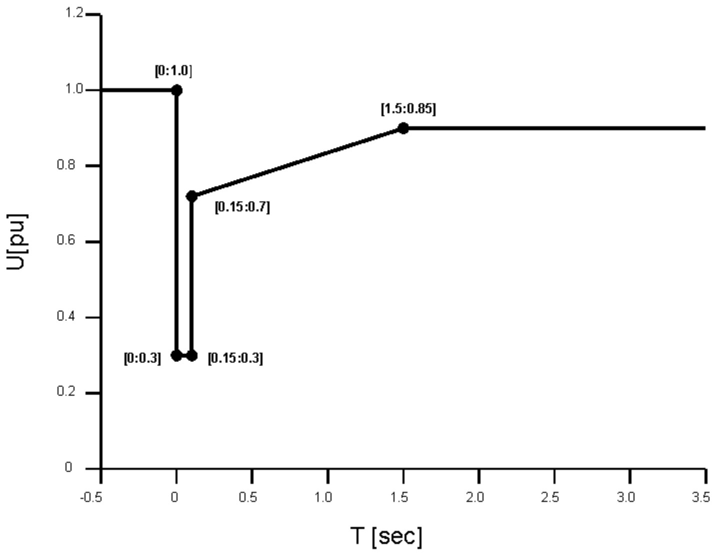
7.11.5 For the avoidance of doubt, the requirements of paragraph CC7.11 shall take precedence in any conflict arising between this **Distribution Code** and Engineering Recommendation G59/1/NI

7.11.6 In line with HSENI recommendations, all **Generators** should review and update relevant risk assessments to take account of the risks associated with islanding, with particular emphasis on out of phase re-closure, when adhering to the requirements of paragraph CC7.11. Further information on this is included in Appendix 4.

7.11.7 Each **Generator** must ensure that, in relation to each of its **Power Stations,** any **Protection** installed to meet its own requirements does not interfere with the correct operation of the **Protection** requirements detailed in paragraph CC7.11. For the avoidance of doubt, any **Protection** employed by the **Generator** should not operate to disconnect the **Power Station** from the **System** ahead of the operation of the **Protection** as required in paragraph CC7.11

~~7.10~~7.12 Fault Ride Through Requirements

~~7.10.1~~7.12.1 **Power Stations** Types A and B shall be capable of remaining connected to the **Distribution System** for voltage dips on any or all phases, where the **Distribution System** phase voltage measured at the **Connection Point** remains above the heavy black line in the diagram titled “ Fault ride through capability of Power Stations < 5 MW “ (below).

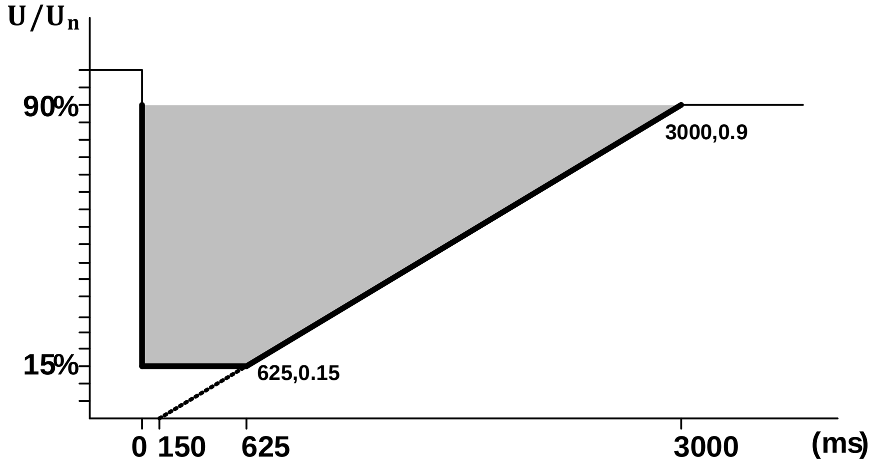


Fault Ride Through capability for Power Stations < 5 MW

~~7.10.1.1.~~7.12.1.1. After fault clearance the **Power Station** shall have the technical capability to provide at least 90% of its maximum available **Active Power** as quickly as the technology allows and in any event within 5 seconds of the voltage at the **Connection Point** recovering to within the normal operational range, as specified within the **Connection Agreement** for the particular site.

~~7.10.2~~7.12.2 A **Power Station** with a **Registered Capacity >5MW** shall have the technical capability to remain connected to the **Distribution System** for voltage dips on any or all phases, and remain stable, where the **Distribution System** phase to phase voltage measured at the **Connection Point** remains above the heavy black line in the diagram below titled "Fault Ride-Through Capability for Generation units ≥ 5MW connected to the Distribution System".

