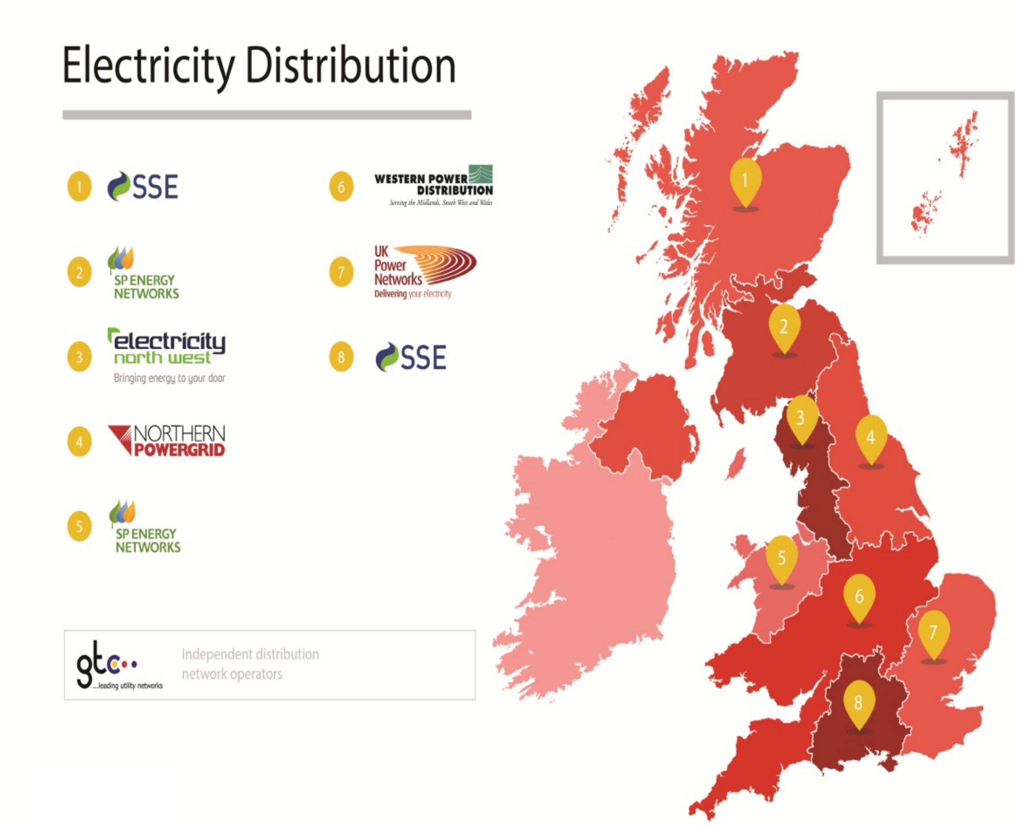
The Licensed Distribution Network Operators of Great Britain

Generator Connexion Requirements – a review of Engineering Recommendation G59/3-1

Report to Authority – June 25 2015



Contents

1 SUMMARY OF PROPOSALS

The proposed changes to G59/3-1 outlined in this report were initiated at the Distribution Code Panel Review (DCRP) meeting on December 4 2014 (please see Appendix 1). The Panel agreed to the establishment of a DCRP working group to undertake the review, culminating in this report.

The DCRP has consulted widely on the issue, ensuring that all relevant stakeholders, and not just Authorized Electricity Operators, are fully aware of the implications of the proposals.

The licensed Distribution Network Operators (DNOs) of Great Britain recommend that the Authority approve these proposals as they considerably add to the clarity of the requirements on customers, and in particular generation scheme developers and installers.

The proposals have generally been welcomed and supported. The proposals have not brought forward any comments from stakeholders that suggest any material detriment to any User or prospective User.

The DCRP, at its meeting on June 4 2015 unanimously supported the changes proposed in this report.

2 INTRODUCTION

Paragraph 21.8 of the DNOs' licences requires that the DNOs periodically review the D Code, its qualifying standards and their implementation.

Paragraph 21.9 then requires that after completing any such review, the DNOs must send to the Authority**:**

(a) a report on the outcome of the review;

(b) a statement of any proposed revisions to the Distribution Code that the licensees (having regard to the outcome of the review) reasonably thinks are appropriate for the continuing achievement of the objectives referred to in paragraph 21.4; and

(c) any written representations or objections from Authorised Electricity Operators (including any proposals by such operators for revisions to the Distribution Code that have not been accepted by the licensees in the course of the review) that were received during the consultation process and have not been withdrawn.

The DCRP consulted widely with all stakeholders likely to be affected by the proposed changes to EREC G59/3-1. The DCRP consultation opened on 16 March 2015 and a consultation pack was circulated to Industry stakeholders and also published on the Distribution Code website. The consultation paper explained the reasoning behind each of the proposed changes. The consultation paper is attached as Appendix 2 to this report.

Comments were invited from all industry participants and stakeholders by a deadline of 13 April 2015.

In total nine responses were submitted by industry stakeholders. There were four responses from DNOs, four responses from relevant Trade Associations and Installers and one response from the Health & Safety Executive (HSE). It is understood the HSE are generally comfortable with the approach adopted in the G59/3-2 drafting.

All responses are summarized in Section 4.

3 DESCRIPTION OF THE PROPOSED AMENDMENTS AND THEIR EFFECTS

3.1 Background

Engineering Recommendation (EREC) G59 (Recommendation for the connection of generating plant to the distribution systems of the licensed distribution network operators of Great Britain) is the primary industry document governing the requirements for connection of embedded generators for operation in parallel with public low-voltage distribution networks, with the exception of those under 16A per phase which can be connected under EREC G83. EREC G59 addresses all technical aspects of the connection process from standards of functionality to site commissioning and was first written and published in 1985 and updated in 1991, 2010, 2013 and with a minor revision in 2014.

EREC G59 is referenced in the Distribution Code as an Annex 1 document and as such forms part of the Distribution Code technical requirements making such connexions easier, simpler and cheaper, yet ensuring that safety and quality of supply are not compromised.

3.2 Drivers for Change

During the development of EREC G59/3-1 provision was made for the Type Testing of Generating Units of up to 50kW or 17kW per phase, this allows many generation connections to be made with reduced on site testing. At the same time more detailed requirements for on-site testing for other generating units were incorporated. One on-site test in particular involving the removal of a single phase connection to the generating unit under load conditions, had not been carried out correctly prior to the issue of G59/3-1 and clarification on how to carry out the test was therefore included. However experience has shown that this test has become unduly problematic for two reasons. Firstly DNOs are now reluctant to remove a cut out fuse under load conditions, due to concerns over interruption’s to customer’s supplies and the meeting of appropriate notice conditions. Secondly there was concern at the cost of providing additional single phase disconnection points as part of the installation by the installer. There were also a number of typographical errors which caused some confusion as to their meaning.

3.3 Proposed Changes

The following is a short description of the issues recognized with the current drafting of EREC G59/3-1. The new draft EREC G59/3-2 encompasses changes to a number of sections and those changes are described below.

3.3.1 - Section 7.3.4 Removal of out of date reference to pevious versions of G59
Reference to EREC G59/2, G59/3 and G59/3-1 removed as are no longer relevant.

3.3.2 - Section 12.4.1 Change of test procedure
In sub section c) (i) the increments of RoCoF and acceptable limits have been changed to 0.025Hzs-1.
In sub section c) (ii) additional RoCoF above setting used for timing tests has been changed to 0.05Hz-1.
In sub section d) (i) starting Vector Shift for testing changed has been changed to 4 degrees.
In sub section d) (ii) additional Vector Shift above setting used for timing tests has been changed to 3 degrees.

While the terms of reference were to look at the issues with respect to an error between the text and the test sheet for RoCoF, evidence was presented to the WG about the practicality of carrying out both the RoCoF and Vector shift tests. It was felt that changes to the Vector Shift test process should be made at the same time so that they are consistent with the revised tests for RoCoF. The above revised tests are no more onerous than those originally described, and the setting values have not been changed.

3.3.3 - Section 12.4.1 sub section (f) removal of single phase test
This section describing a test where a single phase is disconnected during the operation of a generating unit has been removed in its entirety.
As described earlier in 3.2, this single phase test was seen as problematic for DNOs in terms of customer notification requirements, and in some cases incurred additional costs to generators which were hard to justify in terms of the additional value provided by the test compared to the on site test required for all generating units. This on site test is described in section 12.3.1 where a three phase disconnection test is asked for and results are to be recorded for all generating unit installations in Appendix 13.2 of EEC G59/3-2..

In order to understand why the single phase test was asked for in the earlier versions of G59, various network conditions were considered by the working group. The most likely fault conditions which this test replicated would be an open circuit fault on the DNOs network, or the operation of a single phase fuse with the remaining network continuing to operate fairly close to normal, if the generator output and local load beyond the fault were reasonably closely matched.

While this condition may well exist in a small number of faults, the working group then looked at the potential danger from this condition. From a generators point of view the main risks are out of phase reclosing which does not occur for this particular fault as the healthy phases keep in synchronism with the main system and any excessive load current will be dealt with by the generating units overload and/or phase balance protection.

From the DNO point of view the operational practices of all GB DNOs require that LV networks are treated as live at all times and that HV networks are isolated and earthed prior to any work being undertaken on them. Therefore the removal of this test would not create any additional hazards to DNO staff.

It was also noted that the removal of this test did not in any way alter the protection requirements for the connection of a generating unit to a DNO network but that it would simplify on site testing and reduce the costs of connecting a generating unit to a DNO network.

Taking all these things into consideration the working group unanimously agreed to recommend the removal of the test described in section 12.4.1 sub section (f) and in addition revise section 12.3.1 (g) to include the provision of two options to undertake a functional test confirming that the Interface Protection has operated.

3.3.4 - Section 13.3 On-site test schedule

A number of changes have been made to the on-site test schedule for non-type tested generating units. Some of these changes are to reflect the changes made to section 12.4.1 as noted in 3.3.2 of this document, these are in the loss of mains protection tests for RoCoF and Vector Shift on pages 108 and 109. Others have been made to correct typographical errors, and others have been made to clarify the requirements of the test in line with the requirements already set down in section 12.

3.3.5 - Section 13.3 Typographical Correction

There was a numbering error in the sub sections with two numbered 13.8.3.2 and no 13.8.3.3 this has been corrected by renumbering the second sub section covering Over and Under Frequency

DEVELOPMENT OF REVISED APPROACH

The following section outlines how the Panel has ensured appropriate representation and dissemination of the revision to EREC G59/3-1.

Establishment of WG

As explained earlier in section 3.2 this work was considered necessary in order to simplify the connection of generation to the networks of GB DNOs. In December 2014 the DCRP approved the setting up of a WG to consider the issues.

The first meeting of the WG was held in January 2015. The WG comprised of the six main GB DNOs and also included direct representation from the Renewable Energy Industry including installers and manufacturers. A full list of all the organisations represented on the WG, can be found in Appendix 6.

The consultation draft G59/3-2 was completed at the WG meeting in January 2015. Subsequent to the public consultation the WG met a second time on 15 April to consider and deliberate the comments submitted by the industry stakeholders. The WG unanimously agreed to propose the changes as set out in 3.3.

3.4 Impact on DNOs' Systems and the Total System

There is no impact on the DNOs Systems or the Total System as a result of the proposed changes. It is expected that these revisions will assist Users to connect small scale renewable generation, and therefore the revised documents are expected to aid the growth of small scale renewable and low carbon generation connected to distribution system.

3.5 Impact on DNOs' Systems' Users

The principle aim of these revisions is to make it easier for Users to connect small scale generation to the distribution system.

3.6 Assessment against Distribution Code Objectives

The principle Distribution Code objectives, within the specified structure and technical requirements of the Code, are to

(a) permit the development, maintenance, and operation of an efficient, co-ordinated, and economical system for the distribution of electricity; and

(b) facilitate competition in the generation and supply of electricity.

Given that one of the principle aims of these revisions is to make it easier for Users to connect small scale generation to the distribution system, both these objectives are promoted by the current proposals.

3.7 Impact on other Industry Documents

There is no material impact on any other Industry document. With regards to the Distribution Code there is only minor editorial change required to substitute reference to G59/3-1 to G59/3-2.

3.8 Environmental impact Assessment

These proposals are designed to make it easier for all generation to connect to distribution systems, with the assumption that the large majority of such connexions will be by renewable or low carbon generators. Given that these proposals are only an enabler, ie it is the energy market and its support arrangements that is the principal driver of low carbon generation growth; it is not possible to ascribe a direct environmental effect, although it clearly will be positive.

4 CONSULTATION RESPONSES

This section provides a short summary of each response to the consultation, particularly noting any salient points that the respondent has made. The consultation respondants are aware of the final proposals as they were all indirectly represented on the working group.

4.1 Association of Manufacturers of Power Systems

We welcome the proposal to remove of the single phase LoM test. This was difficult to achieve, could encouraged poor practise and, to undertake the test properly, required very expensive and impractical modifications to distributed generator switchgear for little benefit.

4.2 Association for Decentralised Energy

We agree with the proposed removal of the single phase LoM test. Members advise us that the test was challenging to implement, encouraged poor practice and required high-cost modifications to distributed generator switchgear for little practical benefit.

4.3 Cummins Power Generation (Kent) Limited

We welcome the removal of the single phase LoM test. This was difficult to achieve, could encouraged poor practise and, to undertake the test properly, required very expensive and impractical modifications to distributed generator switchgear for little benefit.

4.4 Deepsea PLC

Deepsea plc had a representative on the DCRP working group and thus supported the proposals to remove the single phase test. They also responded by identifying an editorial error on page 107.

4.5 Electricity North West

Electricity North West have reviewed the changes to G59/3-1 associated with the above public consultation, and confirm we agree with all the proposed changes. We support this amendment of G59/3.

4.6 Northern Powergrid

Northern Powergrid submitted a response confirming that they do not have any comments on the consultation documents and agree to the proposed changes.

4.7 ScottishPower Energy Networks

ScottishPower submitted a response indicating that they were not in agreement with the working group proposals to remove of the single phase LoM test. They suggested that the removal of the single phase loss of mains test meant that there would be no longer a final test to confirm that all connections have been replaced correctly (following the earlier 'calibration tests') and that the overall system is working as expected. Retention of the test would also ensure that the DNO witness tests the full installation (including circuit breaker operation) with the generator installed/running and not just testing the functionality of the protection equipment.

Following discussions at the second working group meeting Scottish Power were happy to accept the removal of the test described in section 12.4.1 sub section f by including a revision to section 12.3.1 (g) that would include the provision of two *options to carry out a functional test confirming that the Interface Protection has operated.*

4.8 UK Power Networks

UK Power Networks submitted a response that in the main highlighted a number of editorial comments.

4.9 Health & Safety Executive (HSE)

The HSE submitted a response which indicated they had no comments to offer on the proposed drafting.

5 REVISED DOCUMENTS

Following the closure of the consultation on 13 April 2015 the Working Group subsequently met on 15 April 2015 and debated all the responses received. Amendments have subsequently been proposed aimed at resolving issues that the respondents had originally raised in relation to the single phase test referenced in section 12.3.4 sub section f.

5.1 G59/3-2

As is explained in the consultation paper, G59/3-1 has undergone a revision in particular to address the concerns raised. The proposed changes have been summarised in 3.3. Copies of G59/3-2 in track change and clean format have been provided with this report and they can be found in Appendix

5.2 Distribution Code

The only changes relate to the change of reference of G59/3-1 to G59/3-2. Copy included as Appendix 7.

5.2.1 Retrospective Application

When changes are made to the D Code or to any of its qualifying standards, there is always the question of whether the changes apply retrospectively to existing plant and equipment.

The general approach taken across the industry is that retrospective compliance is not generally expected. Where it is important for compliance to be retrospective, then this should be specifically addressed in both the consultation and the drafting of the amendment. Otherwise as plant and equipment is replaced, or other significant alteration is made, that is the point that compliance with the new or current requirements should be achieved.

5.2.2 Implementation Period

The DCRP has agreed to an immediate implementation of EREC G59/3-2 from date of publication.

6 APPENDICES

6.1 Appendix 1 - DCRP paper

6.2 Appendix 2 - Consultation Paper

6.3 Appendix 3 - Consultation responses and comments

6.4 Appendix 4 –WG response to consultation comments.

6.5 Appendix 5 - Proposed ER G59/3-2 (track change)

6.6 Appendix 6 - Proposed ER G59/3-2 (clean version)

6.7 Appendix 7 – Revised Distribution Code – July 2015 version 26

Appendix 1 - DCRP paper

Draft terms of reference for a working group to consider minor revisions to G59/3-1 following comments from DG installers.

Background

G59/3 was issued in September 2013 and introduced type testing for generating units of up to 50kW and at the same time tried to clarify the requirements for some elements of the testing of non type tested generating units.

Areas to be considered and acted upon by the work group

Two things have caused problems and have been raised by Generators and their staff involved in the commissioning of non type tested generating units. It is proposed to make changes in these two areas.

1/ testing of RoCoF elements, there is a discrepancy between the wording of how to carry out the test and the wording of the specimen test schedule in G59/3.

It is proposed to change the test schedule so that the two parts of the document are consistent.

2/ There is a requirement in G59/3 which has been carried over from earlier versions to carry out a test by removal of a fuse while the generator is running for LV connected generating units. The work group produced the G59/3 revision were aware that some testers were incorrectly interpreting the requirements and removing a fuse supplying voltage to the protection relay. This did not carry out the intended test and a clause was inserted to say that the test should not be carried out this way.

This has caused a lot of problems as the only single phase fusing arrangement in most installations is in the DNOs Cut Out. While technically it is practical for the DNO to remove this fuse there are problems.

a) The DNO does not have to witness tests at LV and DNOs in general do not want to impose costs on generator installers who have an established track record of successful installations by having to witness all tests where non type tested equipment is installed.
b) DNOs need to inform customers if there supply is to be interrupted and this will incur a considerable time overhead in carrying out the notification.
c) Installers can include additional fuses to carry out this test as part of the installation but this comes at a considerable expense to allow a test which is carried out once, on installation only.

The reason for the test was to provide assurance that the generator would disconnect on loss of a phase from the DNO, this does not cause an unusual safety hazard and DNOs live low voltage working practices will continue to provide a safe environment for DNO staff.

There is a very small increased risk to the general public from a broken wire on an overhead line being back fed if this protection does not operate. However this is small compared to the overall risk of wires falling down and still being energised.

It is proposed to remove this requirement from the on site testing process and replace it with a three phase disconnection test which mirrors that required for type tested generating units. It is not proposed to remove the requirement for this test from the type testing process. As most small scale generating units will be type tested in the future this is still a useful feature of the protection systems required under G59/3

Time scales

It is expected that a single meeting of DNOs and invited generator manufacturers and installers will be able to agree a revision of G59/3-1 to produce G59/3-2 in January 2015, go out to public consultation in February 2015 and agree a final text for approval by Ofgem in March 2015 with a target implementation date of 1st May 2015.

Other work affecting G59

Note it is expected that a further minor revision to G59/3 will be required towards the end of 2015 to take account of the work being done by the joint grid and distribution code working party looking at frequency changes during large disturbances.

As such it is proposed to issue free upgrades to all those who have already purchased G59/3 or G59/3-1

Some time in 2016 or possibly 2017 G59 will need to undergo a major revision to incorporate the “Requirements for Generators” issued by ENTSOe

Martin Lee

25th November 2014

Appendix 2 - Consultation Paper

The Licensed Distribution Network Operators of Great Britain

Generator Connection Requirements – a review of Engineering Recommendations G59/3-1 (2014)

1. BACKGROUND

Engineering Recommendation (EREC) G59/3-1(Recommendation for the connection of generating plant to the distribution systems of the licensed distribution network operators of Great Britain) is the primary industry document governing the requirements for connection of embedded generators for operation in parallel with public low-voltage distribution networks, with the exception of those under 16A per phase which can be connected under EREC G83/2 (Dec 2012). EREC G59 addresses all technical aspects of the connection process from standards of functionality to site commissioning and was first written and published in 1985 and updated in 1991, 2010, 2013 and with a minor revision in 2014.

EREC G59 is referenced in the Distribution Code as an Annex 1 document and as such forms part of the Distribution Code technical requirements.

1.1. Drivers for change

During the development of EREC G59/3 provision was made for the Type Testing of Generating Units of up to 50kW or 17kW per phase, this allows many generation connections to be made with reduced on site testing. At the same time more detailed requirements for on site testing for other generating units were incorporated in the document. One on site test in particular involving the removal of a single phase connection to the generating unit under load conditions, had not been carried out correctly prior to the issue of G59/3 and clarification on how to carry out the test was included in G59/3. However experience has shown that this test has become problematic for two reasons. Firstly DNOs are now reluctant to remove a cut out fuse under load conditions, due to concerns over interruption's to customer's supplies and the meeting of appropriate notice conditions. Secondly there was concern at the cost of providing additional single phase disconnection points as part of the installation by the installer. There were also a number of typographical errors which caused some confusion as to their meaning.

2. ISSUES ADRESSED IN THE G59/3-1 REVISION

The following is a short description of the issues recognized with the current drafting of EREC G59/3-1 The new draft of EREC G59/3-2 encompasses changes to the drafting and they are described below.

2.1. Section 7.3.4 Removal off out of date reference

Reference to EREC G59/2 removed as not relevant

2.2. Section 12.4.1 Change of test procedure

Sub section c) (i) increments of RoCoF and acceptable limits changed to 0.025Hzs^{-1}

Sub section c) (ii) additional RoCoF above setting used for timing tests changed to 0.05Hz^{-1}

Sub section d) (i) starting Vector Shift for testing changed to 4 degrees

Sub section d) (ii) additional Vector Shift above setting used for timing tests changed to 3 degrees

While the terms of reference were to look at the issues with respect to an error between the text and the test sheet for RoCoF, evidence was presented to the WG about the practicality of carrying out both the RoCoF and Vector shift tests. It was felt that changes to the Vector Shift test process should be made at the same time so that they are consistent with the revised tests for RoCoF. The revised tests are no more onerous than those originally described, and the setting values have not been changed.

2.3. Section 12.4.1 Sub section f removal of test

This section describing a test where a single phase is disconnected during the operation of a generating unit has been removed in its entirety.

As described above in Drivers for Change this test was seen as problematic in terms of customer notification requirements, and in some cases incurred costs which were hard to justify in terms of the additional value provided by the test compared to the on site test required for all Generation Units. This is described in section 12.3.1 where a three phase disconnection test is asked for and is to be recorded for all Generating Unit installations in section 13.2

In order to understand why the single phase test was asked for in prior versions of G59, various network conditions were considered by the working group. The most likely fault conditions which this test replicated would be an open circuit fault on the DNOs network, or the operation of a single phase fuse with the remaining network continuing to operate fairly close to normal, if the generator output and local load beyond the fault were reasonably closely matched.

While this condition may well exist in a small number of faults, the working group then looked at the potential danger from this condition.

From a Generators point of view the main risks are out of phase reclosing which does not occur for this particular fault as the healthy phases keep in synchronism with the main system and excessive load current which will be dealt with by the Generating Units overload and/or phase balance protection

From the DNO point of view the operational practices of all UK DNOs require that LV networks are treated as live at all times and that HV networks are isolated and earthed prior to any work being undertaken on them. Therefore the removal of this test would not create any additional hazards to DNO staff.

It was also noted that the removal of this test did not in any way alter the protection requirements for the connection of a Generating Unit to a DNO network but that it would simplify on site testing and in some cases reduce the cost of connecting a Generating Unit to a DNOs network.

Taking all these things into consideration the Working Group were happy to recommend the removal of the test described in section 12.4.1 sub section f

2.4. Section 13.3 On site test schedule

A number of changes have been made to the on site test schedule for non Type Tested Generating Units. Some of these changes are to reflect the changes made to section 12.4.1 as noted above under item 2.2 of this document, these are in the loss of mains Protection Tests for RoCoF and Vector Shift on pages 108 and 109. Others have been made to correct typographical errors, and others have been made to clarify the requirements of the test in line with the requirements already set down in section 12.

2.5. Section 13.8.3 Typographical Correction

There was a numbering error in the sub sections with two numbered 13.8.3.2 and no 13.8.3.3 this has been corrected by renumbering the second sub section covering Over and Under Frequency

3. DEVELOPMENT OF REVISED APPROACH

The following section outlines how the Panel has ensured appropriate representation and dissemination of the revision to EREC G59/3-1

3.1. Establishment of WG

As explained in section 1.1 *Drivers for Change* this work was considered necessary in order to simplify the connection of generation to the networks of GB DNOs. The Distribution Code review panel authorized setting up a WG to consider the issues in December 2014.. A meeting of the WG was held in January 2015. The WG comprised the six main GB DNOs and also included direct representation from the Renewable Energy Industry including installers and manufacturers A full list of all the organisations represented on the WG, can be found in appendix 2.

The development of the draft G59/3-2 was completed at the WG meeting in January 2015

4. CONSULTATION

4.1. Published with this consultation paper is both a clean and marked up version of draft EREC G59/3-2.

The marked up version has been provided to specifically support and further explain the issues identified in section 2 of this paper.

4.2. Comments are welcome on any aspect of the new EREC G59/3-2. Comments should be returned on the MS Word proforma “EREC G59/3-2 comment table. doc” which is included with this paper or can be found on the DCode website (www.dcode.org.uk).

4.3. Comments should be sent to DCRP Secretary, David Spillett at the ENA (david.spillett@energynetworks.org) **by Monday 13 April 2015.** The ENA's address is:

Energy Networks Association
6 Floor Dean Bradley House
52 Horseferry Road
London
SW1P 2AF
www.energynetworks.org

APPENDIX 1 WG TERMS OF REFERENCE

Terms of reference for a working group to consider minor revisions to G59/3-1 following comments from DG installers.

Background

G59/3 was issued in September 2013 and introduced type testing for generating units of up to 50kW and at the same time tried to clarify the requirements for some elements of the testing of non type tested generating units.

Areas to be considered and acted upon by the work group

Two things have caused problems and have been raised by Generators and their staff involved in the commissioning of non type tested generating units. It is proposed to make changes in these two areas.

1/ testing of RoCoF elements, there is a discrepancy between the wording of how to carry out the test and the wording of the specimen test schedule in G59/3.

It is proposed to change the test schedule so that the two parts of the document are consistent.

2/ There is a requirement in G59/3 which has been carried over from earlier versions to carry out a test by removal of a fuse while the generator is running for LV connected generating units. The work group produced the G59/3 revision were aware that some testers were incorrectly interpreting the requirements and removing a fuse supplying voltage to the protection relay. This did not carry out the intended test and a clause was inserted to say that the test should not be carried out this way.

This has caused a lot of problems as the only single phase fusing arrangement in most installations is in the DNOs Cut Out. While technically it is practical for the DNO to remove this fuse there are problems.

a) The DNO does not have to witness tests at LV and DNOs in general do not want to impose costs on generator installers who have an established track record of successful installations by having to witness all tests where non type tested equipment is installed.
b) DNOs need to inform customers if there supply is to be interrupted and this will incur a considerable time overhead in carrying out the notification.
c) Installers can include additional fuses to carry out this test as part of the installation but this comes at a considerable expense to allow a test which is carried out once, on installation only.

The reason for the test was to provide assurance that the generator would disconnect on loss of a phase from the DNO, this does not cause an unusual safety hazard and DNOs live low voltage working practices will continue to provide a safe environment for DNO staff.

There is a very small increased risk to the general public from a broken wire on an overhead line being back fed if this protection does not operate. However this is small compared to the overall risk of wires falling down and still being energised.

It is proposed to remove this requirement from the on site testing process and replace it with a three phase disconnection test which mirrors that required for type tested generating units. It is not

proposed to remove the requirement for this test from the type testing process. As most small scale generating units will be type tested in the future this is still a useful feature of the protection systems required under G59/3

Time scales

It is expected that a single meeting of DNOs and invited generator manufacturers and installers will be able to agree a revision of G59/3-1 to produce G59/3-2 in January 2015, go out to public consultation in February 2015 and agree a final text for approval by Ofgem in March 2015 with a target implementation date of 1st May 2015.

Other work affecting G59

Note it is expected that a further minor revision to G59/3 will be required towards the end of 2015 to take account of the work being done by the joint grid and distribution code working party looking at frequency changes during large disturbances.

As such it is proposed to issue free upgrades to all those who have already purchased G59/3 or G59/3-1

Some time in 2016 or possibly 2017 G59 will need to undergo a major revision to incorporate the "Requirements for Generators" issued by ENTSOe

Martin Lee

25th November 2014

APPENDIX 2 G59/3-1 WORKING GROUP MEMBERSHIP

Deepsea plc – Protection relay manufacturer

Electricity North West – DNO

ENER-G Combined Power Limited – CHP installer

Northern Powergrid – DNO

ScottishPower – DNO

Scottish & Southern Energy Power Distribution– DNO

Solarcentury – PV Installer

SolarEdge Technologies – PV inverter manufacturer

UK Power Networks – DNO

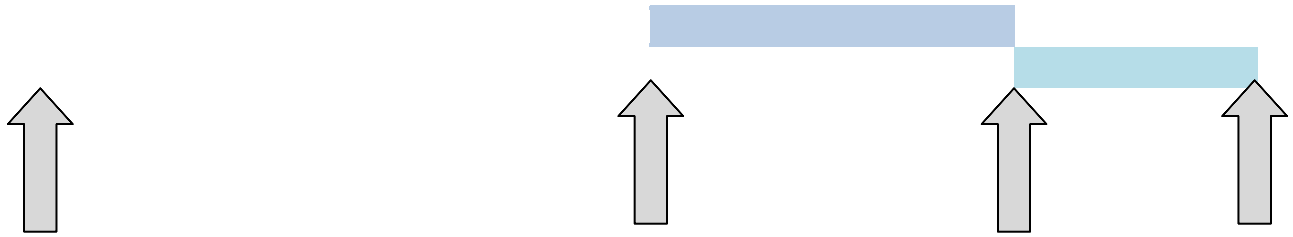
Western Power Distribution – DNO

APPENDIX 3 TIMETABLE TO PUBLICATION

Version 1

Week 1	Week 2	Week 3	Week 4	Week 5	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
16/3/2015	23/3/2015	30/3/2015	6/4/2015	13/4/2015	20/4/2015	27/4/2015	4/5/2015	11/5/2015	18/5/2015	25/5/2015

Consultation
Review of Consultation
Ofgem Consideration



Appendix 3 - Consultation responses and comments

Association of Manufacturers of Power Systems

Association for Decentralised Energy

Cummins Power Generation (Kent) Limited

Deepsea PLC

Electricity North West

Northern Powergrid

ScottishPower Energy Networks

UK Power Networks

Health & Safety Executive

Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015	**Draft G59/3-2 (2015) Public Consultation**
Closing date	
13-04-15	

Industry Stakeholder – Association for Decentralised Energy

Clause/ Subclause	**Paragraph Figure/ Table**	**Type of comment** (General/ Technical/ Editorial)	**COMMENTS**	**PROPOSED CHANGE**	**OBSERVATIONS OF THE WG** on each comment submitted
12.4.1	f	General	We agree with the proposed removal of the single phase LoM test. Members advise us that the test was challenging to implement, encouraged poor practice and required high-cost modifications to distributed generator switchgear for little practical benefit. It is our understanding that only one DNO is applying the test, potentially indicating its low value in ensuring generators are meeting grid requirements.		
13.3		Technical	We would welcome additional clarity on the test limits and adjustments to allow for test equipment performance.		

Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015	**Draft G59/3-2 (2015) Public Consultation**
Closing date	
13-04-15	

Industry Stakeholder –

Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
12.4.1	f	General	We welcome the removal of the single phase LoM test. This was difficult to achieve, could encouraged poor practise and, to undertake the test properly, required very expensive and impractical modifications to distributed generator switchgear for little benefit. The fact that the test appeared to only be employed in one specific area by one specific DNO suggests that this test was not seen by the majority of DNOs as an important test thus supporting the removal from G59/3	Just remove	
13.3		Technical	There has always been some confusion over the intent of the test limits and it is good to have them cleared up. Additionally the adjustments to allow for test equipment performance is welcomed.		

Jawad Al-Tayie
Application Engineering EB Manager
Cummins Generator Technologies
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Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015 Closing date **13-04-15**	**Draft G59/3-2 (2015) Public Consultation**

Industry Stakeholder – Cummins Power Generation (Kent) Limited

Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
12.4.1	f	General	We welcome the removal of the single phase LoM test. This was difficult to achieve, could encouraged poor practise and, to undertake the test properly, required very expensive and impractical modifications to distributed generator switchgear for little benefit. The fact that the test appeared to only be employed in one specific area by one specific DNO suggests that this test was not seen by the majority of DNOs as an important test thus supporting the removal from G59/3		
13.3		Technical	There has always been some confusion over the intent of the test limits and it is good to have them cleared up. Additionally the adjustments to allow for test equipment performance is welcomed.		

Richard Meadows IEng FIET
Technical Director
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richard.meadows@cummins.com

From:	Greg Middleton
To:	David Spillett
Subject:	G59/3-2 draft
Date:	19 March 2015 14:37:17

Hi David, I've spotted what I think is a typo in the draft; on page 107 where it says

"Frequency shall be stepped from 47.1Hz to the test frequency "

I believe it should read 47.7Hz the 'Inside Normal band' value.

Regards
Greg Middleton

Deep Sea Electronics Plc, Highfield House, Hunmanby Industrial Estate, North Yorkshire YO14 0PH, England. Registered in England No. 1319649
http://www.deepseaplc.com mailto:sales@deepseaplc.com
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David Spillett
6th Floor Dean Bradley House
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Electricity North West
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Email: enquiries@enwl.co.uk
Web: www.enwl.co.uk

Direct line: 08433 114169
Email: Peter.Twomey@enwl.co.uk

24th March 2015

Dear David,

Engineering Recommendation G59/3-1 - Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators (2014)

Distribution Code Review Panel (DCRP) - Public Consultation

We have reviewed the changes to G59/3-1 associated with the above public consultation, and confirm we agree with all the proposed changes. We support this amendment of G59/3.

Yours sincerely

Peter Twomey
Planning Policy Manager

RE: Generator Connection Requirements - A review of Engineering Recommendation G59/3-1 (2014) - DCRP Public Consultation - Message (HTML)

Message | Adobe PDF

Reply | Reply to All | Forward | Delete | Move to Folder | Create Rule | Other Actions | Block Sender | Safe Lists | Not Junk | Categorize | Follow Up | Mark as Unread | Find | Related | Select

Respond | Actions | Junk E-mail | Options | Find

You forwarded this message on 03/06/2015 08:38.

From: Penny.Taylor@hse.gsi.gov.uk

Sent: Tue 21/04/2015 12:13

To: David Spillett

Cc:

Subject: RE: Generator Connection Requirements - A review of Engineering Recommendation G59/3-1 (2014) - DCRP Public Consultation

Message | New ER G59-3-2 - public_consultation_DS_160315.pdf (295 KB) | DCRP Comments Form.doc (37 KB) | Draft G59-3-1_170914updatev1280115 track changev4.pdf (1 MB)

David,

Apologies for the delay. It is a nil return from HSE.

Regards

Penny

Penny Taylor
Energy Unit | Policy and Operational Strategy | Health and Safety Executive
Tel: 0151 951 4202

From: David Spillett [mailto:david.spillett@energynetworks.org]
Sent: 20 April 2015 16:53
To: Penny Taylor
Cc: martin.lee@sse.com
Subject: FW: Generator Connection Requirements - A review of Engineering Recommendation G59/3-1 (2014) - DCRP Public Consultation

Dear Penny

We don't appear to have received any comments from HSE regarding the proposed amendments in relation to the recent G59/3-1 review and subsequent public consultation which closed on 13 April. Please see below and attached.

Can you please advise if there any comments expected from the HSE or are you content with the proposed changes, as we are keen to submit the document to Ofgem for approval to publish.

Thank you.

Kind Regards

David

Sharing Screenshot
A link to your screenshot has been copied to your clipboard (click to view).

08:26
25/06/2015

From: Creighton, Alan
To: David Spillett
Cc: Walbank, Michael; Nicholson, Mark; Paine, Jim; Scott, Andrew; Crowe, Michael; Fairbairn, Derek; Van Kesteren, David
Subject: RE: Generator Connection Requirements - A review of Engineering Recommendation G59/3-1 (2014) - DCRP Public Consultation
Date: 13 April 2015 15:03:54

David
Just to confirm that Northern Powergrid does not have any comments on the consultation documents and agree to the proposed changes.
Cheers Alan

Alan Creighton
Senior Asset Management Engineer

Office: 01977 605920
Internal: 760 5920
Mobile: 07850 015515
Mobex: 716 1198

alan.creighton@northernpowergrid.com
www.northernpowergrid.com

From: David Spillett [mailto:david.spillett@energynetworks.org]
Sent: 16 March 2015 15:52
To: David Spillett
Subject: Generator Connection Requirements - A review of Engineering Recommendation G59/3-1 (2014) - DCRP Public Consultation

Engineering Recommendation G59/3-1 - Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators (2014)

Distribution Code Review Panel (DCRP) - Public Consultation

Dear Electricity Industry Stakeholder

At the DCRP meeting in December 2014 the Panel approved the setting up of a small DCRP Working Group (WG) to review some issues associated with the testing requirements contained in G59/3-1 (2014). These issues were causing some concerns for Installers. Subsequently the WG held its first meeting on 28 January 2015. The two main issues that the WG were tasked with resolving were:

1. To review the requirement contained in 12.4.1 (f) to carry out a single phase test by removal of a fuse while the generator is running for LV connected generating units; and

2. To clarify the testing of RoCoF elements ie to remove the discrepancy between the wording of how to carry out the test and the wording of the specimen test schedule in G59/3.

Following discussions the WG unanimously agreed to recommend the removal of section 12.4.1 (f). The test specified in Section 12.3.1 (g) satisfactorily covers the requirement for the installer to undertake a functional test to confirm that the interface protection operates and trips each generating unit when all phases are disconnected between the generating unit and the DNO's system.
The WG also agreed to correct the discrepancy between the words in Section 12.4 *Additional Commissioning requirements for Non Type Tested Generating Units* and the settings contained in Appendix 13.3 *Generating Plant Installation and Commissioning Tests - Commissioning test requirements for non-Type Tested Generating Units in addition to those required in Appendix 13.2***.** Some changes were also made to the test process for Vector Shift to ensure that they were comparable with the RoCoF tests and were practicable for use on site.

As G59/3-1 is an annex 1 document to the Distribution Code, the above proposed changes will require to be publically consulted on.
It is therefore proposed that a 4 week industry consultation will take place commencing **Monday 16 March and will close Monday 13 April**. The working group will then reconvene on Wednesday 15 April to consider the comments submitted by stakeholders. It is hoped that a final report to Authority will be submitted in the first week of May 2015.

Please find attached -

1. DCRP Consultation Paper
2. Draft G59/2-2 (2015) in Track Change mode
3. DCRP Comments form

Should you have any questions or seek clarification on any of the above please do not hesitate to contact me.

Please pass on this communication to any of your industry colleagues who may have an interest in this consultation.

Kind Regards

David

David Spillett
Code Administrator & Secretary to the GB Distribution Code Review Panel

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52 Horseferry Road
London
SW1P 2AF

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Office - 02077065124
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****

Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015	**Draft G59/3-2 (2015) Public Consultation**
Closing date	
13-04-15	

Industry Stakeholder – SP Energy Networks

Clause/ Subclause	**Paragraph Figure/ Table**	**Type of comment** (General/ Technical/ Editorial)	**COMMENTS**	**PROPOSED CHANGE**	**OBSERVATIONS OF THE WG** on each comment submitted
12.4.1 (f)		Technical	Removal of the single phase loss of mains test means that there is no longer a final test to confirm that all connections have been replaced correctly (following the earlier 'calibration tests') and that the overall system is working as expected. Retention of the test ould also ensure that the DNO witness tests the full installation (including circuit breaker operation) with the generator installed/running and not just testing the functionality of the protection equipment.	Retain the test but allowing removal of VT fuses as an acceptable test method would still verify operation of the protection system (albeit with 'false' conditions) as well as the overall tripping functionality and correct shutdown / resynch of the generator. This would allow the tests to be carried out without DNO disconnection (removal of DNO fuses) or incorporating additional isolation points into plant. A single accepted test method would also remove the confusion caused by the alternative of "current imbalance protection" in sections 12.4(f) iii and iv. The tests are easily carried out and could also be specified for both LV and HV generators, removing further confusion and aligning site testing requirements across voltage levels.	

Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
				Proposed rewording is; a) In addition to the 3 phase disconnection test specified in 12.1.3 (g) for non **Type Tested ~~LV~~ Generating Units** the installer shall carry out an additional functional check of the LoM protection by removing one phase of the supply to the **Generating Unit** and confirming that the protection operates to disconnect the **Generating Unit** from the **Distribution system**. This test is applicable to all non **Type Tested ~~LV~~ Generating Unit**s ~~where **LV** protection settings are applied (ie 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. ~~ii. Manufacturers and installers should be~~	

Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
				~~encouraged to incorporate disconnection points into the design of all **LV Generating Unit**s or installations in order to facilitate this test.~~ ~~iii.~~ ~~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 generator).~~ ~~iv.~~ ~~It should be noted that experience of current imbalance protection in this application can be problematic once in service, and has lead to nuisance tripping due~~	

Clause/ Subclause	**Paragraph Figure/ Table**	**Type of comment** (General/ Technical/ Editorial)	**COMMENTS**	**PROPOSED CHANGE**	**OBSERVATIONS OF THE WG** on each comment submitted
				~~to load and network voltage imbalance.~~	

Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015 Closing date **13-04-15**	**Draft G59/3-2 (2015) Public Consultation**

Industry Stakeholder – All responses

Company	Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
	12.4.1 (f)		Editorial	f) In addition to the 3 phase disconnection test specified in 12.1.3 (g) for non **Type Tested LV Generating Units** Incorrect reference	f) In addition to the 3 phase disconnection test specified in 12.3.1 (g) for non **Type Tested LV Generating Units**	
	12.4.1 (e)		Editorial	irespective Typo	irrespective	
	12.3.1 (g)		Editorial	**Generating Unit**and Insert space	**Generating Unit** and	
	Multiple locations		Editorial	G59	EREC G59	

Company	Clause/ Subclause	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted

Appendix 4 - WG responses to consultation comments

Distribution Code Review Panel Public Consultation

Start Date	Document
16-03-2015 Closing date **13-04-15**	**Draft G59/3-2 (2015) Public Consultation**

Industry Stakeholders – All responses

Company	Clause/ Subclause/ page	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
UKPN	12.4.1 (f)		Editorial	f) In addition to the 3 phase disconnection test specified in 12.1.3 (g) for non **Type Tested LV Generating Units** Incorrect reference	f) In addition to the 3 phase disconnection test specified in 12.3.1 (g) for non **Type Tested LV Generating Units**	agreed
UKPN	12.4.1 (e)		Editorial	irespective Typo	irrespective	agreed
UKPN	12.3.1 (g)		Editorial	**Generating Unit**and Insert space	**Generating Unit** and	agreed
UKPN	Multiple locations		Editorial	G59	EREC G59	agreed
Deepsea plc	p107		Editorial	“Frequency shall be stepped from 47.1Hz to the test frequency “	I believe it should read 47.7Hz the ‘Inside Normal band’ value.	agreed

Company	Clause/ Subclause/ page	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
ENW			General	We have reviewed the changes to G59/3-1 associated with the public consultation, and confirm we agree with all the proposed changes. We support this amendment of G59/3.		Noted
AMPS Cummins Power Generation (Kent)			General	We welcome the removal of the single phase LoM test. This was difficult to achieve, could encouraged poor practise and, to undertake the test properly, required very expensive and impractical modifications to distributed generator switchgear for little benefit. The fact that the test appeared to only be employed in one specific area by one specific DNO suggests that this test was not seen by the majority of DNOs as an important test thus supporting the removal from G59/3	Remove	Noted
AMPS Cummins Power Generation (Kent)				There has always been some confusion over the intent of the test limits and it is good to have them cleared up. Additionally the adjustments to allow for test equipment performance is welcomed.		Noted

Company	Clause/ Subclause/ page	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
The Association for Decentralised Energy			General	We agree with the proposed removal of the single phase LoM test. Members advise us that the test was challenging to implement, encouraged poor practice and required high-cost modifications to distributed generator switchgear for little practical benefit. It is our understanding that only one DNO is applying the test, potentially indicating its low value in ensuring generators are meeting grid requirements.		Noted
The Association for Decentralised Energy			Technical	We would welcome additional clarity on the test limits and adjustments to allow for test equipment performance.		Noted

Company	Clause/ Subclause/ page	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
ScottishPower	12.4.1 (f)		Technical	Removal of the single phase loss of mains test means that there is no longer a final test to confirm that all connections have been replaced correctly (following the earlier ‘calibration tests’) and that the overall system is working as expected. Retention of the test ould also ensure that the DNO witness tests the full installation (including circuit breaker operation) with the generator installed/running and not just testing the functionality of the protection equipment.	Retain the test but allowing removal of VT fuses as an acceptable test method would still verify operation of the protection system (albeit with ‘false’ conditions) as well as the overall tripping functionality and correct shutdown / resynch of the generator. This would allow the tests to be carried out without DNO disconnection (removal of DNO fuses) or incorporating additional isolation points into plant. A single accepted test method would also remove the confusion caused by the alternative of “current imbalance protection” in sections 12.4(f) iii and iv. The tests are easily carried out and could also be specified for both LV and HV generators, removing further confusion and aligning site testing requirements across voltage levels.	Not agreed At the working group meeting held on 15 April 2015 all stakeholders including ScottishPower agreed to the new proposal to remove the test described in section 12.4.1 sub section f and revise section 12.3.1 (g) to include the provision of two options to carry out a functional test confirming that the Interface Protection has operated.

Company	Clause/ Subclause/ page	Paragraph Figure/ Table	Type of comment (General/ Technical/ Editorial)	COMMENTS	PROPOSED CHANGE	OBSERVATIONS OF THE WG on each comment submitted
ScottishPower (cont)					a) In addition to the 3 phase disconnection test specified in 12.1.3 (g) for non **Type Tested** ~~**LV**~~ **Generating Units** the installer shall carry out an additional functional check of the LoM protection by removing one phase of the supply to the **Generating Unit** and confirming that the protection operates to disconnect the **Generating Unit** from the **Distribution system**. This test is applicable to all non **Type Tested** ~~**LV**~~ **Generating Unit**s ~~where **LV** protection settings are applied (ie 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 Delete ii, iii and iv	

Appendix 5 – Proposed EREC G59/3-2 (track change)

PRODUCED BY THE OPERATIONS DIRECTORATE OF ENERGY NETWORKS ASSOCIATION

Engineering Recommendation G59

Issue 3 Amendment 2~~1~~ July ~~August~~ 2015~~4~~

RECOMMENDATIONS FOR THE CONNECTION OF GENERATING PLANT TO THE DISTRIBUTION SYSTEMS OF LICENSED DISTRIBUTION NETWORK OPERATORS

www.energynetworks.org

PUBLISHING AND COPYRIGHT INFORMATION

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First published, June 1985

Amendments since publication

Issue	**Date**	**Amendment**
G59/1	1991	Revised incorporating Amendment 1 (1992) and Amendment 2 (1995)
G59/2	Aug 2010	Revised - replaced two previous Engineering Recommendations, ER G59/1 and its associated Engineering Technical Report ETR 113, and ER G75/1.
G59/2-1	March 2011	Revised Amendment 1 – Appendix A13.1 - Change to DC injection current limits
G59/3	Sept 2011	Major revision to the document to align with G83/2 and to cater for type tested equipment upto 50kW. Other areas revised included: • *Connection application and commissioning procedures* • *Connection and Commissioning Procedure for Power Stations above EREC G83/2 limits but less than 50kW or 17kW per phase using Type Tested Generating Units only* • *Connection and Commissioning Procedure for Power Stations above 50kW which use Type Tested Generating Units only* • *Voltage Unbalance* • *Generation capacity for single and split phase supplies* • *Generating Unit performance requirements for Type Tested Units* • *Over and Under Voltage Stability Tests* • *Frequency Drift and Step Change Stability Test.* • *Protection Settings* • *Revised Forms* • *Simplified application form*

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G59/3	Nov 2013	Correction of error. The error relates to the British Standard which is to be used to determine the 'flicker' contribution from small wind turbines. References to this standard are found at 9.6.2.1 and 13.8.5.5 of ER G59/3. The standard that should be referred to is BS EN 61400-12. However, the standard that was referred BS EN 61400-21was incorrect. Therefore, to correct this error, the two references (i.e. at 9.6.2.1 and 13.8.5.5) have been changed and the description of the standard corrected at 3.2 (page 9) of ER G59/3. This will now read: ***BS EN 61400-12-1:2006*** *Wind turbines. Power performance measurements of electricity producing wind turbines.*
G59/3-1	Aug 2014	Revised RoCoF settings in Section 10.5.7
G59/3-2	June 2015	Revocation of Section 12.4 (f) – It is no longer a requirement to undertake an additional functional check of the LoM protection by removing one phase of the supply to the Generating Unit. Revision to section 12.3.1 (g) to include the provision of two options to carry out a functional test confirming that the Interface Protection has operated. Testing of RoCoF elements in Appendix 13.3. A discrepancy has been corrected between the wording contained in Section 12.4 and the testing requirements contained in Appendix 13.3 on how to undertake the test . Section 13.8.3.2 is repeated on page 130. Change to 13.8.3.3 and revise subsequent numbering.

Contents

Foreword

This Engineering Recommendation (EREC) is published by the Energy Networks Association (ENA) and comes into effect from August 2013. 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 G59”, which replaces the previously used abbreviation “ER G59”.

1 Purpose

1.1 The purpose of this Engineering Recommendation (EREC) is to provide guidance on the connection of **Generating Plant** to the **Distribution Systems** 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 **Generating Plant** will be accepted for connection to the **Distribution System**. This Engineering Recommendation replaces Engineering Recommendations ~~EREC G59/2 and EREC G59/2-1.~~ G59/3 and G59/3-1

1.2 The guidance given is designed to facilitate the connection of **Generating Plant** whilst maintaining the integrity of the **Distribution System**, both in terms of safety and supply quality. It applies to all **Generating Plant** 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 **Generator**s and **DNO**s. The mandatory requirements governing the connection of Distributed **Generating Plant** are generally set out in the Distribution Planning and Connection Code 7 (DPC7) of the **Distribution Code** 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.

2 Scope

2.1 This EREC provides guidance on the technical requirements for the connection of **Generating Plant** to the **Distribution Systems** of licensed **DNO**s. For the purposes of this EREC, a **Generating Plant** is any source of electrical energy, irrespective of the prime mover and **Generating Unit** type. This EREC applies to all **Generating Plant** which is not in the scope of EREC G83 or is not compliant with EREC G83 requirements.[1] EREC G59 describes a simplified connection procedure for connection of a **Type Tested single Generating Unit** of less than 17kW per phase or 50kW three phase, or the connection of multiple **Type Tested Generating Units** with a maximum aggregate capacity of less than 17kW per phase or 50kW three phase, per **Customer** installation, provided that any existing connected **Generating Units** are also **Type Tested**.

2.2 This EREC does not provide advice for the design, specification, protection or operation of **Generating Plant** itself. These matters are for the owners of plant to determine.

---

[1] Engineering Recommendation EREC G83/2 – Recommendations for the connection of small-scale embedded generators (up to and including 16 A per phase) in parallel with public low-voltage distribution networks. This Engineering Recommendation provides guidance on the technical requirements for the connection of **Generating Units** rated up to and including 16 A per phase, single or multi-phase, 230/400 Volts AC. The recommendations cover the connection of **Generating Units**, either single or multi-phase within a single Customer's installation up to the limit of 16A per phase, and multiple **Generating Unit**s in a close geographic region with a limit of 16A per phase in each customer installation, under a planned programme of work.

2.3 Specific separate requirements apply to **Generating Plant** comprising **Generating Unit**s less than or equal to 16A per phase and these are covered in EREC G83. However, **Generating Unit**s ≤16A per phase that have not been **Type Tested** in accordance with EREC G83 or whose technology type is not covered by one of the EREC G83 annexes should comply with the requirements set in this document. Section 6 of this document provides more guidance on how to apply this document to **Generating Unit**s that are below the 16A threshold but do not meet the requirements of EREC G83/2.

2.4 The connection of mobile generation owned by the **DNO**, EREC G83/2 compliant **Generating Unit**s or offshore **Transmission System**s containing generation are outside the scope of this Engineering Recommendation.

2.5 This document applies to systems where the **Generating Plant** can be paralleled with a **Distribution System** or where either the **Generating Plant** or a **Distribution System** with **Generating Plant** connected can be used as an alternative source of energy to supply the same electrical load.

2.6 The generic requirements for all types of **Generating Plant** 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 **Medium and Large Power Station**s are, in addition to the general requirements of this EREC, bound by the requirements of the **Grid Code**. In the case of **Large Power Station**s, the **Grid Code** will generally apply in full. For **Medium Power Station**s, only a subset of the **Grid Code** applies directly, and the relevant clauses are listed in DPC7 of the **Distribution Code**.

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.

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

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 Statutory Requirements

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 Standards publications

BS 7671: 2008 Requirements for Electrical Installations

IEE Wiring Regulations: Seventeenth Edition.

BS 7430: 1999

Code of Practice for Earthing.

BS 7354

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 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 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Note: Except where otherwise stated, the terms defined in this section shall have the same meaning as in the Grid Code and the Distribution Code.

Act

The Electricity Act 1989 (as amended.including by the Utilities Act 2000 and the Energy Act 2004).

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.

Connection Agreement

An agreement between the **DNO** and the **User** or any **Customer** setting out the terms relating to a connection with the **DNO**s **Distribution System**.

Connection Point

An **Entry Point** or an **Exit Point** of the **Distribution System** as the case may be.

Customer

A person who is the owner or occupier of premises that are connected to the **Distribution System**.

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.

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 Licence

A distribution licence granted under Section 6(1)(c) of the **Act**.

Distribution System

An electricity **Distribution System** operated by a holder of a **Distribution Licence**.

Distribution Network Operator (DNO)

The person or legal entity named in Part 1 of the **Distribution Licence** and any permitted legal assigns or successors in title of the named party.

Entry Point

The point at which an **Embedded Generator** or other **User**s connect to the **DNO'**s **Distribution System** where power flows into the **DNO'**s **Distribution System** under normal circumstances.

Embedded Generator

A **Generator** including a **Customer** with own generation whose **Generating Unit** is/are connected to the **DNO's Distribution System** or to another authorised distributor connected to the **DNO's Distribution System**.

Exit Point

The point of supply from the **DNO'**s **Distribution System** to a **User** where power flows out from the **DNO'**s **Distribution System** under normal circumstances.

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 System**. 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**.

Generating Plant

A **Power Station** including any **Generating Unit** therein.

Generating Unit

Any apparatus which produces electricity.

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.

Installer

A person who carries out the installation of **Generating Unit(**s**)** on behalf of a **Generator** and who carries out some of the functions required of a **Generator** during the installation and commissioning phases of a **Power Station**.

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 System.** The interface protection is typically not all installed at the interface between the **DNO** and **Customer**s network.

Large Power Station

As defined in the **Distribution Code**.

Low Voltage (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 **Generating Units** which can be **Type Tested** to meet the requirements of this Engineering Recommendation if it is of a suitable size

Medium Power Station

As defined in the **Distribution Code**.

National Electricity Transmission System Operator (NETSO)

National Grid Electricity Transmission (NGET) in its capacity as operator of the National Transmission System.

Point of Common Coupling

The point on a **Distribution System,** electrically nearest the **Customer**'s Installation**,** at which other **Customer**s are, or may be, connected.

Point of Supply

The point of electrical connection between the apparatus owned by the **DNO** and the **Customer**.

Power Station

Generating Units (even where sited separately), which are owned and/or controlled by the same **Generator** and may reasonably be considered as being managed as one **Power Station.** For the purpose of this document a single **Generating Unit** will also be described as a **Power Station**.

Power System Stabiliser (PSS)

Equipment controlling the output of a **Generating Unit** in such a way that power oscillations of the machine are damped. Input variables may be speed, frequency, or power or a combination of variables.

Small Power Station

As defined in the **Distribution Code**.

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 Act; in each case acting in its capacity as a supplier of electricity to Customers.

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.

Synchronism

The condition under which a **Generating Unit** or **System** is connected to another **System** so that the frequencies, voltage and phase relationships of that **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 Plant, Transmission System, Distribution Systems** and associated electrical demand.

Transmission Licence

The licence granted under Section 6(1)(b) of the **Act**.

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 Station**s and substations.

Type Tested

A **Generating Unit** design which has been tested by the **Manufacturer**, component manufacturer or supplier, or a third party, to ensure that the design meets the requirements of this EREC, and for which the **Manufacturer** has declared that all products supplied into the market will be constructed to the same standards, and with the same protection settings as the tested product.

User

A term used in various sections of the **Distribution Code** to refer to the persons using the **DNO'**s **Distribution System**.

5 Legal Aspects

5.1 The operation and design of the electricity system in Great Britain is defined principally by 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 13.9.

5.2 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 **Generating Plant** is entitled to remain connected to the **Distribution System**. 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**.

5.3 **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**.

5.4 In accordance with DPC5.4 of the **Distribution Code**, when details of the interface between a **Generating Plant** and the **Distribution System** 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.

5.5 The **DNO**s have statutory and licence obligations within which they have to offer the most economic, technically feasible option for connecting **Generating Plant** to their **Distribution System**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 Systems** at all voltage levels are adequately earthed;

c. comply with the "Security of Supply" criteria defined in EREC P2;

d. meet improving standards of supply in terms of customer minutes lost (CMLs) and the number of customer interruptions (CIs);

e. facilitate competition in the connection, generation and supply of electricity.

5.6 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 **Generating Plant** or to ensure that the **Generating Plant** is rapidly disconnected from the **Distribution System** under islanded conditions. The next two criteria influence the type of connection that may be offered without jeopardising regulated standards.

5.7 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 System** 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.

5.8 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 System**.

5.9 Under Regulation 22 of the ESQCR 2002, no person may operate **Generating Plant** in parallel with a public **Distribution System** without the agreement of the **DNO**.

5.10 All **Generator**s have to comply with the appropriate parts of the ESQCR.

5.11 The general requirements for **Generator**s wishing to connect their **Generating Plant** to a **Distribution System** are contained in the **Distribution Code.**

5.12 It is important to note that both the **Distribution Code** and **Grid Code** use the terms **Large, Medium and Small** in relation to **Power Station**s. These terms are defined in the Codes and various parts of the Codes apply to different size **Power Station**s, with generally no **Grid Code** requirements applying to **Small Power Station**s. Any collection of **Generating Plant** under the control of one owner or operator in one installation is classed in the Codes as a **Power Station**.

5.13 **Generators** with **Medium Power Station**s will have to comply with a few specific **Grid Code** clauses. The requirement for these clauses is contained in DPC7 of the **Distribution Code**.

5.14 **Power Stations** that are to be connected to a **Distribution System** and contain **Generating Unit**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 **Generating Plant**.

5.15 Information, which should assist **Generator**s wishing to connect to the **Distribution System** 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 System** as well as authorised changes in future years on a rolling basis.

5.16 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[2] grant exemptions. Broadly, generating stations of less than 50MW are automatically exempt from the need to hold a licence, and those between 50MW and 100MW may apply to DECC for an exemption if they wish.

5.17 **Generator**s who are licensed will be required to become parties to the Balancing and Settlement Code and to the Connection and Use of System Code. They will also be bound in their licences to comply with the **Grid Code** and the **Distribution Code**.

5.18 **Generator**s will need appropriate contracts in place for the purchase of any energy that is exported from the **Generator**s' **Power Station**s, 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 **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.

6 Connection Application

6.1 General

This document describes the processes that shall be adopted for both connection of single **Generating Units** and installations that comprise of a number of **Generating Units** The process for the connection of single or multiple **Type Tested Generating Units** with an aggregate installed capacity of less than or equal to 16A per phase is described in EREC G83; the connection of other **Generating Unit**s (ie **Generating Unit**s outside the scope of EREC G83) is covered by this Engineering Recommendation.

Where an installation comprises multiple **Generating Units** the application process and commissioning requirements should be based on the **Power Station** capacity (ie the aggregate capacity of all the **Generating Unit**s to be installed in any one installation), and whether the individual **Generating Units** are **Type Tested**.

Where a new **Generating Unit** 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 **Generating Unit** will be required to meet protection requirements of this Engineering Recommendation.

2 see http://www.opsi.gov.uk/si/si2001/20013270.htm

6.1.1 The following table describes key differentiating features between Power Station capacity that influence the application, connection and commissioning process.

Power Station capacity (ie the aggregate capacity of all the Generating Units to be installed in any one installation).	**≤ 16A per phase**		**> 16A per phase**		
			≤ 50kW 3 phase (or 17kW 1 phase)[3]	**> 50kW 3 phase (or 17kW 1 phase)**	**All Capacities**
Approval Status of individual Generating Units	**G83/2 compliant**	**Not G83/2 compliant**	**G59/3 or G83 Type Tested Equipment**	**G59 Type Tested Equipment**	**Not G59 Type Tested**
Consent required prior to connection **DNO** to carry out impact assessment / electrical studies	As G83	YES	YES	YES	YES
Protection Requirements	As G83/2	As G59/3-2. Section 10	As G59/3-2. Section 10	As G59/3-2. Section 10	As G59/3-2 Section 10
Commissioning Tests	As G83/2	As G59/3-2 Sections 12.3 and 12.4	As G59/3-2 Section 12.3	As G59/3-2 Section 12.3	As G59/3-2 Sections 12.3 and 12.4
Witness testing required by **DNO**	No[4]	At the discretion of the **DNO**[5]	As G59/3-2 section 12.1.4[5]	At the discretion of the **DNO**[5]	YES – for **HV**, but at the discretion of the **DNO** for **LV**[5]

6.1.2 **Generating Unit(s) ≤ to16A per phase and EREC G83 compliant**

A connection procedure to facilitate the connection and operation of **Type Tested Generating Unit**s with aggregate installed capacity of less than or equal to 16A per phase in parallel with public **Low Voltage Distribution System** is given in EREC G83 and is not considered further in this document.