~~7.10.2.1.~~7.12.2.1. After Fault Clearance the **Power Station** shall have the technical capability to provide at least 90% of its maximum available **Active Power** as quickly as the technology allows and in any event within 5 seconds of the voltage at the **Connection Point** recovering to within the normal operational range as specified within the **Connection Agreement** for the particular site.



Fault Ride Through Capability for Power Stations ≥ 5MW connected to the Distribution System

~~7.10.3~~7.12.3 In addition to remaining connected to the **Distribution System**, the **Centrally Dispatched Generation Units** shall have the technical capability to provide the following functions:

~~7.10.3.1.~~7.12.3.1. During voltage dips, the **Power Station** shall provide **Active Power** in proportion to retained voltage and provide **Reactive Power** to the **Distribution System.** The provision of **Reactive Power** shall continue until the distribution voltage recovers to within the normal operational range, as specified within the **Connection Agreement** for the particular site, and in any case within the statutory limits as specified under paragraph CC5.3~~5.3~~, of the voltage level at which the **Power Station** is connected, or for at least 500ms, whichever is the sooner. The **Power Station** may use all or any available **Reactive Power** sources, including installed statcoms or SVCs, when providing reactive support during voltage dips.

~~7.10.3.2.~~7.12.3.2. For voltage dips cleared within 140ms, the **Power Station** shall provide at least 90% of its maximum available **Active Power** as quickly as the technology allows and in any event within 500ms of the voltage at the **Connection Point** recovering to the normal operating range, as specified within the **Connection Agreement** for the particular site, and in any case within the statutory limits as specified under paragraph CC5.3 of the voltage level at which the **Power Station** is connected**,**. For longer duration voltage dips, the **Power Station** shall provide at least 90% of its maximum available **Active Power** within 1 second of the voltage at the **Connection Point** recovering to the normal operating range for the voltage at which it is connected.

~~7.10.3.3.~~7.12.3.3. During and after faults, priority shall always be given to the **Active Power** response as defined in paragraphs CC7.12.3.1~~7.10.3.1~~ and CC7.12.3.2~~7.10.3.2~~. The reactive current response of the **Power Station** shall attempt to control the voltage back towards the voltage at which the **Power Station** is connected and should be at least proportional to the voltage dip. The reactive current response shall be supplied within the rating of the **Power Station** with a rise time no greater than 100ms and a settling time no greater than 300ms. For the avoidance of doubt, the **Power Station** may provide this reactive current response directly from a **Generating Unit**, or other additionally installed dynamic reactive devices on the site, or a combination of both.

~~7.10.3.4.~~7.12.3.4. The **Power Station** shall be capable of providing its transient reactive response irrespective of the reactive control mode in which it was operating at the time of the voltage dip. The **Power Station** shall revert to its pre-fault reactive control mode and set point within 500ms of the voltage at which the **Power Station** is connected, recovering to its normal operating range

~~7.10.3.5.~~7.12.3.5. The DNO may seek to reduce the magnitude of the dynamic reactive response of the **Power Station** if it is found to cause over-voltages on the **Distribution System**. In such a case, the **DNO** will make a formal request to the **Generator.** The **Generator** and the **DNO** shall seek to agree on the required changes, and the **Generator** shall formally confirm that any requested changes have been implemented within 120 days of receiving the formal request from the **DNO**.

~~7.11~~7.13 Minimum connected impedance

~~7.11.1~~7.13.1 For **Generating Units** which do not form part of a **WFPS** the minimum connected impedance applicable to the generator and **Generator Transformer** will be specified in the **Connection Agreement**. The **DNO's** requirements for the impedances will reflect the needs of the **Distribution System** from the fault level and stability points of view.

~~7.11.2~~7.13.2 For **WFPSs** the minimum connected impedance applicable to the whole **WFPS** as a single unit will be specified in the **Connection Agreement**. The **DNO's** requirements for the impedance will reflect the needs of the **Distribution System** from the fault level and stability points of view.

~~7.12~~7.14 Variations in **System Frequency**

~~7.12.1~~7.14.1 In order to comply with its **Grid Code** obligations, the **DNO** requires that, apart from those circumstances set out in ~~sub-~~paragraph CC7.14.2 ~~7.7.2~~, all **Independent Generating Plant** with an **Output** of 100kW or more shall stay connected and operate:

(a) continuously where the **Distribution System Frequency** varies within the range 49.5 to 52.0 Hz;

(b) for a period of up to one hour where the **Distribution System Frequency** varies within the range 48.0 to 49.5 Hz; and

(c) for a period of up to 5 minutes where the **Distribution System Frequency** varies within the range 47.0 to 48.0 Hz.