[3] The rationale for the break points is the support and penetration envisaged for “microgeneration” as captured in the 2006 Climate Change and Sustainable Energy Act 2006, which defines microgeneration as up to 50kW$_e$.

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

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

6.1.3 **Generating Unit(s) ≤ to16A per phase and not EREC G83 compliant**

Where the **Generating Unit** does not meet the requirements of EREC G83 either because the technology is not covered by one of the technology annexes or because the **Generating Unit** has not successfully been through the type testing process the connection process shall follow that for larger **Generating Unit**s as described in this document.

6.1.4 **Generating Unit(s)** EREC G59 **Type Tested** (>16A per phase but ≤ 50kW 3 phase (or 17 kW 1 phase))

The use of **Type Tested** equipment simplifies the connection process, the protection arrangements and reduces the commissioning test requirements. The process is described in this document.

6.1.5 **Generating Unit(s)** not EREC G59 **Type Tested** or > than 50kW 3 phase (or 17kW 1 phase)

The connection process for these **Generating Unit**s is described in this document. When making a connection application for **Medium and Large Power Station**s, there are requirements that should be considered in addition to the general requirements identified in this document.

Medium and Large Power Stations are bound by the requirements of the **Grid Code**. In the case of **Large Power Stations**, the **Grid Code** will generally apply in full. For **Medium Power Station**s, only a small subset of the **Grid Code** applies directly, and the relevant clauses are listed in DPC7 of the **Distribution Code**.

Where **Grid Code** requirements apply, under the **Distribution Code** it is the **Generator**'s responsibility to comply with the **Grid Code** requirements.

6.2 Application for Connection

6.2.1 Information about the **Generating Unit**(s) is needed by the **DNO** so that it can assess the effect that a **Power Station** may have on the **Distribution System**. Section DPC7 and the Distribution Data Registration Code (DDRC) of the **Distribution Code** detail the parameters to be supplied by a **Customer** wishing to connect **Generating Unit(s)** that do not comply with EREC G83 to a **Distribution System**. DPC7 also enables the **DNO** to request more detailed information if required.

6.2.2 Less than or equal to 16A per phase and EREC G83 Compliant **Generating Unit**

The application process is described in EREC G83 and is not considered further in this document.

6.2.3 Less than or equal to 16A per phase and not EREC G83 compliant **Generating Unit**

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 System** 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 System** 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 **Generating Unit** can be commissioned. On successful completion of the commissioning tests, the **DNO** will sanction permanent energisation of the **Generating Unit**.

6.2.4 **Power Stations** >16A per phase but ≤ 50kW three phase (or 17kW single phase) comprising **Generating Units Type Tested** to EREC G59 or EREC G83 (excluding G83/1 and G83/1-1)

The application shall be made using the form in Appendix 13.5 which should include the **Type Tested** Reference Number. Where a reference number is not available the **Generator** or **Installer** shall provide the **DNO** with a **Type Test** report as per Appendix 13.1 confirming that the **Generating Unit** has been **Type Tested** to satisfy the requirements of this Engineering Recommendation. Guidance to **Manufacturers** on type testing is included in Appendix 13.8 of this document. On receipt of the application, the **DNO** will assess whether any **Distribution System** studies are required and whether there is a requirement to witness the commissioning tests.

6.2.5 **Power Stations** which include any non-**Type Tested Generating Units** or any **Power Stations** >50kW three phase (or 17kW 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 will all be defined within DPC7 and DPC8 and the Distribution Data Registration Code (DDRC) of the **Distribution Code**.

6.3 System Analysis for Connection Design

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 ‘Distribution Data Registration Code’ (DDRC) within the **Distribution Code** as part of the connection process.

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 For plant connected at **HV**, it is generally necessary to build an equivalent model of the **Distribution System**. An example is shown as Fig 6.1 below.

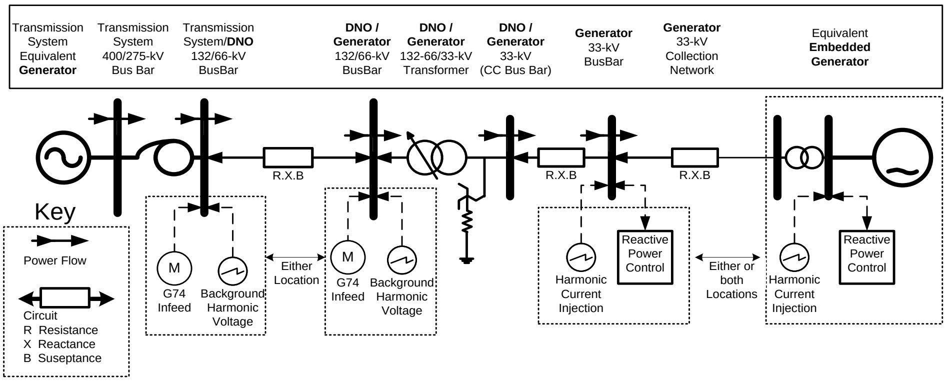


Fig 6.1 Example equivalent **Total System** representation

This model will typically include equivalent source representing existing **Generating Plant** 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.

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 **Generating Plant** 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 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.

6.3.6 For synchronous machines, control systems for **Generating Unit**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 **Generating Unit** and grid connection. The requirement to submit models in this form for directly connected synchronous **Generating Unit**s is written into the **Grid Code and Distribution Code**.

6.3.7 For other generation technologies, the **Grid Code** includes the requirement to submit validated detailed models in respect of non-synchronous **Generating Unit**s which are aggregated into a 'Power Park Module' and where they are also classed as **Medium or Large Power Station**s.

6.3.8 The **Distribution Code** 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 **Generating Unit**s.

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 Station**s embedded within their **Distribution Systems** unless they are connected at a voltage level below that of the lower voltage side of the relevant supergrid transformer. This requires the **Generating Plant** manufacturer to submit a **Generating Unit** or Power Park model in a format suitable for the **NETSO** usually in a documented block diagram format.

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 **Generating Unit**s or Power Parks using their **Generating Unit**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 **Generating Unit** for load flow, fault level and transient analysis for the typical range of faults experienced by **DNO**s.

7 CONNECTION ARRANGEMENTS

7.1 Operating Modes

7.1.1 **Generating Plant** 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.

7.2 Long-Term Parallel Operation

7.2.1 This refers to the frequent or long-term operation of **Generating Plant** in parallel with the **Distribution System**. Unless otherwise stated, all sections in this Engineering Recommendation are applicable to this mode of operation.

7.3 Infrequent Short-Term Parallel Operation

7.3.1 This mode of operation typically enables **Generating Plant** 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 **Generating Plant**.

7.3.2 In this mode of operation, parallel operation of the **Generating Plant** and the **Distribution System** 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 As the design requirements for **Generating Plant** 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 **Generating Plant** may be permitted to operate in parallel with the **DNO**s **Distribution System** for no more than 5 minutes in any month, and no more frequently than once per week. If the duration of parallel connection exceeds this period, or this frequency, then the **Generating Plant** 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 **Generating Plant** 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 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 **Generating Plant** 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 **Generating Plant** supporting an island of **Distribution System** as under voltage or under frequency protection is only likely to disconnect the **Generating Plant** if the load is greater than the **Generating Plant** capacity. Consequently it is appropriate to apply different protection settings for short term parallel connection. As this **Generating Plant** 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 **Generating Unit**'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.

c. Fault Level – There is the need to consider the effect of the **Generating Plant** 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 **Generating Plant** 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 **Generating Unit** ramping down to transfer site load to the mains. If the **Generating Unit** tripped at this point it could introduce a larger **Step Voltage Change** than would normally be acceptable for loss of **Generating Plant** 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 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.

7.4 Switched Alternative-Only Operation

7.4.1 General

7.4.1.1 Under this mode of operation it is not permissible to operate **Generating Plant** in parallel with the **Distribution System**. Regulation 21 of the ESQCR states that it is the **Generator’s** responsibility to ensure that all parts of the **Generating Plant** have been disconnected from the **Distribution System** and remain disconnected while the **Generating Plant** is operational. The earthing, protection, instrumentation etc. for this mode of operation are the responsibility of the **Generator**, however where such **Generating Plant** 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 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 System** 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 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 **Generating Plant** is installed, a conspicuous warning notice should be displayed and securely fixed at the **Point of Supply**.

7.4.2 Changeover Operated at HV

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 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 Changeover Operated at LV

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;

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 The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under ESQCR.

7.5 Balance of Generating Unit output at LV

7.5.1. EREC G83 allows the connection of **Type Tested Generating Units** ≤16A per phase without consultation with the **DNO**. Connection of single phase units up to 17kW under EREC G59 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. A solution to these voltage issues and phase imbalance issues may be to utilise 3-phase **Generating Unit**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 **Generating Unit**s connected across three phases. If these individual Generating Units 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 Generating Unit is connected to in an installation. In addition the DNO may define to an Installer the phases to which the Generating Units in any given installation should be connected.

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 (eg. wind and solar) **Generating Unit**s shall be connected to give a total imbalance of less than 16A based on assumed worst case conditions, those being:

a. One **Generating Unit** at maximum output with the other(s) at zero output –all combinations to be considered.

b. Both / all **Generating Units** being at maximum output

A **Generating Unit** technology which operates at different times due to location eg 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 In order to illustrate this requirement examples of acceptable and unacceptable connections have been given in Appendix 13.10.

7.6 Generation Unit capacity for single and split LV phase supplies

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 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 System** or **Generating Unit** outage. However the connection design should result in imbalance under normal operation to be below 16A between phases as noted above.

7.6.3 **Power Station**s 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 **Customers Installation** or a **Distribution System** outage applies to three phase inverters only and will be tested as part of the type testing of the **Generating Unit**. 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 Stations** above the normal limits as set out above.

7.7 Voltage Management Units in Customer's premises

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 System** before it is used by the **Customer**. In some cases where the **DNOs System** voltage is low they may increase the voltage supplied to the **Customer**. Some technologies are only designed to reduce voltage and can not increase the voltage.

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 If a Voltage Management Unit is installed between the Entry Point and the Generating Unit 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 **Generating Units** connected to **DNO LV Systems** under this Engineering Recommendation must be made on the **Entry Point** side of any Voltage Management Unit installed in a **Customers Installation.**

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 System** under the ESQCR and that provided their **Installer** has designed their installation correctly there should be very little nuisance tripping of the **Generating Unit**. Frequent nuisance tripping of a **Generating Unit** may be due to a fault in the **Customers Installation** or the operation of the **DNO's System** at too high a voltage. **Customers** should satisfy themselves that their installation has been designed correctly and all **Generating Units** 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 **Generating Unit**.

8 EARTHING

8.1 General

8.1.1 The earthing arrangements of the **Generating Plant** shall satisfy the requirements of DPC4 of the **Distribution Code**.

8.2 HV Generating Plant

8.2.1 **HV Distribution System**s may use direct, resistor, reactor or arc suppression coil methods of earthing the **Distribution System** 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 To ensure compatibility with the earthing on the **Distribution System** the earthing arrangements of the **Generating Plant** must be designed in consultation and formally agreed with the **DNO**. The actual earthing arrangements will also be dependent on the number of **Generating Unit**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 **HV Distribution System**s 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 **Generating Plant** 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 Systems operating at 132kV are generally designed for multiple earthing, and in such cases the earthing requirements should be agreed in writing with the **DNO**.

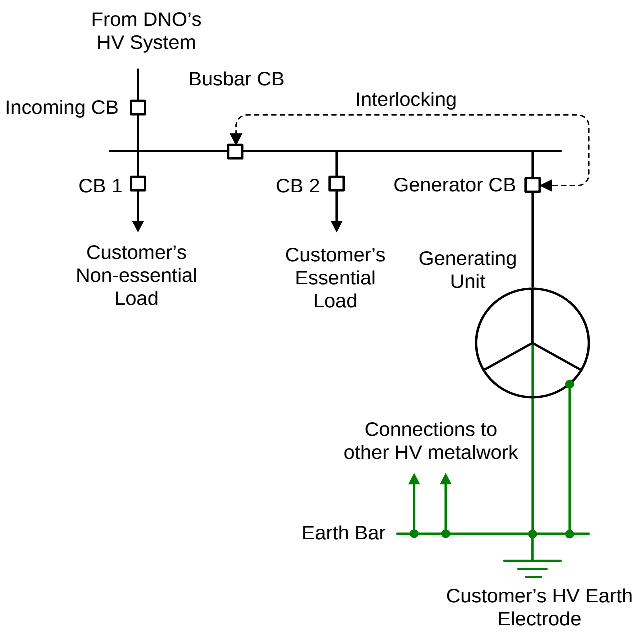
8.2.4 In some cases the **DNO** may allow the **Generator** to earth the **Generator's HV System** when operating in parallel with the **Distribution System**. The details of any such arrangements shall be agreed in writing between the relevant parties.

8.2.5 **Generator**s must take adequate precautions to ensure their **Generating Plant** is connected to earth via their own earth electrodes when operating in isolation from the **Distribution System**.

8.2.6 Typical earthing arrangements are given in figures 8.1 to 8.4.

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). 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 System**.

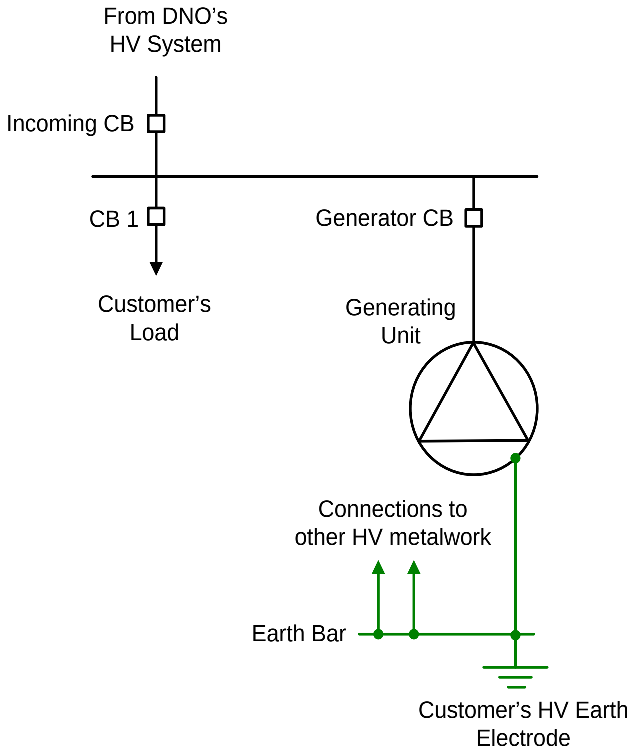
Figure 8.1 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for Independent Operation (ie Standby Operation) Only



NOTE:

(1) Interlocking between busbar CB and **Generator** CB is required to prevent parallel operation of the **Generating Unit** and **DNO System**

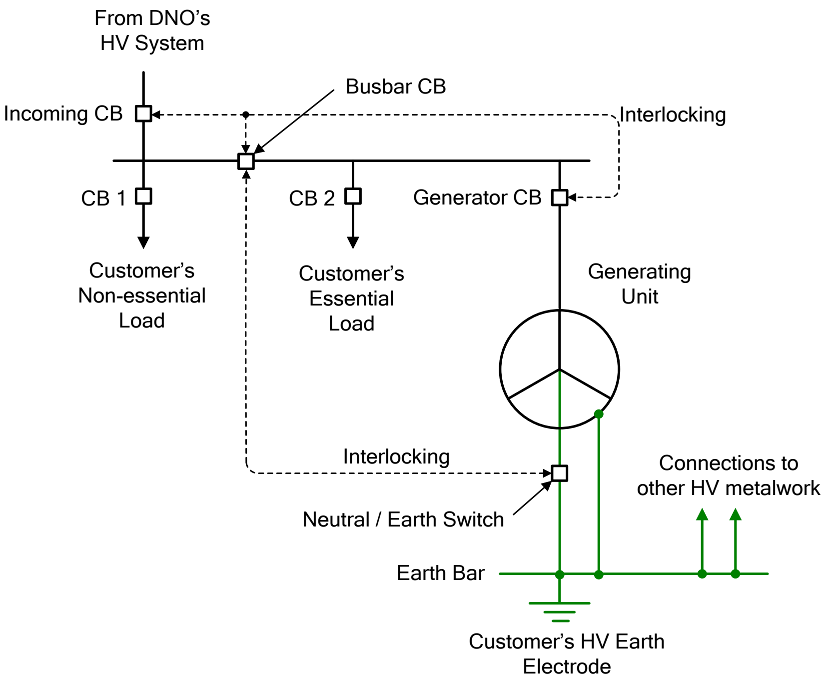
Figure 8.2 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for Parallel Operation Only



NOTE:

(1) **Generating Unit** winding is not connected to earth irrespective of whether it is star or delta connected

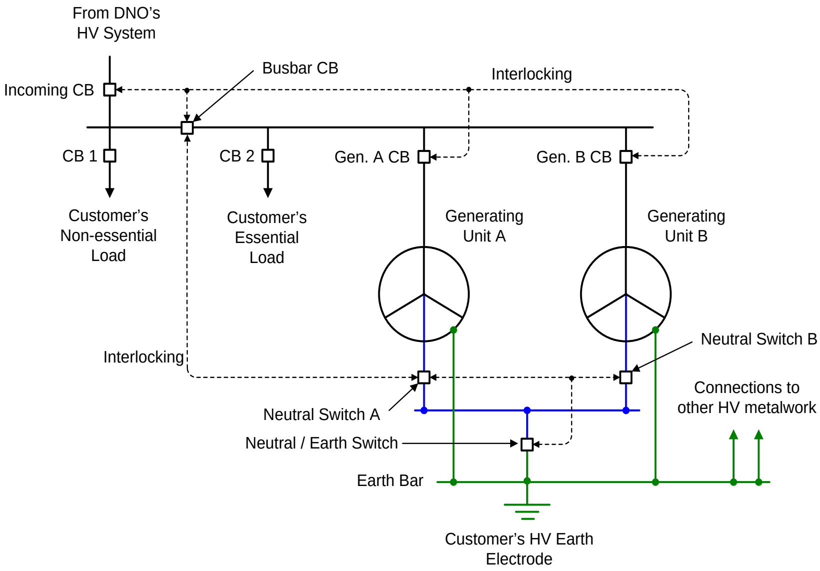
Figure 8.3 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



NOTE:

(1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.
(2) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral / earth switch is closed.
(3) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

Figure 8.4 - Typical Earthing Arrangement for two **HV Generating Unit**s 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 **Generating Units** operate independently from the **DNO** system.
(2) If one **Generating Units** is operating independently from the **DNO** system (ie busbar CB is open) then its neutral switch is closed and the neutral / earth switch is closed.
(3) If both **Generating Units** are operating independently from the **DNO** system (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 **Generating Units** are operating in parallel with the **DNO** system (ie busbar CB is closed) then both neutral switches and the neutral /earth switch are open.

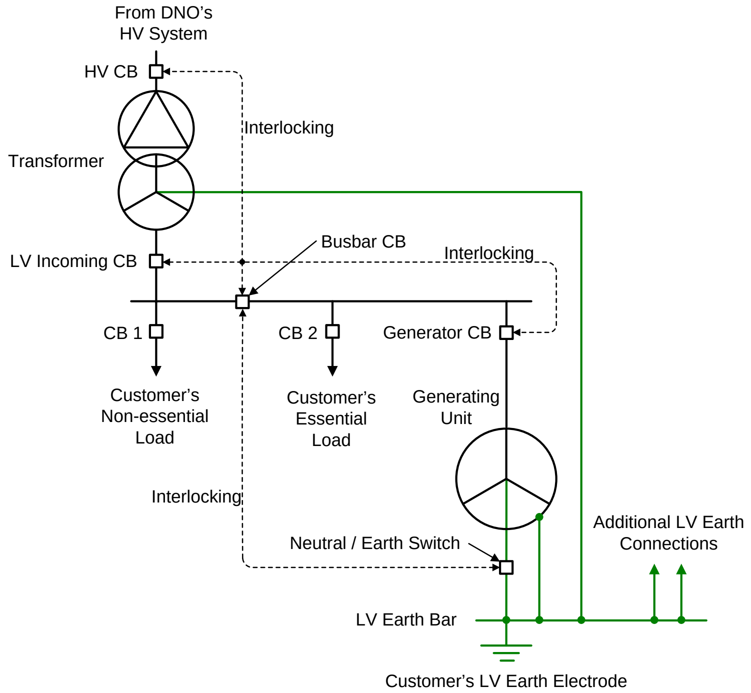
8.3 LV Generating Plant

8.3.1 **LV Distribution System**s are always solidly earthed, and the majority are multiple earthed.

8.3.2 The specific earthing requirements for **LV** connected **Generation Plant** are described in DPC7.4.

8.3.3 The following diagrams 8.5 to 8.9 show typical installations.

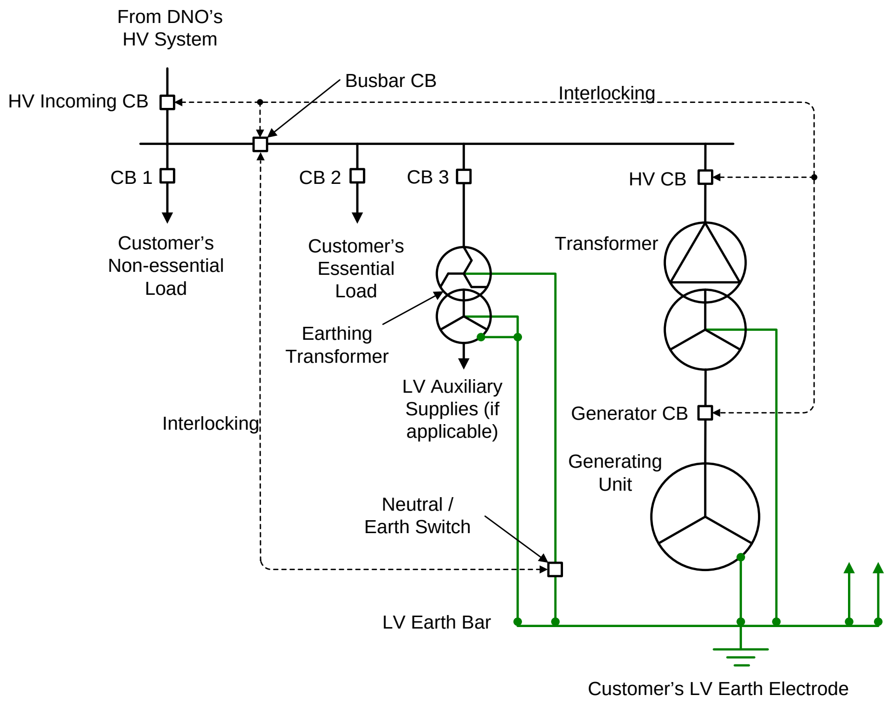
Figure 8.5 - Typical Earthing Arrangement for an **LV Generating Unit** Connected to the **DNO** System at **HV** and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation.



NOTE:

(1) **HV** earthing is not shown.
(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.
(3) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral earth switch is closed.
(4) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

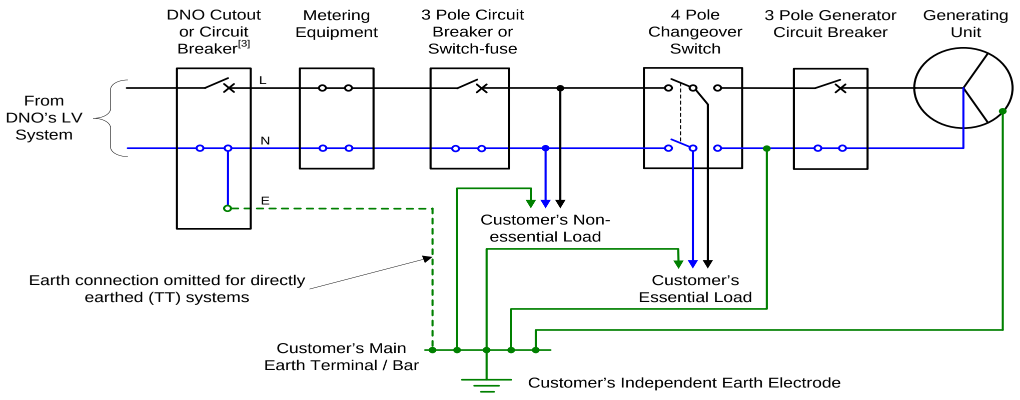
Figure 8.6 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer HV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



NOTE:

(1) **HV** earthing is not shown.
(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.
(3) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral / earth switch is closed.
(4) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

Figure 8.7 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer LV** System and Designed for Independent (i.e. Standby) Operation Only



NOTES

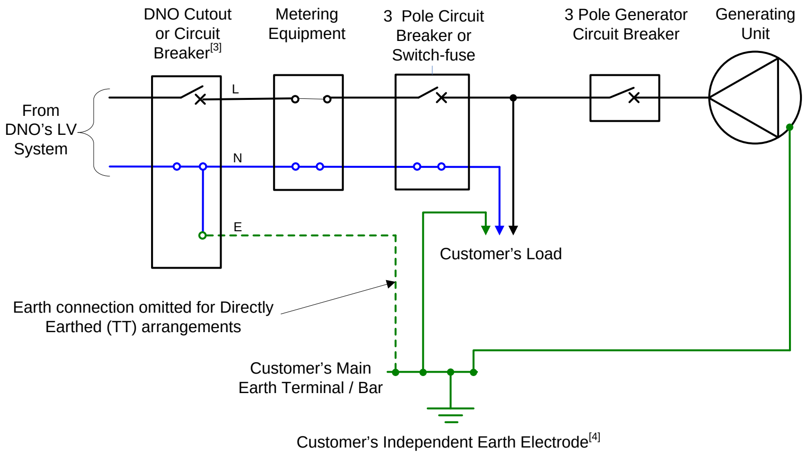
(1) Only one phase of a three phase system is shown to aid clarity.

(2) **Generating Unit** is not designed to operate in parallel with the **DNO**s system.

(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Generating Unit** 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 **Generating Unit** neutral current from inadvertently flowing through the part of the **Customer's System** that is not supported by the **Generating Plant.**

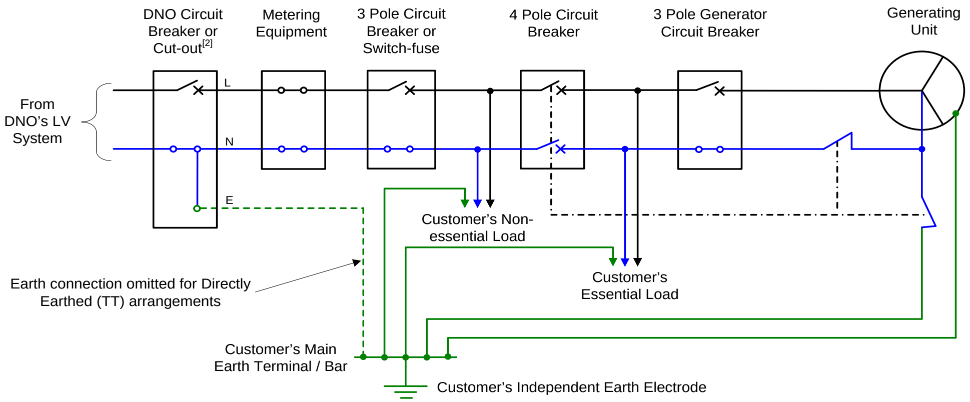
Figure 8.8 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer LV** System and Designed for Parallel Operation Only



NOTES:

(1) Only one phase of the three phase system is shown to aid clarity.
(2) **Generating Unit** is not designed to operate in standby mode.
(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Generating Unit** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.
(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 Generating Unit** 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 **Generating Unit** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

(3) When the **Generating Plant** 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 **Generating Unit** neutral current from inadvertently flowing through the part of the **Customer's System** that is not supported by the **Generating Plant. This switch should also close the generator neutral and earth switches during independent operation.**

9 NETWORK CONNECTION DESIGN AND OPERATION

9.1 General Criteria

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 System**s. These obligations will influence the options for connecting **Generating Plant**.

9.1.2 The technical and design criteria to be applied in the design of the **Distribution System** and **Generating Plant** connection are detailed within the Distribution Planning and Connection Code (DPC) and the standards listed in Annex 1 of the **Distribution Code**. The criteria are based upon the performance requirements of the **Distribution System** necessary to meet the above obligations.

9.1.3 The **Distribution System**, and any **Generating Plant** connection to that System, 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).

b. according to design principles in relation to **Distribution System**'s plant and equipment, earthing, voltage regulation and control, and protection as outlined in DPC4, subject to any modification to which the **DNO** may reasonably consent.

9.1.4 **Generating Plant** 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 DPC7.4 of the **Distribution Code**.

9.1.5 There are additional performance requirements that are specified in the **Grid Code** for all embedded **Medium and Large Power Station**s. The requirements for **Medium Power Station**s are referenced in DPC7.5 of the **Distribution Code**, and are all listed in CC3.3 to CC3.5 of the **Grid Code**.

9.2 Network Connection Design for Generating Plant

9.2.1 The connection of new **Customer**s, including **Generator**s, to the **Distribution System** should not generally increase the risk of interruption to existing Customers. For example, alterations to existing **Distribution System** 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 Connection of **Generating Plant** to 132kV **Distribution System**s may be subject to the requirements of EREC P18. This document sets out the normal limits of complexity of 132kV circuits by stipulating certain restrictions to be applied when they are designed. For example, 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. Most **DNO**s will have similar rules for managing the complexity of 66kV and lower voltage **Distribution System**s.

9.2.3 The security requirements for the connection of **Generating Plant** are subject to economic consideration by the **DNO** and the **Generator.** A firm connection for **Generating Plant** should allow the full MVA capacity to be exported via the **Distribution System** at all times of year and after one outage on any one circuit of the **Distribution System**. ETR 124 provides additional advice on the management of constraints and security.

9.2.4 The decision as to whether or not a firm connection is required should be by agreement between the **DNO** and the **Generator**. The **DNO** should be able to provide an indication of the likely duration and magnitude of any constraints so that the **Generator** can make an informed decision. The **Generator** should consider the financial implications of a non-firm connection against the cost of a firm connection, associated **Distribution System** reinforcement and the risk of any constraints due to **Distribution System** restrictions.

9.2.5 Where the **DNO** expects the **Generating Plant** to contribute to system security, the provisions of EREC P2 and the guidance of ETR 130 will apply. In addition, the **Generating Plant** should either remain synchronised and in parallel with the **Distribution System** 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 When designing a scheme to connect **Generating Plant**, consideration must be given to the contribution which that **Generating Plant** will make to short circuit current flows on the **Distribution System**. The assessment of the fault level contribution from **Generating Plant** and the impact on the suitability of connected switchgear are discussed in Section 9.4.

9.2.7 It is clearly important to avoid unwanted tripping of the **Generating Plant**, particularly where the **Generating Plant** is providing **Distribution System** or **Total System** security. The quality of supply and stability of **Generating Plant** performance are dealt with in Sections 9.6 and 9.7 respectively.

9.2.8 **Generating Plant** may be connected via existing circuits to which load and/or existing **Generating Plant** is also connected. The duty on such circuits, including load cycle, real and reactive power flows, and voltage implications on the **Distribution System** 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 System** 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 A **DNO** assessing a proposed connection of **Generating Plant** must also consider its effects on the **Distribution System** voltage profile and voltage control employed on the **Distribution System**. Voltage limits and control issues are discussed in Section 9.5.

9.3 Generating Plant Performance and Control Requirements

9.3.1 In accordance with DPC7.4.1 of the **Distribution Code**, the rated power output of a **Generating Unit** 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**.

9.3.2 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 System** could rise above 50.5 Hz. Therefore all embedded **Small Power Stations** should be capable of continuing to operate in parallel with the **Distribution System** 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.

b. 47.5 Hz – 51.5 Hz Disconnection by overfrequency or underfrequency protection is not permitted in this range.

c. 51.5 Hz – 52 Hz Operation for a period of at least 90 seconds is required each time the frequency is within this range.

9.3.3 The operational characteristics of the control systems of **Generating Plant** control systems (eg excitation, speed governor, voltage and frequency controls if applicable) must be co-ordinated with other voltage control systems influencing the voltage profile on the **Distribution System**. The **DNO** will provide information on performance requirements in accordance with DPC7.4.2.

9.3.4 Following consultation with the **Generator** and dependent on **Distribution System** voltage studies, a **DNO** will agree the reactive power and voltage control requirements for all **Generating Unit**s that are connected to their **Distribution System**s. It should be noted that the connection to the **Distribution System** 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. For Embedded **Medium and Large Power Station**s, considerations in Section 9.1.5 apply.

9.3.5 Each item of **Generating Plant** and its associated control equipment must be designed for stable operation in parallel with the **Distribution System**.

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 **Generating Plant** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Generating Plant**.

9.3.7 **Type Tested Generating Unit**s Performance Requriements

Type Tested Generating Units should be capable of continuing to operate in parallel with the **Distribution System** as per section 9.2 for non-type tested **Generating Units.** However allowing for tolerances and measurement errors the following test voltages and frequencies at which the tests should be carried out with no trips have been defined. These are shown on the Generating Unit Type test sheet in section 13.1 and described in section 13.8

a. Voltage range:

Maximum Voltage of 258.2V with no time limit, 269.7V for 0.98s and of 277.7V for 0.48s.

Minimum Voltage of 204.1V with no time limit, 188V for 2.48s and 180V for 0.48s

b. Frequency range:

Maximum Frequency 51.3Hz with no time limit, 51.8Hz for 89.98s and 52.2Hz for 0.48s

Minimum frequency 47.7Hz with no time limit, 47.2 Hz for 19.98s and 46.8Hz for 0.48s

c. Rates of Change of Frequency range:

From 50.5Hz to 47.5Hz at 0.19Hz per second and from 49.5Hz to 51.5Hz at 0.19Hz per second

d. Voltage Vector shift rangeof:

plus or minus 9 degrees

e. And when operating at rated power shall operate at a power factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the **DNO** eg for power factor improvement. The test to be carried out at three voltage levels.

The tests required to prove satisfactory operation are detailed in section 13.8 and should be recorded on the **Generating Unit** Type Test sheet in section 13.1

9.4 Fault Contributions and Switchgear Considerations

9.4.1 Under the ESQCR 2002 and the EaWR 1989 the **Generator** 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.

9.4.2 The **Generator** may accept that protection installed on the **Distribution System** can help discharge some of his legal obligations relating to fault clearance and, if requested, the **DNO** should consider allowing such faults on the **Generator's** system to be detected by **DNO** protection systems and cleared by the **DNO'**s circuit breaker. The **DNO** will not allow the **Generator** 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.

9.4.3 The design and safe operation of the **Generator**'s and the **DNO'**s installation's depend upon accurate assessment of the contribution to the short circuit current made by all the **Generating Plant** operating in parallel with the **Distribution System** at the instant of fault and the **Generator** should discuss this with the **DNO** at the earliest possible stage.

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 **Generating Unit**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 System** or **Transmission System**. Studies must therefore consider all credible **Distribution System** running arrangements which are likely to increase **Distribution System** 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.

9.4.5 The connection of **Generating Plant** can raise the **Distribution System** 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 System**. The performance of protection may also be impaired by partial or complete saturation of current transformers resulting from an increase in **Distribution System** X/R ratio.

9.4.6 Newly installed protection systems and circuit breakers for **Generating Unit** 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 beaker will be specified for this duty, but in the case of existing circuit breakers on the **Distribution System**, the **DNO** will need to establish the possibility or otherwise of the **DNO**s protection (or the **Generator**'s protection if arranged to trip the **DNO'**s circuit breaker) initiating a circuit breaker trip during a period when one of more **Generating Unit**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.

9.4.7 When connection of **Generating Plant** is likely to increase short circuit currents above **Distribution System** design ratings, consideration should be given to the installation of reactors, sectionalising networks, connecting the **Generating Plant** to part of the **Distribution System** operating at a higher voltage, changing the **Generating Unit** 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 System** 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 System** design ratings would be exceeded in infrequent but credible **Distribution System** configurations, then constraining the **Generating Plant** off during periods of such **Distribution System** configurations may provide a suitable solution. When assessing short circuit currents against **Distribution System** design ratings, suitable safety margins should be allowed to cater for tolerances that exist in the **Distribution System** data and **Generating Unit** parameters used in system modelling programs. On request from a **Generator** the **DNO** will provide the rationale for determining the value of a specific margin being used in **Distribution System** studies.

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 System** or **Transmission System** plant and equipment. The use of the proposed **Generating Plant** to prevent overloading of **Distribution System** plant and equipment should be considered with reference to EREC P2.

9.4.9 Disconnection of **Generating Plant** 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 **Generating Unit**, 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.

9.5 Voltage Limits and Control

9.5.1 Where **Generating Plant** 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 **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Generating Plant** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.

9.5.2 The connection of a **Generating Plant** to the **Distribution System** shall be designed in such a way that operation of the **Generating Plant** does not adversely affect the voltage profile of and voltage control employed on the **Distribution System**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations.

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 **Generating Plant** is required to operate to a 'setpoint voltage' and 'slope', the **Generating Plant** will have a specific role to control the **Distribution System** voltage. The final responsibility for control of **Distribution System** voltage does however remain with the **DNO**.

9.5.4 Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution System** operating at a higher voltage to parts of the **Distribution System** operating at lower voltages. Export from **Generating Plant** 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 **Generating Plant** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.

9.5.5 **Generating Plant** 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.

9.5.6 An agreement between the **DNO** and the **Generator** 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.

9.5.7 The **Step Voltage Change** caused by the connection and disconnection of **Generating Plant** from the **Distribution System** must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other **Customers** connected to the **Distribution System**. 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 System** 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%. The **Distribution Code** makes allowances for these events in DPC4.

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.

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 (ie 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.

9.5.10 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 System** or on the **Customer**'s system. 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%.

9.5.11 These threshold limits should be complied with at the **Point of Common Coupling** as required by EREC P28.

9.6 Power Quality

9.6.1 Introduction

The connection and operation of **Generating Plant** may cause a distortion of the **Distribution System** voltage waveform resulting in voltage fluctuations, harmonics or phase voltage unbalance. DPC4.2.3 of the **Distribution Code** sets the limits on voltage disturbances and harmonic distortion; DPC7.4.4 sets phase voltage unbalance requirement that any **Generating Plant** connected to the **Distribution System** would need to comply with.

9.6.2 Flicker

Where the input motive power of the **Generating Plant** may vary rapidly, causing corresponding changes in the output power, flicker may result. The operation of **Generating Plant** 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 System** needs to be considered to ensure that the emissions produced by the **Generating Plant** do not cause a problem on the **Distribution System**. For **Type Tested Generating Unit**s of up to 17kW per phase or 50kW three phase voltage step change and flicker measurements as required by BS EN 61000-3-11 shall be made and recorded in the type test declaration for the **Generating Unit**.

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 System** may be required before the **Generating Plant** can be connected.

9.6.2.1 For wind turbines, flicker testing should be carried out during the performance tests specified in IEC 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.

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.

9.6.3 Harmonic Emissions

Harmonic voltages and currents produced within the **Generator**'s **System** may cause excessive harmonic voltage distortion in the **Distribution System**. The **Generator**'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**.

For **Type Tested Generating Unit**s of up to 17kW per phase or 50kW three phase harmonic measurements as required by BS EN 61000-3-12 shall be made and recorded in the type test declaration for the **Generating Unit**.

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 **Generating Unit**. This standard requires a minimum ratio between source fault level and the size of the **Generating Unit**, and connections in some cases may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO's System.**

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 **Generating Unit** size ratio check. **Generating Unit**s meeting the requirements of BS EN 61000-3-2 will need no further assessment with regards to harmonics.

9.6.4 Where the **Generating Plant** 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 **Generating Plant**, then a full harmonic study should be carried out.

9.6.5 Voltage imbalance

EREC P29 is a planning standard which sets the **Distribution System** compatibility levels for voltage unbalance caused by uneven loading of three phase supply systems. **Generating Unit**s should be capable of performing satisfactorily under the conditions it defines. The existing voltage unbalance on an urban **Distribution System** 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.

9.6.6 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.

9.6.6.1 For **Power Stations** of 50kW or less section 7.5 of this document specifies maximum unbalance of **Generating Units**. Where these requirements are met then no further action is required by the **Generator**.

9.6.7 Power factor correction equipment is sometimes used with asynchronous **Generating Unit**s to decrease reactive power flows on the **Distribution System**. 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.

9.6.8 DC Injection

The effects of, and therefore limits for, DC currents injected into the **Distribution System** 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 **Generating Unit**.

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**.

9.7 System Stability

9.7.1 Instability in **Distribution System**s may result in unacceptable quality of supply and tripping of **Customer**'s plant. In severe cases, instability may cascade across the **Distribution System**, resulting in widespread tripping and loss of demand and generation. There is also a risk of damage to plant.

9.7.2 In general, **System Stability** is an important consideration in the design of **Generating Plant** connections to the **Distribution System** at 33kV and above. Stability considerations may also be appropriate for some **Generating Plant** connections at lower voltages. The risks of instability generally increase as **Generating Plant** capacity increases relative to the fault level infeed from the **Distribution System** at the **Connection Point**.

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 System**s, 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.

9.7.4 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 **Generating Unit**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 **Generating Unit**s.

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 System**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.

9.7.6 It is recommended that **Generating Plant** and its connection to the **Distribution System** be designed to maintain stability of the **Distribution System** 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 **Generating Plant** 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 System** circuits (such as transformers, overhead lines and cables) and busbars, that are quickly cleared by main protection.

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. **Generating Unit**s that become unstable following system disturbances should be disconnected as soon as possible.

9.7.7 Various measures may be used, where reasonably practicable, to prevent or mitigate system instability. These may include **Distribution System** and **Generating Plant** solutions, such as:

- improved fault clearance times by means of faster protection;
- improved performance of **Generating Plant** control systems (excitation and governor/prime mover control systems; **Power System Stabilisers** to improve damping);
- improved system voltage support (provision from either **Generating Plant** or **Distribution System** plant);
- reduced plant reactance's (if possible);
- Protection to identify pole-slipping;
- increased fault level infeed from the **Distribution System** 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 System** and **Customer**s in terms of reduced risk of system instability.

9.8 Island Mode

9.8.1 A fault or planned outage, which results in the disconnection of a **Generating Unit**, together with an associated section of **Distribution System**, from the remainder of the **Total System**, creates the potential for island mode operation. The key potential advantage of operating in Island Mode is to maintain continuity of supply to the portion of the **Distribution System** containing the **Generating Unit**. 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.

9.8.2 When considering whether **Generating Plant** 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 **Generator** must be in place and the legal liabilities associated with such operation must be carefully considered by the **DNO** and the **Generator**. 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.

9.8.3 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 System** is operating in island mode, and has been disconnected from the **Total System**, will need to be transmitted to the **Generating Unit(s)** protection and control schemes.

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 **Generating Plant** and its control / protections systems will be required to determine the capability of the **Generating Plant** to meet these requirements immediately as the island is created and for the duration of the island mode operation.

9.8.5 The ESQCR also require that **Distribution System**s are earthed at all times. **Generator**s, who are not permitted to operate their installations and plant with an earthed star-point when in parallel with the **Distribution System**, 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 System** to all users is maintained. Further details are provided in Section 8.

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.

9.8.7 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 **Generator** where appropriate.

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**.

10 PROTECTION

10.1 General

10.1.1 The main function of the protection systems and settings described in this document is to prevent the **Generating Plant** supporting an islanded section of the **Distribution System** when it would or could pose a hazard to the **Distribution System** 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 System** operation, to avoid nuisance tripping, but with a faster trip for greater excursions.

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 **Generating Unit** 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 **Generation Unit**s the complete installation cannot be considered to comprise **Type Tested Generating Unit**s as the protection and connections are made up on site and so cannot be factory tested or **Type Tested**.

10.1.3 In exceptional circumstance additional protection may be required by the **DNO** to protect the **Distribution System** from the **Generating Plant**.

10.2 Protection Requirements

10.2.1 The basic requirements for protection are laid out in DPC7.4 of the **Distribution Code**. The requirements of EREC G59 are as follows:-

- UnderVoltage (2 stage);
- OverVoltage (2 stage);
- UnderFrequency (2 stage);
- OverFrequency (2 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.

It is in the interest of **Generators**, **DNO**s and **NETSO** that **Generating Plant** remains synchronised to the **Distribution System** 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 **Medium Power Station**s and **Large Power Station**s 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 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 flags and is secure from interference by unauthorised personnel.

10.2.3 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 **Generating Plant** is connected to the same feeder. The automatic reset must be inhibited for faults on the **Generator**'s installation.

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).

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 Protection equipment and protection functions may be installed within, or form part of the generator 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 **Generating Plant** 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). This is not a requirement for **Type Tested Generating Units**.

d. a **Type Tested Generating Unit**'s **Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by plug and socket which the **Manufacturer** has made and tested prior to delivery to site.

10.3 Loss of Mains (LoM)

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 **Generating Plant** from the **Distribution System** in the event of loss of one or more phases of the **DNO**s supply. This LoM protection is required to ensure that the Generating Plant is disconnected, to ensure that the requirements for **Distribution System** earthing, and out-of-**Synchronism** closure are complied with and that **Customers** are not supplied with voltage and frequencies outside statutory limits.

10.3.2 LoM is mandatory for all **Small Power Stations**. For **Medium and Large Power Stations** the **DNO** will advise if LoM is required. The requirements of 10.5.2 apply to LoM protection for all **Power Stations**.

10.3.3 A problem can arise for **Generator**s who operate **Generating Plant** in parallel with the **Distribution System** prior to a failure of the network supply because if their **Generating Plant** 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 **Generating Plant** will be out of **Synchronism** with the **Total System** and suffer damage. LoM protection can be employed to disconnect the **Generating Plant** immediately after the supply is lost, thereby avoiding damage to the **Generating Plant**.

10.3.4 Many **Customers** are connected to parts of **Distribution System**s 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 future as **DNO**s seek to improve supply availability by installing automatic switching equipment on their **Distribution System**s.

10.3.5 Where the amount of **Distribution System** load that the **Generating Plant** will attempt to pick up following a fault on the **Distribution System** is significantly more than its capability the **Generating Plant** will rapidly disconnect, or stall. However depending on the exact conditions at the time of the **Distribution System** failure, there may or may not be a sufficient change of load on the **Generating Plant** to be able to reliably detect the failure. The **Distribution System** failure may result in one of the following load conditions being experienced by the **Generating Plant**:

a. The load may slightly increase or reduce, but remain within the capability of the **Generating Plant**. There may even be no change of load;

b. The load may increase above the capability of the prime mover, in which case the **Generating Plant** 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 **Generating Plant**, in which case the following easily detectable conditions will occur:

- Overload and accompanying speed/frequency reduction
- Over current and under voltage on the alternator

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 System** supply being supplied by the **Generating Plant** 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 LoM signals can also be provided by means of intertripping signals from circuit breakers that have operated in response to the **Distribution System** fault.

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 **Generating Plant** available to satisfy the load requirements of the site or the **Generating Plant** circuit breaker can be tripped, leaving the breaker at the interface closed and ready to resume supply when the **Distribution System** supply is restored. The most appropriate arrangement is subject to agreement between the **DNO** and **Generator**.

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 **Generating Plant** rating, the site load conditions and requirements for reactive power.

10.3.10 Where the **Generating Plant** capacity is such that the site will always import power from the **Distribution System**, 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.

10.3.11 However, where the **Generating Plant**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 System** 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 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 **Generating Plant** 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 **Generating Plant** 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 Frequency variations are a constant feature of any AC electrical network. During normal operation of the system NGET maintains frequency within the statutory limits of 49.5Hz to 50.5Hz. However the loss of a large generation infeed, or a large block of load, may disturb the system such that it goes outside statutory limits for a short period. It is important that unnecessary Loss of Mains protection operation does not occur during these short lived excursions. The changing mix of generation and loads on the GB network has already resulted in a wider range of possible system rate of change of frequency (RoCoF) during these events. This wider range of RoCoF could exceed the expectations set out in previous versions of EREC G59 and system RoCoF events above 0.125Hzs^{-1} have already been measured on the GB network. With the changes in generation mix expected over the next decade it is unlikely to be economic to contain all frequency excursions within 0.125Hzs-^{1}. Therefore the maximum system RoCoF which may be experienced for the maximum loss of generation infeed or block of load will rise over time. Studies indicate that by 2023 this may be as high as 0.5Hzs^{-1}, and that even higher levels may be experienced after 2023. The RoCoF settings for Power Stations of 5MW or more laid out in EREC G59/3-2~~1~~ are intended to strike an appropriate balance between the need to detect genuine island conditions and the risk of unnecessary operation for the system conditions anticipated.

10.3.14 The LoM relay that operates on the principle of voltage vector shift can achieve fast disconnection for close up **Distribution System** 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 Systems**. 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 Systems**, and especially on rural **Distribution Systems** where auto-reclosing systems are used, a higher setting may be required to prevent nuisance tripping. Typically this is between 10 and 12 degrees. In order to provide a consistant value for application to **Type Tested Generating Units**, a value of 12 degrees, and a no-trip test of 9 degrees have been introduced for **Type Tested Generating Units**.

10.3.15 RoCoF protection is generally only applicable for **Small Power Stations**. DPC7.4 in the **Distribution Code** details where RoCoF may be used, and what the differences are between Scotland and England and Wales.

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 13.6 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. Protection settings for **Type Tested Generating Units** shall not be changed from the standard settings defined in this Engineering Recommednation.

10.3.17 For a radial or simple **Distribution System** controlled by circuit breakers that would clearly disconnect the entire circuit and associated **Generating Plant**, for a LoM event an intertripping scheme can be easy to design and install. For meshed or ring **Distribution System**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.

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 **Generating Unit,** site and network load conditions. The **DNO** will assist in the decision making process by providing information on the **Distribution System** and its loads. The technique and settings applied must be biased to ensure detection of islanding under all operating conditions as far as is reasonably practicable. More detailed guidance on how **Generators** can assess the risks and on the information that the **DNO** will provide is containedin Appendix 13.11

10.4 Additional DNO Protection

Following the **DNO** connection study, the risk presented to the **Distribution System** by the connection of a **Generating Unit** 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 **Generating Unit**, 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**.

10.4.1 Neutral Voltage Displacement (NVD) Protection

Section 9.8.6 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.

Section 10.3 describes LoM protection which the **Generator** must install to achieve (amongst other things) disconnection of the **Generating Plant** from the **Distribution System** in the event of loss of one or more phases of the **DNO**s supply.

Where **Generating Plant** inadvertently operates in island mode, and where there is an earth fault existing on the **DNO**s **HV System** NVD protection fitted on the **DNO**s **HV** switchgear will detect the earth fault, and disconnect the **HV System** from the island.

DNOs need to consider specific investigation of the need for NVD protection when, downstream of the same prospective island boundary, there are one or more **Generating Unit**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 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 **Generating Unit** connection, of any type with an output less than 200kVA;
- Multiple new **Generating Unit** connections, of any type, on a single site, with an aggregated output less than 200kVA;
- Single or multiple new **Generating Unit** 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 **Generating Unit** 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 **DNOs** will have differing network designs and so decision will be made by **DNO** according to to size of **Generating Unit**, point of connection, network design and planning policy. This is outside the scope of this document.

10.4.3 If the assessed minimum load on a prospective island is less than twice the maximum combined output of new **Generating Plant** 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 Generating Plant connection eg the margin of additional cost associated with NVD protection.

10.5 Protection Settings

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

10.5.1 The protection systems and settings can have an impact on the behaviour of **Generating Plant** when the **Total System** is in distress. Where **Generating Plant** has the capability to operate at the extremes of the possible operating range of the **Total System**, it would be inappropriate to artificially impose protection settings that would cause **Generating Plant** to be disconnected where it would otherwise be capable of remaining connected and help to maintain the integrity of the **Total System**. It is not the intention that this Section specifies the performance requirements of **Generating Plant** connected to **Distribution System**s, only that protection settings do not aggravate the stress on the **Total System** by tripping before there is a definite need in those circumstances. (For **Medium Power Station**s and **Large Power Station**s, performance requirements are specified in the **Grid Code**). For **Type Tested Generating Units** there are performance requirements and these are specified in section 9.3.7

10.5.2 A LoM protection of RoCoF or vector shift type will generally be appropriate for **Small Power Station**s, but this type of LoM protection must not be installed for **Power Station**s 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 fault ride through capability, especially for larger **Generating Unit**s (except where local auto-reclose dead times are 1s or less as a reclose on to a fault is more likely to destabilise generation that is still recovering stability from the first fault). The overall aim is to ensure that **Generating Plant** is not disconnected from the **Distribution System** unless there is material disturbance on the **Distribution System**, as disconnecting generation unnecessarily will tend to make an under voltage situation worse. To that end, for all **LV** and **HV** connected **Generating Plant** a 2-Stage under voltage protection should be applied as follows:

- Stage 1 should have a setting of -13% (ie 10% to cater for a future **LV** statutory voltage limit and an additional 3% to provide immunity from 3% **Step Voltage Change**s permitted under EREC P28) and a time delay of 2.5s.

- Stage 2 should have a setting of –20% (ie to detect a major **Distribution System** disturbance), with a time delay of 0.5s.

The **Grid Code** calls for fault-ride through capability for **Medium Power Stations** and **Large Power Stations** as there is a more material requirement for such **Generating Unit**s to remain connected to the **Distribution System** save in exceptional circumstances. In this case a single stage with a permitted time delay of 2.5s and a setting of –20% should be applied[6].

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[7] 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 **Customers 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 System** efficiency, it is common for the **HV Distribution System** to be normally operated near to the upper statutory voltage limits. The presence of **Generating Plant** within such **Distribution System**s may increase the risk of the statutory limit being exceeded, eg when the **Distribution System** is operating abnormally. In such cases the **DNO** may specify additional over voltage protection at the **Generating Plant** 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.

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6 Grid Code CC6.3 provides further details.

7 Over Voltage Protection is not intended to maintain statutory voltages but to detect islanding

10.5.5 Over Frequency

The **Grid Code** incorporates a requirement for **Medium Power Station**s and **Large Power Station**s to stay connected for **Total System** frequencies up to 52 Hz so as to provide the necessary regulation to control the **Total System** frequency to a satisfactory level. Similarly, the **Distribution Code** DPC7.4.1.3 has the same requirement for **Small Power Station**s. In order to prevent the unnecessary disconnection of a large volume of smaller **Generating Plant** for all **LV** and **HV** connected **Generating Plant** a 2-stage protection is to be applied as follows:

- Stage 1 should have a time delay of 90s and a setting of 51.5 Hz. The 90s setting should provide sufficient time for the **NETSO** to bring the **Total System** frequency below this level. Should the frequency rise be the result of a genuine islanding condition which the LoM protection fails to detect, this setting will help to limit the duration of the islanding period.

- Stage 2 should have a time delay of 0.5s and a setting of 52 Hz (ie to co-ordinate with the **Grid Code** and **Distribution Code** requirements with a practical time delay that can be tolerated by most **Generating Plant**). If the frequency rise to and above 52 Hz is the result of an undetected islanding condition, the **Generating Plant** will be disconnected with a delay of 0.5s plus circuit breaker operating time.

10.5.6 Under Frequency

The **Distribution Code** DPC7.4.1.3 requires **Small Power Station**s 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 **Generating Plant**, 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 **Generating Plant** during **Distribution System** 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 **Generating Plant** type & rating and **Distribution System** 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	Small Power Station				Medium Power Station	
	LV Protection[$]		HV Protection[$]			
	Setting	Time	Setting	Time	Setting	Time
U/V st 1	Vφ-n[†] - 13% = 200.1V	2.5s*	Vφ-φ[‡] -13%	2.5s*	Vφ-φ[‡]- 20%	2.5s*
U/V st 2	Vφ-n[†] - 20% = 184.0V	0.5s	Vφ-φ[‡] - 20%	0.5s		
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	47Hz	0.5s	47Hz	0.5s	47Hz	0.5s
O/F st 1	51.5Hz	90s	51.5Hz	90s	52Hz	0.5s
O/F st 2	52 Hz	0.5s	52Hz	0.5s		
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees[#]		Intertripping expected	
LoM(RoCoF) <5MW[§]	K2 x 0.125 Hz/s		K2 x 0.125 Hz/s[#]		-	

RoCoF[§] settings for Power Stations ≥5MW				
Date of Commissioning		Small Power Stations		Medium Power Stations
		Asynchronous	Synchronous	
Generating Plant Commissioned before 01/08/14	Settings permitted until 01/08/16	Not to be less than K2 x 0.125 Hz/s[#] and not to be greater than 1Hz/s[¶#], time delay 0.5s	Not to be less than K2 x 0.125 Hz/s[#] and not to be greater than 0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping Expected
	Settings permitted on or after 01/08/16	1Hz/s[¶#], time delay 0.5s	0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping expected
Generating Plant commissioned between 01/08/14 and 31/07/16 inclusive		1Hz/s[¶#], time delay 0.5s	0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping expected
Generating Plant commissioned on or after 01/08/16		1Hz/s[¶#], time delay 0.5s	1Hz/s[¶#], 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 G59 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 G59 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 Station**s connected to a **DNO LV Systems**

‡ 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 **Generating Unit** is permitted to reduce/cease exporting in order to protect the **Generating Unit**.

¶ The required protection requirement is expressed in Hertz per second (Hz/s). The time delay should begin when the measured RoCof exceeds the threshold expressed in Hz/s. The time delay should be reset if measured RoCoF falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in Hz/s continuously for 500ms. 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 500ms if the system RoCoF was significantly higher than the threshold.

Ω The minimum setting is 0.5Hz/s. For overall system security reasons, settings closer to 1.0Hz/s are desirable, subject to the capability of the Generating Plant to work to higher settings.

(2) LOM constants

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

K2 = 1.0 (for low impedance networks) or 1.6 (for high impedance networks)

A fault level of less than 10% of the system design maximum fault level should be classed as high impedance.

For **Type Tested Generating Unit**s K1=2.0 and K2=1.6. 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.

(4) For the purposes of 10.5.7.1 the commissioning date means the date by which the tests detailed in 12.3 and 12.4 of EREC G59/3-2 have been completed to the DNO's satisfaction.

The **Manufacturer** must ensure that the **Interface Protection** in a **Type Tested Generating Unit** 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	Small Power Station			
	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 Stations** connected to a **DNO LV System**s

‡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 **Generating Plant**. In exceptional circumstances **Generator**s have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Generating Plant** 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 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 **Generating Plant** when operating in island mode although different settings may be required.

10.5.12 For **LV** connected **Generating Plant**, the voltage settings will be based on the 230V nominal **System** voltage. In some cases **Generating Plant** may be connected to **LV System**s 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 **Generating Units** with non-standard **LV** protection settings cannot be **Type Tested** and these will need to be agreed by the **DNO** on a case by case basis.

10.5.13 Co-ordination with existing protection equipment and auto-reclose scheme is also required, as stated in DPC7.4.3 of the **Distribution Code**. In particular the **Generator**'s protection should detect a LoM situation and disconnect the **Generating Plant** 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 auto-reclosers set with a dead time of 3s, this implies a LoM response time of 2.5s. A similar response time is expected from under and over voltage relays. Where auto-reclosers have a dead time of less than 3s, there may be a need to reduce the operating time of under and over voltage relays. For **Type Tested Generating Unit**s no changes are required to the operating times irrespective of the auto-reclose times.

10.5.14 If automatic resetting of the protective equipment is used, as part of an auto-restore scheme for the **Generating Plant**, there must be a time delay to ensure that healthy supply conditions exist for a continuous period of at least 20 s. The automatic reset must be inhibited for faults on the **Generator**'s installation. Staged timing may be required where more than one **Generating Plant** is connected to the same feeder. For **Type Tested Generating Unit**s the time delay is set at 20s.

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.

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

The standard over and under voltage settings for **LV** connected **Generating Units** 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 **Generating Units** connected to the **Customers LV** network. Where a **DNO** provides a connection at **HV** and the **Customers** 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 Station**s 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.

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For example a **Customer** is using a 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 stage 1	=	219x0.87	=	190.5V
UV stage 2	=	219x0.8	=	175V

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

Where **Generating Units** 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 does not lend itself to **Type Tested Generating Unit**s and should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G59 would allow the **Generation Unit** 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 **Generating Units** produced for a particular **Power Station** comply with the revised over and under voltage settings. All other required data should be provided as for **Type Tested Generating Unit**s. This declaration should make reference to a particular **Power Station** 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 Station**.

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;

b. A display on an electronic device which can communicate with the **Generating Unit** 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 **Generating Unit**.

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.

10.6 Typical Protection Application Diagrams

This Section provides some typical protection application diagrams in relation to parallel operation of **Generating Plant** with **DNO Distribution System**. The diagrams only relate to **DNO** requirements in respect of the connection to the **Distribution System** and do not necessarily cover the safety of the **Generator**'s installation. The diagrams are intended to illustrate typical installations. The protection arrangements for individual schemes will be agreed between the **Generator** and the **DNO** in accordance with this document.

Figure 10.1 - List of Symbols used in Figures 10.2 to 10.6.

Figure 10.2 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for Parallel Operation Only

Figure 10.3 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.4 - Typical Protection Arrangement for an **LV Generating Unit** Connected to a **DNO HV System** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.5 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for Parallel Operation Only

Figure 10.6 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** 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 System**, 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 System** 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.

Figure 10.1 - List of Symbols in Figures 10.2 – 10.6

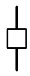
BEF	Balanced Earth Fault
CC	Circulating Current
3DOCI	3 Pole Directional Overcurrent (IDMT)
EI	Earth Fault (IDMT)
LOM	Loss of Mains
M	Metering
NVD	Neutral Voltage Displacement
3OCI	3 Pole Overcurrent (IDMT)
OF UF	Single Stage Over Frequency & Single Stage Under Frequency
OV UV	Single Stage Over Voltage & 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

Figure 10.2 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for Parallel Operation Only

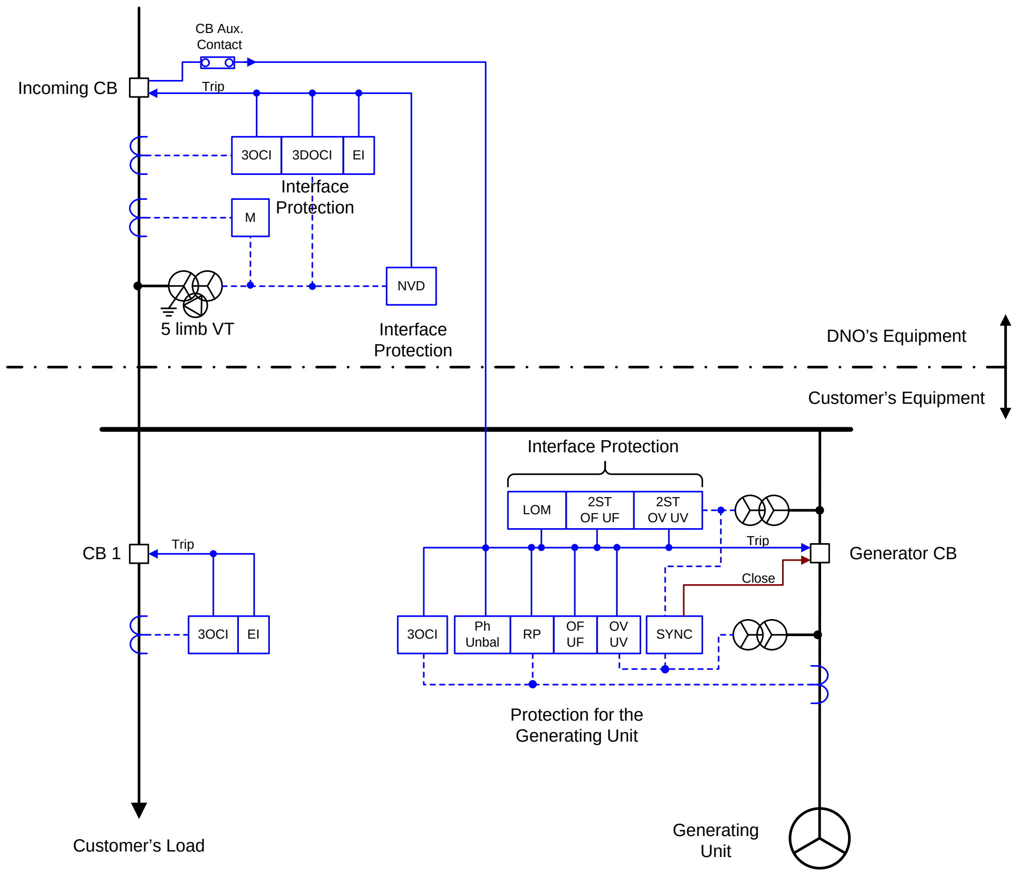


Figure 10.3 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

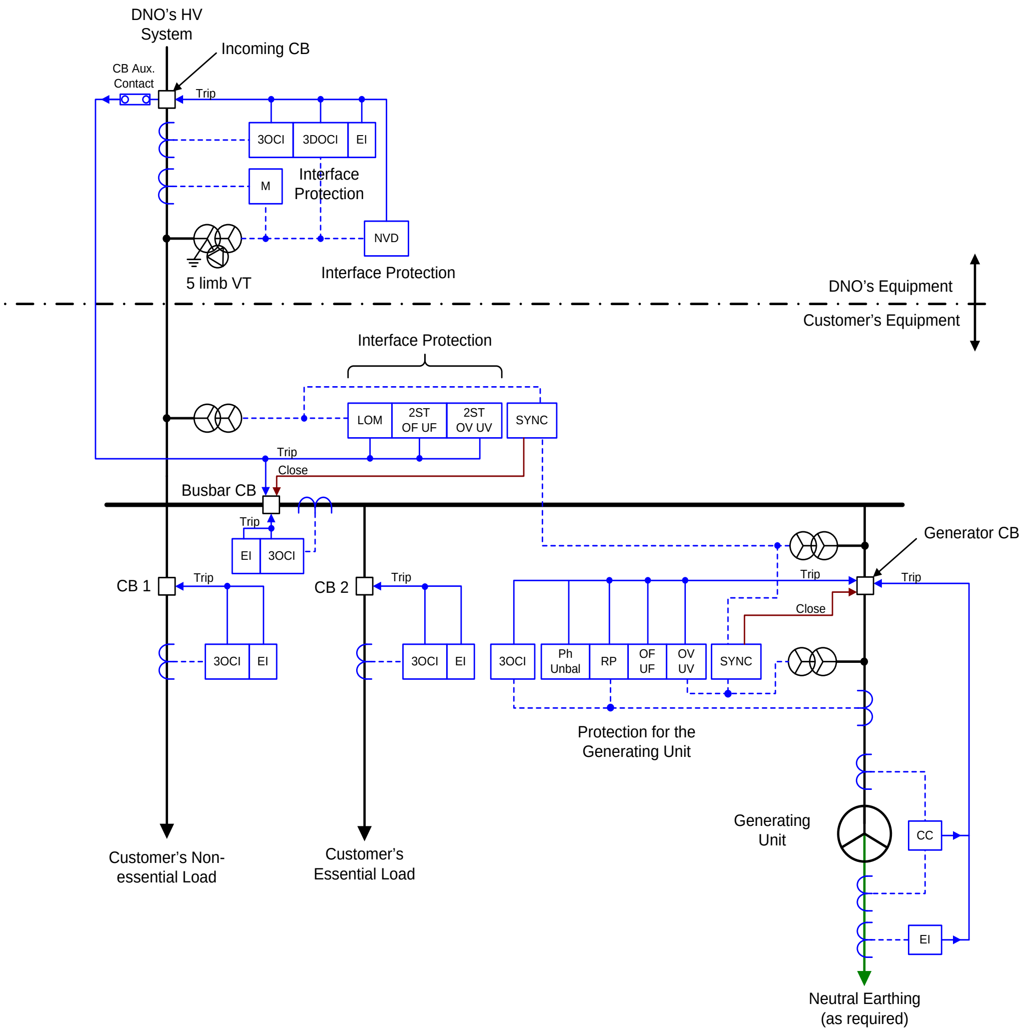


Figure 10.4 - Typical Protection Arrangement for an **LV Generating Unit** Connected to a **DNO HV System** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation..

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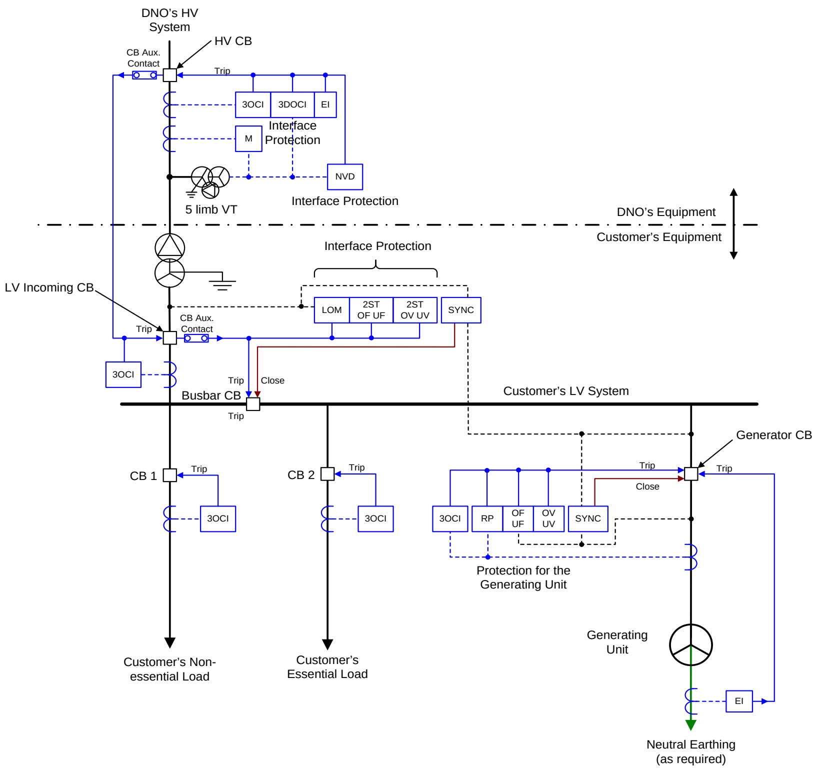


Figure 10.5 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for Parallel Operation Only

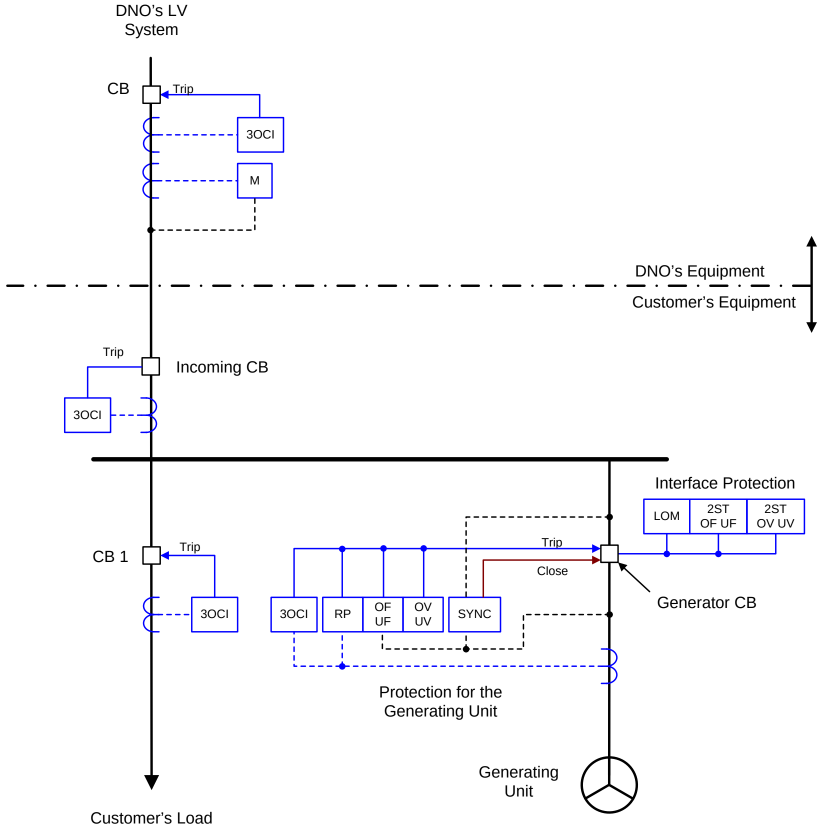
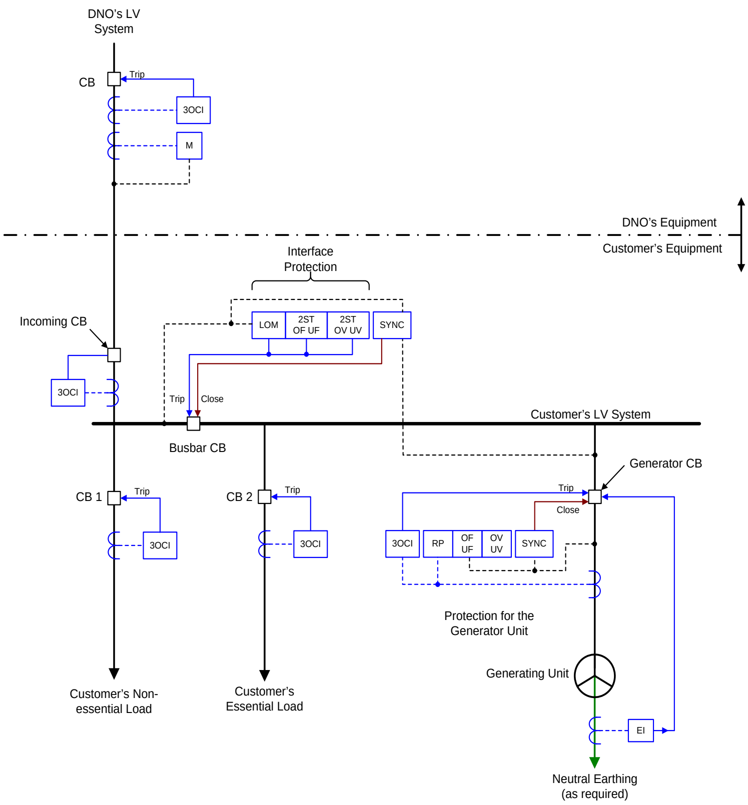


Figure 10.6 - Figure 10.6 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



11 INSTALLATION, OPERATION AND CONTROL INTERFACE

11.1 General

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 **Generating Plant** in compliance with this EREC. Ideally they should have recognised and approved qualifications relating to the fuel / energy sources and general electrical installations[8].

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 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 System** and give rise to danger.

11.1.4 No parameter relating to the electrical connection or setting that is subject to **Type Tested** certification shall be modified as part of or after the installation process unless previously agreed in writing between the **DNO** and the **Generator.** User access to change such parameters shall be prevented by the use of sealing plugs / paper seals / passwords etc.

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 System**, where appropriate;

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;

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8 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

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.

The use of **Type Tested Generating Unit**s for **Power Stations** of up to 50kW (3 phase) or 17kW (1 phase) is deemed to cover this requirement.

11.1.6 The **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 Generating Plant**s and also **Generating Plant**s connected to **LV Distribution System**s supplied indirectly by **HV** overhead lines.

11.2 Isolation and Safety Labelling

11.2.1 Every installation or system which includes **Generating Plant** operating in parallel with the **Distribution System** must include a means of isolation capable of disconnecting the whole of the **Generating Plant**[9] infeed to the **Distribution System.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

11.2.2 The **Generator** must grant the **DNO** rights of access to the means of isolation In accordance with DPC7.2 of the **Distribution Code**.

11.2.3 To ensure that **DNO** staff and that of the User and their contractors are aware of the presence of **Generating Plant**, appropriate warning labels should be used.

11.2.4 Where the installation is connected to the **DNO LV Distribution System** 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 **Generating Plant.** 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.

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[9] Where the generating plant 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 generating plant. See also Figure 8.7 and 8.9

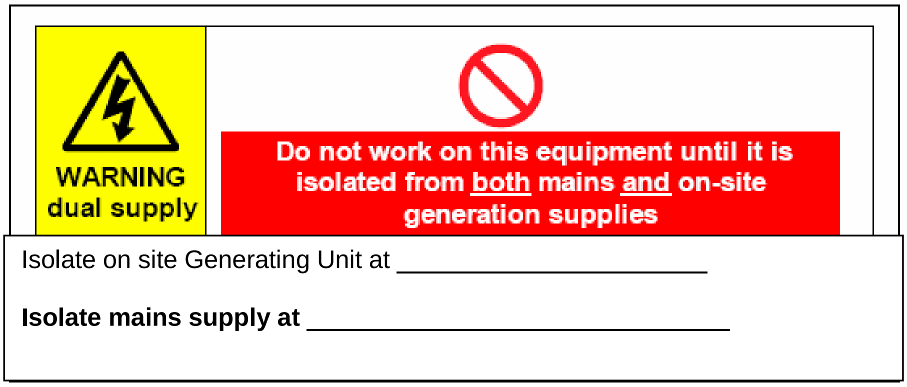

Figure 11.1 Warning label

11.2.5 Where the installation is connected to the **DNO HV Distribution System** 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 **Generating Unit**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.

11.3 Site Responsibility Schedule

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 System** and the **Generating Plant**, 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**. Where the **Power Station** has a total capacity of 50kW or 17kW per phase or less and is connected at **LV** then only compliance with section 11.3.3 is required.

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 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 In the case of a **LV** connected **Generating Plant,** a simple diagram located at the **Point of Supply** may be sufficient. The scope of the diagram should cover the **Distribution System**, **Customer**'s **installation** and the **Generating Plant** 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.

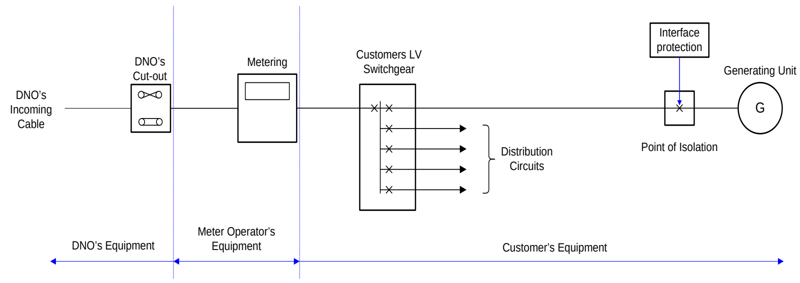

Fig 11.2 – Example of a Operational Diagram

11.3.4 In the case of an **HV** connected **Generating Plant** the diagram is likely to be more complex and contain more detailed information.

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 Operational and Safety Aspects

11.4.1 Where the **Point of Supply** provided by the **DNO** for parallel operation is at **HV**, 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 **Generating Plant** which have caused, or might cause, disturbance to the **Distribution System**, 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 For certain **Generating Plant** 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 System** to ensure stability of the local **Distribution System**. The **DNO** may require agreement on specific written procedures to control the bringing on and taking off of such **Generating Plant**. The action within these procedures will normally be controlled by the **DNO**s Control Engineer.

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 Synchronizing and Operational Control

11.5.1 Before connecting two energised electrical systems, for example a **Distribution System** and **Generating Plant**, it is necessary to synchronise them by minimising their voltage, frequency and phase differences.

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 Automatic synchronising equipment will be the norm which, by control of the **Generating Unit**'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.

11.5.4 The facility to use the **DNO**s circuit breaker manually for synchronizing can only be used with the specific agreement of the **DNO**.

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.

11.5.7 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.

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 **Generator** requires his **Generating Plant** to continue to supply a temporarily disconnected section of the **Distribution System** in island mode**,** the special arrangements necessary will need to be discussed with the **DNO**.

12 TESTING AND COMMISSIONING

12.1 General

12.1.1 A brief summary of generic requirements related to connection application, notification of commissioning and commissioning test requirements for **Power Stations** and **Generating Unit**s are given in Section 6.1. This section provides further details on the testing, commissioning and witnessing requirements.

12.1.2 General procedural issues, including the requirements for witnessing the commissioning tests and checks are described in Section 12.2.

12.1.3 The requirements for the tests and checks themselves are divided into two parts. Section 12.3 specifies the commissioning tests and checks that shall be carried out at all **Power Stations** irrespective of whether the **Generating Unit**s have been **Type Tested** to EREC G59 or EREC G83 or not. Section 12.4 specifies additional requirements for **Generating Unit**s have not been **Type Tested** to EREC G59 or EREC G83.

12.1.4 It is the responsibility of the **Installer** to undertake these commissioning tests / checks and to ensure the **Power Station** and **Generating Unit**s meet all the relevant requirements.

12.1.5 In addition to the commissioning tests and checks required under EREC G59, further tests may be required by the **Manufacturer**, supplier or **Installer** of the **Generating Unit**s or may be required to satisfy legislation and other standards.

12.2 Procedures and Witnessing Requirements

12.2.1 The DNO may decide to witness the **Power Station** and **Generating Unit** 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 Where the **Power Station** capacity is no higher than 50kW 3 phase (17kW 1 phase), the **Generating Unit**s have been type tested to EREC G59 or EREC G83 and they are connected to the **DNO**'s network at **Low Voltage**, the **DNO** will not normally witness the commissioning checks and tests. In such cases, where the **DNO** does decide to witness they will advise this as part of the connection offer. Reasons for witnessing such installations may include:

a. A new **Installer** with no track record in the **DNO** area.
b. A check on the quality of an installation either on a random basis or as a result of problems that have come to light at previous installations.

12.2.3 Where the **Power Station** includes **Generating Unit**s that have not been **Type Tested** or the **Power Station** capacity is greater than 50kW 3 phase (17kW 1 phase) or the **Power Station** is connected at **High Voltage** the **DNO** will normally decide to witness the commissioning checks and tests. In such cases the Installer shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

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.

12.3 Commissioning Tests / Checks required at all Power Stations

12.3.1 The following tests and checks shall be carried out by the Installer at all **Power Stations** and on all **Generating Unit**s irrespective of whether they have been **Type Tested** or not:

a. Inspect the **Power Station** 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 **Generating Unit**s and the rest of the installation.

c. Check that safety labels have been installed in accordance with clause 11.2 of EREC G59;

d. Check interlocking operates as required. Interlocking should prevent **Generating Unit**s being connected to the **DNO** system without being synchronised;

e. Check that the correct protection settings have been applied (in accordance with EREC G59 clause 10.5.7.1);

f. Complete functional tests to ensure each **Generating Unit** synchronises with, and disconnects from, the **DNO**s **System** successfully and that it operates without tripping under normal conditions;

g. After all other tests have been completed successfully (including where required additional tests for non type tested equipment) carry out a functional test to confirm that the **Interface Protection** operates and trips each **Generating Unit** when supplies are disconnected between the **Generating Unit** and the **DNO**s **System**.

1. This test may be carried out by opening a suitably rated switch (not the one expected to open for a protection operation) between the **Generating Unit** and the **DNO**s **Point of Supply** and checking that the **Generating Unit** disconnects quickly (eg within 1s);

2. Alternatively, the test may be carried out by removing one or all of the voltage sensing supplies to the protection relay and checking that the **Generating Unit** disconnects quickly (eg within 1s);

~~g. Carry out a functional test to confirm that the **Interface Protection** operates and trips each **Generating Unit** when all phases are disconnected between the **Generating Unit** and the **DNO**s **System**. This test is carried out by opening a suitably rated switch between the **Generating Unit**and the **DNO**s **Point of Supply** and checking that the **Generating Unit** disconnect quickly (eg within 1s);~~

h. Check that once the phases are restored following the functional test described in (g) at least 20s elapses before the **Generating Unit**s re-connect.

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 **Generating Units** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the commissioning form included in Appendix 13.2. 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).

12.4 Additional Commissioning requirements for Non Type Tested Generating Units

12.4.1 Additional commissioning tests are required for **Generating Units** that have not been **Type Tested** to EREC G59 or EREC G83 or a later version. 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 results of these tests shall be recorded in the schedule provided in Appendix 13.2 and 13.3 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 for each phase, as described below:

   (i) The operating voltage shall be 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 13.3. 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:

(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% (ie 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 13.3. 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 0.025~~5~~Hzs^{-1} or less)~~)~~ 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 0.025~~5~~Hz per second of the required setting.

(ii) Timing tests shall be carried out by applying a falling and a rising frequency at rate of 0.05~~1~~Hzs^{-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 (eg starting at 4~~8~~ degrees). The test shall be repeated with increasing vector shift values (in increments of 1 degree or less) until the pickup value is determined. The tests shall be carried out for both leading and lagging shifts in the voltage vector.

(ii) Timing tests shall be carried out by applying a vector shift of 3~~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 **Generating Unit** or **Power Station**.

~~f) In addition to the 3 phase disconnection test specified in 12.1.3 (g) for non **Type Tested LV Generating Units** the installer shall carry out an additional functional check of the LoM protection by removing one phase of the supply to the **Generating Unit** and confirming that the protection operates to disconnect the **Generating Unit** from the **Distribution system**. This test is applicable to all non **Type Tested LV Generating Unit**s where **LV** protection settings are applied (ie 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.~~

~~ii. Manufacturers and installers should be encouraged to incorporate disconnection points into the design of all **LV Generating Unit**s or installations in order to facilitate this test.~~

~~iii. 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 generator).~~

~~iv.~~i. ~~It should be noted that experience of current imbalance protection in this application can be problematic once in service, and has lead to nuisance tripping due to load and network voltage imbalance.~~

12.4.2 It may be necessary for undertake ad-hoc testing to determine[10], 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 Station**s and to confirm that they remain within the statutory limits.

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

12.5 Periodic Testing

12.5.1 The **Interface Protection** shall be tested by the **Generator** at intervals to be agreed with the **DNO.**

12.6 Changes at the Installation

12.6.1 If during the lifetime of the **Generating Plant** it is necessary to replace a major component of a **Generating Unit** or its protection system, it is only necessary to notify the **DNO** if the operating characteristics of the **Generating Plant** or the protection have been altered when compared against that which was originally commissioned.

12.6.2 In the event that **Generating Plant** is to be decommissioned and will no longer operate as a source of electrical energy in parallel with the **Distribution System**, the **Generator** shall notify the **DNO** by providing the information as detailed in Appendix 13.4. Where the presence of **Generating Plant** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

12.6.3 Where one or more **Generating Unit**s are to be added or replaced at an existing **Power Station** installed under an earlier version of EREC G59, EREC G83 or the **Distribution Code**, it is not necessary to modify the other existing **Generating Units** 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 Substation above the 16A per phase threshold. For example, if a new 3kW one phase **Generating Unit** is added to an existing **Power Station** comprising an existing 3kW 1 phase **Generating Unit** complying with EREC G83/1-1, this increases the capacity of the **Power Station** from 3kW (13.04A per phase) to 6kW (26.08A per phase). In this case the new **Generating Unit** will either have to comply with EREC G59/3 or EREC G83/2 (as amended) but the existing **Generating Unit** will not need to be modified.

12.6.4 If a **Generating Unit** is changed at a **Power Station** the replacement must comply with the current version of EREC G59 or EREC G83, as applicable.

13 APPENDICES

Appendix	Application	Form Title
13.1	Type Testing a **Generating Unit** (>16A per phase but ≤ 50kW 3 phase or 17kW 1 phase.	**Generating Unit** Type Test Sheet **Type Tested Generating Unit**(>16A per phase but ≤ 50 kW 3 phase or 17 kW 1 phase)
13.2	Comissioning a **Power Station** comprising only **Type Tested Generating Units**	**Generating Plant** Installation & Commissioning Confirmation
13.3	Commissioning a **Power Station** comprising one or more non-**Type Tested Generating Units** (Appendix applicable in addition to Appendix 13.2)	**Generating Plant** Installation & Commissioning Tests (Additional commissioning test requirements for non-type tested **Generating Units**)
13.4	Decommissioning of any **Generating Unit**	**Generating Plant** Decommissioning Confirmation
13.5	Connection application for a **Type Tested Generating Unit** in a new or existing installation where the aggregate installed capacity of the **Power Station** will be 50kW or 17kW per phase or less comprising only of **Type Tested Generating Units.** Note for all other **Power Stations** the **DNOs**	Application for connection of **Type Tested Generating Unit(**s) with Total Aggregate **Power Station** Capacity < 50kW 3-Phase, or <17kW Single Phase

	common application form shall be used.	
13.6	Additional Information Relating to System Stability Studies	
13.7	Loss of Mains Protection Analysis	
13.8	Type Testing of **Generation Units** of 50kW three phase, or 17kW per phase or less. Guidance for **Manufacturers**	
13.9	Main Statutory and other Obligations	
13.10	Guidance on acceptable unbalance between phases in a **Power Station**	
13.11	Guidance on Risk Assessment when using RoCoF LoM Protection for **Power Stations** in the 5MW to 50MW range	

13.1 Generating Unit Type Test Sheet

Type Tested Generating Unit(>16A per phase but ≤ 50 kW 3 phase or 17 kW 1 phase)

TYPE TEST SHEET

<table>
<tr><td colspan="6">This Type Test sheet shall be used to record the results of the type testing of Generating Unit between 16A per phase and 17kW per phase maximum output at 230V (17kW limit single phase, 34kW limit split phase, 50kW limit 3 phase)

It includes the Generating Units supplier declaration of compliance with the requirements of Engineering Recommendation G59/3</td></tr>
<tr><td colspan="3">Type Tested reference number</td><td colspan="3"></td></tr>
<tr><td colspan="3">Generating Unit technology</td><td colspan="3"></td></tr>
<tr><td colspan="3">System supplier name</td><td colspan="3"></td></tr>
<tr><td colspan="3">Address</td><td colspan="3"></td></tr>
<tr><td>Tel</td><td colspan="2"></td><td>Fax</td><td colspan="2"></td></tr>
<tr><td>E:mail</td><td colspan="2"></td><td>Web site</td><td colspan="2"></td></tr>
<tr><td colspan="2" rowspan="4">Maximum export capacity, use separate sheet if more than one connection option.</td><td></td><td colspan="3">kW single phase, single, split or three phase system</td></tr>
<tr><td></td><td colspan="3">kW three phase</td></tr>
<tr><td></td><td colspan="3">kW two phases in three phase system</td></tr>
<tr><td></td><td colspan="3">kW two phases split phase system</td></tr>
<tr><td colspan="6">System supplier declaration. - I certify on behalf of the company named above as a supplier of a Generating Unit, that all products supplied by the company with the above Type Test reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the product meets all the requirements of EREC G59/3.</td></tr>
</table>

Signed		On behalf of	
Note that testing can be done by the manufacturer of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate. Where parts of the testing are carried out by persons or organisations other than the supplier then the supplier shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.			

Power Quality. Harmonics. These tests should be carried out as specified in 61000-3-12 or 61000-3-2. Only one set of tests is required and the **Manufacturer** should decide which one to use and complete the relevant table. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of maximum export capacity.

The test should be carried out on a single **Generating Unit.** The results need to comply with the limits of table 2 of BS EN 61000-3-12 for single phase equipment, to table 3 of BS EN 61000-3-12 for three phase equipment or to table 1 of BS EN 61000-3-2 if that standard is used.

Note that Generating Units meeting the requirements of BS EN 61000-3-2 will need no further assesment with regards to harmonics. Generating Units with emissions close to the limits laid down in BS EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO**'s network.

Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)			kVA	Harmonic % =Measured Value (Amps) x 23/rating per phase (kVA)		
Harmonic	At 45-55% of rated output		100% of rated output		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2					8%	8%
3					21.6%	Not stated
4					4%	4%

5						10.7%	10.7%
6						2.67%	2.67%
7						7.2%	7.2%
8						2%	2%
9						3.8%	Not stated
10						1.6%	1.6%
11						3.1%	3.1%
12						1.33%	1.33%
13						2%	2%
THD						23%	13%
PWHD						23%	22%

Generating Unit tested to BS EN 61000-3-2						
Generator Unit rating per phase (rpp)				kW		
Harmonic	At 45-55% of rated output		100% of rated output			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above

2					1.080	
3					2.300	
4					0.430	
5					1.140	
6					0.300	
7					0.770	
8					0.230	
9					0.400	
10					0.184	
11					0.330	
12					0.153	
13					0.210	
14					0.131	
15					0.150	

16					0.115	
17					0.132	
18					0.102	
19					0.118	
20					0.092	
21					0.107	0.160
22					0.084	
23					0.098	0.147
24					0.077	
25					0.090	0.135
26					0.071	
27					0.083	0.124
28					0.066	
29					0.078	0.117

30					0.061	
31					0.073	0.109
32					0.058	
33					0.068	0.102
34					0.054	
35					0.064	0.096
36					0.051	
37					0.061	0.091
38					0.048	
39					0.058	0.087
40					0.046	
Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.						

Power Quality. Voltage fluctuations and Flicker. The tests should be carried out on a single **Generating Unit.** Results should be normalised to a standard source impedance or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

	Starting			Stopping			Running	
	d max	d c	d(t)	d max	d c	d(t)	P st	P lt 2 hours
Measured Values at test impedance								
Normalised to standard impedance								
Normalised to required maximum impedance								
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R		Ω	Xl		Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	Xl	0.15 * 0.25 ^	Ω
Maximum Impedance	R		Ω	Xl		Ω

* Applies to three phase and split single phase **Generating Unit**s

^ Applies to single phase **Generating Unit**s and **Generating Unit**s using two phases on a three phase system

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0.98 or above.

Normalised value = Measured value*reference source resistance/measured source resistance at test point

Single phase units reference source resistance is 0.4 Ω

Two phase units in a three phase system reference source resistance is 0.4 Ω

Two phase units in a split phase system reference source resistance is 0.24 Ω

Three phase units reference source resistance is 0.24 Ω

Where the power factor of the output is under 0.98 then the Xl to R ratio of the test impedance should be close to that of the Standard Impedance.

The stopping test should be a trip from full load operation.

The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below

Test start date		Test end date	
Test location			

Power quality. DC injection. The tests should be carried out on a single **Generating Unit** Tests are to be carried out three power defined levels ±5%. At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10kW three phase inverter has a current output of 43.5A at 230V so DC limit is 108.75mA				
Test power level	10%	55%	100%	
Recorded value in Amps				
as % of rated AC current				
Limit	0.25%	0.25%	0.25%	

Power Quality. Power factor. The tests should be carried out on a single Generating Unit. Testa are to be carried out at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.				
	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.
Measured value				
Limit	>0.95	>0.95	>0.95	

Protection. Frequency tests						
Function	Setting		Trip test		"No-trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
O/F stage 1	51.5Hz	90s			51.3Hz 95s	
O/F stage 2	52Hz	0.5s			51.8Hz 89.98s	
					52.2Hz 0.48s	
U/F stage 1	47.5Hz	20s			47.7Hz 25s	
U/F stage 2	47Hz	0.5s			47.2Hz 19.98s	
					46.8 Hz 0.48s	
Note. For frequency Trip tests the Frequency required to trip is the setting ± 0.1Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used.. The "No-trip tests" need to be carried out at the setting ± 0.2Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Protection. Voltage tests						
Function	Setting		Trip test		"No trip-tests" All phases at same voltage	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
O/V stage 1	262.2V	1.0s			258.2V 2.0 sec	
O/V stage 2	273.7V	0.5s			269.7V 0.98s	

					277.7V 0.48s	
U/V stage 1	200.1V	2.5s			204.1V 3.5s	
U/V stage 2	184V	0.5s			188V 2.48s	
					180v 0.48 sec	
Note. For voltage tests the voltage required to trip is the setting plus or minus 3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the projection. The No-trip tests need to be carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

a) Protection. Loss of Mains test and single phase test. The tests are to be To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.						
To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of **Generating Unit** output	95% of **Generating Unit** output	95% of **Generating Unit** output	105% of **Generating Unit** output	105% of **Generating Unit** output	105% of **Generating Unit** output
Trip time. Limit is 0.5s						
Note. For technologies which have a substantial shut down time this can be added to the 0.5s in establishing that the trip occurred in less than 0.5s maximum. Shut down time could therefore be up to 1.0s for these technologies.						
Indicate additional shut down time included in above results						s
Note as an alternative, inverters can be tested to BS EN 62116. The following sub set of tests should be recorded in the following table.						
Test Power and	33%	66%	100%	33%	66%	100%

imbalance	-5% Q Test 22	-5% Q Test 12	-5% P Test 5	+5% Q Test 31	+5% Q Test 21	+5% P Test 10
Trip time. Limit is 0.5s						
Single phase test for multi phase **Generating Units**. Confirm that when generating in parallel with a network operating at around 50Hz with no network disturbance, that the removal of a single phase connection to the **Generating Unit**, with the remaining phases connected causes a disconnection of the generating unit within a maximum of 1s.						
Ph1 removed	Confirm Trip	Ph2 removed	Confirm Trip	Ph3 removed	Confirm Trip	

b) Protection. Frequency change, Stability test				
	Start Frequency	Change	End Frequency	Confirm no trip
Positive Vector Shift	49.5Hz	+9 degrees		
Negative Vector Shift	50.5Hz	- 9 degrees		
Positive Frequency drift	49.5Hz	$+0.19Hzs^{-1}$	51.5Hz	
Negative Frequency drift	50.5Hz	$-0.19Hzs^{-1}$	47.5Hz	

c) **Protection. Re-connection timer**. The tests should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Test should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Time delay setting (s)	Measured delay (s)	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.5.7.1.			
		At 266.2V	At 196.1V	At 47.4Hz	At 51.6Hz
Confirmation that the **Generating Unit** does not re-connect					

d) Fault level contribution.					
For machines with electro-magnetic output			For Inverter output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p		20ms		
Initial Value of aperiodic current	A		100ms		
Initial symmetrical short-circuit current*	I_k		250ms		
Decaying (aperiodic) component of short circuit current*	i_{DC}		500ms		
Reactance/Resistance Ratio of source*	$^X/_R$		Time to trip		In seconds
For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **Generating Unit** terminals. * Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot					

e) Self Monitoring solid state switching	Yes/NA
It has been verified that in the event of the solid state switching device failing to disconnect the **Generating Unit**, the voltage on the output side of the switching device is reduced to a value below 50 Volts within 0.5 seconds	

Additional comments

13.2 Generating Plant 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 Generator 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 Generating Unit(s) - where applicable

<table>
<tr><th rowspan="3">Manufacturer / Reference</th><th rowspan="3">Date of Installation</th><th rowspan="3">Technology Type</th><th rowspan="3">G83 / G59</th><th rowspan="3">Type Test Ref No.</th><th colspan="5">Generating Unit installed capacity in kW</th></tr>
<tr><th rowspan="2">3-Phase Units</th><th colspan="3">Single Phase Units</th><th rowspan="2">Power Factor</th></tr>
<tr><th>PH1</th><th>PH2</th><th>PH3</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Information to be enclosed	
Description	Confirmation
Final copy of circuit diagram	Yes / No*
Generating Unit Type Test Reference Number, or for **Generating Units** not yet listed on the ENA web site a completed **Generating Unit** 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 **Generating Units** 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 **Generating Unit**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*
Generating Units successfully synchronise with the **DNO** system without causing significant voltage disturbance.	Yes / No*
Generating Units successfully run in parallel with the DNO system without tripping and without causing significant voltage disturbances.	Yes / No*
Generating Units successfully disconnect without causing a significant voltage disturbance, when they are shut down.	Yes / No*
Interface Protection operates and disconnects the **Generating Unit**s quickly (within 1s) as required by section 12.3.1 (g) ~~when a suitably rated switch, located between the **Generating Units** and the **DNO**s incoming connection, is opened.~~	Yes / No*
Generating Unit(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 **Generating Unit** lockout or an alarm to a 24hr manned control centre.	Yes / No*
Balance of Multiple Single Phase Generating Units 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 Stations under 50kW or by the Generator for Power Stations above 50kW
I declare that the **Generating Unit**s and the installation which together form a **Power Station** at the above address, comply with the requirements of EREC G59/3 and the commissioning checks have been successfully completed. *The **Power Station** comprises only **Generating UnitsType Tested** to EREC G59 or EREC G83/2 or later, or *part or all of this **Power Station** contains **Generating Units** not **Type Tested** to EREC G59 or EREC G83 and the **Generating Plant** 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 Station** is deemed to have failed the commissioning tests and the **Generating Units** shall not be put in service.

13.3 Generating Plant Installation and Commissioning Tests

Commissioning test requirements for non-Type Tested Generating Units 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 - step from 230V to test value** ~~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	**262.2V** 230V system	**1.0s**	*258.75*		*265.65*	Pass/Fail	266.2	*1.0s*		*1.1s*	Pass/Fail
L2 - N						Pass/Fail					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	**273.7V** 230V system	0.5s	*270.25*		*277.15*	Pass/Fail	277.7	*0.5s*		*0.6s*	Pass/Fail
L2 - N						Pass/Fail					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	**200.1V** 230V system	2.5s	*196.65*		*203.55*	Pass/Fail	196.1	*2.5s*		*2.6s*	Pass/Fail
L2 - N						Pass/Fail					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	**184.0V** 230V system	0.5s	*180.55*		*187.45*	Pass/Fail	180	*0.5s*		*0.6s*	Pass/Fail
L2 - N						Pass/Fail					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

Overvoltage test - Voltage shall be stepped from 258V to the test voltage and held for the test duration an stepped back to 258V.

Undervoltage test – Voltage shall be stepped from 204.1V to the test voltage and held for the test duratio then stepped back to 204.1V

Additional Comments / Observations::

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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 (Secondary voltages are indicated for convenience, where different VT nominal outputs are present these values should be re-calculated using an appropriate ratio)

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
51.5Hz	90s	*51.40*		*51.60*	Pass/Fail	51.2-51.8Hz	*90.0s*		*90.9s*	Pass/Fail
Stage 2 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*	Pass/Fail ~~51.2-51.8Hz~~	51.7-52.3Hz	*0.50s*		*0.60s*	Pass/Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5Hz	20s	*47.40*		*47.60*	Pass/Fail ~~51.2-51.8Hz~~	47.8-47.2Hz	*20.0s*		*20.2s*	Pass/Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47Hz	0.5s	*46.90*		*47.1*	Pass/Fail ~~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	51.5Hz	90s	> OF Stage 1	51.7Hz	89.0s		Pass/Fail
Stage 2 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

Overfrequency test - Frequency shall be stepped from 51.3Hz to the test frequency and held for the test d and then stepped back to 51.3Hz.

Underfrequency test - Frequency shall be stepped from 47.1Hz to the test frequency and held for the tes duration and then stepped back to 47.1Hz

Additional Comments / Observations:

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Note that the table below applies to Power Stations less than 5 MW capacity.

The DNO will be able to provide, on request, corresponding figures for Power Stations of 5MW and above.

Loss-of-Mains (LOM) Protection Tests – RoCoF for Power Stations <5MW								
Calibration and Accuracy Tests								
Ramp in range 49.5-50.5Hz	**Pickup (**+ / -0.02~~0~~5Hzs^{-1})				**Time Delay** RoCoF = ±**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	*0.1~~20~~* *0.175~~95~~*		*0.15~~30~~* *0.225~~05~~*	Pass/Fail	0.175 Hzs^{-1} 0.25 Hzs^{-1}		*<0.5s*	Pass/Fail
Reducing Frequency	*0.1~~20~~* *0.175~~95~~*		*0.15~~30~~* *0.225~~05~~*	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 0.075~~12~~ Hzs^{-1} or ROCOF - 0.05~~1~~ Hzs^{-1}~~)~~ = ___________	5.0s		Pass/Fail
Inside Normal band	< RoCoF (reducing f)		5.0s		Pass/Fail
Additional Comments / Observations:					

Loss-of-Mains (LOM) Protection Tests - Vector Shift

Calibration and Accuracy Tests

Vector Shift	**Pickup** (± 1~~0~~.5 degree)				**Time Delay** Vector shift = 3~~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	*4~~5~~.5* *10~~11~~.5*		*7~~6~~.5* *13~~2~~.5*	Pass/Fail	9~~8~~ deg 15~~4~~ deg		*<0.5s*	Pass/Fail
Vector Shift : Leading Angle	*4~~5~~.5* *10~~1~~.5*		*7~~6~~.5* *13~~2~~.5*	Pass/Fail	9~~8~~ deg 15~~4~~ 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 4~~5~~ degrees or vector shift -2~~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 **Generating Unit** and the installation comply with the requirements of EREC G59/3 and the additional commissioning checks noted above have been successfully completed in addition to those required for all **Generating Unit** 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 Generating Plant Decommissioning Confirmation

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

Site Details	
Site Address (inc. post code)	
Telephone number	
MPAN(s)	
Distribution Network Operator (DNO)	
Generating Plant Details	
Manufacturer and model type	
Serial number of each **Generating Unit**	
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:

13.5 Application for connection of Type Tested Generating Units with total aggregate Power Station capacity <50kW 3 phase or 17kW single phase.

<table>
<tr><td colspan="11">Application for Connection of Type Tested Generating Unit(s)
with Total Aggregate Capacity < 50kW 3-Phase, or <17kW Single Phase</td></tr>
<tr><td colspan="11">To ABC electricity distribution DNO or IDNO
99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com</td></tr>
<tr><td colspan="11">Installer or Generator Details :</td></tr>
<tr><td>Installer or Generator.</td><td colspan="10"></td></tr>
<tr><td>Accreditation/Qualification</td><td colspan="10"></td></tr>
<tr><td>Address</td><td colspan="10"></td></tr>
<tr><td>Post Code</td><td colspan="10"></td></tr>
<tr><td>Contact person</td><td colspan="10"></td></tr>
<tr><td>Telephone Number</td><td colspan="10"></td></tr>
<tr><td>E-mail address</td><td colspan="10"></td></tr>
<tr><td colspan="11">Installation Details</td></tr>
<tr><td>Address</td><td colspan="10"></td></tr>
<tr><td>Post Code</td><td colspan="10"></td></tr>
<tr><td>MPAN(s)</td><td colspan="10"></td></tr>
<tr><td colspan="11">Details of Existing Generating Unit(s) - where applicable</td></tr>
<tr><td rowspan="3">Manufacturer / Reference</td><td rowspan="3">Approximate Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">G83 / G59</td><td rowspan="3">Type Test Ref No. if available</td><td colspan="5">Generating Unit installed capacity kW</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="10">Details of Proposed Additional Generating Unit(s):</td></tr>
<tr><td rowspan="3">Manufacturer / Reference</td><td rowspan="3">Proposed Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">G83 / G59</td><td rowspan="3">Type Test
Ref No.</td><td colspan="5">Generating Unit installed capacity kW</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Balance of Multiple Single Phase Generating Units – where applicable</td></tr>
<tr><td colspan="10">I confirm that design of the complete installation has been carried out to limit output power imbalance to below 16A/phase, as required by EREC G59</td></tr>
<tr><td colspan="6">Signed :</td><td colspan="4">Date :</td></tr>
</table>

Use continuation sheet where required.

Record **Generating Unit** capacities, in rated output kW at 230V AC, to one decimal place, under PH1 for single phase supplies and under the relevant phase for two and three phase supplies.

Detail on a separate sheet if there are any proposals to limit export to a lower figure than the aggregate rating of all **Generating Units** in the **Power Station**

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 **Generating Plant** 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 (eg 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 **Generating Plant**. If following a disturbance the system is unstable, it will usually experience a progressive increase in angular separation of synchronous **Generating Units'** rotors from the system, or an_uncontrolled increase in the speed of asynchronous **Generating Units'** 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 **Generating Unit**s to remain in **Synchronism** after being subjected to a disturbance, either small or large. Loss of **Synchronism** can occur between one synchronous **Generating Plant** and the rest of the system, or between groups of synchronous **Generating Plants**, 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 **Generating Unit**s, system impedance and loads connected to the **Distribution System**. 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 **Generating Unit**s, can arise following a small disturbance if either

- the transfer capability of the interconnecting **Distribution System** 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 **Generating Units** rotor angles (ie 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 **Generating Plant**.

During a fault the electrical output of each synchronous **Generating Unit** 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 **Generating Unit** controls respond rapidly and with adequate **Distribution System** 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 **Generating Unit** and the **Distribution System**. These may damage synchronous **Generating Units**, cause maloperation of **Distribution System** protection and produce unacceptable voltage depressions in supply systems.

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

In the case of doubly fed asynchronous **Generating Plant** and series converter connected **Generating Plant**, a voltage depression on the local **Distribution System** 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 Station**s the capability to ride through certain **Transmission System** faults is critical to **Distribution System** and **Total System** stability. The **Grid Code** “fault ride through” requirements CC.6.3.15 apply to these **Power Stations.**

Where larger synchronous **Generating Plant**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’ (ie 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 **Generating Plant**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 System** 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. **Generating Unit**s in embedded **Medium** and **Large Power Station**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 **Generating Unit** can move out of **Synchronism** and the consequences for the unit of a reclosure on the **Distribution System**.

13.7.1 Prime Mover Characteristics

A Modern **Generating Unit** can be of four types:-

1. Synchronous **Generating Unit**: 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 **Generating Unit**: 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 **Generating Unit** (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 **Generating Unit** (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 **Generating Unit** 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 Generating Unit Following Load Change

The kinetic energy of a rotating **Generating Unit** 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 **Generating Unit**

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 **Generating Unit** 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 **Generating Unit** 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).

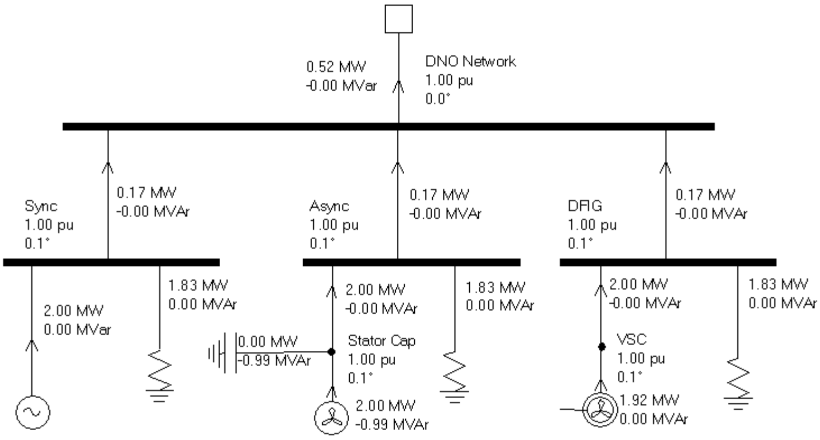


Figure 1 - Three Generator types

Transient Study

At t=0.1 seconds the network connections are broken leaving each generator in an islanded condition supplying 90% of it's 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.

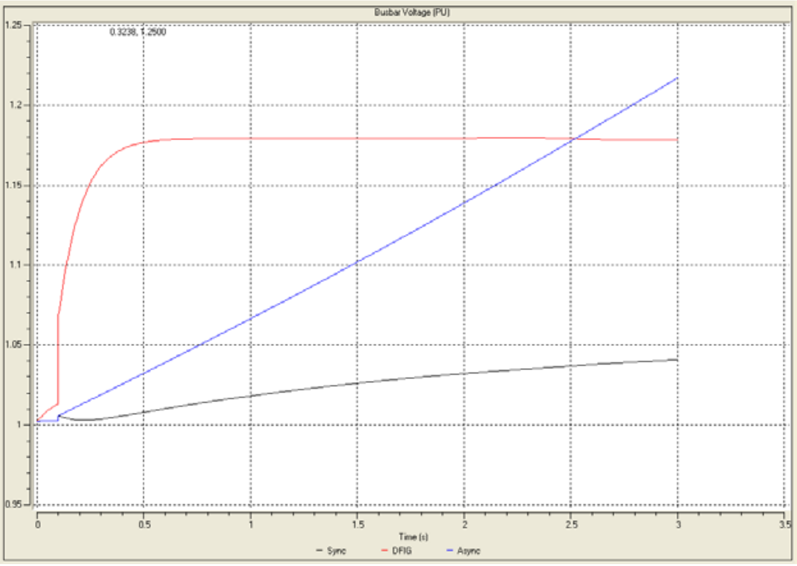


Figure 2 - Voltage Profile

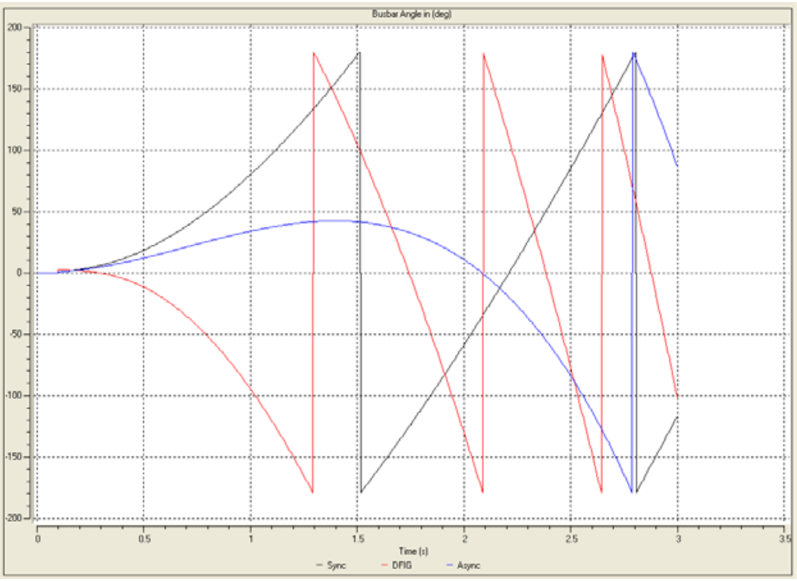


Figure 3 Voltage Angle (flips at +/- 180 Deg)

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)

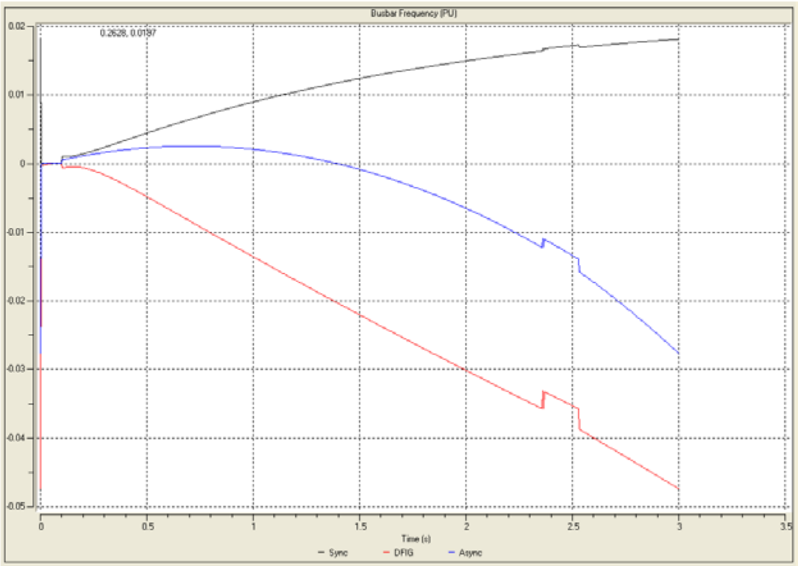


Figure 4 Voltage Frequency Change (PU)

Results

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

Prot Function	Small Power Station			
	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	Generator 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).

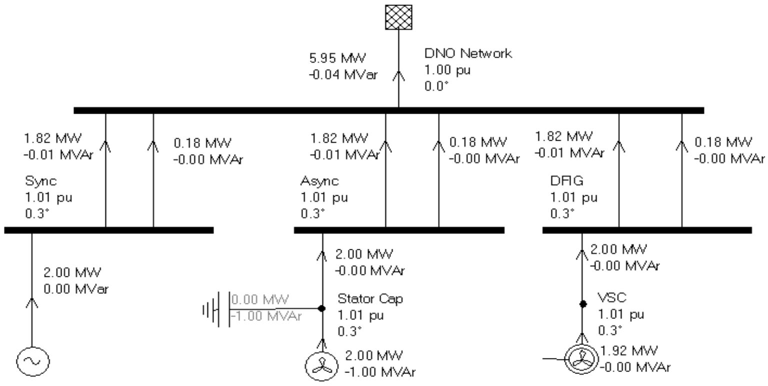


Figure 5 - Impedance Step Change Network

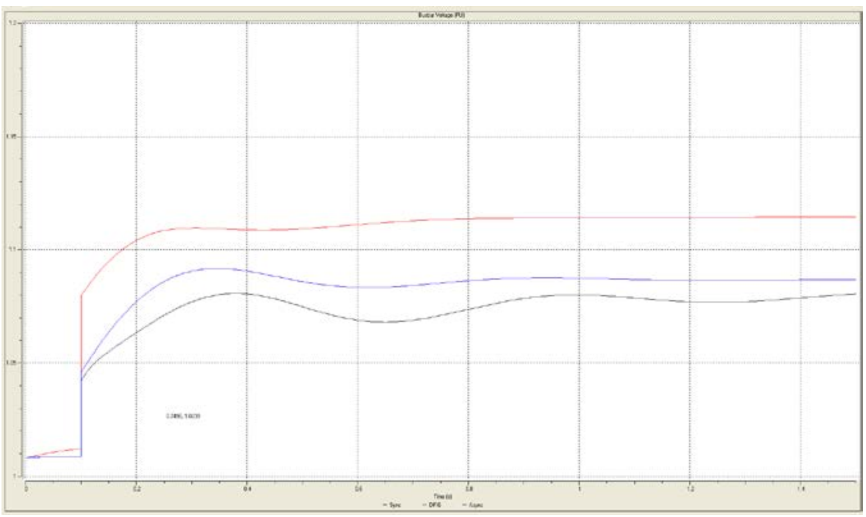


Figure 6 - Voltage Response

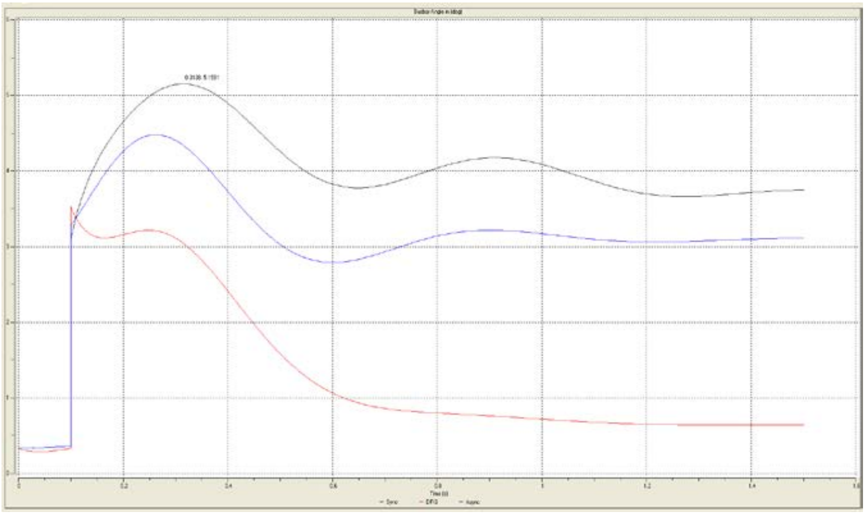


Figure 7 - Voltage Angle

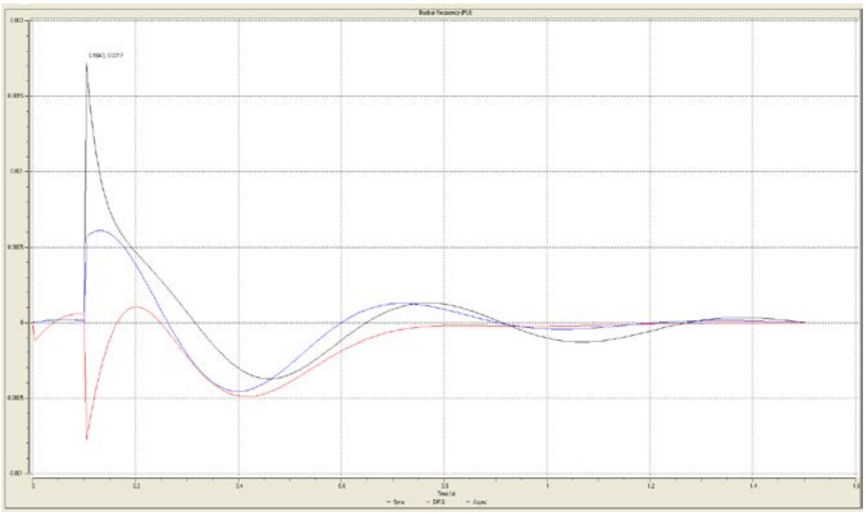


Figure 8 - Voltage Frequency Change (PU)

Results

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

Prot Function	Small Power Station			
	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	Generator 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.

13.8 Type Testing of Generation Units of 50kW three phase, or 17kW per phase or less. Guidance for Manufacturers.

EREC G59/3 makes provision for **Manufacturers** to **Type Test Generating Unit**s of up to 50kW or 17kW per phase. This section gives guidance to **Manufacture**s on how to do this. The results should be recorded on a copy of the **Generating Unit Type Test** declaration which is shown as Appendix 13.1 of this document..

The philosophy behind this testing matches that for the testing of smaller **Generating Unit**s in EREC G83, however in EREC G83 such equipment is called **Generators.** There are sections for **Inverter** connected **Generating Units** and directly connected **Generating Units** followed by a section giving details on specific requirements for different technology types.

In order to preserve commonality between EREC G59 and EREC G83 the numbering of this section will contain a EREC G59 document reference number followed by the equivalent reference(s) from EREC G83 in brackets.

For example **13.8.1 (A1.1,B1.1)** covers both Annex A section 1.1 and Annex B section 1.1 in EREC G83/2 Where these are different then only one reference will be shown.

Normally **Manufacturer**s will only need to provide **Type Test** declarations for **Generating Units** of less than 16A per phase to EREC G83/2 and these units can be used in **Power Station**s of up to 50kW three phase or 17kW per phase. However they may chose to provide Type Test Declarations to EREC G59/3 as well as to EREC G83/2 which will allow multiple **Generating Units** to be used in installations above 50kW three phase or 17kW per phase.

13.8.1 (A1.1,B1.1) General Arrangements

This Annex describes a methodology for obtaining type certification or type verification for the interface equipment between the **Inverter** connected **Generating Unit** and the **Distribution Network System**. Typically, all interface functions are contained within the **Inverter** and in such cases it is only necessary to have the Inverter Type Tested**.** Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested**.

Other Annexes containing **Inverter** connected equipment may make reference to the requirements specified in this Annex.

Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested** but the completed **Generating Unit's Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by plug and socket which the **Manufacturer** has made and tested prior to delivery to site. See section 10.2.5.d)

Note 1: This Appendix is primarily designed for the testing of three phase **Generating Units**. However, where practicable, a single phase, or split phase test may be carried out if it can be shown that it will produce the equivalent results.

Note 2: This Appendix applies for **Generating Units** either with or without load management or energy storage systems which are connected on the **Generating Unit** side of the **Inverter**.

13.8.2 (A1.2,B1.2) CE Marking and Certification

The type verification procedure requires that the **Generating Unit** interface be certified to the relevant requirements of the applicable Directives before the **Generating Unit** can be labelled with a CE mark. Where the protection control is to be provided as a separate device, this must also be **Type Tested** and certified to the relevant requirements of the applicable Directives before it can be labeled with a CE mark.

The **Generating Unit**'s **Interface Protection** shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.