~~7.12.2~~7.14.2 The requirements of paragraph CC7.14.1~~7.12.1~~ do not apply where:

(a) ~~the~~The G59 relay has operated correctly, consistent with the settings agreed pursuant to paragraph CC7.11~~7.8~~; or

(b) The **Distribution System Frequency** has changed at a rate greater than 1.0 Hz/s measured over a rolling 500 ms

(c) ~~there~~There is manual intervention by the **Generator**.

~~7.13~~7.15 Agreement of rate-of-change-of-frequency settings

~~7.13.1~~7.15.1 Where **Power Stations** are equipped with rate-of-change-of-frequency relays or other devices which measure and operate in relation to a rate-of-change-of frequency the procedure in paragraphs CC7.15.2~~7.13.2~~ to CC7.15.5~~7.13.5~~ below will be followed to ensure satisfactory operation of the **Power Station**.

~~7.13.2~~7.15.2 At a reasonable time prior to a **Power Station** being connected to the **Distribution System**, and prior to any relevant modification to a **Power Station** or any relevant **Power Station Equipment**, the **Generator** shall contact the **DNO** with details of the proposed rate-of-change-of-frequency setting.

~~7.13.3~~7.15.3 The **DNO** shall, within a reasonable period and in any case no more than 28 days after being contacted pursuant to paragraph CC7.15.2 ~~7.8.2~~, discuss with the **Generator** whether the proposed settings are satisfactory. The agreed settings shall be specified in the **Connection Agreement**.

~~7.13.4~~7.15.4 In relation to any **Generator** which has agreed the settings with the **DNO** under these provisions, the **DNO** shall notify that **Generator** of any change of which it is aware in the expected rate-of-change-of-frequency on the **Distribution System** which may require new settings to be agreed.

~~7.13.5~~7.15.5 Each **Generator** shall be responsible for protecting the **Generating Unit** owned or operated by it against the risk of damage which might result from any **Frequency** excursion outside the range 52-Hz to 47-Hz and for deciding whether or not to interrupt the connection between its **Plant** and/or **Apparatus** and the **Distribution System** in the event of such a **Frequency** excursion.

~~7.14~~7.16 **Power Station** control arrangements

~~7.14.1~~7.16.1 All **Power Stations** in use after 1 January 2010 must be fitted with a device capable of setting the **power factor** of the **Power Station** within the relevant range, as set out in paragraph CC7.4.

~~7.14.2~~7.16.2 All **Power Stations** first connected on or after 1 January 2010 with an **Output** of 100kW or more, all **WFPSs** with an **Output** of 5**MW** or more first connected on or after 1 November 2007 and all **Power Stations** with an **Output** of 10 **MW** or more (other than **WFPSs**) connected to the **Distribution System** since 31 March 1992, must be fitted with a Fast Acting control system capable of being switched between **Voltage Control** mode and power factor control mode within a voltage band as specified within the **Connection Agreement** for the particular site , and in any case within statutory limits as specified under paragraph CC5.3. If the voltage is outside the specified limit the power factor control must revert to Emergency **Voltage Control** as described within the appropriate **Setting Schedules.** The control of voltage and power factor must ensure stable operation over the entire operating range of the **Power Station**. In the event that action by the **Power Station Active** and **Reactive Power** control functions is unable to achieve a sustained voltage within the statutory limits, the **Power Station** must detect and remain connected to the distribution system unless disconnected directly by a protection operation.

~~7.14.3~~7.16.3 All **Power Stations** first connected on or after 1 January 2010 with an **Output** of 5MW or more, must be fitted with a **Fast Acting** control system capable of being switched between **Voltage Control** mode, VAr control mode and power factor control mode within a voltage band as specified within the **Connection Agreement** for the particular site, and in any case within statutory limits as specified in paragraph CC5.3.