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)

Currently there are no harmonised functional standards that apply to the **Generating Unit**’s **Interface Protection**. Consequently, in cases where power electronics is used for energy conversion along with any separate **Interface Protection** unit they will need to be brought together and tested as a complete **Generating Unit** as described in this Appendix, and recorded in format similar to that shown in Appendix 13.1. Where the **Interface Protection** is physically integrated within the overall **Generating Unit** control system, the functionality of the **Interface Protection** unit should not be compromised by any failure of other elements of the control system (fail safe).

13.8.3 (A1.3,B1,3) Type Verification Functional Testing of the Interface Protection

Type Testing is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Generating Unit Interface Protection** shall result:

a) in the safe disconnection of the **Generating Unit** from the **DNO’s Distribution System** in the event that the protection settings specified in table 10.5.7.1 are exceeded; and

b) in the **Generating Unit** remaining connected to the **DNO’s Distribution System** while network conditions are:

(1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in table 10.5.7.1; and

(2) within the trip delay settings specified in table 10.5.7.1.

The **Type Testing** can be done by the **Manufacturer** of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate.

Wherever possible the **Type Testing** of an **Inverter** designed for a particular type of **Generating Unit** should be proved under normal conditions of operation for that technology (unless otherwise noted).

This will require that the chosen **Generating Unit Interface Protection** is either already incorporated into the **Inverter** or that the discrete device is connected to the **Inverter** for the loss of mains protection test. Testing the voltage and frequency functions may be carried out on the discrete protection device independently or on the **Inverter** complete.

In either case it will be necessary to verify that a protection operation will disconnect the **Generator** from the **DNO's Distribution System**.

13.8.3.1 (A1.3.1,B1.3.1) Disconnection times

The minimum trip delay settings, for tests in 13.8.3.2, 13.8.3.3 and 13.8.3.4, are presented in table 10.5.7.1.

Reconnection shall be checked as detailed in 13.8.3.5 below.

In some systems it may be safer and more convenient to test the trip delay time and the disconnection time separately. This will allow the trip delay time to be measured in a test environment (in a similar way as you could test a protection relay). The disconnection time can be measured in the **Generating Unit**s normal operation, allowing accurate measurement with correct inertia and prime mover characteristics. This is permitted providing the total disconnection time does not exceed the trip delay time plus 0.5s. When measuring the shutdown time, 5 shutdowns should be initiated, and the average time recorded.

13.8.3.2 (A1.3.2,B1.3.2) Over / Under Voltage

The **Generating Unit** shall be tested by operating the **Generating Unit** in parallel with a variable **AC** test supply, see figure A2. Correct protection and ride-through operation shall be confirmed during operation of the **Generating Unit.** The set points for over and under voltage at which the **Generating Unit** disconnects from the supply will be established by varying the **AC** supply voltage.

To establish a trip voltage, the test voltage should be applied in steps of ± 0.5% or less, of the nominal voltage for a duration that is longer than the trip time delay, for example 1 second in the case of a delay setting of 0.5s starting at least 4V below or above the setting. The test voltage at which this trip occurred is to be recorded. Additional tests just above and below the trip voltage should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the **Type Test** declaration Appendix 13.1.

To establish the trip time, the test voltage should be applied starting from 4V below or above the recorded trip voltage and should be changed to 4V above or below the recorded trip voltage in a single step. The time taken from the step change to the **Generating Unit** tripping is to be recorded on the **Type Test** declaration Appendix 13.1.

To establish correct ride-through operation, the test voltage should be applied at each setting ±4V and for the relevant times shown in the table in section 13.1

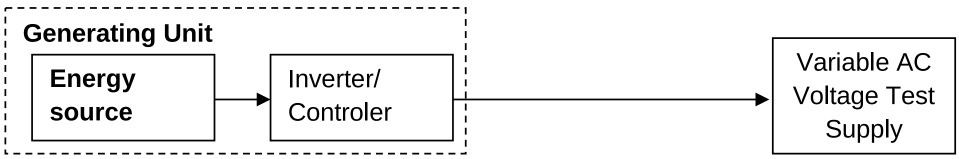
For example to test overvoltage setting stage 1 which is required to be set at 262.2V the circuit should be set up as shown below and the voltage adjusted to 254.2V. The **Inverter** should then be powered up to export a measureable amount of energy so that it can be confirmed that the **Inverter** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal (1.15V) maintaining the voltage for at least 1.5s (trip time plus 0.5s) at each voltage level. At each voltage level confirmation that the **Inverter** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as been 255V. The variable voltage supply should be set to 251V the **Inverter** set to produce a measureable output and then the voltage raised to 259V in a single step. The time from the step change to the output of **Inverter** falling to zero should be recorded as the trip time.

The **Inverter** then needs to operate at 4V below the nominal overvoltage stage 1 setting which is 258.2V for a period of at least 2s without tripping and while producing a measurable output. This can be confirmed as a no trip in the relevant part of section 13.1. The voltage then needs to be stepped up to the next level of 269.7V for a period of 0.98s and then back to 258.2V during which time the output of the relay should continue with no interruption though it may change due to the change in voltage, this can be recorded as a no trip for the second value. The step up and step down test needs to be done a second time with a max value of 277.7V and with a time of 0.48s. The **Inverter** is allowed to shut down during this period to protect its self as allowed by note $ of Table 10.5.7.1 of EREC G59/3, but it must resume production again when the voltage has been restored to 258.2V or it may continue to produce an output during this period. There is no defined time for resumption of production but it must be shown that the restart timer has not operated so it must begin producing again in less than 20s.

The “No-trip tests” need to be carried out at the relevant values and times as shown in the tables in 13.1 to ensure that the protection will not trip in error.

Note that this philosophy should be also be applied to the under voltage tests and to the over and under frequency, RoCoF and Vector shift stability tests which follow in sections 13.8.3.2, 13.8.3.3, 13.8.3.4A and 13.8.3.4B

Figure A2. Generator Test set up – Over / Under Voltage



13.8.3.~~2~~ 3(A1.3. 3,B1.3.3) Over / Under Frequency

Comment [DS1]: this should read 13.8.3.3

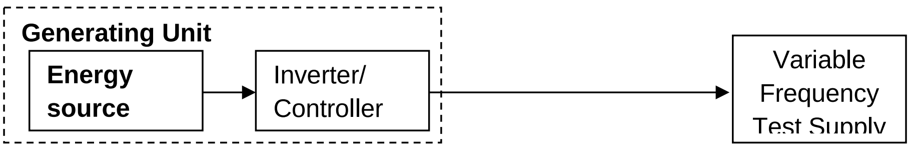
The **Generating Unit** shall be tested by operating it in parallel with a low impedance, variable frequency test supply system, see figure A3. Correct protection and ride-through operation should be confirmed during operation of the **Generating Unit**. The set points for over and under frequency at which the **Generating Unit** disconnects from the supply will be established by varying the test supply frequency.

To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs^{-1}, or if this is not possible in steps of 0.05Hz for a duration that is longer than the trip time delay, for example 1s in the case of a delay setting of 0.5s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the **Type Test** declaration Appendix 13.1.

To establish the trip time, the test frequency should be applied starting from 0.3Hz below or above the recorded trip frequency and should be changed to 0.3Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the **Generating Unit** tripping is to be recorded on the **Type Test** declaration section 13.1. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection. There are two ways around this. Firstly the loss of mains protection may be able to be turned off in order to carry out this test. Secondly by establishing an accurate frequency for the trip a much smaller step change could be used to initiate the trip and establish a trip time. This may require the test to be repeated several times to establish that the time delay is correct.

To establish correct ride-through operation, the test frequency should be applied at each setting plus or minus 0.2Hz and for the relevant times shown in Appendix 13.1

Figure A3 Generator Test set up – Over / Under Frequency



13.8.3.4A (A.3.4) Loss of Mains Protection, Inverter connected machines

The tests should be carried out in accordance with BS EN 62116 and a subset of results should be recorded as indicated in the Protection – Loss of Mains test section of the **Type Test** declaration Appendix 13.1.

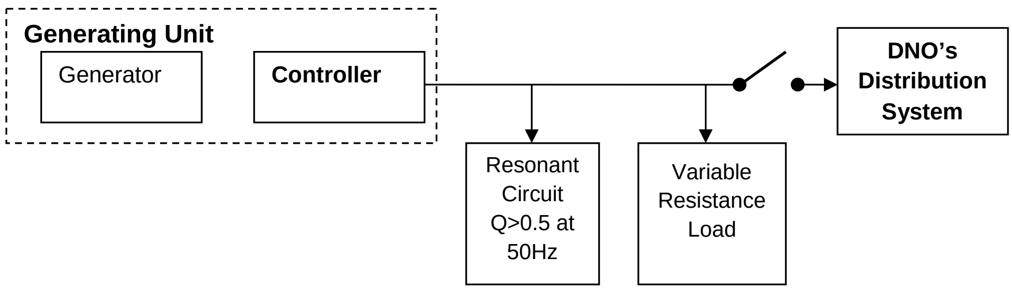
For Multi phase **Generating Units** they should be operated at part load while connected to a network running at about 50Hz and one phase only shall be disconnected with no disturbance to the other phases. The Generating Unit should trip within 1 second. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the Type Test declaration.

13.8.3.4B (B.3.4) Loss of Mains Protection, Directly connected machines

The resonant test circuit specified in this test has been designed to model the interaction of the directly coupled **Generator** under test with the local load including multiple directly coupled connected **Generator**s in parallel.

The directly coupled **Generating Unit** output shall be connected to a network combining a resonant circuit with a Q factor of >0.5 and a variable load. The value of the load is to match the directly coupled **Generating Unit** output. To facilitate the test for LoM there shall be a switch placed between the test load/directly coupled **Generating Unit** combination and the **DNO's Distribution System**, as shown below:

Figure B4 Generator Test set up - Loss of Mains



The directly coupled **Generating Unit** is to be tested at three levels of the directly coupled **Generating Units** output power: 10%, 55% and 100% and the results recorded on the **Type Test** declaration section 13.1. For each test the load match is to be within ± 5%. Each test is to be repeated five times.

Load match conditions are defined as being when the current from the directly coupled **Generating Unit** meets the requirements of the test load ie there is no export or import of supply frequency current to or from the **DNO**'s distribution system.

The tests will record the directly coupled **Generating Units** output voltage and frequency from at least 2 cycles before the switch is opened until the protection system operates and disconnects itself from the **DNO's Distribution System**, or for five seconds whichever is the lower duration.

The time from the switch opening until the protection disconnection occurs is to be measured and must comply with the requirements in table 10.5.7.1.

For Multi phase **Generating Units** they should be operated at part load while connected to a network running at about 50Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Generating Unit** should trip within 1s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the **Type Test** declaration.

13.8.3.5 (A1.3.5,B1.3.5) Reconnection

Further tests will be carried out with the three test circuits above to check the **Inverter** time out feature prior to automatic network reconnection. This test will confirm that once the **AC** supply voltage and frequency have returned to be within the stage 1 settings specified in table 10.5.7.1 following an automatic protection trip operation there is a minimum time delay of 20s before the **Generating Unit** output is restored (ie before automatically reconnecting to the network).

13.8.3.6 (A1.3.6,B1.3.6) Frequency Drift and Step Change Stability test.

The tests will be carried out using the same circuit as specified in 13.8.3.3 above and following confirmation that the **Generating Unit** has passed the under and over frequency trip tests and the under and over frequency stability tests.

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Generating Unit** should not trip during the test.

For the step change test the **Generating Unit** should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10s to complete the test. The **Generating Unit** should not trip during this test.

For frequency drift tests the **Generating Unit** should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0.19Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10s. The **Generating Unit** should not trip during this test.

13.8.4 Power Quality

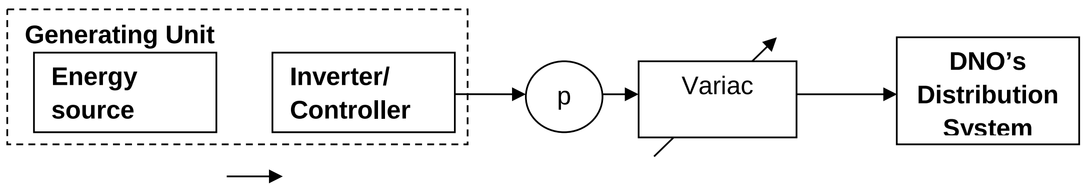
13.8.4.1 (A1.4.1,B1.4.1) Harmonics

The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of maximum export capacity. The required supply minimum fault level should be recorded in the relevant part of **Type Test** declaration section 13.1. If the harmonics meet the technical requirements of BS EN 61000-3-2 then the relevant alternative part of the document can be completed and there will be no need to specify the minimum fault level required.

13.8.4.2 (A1.4.2,B1.4.2) Power Factor

The test set up shall be such that the **Generating Unit** supplies full load to the **DNO's Distribution System** via the power factor (pf) meter and the variac as shown below in figure A5. The **Generating Units** pf should be within the limits given in 9.3.7, for three test voltages 230 V –6%, 230V and 230 V +10%.

Figure A5 Generator Test set up – Power Factor



NOTE 1 For reasons of clarity the points of isolation are not shown.

NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown.

13.8.4.3 (A1.4.3,B1.4.3) Voltage Flicker

The voltage fluctuations and flicker emissions from the **Generating Unit** shall be measured in accordance with BS EN 61000-3-11 and technology specific annex. The required maximum supply impedance should be calculated and recorded in the **Type Test** declaration Appendix 13.1.

Where the **Generating Unit** meets the technical requirements of BS EN 61000-3-3 then this can be stated as an alternative and there is no need to specify the maximum supply impedance.

13.8.4.4 (A1.4.4,B1.4.4) DC Injection

The level of **DC** injection from the **Generating Unit** in to the **DNO's Distribution System** shall not exceed the levels specified in 9.6.4 when measured during operation at three levels, 10%, 55% and 100% of rating with a tolerance of ± 5% of the rating.

The DC injection requirements can be satisfied by the installation of an isolation transformer on the **AC** side of an **Inverter**-connected **Generating Unit**. A declaration that an isolating transformer is fitted can be made in lieu of the tests noted above.

13.8.4.5 (A1.4.5,B1.4.5) Over current Protection

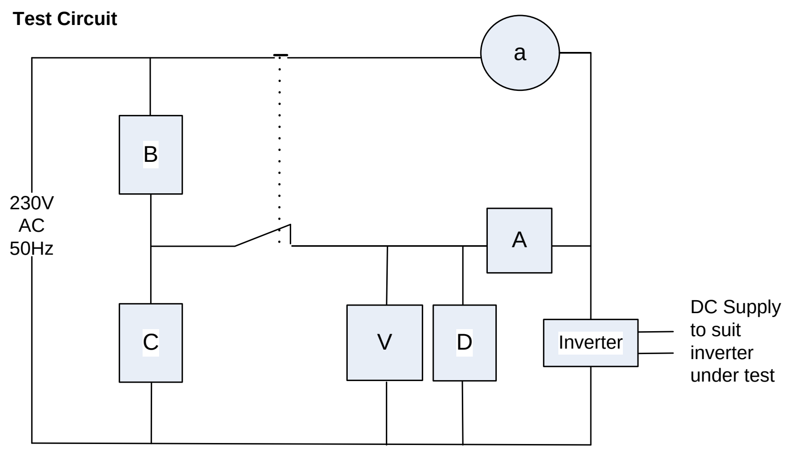
Where appropriate the protection shall comply with the requirements of BS7671.

13.8.4.6A (A1.4.6) Short Circuit Current Contribution Inverter connected Generating Units

Inverter connected **Generating Units** generally have small short circuit fault contributions however **DNO**'s need to understand the contribution that they do make to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.

The following type tests shall be carried out and the results noted in the **Type Test** declaration Appendix 13.1.

Test circuit



A and V are ammeters and voltmeters used to record the test data required. Component D is a resistive load plus resonant circuit as required for the loss of mains test as specified in BS EN 62116 set up to absorb 100% rated output of the **Inverter**, component a is an ammeter used to confirm that all the output from the **Inverter** is being absorbed by component D. Components B and C are set up to provide a voltage of between 10% and 15% of nominal when component C carries the rated output of the **Inverter**. Component C should be short term rated to carry the load which would appear through it should it be energised at 253V for at least 1s. Component B is to have an impedance of between 10 and 20 Ω per phase. If components B and C are short time rated than an additional switch in series with B and C can be inserted and arranged to be closed shortly before the main change over switch shown on the drawing and opened at the end of the test period. Components B and C are to have an X to R ratio of 2.5 to 1.

The test is carried out by setting up the **Inverter** and load D to produce and then absorb full rated output of the **Inverter**. When zero export is shown by ammeter "a" then the changeover switch shown is operated disconnecting the **Inverter** from the normal load and connecting it to the reduced voltage connection created by components B and C creating similar conditions to a network fault.

The values of voltage and current should be recorded for a period of up to 1 second when the changeover switch should be operated to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Appendix 4) including the time taken for the **Inverter** to trip. (It is expected that the **Inverter** will trip on either loss of mains or under voltage in less than one second).

13.8.4.6B(B1.4.6) Short Circuit Current Contribution

DNO's need to understand the contribution a **Generating Unit** makes to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.

For rotating machines BS EN 60034-4:1995 Methods for determining synchronous machine quantities from tests should be used to establish the parameters required to be recorded in Appendix 13.1 under the section Fault Level Contribution.

For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **Generating Unit** terminals.

*Values for parameters marked in Appendix 13.1 should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot.

13.8.4.7(A1.4.7) Self-Monitoring - Solid State Disconnection

Some **Inverter**s include solid state switching devices to disconnect from the **DNO's Distribution System**. In this case 9.4.9 requires the control equipment to monitor the output stage of the **Inverter** to ensure that in the event of a protection initiated trip the output voltage is either disconnected completely or reduced to a value below 50V **AC**. This shall be verified either by self-certification by the **Manufacturer**, or additional material shall be presented to the tester sufficient to allow an assessment to be made.

13.8.4.8(A1.4.8,B1.4.7) Electromagnetic Compatibility (EMC)

All equipment shall comply with the generic EMC standards: BS EN61000-6-3: 2007 Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: 2007 Electromagnetic Compatibility, Generic Immunity Standard.

13.8.5 Separate Specific Technology Requirements

13.8.5.1(C1.1) Domestic CHP

For Domestic CHP **Generating Units** connected to the **DNO's Distribution System** the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected **Generating Unit** clauses will apply.

13.8.5.2(C1.2) Photovoltaic

As all current Photovoltaic **Generation Units** will connect to the **DNO's Distribution System** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

13.8.5.3(C1.3) Fuel Cells

As all current Fuel Cell **Generation Unit**s will connect to the **DNO's Distribution System** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

13.8.5.4(C1.4) Hydro

Hydro can be connected to the **DNO's Distribution System** directly using induction or synchronous generators or it can be connected by an **Inverter**.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply.

In addition the following needs to be taken into consideration.

Generating Units with manually fixed output or where the output is fixed by controlling the water flow through the turbine to a steady rate, need to comply with the maximum voltage change requirements of BS EN 61000-3-11 or to the technical requirements of BS EN 61000-3-3 but do not need to be tested for P_{st} or P_{lt}.

Generating Units where the output is controlled by varying the load on the generator using the **Inverter** and which therefore produces variable output need to comply with the maximum voltage change requirements of BS EN 61000-3-11 or the technical requirements of BS EN 61000-3-3 and also need to be tested for P_{st} and P_{lt} over a period where the range of flows varies over the design range of the turbine with a period of at least 2 hours at each step with there being 10 steps from min flow to maximum flow. P_{st} and P_{lt} values to recorded and normalised as per the method laid down in Appendix 13.1.

13.8.5.5(C1.5) Wind

Wind turbines can be connected to the **DNO's Distribution System** directly, typically using asynchronous induction generators, or using **Inverter**s.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply

In addition, in either case, the note regarding wind turbine voltage flicker testing specified in 9.6.2.1 shall apply.

Note: For wind turbines, flicker testing should be carried out during the performance tests specified in IEC 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.

13.8.5.6(C1.6) Energy Storage Device

Energy Storage Devices can be connected to the **DNO's Distribution System** directly or using **Inverter**s.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply.

13.9 Main Statutory and other Obligations

This appendix summarises the main statutory and other obligations on **DNO**s, **Generator**s and **Users** in relation to the design and operation of primary and protection equipment associated with **Distribution Systems**.

The key driver on the **DNO** is to ensure that it can comply with its statutory duties, and its regulatory obligations, in protecting its network, and disconnecting the minimum amount of equipment when unsafe situations have developed, as well as preserving supplies to other customers.

A key consideration of **Generator**s and **User**s is similarly to ensure that they can comply with their statutory duties to protect their entire network and to disconnect relevant equipment when unsafe situations have developed.

Reference	**Obligation**	**DNO**	**Generator**	**User**
ESQCR Reg 3	Ensure equipment is sufficient for purpose and electrically protected to prevent danger, so far as is reasonably practicable.	X	X	-
ESQCR Reg 4	Disclose information and co-operate with each other to ensure compliance with the ESQC Regulations 2002	X	X	-
ESQCR Reg 6	Apply protective devices to their network, so far as is reasonably practicable, to prevent overcurrents from exceeding equipment ratings.	X	X	-
ESQC Reg 7	Ensure continuity of the neutral conductor and not introduce any protective device in the neutral conductor or earthing connection of **LV** networks.	X	X	-
ESQCR Reg 8	Connect the network to earth at or as near as reasonably practicable to the source of voltage; the earth connection need only be made at one point.	X	X	-
ESQCR Reg 11	Take all reasonable precautions to minimise the risk of fire from substation equipment.	X	X	-
ESQCR Reg 21	Ensure that switched alternative sources of energy to distribution networks cannot operate in parallel with those networks and that such equipment which is part of an **LV** consumer’s installation complies with BS 7671.		X	X
ESQCR Reg 22	Not install or operate sources of energy in parallel with distribution networks unless there are: appropriate equipment, personnel and procedures to prevent danger, so far as is reasonably practicable; **LV** consumers’ equipment complies with BS 7671; and specific requirements are agreed with the **DNO**.		X	X

Reference	Obligation	DNO	Generator	User
ESQCR Reg 24	**DNO** equipment which is on a consumer's premises but not under the consumer's control is protected by a suitable fused cut-out or circuit breaker which is situated as close as reasonably practicable to the supply terminals, which is enclosed in a locked or sealed container.	X		
ESQCR Reg 25	Not give consent to making or altering of connections where there are reasonable grounds to believe that the consumer's installation does not comply with ESQCR / BS 7671 or, so far as is reasonably practicable, is not protected to prevent danger or interruption of supply.	X		
ESQCR Reg 27	Declare the number of phases, frequency and voltage of the supply and, save in exceptional circumstances, keep this within permitted variations.	X		
ESQCR Reg 28	Provide a written statement of the type and rating of protective devices.	X		
EAWR Reg 4	Construct systems including suitable protective devices that can handle the likely load and fault conditions.	X	X	X
EAWR Reg 5	Not put into service electrical equipment where it strength and capability may be exceeded in such a way as to pose a danger.	X	X	X
EAWR Reg 11	Provide an efficient and suitably located means to protect against excess current that would otherwise result in danger.	X	X	X
MHSWR Reg 3	Carry out an assessment of risks to which employees are exposed to at work and risks to other persons not employed arising from the activities undertaken.	X	X	X
BS 7671	Provide protective devices to break overload/fault current in **LV** consumer installations before danger arises.			X
BS 7671	Take suitable precautions where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger.			X

Reference	Obligation	DNO	Generator	User
Distribution Code DPC4.4.4	Incorporate protective devices in **Distribution Systems** in accordance with the requirements of the ESQCR.	X	X	X
	Agree protection systems, operating times, discrimination and sensitivity at the ownership boundary.	X	X	X
	Normally provide back-up protection in case of circuit breaker failure on **HV** systems.	X	X	X
Distribution Code DPC6.3	User's equipment must be compatible with **DNO** standards and practices.		X	X
	Design protection systems that take into account auto-reclosing or sequential switching features on the **DNO** network.		X	X
	Be aware that **DNO** protection arrangements may cause disconnection of one or two phases only of a three phase supply.		X	X
Distribution Code DPC7.4.3	Co-ordinate protection of embedded **Generator** with **DNO** network and meet target clearance times		X	
	Agree protection settings at network ownership boundary in writing during the connection consultation process	X	X	
Distribution Code DPC7.4.4	**Generating Units** or **Power Stations** must withstand NPS loading incurred during clearance of a close-up phase to phase fault by system back-up protection		X	
Distribution Code DPC7.4.5	Agree transformer winding configuration and method of earthing with **DNO**		X	
Distribution Code DPC8.10	Assess the transient overvoltage effects at the network ownership boundary, where necessary.	X	X	

13.10 Example calculations to determine if unequal generation across different phases is acceptable or not.

13.10.1 A **Customer** installation might have 12kW of PV and a 3kW CHP plant. Due to the areas of roof available the PV plant comprises 2 by 4.5kW inverters and a 3kW inverter.

A The following connection would be deemed acceptable.

- Ph 1 4.5kW PV
- Ph 2 3kW PV plus 3kW CHP
- Ph 3 4.5kW PV

This would lead to

- 1.5kW imbalance with CHP at zero output
- 1.5kW imbalance with CHP and PV at maximum output
- 3kW imbalance with CHP at maximum output and PV at zero output.

All of which are below the 16A imbalance limit.

B The following alternative connection for the same plant would be deemed unacceptable

- Ph1 4.5kW PV plus 3kW CHP
- Ph 2 3kW PV
- Ph3 4.5kW PV

This is not acceptable as at full output Ph1 would have 4.5kW more output than Ph2 and this exceeds the 16A limit described above even though on an individual technology basis the limit of 16A is not exceeded.

13.10.2. If a **Customer** installation has a single technology installed which has **Generating Units** with different output patterns for example PV mounted on roofs facing different directions then they should be regarded separately

(For these cases the assumption is that in the morning the east roof would produce full output and the west roof zero output with the opposite in the afternoon. Whilst this might not be strictly true the simplification makes the calculations much simpler)

A The following connection would be deemed acceptable.

- Ph 1 6kW east roof 6kW west roof
- Ph 2 6kW east roof 6kW west roof
- Ph 3 5kW east roof 5kW west roof

B The following alternative connection for the same plant would be deemed unacceptable.

- Ph1 12kW east roof
- Ph2 5kW east roof 5kW west roof
- Ph 3 12kW west roof

This is not acceptable as Ph 1 would produce more than Ph 3 in the morning and in the afternoon Ph 3 would produce more than Ph 1 in each case by a margin greater than 16A.

13.11 Guidance on Risk Assessment when using RoCoF LoM Protection for Power Stations in the 5MW to 50MW range

This procedure aims to provide guidance on assessing the risks to a **Generator's** plant and equipment where a **Generator** with synchronous **Generating Units** is considering the effect of applying higher RoCoF settings than 0.2Hzs^{-1}. It is based on analysis undertaken for the network licensees by Strathclyde Universtity[11].

13.11.1 The guidance in this section 13.11 relates to a new activity. Early experience may suggest there are more efficient or effective ways of assessing the risk. **DNOs** and **Generators** will be free to adapt this procedure to achieve the **Generators'** ends.

13.11.2 First determine whether the **Power Station** includes a synchronous **Generating Unit**. This type of **Generating Unit** is at risk from an out-of-phase reclosure on a **DNO'**s network where the **DNO** employs auto-reclose or automatic restoration schemes and the loss of mains protection has failed to disconnect the **Generating Unit** before the supply is restored by the **DNO's** automatic equipment.

13.11.3 If all the synchronous **Generating Units** in a **Power Station** are operating with a fixed power factor then the chance of sustaining an island is low and the **Generator** may wish to consider that there is no need to take any further action though this does not eliminate the risk of an out-of-phase reclosure. If any synchronous **Generating Unit** is operating with voltage control then the risk of an out-of-phase reclosure is increased and the **Generator** is advised to continue with the risk assement process as described in sections 13.11.4 to 13.11.9 below.

13.11.4 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 Generating 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 **Generating Plant,** hence the trapped load assessment may need to be carried out periodically.

13.11.5 **DNO**s will also be able to provide indicative fault rates for their network that lead to the tripping of the automatic switching points in 13.11.4 above.

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11 A. Dyśko, I. Abdulhadi, X. Li, C. Booth "Assessment of Risks Resulting from the Adjustment of ROCOF Based Loss of Mains Protection Settings – Phase I", Institute for Energy and Environment, Department of Electronic and Electrical Engineering, University of Strathclyde, Glasgow, June 2013.

13.11.6 **DNO**s will provide any known or expected likely topology changes to the network and a view of the effects of this on the data provided in 13.11.4 and 13.11.5

13.11.7 **DNO**s will also be able to provide the automatic switching times employed by any auto-reclose switchgear employed at switching points identified in 13.11.4. This will include any potential changes to automatic switching times that it might be possible to deploy to reduce the risk of out-of-phase reclosure. The DNO will need to consider any potential effect from network faults on customer service and system performance before agreeing to modifying automatic switching times.

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

13.11.9 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.

13.11.10 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 reclosure incident. Where the **Generator** considers these risks to be too high, sensitivity analysis should enable them to identify the effectiveness of various remedial actions.

Appendix 6 - Proposed EREC G59/3-2 (clean)

PRODUCED BY THE OPERATIONS DIRECTORATE OF ENERGY NETWORKS ASSOCIATION

Engineering Recommendation G59

Issue 3 Amendment 2 July 2015

RECOMMENDATIONS FOR THE CONNECTION OF GENERATING PLANT TO THE DISTRIBUTION SYSTEMS OF LICENSED DISTRIBUTION NETWORK OPERATORS

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PUBLISHING AND COPYRIGHT INFORMATION

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First published, June 1985

Amendments since publication

Issue	**Date**	**Amendment**
G59/1	1991	Revised incorporating Amendment 1 (1992) and Amendment 2 (1995)
G59/2	Aug 2010	Revised - replaced two previous Engineering Recommendations, ER G59/1 and its associated Engineering Technical Report ETR 113, and ER G75/1.
G59/2-1	March 2011	Revised Amendment 1 – Appendix A13.1 - Change to DC injection current limits
G59/3	Sept 2011	Major revision to the document to align with G83/2 and to cater for type tested equipment upto 50kW. Other areas revised included: • *Connection application and commissioning procedures* • *Connection and Commissioning Procedure for Power Stations above EREC G83/2 limits but less than 50kW or 17kW per phase using Type Tested Generating Units only* • *Connection and Commissioning Procedure for Power Stations above 50kW which use Type Tested Generating Units only* • *Voltage Unbalance* • *Generation capacity for single and split phase supplies* • *Generating Unit performance requirements for Type Tested Units* • *Over and Under Voltage Stability Tests* • *Frequency Drift and Step Change Stability Test.* • *Protection Settings* • *Revised Forms* • *Simplified application form*

G59/3	Nov 2013	Correction of error. The error relates to the British Standard which is to be used to determine the 'flicker' contribution from small wind turbines. References to this standard are found at 9.6.2.1 and 13.8.5.5 of ER G59/3. The standard that should be referred to is BS EN 61400-12. However, the standard that was referred BS EN 61400-21was incorrect. Therefore, to correct this error, the two references (i.e. at 9.6.2.1 and 13.8.5.5) have been changed and the description of the standard corrected at 3.2 (page 9) of ER G59/3. This will now read: ***BS EN 61400-12-1:2006*** *Wind turbines. Power performance measurements of electricity producing wind turbines.*
G59/3-1	Aug 2014	Revised RoCoF settings in Section 10.5.7
G59/3-2	June 2015	Revocation of Section 12.4 (f) – It is no longer a requirement to undertake an additional functional check of the LoM protection by removing one phase of the supply to the Generating Unit. Revision to section 12.3.1 (g) to include the provision of two options to carry out a functional test confirming that the Interface Protection has operated. Testing of RoCoF elements in Appendix 13.3. A discrepancy has been corrected between the wording contained in Section 12.4 and the testing requirements contained in Appendix 13.3 on how to undertake the test . Section 13.8.3.2 is repeated on page 130. Change to 13.8.3.3 and revise subsequent numbering.

Contents

Foreword

This Engineering Recommendation (EREC) is published by the Energy Networks Association (ENA) and comes into effect from August 2013. 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 G59”, which replaces the previously used abbreviation “ER G59”.

1 Purpose

1.1 The purpose of this Engineering Recommendation (EREC) is to provide guidance on the connection of **Generating Plant** to the **Distribution Systems** 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 **Generating Plant** will be accepted for connection to the **Distribution System**. This Engineering Recommendation replaces Engineering Recommendations G59/3 and G59/3-1

1.2 The guidance given is designed to facilitate the connection of **Generating Plant** whilst maintaining the integrity of the **Distribution System**, both in terms of safety and supply quality. It applies to all **Generating Plant** 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 **Generator**s and **DNO**s. The mandatory requirements governing the connection of Distributed **Generating Plant** are generally set out in the Distribution Planning and Connection Code 7 (DPC7) of the **Distribution Code** 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.

2 Scope

2.1 This EREC provides guidance on the technical requirements for the connection of **Generating Plant** to the **Distribution System**s of licensed **DNO**s. For the purposes of this EREC, a **Generating Plant** is any source of electrical energy, irrespective of the prime mover and **Generating Unit** type. This EREC applies to all **Generating Plant** which is not in the scope of EREC G83 or is not compliant with EREC G83 requirements.[1] EREC G59 describes a simplified connection procedure for connection of a **Type Tested single Generating Unit** of less than 17kW per phase or 50kW three phase, or the connection of multiple **Type Tested Generating Units** with a maximum aggregate capacity of less than 17kW per phase or 50kW three phase, per **Customer** installation, provided that any existing connected **Generating Units** are also **Type Tested**.

2.2 This EREC does not provide advice for the design, specification, protection or operation of **Generating Plant** itself. These matters are for the owners of plant to determine.

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[1] Engineering Recommendation EREC G83/2 – Recommendations for the connection of small-scale embedded generators (up to and including 16 A per phase) in parallel with public low-voltage distribution networks. This Engineering Recommendation provides guidance on the technical requirements for the connection of **Generating Units** rated up to and including 16 A per phase, single or multi-phase, 230/400 Volts AC. The recommendations cover the connection of **Generating Units**, either single or multi-phase within a single Customer's installation up to the limit of 16A per phase, and multiple **Generating Unit**s in a close geographic region with a limit of 16A per phase in each customer installation, under a planned programme of work.

2.3 Specific separate requirements apply to **Generating Plant** comprising **Generating Unit**s less than or equal to 16A per phase and these are covered in EREC G83. However, **Generating Unit**s ≤16A per phase that have not been **Type Tested** in accordance with EREC G83 or whose technology type is not covered by one of the EREC G83 annexes should comply with the requirements set in this document. Section 6 of this document provides more guidance on how to apply this document to **Generating Unit**s that are below the 16A threshold but do not meet the requirements of EREC G83/2.

2.4 The connection of mobile generation owned by the **DNO**, EREC G83/2 compliant **Generating Unit**s or offshore **Transmission System**s containing generation are outside the scope of this Engineering Recommendation.

2.5 This document applies to systems where the **Generating Plant** can be paralleled with a **Distribution System** or where either the **Generating Plant** or a **Distribution System** with **Generating Plant** connected can be used as an alternative source of energy to supply the same electrical load.

2.6 The generic requirements for all types of **Generating Plant** 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 **Medium and Large Power Station**s are, in addition to the general requirements of this EREC, bound by the requirements of the **Grid Code**. In the case of **Large Power Station**s, the **Grid Code** will generally apply in full. For **Medium Power Station**s, only a subset of the **Grid Code** applies directly, and the relevant clauses are listed in DPC7 of the **Distribution Code**.

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.

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

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 Statutory Requirements

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 Standards publications

BS 7671: 2008 Requirements for Electrical Installations

IEE Wiring Regulations: Seventeenth Edition.

BS 7430: 1999

Code of Practice for Earthing.

BS 7354

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 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 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Note: Except where otherwise stated, the terms defined in this section shall have the same meaning as in the Grid Code and the Distribution Code.

Act

The Electricity Act 1989 (as amended.including by the Utilities Act 2000 and the Energy Act 2004).

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.

Connection Agreement

An agreement between the **DNO** and the **User** or any **Customer** setting out the terms relating to a connection with the **DNO**s **Distribution System**.

Connection Point

An **Entry Point** or an **Exit Point** of the **Distribution System** as the case may be.

Customer

A person who is the owner or occupier of premises that are connected to the **Distribution System**.

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.

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 Licence

A distribution licence granted under Section 6(1)(c) of the **Act**.

Distribution System

An electricity **Distribution System** operated by a holder of a **Distribution Licence**.

Distribution Network Operator (DNO)

The person or legal entity named in Part 1 of the **Distribution Licence** and any permitted legal assigns or successors in title of the named party.

Entry Point

The point at which an **Embedded Generator** or other **User**s connect to the **DNO'**s **Distribution System** where power flows into the **DNO'**s **Distribution System** under normal circumstances.

Embedded Generator

A **Generator** including a **Customer** with own generation whose **Generating Unit** is/are connected to the **DNO's Distribution System** or to another authorised distributor connected to the **DNO's Distribution System**.

Exit Point

The point of supply from the **DNO'**s **Distribution System** to a **User** where power flows out from the **DNO'**s **Distribution System** under normal circumstances.

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 System**. 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**.

Generating Plant

A **Power Station** including any **Generating Unit** therein.

Generating Unit

Any apparatus which produces electricity.

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.

Installer

A person who carries out the installation of **Generating Unit(**s**)** on behalf of a **Generator** and who carries out some of the functions required of a **Generator** during the installation and commissioning phases of a **Power Station**.

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 System.** The interface protection is typically not all installed at the interface between the **DNO** and **Customer**s network.

Large Power Station

As defined in the **Distribution Code**.

Low Voltage (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 **Generating Units** which can be **Type Tested** to meet the requirements of this Engineering Recommendation if it is of a suitable size

Medium Power Station

As defined in the **Distribution Code**.

National Electricity Transmission System Operator (NETSO)

National Grid Electricity Transmission (NGET) in its capacity as operator of the National Transmission System.

Point of Common Coupling

The point on a **Distribution System,** electrically nearest the **Customer**'s Installation**,** at which other **Customer**s are, or may be, connected.

Point of Supply

The point of electrical connection between the apparatus owned by the **DNO** and the **Customer**.

Power Station

Generating Units (even where sited separately), which are owned and/or controlled by the same **Generator** and may reasonably be considered as being managed as one **Power Station.** For the purpose of this document a single **Generating Unit** will also be described as a **Power Station**.

Power System Stabiliser (PSS)

Equipment controlling the output of a **Generating Unit** in such a way that power oscillations of the machine are damped. Input variables may be speed, frequency, or power or a combination of variables.

Small Power Station

As defined in the **Distribution Code**.

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 Act; in each case acting in its capacity as a supplier of electricity to Customers.

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.

Synchronism

The condition under which a **Generating Unit** or **System** is connected to another **System** so that the frequencies, voltage and phase relationships of that **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 Plant, Transmission System, Distribution Systems** and associated electrical demand.

Transmission Licence

The licence granted under Section 6(1)(b) of the **Act**.

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 Station**s and substations.

Type Tested

A **Generating Unit** design which has been tested by the **Manufacturer**, component manufacturer or supplier, or a third party, to ensure that the design meets the requirements of this EREC, and for which the **Manufacturer** has declared that all products supplied into the market will be constructed to the same standards, and with the same protection settings as the tested product.

User

A term used in various sections of the **Distribution Code** to refer to the persons using the **DNO'**s **Distribution System**.

5 Legal Aspects

5.1 The operation and design of the electricity system in Great Britain is defined principally by 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 13.9.

5.2 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 **Generating Plant** is entitled to remain connected to the **Distribution System**. 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**.

5.3 **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**.

5.4 In accordance with DPC5.4 of the **Distribution Code**, when details of the interface between a **Generating Plant** and the **Distribution System** 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.

5.5 The **DNO**s have statutory and licence obligations within which they have to offer the most economic, technically feasible option for connecting **Generating Plant** to their **Distribution System**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 Systems** at all voltage levels are adequately earthed;

c. comply with the "Security of Supply" criteria defined in EREC P2;

d. meet improving standards of supply in terms of customer minutes lost (CMLs) and the number of customer interruptions (CIs);

e. facilitate competition in the connection, generation and supply of electricity.

5.6 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 **Generating Plant** or to ensure that the **Generating Plant** is rapidly disconnected from the **Distribution System** under islanded conditions. The next two criteria influence the type of connection that may be offered without jeopardising regulated standards.

5.7 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 System** 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.

5.8 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 System**.

5.9 Under Regulation 22 of the ESQCR 2002, no person may operate **Generating Plant** in parallel with a public **Distribution System** without the agreement of the **DNO**.

5.10 All **Generator**s have to comply with the appropriate parts of the ESQCR.

5.11 The general requirements for **Generator**s wishing to connect their **Generating Plant** to a **Distribution System** are contained in the **Distribution Code.**

5.12 It is important to note that both the **Distribution Code** and **Grid Code** use the terms **Large, Medium and Small** in relation to **Power Station**s. These terms are defined in the Codes and various parts of the Codes apply to different size **Power Station**s, with generally no **Grid Code** requirements applying to **Small Power Station**s. Any collection of **Generating Plant** under the control of one owner or operator in one installation is classed in the Codes as a **Power Station**.

5.13 **Generators** with **Medium Power Station**s will have to comply with a few specific **Grid Code** clauses. The requirement for these clauses is contained in DPC7 of the **Distribution Code**.

5.14 **Power Stations** that are to be connected to a **Distribution System** and contain **Generating Unit**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 **Generating Plant**.

5.15 Information, which should assist **Generator**s wishing to connect to the **Distribution System** 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 System** as well as authorised changes in future years on a rolling basis.

5.16 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[2] grant exemptions. Broadly, generating stations of less than 50MW are automatically exempt from the need to hold a licence, and those between 50MW and 100MW may apply to DECC for an exemption if they wish.

5.17 **Generator**s who are licensed will be required to become parties to the Balancing and Settlement Code and to the Connection and Use of System Code. They will also be bound in their licences to comply with the **Grid Code** and the **Distribution Code**.

5.18 **Generator**s will need appropriate contracts in place for the purchase of any energy that is exported from the **Generator**s' **Power Station**s, 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 **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.

6 Connection Application

6.1 General

This document describes the processes that shall be adopted for both connection of single **Generating Units** and installations that comprise of a number of **Generating Units** The process for the connection of single or multiple **Type Tested Generating Units** with an aggregate installed capacity of less than or equal to 16A per phase is described in EREC G83; the connection of other **Generating Unit**s (ie **Generating Unit**s outside the scope of EREC G83) is covered by this Engineering Recommendation.

Where an installation comprises multiple **Generating Units** the application process and commissioning requirements should be based on the **Power Station** capacity (ie the aggregate capacity of all the **Generating Unit**s to be installed in any one installation), and whether the individual **Generating Units** are **Type Tested**.

Where a new **Generating Unit** 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 **Generating Unit** will be required to meet protection requirements of this Engineering Recommendation.

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2 see http://www.opsi.gov.uk/si/si2001/20013270.htm

6.1.1 The following table describes key differentiating features between Power Station capacity that influence the application, connection and commissioning process.

Power Station capacity (ie the aggregate capacity of all the Generating Units to be installed in any one installation).	**≤ 16A per phase**		**> 16A per phase**		
			≤ 50kW 3 phase (or 17kW 1 phase)[3]	**> 50kW 3 phase (or 17kW 1 phase)**	**All Capacities**
Approval Status of individual Generating Units	**G83/2 compliant**	**Not G83/2 compliant**	**G59/3 or G83 Type Tested Equipment**	**G59 Type Tested Equipment**	**Not G59 Type Tested**
Consent required prior to connection **DNO** to carry out impact assessment / electrical studies	As G83	YES	YES	YES	YES
Protection Requirements	As G83/2	As G59/3-2. Section 10	As G59/3-2. Section 10	As G59/3-2. Section 10	As G59/3-2 Section 10
Commissioning Tests	As G83/2	As G59/3-2 Sections 12.3 and 12.4	As G59/3-2 Section 12.3	As G59/3-2 Section 12.3	As G59/3-2 Sections 12.3 and 12.4
Witness testing required by **DNO**	No[4]	At the discretion of the **DNO**[5]	As G59/3-2 section 12.1.4[5]	At the discretion of the **DNO**[5]	YES – for **HV**, but at the discretion of the **DNO** for **LV**[5]

6.1.2 **Generating Unit(s) ≤ to16A per phase and EREC G83 compliant**

A connection procedure to facilitate the connection and operation of **Type Tested Generating Unit**s with aggregate installed capacity of less than or equal to 16A per phase in parallel with public **Low Voltage Distribution System** is given in EREC G83 and is not considered further in this document.

[3] The rationale for the break points is the support and penetration envisaged for "microgeneration" as captured in the 2006 Climate Change and Sustainable Energy Act 2006, which defines microgeneration as up to $50kW_e$.

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

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

6.1.3 **Generating Unit(s) ≤ to16A per phase and not EREC G83 compliant**

Where the **Generating Unit** does not meet the requirements of EREC G83 either because the technology is not covered by one of the technology annexes or because the **Generating Unit** has not successfully been through the type testing process the connection process shall follow that for larger **Generating Unit**s as described in this document.

6.1.4 **Generating Unit(s)** EREC G59 **Type Tested** (>16A per phase but ≤ 50kW 3 phase (or 17 kW 1 phase))

The use of **Type Tested** equipment simplifies the connection process, the protection arrangements and reduces the commissioning test requirements. The process is described in this document.

6.1.5 **Generating Unit(s)** not EREC G59 **Type Tested** or > than 50kW 3 phase (or 17kW 1 phase)

The connection process for these **Generating Unit**s is described in this document. When making a connection application for **Medium and Large Power Station**s, there are requirements that should be considered in addition to the general requirements identified in this document.

Medium and Large Power Stations are bound by the requirements of the **Grid Code**. In the case of **Large Power Stations**, the **Grid Code** will generally apply in full. For **Medium Power Station**s, only a small subset of the **Grid Code** applies directly, and the relevant clauses are listed in DPC7 of the **Distribution Code**.

Where **Grid Code** requirements apply, under the **Distribution Code** it is the **Generator**'s responsibility to comply with the **Grid Code** requirements.

6.2 Application for Connection

6.2.1 Information about the **Generating Unit**(s) is needed by the **DNO** so that it can assess the effect that a **Power Station** may have on the **Distribution System**. Section DPC7 and the Distribution Data Registration Code (DDRC) of the **Distribution Code** detail the parameters to be supplied by a **Customer** wishing to connect **Generating Unit(s)** that do not comply with EREC G83 to a **Distribution System**. DPC7 also enables the **DNO** to request more detailed information if required.

6.2.2 Less than or equal to 16A per phase and EREC G83 Compliant **Generating Unit**

The application process is described in EREC G83 and is not considered further in this document.

6.2.3 Less than or equal to 16A per phase and not EREC G83 compliant **Generating Unit**

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 System** 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 System** 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 **Generating Unit** can be commissioned. On successful completion of the commissioning tests, the **DNO** will sanction permanent energisation of the **Generating Unit**.

6.2.4 **Power Stations** >16A per phase but ≤ 50kW three phase (or 17kW single phase) comprising **Generating Units Type Tested** to EREC G59 or EREC G83 (excluding G83/1 and G83/1-1)

The application shall be made using the form in Appendix 13.5 which should include the **Type Tested** Reference Number. Where a reference number is not available the **Generator** or **Installer** shall provide the **DNO** with a **Type Test** report as per Appendix 13.1 confirming that the **Generating Unit** has been **Type Tested** to satisfy the requirements of this Engineering Recommendation. Guidance to **Manufacturers** on type testing is included in Appendix 13.8 of this document. On receipt of the application, the **DNO** will assess whether any **Distribution System** studies are required and whether there is a requirement to witness the commissioning tests.

6.2.5 **Power Stations** which include any non-**Type Tested Generating Units** or any **Power Stations** >50kW three phase (or 17kW 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 will all be defined within DPC7 and DPC8 and the Distribution Data Registration Code (DDRC) of the **Distribution Code**.

6.3 System Analysis for Connection Design

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 'Distribution Data Registration Code' (DDRC) within the **Distribution Code** as part of the connection process.

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 For plant connected at **HV**, it is generally necessary to build an equivalent model of the **Distribution System**. An example is shown as Fig 6.1 below.

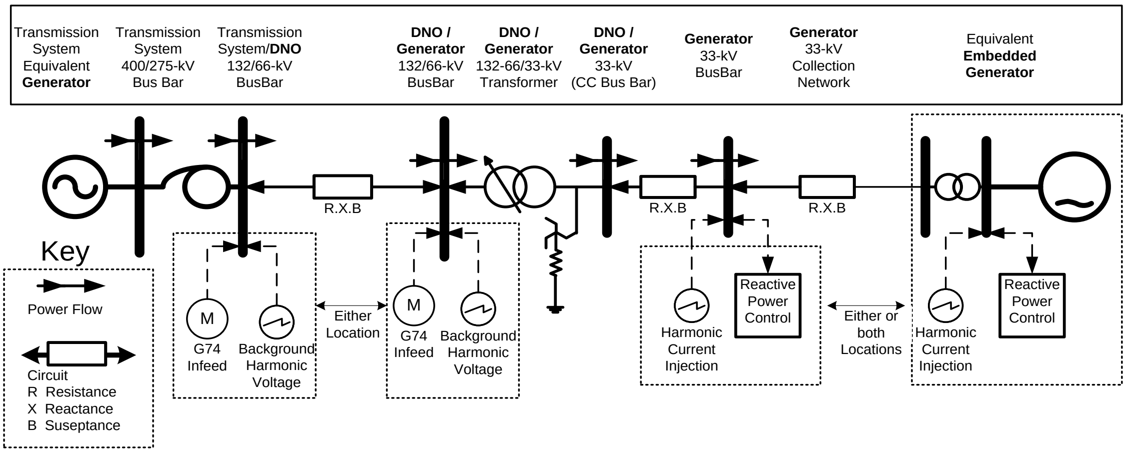


Fig 6.1 Example equivalent **Total System** representation

This model will typically include equivalent source representing existing **Generating Plant** 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.

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 **Generating Plant** 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 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.

6.3.6 For synchronous machines, control systems for **Generating Unit**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 **Generating Unit** and grid connection. The requirement to submit models in this form for directly connected synchronous **Generating Unit**s is written into the **Grid Code and Distribution Code**.

6.3.7 For other generation technologies, the **Grid Code** includes the requirement to submit validated detailed models in respect of non-synchronous **Generating Unit**s which are aggregated into a 'Power Park Module' and where they are also classed as **Medium or Large Power Station**s.

6.3.8 The **Distribution Code** 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 **Generating Unit**s.

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 Station**s embedded within their **Distribution Systems** unless they are connected at a voltage level below that of the lower voltage side of the relevant supergrid transformer. This requires the **Generating Plant** manufacturer to submit a **Generating Unit** or Power Park model in a format suitable for the **NETSO** usually in a documented block diagram format.

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 **Generating Unit**s or Power Parks using their **Generating Unit**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 **Generating Unit** for load flow, fault level and transient analysis for the typical range of faults experienced by **DNO**s.

7 CONNECTION ARRANGEMENTS

7.1 Operating Modes

7.1.1 **Generating Plant** 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.

7.2 Long-Term Parallel Operation

7.2.1 This refers to the frequent or long-term operation of **Generating Plant** in parallel with the **Distribution System**. Unless otherwise stated, all sections in this Engineering Recommendation are applicable to this mode of operation.

7.3 Infrequent Short-Term Parallel Operation

7.3.1 This mode of operation typically enables **Generating Plant** 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 **Generating Plant**.

7.3.2 In this mode of operation, parallel operation of the **Generating Plant** and the **Distribution System** 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 As the design requirements for **Generating Plant** 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 **Generating Plant** may be permitted to operate in parallel with the **DNO**s **Distribution System** for no more than 5 minutes in any month, and no more frequently than once per week. If the duration of parallel connection exceeds this period, or this frequency, then the **Generating Plant** 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 **Generating Plant** 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 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 **Generating Plant** is operating in parallel. A specific Loss of Mains (LoM) protection relay is not required, although many 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 **Generating Plant** supporting an island of **Distribution System** as under voltage or under frequency protection is only likely to disconnect the **Generating Plant** if the load is greater than the **Generating Plant** capacity. Consequently it is appropriate to apply different protection settings for short term parallel connection. As this **Generating Plant** 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 **Generating Unit**'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.

c. Fault Level – There is the need to consider the effect of the **Generating Plant** 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 **Generating Plant** 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 **Generating Unit** ramping down to transfer site load to the mains. If the **Generating Unit** tripped at this point it could introduce a larger **Step Voltage Change** than would normally be acceptable for loss of **Generating Plant** 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 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.

7.4 Switched Alternative-Only Operation

7.4.1 General

7.4.1.1 Under this mode of operation it is not permissible to operate **Generating Plant** in parallel with the **Distribution System**. Regulation 21 of the ESQCR states that it is the **Generator's** responsibility to ensure that all parts of the **Generating Plant** have been disconnected from the **Distribution System** and remain disconnected while the **Generating Plant** is operational. The earthing, protection, instrumentation etc. for this mode of operation are the responsibility of the **Generator**, however where such **Generating Plant** 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 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 System** 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 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 **Generating Plant** is installed, a conspicuous warning notice should be displayed and securely fixed at the **Point of Supply**.

7.4.2 Changeover Operated at HV

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 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 Changeover Operated at LV

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;

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 The **Generator** must be satisfied that any arrangement will be sufficient to fulfil their obligations under ESQCR.

7.5 Balance of Generating Unit output at LV

7.5.1. EREC G83 allows the connection of **Type Tested Generating Units** ≤16A per phase without consultation with the **DNO**. Connection of single phase units up to 17kW under EREC G59 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. A solution to these voltage issues and phase imbalance issues may be to utilise 3-phase **Generating Unit**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 **Generating Unit**s connected across three phases. If these individual Generating Units 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 Generating Unit is connected to in an installation. In addition the DNO may define to an Installer the phases to which the Generating Units in any given installation should be connected.

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 (eg. wind and solar) **Generating Unit**s shall be connected to give a total imbalance of less than 16A based on assumed worst case conditions, those being:

a. One **Generating Unit** at maximum output with the other(s) at zero output –all combinations to be considered.

b. Both / all **Generating Units** being at maximum output

A **Generating Unit** technology which operates at different times due to location eg 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 In order to illustrate this requirement examples of acceptable and unacceptable connections have been given in Appendix 13.10.

7.6 Generation Unit capacity for single and split LV phase supplies

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 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 System** or **Generating Unit** outage. However the connection design should result in imbalance under normal operation to be below 16A between phases as noted above.

7.6.3 **Power Station**s 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 **Customers Installation** or a **Distribution System** outage applies to three phase inverters only and will be tested as part of the type testing of the **Generating Unit**. 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 Stations** above the normal limits as set out above.

7.7 Voltage Management Units in Customer's premises

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 System** before it is used by the **Customer**. In some cases where the **DNOs System** voltage is low they may increase the voltage supplied to the **Customer**. Some technologies are only designed to reduce voltage and can not increase the voltage.

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 If a Voltage Management Unit is installed between the Entry Point and the Generating Unit 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 **Generating Units** connected to **DNO LV Systems** under this Engineering Recommendation must be made on the **Entry Point** side of any Voltage Management Unit installed in a **Customers Installation.**

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 System** under the ESQCR and that provided their **Installer** has designed their installation correctly there should be very little nuisance tripping of the **Generating Unit**. Frequent nuisance tripping of a **Generating Unit** may be due to a fault in the **Customers Installation** or the operation of the **DNO's System** at too high a voltage. **Customers** should satisfy themselves that their installation has been designed correctly and all **Generating Units** 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 **Generating Unit**.

8 EARTHING

8.1 General

8.1.1 The earthing arrangements of the **Generating Plant** shall satisfy the requirements of DPC4 of the **Distribution Code**.

8.2 HV Generating Plant

8.2.1 **HV Distribution System**s may use direct, resistor, reactor or arc suppression coil methods of earthing the **Distribution System** 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 To ensure compatibility with the earthing on the **Distribution System** the earthing arrangements of the **Generating Plant** must be designed in consultation and formally agreed with the **DNO**. The actual earthing arrangements will also be dependent on the number of **Generating Unit**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 **HV Distribution System**s 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 **Generating Plant** 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 Systems operating at 132kV are generally designed for multiple earthing, and in such cases the earthing requirements should be agreed in writing with the **DNO**.

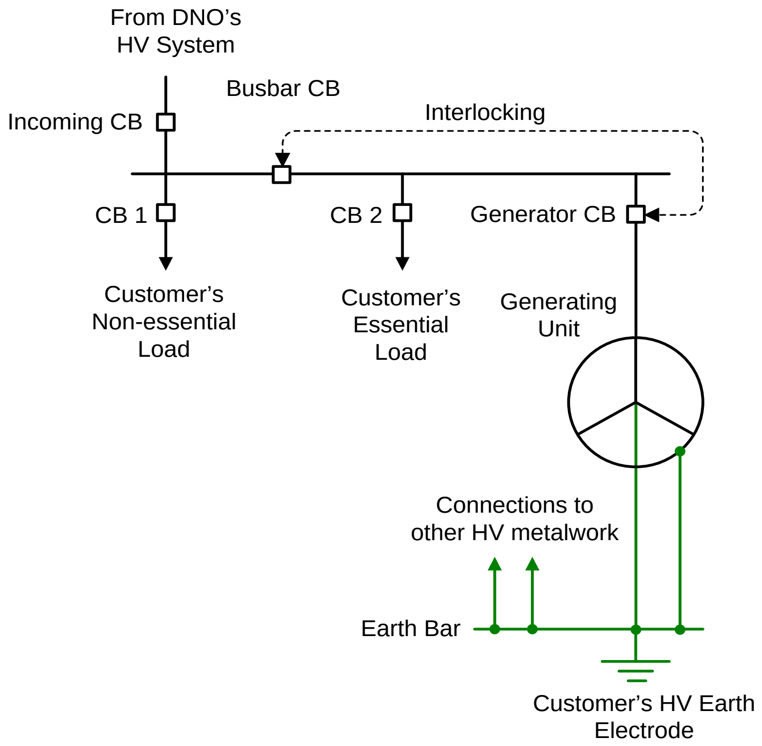
8.2.4 In some cases the **DNO** may allow the **Generator** to earth the **Generator's HV System** when operating in parallel with the **Distribution System**. The details of any such arrangements shall be agreed in writing between the relevant parties.

8.2.5 **Generator**s must take adequate precautions to ensure their **Generating Plant** is connected to earth via their own earth electrodes when operating in isolation from the **Distribution System**.

8.2.6 Typical earthing arrangements are given in figures 8.1 to 8.4.

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). 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 System**.

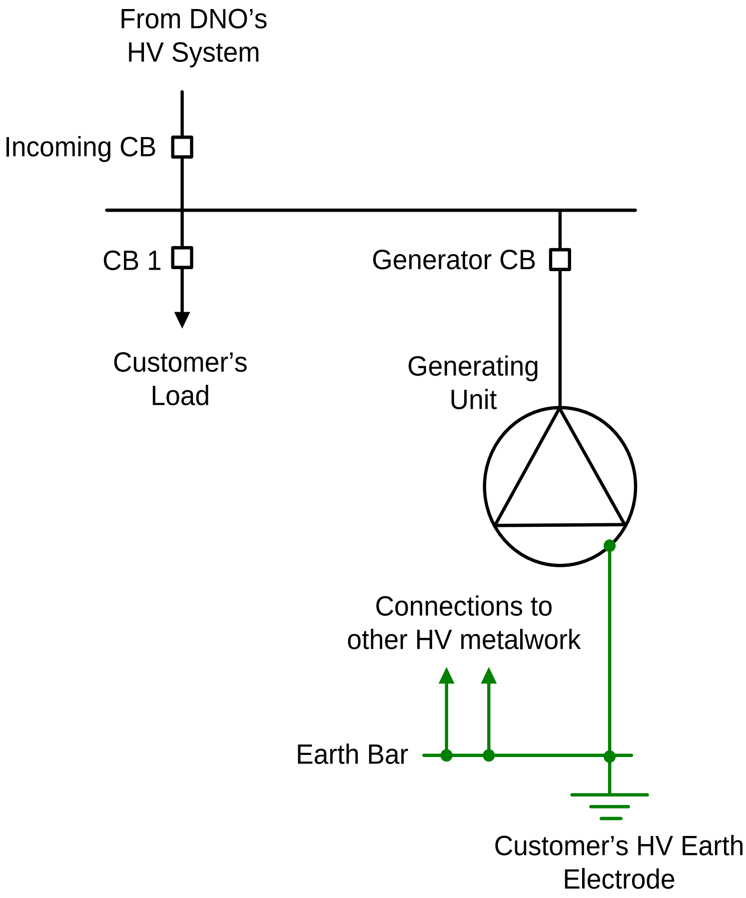
Figure 8.1 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for Independent Operation (ie Standby Operation) Only



NOTE:

(1) Interlocking between busbar CB and **Generator** CB is required to prevent parallel operation of the **Generating Unit** and **DNO System**

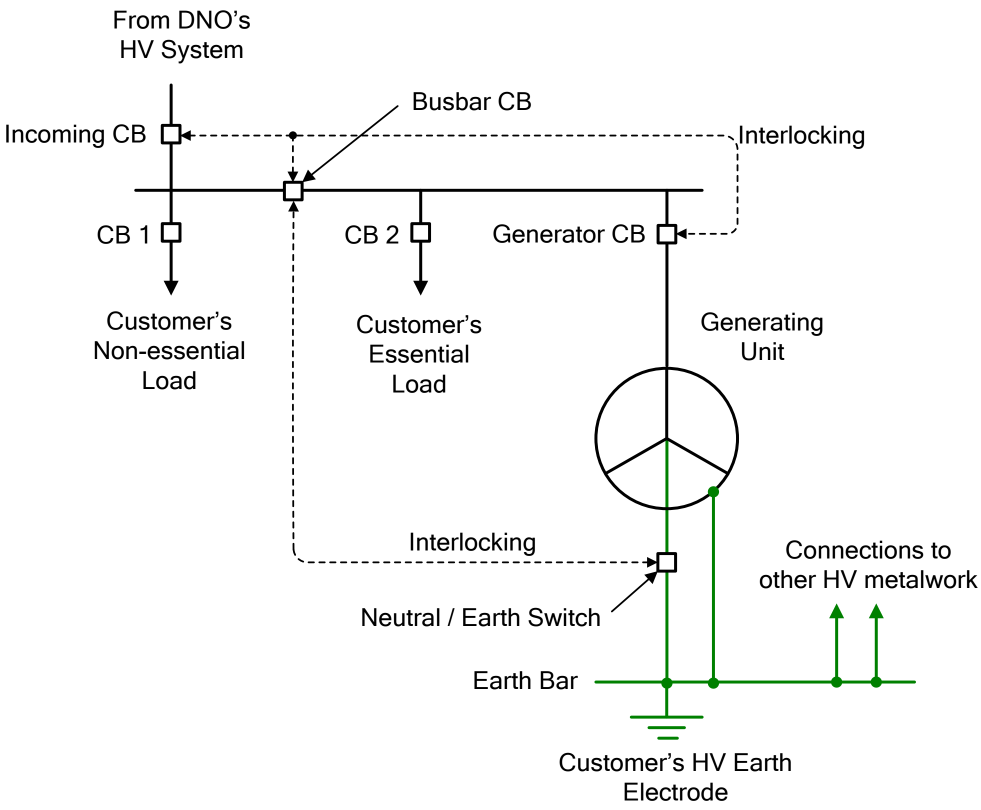
Figure 8.2 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for Parallel Operation Only



NOTE:

(1) **Generating Unit** winding is not connected to earth irrespective of whether it is star or delta connected

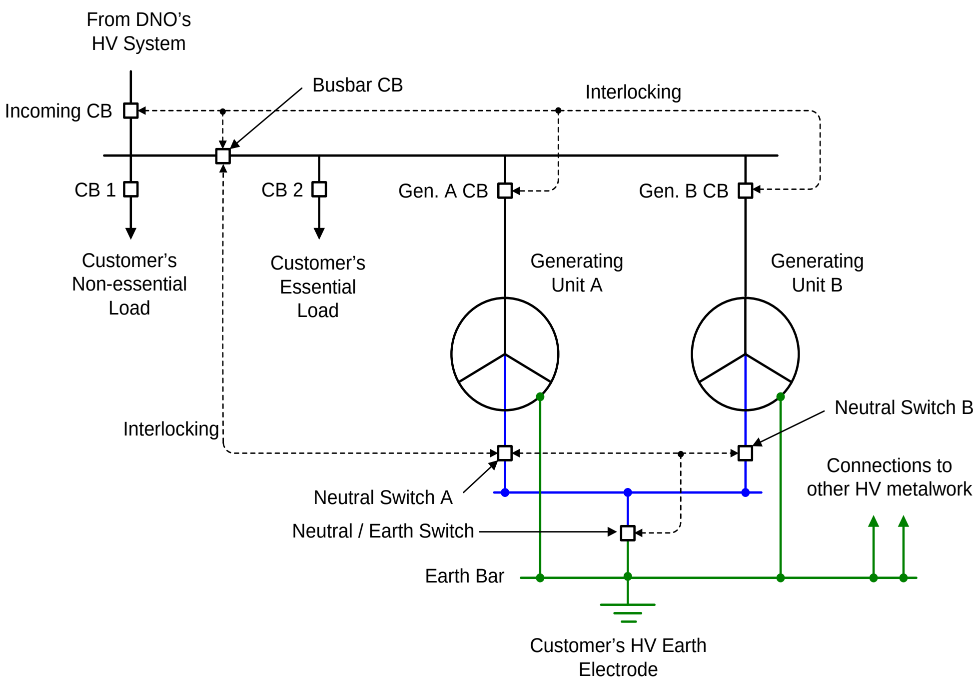
Figure 8.3 - Typical Earthing Arrangement for an **HV Generating Unit** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



NOTE:

(1) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.
(2) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral / earth switch is closed.
(3) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

Figure 8.4 - Typical Earthing Arrangement for two **HV Generating Unit**s 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 **Generating Units** operate independently from the **DNO** system.
(2) If one **Generating Units** is operating independently from the **DNO** system (ie busbar CB is open) then its neutral switch is closed and the neutral / earth switch is closed.
(3) If both **Generating Units** are operating independently from the **DNO** system (ie busbar CB is open) then <u>one</u> neutral switch is closed and the neutral / earth switch is closed.
(4) If one or both of the **Generating Units** are operating in parallel with the **DNO** system (ie busbar CB is closed) then both neutral switches and the neutral /earth switch are open.

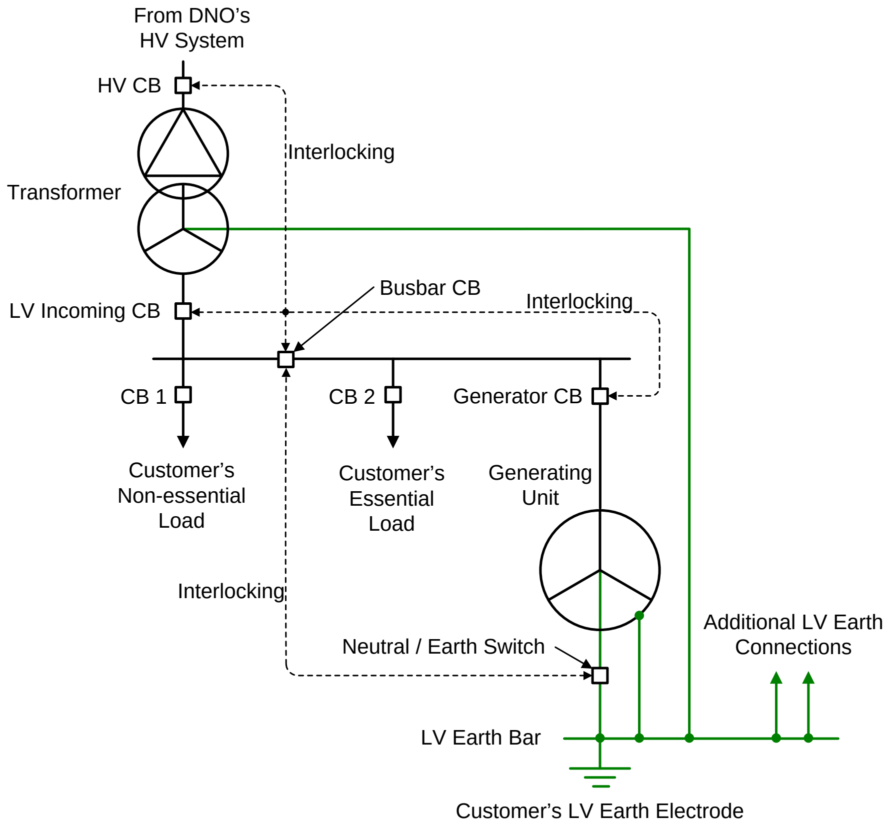
8.3 LV Generating Plant

8.3.1 **LV Distribution System**s are always solidly earthed, and the majority are multiple earthed.

8.3.2 The specific earthing requirements for **LV** connected **Generation Plant** are described in DPC7.4.

8.3.3 The following diagrams 8.5 to 8.9 show typical installations.

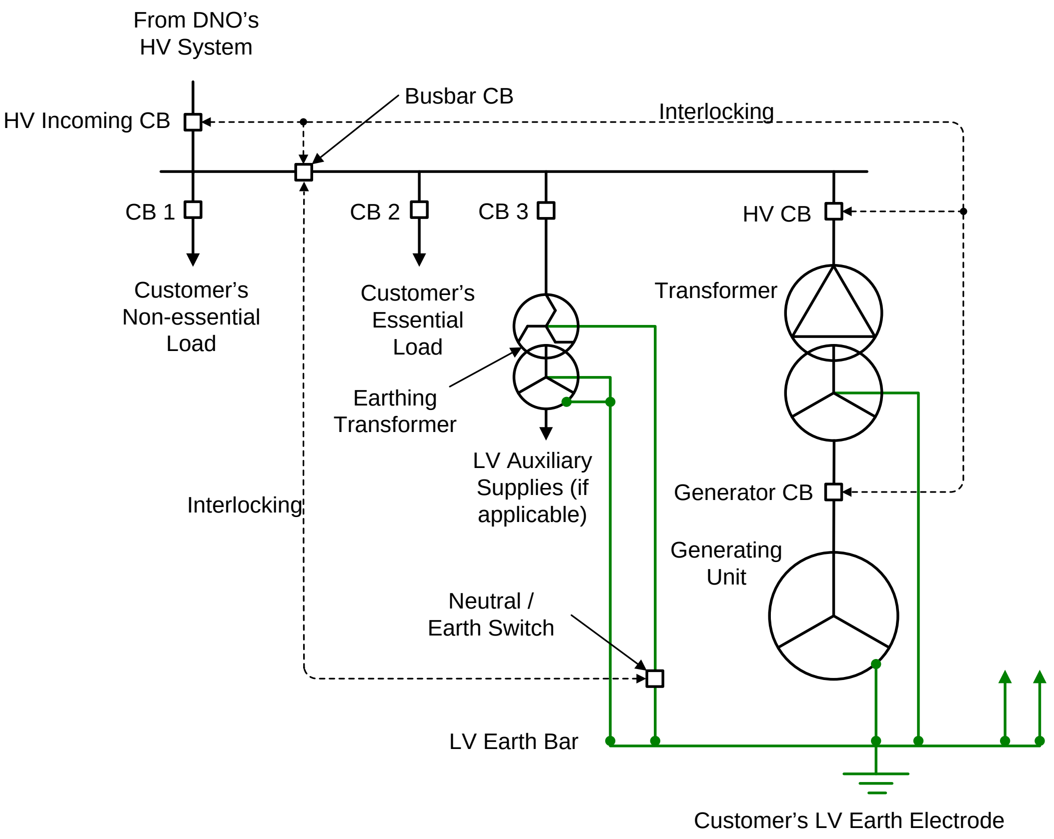
Figure 8.5 - Typical Earthing Arrangement for an **LV Generating Unit** Connected to the **DNO** System at **HV** and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation.



NOTE:

(1) **HV** earthing is not shown.
(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.
(3) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral earth switch is closed.
(4) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

Figure 8.6 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer HV** System and Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



NOTE:

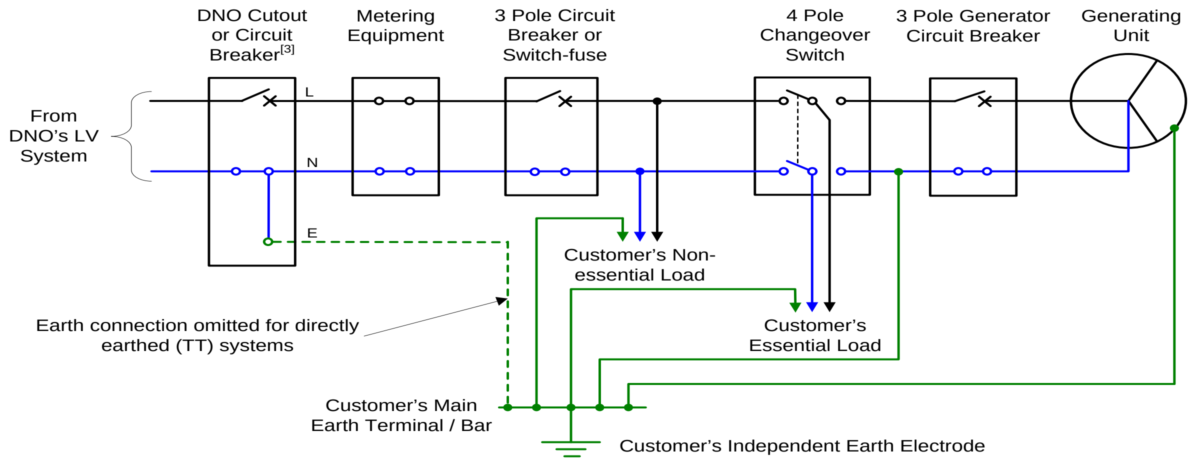
(1) **HV** earthing is not shown.

(2) Protection, interlocking and control systems are designed to ensure that busbar CB is open when the **Generating Unit** operates independently from the **DNO** system.

(3) When the **Generating Unit** operates independently from the **DNO** system (ie busbar CB is open) the neutral / earth switch is closed.

(4) When the **Generating Unit** operates in parallel with the **DNO** system (ie busbar CB is closed) the neutral / earth switch is open.

Figure 8.7 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer LV** System and Designed for Independent (i.e. Standby) Operation Only



NOTES

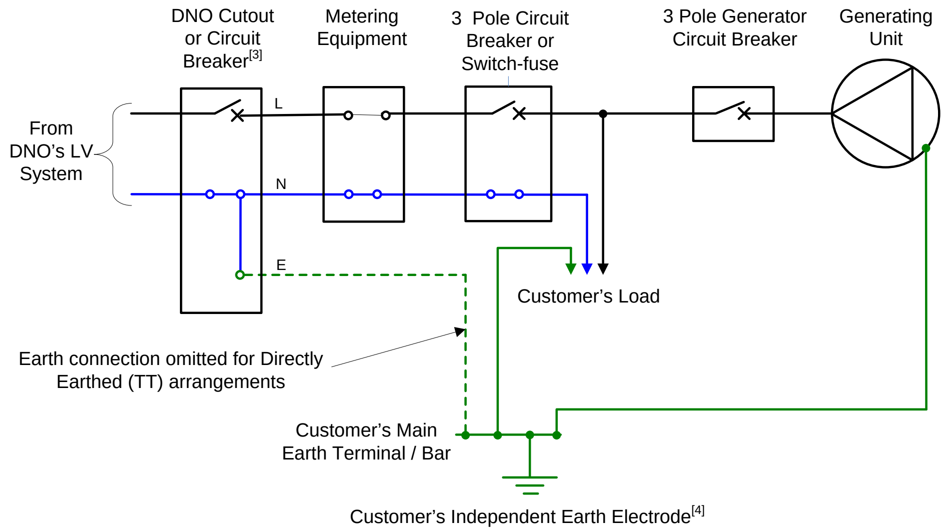
(1) Only one phase of a three phase system is shown to aid clarity.

(2) **Generating Unit** is not designed to operate in parallel with the **DNO**s system.

(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Generating Unit** 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 **Generating Unit** neutral current from inadvertently flowing through the part of the **Customer's System** that is not supported by the **Generating Plant.**

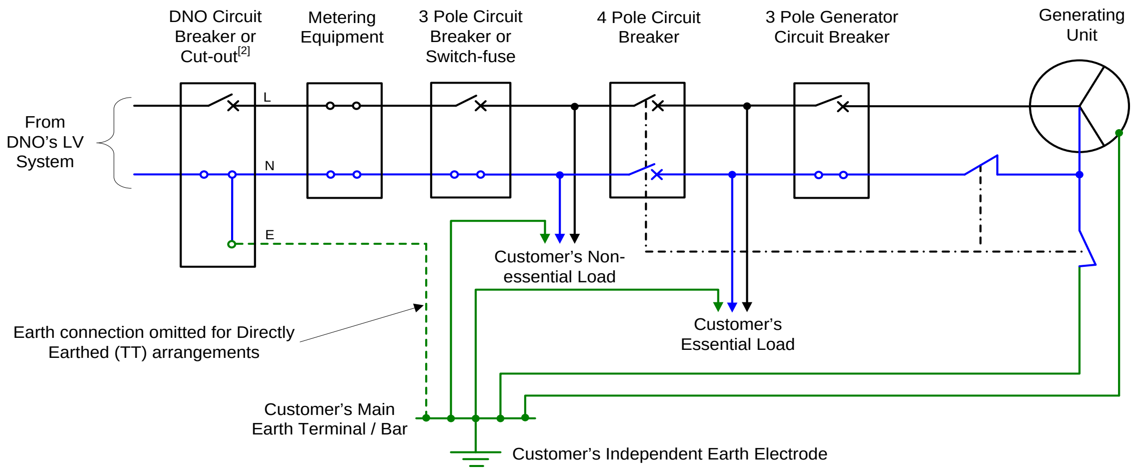
Figure 8.8 - Typical Earthing Arrangement for an **LV Generating Unit** Embedded within a **Customer LV** System and Designed for Parallel Operation Only



NOTES:

(1) Only one phase of the three phase system is shown to aid clarity.
(2) **Generating Unit** is not designed to operate in standby mode.
(3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Generating Unit** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.
(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 Generating Unit** 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 **Generating Unit** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

(3) When the **Generating Plant** 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 **Generating Unit** neutral current from inadvertently flowing through the part of the **Customer's System** that is not supported by the **Generating Plant. This switch should also close the generator neutral and earth switches during independent operation.**

9 NETWORK CONNECTION DESIGN AND OPERATION

9.1 General Criteria

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 System**s. These obligations will influence the options for connecting **Generating Plant**.

9.1.2 The technical and design criteria to be applied in the design of the **Distribution System** and **Generating Plant** connection are detailed within the Distribution Planning and Connection Code (DPC) and the standards listed in Annex 1 of the **Distribution Code**. The criteria are based upon the performance requirements of the **Distribution System** necessary to meet the above obligations.

9.1.3 The **Distribution System**, and any **Generating Plant** connection to that System, 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).

b. according to design principles in relation to **Distribution System**'s plant and equipment, earthing, voltage regulation and control, and protection as outlined in DPC4, subject to any modification to which the **DNO** may reasonably consent.

9.1.4 **Generating Plant** 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 DPC7.4 of the **Distribution Code**.

9.1.5 There are additional performance requirements that are specified in the **Grid Code** for all embedded **Medium and Large Power Station**s. The requirements for **Medium Power Station**s are referenced in DPC7.5 of the **Distribution Code**, and are all listed in CC3.3 to CC3.5 of the **Grid Code**.

9.2 Network Connection Design for Generating Plant

9.2.1 The connection of new **Customer**s, including **Generator**s, to the **Distribution System** should not generally increase the risk of interruption to existing Customers. For example, alterations to existing **Distribution System** 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 Connection of **Generating Plant** to 132kV **Distribution System**s may be subject to the requirements of EREC P18. This document sets out the normal limits of complexity of 132kV circuits by stipulating certain restrictions to be applied when they are designed. For example, 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. Most **DNO**s will have similar rules for managing the complexity of 66kV and lower voltage **Distribution System**s.

9.2.3 The security requirements for the connection of **Generating Plant** are subject to economic consideration by the **DNO** and the **Generator.** A firm connection for **Generating Plant** should allow the full MVA capacity to be exported via the **Distribution System** at all times of year and after one outage on any one circuit of the **Distribution System**. ETR 124 provides additional advice on the management of constraints and security.

9.2.4 The decision as to whether or not a firm connection is required should be by agreement between the **DNO** and the **Generator**. The **DNO** should be able to provide an indication of the likely duration and magnitude of any constraints so that the **Generator** can make an informed decision. The **Generator** should consider the financial implications of a non-firm connection against the cost of a firm connection, associated **Distribution System** reinforcement and the risk of any constraints due to **Distribution System** restrictions.

9.2.5 Where the **DNO** expects the **Generating Plant** to contribute to system security, the provisions of EREC P2 and the guidance of ETR 130 will apply. In addition, the **Generating Plant** should either remain synchronised and in parallel with the **Distribution System** 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 When designing a scheme to connect **Generating Plant**, consideration must be given to the contribution which that **Generating Plant** will make to short circuit current flows on the **Distribution System**. The assessment of the fault level contribution from **Generating Plant** and the impact on the suitability of connected switchgear are discussed in Section 9.4.

9.2.7 It is clearly important to avoid unwanted tripping of the **Generating Plant**, particularly where the **Generating Plant** is providing **Distribution System** or **Total System** security. The quality of supply and stability of **Generating Plant** performance are dealt with in Sections 9.6 and 9.7 respectively.

9.2.8 **Generating Plant** may be connected via existing circuits to which load and/or existing **Generating Plant** is also connected. The duty on such circuits, including load cycle, real and reactive power flows, and voltage implications on the **Distribution System** 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 System** 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 A **DNO** assessing a proposed connection of **Generating Plant** must also consider its effects on the **Distribution System** voltage profile and voltage control employed on the **Distribution System**. Voltage limits and control issues are discussed in Section 9.5.

9.3 Generating Plant Performance and Control Requirements

9.3.1 In accordance with DPC7.4.1 of the **Distribution Code**, the rated power output of a **Generating Unit** 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**.

9.3.2 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 System** could rise above 50.5 Hz. Therefore all embedded **Small Power Stations** should be capable of continuing to operate in parallel with the **Distribution System** 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.

b. 47.5 Hz – 51.5 Hz Disconnection by overfrequency or underfrequency protection is not permitted in this range.

c. 51.5 Hz – 52 Hz Operation for a period of at least 90 seconds is required each time the frequency is within this range.

9.3.3 The operational characteristics of the control systems of **Generating Plant** control systems (eg excitation, speed governor, voltage and frequency controls if applicable) must be co-ordinated with other voltage control systems influencing the voltage profile on the **Distribution System**. The **DNO** will provide information on performance requirements in accordance with DPC7.4.2.

9.3.4 Following consultation with the **Generator** and dependent on **Distribution System** voltage studies, a **DNO** will agree the reactive power and voltage control requirements for all **Generating Unit**s that are connected to their **Distribution System**s. It should be noted that the connection to the **Distribution System** 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. For Embedded **Medium and Large Power Station**s, considerations in Section 9.1.5 apply.

9.3.5 Each item of **Generating Plant** and its associated control equipment must be designed for stable operation in parallel with the **Distribution System**.

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 **Generating Plant** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Generating Plant**.

9.3.7 **Type Tested Generating Unit**s Performance Requriements

Type Tested Generating Units should be capable of continuing to operate in parallel with the **Distribution System** as per section 9.2 for non-type tested **Generating Units.** However allowing for tolerances and measurement errors the following test voltages and frequencies at which the tests should be carried out with no trips have been defined. These are shown on the Generating Unit Type test sheet in section 13.1 and described in section 13.8

a. Voltage range:

Maximum Voltage of 258.2V with no time limit, 269.7V for 0.98s and of 277.7V for 0.48s.

Minimum Voltage of 204.1V with no time limit, 188V for 2.48s and 180V for 0.48s

b. Frequency range:

Maximum Frequency 51.3Hz with no time limit, 51.8Hz for 89.98s and 52.2Hz for 0.48s

Minimum frequency 47.7Hz with no time limit, 47.2 Hz for 19.98s and 46.8Hz for 0.48s

c. Rates of Change of Frequency range:

From 50.5Hz to 47.5Hz at 0.19Hz per second and from 49.5Hz to 51.5Hz at 0.19Hz per second

d. Voltage Vector shift rangeof:

plus or minus 9 degrees

e. And when operating at rated power shall operate at a power factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the **DNO** eg for power factor improvement. The test to be carried out at three voltage levels.

The tests required to prove satisfactory operation are detailed in section 13.8 and should be recorded on the **Generating Unit** Type Test sheet in section 13.1

9.4 Fault Contributions and Switchgear Considerations

9.4.1 Under the ESQCR 2002 and the EaWR 1989 the **Generator** 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.

9.4.2 The **Generator** may accept that protection installed on the **Distribution System** can help discharge some of his legal obligations relating to fault clearance and, if requested, the **DNO** should consider allowing such faults on the **Generator's** system to be detected by **DNO** protection systems and cleared by the **DNO'**s circuit breaker. The **DNO** will not allow the **Generator** 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.

9.4.3 The design and safe operation of the **Generator**'s and the **DNO'**s installation's depend upon accurate assessment of the contribution to the short circuit current made by all the **Generating Plant** operating in parallel with the **Distribution System** at the instant of fault and the **Generator** should discuss this with the **DNO** at the earliest possible stage.

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 **Generating Unit**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 System** or **Transmission System**. Studies must therefore consider all credible **Distribution System** running arrangements which are likely to increase **Distribution System** 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.

9.4.5 The connection of **Generating Plant** can raise the **Distribution System** 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 System**. The performance of protection may also be impaired by partial or complete saturation of current transformers resulting from an increase in **Distribution System** X/R ratio.

9.4.6 Newly installed protection systems and circuit breakers for **Generating Unit** 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 beaker will be specified for this duty, but in the case of existing circuit breakers on the **Distribution System**, the **DNO** will need to establish the possibility or otherwise of the **DNO**s protection (or the **Generator**'s protection if arranged to trip the **DNO'**s circuit breaker) initiating a circuit breaker trip during a period when one of more **Generating Unit**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.

9.4.7 When connection of **Generating Plant** is likely to increase short circuit currents above **Distribution System** design ratings, consideration should be given to the installation of reactors, sectionalising networks, connecting the **Generating Plant** to part of the **Distribution System** operating at a higher voltage, changing the **Generating Unit** 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 System** 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 System** design ratings would be exceeded in infrequent but credible **Distribution System** configurations, then constraining the **Generating Plant** off during periods of such **Distribution System** configurations may provide a suitable solution. When assessing short circuit currents against **Distribution System** design ratings, suitable safety margins should be allowed to cater for tolerances that exist in the **Distribution System** data and **Generating Unit** parameters used in system modelling programs. On request from a **Generator** the **DNO** will provide the rationale for determining the value of a specific margin being used in **Distribution System** studies.

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 System** or **Transmission System** plant and equipment. The use of the proposed **Generating Plant** to prevent overloading of **Distribution System** plant and equipment should be considered with reference to EREC P2.

9.4.9 Disconnection of **Generating Plant** 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 **Generating Unit**, 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.

9.5 Voltage Limits and Control

9.5.1 Where **Generating Plant** 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 **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Generating Plant** to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.

9.5.2 The connection of a **Generating Plant** to the **Distribution System** shall be designed in such a way that operation of the **Generating Plant** does not adversely affect the voltage profile of and voltage control employed on the **Distribution System**. ETR 126 provides **DNO**s with guidance on active management solutions to overcome voltage control limitations.

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 **Generating Plant** is required to operate to a 'setpoint voltage' and 'slope', the **Generating Plant** will have a specific role to control the **Distribution System** voltage. The final responsibility for control of **Distribution System** voltage does however remain with the **DNO**.

9.5.4 Automatic Voltage Control (AVC) schemes employed by the **DNO** assume that power flows from parts of the **Distribution System** operating at a higher voltage to parts of the **Distribution System** operating at lower voltages. Export from **Generating Plant** 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 **Generating Plant** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.

9.5.5 **Generating Plant** 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.

9.5.6 An agreement between the **DNO** and the **Generator** 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.

9.5.7 The **Step Voltage Change** caused by the connection and disconnection of **Generating Plant** from the **Distribution System** must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other **Customers** connected to the **Distribution System**. 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 System** 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%. The **Distribution Code** makes allowances for these events in DPC4.

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.

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 (ie 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.

9.5.10 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 System** or on the **Customer**'s system. 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%.

9.5.11 These threshold limits should be complied with at the **Point of Common Coupling** as required by EREC P28.

9.6 Power Quality

9.6.1 Introduction

The connection and operation of **Generating Plant** may cause a distortion of the **Distribution System** voltage waveform resulting in voltage fluctuations, harmonics or phase voltage unbalance. DPC4.2.3 of the **Distribution Code** sets the limits on voltage disturbances and harmonic distortion; DPC7.4.4 sets phase voltage unbalance requirement that any **Generating Plant** connected to the **Distribution System** would need to comply with.

9.6.2 Flicker

Where the input motive power of the **Generating Plant** may vary rapidly, causing corresponding changes in the output power, flicker may result. The operation of **Generating Plant** 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 System** needs to be considered to ensure that the emissions produced by the **Generating Plant** do not cause a problem on the **Distribution System**. For **Type Tested Generating Unit**s of up to 17kW per phase or 50kW three phase voltage step change and flicker measurements as required by BS EN 61000-3-11 shall be made and recorded in the type test declaration for the **Generating Unit**.

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 System** may be required before the **Generating Plant** can be connected.

9.6.2.1 For wind turbines, flicker testing should be carried out during the performance tests specified in IEC 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.

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.

9.6.3 Harmonic Emissions

Harmonic voltages and currents produced within the **Generator**'s **System** may cause excessive harmonic voltage distortion in the **Distribution System**. The **Generator**'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**.

For **Type Tested Generating Unit**s of up to 17kW per phase or 50kW three phase harmonic measurements as required by BS EN 61000-3-12 shall be made and recorded in the type test declaration for the **Generating Unit**.

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 **Generating Unit**. This standard requires a minimum ratio between source fault level and the size of the **Generating Unit**, and connections in some cases may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO's System.**

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 **Generating Unit** size ratio check. **Generating Unit**s meeting the requirements of BS EN 61000-3-2 will need no further assessment with regards to harmonics.

9.6.4 Where the **Generating Plant** 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 **Generating Plant**, then a full harmonic study should be carried out.

9.6.5 Voltage imbalance

EREC P29 is a planning standard which sets the **Distribution System** compatibility levels for voltage unbalance caused by uneven loading of three phase supply systems. **Generating Unit**s should be capable of performing satisfactorily under the conditions it defines. The existing voltage unbalance on an urban **Distribution System** 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.

9.6.6 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.

9.6.6.1 For **Power Stations** of 50kW or less section 7.5 of this document specifies maximum unbalance of **Generating Units**. Where these requirements are met then no further action is required by the **Generator**.

9.6.7 Power factor correction equipment is sometimes used with asynchronous **Generating Unit**s to decrease reactive power flows on the **Distribution System**. 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.

9.6.8 DC Injection

The effects of, and therefore limits for, DC currents injected into the **Distribution System** 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 **Generating Unit**.

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**.

9.7 System Stability

9.7.1 Instability in **Distribution System**s may result in unacceptable quality of supply and tripping of **Customer**'s plant. In severe cases, instability may cascade across the **Distribution System**, resulting in widespread tripping and loss of demand and generation. There is also a risk of damage to plant.

9.7.2 In general, **System Stability** is an important consideration in the design of **Generating Plant** connections to the **Distribution System** at 33kV and above. Stability considerations may also be appropriate for some **Generating Plant** connections at lower voltages. The risks of instability generally increase as **Generating Plant** capacity increases relative to the fault level infeed from the **Distribution System** at the **Connection Point**.

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 System**s, 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.

9.7.4 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 **Generating Unit**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 **Generating Unit**s.

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 System**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.

9.7.6 It is recommended that **Generating Plant** and its connection to the **Distribution System** be designed to maintain stability of the **Distribution System** 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 **Generating Plant** 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 System** circuits (such as transformers, overhead lines and cables) and busbars, that are quickly cleared by main protection.

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. **Generating Unit**s that become unstable following system disturbances should be disconnected as soon as possible.

9.7.7 Various measures may be used, where reasonably practicable, to prevent or mitigate system instability. These may include **Distribution System** and **Generating Plant** solutions, such as:

- improved fault clearance times by means of faster protection;
- improved performance of **Generating Plant** control systems (excitation and governor/prime mover control systems; **Power System Stabilisers** to improve damping);
- improved system voltage support (provision from either **Generating Plant** or **Distribution System** plant);
- reduced plant reactance's (if possible);
- Protection to identify pole-slipping;
- increased fault level infeed from the **Distribution System** 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 System** and **Customer**s in terms of reduced risk of system instability.

9.8 Island Mode

9.8.1 A fault or planned outage, which results in the disconnection of a **Generating Unit**, together with an associated section of **Distribution System**, from the remainder of the **Total System**, creates the potential for island mode operation. The key potential advantage of operating in Island Mode is to maintain continuity of supply to the portion of the **Distribution System** containing the **Generating Unit**. 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.

9.8.2 When considering whether **Generating Plant** 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 **Generator** must be in place and the legal liabilities associated with such operation must be carefully considered by the **DNO** and the **Generator**. 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.

9.8.3 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 System** is operating in island mode, and has been disconnected from the **Total System**, will need to be transmitted to the **Generating Unit(s)** protection and control schemes.

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 **Generating Plant** and its control / protections systems will be required to determine the capability of the **Generating Plant** to meet these requirements immediately as the island is created and for the duration of the island mode operation.

9.8.5 The ESQCR also require that **Distribution System**s are earthed at all times. **Generator**s, who are not permitted to operate their installations and plant with an earthed star-point when in parallel with the **Distribution System**, 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 System** to all users is maintained. Further details are provided in Section 8.

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.

9.8.7 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 **Generator** where appropriate.

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**.

10 PROTECTION

10.1 General

10.1.1 The main function of the protection systems and settings described in this document is to prevent the **Generating Plant** supporting an islanded section of the **Distribution System** when it would or could pose a hazard to the **Distribution System** 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 System** operation, to avoid nuisance tripping, but with a faster trip for greater excursions.

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 **Generating Unit** 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 **Generation Unit**s the complete installation cannot be considered to comprise **Type Tested Generating Unit**s as the protection and connections are made up on site and so cannot be factory tested or **Type Tested**.

10.1.3 In exceptional circumstance additional protection may be required by the **DNO** to protect the **Distribution System** from the **Generating Plant**.

10.2 Protection Requirements

10.2.1 The basic requirements for protection are laid out in DPC7.4 of the **Distribution Code**. The requirements of EREC G59 are as follows:-

- UnderVoltage (2 stage);
- OverVoltage (2 stage);
- UnderFrequency (2 stage);
- OverFrequency (2 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.

It is in the interest of **Generators**, **DNO**s and **NETSO** that **Generating Plant** remains synchronised to the **Distribution System** 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 **Medium Power Station**s and **Large Power Station**s 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 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 flags and is secure from interference by unauthorised personnel.

10.2.3 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 **Generating Plant** is connected to the same feeder. The automatic reset must be inhibited for faults on the **Generator**'s installation.

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).

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 Protection equipment and protection functions may be installed within, or form part of the generator 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 **Generating Plant** 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). This is not a requirement for **Type Tested Generating Units**.

d. a **Type Tested Generating Unit**'s **Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by plug and socket which the **Manufacturer** has made and tested prior to delivery to site.

10.3 Loss of Mains (LoM)

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 **Generating Plant** from the **Distribution System** in the event of loss of one or more phases of the **DNO**s supply. This LoM protection is required to ensure that the Generating Plant is disconnected, to ensure that the requirements for **Distribution System** earthing, and out-of-**Synchronism** closure are complied with and that **Customers** are not supplied with voltage and frequencies outside statutory limits.

10.3.2 LoM is mandatory for all **Small Power Stations**. For **Medium and Large Power Stations** the **DNO** will advise if LoM is required. The requirements of 10.5.2 apply to LoM protection for all **Power Stations**.

10.3.3 A problem can arise for **Generator**s who operate **Generating Plant** in parallel with the **Distribution System** prior to a failure of the network supply because if their **Generating Plant** 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 **Generating Plant** will be out of **Synchronism** with the **Total System** and suffer damage. LoM protection can be employed to disconnect the **Generating Plant** immediately after the supply is lost, thereby avoiding damage to the **Generating Plant**.

10.3.4 Many **Customers** are connected to parts of **Distribution System**s 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 future as **DNO**s seek to improve supply availability by installing automatic switching equipment on their **Distribution System**s.

10.3.5 Where the amount of **Distribution System** load that the **Generating Plant** will attempt to pick up following a fault on the **Distribution System** is significantly more than its capability the **Generating Plant** will rapidly disconnect, or stall. However depending on the exact conditions at the time of the **Distribution System** failure, there may or may not be a sufficient change of load on the **Generating Plant** to be able to reliably detect the failure. The **Distribution System** failure may result in one of the following load conditions being experienced by the **Generating Plant**:

a. The load may slightly increase or reduce, but remain within the capability of the **Generating Plant**. There may even be no change of load;

b. The load may increase above the capability of the prime mover, in which case the **Generating Plant** 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 **Generating Plant**, in which case the following easily detectable conditions will occur:

- Overload and accompanying speed/frequency reduction
- Over current and under voltage on the alternator

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 System** supply being supplied by the **Generating Plant** 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 LoM signals can also be provided by means of intertripping signals from circuit breakers that have operated in response to the **Distribution System** fault.

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 **Generating Plant** available to satisfy the load requirements of the site or the **Generating Plant** circuit breaker can be tripped, leaving the breaker at the interface closed and ready to resume supply when the **Distribution System** supply is restored. The most appropriate arrangement is subject to agreement between the **DNO** and **Generator**.

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 **Generating Plant** rating, the site load conditions and requirements for reactive power.

10.3.10 Where the **Generating Plant** capacity is such that the site will always import power from the **Distribution System**, 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.

10.3.11 However, where the **Generating Plant**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 System** 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 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 **Generating Plant** 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 **Generating Plant** 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 Frequency variations are a constant feature of any AC electrical network. During normal operation of the system NGET maintains frequency within the statutory limits of 49.5Hz to 50.5Hz. However the loss of a large generation infeed, or a large block of load, may disturb the system such that it goes outside statutory limits for a short period. It is important that unnecessary Loss of Mains protection operation does not occur during these short lived excursions. The changing mix of generation and loads on the GB network has already resulted in a wider range of possible system rate of change of frequency (RoCoF) during these events. This wider range of RoCoF could exceed the expectations set out in previous versions of EREC G59 and system RoCoF events above $0.125Hzs^{-1}$ have already been measured on the GB network. With the changes in generation mix expected over the next decade it is unlikely to be economic to contain all frequency excursions within $0.125Hzs\text{-}^{1}$. Therefore the maximum system RoCoF which may be experienced for the maximum loss of generation infeed or block of load will rise over time. Studies indicate that by 2023 this may be as high as $0.5Hzs^{-1}$, and that even higher levels may be experienced after 2023. The RoCoF settings for Power Stations of 5MW or more laid out in EREC G59/3-2 are intended to strike an appropriate balance between the need to detect genuine island conditions and the risk of unnecessary operation for the system conditions anticipated.

10.3.14 The LoM relay that operates on the principle of voltage vector shift can achieve fast disconnection for close up **Distribution System** 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 System**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 System**s, and especially on rural **Distribution System**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. In order to provide a consistant value for application to **Type Tested Generating Unit**s, a value of 12 degrees, and a no-trip test of 9 degrees have been introduced for **Type Tested Generating Units**.

10.3.15 RoCoF protection is generally only applicable for **Small Power Station**s. DPC7.4 in the **Distribution Code** details where RoCoF may be used, and what the differences are between Scotland and England and Wales.

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 13.6 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. Protection settings for **Type Tested Generating Unit**s shall not be changed from the standard settings defined in this Engineering Recommednation.

10.3.17 For a radial or simple **Distribution System** controlled by circuit breakers that would clearly disconnect the entire circuit and associated **Generating Plant**, for a LoM event an intertripping scheme can be easy to design and install. For meshed or ring **Distribution System**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.

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 **Generating Unit,** site and network load conditions. The **DNO** will assist in the decision making process by providing information on the **Distribution System** and its loads. The technique and settings applied must be biased to ensure detection of islanding under all operating conditions as far as is reasonably practicable. More detailed guidance on how **Generators** can assess the risks and on the information that the **DNO** will provide is containedin Appendix 13.11

10.4 Additional DNO Protection

Following the **DNO** connection study, the risk presented to the **Distribution System** by the connection of a **Generating Unit** 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 **Generating Unit**, 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**.

10.4.1 Neutral Voltage Displacement (NVD) Protection

Section 9.8.6 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.

Section 10.3 describes LoM protection which the **Generator** must install to achieve (amongst other things) disconnection of the **Generating Plant** from the **Distribution System** in the event of loss of one or more phases of the **DNO**s supply.

Where **Generating Plant** inadvertently operates in island mode, and where there is an earth fault existing on the **DNO**s **HV System** NVD protection fitted on the **DNO**s **HV** switchgear will detect the earth fault, and disconnect the **HV System** from the island.

DNOs need to consider specific investigation of the need for NVD protection when, downstream of the same prospective island boundary, there are one or more **Generating Unit**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 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 **Generating Unit** connection, of any type with an output less than 200kVA;
- Multiple new **Generating Unit** connections, of any type, on a single site, with an aggregated output less than 200kVA;
- Single or multiple new **Generating Unit** 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 **Generating Unit** 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 **DNOs** will have differing network designs and so decision will be made by **DNO** according to to size of **Generating Unit**, point of connection, network design and planning policy. This is outside the scope of this document.

10.4.3 If the assessed minimum load on a prospective island is less than twice the maximum combined output of new **Generating Plant** 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 Generating Plant connection eg the margin of additional cost associated with NVD protection.

10.5 Protection Settings

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

10.5.1 The protection systems and settings can have an impact on the behaviour of **Generating Plant** when the **Total System** is in distress. Where **Generating Plant** has the capability to operate at the extremes of the possible operating range of the **Total System**, it would be inappropriate to artificially impose protection settings that would cause **Generating Plant** to be disconnected where it would otherwise be capable of remaining connected and help to maintain the integrity of the **Total System**. It is not the intention that this Section specifies the performance requirements of **Generating Plant** connected to **Distribution System**s, only that protection settings do not aggravate the stress on the **Total System** by tripping before there is a definite need in those circumstances. (For **Medium Power Station**s and **Large Power Station**s, performance requirements are specified in the **Grid Code**). For **Type Tested Generating Units** there are performance requirements and these are specified in section 9.3.7

10.5.2 A LoM protection of RoCoF or vector shift type will generally be appropriate for **Small Power Station**s, but this type of LoM protection must not be installed for **Power Station**s 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 fault ride through capability, especially for larger **Generating Unit**s (except where local auto-reclose dead times are 1s or less as a reclose on to a fault is more likely to destabilise generation that is still recovering stability from the first fault). The overall aim is to ensure that **Generating Plant** is not disconnected from the **Distribution System** unless there is material disturbance on the **Distribution System**, as disconnecting generation unnecessarily will tend to make an under voltage situation worse. To that end, for all **LV** and **HV** connected **Generating Plant** a 2-Stage under voltage protection should be applied as follows:

- Stage 1 should have a setting of -13% (ie 10% to cater for a future **LV** statutory voltage limit and an additional 3% to provide immunity from 3% **Step Voltage Change**s permitted under EREC P28) and a time delay of 2.5s.

- Stage 2 should have a setting of –20% (ie to detect a major **Distribution System** disturbance), with a time delay of 0.5s.

The **Grid Code** calls for fault-ride through capability for **Medium Power Stations** and **Large Power Stations** as there is a more material requirement for such **Generating Unit**s to remain connected to the **Distribution System** save in exceptional circumstances. In this case a single stage with a permitted time delay of 2.5s and a setting of –20% should be applied[6].

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[7] 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 **Customers 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 System** efficiency, it is common for the **HV Distribution System** to be normally operated near to the upper statutory voltage limits. The presence of **Generating Plant** within such **Distribution System**s may increase the risk of the statutory limit being exceeded, eg when the **Distribution System** is operating abnormally. In such cases the **DNO** may specify additional over voltage protection at the **Generating Plant** 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.

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[6] Grid Code CC6.3 provides further details.

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

10.5.5 Over Frequency

The **Grid Code** incorporates a requirement for **Medium Power Station**s and **Large Power Station**s to stay connected for **Total System** frequencies up to 52 Hz so as to provide the necessary regulation to control the **Total System** frequency to a satisfactory level. Similarly, the **Distribution Code** DPC7.4.1.3 has the same requirement for **Small Power Station**s. In order to prevent the unnecessary disconnection of a large volume of smaller **Generating Plant** for all **LV** and **HV** connected **Generating Plant** a 2-stage protection is to be applied as follows:

- Stage 1 should have a time delay of 90s and a setting of 51.5 Hz. The 90s setting should provide sufficient time for the **NETSO** to bring the **Total System** frequency below this level. Should the frequency rise be the result of a genuine islanding condition which the LoM protection fails to detect, this setting will help to limit the duration of the islanding period.

- Stage 2 should have a time delay of 0.5s and a setting of 52 Hz (ie to co-ordinate with the **Grid Code** and **Distribution Code** requirements with a practical time delay that can be tolerated by most **Generating Plant**). If the frequency rise to and above 52 Hz is the result of an undetected islanding condition, the **Generating Plant** will be disconnected with a delay of 0.5s plus circuit breaker operating time.

10.5.6 Under Frequency

The **Distribution Code** DPC7.4.1.3 requires **Small Power Station**s 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 **Generating Plant**, 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 **Generating Plant** during **Distribution System** 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 **Generating Plant** type & rating and **Distribution System** 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	Small Power Station				Medium Power Station	
	LV Protection[$]		HV Protection[$]			
	Setting	Time	Setting	Time	Setting	Time
U/V st 1	Vφ-n[†] - 13% = 200.1V	2.5s*	Vφ-φ[‡] -13%	2.5s*	Vφ-φ[‡]- 20%	2.5s*
U/V st 2	Vφ-n[†] - 20% = 184.0V	0.5s	Vφ-φ[‡] - 20%	0.5s		
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	47Hz	0.5s	47Hz	0.5s	47Hz	0.5s
O/F st 1	51.5Hz	90s	51.5Hz	90s	52Hz	0.5s
O/F st 2	52 Hz	0.5s	52Hz	0.5s		
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees[#]		Intertripping expected	
LoM(RoCoF) <5MW[§]	K2 x 0.125 Hz/s		K2 x 0.125 Hz/s[#]		-	

RoCoF[§] settings for Power Stations ≥5MW				
Date of Commissioning		Small Power Stations		Medium Power Stations
		Asynchronous	Synchronous	
Generating Plant Commissioned before 01/08/14	Settings permitted until 01/08/16	Not to be less than K2 x 0.125 Hz/s[#] and not to be greater than 1Hz/s[¶#], time delay 0.5s	Not to be less than K2 x 0.125 Hz/s[#] and not to be greater than 0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping Expected
	Settings permitted on or after 01/08/16	1Hz/s[¶#], time delay 0.5s	0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping expected
Generating Plant commissioned between 01/08/14 and 31/07/16 inclusive		1Hz/s[¶#], time delay 0.5s	0.5Hz/s[¶# Ω], time delay 0.5s	Intertripping expected
Generating Plant commissioned on or after 01/08/16		1Hz/s[¶#], time delay 0.5s	1Hz/s[¶#], 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 G59 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 G59 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 Station**s connected to a **DNO LV Systems**

‡ 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 **Generating Unit** is permitted to reduce/cease exporting in order to protect the **Generating Unit**.

¶ The required protection requirement is expressed in Hertz per second (Hz/s). The time delay should begin when the measured RoCof exceeds the threshold expressed in Hz/s. The time delay should be reset if measured RoCoF falls below that threshold. The relay must not trip unless the measured rate remains above the threshold expressed in Hz/s continuously for 500ms. 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 500ms if the system RoCoF was significantly higher than the threshold.

Ω The minimum setting is 0.5Hz/s. For overall system security reasons, settings closer to 1.0Hz/s are desirable, subject to the capability of the Generating Plant to work to higher settings.

(2) LOM constants

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

K2 = 1.0 (for low impedance networks) or 1.6 (for high impedance networks)

A fault level of less than 10% of the system design maximum fault level should be classed as high impedance.

For **Type Tested Generating Unit**s K1=2.0 and K2=1.6. 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.

(4) For the purposes of 10.5.7.1 the commissioning date means the date by which the tests detailed in 12.3 and 12.4 of EREC G59/3-2 have been completed to the DNO's satisfaction.

The **Manufacturer** must ensure that the **Interface Protection** in a **Type Tested Generating Unit** 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	Small Power Station			
	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 Stations** connected to a **DNO LV Systems**

‡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 **Generating Plant**. In exceptional circumstances **Generators** have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Generating Plant** 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 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 **Generating Plant** when operating in island mode although different settings may be required.

10.5.12 For **LV** connected **Generating Plant**, the voltage settings will be based on the 230V nominal **System** voltage. In some cases **Generating Plant** 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 **Generating Units** with non-standard **LV** protection settings cannot be **Type Tested** and these will need to be agreed by the **DNO** on a case by case basis.

10.5.13 Co-ordination with existing protection equipment and auto-reclose scheme is also required, as stated in DPC7.4.3 of the **Distribution Code**. In particular the **Generator**'s protection should detect a LoM situation and disconnect the **Generating Plant** 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 auto-reclosers set with a dead time of 3s, this implies a LoM response time of 2.5s. A similar response time is expected from under and over voltage relays. Where auto-reclosers have a dead time of less than 3s, there may be a need to reduce the operating time of under and over voltage relays. For **Type Tested Generating Unit**s no changes are required to the operating times irrespective of the auto-reclose times.

10.5.14 If automatic resetting of the protective equipment is used, as part of an auto-restore scheme for the **Generating Plant**, there must be a time delay to ensure that healthy supply conditions exist for a continuous period of at least 20 s. The automatic reset must be inhibited for faults on the **Generator**'s installation. Staged timing may be required where more than one **Generating Plant** is connected to the same feeder. For **Type Tested Generating Unit**s the time delay is set at 20s.

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.

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

The standard over and under voltage settings for **LV** connected **Generating Units** 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 **Generating Units** connected to the **Customers LV** network. Where a **DNO** provides a connection at **HV** and the **Customers** 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 Station**s 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.

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For example a **Customer** is using a 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.

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

$V_{LVsys} = 230 \times 11000/11550 = 219V$

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 stage 1	=	219x0.87	=	190.5V
UV stage 2	=	219x0.8	=	175V

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

Where **Generating Units** 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 does not lend itself to **Type Tested Generating Unit**s and should only be used by prior arrangement with the host **DNO**. Where all other requirements of EREC G59 would allow the **Generation Unit** 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 **Generating Units** produced for a particular **Power Station** comply with the revised over and under voltage settings. All other required data should be provided as for **Type Tested Generating Unit**s. This declaration should make reference to a particular **Power Station** 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 Station**.

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;

b. A display on an electronic device which can communicate with the **Generating Unit** 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 **Generating Unit**.

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.

10.6 Typical Protection Application Diagrams

This Section provides some typical protection application diagrams in relation to parallel operation of **Generating Plant** with **DNO Distribution System**. The diagrams only relate to **DNO** requirements in respect of the connection to the **Distribution System** and do not necessarily cover the safety of the **Generator**'s installation. The diagrams are intended to illustrate typical installations. The protection arrangements for individual schemes will be agreed between the **Generator** and the **DNO** in accordance with this document.

Figure 10.1 - List of Symbols used in Figures 10.2 to 10.6.

Figure 10.2 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for Parallel Operation Only

Figure 10.3 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.4 - Typical Protection Arrangement for an **LV Generating Unit** Connected to a **DNO HV System** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation

Figure 10.5 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for Parallel Operation Only

Figure 10.6 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** 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 System**, 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 System** 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.

Figure 10.1 - List of Symbols in Figures 10.2 – 10.6

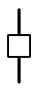
BEF	Balanced Earth Fault
CC	Circulating Current
3DOCI	3 Pole Directional Overcurrent (IDMT)
EI	Earth Fault (IDMT)
LOM	Loss of Mains
M	Metering
NVD	Neutral Voltage Displacement
3OCI	3 Pole Overcurrent (IDMT)
OF UF	Single Stage Over Frequency & Single Stage Under Frequency
OV UV	Single Stage Over Voltage & 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

Figure 10.2 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for Parallel Operation Only

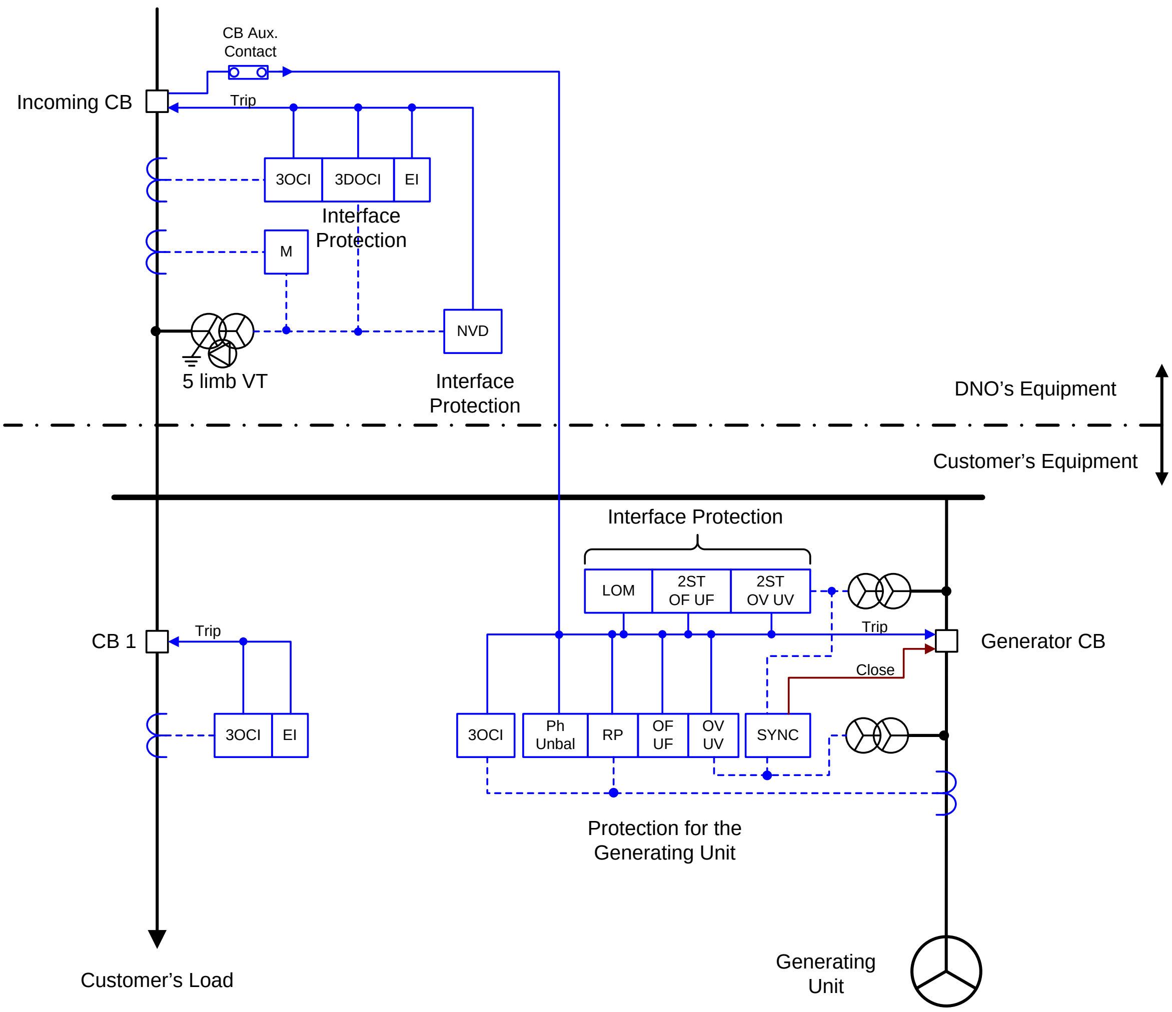


Figure 10.3 - Typical Protection Arrangement for an **HV Generating Unit** Connected to a **DNO HV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation

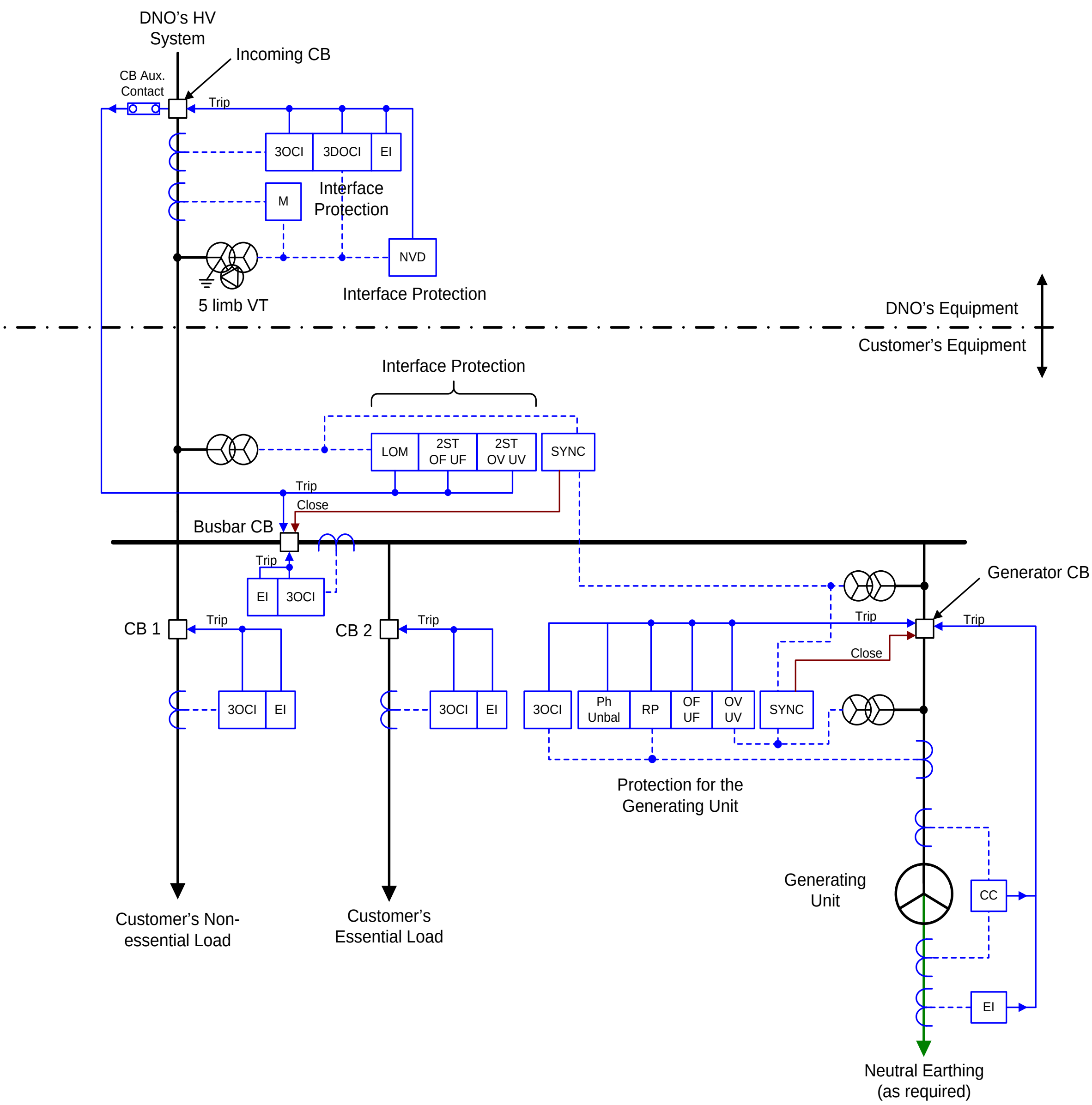


Figure 10.4 - Typical Protection Arrangement for an **LV Generating Unit** Connected to a **DNO HV System** and designed for both Independent Operation (ie Standby Operation) and Parallel Operation..