All **Power Stations** connected after 1 January 2012 must be fitted with voltage, power and frequency control and droop capabilities as described within the appropriate **Setting Schedules.**

7.14.4 Other **Voltage Control** schemes may be possible, but agreement between the **Generator** and the **DNO** must be reached at the application stage for connection about their suitability. If **Voltage Control** is implemented for the **Controllable WFPS** or **Dispatchable WFPS**, rather than on individual wind turbines, then the range of **Reactive Power** available should not be less than that which would have been available if **Voltage Control** had been on individual wind turbines. **Voltage Control** schemes based upon equipment located on the **DNO's** side of the connection may be possible, but such schemes are considered special, and the details, responsibilities and cost schedule must be agreed between the **Generator** and the **DNO** in the **Connection Agreement.**

~~7.15~~7.17 **Power Station** SCADA and control

~~7.15.1~~7.17.1 **Generators** shall in respect of their **Power Stations** in any of the following three categories comply with the SCADA signal requirements set out in this paragraph CC7.17~~7.15~~ and, in addition, such other SCADA signal requirements as the **DNO** may require because of network reasons, which will be specified prior to entry into the **Connection Agreement**:

(a) **Power Stations** with an **Output** of 1**MW** or more which are first connected after 1 January 2010;

(b) **Power Stations** with an **Output** of 100kW or more up to 1**MW** which are first connected after 1 January 2010 where the **DNO** decides that SCADA is required because of local network reasons; and

(c) **Power Stations** with an **Output** of 5**MW** or more which were connected prior to 1 January 2010.

~~7.15.2~~7.17.2 The **DNO** shall issue control instructions by means of the SCADA signals set out in the appropriate **Setting Schedules** or, in the event of a SCADA malfunction, such other means as are determined by the **DNO** in consultation with the **User**.

~~7.15.3~~7.17.3 The **User** shall acknowledge, where relevant, receipt of a control instruction issued under this paragraph CC7.17~~7.10~~ and shall comply promptly with the control instruction.

~~7.15.4~~7.17.4 The following signal formats shall be used where required by the particular connection:

(a) Analogue signals: 4 to 20 mA

(b) Digital pulse from the **DNO**: 24V dc

(c) Digital input from the **User**: 0 and 24V dc

~~7.15.5~~7.17.5 Analogue signals:

~~7.15.5.1.~~7.17.5.1. The analogue signal requirements for connecting Generators are set out in the appropriate **Setting Schedules.**

~~7.15.6~~7.17.6 Digital signals:

~~7.15.6.1.~~7.17.6.1. The digital signal requirements for connecting Generators are set out in the appropriate **Setting Schedules**

~~7.16~~7.18 Neutral **Earthing**

~~7.16.1~~7.18.1 The winding configuration and method of **Earthing** of **Generating Units** and associated **Generator Transformers** shall be agreed with the **DNO** or, if agreement cannot be reached, determined by the **DNO**.

APPENDIX 4

GUIDANCE ON RISK ASSESSMENT WHEN USING ROCOF LOM PROTECTION

1 This procedure aims to provide guidance on assessing the risks to a **Generator's Plant** and equipment where a **Power Station** is considering the effect of applying higher interface **Protection** settings. Information provided by the **DNO** in relation to this appendix 4 may be at the expense of the **Generator.**

1.1 The guidance in this appendix 4 relates to a new activity. Early experience may suggest there are more efficient or effective ways of assessing the risk. The **DNO** and **Generators** will be free to adapt this procedure to achieve the **Generators'** ends.

1.2 When a **Generator** wishes to carry out a risk assessment the **DNO** will be able to provide an estimate of the net (ie taking into account as appropriate other Generation on that part of the network) potential trapped load. This can be in the form of a yearly profile, and possibly in the form of a load duration curve. It is possible that an island may form at more than one automatic switching point on the **DNO's** network and the **DNO** will be able to provide a profile or estimate of a profile for each. This will enable a quick assessment to be made as to the whether the mismatch between load and generation is so gross as to obviate further study. It is for the **Generator** to determine what a gross mismatch is depending on the **Generating Unit's** response to a change in real or reactive power. The **Generator** should be aware that the trapped load on a network can change over time, due to the connection or disconnection of load and or Generation and network topology changes; hence the trapped load assessment may need to be carried out periodically.

1.3 **DNOs** will also be able to provide indicative fault rates for their network that lead to the tripping of the automatic switching points in paragraph 1.2 above.

1.4 **DNOs** will also be able to provide the automatic switching times employed by any auto-reclose switchgear employed at switching points identified in paragraph 1.2.

1.5 **DNOs** will provide the information above and any other relevant information reasonably required within a reasonable time when requested by the **Generator**.

1.6 A key influence on the stability of any power island will be the short term, ie second by second, variation of the trapped load. The **DNO** will be able to provide either a generic variability of the load with typically 1s resolution data points, or at the **Generator's** expense will be able to measure actual load variability for the network in question for some representative operating conditions.

1.7 Armed with the above information the **Generator** will be able to commission appropriate modelling to simulate the stability of the **Generator's Plant** when subject to an islanding condition and hence assess the risks associated with an out-of-phase re-closure incident. Where the Generator considers these risks to be too high, sensitivity analysis should enable them to identify the effectiveness of various remedial actions.