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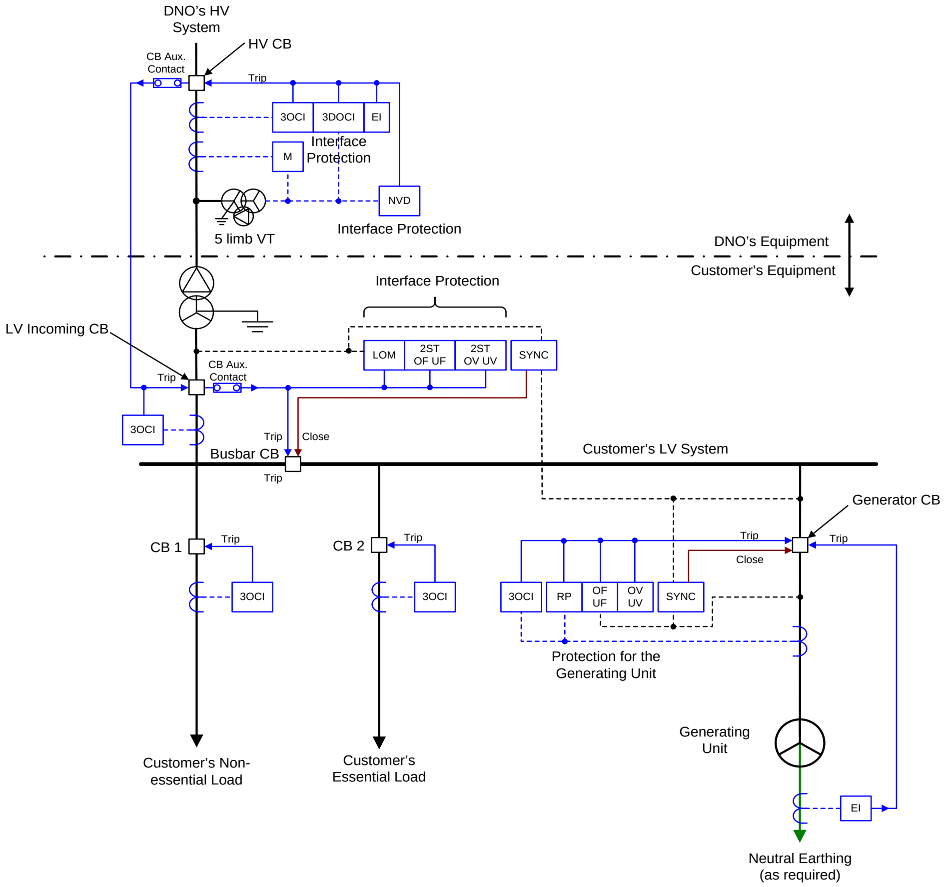


Figure 10.5 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for Parallel Operation Only

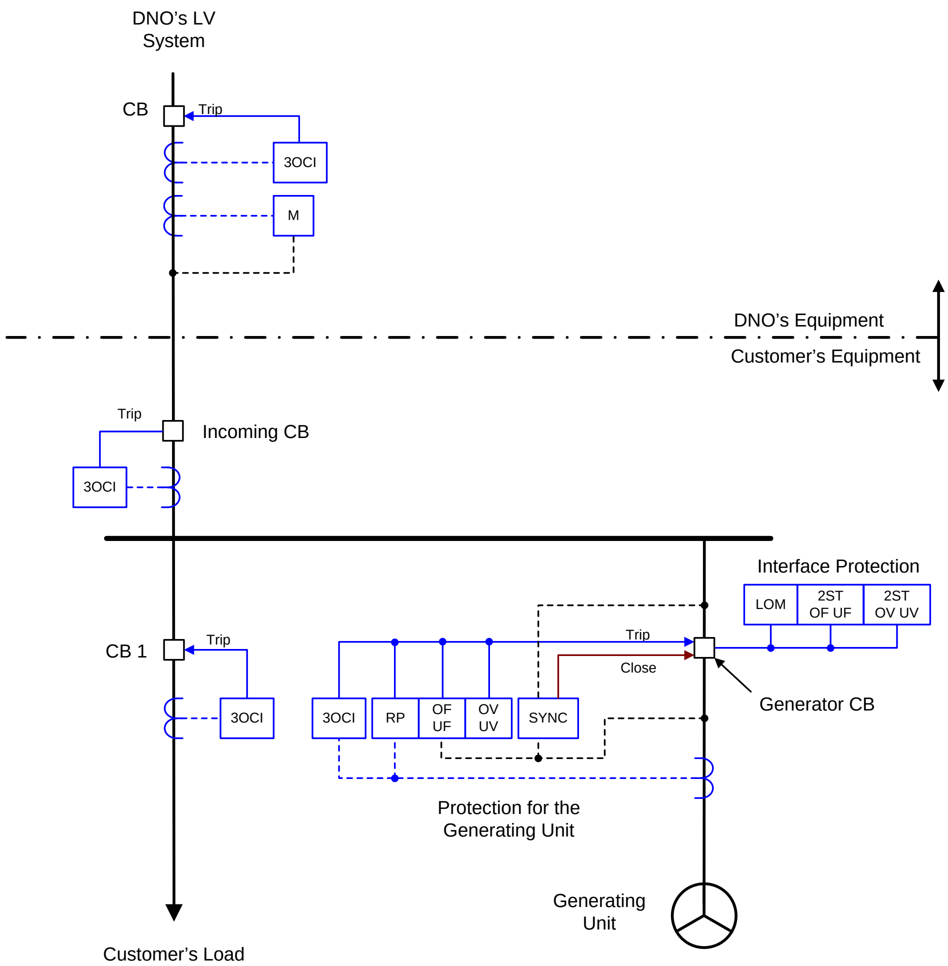
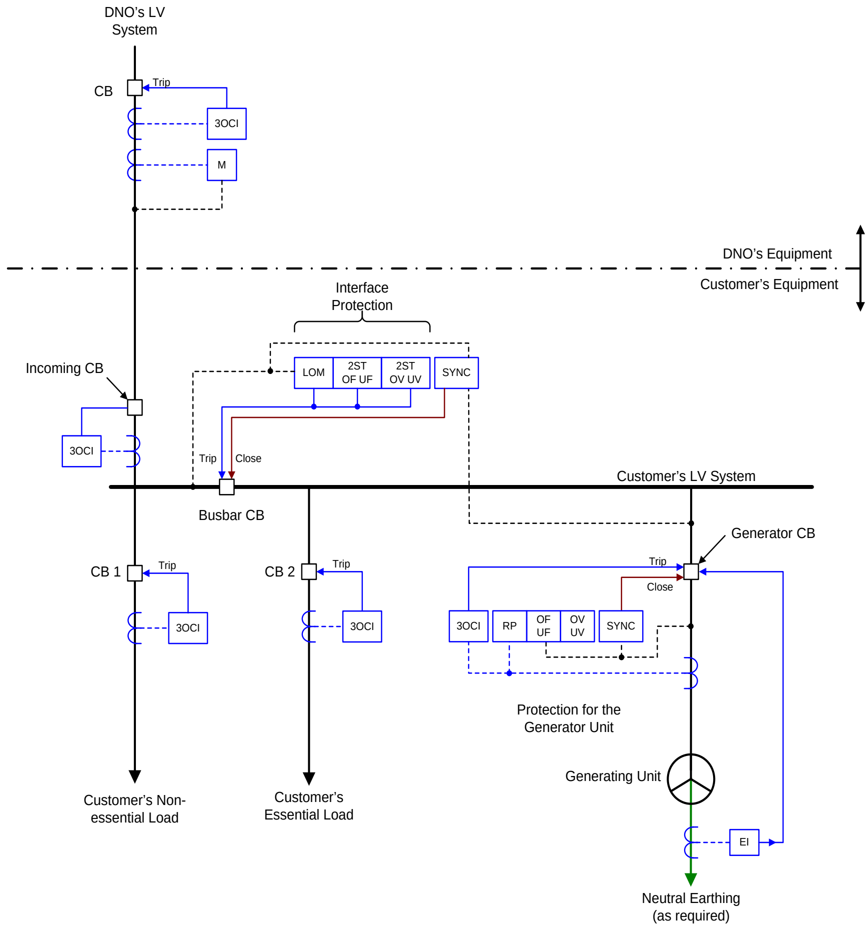


Figure 10.6 - Figure 10.6 - Typical Protection Diagram for an **LV Generating Unit** Connected to a **DNO LV System** Designed for both Independent Operation (ie Standby Operation) and Parallel Operation



11 INSTALLATION, OPERATION AND CONTROL INTERFACE

11.1 General

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 **Generating Plant** in compliance with this EREC. Ideally they should have recognised and approved qualifications relating to the fuel / energy sources and general electrical installations[8].

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 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 System** and give rise to danger.

11.1.4 No parameter relating to the electrical connection or setting that is subject to **Type Tested** certification shall be modified as part of or after the installation process unless previously agreed in writing between the **DNO** and the **Generator.** User access to change such parameters shall be prevented by the use of sealing plugs / paper seals / passwords etc.

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 System**, where appropriate;

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;

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8 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

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.

The use of **Type Tested Generating Unit**s for **Power Stations** of up to 50kW (3 phase) or 17kW (1 phase) is deemed to cover this requirement.

11.1.6 The **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 Generating Plant**s and also **Generating Plant**s connected to **LV Distribution System**s supplied indirectly by **HV** overhead lines.

11.2 Isolation and Safety Labelling

11.2.1 Every installation or system which includes **Generating Plant** operating in parallel with the **Distribution System** must include a means of isolation capable of disconnecting the whole of the **Generating Plant**[9] infeed to the **Distribution System.** This equipment will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

11.2.2 The **Generator** must grant the **DNO** rights of access to the means of isolation In accordance with DPC7.2 of the **Distribution Code**.

11.2.3 To ensure that **DNO** staff and that of the User and their contractors are aware of the presence of **Generating Plant**, appropriate warning labels should be used.

11.2.4 Where the installation is connected to the **DNO LV Distribution System** 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 **Generating Plant.** 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.

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[9] Where the generating plant 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 generating plant. See also Figure 8.7 and 8.9

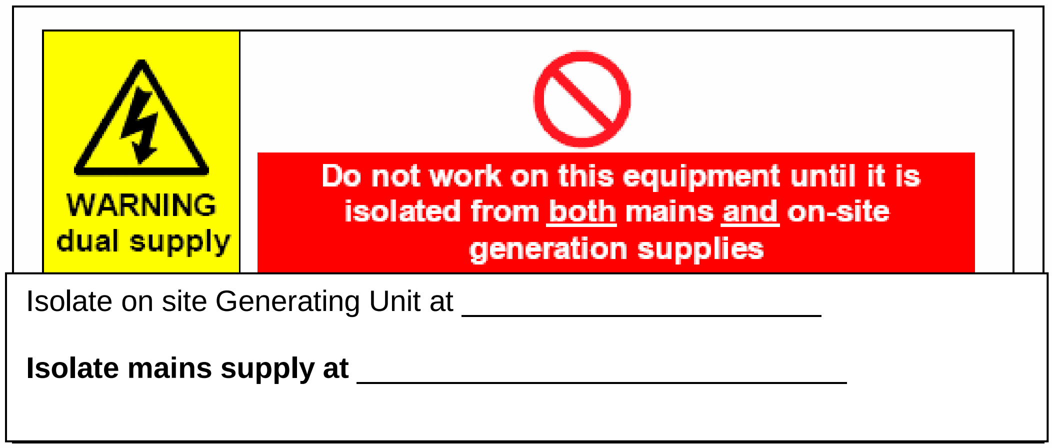


Figure 11.1 Warning label

11.2.5 Where the installation is connected to the **DNO HV Distribution System** 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 **Generating Unit**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.

11.3 Site Responsibility Schedule

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 System** and the **Generating Plant**, 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**. Where the **Power Station** has a total capacity of 50kW or 17kW per phase or less and is connected at **LV** then only compliance with section 11.3.3 is required.

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 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 In the case of a **LV** connected **Generating Plant,** a simple diagram located at the **Point of Supply** may be sufficient. The scope of the diagram should cover the **Distribution System**, **Customer**'s **installation** and the **Generating Plant** 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.

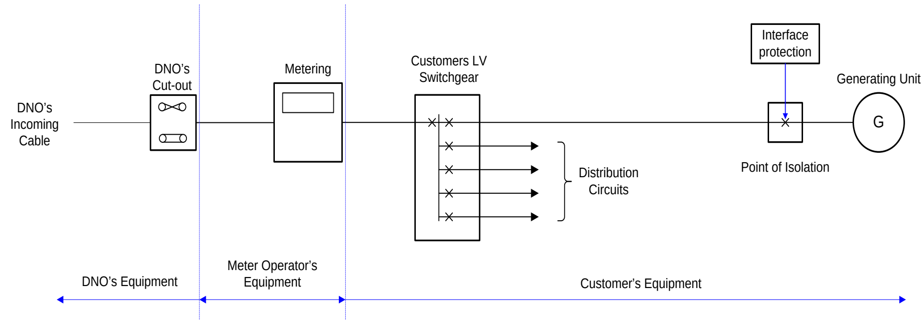


Fig 11.2 – Example of a Operational Diagram

11.3.4 In the case of an **HV** connected **Generating Plant** the diagram is likely to be more complex and contain more detailed information.

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 Operational and Safety Aspects

11.4.1 Where the **Point of Supply** provided by the **DNO** for parallel operation is at **HV**, 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 **Generating Plant** which have caused, or might cause, disturbance to the **Distribution System**, 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 For certain **Generating Plant** 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 System** to ensure stability of the local **Distribution System**. The **DNO** may require agreement on specific written procedures to control the bringing on and taking off of such **Generating Plant**. The action within these procedures will normally be controlled by the **DNO**s Control Engineer.

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 Synchronizing and Operational Control

11.5.1 Before connecting two energised electrical systems, for example a **Distribution System** and **Generating Plant**, it is necessary to synchronise them by minimising their voltage, frequency and phase differences.

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 Automatic synchronising equipment will be the norm which, by control of the **Generating Unit**'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.

11.5.4 The facility to use the **DNO**s circuit breaker manually for synchronizing can only be used with the specific agreement of the **DNO**.

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.

11.5.7 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.

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 **Generator** requires his **Generating Plant** to continue to supply a temporarily disconnected section of the **Distribution System** in island mode**,** the special arrangements necessary will need to be discussed with the **DNO**.

12 TESTING AND COMMISSIONING

12.1 General

12.1.1 A brief summary of generic requirements related to connection application, notification of commissioning and commissioning test requirements for **Power Stations** and **Generating Unit**s are given in Section 6.1. This section provides further details on the testing, commissioning and witnessing requirements.

12.1.2 General procedural issues, including the requirements for witnessing the commissioning tests and checks are described in Section 12.2.

12.1.3 The requirements for the tests and checks themselves are divided into two parts. Section 12.3 specifies the commissioning tests and checks that shall be carried out at all **Power Stations** irrespective of whether the **Generating Unit**s have been **Type Tested** to EREC G59 or EREC G83 or not. Section 12.4 specifies additional requirements for **Generating Unit**s have not been **Type Tested** to EREC G59 or EREC G83.

12.1.4 It is the responsibility of the **Installer** to undertake these commissioning tests / checks and to ensure the **Power Station** and **Generating Unit**s meet all the relevant requirements.

12.1.5 In addition to the commissioning tests and checks required under EREC G59, further tests may be required by the **Manufacturer**, supplier or **Installer** of the **Generating Unit**s or may be required to satisfy legislation and other standards.

12.2 Procedures and Witnessing Requirements

12.2.1 The DNO may decide to witness the **Power Station** and **Generating Unit** 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 Where the **Power Station** capacity is no higher than 50kW 3 phase (17kW 1 phase), the **Generating Unit**s have been type tested to EREC G59 or EREC G83 and they are connected to the **DNO**'s network at **Low Voltage**, the **DNO** will not normally witness the commissioning checks and tests. In such cases, where the **DNO** does decide to witness they will advise this as part of the connection offer. Reasons for witnessing such installations may include:

a. A new **Installer** with no track record in the **DNO** area.
b. A check on the quality of an installation either on a random basis or as a result of problems that have come to light at previous installations.

12.2.3 Where the **Power Station** includes **Generating Unit**s that have not been **Type Tested** or the **Power Station** capacity is greater than 50kW 3 phase (17kW 1 phase) or the **Power Station** is connected at **High Voltage** the **DNO** will normally decide to witness the commissioning checks and tests. In such cases the Installer shall make arrangements for the **DNO** to witness the commissioning tests unless otherwise agreed with the **DNO**.

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.

12.3 Commissioning Tests / Checks required at all Power Stations

12.3.1 The following tests and checks shall be carried out by the Installer at all **Power Stations** and on all **Generating Unit**s irrespective of whether they have been **Type Tested** or not:

a. Inspect the **Power Station** 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 **Generating Unit**s and the rest of the installation.

c. Check that safety labels have been installed in accordance with clause 11.2 of EREC G59;

d. Check interlocking operates as required. Interlocking should prevent **Generating Unit**s being connected to the **DNO** system without being synchronised;

e. Check that the correct protection settings have been applied (in accordance with EREC G59 clause 10.5.7.1);

f. Complete functional tests to ensure each **Generating Unit** synchronises with, and disconnects from, the **DNO**s **System** successfully and that it operates without tripping under normal conditions;

g. After all other tests have been completed successfully (including where required additional tests for non type tested equipment) carry out a functional test to confirm that the **Interface Protection** operates and trips each **Generating Unit** when supplies are disconnected between the **Generating Unit** and the **DNO**s **System**.

1. This test may be carried out by opening a suitably rated switch (not the one expected to open for a protection operation) between the **Generating Unit** and the **DNO**s **Point of Supply** and checking that the **Generating Unit** disconnects quickly (eg within 1s);

2. Alternatively, the test may be carried out by removing one or all of the voltage sensing supplies to the protection relay and checking that the **Generating Unit** disconnects quickly (eg within 1s);

h. Check that once the phases are restored following the functional test described in (g) at least 20s elapses before the **Generating Unit**s re-connect.

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 **Generating Units** are installed in different phases), when that part of the installation has been completed. The results of these tests shall be recorded on the commissioning form included in Appendix 13.2. 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).

12.4 Additional Commissioning requirements for Non Type Tested Generating Units

12.4.1 Additional commissioning tests are required for **Generating Units** that have not been **Type Tested** to EREC G59 or EREC G83 or a later version. 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 results of these tests shall be recorded in the schedule provided in Appendix 13.2 and 13.3 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 for each phase, as described below:

(i) The operating voltage shall be 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 13.3. 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:

(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% (ie 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 13.3. 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 0.025Hzs^{-1} or less) 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 0.025Hz per second of the required setting.

(ii) Timing tests shall be carried out by applying a falling and a rising frequency at rate of 0.05Hzs^{-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 (eg starting at 4 degrees). The test shall be repeated with increasing vector shift values (in increments of 1 degree or less) until the pickup value is determined. The tests shall be carried out for both leading and lagging shifts in the voltage vector.

(ii) Timing tests shall be carried out by applying a vector shift of 3 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 irespective of the type of loss of mains protection employed for a particular **Generating Unit** or **Power Station**.

12.4.2 It may be necessary for undertake ad-hoc testing to determine[10], 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 Station**s and to confirm that they remain within the statutory limits.

12.5 Periodic Testing

12.5.1 The **Interface Protection** shall be tested by the **Generator** at intervals to be agreed with the **DNO.**

12.6 Changes at the Installation

12.6.1 If during the lifetime of the **Generating Plant** it is necessary to replace a major component of a **Generating Unit** or its protection system, it is only necessary to notify the **DNO** if the operating characteristics of the **Generating Plant** or the protection have been altered when compared against that which was originally commissioned.

12.6.2 In the event that **Generating Plant** is to be decommissioned and will no longer operate as a source of electrical energy in parallel with the **Distribution System**, the **Generator** shall notify the **DNO** by providing the information as detailed in Appendix 13.4. Where the presence of **Generating Plant** is indicated in a bespoke **Connection Agreement**, it will be necessary to amend the **Connection Agreement** appropriately.

12.6.3 Where one or more **Generating Unit**s are to be added or replaced at an existing **Power Station** installed under an earlier version of EREC G59, EREC G83 or the **Distribution Code**, it is not necessary to modify the other existing **Generating Units** 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 Substation above the 16A per phase threshold. For example, if a new 3kW one phase **Generating Unit** is added to an existing **Power Station** comprising an existing 3kW 1 phase **Generating Unit** complying with EREC G83/1-1, this increases the capacity of the **Power Station** from 3kW (13.04A per phase) to 6kW (26.08A per phase). In this case the new **Generating Unit** will either have to comply with EREC G59/3 or EREC G83/2 (as amended) but the existing **Generating Unit** will not need to be modified.

12.6.4 If a **Generating Unit** is changed at a **Power Station** the replacement must comply with the current version of EREC G59 or EREC G83, as applicable.

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

13 APPENDICES

Appendix	Application	Form Title
13.1	Type Testing a **Generating Unit** (>16A per phase but ≤ 50kW 3 phase or 17kW 1 phase.	**Generating Unit** Type Test Sheet **Type Tested Generating Unit**(>16A per phase but ≤ 50 kW 3 phase or 17 kW 1 phase)
13.2	Comissioning a **Power Station** comprising only **Type Tested Generating Units**	**Generating Plant** Installation & Commissioning Confirmation
13.3	Commissioning a **Power Station** comprising one or more non-**Type Tested Generating Units** (Appendix applicable in addition to Appendix 13.2)	**Generating Plant** Installation & Commissioning Tests (Additional commissioning test requirements for non-type tested **Generating Units**)
13.4	Decommissioning of any **Generating Unit**	**Generating Plant** Decommissioning Confirmation
13.5	Connection application for a **Type Tested Generating Unit** in a new or existing installation where the aggregate installed capacity of the **Power Station** will be 50kW or 17kW per phase or less comprising only of **Type Tested Generating Units.** Note for all other **Power Stations** the **DNOs** common application form shall be used.	Application for connection of **Type Tested Generating Unit(**s) with Total Aggregate **Power Station** Capacity < 50kW 3-Phase, or <17kW Single Phase
13.6	Additional Information Relating to System Stability Studies	
13.7	Loss of Mains Protection Analysis	
13.8	Type Testing of **Generation Units** of 50kW three phase, or 17kW per	

	phase or less. Guidance for **Manufacturers**	
13.9	Main Statutory and other Obligations	
13.10	Guidance on acceptable unbalance between phases in a **Power Station**	
13.11	Guidance on Risk Assessment when using RoCoF LoM Protection for **Power Stations** in the 5MW to 50MW range	

13.1 Generating Unit Type Test Sheet

Type Tested Generating Unit(>16A per phase but ≤ 50 kW 3 phase or 17 kW 1 phase)

TYPE TEST SHEET

<table>
<tr><td colspan="4">This Type Test sheet shall be used to record the results of the type testing of Generating Unit between 16A per phase and 17kW per phase maximum output at 230V (17kW limit single phase, 34kW limit split phase, 50kW limit 3 phase)

It includes the Generating Units supplier declaration of compliance with the requirements of Engineering Recommendation G59/3</td></tr>
<tr><td colspan="2">Type Tested reference number</td><td colspan="2"></td></tr>
<tr><td colspan="2">Generating Unit technology</td><td colspan="2"></td></tr>
<tr><td colspan="2">System supplier name</td><td colspan="2"></td></tr>
<tr><td colspan="2">Address</td><td colspan="2"></td></tr>
<tr><td>Tel</td><td></td><td>Fax</td><td></td></tr>
<tr><td>E:mail</td><td></td><td>Web site</td><td></td></tr>
<tr><td rowspan="4">Maximum export capacity, use separate sheet if more than one connection option.</td><td></td><td colspan="2">kW single phase, single, split or three phase system</td></tr>
<tr><td></td><td colspan="2">kW three phase</td></tr>
<tr><td></td><td colspan="2">kW two phases in three phase system</td></tr>
<tr><td></td><td colspan="2">kW two phases split phase system</td></tr>
<tr><td colspan="4">System supplier declaration. - I certify on behalf of the company named above as a supplier of a Generating Unit, that all products supplied by the company with the above Type Test reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the product meets all the requirements of EREC G59/3.</td></tr>
</table>

Signed		On behalf of	
Note that testing can be done by the manufacturer of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate. Where parts of the testing are carried out by persons or organisations other than the supplier then the supplier shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.			

Power Quality. Harmonics. These tests should be carried out as specified in 61000-3-12 or 61000-3-2. Only one set of tests is required and the **Manufacturer** should decide which one to use and complete the relevant table. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of maximum export capacity.

The test should be carried out on a single **Generating Unit.** The results need to comply with the limits of table 2 of BS EN 61000-3-12 for single phase equipment, to table 3 of BS EN 61000-3-12 for three phase equipment or to table 1 of BS EN 61000-3-2 if that standard is used.

Note that Generating Units meeting the requirements of BS EN 61000-3-2 will need no further assesment with regards to harmonics. Generating Units with emissions close to the limits laid down in BS EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the **Generating Unit** in order to accept the connection to a **DNO**'s network.

Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)				kVA	Harmonic % =Measured Value (Amps) x 23/rating per phase (kVA)	
Harmonic	At 45-55% of rated output		100% of rated output		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2					8%	8%
3					21.6%	Not stated
4					4%	4%

5						10.7%	10.7%
6						2.67%	2.67%
7						7.2%	7.2%
8						2%	2%
9						3.8%	Not stated
10						1.6%	1.6%
11						3.1%	3.1%
12						1.33%	1.33%
13						2%	2%
THD						23%	13%
PWHD						23%	22%

Generating Unit tested to BS EN 61000-3-2						
Generator Unit rating per phase (rpp)			kW			
Harmonic	At 45-55% of rated output		100% of rated output			
	Measured Value MV in Amps		Measured Value MV in Amps		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above

2					1.080	
3					2.300	
4					0.430	
5					1.140	
6					0.300	
7					0.770	
8					0.230	
9					0.400	
10					0.184	
11					0.330	
12					0.153	
13					0.210	
14					0.131	
15					0.150	

16					0.115	
17					0.132	
18					0.102	
19					0.118	
20					0.092	
21					0.107	0.160
22					0.084	
23					0.098	0.147
24					0.077	
25					0.090	0.135
26					0.071	
27					0.083	0.124
28					0.066	
29					0.078	0.117

30					0.061	
31					0.073	0.109
32					0.058	
33					0.068	0.102
34					0.054	
35					0.064	0.096
36					0.051	
37					0.061	0.091
38					0.048	
39					0.058	0.087
40					0.046	
Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.						

Power Quality. Voltage fluctuations and Flicker. The tests should be carried out on a single **Generating Unit.** Results should be normalised to a standard source impedance or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

	Starting			Stopping			Running	
	d max	d c	d(t)	d max	d c	d(t)	P st	P lt 2 hours
Measured Values at test impedance								
Normalised to standard impedance								
Normalised to required maximum impedance								
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R		Ω	Xl		Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	Xl	0.15 * 0.25 ^	Ω
Maximum Impedance	R		Ω	Xl		Ω

* Applies to three phase and split single phase **Generating Unit**s

^ Applies to single phase **Generating Unit**s and **Generating Unit**s using two phases on a three phase system

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0.98 or above.

Normalised value = Measured value*reference source resistance/measured source resistance at test point

Single phase units reference source resistance is 0.4 Ω

Two phase units in a three phase system reference source resistance is 0.4 Ω

Two phase units in a split phase system reference source resistance is 0.24 Ω

Three phase units reference source resistance is 0.24 Ω

Where the power factor of the output is under 0.98 then the Xl to R ratio of the test impedance

should be close to that of the Standard Impedance. The stopping test should be a trip from full load operation. The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below			
Test start date		Test end date	
Test location			

Power quality. DC injection. The tests should be carried out on a single **Generating Unit** Tests are to be carried out three power defined levels ±5%. At 230V a 2kW single phase inverter has a current output of 8.7A so DC limit is 21.75mA, a 10kW three phase inverter has a current output of 43.5A at 230V so DC limit is 108.75mA				
Test power level	10%	55%	100%	
Recorded value in Amps				
as % of rated AC current				
Limit	0.25%	0.25%	0.25%	

Power Quality. Power factor. The tests should be carried out on a single Generating Unit. Testa are to be carried out at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.				
	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within + or – 1.5% of the stated level during the test.
Measured value				
Limit	>0.95	>0.95	>0.95	

Protection. Frequency tests						
Function	Setting		Trip test		"No-trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
O/F stage 1	51.5Hz	90s			51.3Hz 95s	
O/F stage 2	52Hz	0.5s			51.8Hz 89.98s	
					52.2Hz 0.48s	
U/F stage 1	47.5Hz	20s			47.7Hz 25s	
U/F stage 2	47Hz	0.5s			47.2Hz 19.98s	
					46.8 Hz 0.48s	
Note. For frequency Trip tests the Frequency required to trip is the setting ± 0.1Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used.. The "No-trip tests" need to be carried out at the setting ± 0.2Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Protection. Voltage tests						
Function	Setting		Trip test		"No trip-tests" All phases at same voltage	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
O/V stage 1	262.2V	1.0s			258.2V 2.0 sec	
O/V stage 2	273.7V	0.5s			269.7V 0.98s	

					277.7V 0.48s	
U/V stage 1	200.1V	2.5s			204.1V 3.5s	
U/V stage 2	184V	0.5s			188V 2.48s	
					180v 0.48 sec	
Note. For voltage tests the voltage required to trip is the setting plus or minus 3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the projection. The No-trip tests need to be carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

a) Protection. Loss of Mains test and single phase test. The tests are to be To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.						
To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of **Generating Unit** output	95% of **Generating Unit** output	95% of **Generating Unit** output	105% of **Generating Unit** output	105% of **Generating Unit** output	105% of **Generating Unit** output
Trip time. Limit is 0.5s						
Note. For technologies which have a substantial shut down time this can be added to the 0.5s in establishing that the trip occurred in less than 0.5s maximum. Shut down time could therefore be up to 1.0s for these technologies.						
Indicate additional shut down time included in above results						s
Note as an alternative, inverters can be tested to BS EN 62116. The following sub set of tests should be recorded in the following table.						
Test Power and	33%	66%	100%	33%	66%	100%

imbalance	-5% Q Test 22	-5% Q Test 12	-5% P Test 5	+5% Q Test 31	+5% Q Test 21	+5% P Test 10
Trip time. Limit is 0.5s						

Single phase test for multi phase **Generating Units**. Confirm that when generating in parallel with a network operating at around 50Hz with no network disturbance, that the removal of a single phase connection to the **Generating Unit**, with the remaining phases connected causes a disconnection of the generating unit within a maximum of 1s.						
	Ph1 removed	Confirm Trip	Ph2 removed	Confirm Trip	Ph3 removed	Confirm Trip

b) Protection. Frequency change, Stability test				
	Start Frequency	Change	End Frequency	Confirm no trip
Positive Vector Shift	49.5Hz	+9 degrees		
Negative Vector Shift	50.5Hz	- 9 degrees		
Positive Frequency drift	49.5Hz	$+0.19Hzs^{-1}$	51.5Hz	
Negative Frequency drift	50.5Hz	$-0.19Hzs^{-1}$	47.5Hz	

c) **Protection. Re-connection timer**. The tests should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Test should prove that the reconnection sequence starts in no less than 20s for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1					
Time delay setting (s)	Measured delay (s)	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 10.5.7.1.			
		At 266.2V	At 196.1V	At 47.4Hz	At 51.6Hz
Confirmation that the **Generating Unit** does not re-connect					

d) Fault level contribution.					
For machines with electro-magnetic output			For Inverter output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p		20ms		
Initial Value of aperiodic current	A		100ms		
Initial symmetrical short-circuit current*	I_k		250ms		
Decaying (aperiodic) component of short circuit current*	i_{DC}		500ms		
Reactance/Resistance Ratio of source*	$^X/_R$		Time to trip		In seconds
For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **Generating Unit** terminals. * Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot					

e) Self Monitoring solid state switching	Yes/NA
It has been verified that in the event of the solid state switching device failing to disconnect the **Generating Unit**, the voltage on the output side of the switching device is reduced to a value below 50 Volts within 0.5 seconds	

Additional comments

13.2 Generating Plant Installation and Commissioning Confirmation

<table>
<tr><th colspan="10">Commissioning Confirmation Form for all Installations</th></tr>
<tr><td colspan="10">To ABC electricity distribution
99 West St, Imaginary Town, ZZ99 9AA
DNO or IDNO
abced@wxyz.com</td></tr>
<tr><td colspan="10">Installer or Generator Details :</td></tr>
<tr><td>Installer</td><td colspan="9"></td></tr>
<tr><td>Accreditation/Qualification</td><td colspan="9"></td></tr>
<tr><td>Address</td><td colspan="9"></td></tr>
<tr><td>Post Code</td><td colspan="9"></td></tr>
<tr><td>Contact person</td><td colspan="9"></td></tr>
<tr><td>Telephone Number</td><td colspan="9"></td></tr>
<tr><td>E-mail address</td><td colspan="9"></td></tr>
<tr><td colspan="10">Installation Details</td></tr>
<tr><td>Site Contact Details</td><td colspan="9"></td></tr>
<tr><td>Address</td><td colspan="9"></td></tr>
<tr><td>Post Code</td><td colspan="9"></td></tr>
<tr><td>Site Telephone Number</td><td colspan="9"></td></tr>
<tr><td>MPAN(s)</td><td colspan="9"></td></tr>
<tr><td>Location within Customer’s Installation</td><td colspan="9"></td></tr>
<tr><td>Location of Lockable Isolation Switch</td><td colspan="9"></td></tr>
<tr><td colspan="10">Details of Generating Unit(s) - where applicable</td></tr>
<tr><td rowspan="3">Manufacturer / Reference</td><td rowspan="3">Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">G83 / G59</td><td rowspan="3">Type Test Ref No.</td><td colspan="5">Generating Unit installed capacity in kW</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Information to be enclosed	
Description	Confirmation
Final copy of circuit diagram	Yes / No*
Generating Unit Type Test Reference Number, or for **Generating Units** not yet listed on the ENA web site a completed **Generating Unit** 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 **Generating Units** 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 **Generating Unit**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*
Generating Units successfully synchronise with the **DNO** system without causing significant voltage disturbance.	Yes / No*
Generating Units successfully run in parallel with the DNO system without tripping and without causing significant voltage disturbances.	Yes / No*
Generating Units successfully disconnect without causing a significant voltage disturbance, when they are shut down.	Yes / No*
Interface Protection operates and disconnects the **Generating Unit**s quickly (within 1s) as required by section 12.3.1 (g)	Yes / No*
Generating Unit(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 **Generating Unit** lockout or an alarm to a 24hr manned control centre.	Yes / No*
Balance of Multiple Single Phase Generating Units 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 Stations under 50kW or by the Generator for Power Stations above 50kW	
I declare that the **Generating Unit**s and the installation which together form a **Power Station** at the above address, comply with the requirements of EREC G59/3 and the commissioning checks have been successfully completed. *The **Power Station** comprises only **Generating UnitsType Tested** to EREC G59 or EREC G83/2 or later, or *part or all of this **Power Station** contains **Generating Units** not **Type Tested** to EREC G59 or EREC G83 and the **Generating Plant** 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 Station** is deemed to have failed the commissioning tests and the **Generating Units** shall not be put in service.

13.3 Generating Plant Installation and Commissioning Tests

Commissioning test requirements for non-Type Tested Generating Units 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 - step from 230V to test value**				
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

Overvoltage test - Voltage shall be stepped from 258V to the test voltage and held for the test duration and then stepped back to 258V.

Undervoltage test – Voltage shall be stepped from 204.1V to the test voltage and held for the test duration and then stepped back to 204.1V

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 (**Secondary voltages are indicated for convenience, where different VT nominal outputs are present these values should be re-calculated using an appropriate ratio**)**							
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
51.5Hz	90s	*51.40*		*51.60*	Pass/Fail	51.2-51.8Hz	*90.0s*		*90.9s*	Pass/Fail
Stage 2 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*	Pass/Fail	51.7-52.3Hz	*0.50s*		*0.60s*	Pass/Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5Hz	20s	*47.40*		*47.60*	Pass/Fail	47.8-47.2Hz	*20.0s*		*20.2s*	Pass/Fail
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47Hz	0.5s	*46.90*		*47.1*	Pass/Fail	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	51.5Hz	90s	> OF Stage 1	51.7Hz	89.0s		Pass/Fail
Stage 2 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

Overfrequency test - Frequency shall be stepped from 51.3Hz to the test frequency and held for the test duration and then stepped back to 51.3Hz.

Underfrequency test - Frequency shall be stepped from 47.1Hz to the test frequency and held for the test duration and then stepped back to 47.1Hz

Additional Comments / Observations:

Note that the table below applies to Power Stations less than 5 MW capacity.

The DNO will be able to provide, on request, corresponding figures for Power Stations of 5MW and above.

Loss-of-Mains (LOM) Protection Tests – RoCoF for Power Stations <5MW								
Calibration and Accuracy Tests								
Ramp in range 49.5-50.5Hz	**Pickup (**+ / -0.025Hzs^{-1})				**Time Delay** RoCoF = **+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	*0.1* *0.175*		*0.15* *0.225*	Pass/Fail	0.175 Hzs^{-1} 0.25 Hzs^{-1}		*<0.5s*	Pass/Fail
Reducing Frequency	*0.1* *0.175*		*0.15* *0.225*	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 0.075 Hzs^{-1} or ROCOF - 0.05 Hzs^{-1} = ____________		5.0s			Pass/Fail
Inside Normal band	< RoCoF (reducing f)				5.0s			Pass/Fail
Additional Comments / Observations:								

Loss-of-Mains (LOM) Protection Tests - Vector Shift

Calibration and Accuracy Tests

Vector Shift	**Pickup** (± 1.5 degree)				**Time Delay** Vector shift = 3 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	*4.5* *10.5*		*7.5* *13.5*	Pass/Fail	9 deg 15 deg		*<0.5s*	Pass/Fail
Vector Shift : Leading Angle	*4.5* *10.5*		*7.5* *13.5*	Pass/Fail	9 deg 15 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 4 degrees or vector shift -2 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

<table>
<tr><th colspan="2">Declaration – to be completed by Generator or Generators Appointed Technical Representative.</th></tr>
<tr><td colspan="2">I declare that the Generating Unit and the installation comply with the requirements of EREC G59/3 and the additional commissioning checks noted above have been successfully completed in addition to those required for all Generating Unit installations (see Appendix 13.2)</td></tr>
<tr><td>Signature:</td><td>Date:</td></tr>
<tr><td colspan="2">Position.</td></tr>
<tr><th colspan="2">Declaration – to be completed by DNO Witnessing Representative</th></tr>
<tr><td colspan="2">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</td></tr>
<tr><td>Signature:</td><td>Date:</td></tr>
</table>

13.4 Generating Plant Decommissioning Confirmation

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

Site Details	
Site Address (inc. post code)	
Telephone number	
MPAN(s)	
Distribution Network Operator (DNO)	
Generating Plant Details	
Manufacturer and model type	
Serial number of each **Generating Unit**	
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:

13.5 Application for connection of Type Tested Generating Units with total aggregate Power Station capacity <50kW 3 phase or 17kW single phase.

<table>
<tr><td colspan="10">Application for Connection of Type Tested Generating Unit(s)
with Total Aggregate Capacity < 50kW 3-Phase, or <17kW Single Phase</td></tr>
<tr><td colspan="10">To ABC electricity distribution DNO or IDNO
99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com</td></tr>
<tr><td colspan="10">Installer or Generator Details :</td></tr>
<tr><td>Installer or Generator.</td><td colspan="9"></td></tr>
<tr><td>Accreditation/Qualification</td><td colspan="9"></td></tr>
<tr><td>Address</td><td colspan="9"></td></tr>
<tr><td>Post Code</td><td colspan="9"></td></tr>
<tr><td>Contact person</td><td colspan="9"></td></tr>
<tr><td>Telephone Number</td><td colspan="9"></td></tr>
<tr><td>E-mail address</td><td colspan="9"></td></tr>
<tr><td colspan="10">Installation Details</td></tr>
<tr><td>Address</td><td colspan="9"></td></tr>
<tr><td>Post Code</td><td colspan="9"></td></tr>
<tr><td>MPAN(s)</td><td colspan="9"></td></tr>
<tr><td colspan="10">Details of Existing Generating Unit(s) - where applicable</td></tr>
<tr><td rowspan="3">Manufacturer / Reference</td><td rowspan="3">Approximate Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">G83 / G59</td><td rowspan="3">Type Test Ref No. if available</td><td colspan="5">Generating Unit installed capacity kW</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="10">Details of Proposed Additional Generating Unit(s):</th></tr>
<tr><td rowspan="3">Manufacturer / Reference</td><td rowspan="3">Proposed Date of Installation</td><td rowspan="3">Technology Type</td><td rowspan="3">G83 / G59</td><td rowspan="3">Type Test
Ref No.</td><td colspan="5">Generating Unit installed capacity kW</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td><td rowspan="2">Power Factor</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="10">Balance of Multiple Single Phase Generating Units – where applicable</th></tr>
<tr><td colspan="10">I confirm that design of the complete installation has been carried out to limit output power imbalance to below 16A/phase, as required by EREC G59</td></tr>
<tr><td colspan="6">Signed :</td><td colspan="4">Date :</td></tr>
</table>

Use continuation sheet where required.

Record **Generating Unit** capacities, in rated output kW at 230V AC, to one decimal place, under PH1 for single phase supplies and under the relevant phase for two and three phase supplies.

Detail on a separate sheet if there are any proposals to limit export to a lower figure than the aggregate rating of all **Generating Units** in the **Power Station**

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 **Generating Plant** 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 (eg 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 **Generating Plant**. If following a disturbance the system is unstable, it will usually experience a progressive increase in angular separation of synchronous **Generating Units'** rotors from the system, or an_uncontrolled increase in the speed of asynchronous **Generating Units'** 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 **Generating Unit**s to remain in **Synchronism** after being subjected to a disturbance, either small or large. Loss of **Synchronism** can occur between one synchronous **Generating Plant** and the rest of the system, or between groups of synchronous **Generating Plants**, 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 **Generating Unit**s, system impedance and loads connected to the **Distribution System**. 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 **Generating Unit**s, can arise following a small disturbance if either

- the transfer capability of the interconnecting **Distribution System** 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 **Generating Units** rotor angles (ie 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 **Generating Plant**.

During a fault the electrical output of each synchronous **Generating Unit** 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 **Generating Unit** controls respond rapidly and with adequate **Distribution System** 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 **Generating Unit** and the **Distribution System**. These may damage synchronous **Generating Units**, cause maloperation of **Distribution System** protection and produce unacceptable voltage depressions in supply systems.

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

In the case of doubly fed asynchronous **Generating Plant** and series converter connected **Generating Plant**, a voltage depression on the local **Distribution System** 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 Station**s the capability to ride through certain **Transmission System** faults is critical to **Distribution System** and **Total System** stability. The **Grid Code** “fault ride through” requirements CC.6.3.15 apply to these **Power Stations.**

Where larger synchronous **Generating Plant**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’ (ie 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 **Generating Plant**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 System** 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. **Generating Unit**s in embedded **Medium** and **Large Power Station**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 **Generating Unit** can move out of **Synchronism** and the consequences for the unit of a reclosure on the **Distribution System**.

13.7.1 Prime Mover Characteristics

A Modern **Generating Unit** can be of four types:-

1. Synchronous **Generating Unit**: 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 **Generating Unit**: 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 **Generating Unit** (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 **Generating Unit** (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 **Generating Unit** 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 Generating Unit Following Load Change

The kinetic energy of a rotating **Generating Unit** 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 **Generating Unit**

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 **Generating Unit** 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 **Generating Unit** 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).

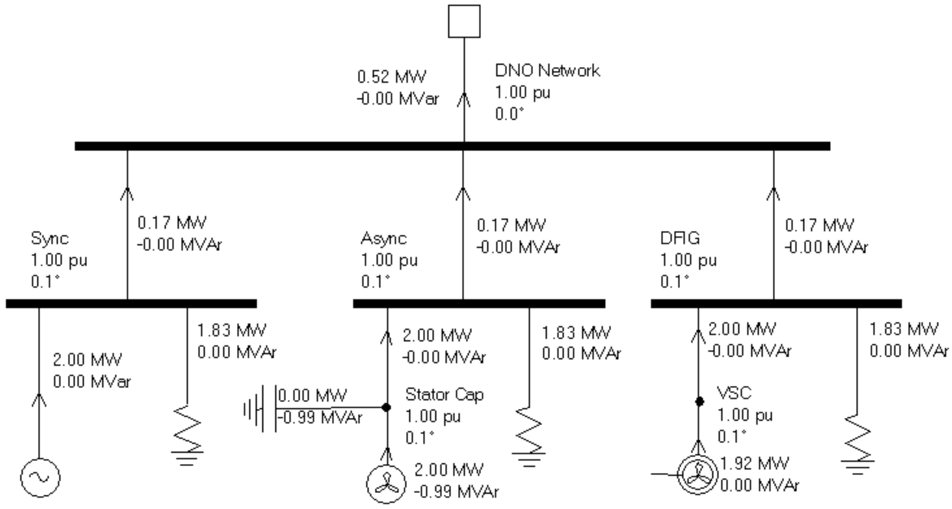


Figure 1 - Three Generator types

Transient Study

At t=0.1 seconds the network connections are broken leaving each generator in an islanded condition supplying 90% of it's 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.

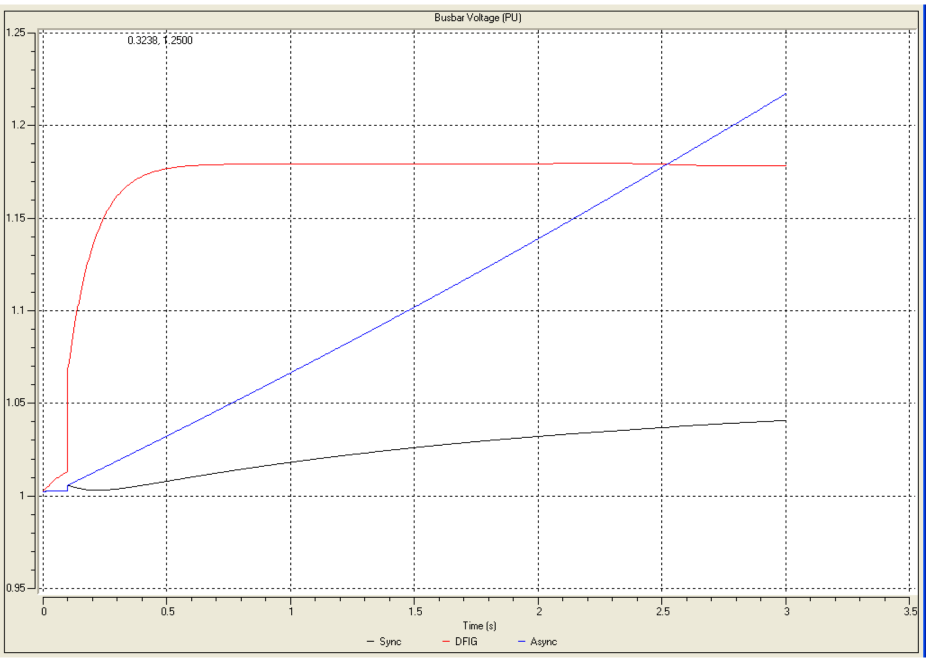


Figure 2 - Voltage Profile

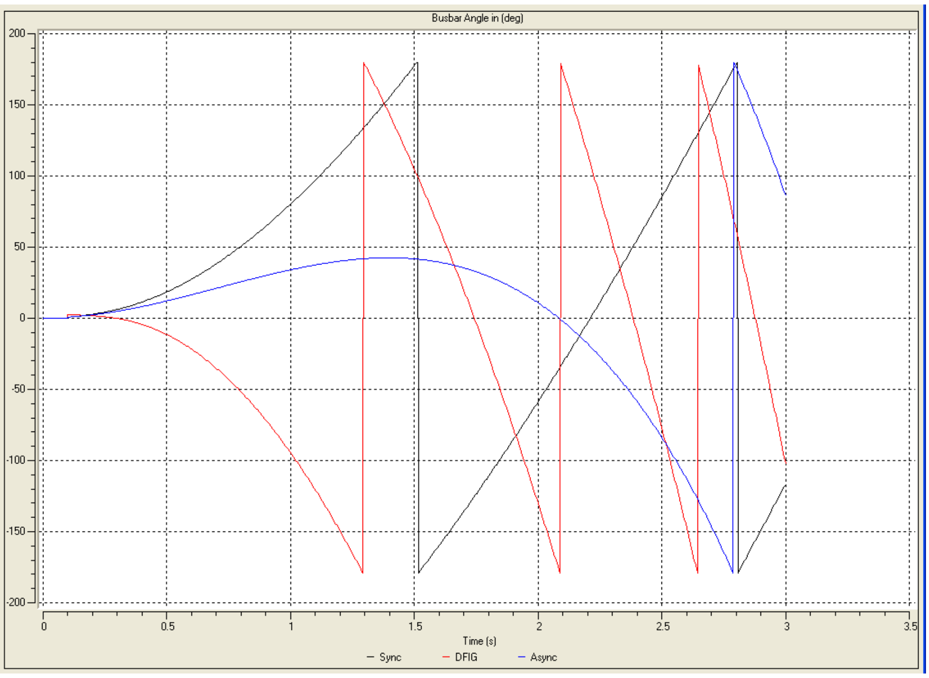


Figure 3 Voltage Angle (flips at +/- 180 Deg)

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)

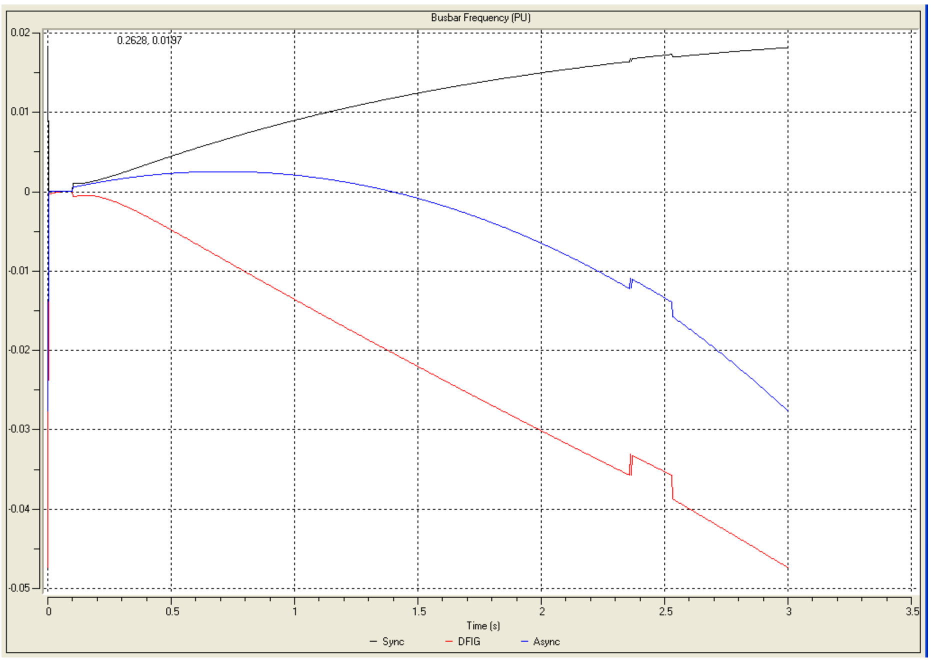


Figure 4 Voltage Frequency Change (PU)

Results

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

Prot Function	**Small Power Station**			
	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	**Generator 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).

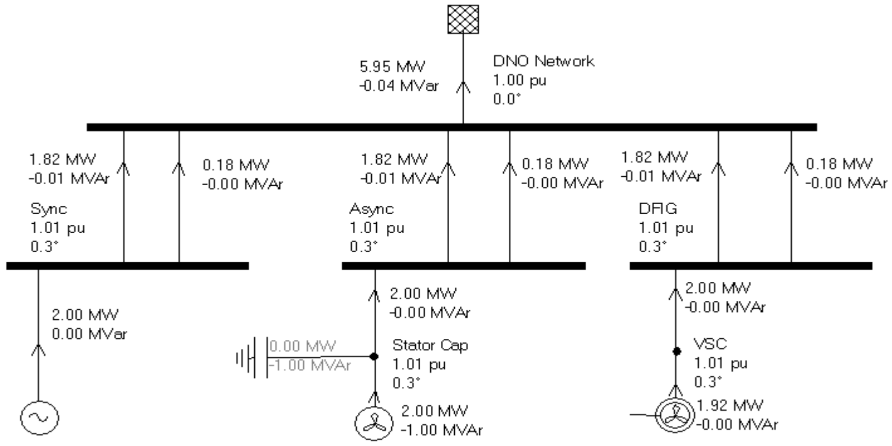


Figure 5 - Impedance Step Change Network

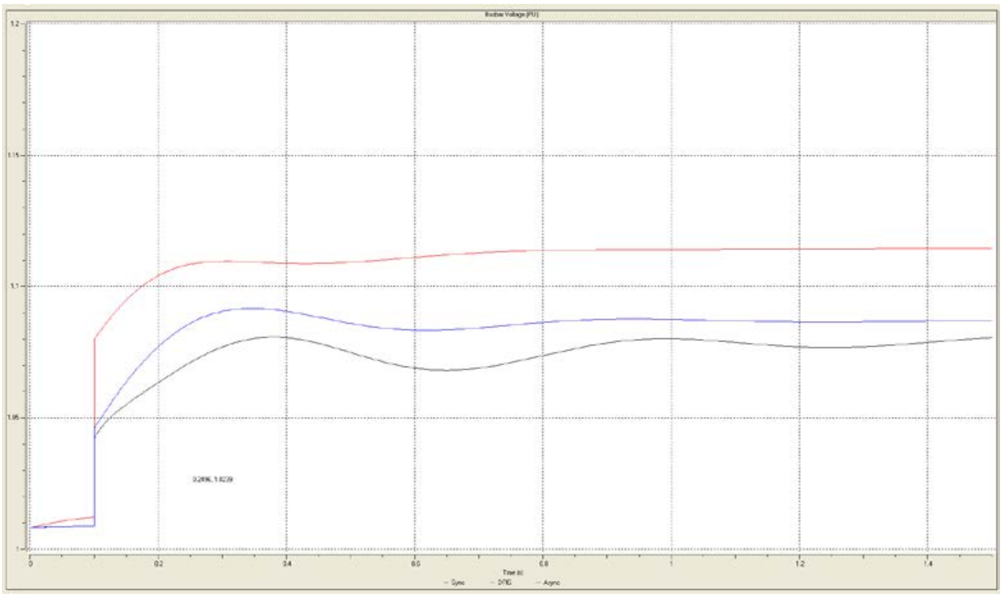


Figure 6 - Voltage Response

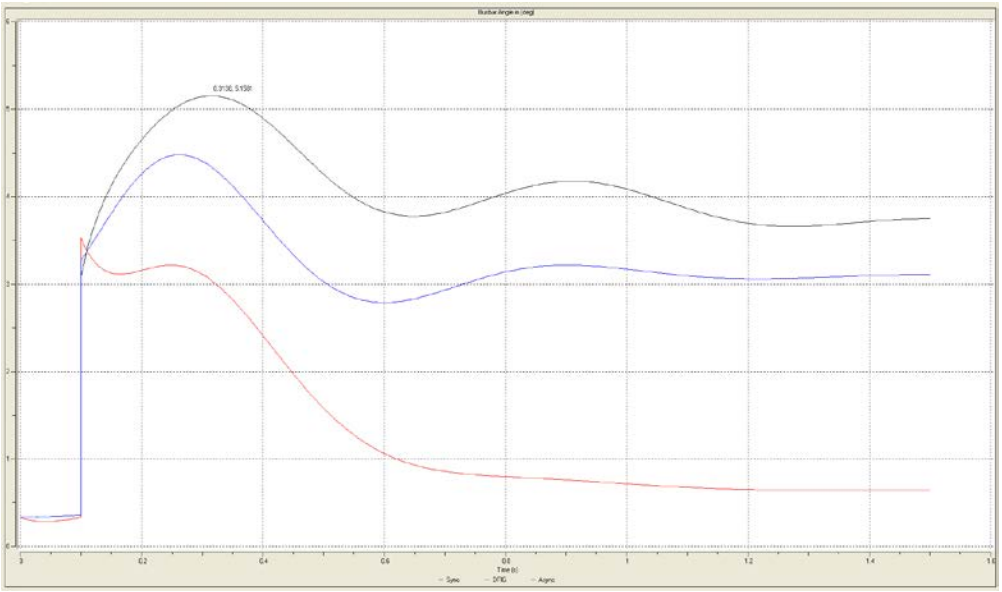


Figure 7 - Voltage Angle

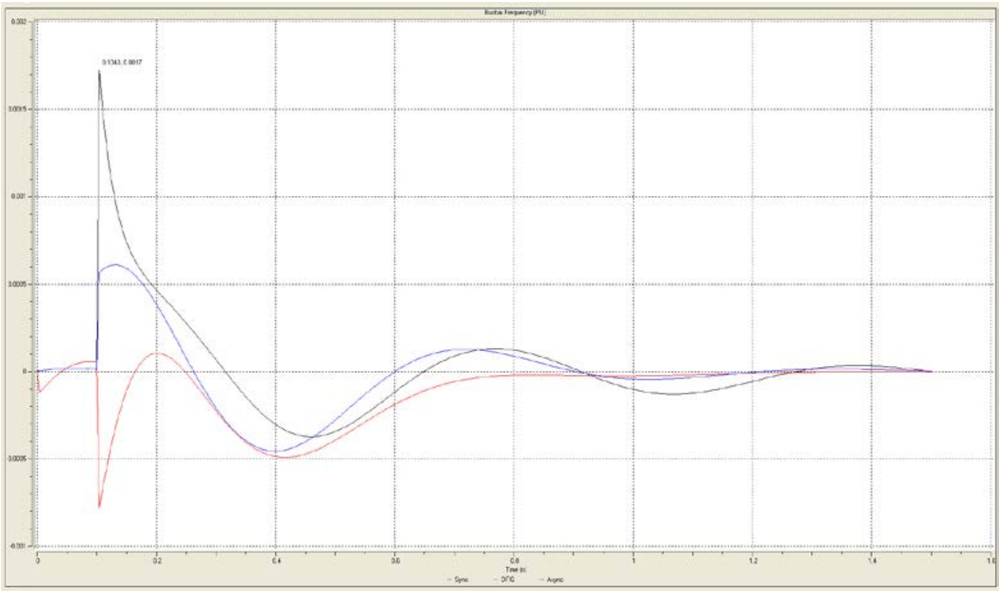


Figure 8 - Voltage Frequency Change (PU)

Results

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

Prot Function	Small Power Station			
	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	Generator 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.

13.8 Type Testing of Generation Units of 50kW three phase, or 17kW per phase or less. Guidance for Manufacturers.

EREC G59/3 makes provision for **Manufacturers** to **Type Test Generating Unit**s of up to 50kW or 17kW per phase. This section gives guidance to **Manufacture**s on how to do this. The results should be recorded on a copy of the **Generating Unit Type Test** declaration which is shown as Appendix 13.1 of this document..

The philosophy behind this testing matches that for the testing of smaller **Generating Unit**s in EREC G83, however in EREC G83 such equipment is called **Generators.** There are sections for **Inverter** connected **Generating Units** and directly connected **Generating Units** followed by a section giving details on specific requirements for different technology types.

In order to preserve commonality between EREC G59 and EREC G83 the numbering of this section will contain a EREC G59 document reference number followed by the equivalent reference(s) from EREC G83 in brackets.

For example **13.8.1 (A1.1,B1.1)** covers both Annex A section 1.1 and Annex B section 1.1 in EREC G83/2 Where these are different then only one reference will be shown.

Normally **Manufacturer**s will only need to provide **Type Test** declarations for **Generating Units** of less than 16A per phase to EREC G83/2 and these units can be used in **Power Station**s of up to 50kW three phase or 17kW per phase. However they may chose to provide Type Test Declarations to EREC G59/3 as well as to EREC G83/2 which will allow multiple **Generating Units** to be used in installations above 50kW three phase or 17kW per phase.

13.8.1 (A1.1,B1.1) General Arrangements

This Annex describes a methodology for obtaining type certification or type verification for the interface equipment between the **Inverter** connected **Generating Unit** and the **Distribution Network System**. Typically, all interface functions are contained within the **Inverter** and in such cases it is only necessary to have the Inverter Type Tested**.** Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested**.

Other Annexes containing **Inverter** connected equipment may make reference to the requirements specified in this Annex.

Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested** but the completed **Generating Unit's Interface Protection** must not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections must be made by plug and socket which the **Manufacturer** has made and tested prior to delivery to site. See section 10.2.5.d)

Note 1: This Appendix is primarily designed for the testing of three phase **Generating Units**. However, where practicable, a single phase, or split phase test may be carried out if it can be shown that it will produce the equivalent results.

Note 2: This Appendix applies for **Generating Units** either with or without load management or energy storage systems which are connected on the **Generating Unit** side of the **Inverter**.

13.8.2 (A1.2,B1.2) CE Marking and Certification

The type verification procedure requires that the **Generating Unit** interface be certified to the relevant requirements of the applicable Directives before the **Generating Unit** can be labelled with a CE mark. Where the protection control is to be provided as a separate device, this must also be **Type Tested** and certified to the relevant requirements of the applicable Directives before it can be labeled with a CE mark.

The **Generating Unit**'s **Interface Protection** shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.

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)

Currently there are no harmonised functional standards that apply to the **Generating Unit**'s **Interface Protection**. Consequently, in cases where power electronics is used for energy conversion along with any separate **Interface Protection** unit they will need to be brought together and tested as a complete **Generating Unit** as described in this Appendix, and recorded in format similar to that shown in Appendix 13.1. Where the **Interface Protection** is physically integrated within the overall **Generating Unit** control system, the functionality of the **Interface Protection** unit should not be compromised by any failure of other elements of the control system (fail safe).

13.8.3 (A1.3,B1,3) Type Verification Functional Testing of the Interface Protection

Type Testing is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Generating Unit Interface Protection** shall result:

a) in the safe disconnection of the **Generating Unit** from the **DNO's Distribution System** in the event that the protection settings specified in table 10.5.7.1 are exceeded; and

b) in the **Generating Unit** remaining connected to the **DNO's Distribution System** while network conditions are:
   (1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in table 10.5.7.1; and

   (2) within the trip delay settings specified in table 10.5.7.1.

The **Type Testing** can be done by the **Manufacturer** of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate.

Wherever possible the **Type Testing** of an **Inverter** designed for a particular type of **Generating Unit** should be proved under normal conditions of operation for that technology (unless otherwise noted).

This will require that the chosen **Generating Unit Interface Protection** is either already incorporated into the **Inverter** or that the discrete device is connected to the **Inverter** for the loss of mains protection test. Testing the voltage and frequency functions may be carried out on the discrete protection device independently or on the **Inverter** complete.

In either case it will be necessary to verify that a protection operation will disconnect the **Generator** from the **DNO's Distribution System**.

13.8.3.1 (A1.3.1,B1.3.1) Disconnection times

The minimum trip delay settings, for tests in 13.8.3.2, 13.8.3.3 and 13.8.3.4, are presented in table 10.5.7.1.

Reconnection shall be checked as detailed in 13.8.3.5 below.

In some systems it may be safer and more convenient to test the trip delay time and the disconnection time separately. This will allow the trip delay time to be measured in a test environment (in a similar way as you could test a protection relay). The disconnection time can be measured in the **Generating Unit**s normal operation, allowing accurate measurement with correct inertia and prime mover characteristics. This is permitted providing the total disconnection time does not exceed the trip delay time plus 0.5s. When measuring the shutdown time, 5 shutdowns should be initiated, and the average time recorded.

13.8.3.2 (A1.3.2,B1.3.2) Over / Under Voltage

The **Generating Unit** shall be tested by operating the **Generating Unit** in parallel with a variable **AC** test supply, see figure A2. Correct protection and ride-through operation shall be confirmed during operation of the **Generating Unit.** The set points for over and under voltage at which the **Generating Unit** disconnects from the supply will be established by varying the **AC** supply voltage.

To establish a trip voltage, the test voltage should be applied in steps of ± 0.5% or less, of the nominal voltage for a duration that is longer than the trip time delay, for example 1 second in the case of a delay setting of 0.5s starting at least 4V below or above the setting. The test voltage at which this trip occurred is to be recorded. Additional tests just above and below the trip voltage should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the **Type Test** declaration Appendix 13.1.

To establish the trip time, the test voltage should be applied starting from 4V below or above the recorded trip voltage and should be changed to 4V above or below the recorded trip voltage in a single step. The time taken from the step change to the **Generating Unit** tripping is to be recorded on the **Type Test** declaration Appendix 13.1.

To establish correct ride-through operation, the test voltage should be applied at each setting ±4V and for the relevant times shown in the table in section 13.1

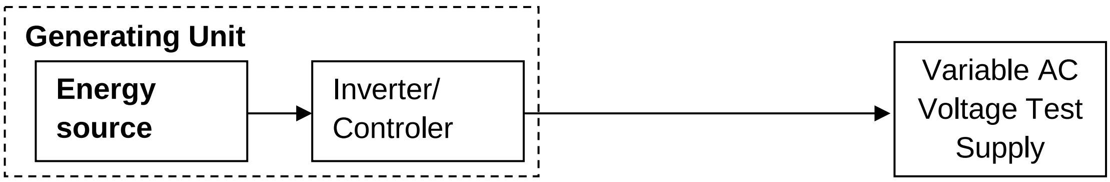
For example to test overvoltage setting stage 1 which is required to be set at 262.2V the circuit should be set up as shown below and the voltage adjusted to 254.2V. The **Inverter** should then be powered up to export a measureable amount of energy so that it can be confirmed that the **Inverter** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal (1.15V) maintaining the voltage for at least 1.5s (trip time plus 0.5s) at each voltage level. At each voltage level confirmation that the **Inverter** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as been 255V. The variable voltage supply should be set to 251V the **Inverter** set to produce a measureable output and then the voltage raised to 259V in a single step. The time from the step change to the output of **Inverter** falling to zero should be recorded as the trip time.

The **Inverter** then needs to operate at 4V below the nominal overvoltage stage 1 setting which is 258.2V for a period of at least 2s without tripping and while producing a measurable output. This can be confirmed as a no trip in the relevant part of section 13.1. The voltage then needs to be stepped up to the next level of 269.7V for a period of 0.98s and then back to 258.2V during which time the output of the relay should continue with no interruption though it may change due to the change in voltage, this can be recorded as a no trip for the second value. The step up and step down test needs to be done a second time with a max value of 277.7V and with a time of 0.48s. The **Inverter** is allowed to shut down during this period to protect its self as allowed by note $ of Table 10.5.7.1 of EREC G59/3, but it must resume production again when the voltage has been restored to 258.2V or it may continue to produce an output during this period. There is no defined time for resumption of production but it must be shown that the restart timer has not operated so it must begin producing again in less than 20s.

The “No-trip tests” need to be carried out at the relevant values and times as shown in the tables in 13.1 to ensure that the protection will not trip in error.

Note that this philosophy should be also be applied to the under voltage tests and to the over and under frequency, RoCoF and Vector shift stability tests which follow in sections 13.8.3.2, 13.8.3.3, 13.8.3.4A and 13.8.3.4B

Figure A2. Generator Test set up – Over / Under Voltage



13.8.3.3(A1.3. 3,B1.3.3) Over / Under Frequency

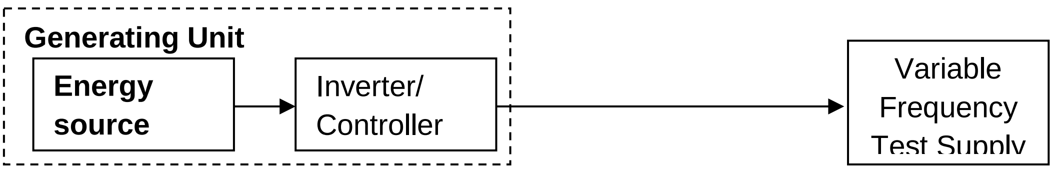
The **Generating Unit** shall be tested by operating it in parallel with a low impedance, variable frequency test supply system, see figure A3. Correct protection and ride-through operation should be confirmed during operation of the **Generating Unit**. The set points for over and under frequency at which the **Generating Unit** disconnects from the supply will be established by varying the test supply frequency.

To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs^{-1}, or if this is not possible in steps of 0.05Hz for a duration that is longer than the trip time delay, for example 1s in the case of a delay setting of 0.5s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the **Type Test** declaration Appendix 13.1.

To establish the trip time, the test frequency should be applied starting from 0.3Hz below or above the recorded trip frequency and should be changed to 0.3Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the **Generating Unit** tripping is to be recorded on the **Type Test** declaration section 13.1. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection. There are two ways around this. Firstly the loss of mains protection may be able to be turned off in order to carry out this test. Secondly by establishing an accurate frequency for the trip a much smaller step change could be used to initiate the trip and establish a trip time. This may require the test to be repeated several times to establish that the time delay is correct.

To establish correct ride-through operation, the test frequency should be applied at each setting plus or minus 0.2Hz and for the relevant times shown in Appendix 13.1

Figure A3 Generator Test set up – Over / Under Frequency



13.8.3.4A (A.3.4) Loss of Mains Protection, Inverter connected machines

The tests should be carried out in accordance with BS EN 62116 and a subset of results should be recorded as indicated in the Protection – Loss of Mains test section of the **Type Test** declaration Appendix 13.1.

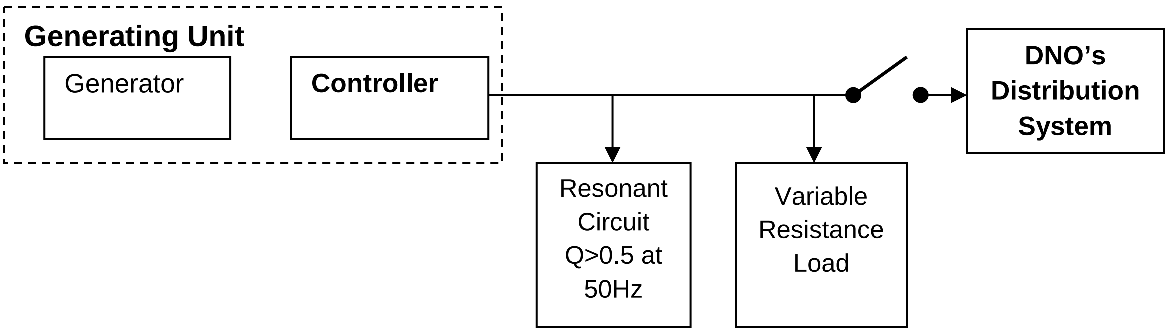
For Multi phase **Generating Units** they should be operated at part load while connected to a network running at about 50Hz and one phase only shall be disconnected with no disturbance to the other phases. The Generating Unit should trip within 1 second. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the Type Test declaration.

13.8.3.4B (B.3.4) Loss of Mains Protection, Directly connected machines

The resonant test circuit specified in this test has been designed to model the interaction of the directly coupled **Generator** under test with the local load including multiple directly coupled connected **Generator**s in parallel.

The directly coupled **Generating Unit** output shall be connected to a network combining a resonant circuit with a Q factor of >0.5 and a variable load. The value of the load is to match the directly coupled **Generating Unit** output. To facilitate the test for LoM there shall be a switch placed between the test load/directly coupled **Generating Unit** combination and the **DNO's Distribution System**, as shown below:

Figure B4 Generator Test set up - Loss of Mains



The directly coupled **Generating Unit** is to be tested at three levels of the directly coupled **Generating Units** output power: 10%, 55% and 100% and the results recorded on the **Type Test** declaration section 13.1. For each test the load match is to be within ± 5%. Each test is to be repeated five times.

Load match conditions are defined as being when the current from the directly coupled **Generating Unit** meets the requirements of the test load ie there is no export or import of supply frequency current to or from the **DNO**'s distribution system.

The tests will record the directly coupled **Generating Units** output voltage and frequency from at least 2 cycles before the switch is opened until the protection system operates and disconnects itself from the **DNO's Distribution System**, or for five seconds whichever is the lower duration.

The time from the switch opening until the protection disconnection occurs is to be measured and must comply with the requirements in table 10.5.7.1.

For Multi phase **Generating Units** they should be operated at part load while connected to a network running at about 50Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Generating Unit** should trip within 1s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the **Type Test** declaration.

13.8.3.5 (A1.3.5,B1.3.5) Reconnection

Further tests will be carried out with the three test circuits above to check the **Inverter** time out feature prior to automatic network reconnection. This test will confirm that once the **AC** supply voltage and frequency have returned to be within the stage 1 settings specified in table 10.5.7.1 following an automatic protection trip operation there is a minimum time delay of 20s before the **Generating Unit** output is restored (ie before automatically reconnecting to the network).

13.8.3.6 (A1.3.6,B1.3.6) Frequency Drift and Step Change Stability test.

The tests will be carried out using the same circuit as specified in 13.8.3.3 above and following confirmation that the **Generating Unit** has passed the under and over frequency trip tests and the under and over frequency stability tests.

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Generating Unit** should not trip during the test.

For the step change test the **Generating Unit** should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10s to complete the test. The **Generating Unit** should not trip during this test.

For frequency drift tests the **Generating Unit** should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0.19Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10s. The **Generating Unit** should not trip during this test.

13.8.4 Power Quality

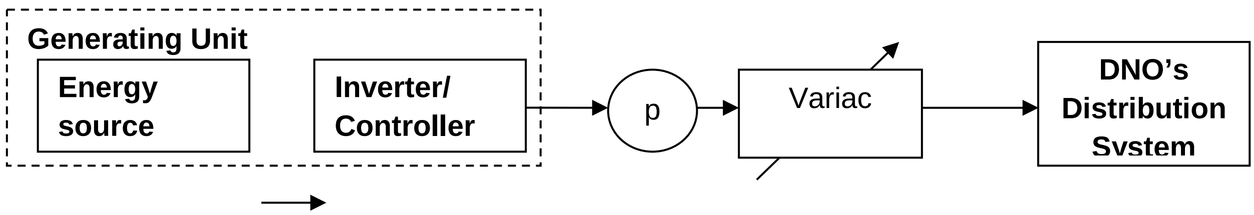
13.8.4.1 (A1.4.1,B1.4.1) Harmonics

The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of maximum export capacity. The required supply minimum fault level should be recorded in the relevant part of **Type Test** declaration section 13.1. If the harmonics meet the technical requirements of BS EN 61000-3-2 then the relevant alternative part of the document can be completed and there will be no need to specify the minimum fault level required.

13.8.4.2 (A1.4.2,B1.4.2) Power Factor

The test set up shall be such that the **Generating Unit** supplies full load to the **DNO's Distribution System** via the power factor (pf) meter and the variac as shown below in figure A5. The **Generating Units** pf should be within the limits given in 9.3.7, for three test voltages 230 V –6%, 230V and 230 V +10%.

Figure A5 Generator Test set up – Power Factor



NOTE 1 For reasons of clarity the points of isolation are not shown.

NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown.

13.8.4.3 (A1.4.3,B1.4.3) Voltage Flicker

The voltage fluctuations and flicker emissions from the **Generating Unit** shall be measured in accordance with BS EN 61000-3-11 and technology specific annex. The required maximum supply impedance should be calculated and recorded in the **Type Test** declaration Appendix 13.1.

Where the **Generating Unit** meets the technical requirements of BS EN 61000-3-3 then this can be stated as an alternative and there is no need to specify the maximum supply impedance.

13.8.4.4 (A1.4.4,B1.4.4) DC Injection

The level of **DC** injection from the **Generating Unit** in to the **DNO's Distribution System** shall not exceed the levels specified in 9.6.4 when measured during operation at three levels, 10%, 55% and 100% of rating with a tolerance of ± 5% of the rating.

The DC injection requirements can be satisfied by the installation of an isolation transformer on the **AC** side of an **Inverter**-connected **Generating Unit**. A declaration that an isolating transformer is fitted can be made in lieu of the tests noted above.

13.8.4.5 (A1.4.5,B1.4.5) Over current Protection

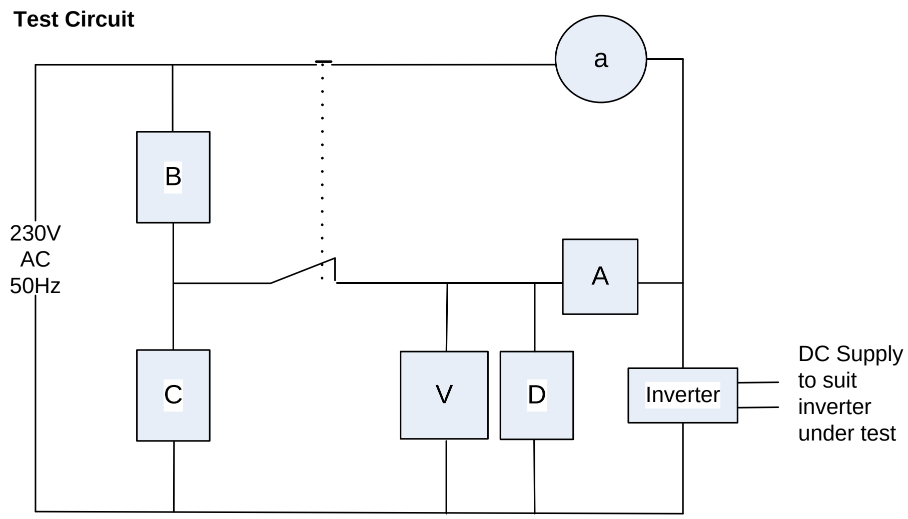
Where appropriate the protection shall comply with the requirements of BS7671.

13.8.4.6A (A1.4.6) Short Circuit Current Contribution Inverter connected Generating Units

Inverter connected **Generating Units** generally have small short circuit fault contributions however **DNO**'s need to understand the contribution that they do make to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.

The following type tests shall be carried out and the results noted in the **Type Test** declaration Appendix 13.1.

Test circuit



A and V are ammeters and voltmeters used to record the test data required. Component D is a resistive load plus resonant circuit as required for the loss of mains test as specified in BS EN 62116 set up to absorb 100% rated output of the **Inverter**, component a is an ammeter used to confirm that all the output from the **Inverter** is being absorbed by component D. Components B and C are set up to provide a voltage of between 10% and 15% of nominal when component C carries the rated output of the **Inverter**. Component C should be short term rated to carry the load which would appear through it should it be energised at 253V for at least 1s. Component B is to have an impedance of between 10 and 20 Ω per phase. If components B and C are short time rated than an additional switch in series with B and C can be inserted and arranged to be closed shortly before the main change over switch shown on the drawing and opened at the end of the test period. Components B and C are to have an X to R ratio of 2.5 to 1.

The test is carried out by setting up the **Inverter** and load D to produce and then absorb full rated output of the **Inverter**. When zero export is shown by ammeter “a” then the changeover switch shown is operated disconnecting the **Inverter** from the normal load and connecting it to the reduced voltage connection created by components B and C creating similar conditions to a network fault.

The values of voltage and current should be recorded for a period of up to 1 second when the changeover switch should be operated to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Appendix 4) including the time taken for the **Inverter** to trip. (It is expected that the **Inverter** will trip on either loss of mains or under voltage in less than one second).

13.8.4.6B(B1.4.6) Short Circuit Current Contribution

DNO’s need to understand the contribution a **Generating Unit** makes to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.

For rotating machines BS EN 60034-4:1995 Methods for determining synchronous machine quantities from tests should be used to establish the parameters required to be recorded in Appendix 13.1 under the section Fault Level Contribution.

For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the **Generating Unit** terminals.

*Values for parameters marked in Appendix 13.1 should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot.

13.8.4.7(A1.4.7) Self-Monitoring - Solid State Disconnection

Some **Inverter**s include solid state switching devices to disconnect from the **DNO’s Distribution System**. In this case 9.4.9 requires the control equipment to monitor the output stage of the **Inverter** to ensure that in the event of a protection initiated trip the output voltage is either disconnected completely or reduced to a value below 50V **AC**. This shall be verified either by self-certification by the **Manufacturer**, or additional material shall be presented to the tester sufficient to allow an assessment to be made.

13.8.4.8(A1.4.8,B1.4.7) Electromagnetic Compatibility (EMC)

All equipment shall comply with the generic EMC standards: BS EN61000-6-3: 2007 Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: 2007 Electromagnetic Compatibility, Generic Immunity Standard.

13.8.5 Separate Specific Technology Requirements

13.8.5.1(C1.1) Domestic CHP

For Domestic CHP **Generating Units** connected to the **DNO's Distribution System** the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected **Generating Unit** clauses will apply.

13.8.5.2(C1.2) Photovoltaic

As all current Photovoltaic **Generation Units** will connect to the **DNO's Distribution System** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

13.8.5.3(C1.3) Fuel Cells

As all current Fuel Cell **Generation Unit**s will connect to the **DNO's Distribution System** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

13.8.5.4(C1.4) Hydro

Hydro can be connected to the **DNO's Distribution System** directly using induction or synchronous generators or it can be connected by an **Inverter**.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply.

In addition the following needs to be taken into consideration.

Generating Units with manually fixed output or where the output is fixed by controlling the water flow through the turbine to a steady rate, need to comply with the maximum voltage change requirements of BS EN 61000-3-11 or to the technical requirements of BS EN 61000-3-3 but do not need to be tested for P_{st} or P_{lt}.

Generating Units where the output is controlled by varying the load on the generator using the **Inverter** and which therefore produces variable output need to comply with the maximum voltage change requirements of BS EN 61000-3-11 or the technical requirements of BS EN 61000-3-3 and also need to be tested for P_{st} and P_{lt} over a period where the range of flows varies over the design range of the turbine with a period of at least 2 hours at each step with there being 10 steps from min flow to maximum flow. P_{st} and P_{lt} values to recorded and normalised as per the method laid down in Appendix 13.1.

13.8.5.5(C1.5) Wind

Wind turbines can be connected to the **DNO's Distribution System** directly, typically using asynchronous induction generators, or using **Inverter**s.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply

In addition, in either case, the note regarding wind turbine voltage flicker testing specified in 9.6.2.1 shall apply.

Note: For wind turbines, flicker testing should be carried out during the performance tests specified in IEC 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.

13.8.5.6(C1.6) Energy Storage Device

Energy Storage Devices can be connected to the **DNO's Distribution System** directly or using **Inverter**s.

The type verification testing and **Interface Protection** requirements will be as per the requirements defined in sections 13.8.1 to 13.8.4 inclusive.

Where appropriate the **Inverter** or directly connected generator clauses will apply.

13.9 Main Statutory and other Obligations

This appendix summarises the main statutory and other obligations on **DNO**s, **Generator**s and **Users** in relation to the design and operation of primary and protection equipment associated with **Distribution Systems**.

The key driver on the **DNO** is to ensure that it can comply with its statutory duties, and its regulatory obligations, in protecting its network, and disconnecting the minimum amount of equipment when unsafe situations have developed, as well as preserving supplies to other customers.

A key consideration of **Generator**s and **User**s is similarly to ensure that they can comply with their statutory duties to protect their entire network and to disconnect relevant equipment when unsafe situations have developed.

Reference	Obligation	DNO	Generator	User
ESQCR Reg 3	Ensure equipment is sufficient for purpose and electrically protected to prevent danger, so far as is reasonably practicable.	X	X	-
ESQCR Reg 4	Disclose information and co-operate with each other to ensure compliance with the ESQC Regulations 2002	X	X	-
ESQCR Reg 6	Apply protective devices to their network, so far as is reasonably practicable, to prevent overcurrents from exceeding equipment ratings.	X	X	-
ESQC Reg 7	Ensure continuity of the neutral conductor and not introduce any protective device in the neutral conductor or earthing connection of **LV** networks.	X	X	-
ESQCR Reg 8	Connect the network to earth at or as near as reasonably practicable to the source of voltage; the earth connection need only be made at one point.	X	X	-
ESQCR Reg 11	Take all reasonable precautions to minimise the risk of fire from substation equipment.	X	X	-
ESQCR Reg 21	Ensure that switched alternative sources of energy to distribution networks cannot operate in parallel with those networks and that such equipment which is part of an **LV** consumer's installation complies with BS 7671.		X	X
ESQCR Reg 22	Not install or operate sources of energy in parallel with distribution networks unless there are: appropriate equipment, personnel and procedures to prevent danger, so far as is reasonably practicable; **LV** consumers' equipment complies with BS 7671; and specific requirements are agreed with the **DNO**.		X	X

Reference	Obligation	DNO	Generator	User
ESQCR Reg 24	**DNO** equipment which is on a consumer's premises but not under the consumer's control is protected by a suitable fused cut-out or circuit breaker which is situated as close as reasonably practicable to the supply terminals, which is enclosed in a locked or sealed container.	X		
ESQCR Reg 25	Not give consent to making or altering of connections where there are reasonable grounds to believe that the consumer's installation does not comply with ESQCR / BS 7671 or, so far as is reasonably practicable, is not protected to prevent danger or interruption of supply.	X		
ESQCR Reg 27	Declare the number of phases, frequency and voltage of the supply and, save in exceptional circumstances, keep this within permitted variations.	X		
ESQCR Reg 28	Provide a written statement of the type and rating of protective devices.	X		
EAWR Reg 4	Construct systems including suitable protective devices that can handle the likely load and fault conditions.	X	X	X
EAWR Reg 5	Not put into service electrical equipment where it strength and capability may be exceeded in such a way as to pose a danger.	X	X	X
EAWR Reg 11	Provide an efficient and suitably located means to protect against excess current that would otherwise result in danger.	X	X	X
MHSWR Reg 3	Carry out an assessment of risks to which employees are exposed to at work and risks to other persons not employed arising from the activities undertaken.	X	X	X
BS 7671	Provide protective devices to break overload/fault current in **LV** consumer installations before danger arises.			X
BS 7671	Take suitable precautions where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger.			X

Reference	Obligation	DNO	Generator	User
Distribution Code DPC4.4.4	Incorporate protective devices in **Distribution Systems** in accordance with the requirements of the ESQCR. Agree protection systems, operating times, discrimination and sensitivity at the ownership boundary. Normally provide back-up protection in case of circuit breaker failure on **HV** systems.	X X X	X X X	X X X
Distribution Code DPC6.3	User's equipment must be compatible with **DNO** standards and practices. Design protection systems that take into account auto-reclosing or sequential switching features on the **DNO** network. Be aware that **DNO** protection arrangements may cause disconnection of one or two phases only of a three phase supply.		X X X	X X X
Distribution Code DPC7.4.3	Co-ordinate protection of embedded **Generator** with **DNO** network and meet target clearance times		X	
	Agree protection settings at network ownership boundary in writing during the connection consultation process	X	X	
Distribution Code DPC7.4.4	**Generating Units** or **Power Stations** must withstand NPS loading incurred during clearance of a close-up phase to phase fault by system back-up protection		X	
Distribution Code DPC7.4.5	Agree transformer winding configuration and method of earthing with **DNO**		X	
Distribution Code DPC8.10	Assess the transient overvoltage effects at the network ownership boundary, where necessary.	X	X	

13.10 Example calculations to determine if unequal generation across different phases is acceptable or not.

13.10.1 A **Customer** installation might have 12kW of PV and a 3kW CHP plant. Due to the areas of roof available the PV plant comprises 2 by 4.5kW inverters and a 3kW inverter.

A The following connection would be deemed acceptable.

- Ph 1 4.5kW PV
- Ph 2 3kW PV plus 3kW CHP
- Ph 3 4.5kW PV

This would lead to

- 1.5kW imbalance with CHP at zero output
- 1.5kW imbalance with CHP and PV at maximum output
- 3kW imbalance with CHP at maximum output and PV at zero output.

All of which are below the 16A imbalance limit.

B The following alternative connection for the same plant would be deemed unacceptable

- Ph1 4.5kW PV plus 3kW CHP
- Ph 2 3kW PV
- Ph3 4.5kW PV

This is not acceptable as at full output Ph1 would have 4.5kW more output than Ph2 and this exceeds the 16A limit described above even though on an individual technology basis the limit of 16A is not exceeded.

13.10.2. If a **Customer** installation has a single technology installed which has **Generating Units** with different output patterns for example PV mounted on roofs facing different directions then they should be regarded separately

(For these cases the assumption is that in the morning the east roof would produce full output and the west roof zero output with the opposite in the afternoon. Whilst this might not be strictly true the simplification makes the calculations much simpler)

A The following connection would be deemed acceptable.

- Ph 1 6kW east roof 6kW west roof
- Ph 2 6kW east roof 6kW west roof
- Ph 3 5kW east roof 5kW west roof

B The following alternative connection for the same plant would be deemed unacceptable.

- Ph1 12kW east roof
- Ph2 5kW east roof 5kW west roof
- Ph 3 12kW west roof

This is not acceptable as Ph 1 would produce more than Ph 3 in the morning and in the afternoon Ph 3 would produce more than Ph 1 in each case by a margin greater than 16A.

13.11 Guidance on Risk Assessment when using RoCoF LoM Protection for Power Stations in the 5MW to 50MW range

This procedure aims to provide guidance on assessing the risks to a **Generator's** plant and equipment where a **Generator** with synchronous **Generating Units** is considering the effect of applying higher RoCoF settings than 0.2Hzs^{-1}. It is based on analysis undertaken for the network licensees by Strathclyde Universtity[11].

13.11.1 The guidance in this section 13.11 relates to a new activity. Early experience may suggest there are more efficient or effective ways of assessing the risk. **DNOs** and **Generators** will be free to adapt this procedure to achieve the **Generators'** ends.

13.11.2 First determine whether the **Power Station** includes a synchronous **Generating Unit**. This type of **Generating Unit** is at risk from an out-of-phase reclosure on a **DNO'**s network where the **DNO** employs auto-reclose or automatic restoration schemes and the loss of mains protection has failed to disconnect the **Generating Unit** before the supply is restored by the **DNO's** automatic equipment.

13.11.3 If all the synchronous **Generating Units** in a **Power Station** are operating with a fixed power factor then the chance of sustaining an island is low and the **Generator** may wish to consider that there is no need to take any further action though this does not eliminate the risk of an out-of-phase reclosure. If any synchronous **Generating Unit** is operating with voltage control then the risk of an out-of-phase reclosure is increased and the **Generator** is advised to continue with the risk assement process as described in sections 13.11.4 to 13.11.9 below.

13.11.4 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 Generating 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 **Generating Plant,** hence the trapped load assessment may need to be carried out periodically.

13.11.5 **DNO**s will also be able to provide indicative fault rates for their network that lead to the tripping of the automatic switching points in 13.11.4 above.

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[11] A. Dyśko, I. Abdulhadi, X. Li, C. Booth "Assessment of Risks Resulting from the Adjustment of ROCOF Based Loss of Mains Protection Settings – Phase I", Institute for Energy and Environment, Department of Electronic and Electrical Engineering, University of Strathclyde, Glasgow, June 2013.

13.11.6 **DNO**s will provide any known or expected likely topology changes to the network and a view of the effects of this on the data provided in 13.11.4 and 13.11.5

13.11.7 **DNO**s will also be able to provide the automatic switching times employed by any auto-reclose switchgear employed at switching points identified in 13.11.4. This will include any potential changes to automatic switching times that it might be possible to deploy to reduce the risk of out-of-phase reclosure. The DNO will need to consider any potential effect from network faults on customer service and system performance before agreeing to modifying automatic switching times.

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

13.11.9 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.

13.11.10 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 reclosure incident. Where the **Generator** considers these risks to be too high, sensitivity analysis should enable them to identify the effectiveness of various remedial actions.

Appendix 7 –Revised Distribution Code – July 2015 version 26

THE DISTRIBUTION CODE

and

THE GUIDE TO THE DISTRIBUTION CODE

OF LICENSED DISTRIBUTION NETWORK OPERATORS OF GREAT BRITAIN

Issue 26~~5~~ – 01 ~~November~~ August 2015~~4~~

THE DISTRIBUTION CODE OF GREAT BRITAIN

DOCUMENT CONTENTS

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The following items do not form part of the approved Distribution Code and are for information only:

- Guidance Notes 1 to 3
- The Introduction to the Distribution Code, ie DIN1 to DIN 7
- The Guide to the Distribution Code of Great Britain

GUIDANCE NOTE 1

(Dated 01.04.1993 England and Wales Distribution Code

Adopted for the Distribution Code of Great Britain)

ENGINEERING RECOMMENDATION P2/6

The **Distribution Code Review Panel** has reviewed Engineering Recommendation P2/6 and for **Customers** falling within the remit of the **Distribution Code** has agreed that:-

The main section of this document deals with the establishment of recommendations for the security of electricity transmission and distribution systems of network operators. It does not apply to the supply connection of a **Customer**.

Each **Customer** supply connection needs to be considered on its own merits by discussion between the **Customer** and the network operator. The costs of providing a **Customer** supply connection by the network operator will be partly dependent upon the nature of the network operator's electrical system and the location of the **Customer's** premises. It will be for the **Customer** to decide, in negotiations with the network operator, the level of security required for the electricity supply to be provided to the **Customer's** premises. In general, the greater the level of security of supply required by the **Customer**, the greater the capital investment required by the network operator, as a consequence this will require the **Customer** to meet a higher level of supply connection charge.

GUIDANCE NOTE 2/4

First issued 03 March 2011 – updated 06 October 2011

Second Issue 29 March 2012

Third Issue December 2012.

Fourth Issue September 2013

ENGINEERING RECOMMENDATIONS G83 AND G59

This guidance note was originally issued on 03 March 2011 and its main provision was to allow the use small scale generation of capacity greater than 16A per phase, provided it had been type tested to the requirements of G83/1-1 but with a modified over frequency protection setting.

It has been updated on the dates above to allow a period of grace following the introduction of revised versions of G59 and G83 in which manufacturers can adapt their equipment to the changed requirements of these documents.

Now that G83/2 and G59/3 have been published the Distribution Code Review Panel wishes to see the following continuing interpretation:

- For all small scale embedded generation sets of up to and including 16A per phase (provided that the aggregate capacity of installed generation is less than or equal to 16A per phase), until 1 March 2014 it is permissible to connect to the general requirements of previous versions of G83 provided this is through an inverter or controller with a protection/control system that has either been fully type tested in accordance with G83/1-1, G83/2 or in accordance with G59/2. After 1 March 2014 it will only be allowable to connect small scale embedded generation of up to and including 16A per phase that complies with G83/2 (or with G59/3-1for small scale embedded generation sets non-compliant with G83/2).

- Connection of small scale embedded generation of above 16A per phase (including the connection of small scale embedded generation of less than 16A per phase where the aggregate capacity of installed generation is greater than 16A per phase) made before 1 December 2014 can be in accordance with either G59/2-1 or G59/3-2~~1~~. Such connections made after 1 December 2014 must be made in accordance with G59/3-2~~1~~.

GUIDANCE NOTE 3

First issued 1 December 2012

ENGINEERING RECOMMENDATIONS G83

The Panel is aware that small scale generation using the Stirling engine as a prime mover has been designed using resonance to operate within ±1% of the nominal frequency of 50Hz. Accordingly it is not technically possible for generation using this technology currently to remain connected down to 47.0 Hz as required by G83/2.

Recognizing the limitations of the current technology, and noting that currently the adoption of this technology is niche and far from mass market, the Panel believes that those G83/2 tests relating to behaviour at frequencies out side of the ±1% range should be waived or modified, thus allowing this technology to continue its niche use.

In the longer term the Panel expects that either the requirements of the EU Network Code "Requirements for all Generators" when enacted in UK law will require Stirling engine designs to be modified to comply, or to seek a specific derogation. Similarly if the growth of this technology showed a risk of being material, then again full compliance with G83 would be required. The Panel believes that a sensible threshold of materiality, considering the technical and commercial effects of the technology, to be 50MW.

This note applies from 1 December 2012 and applies in force until 31 December 2016.

DISTRIBUTION GLOSSARY AND DEFINITIONS (DGD)

DISTRIBUTION GLOSSARY AND DEFINITIONS (DGD)

DGD 1. EXPRESSIONS

In this **Distribution Code** the following words and expressions shall, unless the subject matter or context otherwise requires or is inconsistent therewith, bear the listed meanings:-

Act	The Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004).
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).
Annex 1 Standard	A electricity industry national standard that implements **Distribution Code r**equirements and which is listed in Annex 1 of the **Distribution Code,** and forms part of the **Distribution Code**.
Annual Average Cold Spell (ACS) Conditions	A particular combination of weather elements that give rise to a level of **Peak Demand** within a financial year which has a 50% chance of being exceeded as a result of weather variation alone.
Apparatus	All **Equipment** in which electrical conductors are used, supported or of which they may form a part.
Appendix 2 Standard	A electricity industry national standard that has a material effect on **Users** but does not implement any **Distribution Code** requirements and does not form part of the **Distribution Code** technical requirements. A list of these standards is maintained by the **Distribution Code Review Panel** as Appendix 2 to the Guide to the Distribution Code.
Authorised Electricity Operator or AEO	Any person (other than the **DNO** in its capacity as an operator of a Distribution System) who is authorised to generate, participate in the transmission of, distribute or supply electricity.
Authority	The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000.
Average Conditions	That combination of weather elements within a period of timewhich is the average of the observed values of these weather elements during equivalent periods over many years (Sometimes referred to as normal weather).
Balancing and Settlement Code (BSC)	The code of that title as from time to time amended.
Balancing Mechanism	Has the meaning set out in **NGC's Transmission Licence**.

BM Unit	Has the meaning set out in the **BSC**, except that for the purposes of the **Distribution Code** the reference to "Party" in the **BSC** shall be a reference to a **User**.
BM Participant	A person who is responsible for and controls one or more **BM Units** or where a **CUSC Bilateral Agreement** specifies that a **User** is required to be treated as a **BM Participant** for the purpose of the **Grid Code.** For the avoidance of doubt, it does not imply that they must be active in the **Balancing Mechanism**.
Black Start	The procedure necessary for a recovery from a **Total Shutdown** or **Partial Shutdown.**
Black Start Station	A **Power Station** which is registered pursuant to a **CUSC Bilateral Agreement** with **NGC**, as having a Black Start Capability.
CENELEC	European Committee for Electrotechnical Standardisation.
Citizens Advice (CA)	National Association of Citizens Advice Bureaux
Citizens Advice Scotland (CAS)	Scottish Associatin of Citizens Advice Bureaux
Civil Emergency Direction	Directions given by the **Secretary of State** to **AEOs** for the purpose of mitigating the effects of any natural disaster or other emergency which, in the opinion of the **Secretary of State**, is or may be likely to disrupt electricity supplies.
Committed Project Planning Data	Data relating to a **User Development** once the offer for a **Connection Agreement** is accepted.
Connection Agreement	An agreement between the **DNO** and the **User** or any **Customer** setting out the terms relating to a connection with the **DNO's Distribution System** (excluding any **CUSC Bilateral Agreement**).
Connection Point	An **Entry Point** or an **Exit Point** of the **Distribution System** as the case may be**.**
Control Centre	A location used for the purpose of control and operation of all, or of part of a **Distribution System**, **National Electricity Transmission System** or the **System** of a **User.**
Control Person	A person who has been nominated by an appropriate officer of the **DNO, Transmission Licensee** or a **User** to be responsible for controlling and co-ordinating safety activities necessary to achieve **Safety From The System.**
Control Phase	The period 0-24 hours inclusive ahead of real time operation. The **Control Phase** follows on from the **Programming Phase** and covers the period down to real time.
CUSC	Has the meaning set out in **NGC's Transmission Licence**

CUSC Bilateral Agreement	An agreement pursuant to the **CUSC Framework Agreement** made between **NGC** and a **User** of the **National Electricity Transmission System**
CUSC Disputes Resolution Procedure	The procedure described in **CUSC** relating to disputes resolution.
CUSC Framework Agreement	Has the meaning set out in **NGC's Transmission Licence.**
Customer	Any person supplied or entitled to be supplied with electricity at any premises within **Great Britain** but shall not include any **Authorised Electricity Operator** in its capacity as such.
Customer With Own Generation or CWOG	A **Customer** with one or more **Generation Sets** connected to the **Customer's System**, providing all or part of the **Customer's** electricity requirements**,** and which may use the **DNO's Distribution System** for the transport of any surplus of electricity being exported.
DC Converter	Any **Apparatus** used to convert alternating current electricity to direct current electricity, or vice versa. A **DC Converter** is a standalone operative configuration at a single site comprising one or more converter bridges, together with one or more converter transformers, converter control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion. In a bipolar arrangement, a **DC Converter** represents the bipolar configuration.
DNO's Distribution System	The **System** consisting (wholly or mainly) of electric lines owned or operated by the **DNO** and used for the distribution of electricity between the **Grid Supply Points** or **Generation Sets** or other **Entry Points** to the points of delivery to **Customer**s or **Authorised Electricity Operators**, or any **Transmission Licensee** within **Great Britain** and **Offshore** in its capacity as operator of the licensee's **Transmission System** or the **National Electricity Transmission System** and includes any **Remote Transmission Assets** (owned by a **Transmission Licensee** within **Great Britain**), operated by the **DNO** and any electrical plant and meters and metering equipment owned or operated by the **DNO** in connection with the distribution of electricity, but shall not include any part of the **National Electricity Transmission System**
Decimal Week	The week numbering system where week 1 commences in the first week of January on a date as advised by the **DNO**.
Demand	The demand of MW or MVAr of electricity (ie both **Active Power** and **Reactive Power** respectively) unless otherwise stated.

Demand Control	Any or all of the following methods of achieving a **Demand** reduction: (a) **Customer** voltage reduction initiated by the **DNO** (other than following an instruction from **NGC**); (b) **Customer Demand** reduction by disconnection initiated by the **DNO** (other than following an instruction from **NGC**); (c) **Demand** reduction instructed by **NGC**; (d) automatic low frequency **Demand** disconnection; (e) emergency manual **Demand** disconnection
Demand Control Notification Level	The level above which the **DNO** has to notify **NGC** of its proposed or achieved use of **Demand Control** which is 12 MW in England and Wales and 5 MW in Scotland.
Detailed Planning Data (DPD)	Detailed additional data which the **DNO** requires under the **Distribution Planning and Connection Code** in support of **Standard Planning Data.**
Distribution Business	The authorised business of the **DNO** or any affiliate or related undertaking of the **DNO** (whether the business is undertaken by the **DNO** or another licence holder), comprising: (a) the distribution of electricity through the **DNO's Distribution System**, including any business in providing connections to such **System**; and (b) the provision of Distributor Metering and Data Services as defined in the **Distribution Licence**.
Distribution Code	A code required to be prepared by a **DNO** pursuant to condition 9 (**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 General Conditions.**
Distribution Data Registration Code	That portion of the **Distribution Code** which is identified as the **Distribution Data Registration Code.**
Distribution General Conditions or DGC	That portion of the **Distribution Code** which is identified as the **Distribution General Conditions.**
Distribution Glossary and Definitions	That portion of the **Distribution Code** which is identified as the **Distribution Glossary and Definitions.**
Distribution Introduction (DIN)	That portion of the **Distribution Code** which is identified as the **Distribution Introduction**.
Distribution Licence	A distribution licence granted under Section 6(1)(c) of the **Act**.
Distribution Network Operator (DNO)	The person or legal entity named in Part 1 of the **Distribution Licence** and any permitted legal assigns or successors in title of the named party.

Distribution Operating Code (DOC)	That portion of the **Distribution Code** which is identified as the **Distribution Operating Code.**
Distribution Planning and Connection Code (DPC)	That portion of the **Distribution Code** which is identified as the **Distribution Planning and Connection Code.**
Distribution System	The electrical network operated by an **Other Authorised Distributor.**
Distribution Use of System Agreement	The standard form of agreement of that name, as amended from time to time.
Earthing Device	A means of providing a connection between an **Isolated** conductor and earth.
Electricity Safety, Quality and Continuity Regulations (ESQCR)	The statutory instrument entitled The Electricity Safety, Quality and Continuity Regulations 2002 as amended from time to time and including any further statutory instruments issued under the **Act** in relation to the distribution of electricity.
Embedded	Having a direct electrical connection to a **Distribution System.**
Embedded Generator	A **Generator** including a **Customer With Own Generation** whose **Generation Sets** are directly connected to the **DNO's Distribution System** or to an **Other Authorised Distributor** connected to the **DNO's Distribution System.** The definition of **Embedded Generator** also includes the **OTSO** in relation to any **Embedded Transmission System**
Embedded Transmisison Licensee	**Offshore Transmission Licensee** for an **Embedded Transmission System**
Embedded Transmission System	An **Offshore Transmission System** directly connected to the **DNO's Distribution System** or to an **Other Authorised Distributor** connected to the **DNO's Distribution System.**
Entry Point	The point at which an **Embedded Generator** or other **Users** connect to the **DNO's Distribution System** where power flows into the **DNO's Distribution System** under normal circumstances.
Equipment	**Plant** and/or **Apparatus.**
Electricity Supply Industry (ESI)	Electricity Supply Industry.
Event	An unscheduled or unplanned (although it may be anticipated) occurrence on or relating to a **System** including, without limiting that general description, faults, incidents and breakdowns and adverse weather conditions being experienced.

Existing Offshore Generators	A **Generator** with a **Power Station** located in offshore waters that has an agreement for connection to the **DNO's Distribution System** via lines of 132kV or above that are wholly or partly in offshore waters.
Exit Point	The point of supply from the **DNO's Distribution System** to a **User** where power flows out from the **DNO's Distribution System** under normal circumstances**.**
External Interconnection	A connection to a party outside the **Total System.**
Fault Level	Prospective current that would flow into a short circuit at a stated point in the **System** and which may be expressed in kA or, if referred to a particular voltage, in MVA.
Feasibility Project Planning Data	Data relating to a proposed **User Development** until such time that the **User** applies for a **Connection Agreement**.
Frequency	The number of alternating current cycles per second (expressed in Hertz) at which a **System** is running.
Fuel Security Code	The document of that title designated as such by the **Secretary of State**, as from time to time amended.
Generating Plant	A **Power Station** including any **Generation Set** therein.
Generating Plant Output	That portion of the output of **Generating Plant** which is contributing to meeting **Demand.**
Generation Set	Any **Apparatus** which produces electricity.
Generator	A person who generates electricity under licence or exemption under the **Act.** A person who has connected a **Generation Set(s)** in accordance with Item 13 DGD Engineering Recommendation G83/2 ("Recommendations For The Connection of Type Tested Small-Scale Embedded Generators (Up To 16 A Per Phase) in Parallel With Public Low-Voltage Distribution Networks") and where this is (are) their only **Generation Set(s)**, is not classed as a **Generator** for the purpose of this **Distribution Code.**
Great Britain or GB	"The landmass of England & Wales and Scotland, including internal waters".
Grid Code	The code which **NGC** 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**.
Grid Supply Point	Any point at which electricity is delivered from the **National Electricity Transmission System** to the **DNO's Distribution System.**
High Voltage (HV)	A voltage exceeding 1000 Volts**.**

High Voltage Customer	A **Customer** connected to a part of the **Distribution System** which is operating at **HV**.
Implementing Control Person	Pursuant to DOC8, the person implementing **Safety Precautions** at an Operational Boundary.
Individual DNO Standard	A standard adopted by an individual **DNO** and which is published as such by an individual **DNO** and that has a material effect on **Users.**
IEC	International Electrotechnical Commission.
Independent Distribution Network Operator	A **DNO** that does not have a Distribution Services Obligation Area in its **Distribution Licence** and is not an ex Public Electricity Supplier
Industry Codes Technical Group (ITCG)	A a standing body comprised of representatives of all the **DNO**s to carry out the functions referred to in its own Constitution and Rules
Isolated	Disconnected from associated **Plant** and **Apparatus** by an **Isolating Device(s)** in the isolating position or by adequate physical separation or sufficient gap.
Isolating Device	A device for rendering **Plant** and **Apparatus Isolated.**
Joint System Incident	Is an **Event** occurring on the **System** or installation, which, in the opinion of the **DNO**, has or may have a serious and/or widespread effect on the **System** or installation of another.
Large Power Station	A **Power Station** which is connected to a **System** notionally connected to a **Grid Supply Point** in; a. **NGC's** Transmission Area with a **Registered Capacity** of 100 MW or more; b. SP Transmission Limited's Transmission Area with a **Registered Capacity** of 30MW or more; c. Scottish Hydro-Electric Transmission Limited's Transmission Area with a **Registered Capacity** of 10MW or more.
Limited Frequency Sensitive Mode	A mode whereby the operation of a **Generation Set** is **Frequency** insensitive except when the **System Frequency** exceeds 50.4Hz, from which point **Limited High Frequency Response** must be provided.
Limited High Frequency Response	A response of a **Generation Set** to an increase in **System Frequency** above 50.4Hz leading to a reduction in **Active Power** in accordance with the provisions of **Grid Code** BC3.7.2.
Load Managed Area	Has the meaning given to that term in the **Distribution Use of System Agreement**.

Low Voltage or LV	In relation to alternating current, a voltage exceeding 50 volts but not exceeding 1 000 volts**.**
Maximum Generation	The additional output obtainable from **Generating Plant** in excess of **Registered Capacity.**
Medium Power Station	A **Power Station** which is connected to a **System** notionally connected to a **Grid Supply Point** in **NGC**'s Transmission Area with a **Registered Capacity** of 50 MW or more but less than 100 MW. For the avoidance of doubt an installation comprising one or more **DC Converters** with an aggregate capacity of between 50 and 100MW will be classed as a Medium Power Station for the purposes of this Distribution Code.
Meter Operation Code of Practice Agreement	The agreement of that name, as amended from time to time.
Meter Operator	A person, registered with the Registration **Authority**, appointed by either a **Supplier** or **Customer** to provide electricity meter operation services. (This **Distribution Code** does not place any direct obligation on **Meter Operators** other than through the appointment by either a **Supplier** or a **Customer**.)
Minimum Generation	The minimum output which a **Generation Set** can reasonably generate as registered under the **Distribution Data Registration Code**,
National Electricity Transmission System	The **Onshore Transmission System** and **Offshore Transmission System .**
National Electricity Transmission System Demand	The amount of electricity supplied from the **Grid Supply Points** plus:- (a) that supplied by **Embedded Large Power Stations**, and (b) that supplied by **Embedded Transmission System**, and (c) exports from the **National Electricity Transmission System** across **External Interconnections**, and (d) **National Electricity Transmission System** losses,and, for the purposes of this definition, includes the **Demand** taken by Station Transformers and Pumped Storage Units.
NGC	National Grid Electricity Transmission plc.
Normal Operating Frequency	The number of Alternating Current cycles per second, expressed in Hertz at which the **System** normally operates, ie 50 Hertz.
Offshore	Means in Offshore Waters, as defined in Section 90(9) of the Energy Act 2004.
Offshore Transmission Implementation Plan	As defined in the Transmission Licence

Offshore Transmission System Operator (OTSO)	The **NGC** acting as operator of an **Offshore Transmission System .**
Offshore Transmission Licensee	The holder of a licence granted under Section 6 (1)(b) of the **Act** excluding **NGC**, **SPT** and **SHETL**.
Offshore Transmission System	Has the meaning set out in the **Grid Code**.
Onshore Transmission Licensees	**NGC**, **SHETL** and **SPT**
Onshore Transmission System	Has the meaning set out in the **Grid Code.**
Operation	A scheduled or planned action relating to the operation of the **System.**
Operation Diagrams	Diagrams which are a schematic representation of the **HV Apparatus** and the connections to all external circuits at a **Connection Point,** incorporating its numbering, nomenclature and labelling.
Operational Boundary	The boundary between the **Apparatus** operated by the **DNO** or a **User** and the **Apparatus** operated by **Other Authorised Distributor(s)** or other **User(s)**, as specified in the relevant **Site Responsibility Schedule**.
Operational Data (OD)	Information to be supplied pursuant to the **Distribution Operating Codes** and as set out in the Schedules to the **DDRC**.
Operational Day	The period from 0500 hours on one day to 0500 on the following day.
Operational Effect	Any effect on the **Operation** of the relevant other **System** which causes the **National Electricity Transmission System** or **DNO's Distribution System**or the **System** of the other **User** or **Users,** as the case may be, to operate (or be at a materially increased risk of operating) differently from the way in which they would or may have operated in the absence of such an effect.
Operational Planning	The procedure set out in **Distribution Operating Code** DOC2 comprising, through various timescales, the co-ordination of planned outages of **Users' Plant** and **Apparatus**.
Operational Planning Phase	The period from 8 weeks to 3 years inclusive ahead of real time operation.
Other Authorised Distributor	A **User** authorised by Licence or exemption to distribute electricity and having a **User Distribution System** connected to the **DNO's Distribution System.**

Output Usable or OU	That portion of **Registered Capacity** which is not unavailable due to a **Planned Outage** or breakdown.
Ownership Boundary	The electrical boundary between the **Equipment** owned by one **DNO** or **User** and the **Equipment** owned by another **User**.
Partial Shutdown	The same as a **Total Shutdown** except that all generation has ceased in a separated part of the **Total System** and there is no electricity supply from **External Interconnections** or other parts of **Total System** to that part of the **Total System** and, therefore, that part of the **Total System** is shutdown with the result that it is not possible for that part of the **Total System** to begin to function again without **NGC's** directions relating to a **Black Start**.
Peak Demand	The highest level of **Demand** recorded/forecast for a 12-month period, as specified in the relevant sections of the **Distribution Code**.
Phase (Voltage) Unbalance	The ratio (in percent) between the rms values of the negative sequence component and the positive sequence component of the voltage.
Planned Outage	An outage of **Generating Plant** or of part of the **National Electricity Transmission System** or of part of a **Distribution System.**
Plant	Fixed and movable items used in the generation and/or supply and/or transmission of electricity other than **Apparatus**.
Power Factor	The ratio of **Active Power** to apparent power (apparent power being the product of voltage and alternating current measured in volt-amperes and standard multiples thereof, ie VA, kVA, MVA).
Power Island	**Generation Sets** at an isolated **Power Station**, together with complementary local **Demand.** In Scotland a **Power Island** may include more than one **Power Station**.
Power Station	An installation comprising one or more **Generation Sets** (even where sited separately) and/or controlled by the same **Generator** and which may reasonably be considered as being managed as one **Power Station.**
Preliminary Project Planning Data	Data relating to a proposed **User Development** at the time the **User** applies for a **Connection Agreement** but before an offer is made.
Programming Phase	The period between the **Operational Planning Phase** and the **Control Phase**. It starts at the 8 weeks ahead stage and finishes at 17:00 on the day ahead of real time
Protection	The provisions for detecting abnormal conditions in a **System** and initiating fault clearance or actuating signals or indications.

Qualifying Standard	Electrical standards in use by **DNO**s and included in the **Distribution Code Review Panel's** governance procedures, and falling into one of the categories below: **i. Annex 1 Standard** **ii. Appendix 2 Standard** **iii. Individual DNO Standard**
Reactive Power	The product of voltage and current and the sine of the phase angle between them which is normally measured in kilovar (kVAr) or megavar (MVAr).
Registered Capacity	The normal full load capacity of a **Generation Set** as declared by the **Generator** less the MW consumed when producing the same; ie for all **Generators**, including **Customer With Own Generation,** this will relate to the maximum level of **Active Power** deliverable to the **DNO's Distribution System**. For **Generation Sets** connected to the **DNO's Distribution Systemvia** an inverter, the inverter rating is deemed to be the **Generation Set's** rating.
Registered Data	Data referred to in the schedules to the **Distribution Data Registration Code.**
Remote Transmission Assets.	Any **Plant** and **Apparatus** or meters owned by **NGC** which: a) are **Embedded** in the **DNO's Distribution System** and which are not directly connected by **Plant** and/or **Apparatus** owned by **NGC** to a sub-station owned by **NGC**; and b) are by agreement between **NGC** and the **DNO** operated under thedirection and control of the **DNO.**
Requesting Control Person	Pursuant to DOC8, the person requesting **Safety Precautions** at an **Operational Boundary**.
Safety From The System	That condition which safeguards persons working on or testing **Apparatus** from the dangers which are inherent in working on items of **Apparatus** which are used separately or in combination in any process associated with the generation, transmission or distribution of electricity.
Safety Management System	The procedure adopted by the **DNO** or a **User** to ensure the safe **Operation** of the **System** and the safety of personnel required to work on that **System**.
Safety Precautions	The procedures specified within a **Safety Management System.**
Safety Rules	The rules or procedure of the **DNO** or a **User** to ensure **Safety From The System**.

Scheduling	The procedure for determining intended usage of **Generating Plant.**
Secretary of State	Has the same meaning as in the **Act**.
SHETL	Scottish Hydro-Electric Transmission Limited
Significant Incident	An **Event** on the **Transmission System** or **DNO's Distribution System** or in a **User's System** which has or may have a significant effect on the **System** of others.
Site Responsibility Schedule	A schedule defining the ownership, operation and maintenance responsibility of **Plant** and **Apparatus** at a **Connection Point** of the **DNO**.
Small Power Station	A **Power Station** which is connected to a **System** notionally connected to a **Grid Supply Point** in: a. **NGC's** Transmission Area with a **Registered Capacity** of less than 50MW; b. SP Transmission Limited's Transmission Area with a **Registered Capacity** of less than 30MW; c. Scottish Hydro-Electric Transmission Limited's Transmission Area with a **Registered Capacity** of less than 10 MW.
SPT	Scottish Power Transmission Limited
Standard Planning Data (SPD)	General information required by the **DNO** under the **Distribution Planning Code**.
Standby	The supply of electricity by a **Supplier** to a **Customer** on a periodic or intermittent basis to make good any shortfall between the **Customer's** total supply requirements and that met by his own generation.
Superimposed Signals	Those electrical signals present on a **Distribution System** for the purposes of information transfer.
Supplier	(a) A person supplying electricity under an Electricity Supply Licence; or (b) A person supplying electricity under exemption under the **Act**; in each case acting in its capacity as a supplier of electricity to **Customers** in **Great Britain** .
Supply Agreement	An agreement for the supply of electricity made between a **Supplier** and a consumer of electricity.
System	An electrical network running at various voltages.
System Control	The administrative and other arrangements established to maintain as far as possible the proper safety and security of the **System**.

System Incident Centre	A centre set up by the **DNO** pursuant to the declaration of a **Joint System Incident**, under DOC 9, to assume control of the incident.
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 disturbance, with most **System** variables being within acceptable limits so that practically the whole **System** remains intact.
System Test	That test or tests which involve simulating conditions or the controlled application of irregular, unusual or extreme conditions on the **Total System** or any part of it, but not including routine testing, commissioning or recommissioning tests.
Test Coordinator	A suitably qualified person appointed to coordinate **System Test** pursuant to DOC12.
Test Panel	A panel, the composition of which is detailed in DOC12, and which will be responsible for formulating **System Test** proposals and submitting a test programme.
Top - Up	The supply of electricity by any **Supplier** to the **Customer** on a continuing or regular basis to make good any shortfall between the **Customer's** total supply requirements and that met from other sources.
Total Shutdown	The situation existing when all generation has ceased and there is no electricity supply from **External Interconnections** and therefore the **Total System** has shutdown with the result that it is not possible for the **Total System** to begin to function again without **NGC's** directions relating to a **Black Start** .
Total System	The **National Electricity Transmission System** and all **Systems** of **Users** of this **National Electricity Transmission System** in **Great Britain and Offshore.**
Transmission Licence	The licence granted under Section 6(1)(b) of the **Act**.
Transmission Licensee	Any **Onshore Transmission Licensee** or **Offshore Transmission Licensee**.
Transmission System	Has the same meaning as the term "licensee's transmission system" in the **Transmission Licence** of a **Transmission Licensee**.
Unmetered Supply	A supply of electricity to premises which is not, for the purposes of calculating charges for electricity supplied to the **Customer** at such premises, measured by metering equipment.

User	A term used in various sections of the **Distribution Code** to refer to the persons using the **DNO's Distribution System**, more particularly identified in each section of the **Distribution Code**, including for the avoidance of doubt the **OTSO** for **Embedded Transmission System.**
User Development	Either a **User's Plant** and/or **Apparatus** and/or **System** to be connected to the **DNO's Distribution System**, or a modification relating to a **User's Plant** and/or **Apparatus** and/or **System** already connected to the **DNO's Distribution System**, or a proposed new connection or modification to the connection within the **User's System**.
Voltage Reduction	The method to temporarily control **Demand** by reduction of **System** voltage.
Weekly Average Cold Spell (ACS) Condition	That particular combination of weather elements that gives rise to a level of **Peak Demand** within a week, taken to commence on a Monday and end on a Sunday, which has a particular chance of being exceeded as a result of weather variation alone. This particular chance is determined such that the combined probabilities of **Demand** in all weeks of the year exceeding the annual **Peak Demand** under **Annual ACS Conditions** is 50%, and in the week of maximum risk the weekly **Peak Demand** under **Weekly ACS Conditions** is equal to the annual **Peak Demand** under **Annual ACS Conditions.**

DGD 2. CONSTRUCTION OF REFERENCES

In this **Distribution Code**:-

(i) The Table of contents, the Guide and headings are inserted for convenience only and shall be ignored in construing the **Distribution Code**.

(ii) Unless the context otherwise requires, all references to a particular paragraph, sub-paragraph, Annex, Appendix or Schedule shall be a reference to that paragraph, sub-paragraph, Annex, Appendix or Schedule in or to that part of the **Distribution Code** in which the reference is made.

(iii) Unless the context otherwise requires the singular shall include the plural and vice versa, references to any gender shall include any individual, body corporate, unincorporated association, firm or partnership and any other legal entity.

(iv) References to the words "include" or "including" are to be construed without limitation to the generality of the preceding words.

(v) Unless there is something in the subject matter or the context which is inconsistent therewith, any reference to an Act of Parliament or any Section of or Schedule to, or other provision of an Act of Parliament shall be construed at the particular time, as including a reference to any modification, extension or re-enactment thereof then in force and to all instruments, orders and regulations then in force and made or deriving validity from the relevant Act of Parliament.

(vi) References to “in writing” or “written” include typewriting, printing, lithography and other modes of reproducing words in a legible and non-transitory form and, except where otherwise stated, includes suitable means of electronic transfer, such as electronic mail. In all cases the form of notification and the nominated persons or departments and addresses of the sender and recipient of the data or information shall be agreed by the **DNO** and **User** and the sender shall be able to confirm receipt of the information by the recipient. In the case of electronic transfer the sender and recipient shall be able to reproduce the information in non-transitory form.

(vii) Where the **Distribution Glossary and Definitions** refers to any word or term which is more particularly defined in a part of the **Distribution Code**, the definition in that part of the **Distribution Code** will prevail over the definition in the **Distribution Glossary and Definitions** in the event of any inconsistency.

(viii) A cross reference to another document or part of the **Distribution Code** shall not of itself impose any additional or further or co-existent right in the part of the text where such cross-reference is contained.

(ix) Nothing in the **Distribution Code** is intended to or shall derogate from the **DNO’s** statutory or licence obligations.

ANNEX 1

(This Annex forms part of the **Distribution Code** technical requirements)

Distribution Glossary and Definitions

Distribution Code REQUIREMENTS IMPLEMENTED VIA ELECTRICITY SUPPLY INDUSTRY STANDARDS Copies of the Engineering Recommendations and Technical Specifications are available from the Energy Networks Association, 6th Floor, Dean Bradley House, 52 Horseferry Road, London SW1P 2AF, www.energynetworks.org. A copy of Engineering Memorandum 7907 is available from Scottish Hydro Electric Power Distribution Ltd on request.

1 **Engineering Recommendation G5/4-1**

Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution systems in the United Kingdom.

2 **Engineering Recommendation G12/4**

Requirements for the application of protective multiple earthing to low voltage networks.

3 **Engineering Recommendation G59/3-2~~1~~**

Recommendation for the connection of generating plant to the distribution systems of licensed distribution network operators

4 (a) **Engineering Recommendation P2/6**

Security of Supply.

(b) **EM7907**

Distribution planning standards of voltage and of security of supply. (Parts of Scottish Hydro Electric Power Distribution Ltd Area)

5 **Engineering Recommendation P14**

Preferred switchgear ratings.

6 **Engineering Recommendation P24**

AC traction supplies to British Rail.

7 **Engineering Recommendation P25**

The short circuit characteristics of electricity boards low voltage distribution networks and the co-ordination of overcurrent protective devices on 230V single phase supplies up to 100A.

8 **Engineering Recommendation P26/1**

The estimation of the maximum prospective short circuit current for three phase 415V supplies.

9 **Engineering Recommendation P28**

Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom.

10 **Engineering Recommendation P29**

Planning limits for voltage unbalance in the United Kingdom for 132kV and below.

ANNEX 1

11 **Technical Specification 41-24 November 2009**

Guidance for the design, installation, testing and maintenance of main earthing systems in substations

12 **Engineering Recommendation S34**

A guide for assessing the rise of earth potential at substation sites.

13 **Engineering Recommendation G83/2**

Recommendations For The Connection of Type Tested Small-Scale Embedded Generators (Up To 16 A Per Phase) In Parallel With Public Low-Voltage Distribution Networks.

DISTRIBUTION CODE INTRODUCTION (DIN)

DISTRIBUTION INTRODUCTION (DIN)

DIN1 INTERPRETATION

DIN1.1 This **Distribution Code** has been prepared by the **DNOs**. Words and expressions printed in bold type are listed in the **Distribution Glossary and Definitions.**

DIN1.2 The **DNO**, unless indicated otherwise, shall be construed as acting in its **Distribution Business** capacity**.**

DIN2 DISTRIBUTION LICENCE DUTY

DIN2.1 The **Distribution Licence** (Condition 21) requires the **DNO** in consultation with **Authorised Electricity Operators** liable to be materially affected thereby to prepare and at all times have in force and implement and comply with a **Distribution Code** which:

(a) Covers all material technical aspects relating to connections to and the operation and use of the **DNO's Distribution System** and the operation of electric lines and electrical **Plant** and **Apparatus** connected to the **DNO's Distribution System**. The **Distribution System** of any **Other Authorised Distributor** shall comply with the **Distribution Code** at the point of connection with the **DNO's Distribution System**.

(b) Is designed so as to:

(i) Permit the development, maintenance, and operation of an efficient, coordinated and economical **System** for the distribution of electricity.

(ii) Facilitate competition in the generation and supply of electricity.

(iii) Efficiently discharge the obligations imposed upon **DNOs** by the **Distribution Licence** and comply with the Regulation (where Regulation has the meaning defined in the **Distribution Licence**) and any relevant legally binding decision of the European Commission and/or Agency for the Co-operation of Energy Regulators.

DIN2.2 The **Distribution Code** is in the same form for all **Users** of the same category. In drawing up and implementing the **Distribution Code,** the **Distribution Licence** requires that the **DNO** shall not discriminate against or prefer:

(a) any one or any group of persons, or

(b) the **DNO** in the conduct of any business other than the **Distribution Business**, in favour of or against any one other or any other group of persons.

DIN2.3 It is also a requirement of the **Distribution Licence** that the **DNO** shall comply with the provisions of the **Grid Code** so far as applicable to the licensed business, and the **Distribution Code** is designed to ensure that these obligations can be met by the **DNO.**

DIN3 SCOPE

The **Distribution Code** shall be complied with by the **DNO** and by potential and existing **Generators**, **Suppliers** and **Customers** connected to or seeking connection to the **DNO's Distribution System** being referred to as **Users** as expressly defined in the various parts of the **Distribution Code**.

DIN4 GENERAL REQUIREMENTS

DIN4.1 The **Distribution Code** contains procedures to permit equitable management of day to day technical situations in the Electricity Supply Industry, taking account of a wide range of operational conditions likely to be encountered under both normal and exceptional circumstances. It is nevertheless necessary to recognise that the **Distribution Code** cannot predict and address all possible operational situations. **Users** must therefore understand and accept that the **DNO**, in such unforeseen circumstances, will be required, in the course of the reasonable and prudent discharge of its responsibilities, to act in pursuance of any one or any combination of the following "General Requirements":

(a) The need to preserve or restore the integrity of the **DNO's Distribution System** or the **National Electricity Transmission System**

(b) The compliance by the **DNO** with its **Distribution Licence** obligations.

(c) The compliance by others with obligations imposed by Licences issued under the **Act.**

(d) The avoidance of breakdown, separation or collapse (total or partial) of the **DNO's Distribution System** or the **National Electricity Transmission System** or the **Total System**.

(e) The preservation of safety under all circumstances, including the prevention of personal injury.

(f) The prevention of damage to **Plant** and/or **Apparatus**.

(g) The achievement of objectives specifically identified in the **Distribution Code**.

(h) The compliance by the **DNO** with the **Grid Code**.

(i) In the absence of an applicable provision of the **Distribution Code** or any of these General Requirements:

(i) The application of a policy aimed at the equitable sharing amongst **User** of any temporary restriction that might be necessary in exceptional circumstances, and

(ii) The application of then current industry practice.

DIN4.2 **Users** shall provide such reasonable co-operation and assistance as the **DNO** may reasonably request in pursuance of the above General Requirements.

DIN5 CODE RESPONSIBILITIES

DIN5.1 The **Distribution Code** sets out procedures and principles governing the **DNO's** relationship with all **Users** of the **DNO's Distribution System.**

DIN5.2 The **DNO** and all **Users** have a duty under this **Distribution Code** to provide such information and resources as are necessary to facilitate compliance with and implementation of the **Distribution Code**. The **DNO** can only plan and operate the **DNO's Distribution System** and provide information for the planning and operation of the **National Electricity Transmission System**, having regard to the requirements which **Users** have informed the **DNO** they wish to make of the **DNO's Distribution System**. The **DNO** must be able to rely upon the information which **Users** have supplied to it and will not be held responsible for any consequences which arise from its reasonable and prudent actions on the basis of such information supplied by any **User** or **Users**.

DIN6 CONFIDENTIALITY

The **Distribution Code** contains procedures under which the **DNO's Distribution Business**, in pursuance of its obligation as a **DNO**, will receive information from **Users** relating to the intentions of such **Users**. The **DNO** shall not, except in pursuance of specific requirements of the **Distribution Code**, disclose such information to any **User** or other person without the prior written consent of the provider of the information, subject to the requirements of the **Distribution Licence** (Condition 39).

DIN7 PUBLICATIONS

The **Distribution Code** contains references to various Electricity Supply Industry publications which provide guidance on planning and design criteria. A list of the publications referred to is included as an Annex 1 to the **Distribution Code**.

DISTRIBUTION GENERAL CONDITIONS **(DGC)**

DISTRIBUTION GENERAL CONDITIONS (DGC)

DGC1 INTRODUCTION

The **Distribution Glossary and Definitions** apply to all provisions of the **Distribution Code**. Their objective is to ensure, to the extent possible, that various sections of the **Distribution Code** work together and work in practice for the benefit of all **Users**.

DGC2 SCOPE

The **Distribution Glossary and Definitions** apply to the **DNO** and to all **Users**.

DGC3 UNFORESEEN CIRCUMSTANCES

If circumstances not envisaged by the provisions of the **Distribution Code** should arise, the **DNO** shall, to the extent reasonably practicable in the circumstances, consult promptly and in good faith with all affected **Users** in an effort to reach agreement as to what should be done. If agreement between the **DNO** and those **Users** cannot be reached in the time available, the **DNO** shall determine what is to be done.

Wherever the **DNO** makes a determination, it shall do so having regard, wherever possible, to the views expressed by **Users** and, in any event, to what is reasonable in all the circumstances. Each **User** shall comply with all instructions given to it by the **DNO** following such a determination provided that the instructions are consistent with the then current technical parameters of the particular **User's System** registered under the **Distribution Code**. The **DNO** shall promptly refer all such unforeseen circumstances and any such determination to the **Distribution Code Review Panel** for consideration in accordance with DGC4.2(e).

DGC4 THE DISTRIBUTION CODE REVIEW PANEL

DGC4.1 The **DNOs** shall establish and maintain the **Panel**, which shall be a standing body, to carry out the functions referred to in paragraph DGC4.2.

DGC4.2 The **Panel** shall:-

(a) Keep the **Distribution Code** and its working under review, including any necessary requirements for maintaining variations for Scotland and England and Wales;

(b) to minimize the necessary differences in the treatment of issues in Scotland from their treatment in England and Wales;

(c) review all suggestions for modifications to the **Distribution Code** which the **Authority** or any **User** may wish to submit to a **DNO** for consideration by the **Panel** from time to time;

(d) publish recommendations as to modifications to the **Distribution Code** that a **DNO** or the **Panel** feels are necessary or desirable and the reasons for the recommendations;

(e) issue guidance in relation to the **Distribution Code** and its implementation, performance and interpretation when asked to do so by any **User;** and

(f) consider what changes are necessary to the **Distribution Code** arising out of any unforeseen circumstances referred to it by the **DNO** under DGC3.

(g) produce an Annual Report of the activities of the **Panel**; and

(h) establish and maintain governance arrangements for **Qualifying Standard**s that have a material effect on **User**s of the **Distribution System** as follows:

(1) national electricity industry standards that implement **Distribution Code** requirements, and which are listed in Annex 1 of the Distribution Code and form part of the **Distribution Code**;

(2) other national electricity industry standards that have a material affect on **User**s but do not implement **Distribution Code** requirements and which do not form part of the **Distribution Code** technical requirements. The Panel will maintain a list of these standards. For convenience this list is attached as Appendix 2 to the Guide to the Distribution Code; and

(3) standards adopted by individual DNOs, which are published as such by those DNOs and which have a material effect on Users;

(i) maintain a detailed procedure for the overall governance arrangements for **Qualifying Standard**s, which shall be agreed by resolution of the **Panel** from time to time; and

(j) have regard for commercial matters insofar as they interact with the **Distribution Code** and take into account the commercial implications of **Distribution Code** provisions when developing modifications to the **Distribution Code** and **Annex 1 Standard** and **Appendix 2 Standard**. However the **Panel** shall not be required to discuss issues relating solely to commercial matters.

DGC4.3 The **Panel** shall consist of:-

(a) A Chairman and up to 5 members appointed by the **ITCG**, at least one of whom will be a member of the Grid Code Review Panel and at least one of whom will be an **Independent Distribution Network Operator**;

(b) a person appointed by the **Authority**;

(c) the following members:-

(i) 2 persons representing onshore **Generators** with **Embedded Generating Plant** who are **BM Participants** and are active (ie submitting bid-offer data) in the **Balancing Mechanism**;

(ii) 2 persons representing onshore **Generators** with **Embedded Generating Plant** other than those in (i) above; and

(iii) 2 persons, other than **Supplier**, representing **Users** without **Generating Plant;**

(iv) a person representing the **OTSO;**

(v) a person representing **Suppliers**; and

(d) A person representing customers appointed by the **CA** and **CAS.**

Each of the above shall be appointed pursuant to the rules issued pursuant to DGC4.4.

DGC4.4 The **Panel** shall establish and comply at all times with its own Constitution and Rules and procedures relating to the conduct of its business, which Constitution Rules and procedures shall be approved by the **Authority** and are set out in the "Constitution and Rules of the **Distribution Code Review Panel**".

DGC4.5 As part of the **DNO**'s obligation to review periodically the **Distribution Code**and its implementation as required by Condition 21 of the **DNO**'s **Distribution Licence**, the **DNO** shall consult all **Authorised Electricity Operators** liable to be affected in relation to all proposed modifications to the **Distribution Code** and shall submit all proposed modifications to the **Distribution Code** to the **Panel** for discussion prior to such consultation. Such review of the **Distribution Code** undertaken by the **DNO** shall involve an evaluation of whether any modification would better facilitate the achievement of the **Distribution Code** objectives, as provided in the **DNO**'s **Distribution Licence,** and, where the impact on greenhouse gasses is likely to be material, this shall include an assessment of the quantifiable impact of any proposed modification on greenhouse gas emissions, to be conducted in accordance with any guidance (on the treatment of carbon costs and evaluation of greenhouse gas emissions) as may be issued by the **Authority** from time to time and in accordance with the rules pursuant to DGC4.4.

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DGC4.6 The **DNO**s shall establish and maintain a group to be known as the **ITCG**, which shall be a standing body comprised of representatives of the **DNO**s to carry out the functions referred to in its own constitution and rules.

DGC4.7 The **ITCG** shall establish and comply at all times with its own constitution and rules relating to the conduct of its business, which constitution and rules shall be approved by the **Authority**.

DGC4.8 The **DNO**s shall fund and share the costs incurred by or on behalf of the **DNO**s in relation to the operation of the **Panel** and the **ITCG** in accordance with the cost apportionment mechanism set out in the constitution and rules of the **ITCG**.

DGC5 COMMUNICATION BETWEEN THE DNO AND USERS

Unless otherwise specified in the **Distribution Code,** the methods of operational communication (other than relating to the submission of data and notices) shall be agreed between the **DNO** and **User** from time to time. The **DNO** shall operate an enquiry service for dealing with incidents on the **DNO's Distribution System** and interruptions in supply.

DGC6 DATA AND NOTICES

DGC6.1 Data and notices to be exchanged between the **DNO** and **User** under the **Distribution Code** (other than data which is the subject of a specific requirement of the **Distribution Code** as to the manner of its delivery) shall be delivered in writing in accordance with DGD2 (vi).

DGC6.2 All data items, where applicable, will be referenced to nominal voltage and **Frequency** unless otherwise stated.

DGC7 OWNERSHIP OF PLANT **AND/OR** APPARATUS

References in the **Distribution Code** to **Plant** and/or **Apparatus** of a **User** include **Plant** and/or **Apparatus** used by a **User** under an agreement with a third party.

DGC8 SYSTEM CONTROL

Where a **User's System** (or part thereof) is, by agreement, under the control of the **DNO**, then for the purposes of communication and co-ordination in operational timescales the **DNO** can (for those purposes only) treat that **User's System** (or part thereof) as part of the **DNO's Distribution System** but as between the **DNO** and **Users**, it shall remain to be treated as the **User's System** (or part thereof).

DGC9 EMERGENCY SITUATIONS

Users should note that the provisions of the **Distribution Code** may be suspended in whole or in part during a Security Period as more particularly provided for in the **Fuel Security Code**, or in accordance with a **Civil Emergency Direction** issued under a Civil Emergency in accordance with **Distribution Operating Code** DOC9.

DGC10 DISTRIBUTION CODE RESPONSIBILITIES

The **Distribution Code** sets out procedures and principles governing the relationship between the **DNO** and all **Users** of the **DNO's Distribution System.**

DGC11 MODIFICATIONS TO THE DISTRIBUTION CODE

DGC11.1 Modifications to the **Distribution Code** shall be made in accordance with the procedures set out in the Constitution and Rules of the **Distribution Code Review Panel**.

DGC11.2 Modifications to the **Distribution Code** that change the obligations on **Users** and **DNO**s in relation to the specification of **Equipment** that each has to provide to comply with the **Distribution Code** will not apply retrospectively to **Equipment** already existing at the date of the implemention of the **Distribution Code** change, unless specifically required in the relevant **Distribution Code** clause. However, where the **DNO** or the **User** makes a material alteration to the relevant **Equipment**, then the **DNO** or the **User** will comply with the requirements of the **Distribution Code** currently in force at the date of the material alteration.

DGC11.3 The **DNOs** shall appoint a Code Administrator (as defined in the **Distribution Licence**). The Code Administrator shall (in addition to any powers, duties or functions set out in the **Distribution Code** or the Constitution and Rules of the **Distribution Code Review Panel**):

(a) together with other code administrators, publish, review, and (where appropriate) amend from time to time the Code of Practice (Code of Practice in DGC11.3 has the meaning defined in the **Distribution Licence**);

(b) facilitate the procedures for making a modification to the **Distribution Code**;

(c) have regard to, and in particular (to the extent relevant) be consistent with, the principles contained in the Code of Practice;

(d) provide assistance, insofar as it is reasonably practicable and on reasonable request, to **Authorised Electricity Operators** (including in particular Small Participants as defined in the **Distribution Licence**) and, to the extent relevant, consumer representatives that request the Code Administrator's assistance, in relation to the **Distribution Code** including, but not limited to, understanding the operation of the **Distribution Code**, their involvement in, and representation during, the modification processes (including, but not limited to, **Panel** and/or working group meetings), and accessing information relating to modification proposals and/or modifications.

DISTRIBUTION PLANNING AND CONNECTION CODE **(DPC)**

DISTRIBUTION PLANNING AND CONNECTION CODE (DPC)

DISTRIBUTION PLANNING AND CONNECTION CODE 1

DPC1 GENERAL INTRODUCTION

DPC1.1 The **Distribution Planning and Connection Code** specifies the technical and design criteria and the procedures to be applied by the **DNO** in the planning and development of the **DNO's Distribution System** and to be taken into account by **Users**, as defined in DPC3 below, in the planning and development of their own **Systems** insofar as the latter affect the operation and use of the **DNO's Distribution System**. Developments on the **DNO's Distribution System** may have an impact on the **National Electricity Transmission System** and this will be taken into account in the planning and development of the **DNO's Distribution System** and the conditions of the **Grid Code** complied with as appropriate.

DPC1.2 This **Distribution Planning and Connection Code** also specifies the technical, design and operational criteria which must be complied with by the **Users**, defined in DPC3 below connected to, or seeking connection to the **DNO's Distribution System,** in the planning and development of their **Systems** in so far as they affect the **DNO's Distribution System.**

DPC1.3 A requirement for reinforcement or extension of the **DNO's Distribution System** or the **National Electricity Transmission System** may arise due to the requirements of a **User** or for a number of other reasons including, but not limited to:

(a) A development on a **User's System** already connected to the **DNO's Distribution System** as a **User Development**.

(b) The introduction of a new **Connection Point** between a **User's System** and the **DNO's Distribution System**.

(c) Transient, or steady state stability considerations.

(d) The development of an existing, or the connection of a new **Customer**.

(e) The cumulative effect of any combination of the above.

DPC1.4 Accordingly, the reinforcement or extension of the **DNO's Distribution System** or the **National Electricity Transmission System** may involve work:

(a) At the **Connection Point** between a **User's System** and the **DNO's Distribution System**.

(b) On distribution or transmission lines or substations or other facilities which join the **Connection Point** to the remainder of the **DNO's Distribution System** or the **National Electricity Transmission System**

(c) At or between points on the **DNO's Distribution System** remote from the **Connection Point.**

DPC1.5 The time required for the planning and development of the **DNO's Distribution System** and any consequential requirement of the **DNO's** interface with the **National Electricity Transmission System** will depend on the type and extent of the necessary reinforcement and/or extension work, the need or otherwise to obtain statutory or other consents by all parties, the associated possibility for a public inquiry and the degree of complexity in undertaking the new work whilst maintaining satisfactory security and quality of supply on the **DNO's Distribution System.** The **Distribution Licence** imposes appropriate timescales on the exchange of information between the **DNO** and **Users.**

DPC1.6 **Planning Data**

DPC1.6.1 **Standard Planning Data**

Standard Planning Data is that data first to be provided by a **User** at the time of an application for a **Connection Agreement**. It comprises data, which is expected normally to be sufficient for the **DNO** to investigate the impact on the **DNO's Distribution System** of any **User Development** associated with an application by the **User** for a **Connection Agreement**. The **DNO** will inform **Users** where more detailed information is required.

DPC1.6.2 **Detailed Planning Data**

Detailed Planning Data comprises additional, more detailed, data not normally expected to be required by the **DNO** to investigate the impact on the **DNO's Distribution System** of any **User Development** associated with an application by the **User** for a **Connection Agreement**.

The **User** may, however, be required by the **DNO** to provide the **Detailed Planning Data** before the **DNO** can make an offer for a **Connection Agreement.** The **DNO** shall only request **Detailed Planning Data** where it considers the provision of such data to be necessary and in such cases the **DNO** shall specify which elements of **Detailed Planning Data** are required.

DPC1.6.3 **Standard Planning Data** and **Detailed Planning Data** requirements are specified for different **User Developments** of different types in DPC5 and DPC7 of this **Distribution Planning and Connection Code** and summarised in the **Distribution Data Registration Code.**

DPC1.6.4 **Estimated Data**

Where data is not available at the feasibility stage or preliminary stage of a **User Development** then the **User** may provide a reasonable estimate of the data to be requested by the **DNO** and in such cases the data shall be identified as estimated data by the **User.** Estimated data supplied by **Users** in pursuance of this **Distribution Planning and Connection Code** should, where practicable, be replaced by actual validated values prior to connection.

DPC1.6.5 **Assumed Data**

Where data is not available or has not been provided by the **User** at the feasibility stage or preliminary stage of a **User Development** then the **DNO** may make reasonable assumptions of the data required for assessment of the **User Development** and in such cases the **User** shall be notified of the assumed values adopted. Where the **DNO** has notified the **User** that assumed data has been adopted by the **DNO** in pursuance of this **Distribution Planning and Connection Code** then the **User** should, where practicable provide actual validated values to replace the assumed values prior to connection.

DPC1.7 **Status of Planning Data**

It is in the interests of all **Users** to initiate early discussion with the **DNO** regarding any proposed **User Development,** which may have an impact on the **DNO's Distribution System**.

For the purposes of this **Distribution Planning and Connection Code** it is considered that development will consist of four stages: -

(a) Feasibility Project Stage

At this optional stage the **User** will be considering a **User Development**. The **DNO** will be pleased to conduct a short meeting to discuss the **User's** requirements and provide guidance on the likely implications for the **DNO's Distribution System**.

If at this stage the **User** requires further information then the **DNO** will request **Standard Planning Data** from the **User** and provide a feasibility assessment identifying items of significant cost to the extent permitted by the information provided by the **User**. In accordance with the **DNO's** Statement of Charges a charge will be payable by any potential **User** for such an assessment.

At the feasibility project stage a number of iterative studies may be carried out by the **DNO** at the request of the **User** (or by the **User**) to identify opportunities for connection and corresponding costs and technical issues. The **Feasibility Project Data** requested by the **DNO** from the **User** to carry out these feasibility studies may include both **Standard Planning Data** and **Detailed Planning Data** depending on the complexity of the assessment studies required to be carried out by the **DNO**.

(b) Preliminary Project Stage

At this stage the **User** will have submitted an application for a **Connection Agreement**. The **Preliminary Project Planning Data** requested by the **DNO** from the **User** for assessing the connection and costs may include both **Standard Planning Data** and **Detailed Planning Data.**

c) Committed Project Stage

At this stage a **Connection Agreement** will have been established. The **Committed Project Planning Data** on which the **Connection Agreement** is based may include both **Standard Planning Data** and **Detailed Planning Data.**

(d) Registered Project Stage

At this stage the connection will be physically established. The **Registered Data** for the connection shall include replacements for estimated and assumed values, where practicable, using validated actual values and updated forecasts for future data items.

DPC1.8 Reference is made in the **Distribution Planning and Connection Code t**o the **DNO** supplying information or advice to **Users**. For the avoidance of doubt, unless the context otherwise requires, such information or advice will be furnished by the **DNO** upon request by the **User** (whether during the application for connection process or otherwise).

DPC1.9 The provisions of the **Distribution Planning and Connection Code** shall, subject to DPC1.8, be applicable to:

(a) All existing connections as at the date of commencement of **DNO's Distribution Licence.**

(b) All new or modified connections thereafter.

DPC1.10 In considering the approval of existing connections at the date of commencement of its **Distribution Licence,** the **DNO** shall have regard to the fact that previous changes in technical and design standards have not been applied retrospectively in every case, and the **DNO** shall not seek, under the terms of these **Distribution Planning and Connection Code** Conditions, to impose retrospective changes where these had not been required in the past, except where the **DNO** can reasonably demonstrate that significant change has occurred to conditions which existed when the matter was previously considered by the **DNO** or its predecessors.

DISTRIBUTION PLANNING AND CONNECTION CODE 2

DPC2 OBJECTIVES

The objectives of the Distribution Planning and Connection Code are to:-

(a) Enable the **DNO's Distribution System** to be planned, designed and constructed to operate economically, securely and safely.

(b) Facilitate the use of the **DNO's Distribution System** by others and to specify a standard of supply to be provided.

(c) Establish technical conditions which facilitate the interfacing of **Systems** at points of entry to and exit from the **DNO's Distribution System**.

(d) Formalise the exchange of **System** planning data.

(e) Provide sufficient information for a **User** to assess opportunities for connection and to plan and develop his **System** such as to be compatible with the **DNO's Distribution System.**

DISTRIBUTION PLANNING AND CONNECTION CODE 3

DPC3 SCOPE

DPC3.1 The **Distribution Planning and Connection Code** specifies the planning, design and connection requirements for **Distribution Systems** owned by the **DNO** and for connections to those **Systems**.

DPC3.2 The **Users** to whom the **Distribution Planning and Connection Code** applies are those who use or intend to use the **DNO's Distribution System** and comprise the following:-

(a) **Embedded Generators.**

(b) **Suppliers**.

(c) **Customers** including those with **Unmetered Supplies** who are connected to the **DNO's Distribution System**.

(d) **Other Authorised Distributors** connected to the **DNO's Distribution System.**

(e) **Meter Operators** which perform services in respect of **Equipment** connected to the **DNO's Distribution System.**

DISTRIBUTION PLANNING AND CONNECTION CODE (DPC)

DISTRIBUTION PLANNING AND CONNECTION CODE 4

DPC4 DESIGN PRINCIPLES AND STANDARDS

DPC4.1 **Introduction**

DPC4.1.1 Planning criteria are based on the requirement to comply with statutory requirements, **Distribution Licence** conditions and other obligations placed on the **DNO** and **Users**.

DPC4.1.2 The **DNO** has a duty to develop and maintain an efficient, secure and co-ordinated **System** of electricity supply that is both economical and safe.

DPC4.1.3 **DPC4** sets out current principles and standards to be applied in the design of the **DNO's Distribution System** and any **User** connections to that **System.** Each scheme for reinforcement or modification of the **DNO's Distribution System** is individually designed in the light of economic and technical features associated with the particular **System** limitations under consideration.

DPC4.1.4 Nothing in DPC4 is intended to inhibit design innovation**.** DPC4 is, therefore, based upon the performance requirements of the **DNO's Distribution System** necessary to meet the above criteria.

DPC4.1.5 The technical and design criteria applied in the planning and development of the **DNO's Distribution System** are listed in Annex 1 to the **Distribution Code**. These standards may be subject to revision from time to time in accordance with the provision of the **Distribution Licence**.

DPC4.2 **Standard of Supply**

DPC4.2.1 **Security**

In accordance with the Condition 5 of the **Distribution Licence, DNOs** shall plan and develop their **DNO's Distribution Systems** to a standard not less than that set out in DGD Annex 1 Item 4, Engineering Recommendation P2/6 – "Security of Supply" or such other standard of planning as **DNOs** may, with the approval of the **Authority**, adopt from time to time

In accordance with the **Distribution Licence** Scottish Hydro Electric Power Distribution Ltd shall plan and develop its **DNO's Distribution System** in Scotland to a standard set out in EM7907. Engineering Recommendation P2/6 – "Security of Supply" has been modified by Scottish Hydro Electric Power Distribution Ltd as EM7907 and this is accepted by the **Authority**.

DPC4.2.2 **Frequency and Voltage**

DPC4.2.2.1 The **DNO's Distribution System** and any **User** connections to that **System** shall be designed to enable the **Normal Operating Frequency** and voltages supplied to **Customers** to comply with the **ESQCR**.

DPC4.2.2.2 The **Frequency** of the **DNO's Distribution System** shall be nominally 50 Hz and shall normally be controlled within the limits of 49.5 - 50.5 Hz in accordance with principles outlined in the **ESQCR**.

DPC4.2.2.3 In exceptional circumstances, **System Frequency** could rise to values of the order of 52 Hz or fall to values of the order of 47 Hz. Sustained operation outwith the range 47 - 52 Hz is not taken into account in the design of **Plant** and **Apparatus.**

DPC4.2.2.4 Any extension or connection to the **DNO's Distribution System** shall be designed in such a way that it does not adversely affect the voltage control employed on the **DNO's Distribution System**. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **User.**

DPC4.2.3 **Voltage Disturbances and Harmonic Distortion**

DPC4.2.3.1 General

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 System** 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**.

DPC4.2.3.2 Voltage Disturbances

Distortion of the **System** voltage waveform, caused by certain types of **Equipment**, may result in annoyance to **Users** of the **DNO's Distribution System** or damage to connected **Apparatus**. In order to limit these effects the following shall apply to **Users'** loads connected to the **DNO's Distribution System:-**

(a) Voltage fluctuations shall comply with the limits set out in DGD Annex 1, Item 9 Engineering Recommendation P28, "Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom".

(b) The harmonic content of a load shall comply with the limits set out in DGD Annex 1, Item 1 Engineering Recommendation G5/4-1, "Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission and distribution systems in the United Kingdom."

(c) **Phase (Voltage) Unbalance**shall comply with the levels laid down in DGD Annex 1, Item 10 Engineering Recommendation P29, "Planning limits for voltage unbalance in the United Kingdom for 132kV and below".

(d) Traction supplies shall comply as appropriate with the requirements of DGD Annex 1, Item 6. Engineering Recommendation P24 "A.C. traction supplies to British Rail".

Under certain circumstances the **DNO** may agree to other limits or levels.

DPC4.2.3.3 Voltage Step Changes

The effect of voltage step changes caused by the connection and disconnection of **User**’s **Equipment** or **Customer**’s **Demand** to or from the **DNO’s Distribution System** must be considered and be subject to limits to avoid unacceptable voltage changes being experienced by other **Customer**s connected to the **DNO’s Distribution System**. The magnitude of a voltage step change depends on the method of voltage control, types of load connected and the presence of local generation. Typical limits for voltage step changes caused by the connection and disconnection of **User**’s **Equipment** or **Customer**’s **Demand** to the **DNO’s Distribution System**, are ±3% for infrequent planned switching events or outages (in accordance with Engineering Recommendation P28). For unplanned outages such as faults it will generally be acceptable to design to a voltage step change of ±10%.

For the purpose of the **Distribution Code** a voltage step change should be considered to be the change from the initial voltage level to the resulting voltage level after all the **Generation Set** 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

The voltage depression arising from transformer magnetising inrush current is a short-time phenomenon not generally easily captured by the definition of voltage step change used above. 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 under one second.

User’s installations should be designed such that transformer magnetising inrush current associated with normal routine switching operations does not cause voltage fluctuations outside those in Engineering Recommendation P28 (ie a maximum of ±3%). To achieve this it may be necessary install switchgear so that sites containing multiple transformers can be energised in stages.

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 maintenance switching, or carrying out commissioning tests on the **DNO’s Distribution System** or on **User**s’ Systems. In these situations it will generally be acceptable to design to an expected depression of around ±10%, recognizing that a worst case energization might cause 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%.

DPC4.2.4 **Auto-reclosing and Single Phase Protection Operation**

In connecting to the **DNO’s Distribution System** the **User** should be aware that auto-reclosing or sequential switching features may be in use on the **DNO’s Distribution System**. 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 Systems** may cause disconnection of one phase or two phases only of a three phase supply for certain types of fault.

DPC4.3 **Design Principles**

This section sets out design principles for **Users** (excluding **Generators,** the **OTSO** and **Users** with **Unmetered Supply**), connected at **Low Voltage** and having single phase or three phase supplies protected by fuse(s) or other device(s) rated at 100 amps or less.

DPC4.3.1 Any **User's** installation which complies with the provisions of the Requirements of Electrical Installations BS 7671 as amended from time to time, shall be deemed to comply with the requirements of the **Distribution Code** as regards design and safety.

DPC4.3.2 On the request of a **User** the **DNO** will provide such information, as may be reasonably required, on the design and other characteristics of the **DNO's Distribution System**.

Guidance on the short circuit characteristics of the **Low Voltage System** and associated supplies is provided in **Electricity Supply Industry** engineering publications, including Items 7 and 8 in Annex 1 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".

Design practice for protective multiple earthing is detailed in the **Electricity Supply Industry** engineering publications (including Item 2 in Annex 1 Engineering Recommendation G12/4, "Application of protective multiple earthing to low voltage networks") and in the references contained in those publications.

The **DNO's** information requirements are detailed in DPC5.2.1.

DPC4.4 **Design Principles for all other Users not included in DPC4.3**

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 System** 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 System** 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".

(e) Connections to the **DNO's Distribution System** at 132kV may be subject to the requirements of Appendix 2 item 5 (ER P18). **DNO**s will have network specific complexity limits for **System**s operating at voltages below 132kV which they will make available on request.

(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.

DPC4.4.2 **Earthing**

(a) The arrangements for connecting the **DNO's Distribution System** 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 Items 11, and 12 in DGD Annex 1 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 **Generating Plant** are given in DPC7.

(b) The method of earthing of the **DNO's Distribution System**, 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 Item 2 DGD Annex 1 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.)

DPC4.4.3 **Voltage Regulation and Control**

Any extension or connection to the **DNO's Distribution System** shall be designed in such a way that it does not adversely affect the voltage control employed by the **DNO's Distribution System**. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **User.**

DPC4.4.4 **Protection**

(a) The **DNO's Distribution System** and the **System** of any **User** connected to the **DNO's Distribution System** shall incorporate protective devices in accordance with the requirements of the **ESQCR**.

(b) In order to ensure satisfactory operation of the **DNO's Distribution System**, **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 System**.

(d) Unless the **DNO** should advise otherwise, it is not acceptable for **Users** to limit the fault current infeed to the **DNO's Distribution System** 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.

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 System**, the prior agreement of the **DNO** is required.

DPC4.5 **Network Statements**

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 System** 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 system 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 system 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

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.

DISTRIBUTION PLANNING AND CONNECTION CODE (DPC)

DISTRIBUTION PLANNING AND CONNECTION CODE 5

DPC5 GENERAL REQUIREMENTS FOR CONNECTION

DPC5.1 Introduction

DPC5.1.1 **Distribution Planning and Connection Code** (DPC5) ensures that all **Users** of the **DNO's Distribution System** are subject to the same requirements for connection.

DPC5.1.2 Data exchange requirements specified in this **Distribution Planning and Connection Code** apply to any **User Development**, which has an impact on the **DNO's Distribution System.**

DPC5.1.3 DPC5.2.2 specifies the information required from **Users** by the **DNO** in order to ensure that adequate technical provision is made for new supplies or increases in existing load; DPC5.2.2 also applies to **Embedded Generators** who operate in parallel with the **DNO's Distribution System**, where a supply is required from the **DNO** under normal or emergency conditions. Information required from **Embedded Generators**, with connections at **HV** or **Low Voltage**, in respect of the import of energy to the **DNO's Distribution System**, is covered in DPC7. Transfer of Planning Data for **Users** connected at **HV** is set out in DPC 8.

DPC5.2 Declaration of Load Characteristics

DPC5.2.1 For supplies at **Low Voltage** under terms in the **Supply Agreement** it is possible in most cases to assess whether a proposed connection is acceptable, and to determine the necessary supply arrangements, from analysis of the following limited data:-

(a) Maximum power requirements (kVA or kW);

(b) Type and electrical loading of **Equipment** to be connected, eg number and size of motors, cookers, showers, space and water electrical heating arrangements, including details of equipment which is subject to switching by the **Supplier**; and

(c) The date when the connection is required.

These requirements will be specified on the appropriate application for a connection form obtainable from the **DNO**.

Should a preliminary examination of this data indicate that more detailed information is required then it shall be provided to the **DNO** upon request if reasonably required.

Users, shall contact the **DNO** in advance if it is proposed to make any significant change to the connection, electric lines or electrical **Equipment**, install or operate any generating equipment or do anything else that could affect the **DNO's Distribution System** or require alterations to the connection.

Users shall provide the **DNO** with any information it asks for about the nature, or use by the **User**, of electrical equipment on the **User's** premises (including that specified in DPC5.2.1 (a), (b), and (c) above). The **DNO** will only ask for information that is needed by it in relation to its **Distribution Licence** or the **Distribution Code** or to comply with the **ESQCR** or the **Act.**

DPC5.2.2 The provisions of DPC5.2.1 also apply to supplies other than those at **Low Voltage.** It may be necessary for the following more comprehensive information, in addition to that detailed in DPC5.2.1, to be provided on request:-

DPC5.2.2.1 **Standard Planning Data**

It is possible in most cases to assess whether a proposed connection is acceptable, and to determine the necessary supply arrangements, from analysis of the following limited **Planning Data** which will be specified on the appropriate standard application form obtainable from the **DNO**:

(a) Point of Connection to the **DNO's Distribution System** (geographical and electrical).

(b) The date when connection is required.

(c) Single line diagrams of existing and proposed arrangements of main **Plant** and **Apparatus** showing equipment rating.

(d) Type and electrical loading of equipment to be connected, eg number and size of motors, electrical heating arrangements, etc.

(e) Maximum power requirements MVA.

(f) Maximum **Active Power Demand** (MW).

(g) Maximum and minimum **Reactive Power** requirements (MVAr).

(h) The maximum **Phase (Voltage) Unbalance** which the **User** would expect the **Demand** to impose on the **DNO's Distribution System.**

(i) The maximum harmonic content which will be imposed on the **DNO's Distribution System.**

(j) Details of change of **Demand (Active Power** and **Reactive Power).**

(k) Details of any load management scheme to be applied by the **User** on the **User System**.

(l) **Peak Demand** profiles at the **Exit Point**, both 2 hourly on day of **User's Peak Demand** and monthly **Peak Demand** variations.

(m) Three phase short circuit infeed from all sources within the **User's System**, based on **Generation Set** sub-transient reactance and the minimum zero phase sequence impedance of the **User's System**.

(n) Standard load profiles

Should a preliminary examination of this data indicate that more detailed information is required then it shall be provided to the **DNO** on request.

DPC5.2.2.2 **Detailed Planning Data**

It may be necessary for the **User** in addition to that in DPC5.2.2.1, to provide the following more comprehensive **Detailed Planning Data** on request.

In relation to **Demand**:

(a) Type of load and control arrangements (eg controlled rectifier or large motor drives and type of starter employed).

(b) Maximum load on each phase at the time of **Peak Demand**

(c) **Demand** profiles (48 x half hour average estimates) for **Active** and **Reactive Power Demand** for the day of the **Exit Point Peak Demand** and for the day of the **National Electricity Transmission System Peak Demand** at **Annual Average Cold Spell (ACS) Conditions.**

In relation to fluctuating loads:-

(a) The rates of change of **Demand (Active Power** and **Reactive Power)** both increasing and decreasing.

(b) The shortest repetitive time interval between fluctuations in **Demand (Active Power** and **Reactive Power)**.

(c) The magnitude of the largest step changes in **Active Power** and **Reactive Power**, both increasing and decreasing.

In some cases, more detailed information may need to be provided to permit a full assessment of the effect of the **User's** load on the **DNO's Distribution System**. Such information may include an indication of the pattern of build up of load and a proposed commissioning programme. This information will be specifically requested by the **DNO** when necessary.

DPC5.2.3 A **DNO** is only entitled to use any information provided by a **User** under this **Distribution Code** for the purpose of fulfilling its obligations in respect of its **Distribution System** required by the **Distribution Licence** or the **Distribution Code**, including operating the procedures for **Load Managed Areas** and associated Security Restriction Notices specified in the **Distribution Use of System Agreement.**

DPC5.3 **Connection Arrangements**

DPC5.3.1 The design of connections between the **DNO's Distribution System** and **Users** shall be in accordance with the principles set out in DPC4, subject to any modification to which the **DNO** may reasonably consent.

DPC5.3.2 During the application for connection process the **DNO** will agree with the **User** the voltage level to which a **User** will be connected in accordance with its normal practice for the type of load to be supplied. The **DNO** may on occasion specify a different connection voltage from normal in order to avoid potential disturbance caused by the **User's Apparatus** to other **Users** of the **DNO's Distribution System** or for other technical reasons or may agree alternative methods for minimising the effects of disturbing loads.

DPC5.3.3 Before entering into a **Connection Agreement** and before making a connection to a **User** at a **Connection Point**, it will be necessary for the **DNO** to be reasonably satisfied that the **User's System** at the boundary with the **DNO's Distribution System** will comply with all appropriate requirements of the **Distribution Code.**

DPC5.3.4 The **User's** installation shall comply with the principles expected in Regulation 25(2)(a) of the **ESQCR,** or relevant European and British Standard as appropriate.

DPC5.4 **Ownership Boundaries**

DPC5.4.1 The point or points at which supply is given or taken between the **DNO's Distribution System** and **Users** will be agreed between the **DNO** and the **User** as required. For supplies at **Low Voltage** the general rule is that the point of supply will be at the outgoing (ie **User**'s side) terminals of the item of **DNO** or **Meter Operator** owned **Apparatus** where the transition is made to the **User**'s tails or other **User** owned **Apparatus**. For **HV** supplies, including connections between the **DNO** and **User**, and where necessary busbar connected supplies at **Low Voltage**, the points of supply will be subject to specific agreement between the parties in each case.

DPC5.4.2 The respective ownership of **Plant** or **Apparatus** will be recorded in a written agreement between the **DNO** and the **User** as required. In the absence of a separate agreement between the parties to the contrary, construction, commissioning, control, operation and maintenance responsibilities follow ownership.

DPC5.4.3 For supplies to **Embedded Generator**s who operate in parallel with the **DNO's Distribution System** and all supplies at **HV** the **DNO** will with the **User's** agreement prepare a **Site Responsibility Schedule** and, where determined by the **DNO** during the application for connection process, **Operation Diagrams** showing the agreed **Ownership Boundary**.

The **Site Responsibility Schedule** shall detail the demarcation of responsibility for safety of persons carrying out work or testing at sites having a **Connection Point** to the **DNO's Distribution System** and/or circuits which cross an **Ownership Boundary** at any point.

More detailed information on procedures and responsibilities involved in the provision of safety at interfaces between the **DNO's Distribution System** and a **User's System** is set out in **Distribution Operating Code** DOC8.

Copies of these documents will be retained by the **DNO** and the **User.** Changes in the boundary arrangements proposed by either party must be agreed in advance and will be recorded on the **DNO Operation Diagrams**.

DISTRIBUTION PLANNING AND CONNECTION CODE (DPC)

DISTRIBUTION PLANNING AND CONNECTION CODE 6

DPC6 TECHNICAL REQUIREMENTS FOR CONNECTIONS

DPC6.1 Introduction

Distribution Planning and Connection Code DPC6 specifies the technical arrangements required at the **Ownership Boundary** between the **DNO's Distribution System** and the **System** of the **User** and is applicable at all voltage levels, but excludes **Users** (including those with **Unmetered Supplies)** connected at **Low Voltage**, without Generation, and protected by fuse(s) or other device(s) rated at 100 amps or less.

DPC6.2 Equipment at the Ownership Boundary

All **Equipment** at the **Ownership Boundary** shall meet the design principles contained within DPC4.4.1. Connections for entry to and exit from the **DNO's Distribution System** shall incorporate a means of disconnection of the **User's** installation by the **DNO**.

DPC6.3 Protection Requirements

Protection requirements vary widely depending on established practices and the needs of the particular **DNO's Distribution System**. 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 System**, 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:-

(a) 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 System**.

(b) In connecting to the **DNO's Distribution System** the **User** should be aware that auto-reclosing or sequential switching features may be in use on the **DNO's Distribution System**. 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.

(c) **Users** should also be aware that the **Protection** arrangements on some **DNO's Distribution Systems** may cause disconnection of one phase or two phases only of a three phase supply for certain types of fault.

DPC6.4 Earthing

Earthing of that part of the **User's System** that is connected to the **DNO's Distribution System** shall comply with the arrangements specified in **DPC4**.

DPC6.5 **Fault Level Considerations**

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 System** 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 DGD Annex 1, Items 7 and 8, 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 **System** will take into account the contribution to **Fault Level** of the **User's** connected **System** and **Apparatus**.

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 System.**

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 System** 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 System** is suitably rated.

(b) To show that the performance of the **DNO's Distribution System** 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.

DPC6.7 **Communications and Telemetry Equipment**

DPC6.7.1 Where required by the **DNO** in order to ensure control of the **DNO's Distribution System,** 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.

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.**

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**.

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.

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.

DPC6.7.6 **Data Entry Terminals**

The **User** shall accommodate the **DNO's** data entry terminals for the purpose of information exchange.

DPC6.7.7 **System Monitoring**

Monitoring equipment is provided on the **DNO's Distribution System** 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.**

DISTRIBUTION PLANNING AND CONNECTION CODE 7

DPC7 REQUIREMENTS FOR EMBEDDED GENERATORS

DPC7.1 Introduction

DPC7.1.1 This **Distribution Planning and Connection Code** DPC7 is applicable to all **Embedded Generators** including a **Customer With Own Generation** and **Other Authorised Distributors,** having **Generating Plant** operating or capable of operating in parallel with the **DNO's Distribution System**.

DPC7.1.2 In addition to meeting the requirements of DPC7, **Embedded Generators** will need to meet the requirements of other relevant sections of the **Distribution Code**.

DPC7.1.3 For the avoidance of doubt a **User** who has installed a **Generation Set** in accordance with Item 13 DGD Annex 1 Engineering Recommendation G83/2 ("Recommendations For The Connection of Type Tested Small-Scale Embedded Generators (Up To 16 A Per Phase) in Parallel With Public Low-Voltage Distribution Networks") and where this is (are) their only **Generation Set(s)**, and which has been installed, commissioned and operated in accordance with Annex 1, Item 13, that **User** shall not be required to comply with the requirements of DPC7 in respect of that (those) **Generation Set.**

DPC7.1.4 Where **Generating Plant** is not intended for parallel operation, but where short term paralleling is desirable to avoid loss of supply during changeover, then the **Generating Plant** may be permitted to operate in parallel with the **DNO's Distribution System** for no more than 5 minutes in any month, and no more frequently than once per week. If the duration of parallel connection exceeds this period, or this frequency, then the **Generating Plant** 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 **Generating Plant** design.

DPC7.1.5 Where DPC 7.1.4 applies, 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.

DPC7.2 General Requirements

DPC7.2.1 **Embedded Generators** connected to the **DNO's Distribution System**will comply with the requirements of Item 3, DGD Annex 1 Engineering Recommendation G59/3-2~~1~~, "Recommendation for the connection of generating plant to the distribution systems of licensed distribution network operators".

DPC7.2.2 Every installation or network which includes **Generating Plant** operating in parallel with the **DNO's Distribution System** must include an **Isolating Device** capable of disconnecting the whole of the **Generating Plant** infeed from the **DNO's Distribution System**. This **Isolating Device** will normally be owned by the **Generator**, but may by agreement be owned by the **DNO**.

DPC7.2.3 The **Generator** must grant the **DNO** rights of access to the **Isolating Device** without undue delay and the **DNO** must have the right to isolate the **Generator**'s 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.

DPC7.2.4 To ensure that **DNO** staff and that of the **User** and the **User**'s contractors are aware of the presence of **Generating Plant**, appropriate warning labels should be used. Where the installation is connected to the **DNO's Distribution System** at **Low Voltage** the installer should generally provide labelling at the **Connection Point**, meter position, consumer's unit and at all points of isolation within the **User**'s premises to indicate the presence of **Generating Plant**. 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.

DPC7.2.5 The disconnection of **Generating Plant** 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.

DPC7.2.6 Where the **Connection Point** provided by the **DNO** for parallel operation is at **HV**, in addition to the provisions of DOC8, the **Generator** must ensure that a person with authority, or his staff, is available at all times to receive communications from the **DNO Control Person** 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 Person** of any abnormalities that occur on the **Generating Plant** which have caused, or might cause, disturbance to the **DNO's Distribution System**, for example earth faults.

DPC7.2.7 Manual synchronizing can only be done with the specific agreement of the **DNO**.

DPC7.2.8 The **DNO**'s interface circuit breaker will not be used for synchronizing, without the express agreement of the **DNO**.

DPC7.3 **Provision of Information**

Embedded Generators can have a significant effect on the **DNO's Distribution System** and as a result its **Users**. To enable the **DNO** to assess the impact **Embedded Generating Plant** or an **Embedded Transmission System** will have on the **DNO's Distribution System,** the **Embedded Generator** will be required to supply information to the **DNO.**

Embedded Generators 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 Station** and site data for all **Embedded Generators** excluding the **OTSO.**	DPC7.3.1 and Schedule 5a of the DDRC
(b)	**Generation Set** data for all **Embedded Generating Plant**	DPC7.3.2 and Schedule 5b of the DDRC
(c)	**Generation Set** data for specified types of **Embedded Generating Plant** 5c(i) Synchronous generators 5c(ii) Fixed speed induction generators 5c(iii) Double fed induction generators 5c(iv) Converter connected generators 5c(v) Transformers	DPC7.3.2 and Schedules 5c of the DDRC
(d)	**Generation Set** data for **Embedded Medium Power Station**s	DPC7.3.3 and Schedules 5c of the DDRC
(e)	**Embedded Transmission System** data	DPC7.3.1, DPC7.3.2 and DPC7.3.3 and Schedule 5e of DDRC

When applying for connection to the **DNO's Distribution System Embedded Generators** shall also refer to DPC5.

The **DNO** will use the information provided to model the **DNO's Distribution System** 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 DPC7.3.1 will be required for **Embedded Generators** 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.

DPC7.3.1 **Information Required from all Embedded Generators**

It will be necessary for each **Embedded Generator** to provide to the **DNO** information on physical and electrical characteristics of the **Power Station** and site as a whole as set out in Schedules 5a or 5e of the **Distribution Data Registration Code** before entering into an agreement to connect any **Generating Plant** or an **Embedded Transmission System** onto the **DNO's Distribution System:-**

The information required includes:

(a) Details of the proposed connection point (geographical and electrical) and connection voltage.

(b) The number and types of generators and the total capacity of the power station 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 **Embedded Generator's System** directly connected to the **DNO's Distribution System**.

(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 Generator'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 System**. This information will need to be provided by the **Embedded Generator** at the reasonable request of the **DNO**.

DPC7.3.2 **Additional Generation Set and Plant and Equipment Data Required from Embedded Generators.**

The **Standard Planning Data** and **Detailed Planning Data** specified in Schedule 5b and Schedule 5c (or Schedule 5e for the **OTSO**) of the **Distribution Data Registration Code** may be requested by the **DNO** from the **User** before entering into an agreement to connect any **Generating Plant** or **Embedded Transmission System** onto the **DNO's Distribution System.**

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 Set**:

(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 Generator** at the request of the **DNO.**

DPC7.3.3 **Extra Information From Embedded Generators to be Provided to Meet Grid Code Requirements**

DPC 7.3.3(a) The **DNO** has an obligation under PC3.3 of the **Grid Code** to submit certain planning data relating to **Embedded Medium Power Stations** to **NGC**. 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 Stations** to provide this data listed in PC3.3 of the **Grid Code** to the **DNO**.

Where a **Generator** in respect of an **Embedded Power Station** is a party to the **CUSC** this DPC 7.3.3 will not apply.

DPC7.3.3(b) In addition to supplying the **DNO** with details of **Embedded Generating Plant** there is a requirement to provide information to **NGC** where it has been specifically requested by **NGC** in the circumstances provided for under the **Grid Code**.

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 System** as set out in DPC4.5**.** Comprehensive information on the **DNO's Distribution System** 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.

DPC7.4 **Technical Requirements**

DPC7.4.1 **Generating Plant Performance Requirements**

DPC7.4.1.1 The requirements of this DPC7.4.1 do not apply to **Generation Sets** that are designed and installed for infrequent short term parallel operation only.

DPC7.4.1.2 For **Embedded Generating Plant,** which does 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. A **Generation Set** or **Power Station** must be capable of supplying its **Registered Capacity** within the **System Frequency** range 49.5 to 50.5 Hz. The output power should not be affected by voltage changes in the permitted operating range.

DPC7.4.1.3 In exceptional circumstances, the **Frequency** of the **DNO's Distribution System** could rise above 50.5 Hz or fall below 49.5 Hz. **Generation Sets** in **Embedded Small Power Stations** shall be capable of continuing to operate in parallel with the **DNO's Distribution System** 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
b.	47.5 Hz – 51.5 Hz	Disconnection by overfrequency or underfrequency **Protection** is not permitted in this range
c.	51.5 Hz – 52 Hz	Operation for a period of at least 90 seconds is required each time the **Frequency** is within this range

DPC7.4.1.4 These **Frequency** operating range requirements also apply to **Generation Sets** in **Embedded Small Power Stations** already connected on or before 1 August 2010, unless the **Registered Capacity** of the **Embedded Small Power Station** is below 5 MW**.**

DPC7.4.1.5 For the avoidance of doubt, the above requirements do not preclude disconnection of **Generation Sets** by **Protection** agreed with the **DNO** or when necessary to protect **Plant** or **Apparatus** from being damaged

DPC7.4.1.6 **Embedded Medium Power Stations** additionally have to comply with DPC 7.5.

DPC7.4.2 **Control Arrangements**

DPC7.4.2.1 The **DNO** will specify in writing if a continuously acting fast response automatic excitation control system is required to control the **Generation Set** voltage without instability over the entire operating range of the **Generation Set** or **Power Station**. This will be dependent on the size and type of **Generating Plant** or **Power Station** and the adjacent part of the **DNO's Distribution System** to which it is connected.

DPC7.4.2.2 The **Generator** 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 **Generator** and **DNO**. The information to be provided is detailed in Schedule 5a and Schedule 5b.

DPC7.4.3 Protection Requirements

DPC7.4.3.1 **Co-ordinating with Existing Protection**

It will be necessary for the **Protection** associated with **Embedded Generating Plant** and any **Embedded Transmission System** to co-ordinate with the **Protection** associated with the **DNO's Distribution System** as follows:-

(a) For **Generating Plant** and any **Embedded Transmission System** directly connected to the **DNO's Distribution System** the **Embedded Generator** must meet the target clearance times for fault current interchange with the **DNO's Distribution System** in order to reduce to a minimum the impact on the **DNO's Distribution System** of faults on circuits owned by **Embedded Generators** or on an **Embedded Transmission System**. The **DNO** will ensure that the **DNO Protection** settings meet its own target clearance times.

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**.

(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 **DNO's Distribution System**, 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.

The **Protection** settings or operating values shall not be changed without the express agreement of the **DNO**.

(c) It will be necessary for the **Generating Plant Protection** and **Embedded Transmission System Protection** to co-ordinate with any auto-reclose policy specified by the **DNO**. In particular the **Generating Plant Protection** should detect a loss of mains situation and disconnect the **Generating Plant** 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.

DPC7.4.3.2 Specific **Protection** Required for**Embedded Generating Plant**

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 **Generating Plant**:

a. To disconnect the **Generating Plant** 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 **Generating Plant**, 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 **Generating Plant**

a. To inhibit connexion of **Generating Plant** 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 **Generating Plant** from the **System** in the event of the loss of one or more phases of the **DNO's Distribution System**;

iii. For single phase **Generating Plant**

a. To inhibit connexion of **Generating Plant** 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 **Generating Plant** from the **System** in the event of the loss of that phase of the **DNO's Distribution System**;

DPC7.4.3.3 Suitable **Protection** arrangements and settings will depend upon the particular **Generator**'s installation and the requirements of the **DNO's 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 the **System** voltage at which the **Generating Plant** is connected (LV or HV) and also its size (eg **Small Power Station**, **Medium Power Station** and **Large Power Station**).

Protection settings for a **Large Power Station** 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 **NGC** – see DPC7.4.3.8 below.

For the purposes of DPC 7.4.3 the date of commissioning of **Generating Plant** is the date on which the tests required by DPC 7.4.9 have been complete to the **DNO**'s satisfaction.

DPC7.4.3.4 The following summarizes the required **Protection** settings that will generally be applied:

Prot Function	Small Power Station				Medium Power Station	
	LV Protection$		HV Protection$			
	Setting	Time	Setting	Time	Setting	Time
U/V st 1	Vφ-n† - 13% = 200.1V	2.5s*	Vφ-φ‡ -13%	2.5s*	Vφ-φ‡- 20%	2.5s*
U/V st 2	Vφ-n† - 20% = 184.0V	0.5s	Vφ-φ‡ - 20%	0.5s		
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	47Hz	0.5s	47Hz	0.5s	47Hz	0.5s
O/F st 1	51.5Hz	90s	51.5Hz	90s	52Hz	0.5s
O/F st 2	52 Hz	0.5s	52Hz	0.5s		
LoM (Vector Shift)	K1 x 6 degrees		K1 x 6 degrees#		Intertripping expected	
LoM(RoCoF) <5MW§	K2 x 0.125 Hz/s		K2 x 0.125 Hz/s#		-	

RoCoF§ settings for Power Stations ≥5MW				
Date of Commissioning		Small Power Stations		Medium Power Stations
		Asynchronous	Synchronous	
Generating Plant Commissioned before 01/08/14	Settings permitted until 01/08/16	Not to be less than K2 x 0.125 Hz/s# and not to be greater than 1Hz/s¶#, time delay 0.5s	Not to be less than K2 x 0.125 Hz/s# and not to be greater than 0.5Hz/s¶# Ω, time delay 0.5s	Intertripping Expected
	Settings permitted on or after 01/08/16	1Hz/s¶#, time delay 0.5s	0.5Hz/s¶# Ω, time delay 0.5s	Intertripping expected
Generating Plant commissioned between 01/08/14 and 31/07/16		1Hz/s¶#, time delay 0.5s	0.5Hz/s¶# Ω, time delay 0.5s	Intertripping expected
Generating Plant commissioned on or after 01/08/16		1Hz/s¶#, time delay 0.5s	1Hz/s¶#, time delay 0.5s	Intertripping expected

Notes:

φ-n; φ-φ denote RMS phase to neutral and phase-phase values respectively of the voltage at the **Connection Point**

$ HV and LV Protection settings are to be applied according to the voltage reference at which the protection is measuring, ie:

- If the G59 protection takes its voltage reference from an LV source then LV protection settings shall be applied.
- If the G59 protection takes its voltage reference from an HV source then HV protection settings shall be applied.

†A value of 230V shall be used for all DNO LV systems

‡A value to suit the voltage of the connexion point

* Might need to be reduced if auto-reclose dead times are <3s

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

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

K2 = 1.0 (for low impedance networks) or 1.6 (for high impedance networks)

§ Rate of change of frequency

¶ 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 500ms. 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 500ms if the rate was significantly higher than the threshold.

Ω The minimum setting is 0.5Hz/s. For overall system security reasons, settings closer to 1.0Hz/s are desirable, subject to the capability of the generating plant to work to higher settings.

DPC7.4.3.5 Over and Under voltage **Protection** must operate independently for all phases in all cases.

DPC7.4.3.6 The settings in DPC7.4.3.4 apply to **Embedded Small Power Station**s and **Embedded Medium Power Station**s. In exceptional circumstances **Generator**s have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Generating Plant** may become unstable or suffer damage with the settings specified in DPC7.4.3.4. The agreed settings should be recorded in the **Connection Agreement**.

DPC7.4.3.7 The underfrequency and overfrequency **Protection** settings set out in DPC7.4.3.4 also apply to **Generation Sets** in **Embedded Small Power Stations** already existing on or before 1 August 2010 with a **Registered Capacity** at or above 5 MW**,** except where single stage **Frequency Protection** relays are used, in which case the following settings apply.

Protection Function	Setting	Time
U/F	47.5Hz	0.5 s
O/F	51.5Hz	0.5 s

In exceptional circumstances **Generator**s have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Generating Plant** may become unstable or suffer damage with the settings specified above. The agreed settings should be recorded in the **Connection Agreement**.

DPC7.4.3.8 A loss of mains **Protection** of RoCoF or vector shift type will generally be appropriate for **Small Power Station**s, but this type of loss of mains **Protection** must not be installed for **Power Station**s >50MW. In those cases where the **DNO** requires loss of mains **Protection** this must be provided by a means not susceptible to spurious or nuisance tripping, eg intertripping.

DPC7.4.3.9 Where short term paralleling in accordance with DPC7.1.4 is employed, the protection settings in the following table should be used in preference to those in DPC7.4.3.4.

Prot Function	Infrequent Short Term Parallel Operation			
	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 **DNO LV** systems

‡A value to suit the voltage of the **HV** connexion point

DPC7.4.4 **Fault Ride Through and Phase Voltage Unbalance**

Any **Generation Set** or **Power Station** connected to the **DNO's Distribution System,** where it has been agreed between the **DNO** and the **Generator** that the **Generator**'s **Power Station** will contribute to the **DNO's Distribution System** 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 Generator** 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 System** the **DNO,** on request during the **Connection Agreement** process, will advise the **Embedded Generator** of the expected **Phase Voltage Unbalance**.

DPC7.4.5 **System Stability**

DPC7.4.5.1 The following requirements for system design within this DPC 7.4.5 will generally be applied by the **DNO** to **Power Station**s connected at 33kV and above. However there will be cases where the specific network conditions, including existing connected **Power Station**s, requires the **DNO** to apply these considerations at lower voltages.

DPC7.4.5.2 With the **System** in its normal operating state, it is desirable that all **Generation Set**s 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

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**.

DPC7.4.6 **Neutral Earthing**

The winding configuration and method of earthing connection shall be agreed with the **DNO.**

In addition, where the **Generator**'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 **Generator** for earthing the **Generating Plant**, provided the **DNO** earth connection is of adequate capacity. If the **Generating Plant** is intended to operate independently of the **DNO**'s supply, the **Generating Plant** 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 **Generating Plant** 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 **Generating Plant** may be operated as a switched alternative only to the **DNO**'s **System**, the **Generator** 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 **Generating Plant** for this purpose, for those periods when it is paralleled with the **DNO**'s **System**. However, if the **Generating Plant** is operating in isolation from the **DNO's Distribution System** it will be necessary to have the **Generating Plant** directly earthed.

(d) Where the **Generating Plant** is designed to operate independently from the **DNO's Distribution System** the switchgear that is used to separate the two **System**s shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Generating Plant**, from flowing into the **DNO's Distribution System** when it operates as a switched alternative only supply

DPC7.4.7 **Frequency Sensitive Relays**

It is conceivable that a part of the **DNO's Distribution System**, to which **Embedded Generators** are connected can, during emergency conditions, become detached from the rest of the **System**. It will be necessary for the **DNO** to decide, dependent on local network conditions, if it is desirable for the **Embedded Generators** to continue to generate onto the islanded **DNO's Distribution System**.

If no facilities exist for the subsequent resynchronisation with the rest of the **DNO's Distribution System** then the **Embedded Generator** will under **DNO** instruction, ensure that the **Generating Plant** and/or **Embedded Transmission System** is disconnected for re-synchronisation.

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 **Embedded Generator** to notify the **DNO** if its **Generating Plant** has a restart capability without connection to an external power supply, unless the **Embedded Generator** shall have previously notified **NGC** accordingly under the **Grid Code**. Such generation may be registered by **NGC** as a **Black Start Station.**

DPC7.4.9 **Commissioning Tests**

DPC7.4.9.1 Where **Generating Plant** or an **Embedded Transmission System** requires connection to the **DNO's Distribution System** in advance of the commissioning date, for the purposes of testing, the **Embedded Generator** must comply with the requirements of the **Connection Agreement**. The **Embedded Generator** 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.

DPC7.4.9.2 The **Generator** will demonstrate all the commissioning tests performed on his **Generating Plant** in order to discharge the requirements of the **Distribution Code** and Annex 1, item 3 (ER G59/3-2~~1~~). In general the **DNO** will witness these tests for **Generating Plant** connected to the **DNO's Distribution System** at **HV**. For **Generating Plant** connected to the **DNO's Distribution System** at **Low Voltage** it is expected that the **DNO** will not witness the commissioning tests in the majority of cases.

DPC7.5 **Technical Requirements for Medium Power Stations**

DPC7.5.1 Where a **Generator** in respect of an **Embedded Power Station** is a party to the **CUSC** this DPC 7.5 will not apply.

DPC7.5.2 In addition to the requirements in DPC7.4, 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 Stations** to 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 Converter** 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**.

DPC7.5.3 Where data is required by **NGC** from **Medium Power Stations**, nothing in the **Grid Code** or **Distribution Code** precludes the **Generator** 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**.

DPC7.5.4 **Grid Code Connection Conditions Compliance**

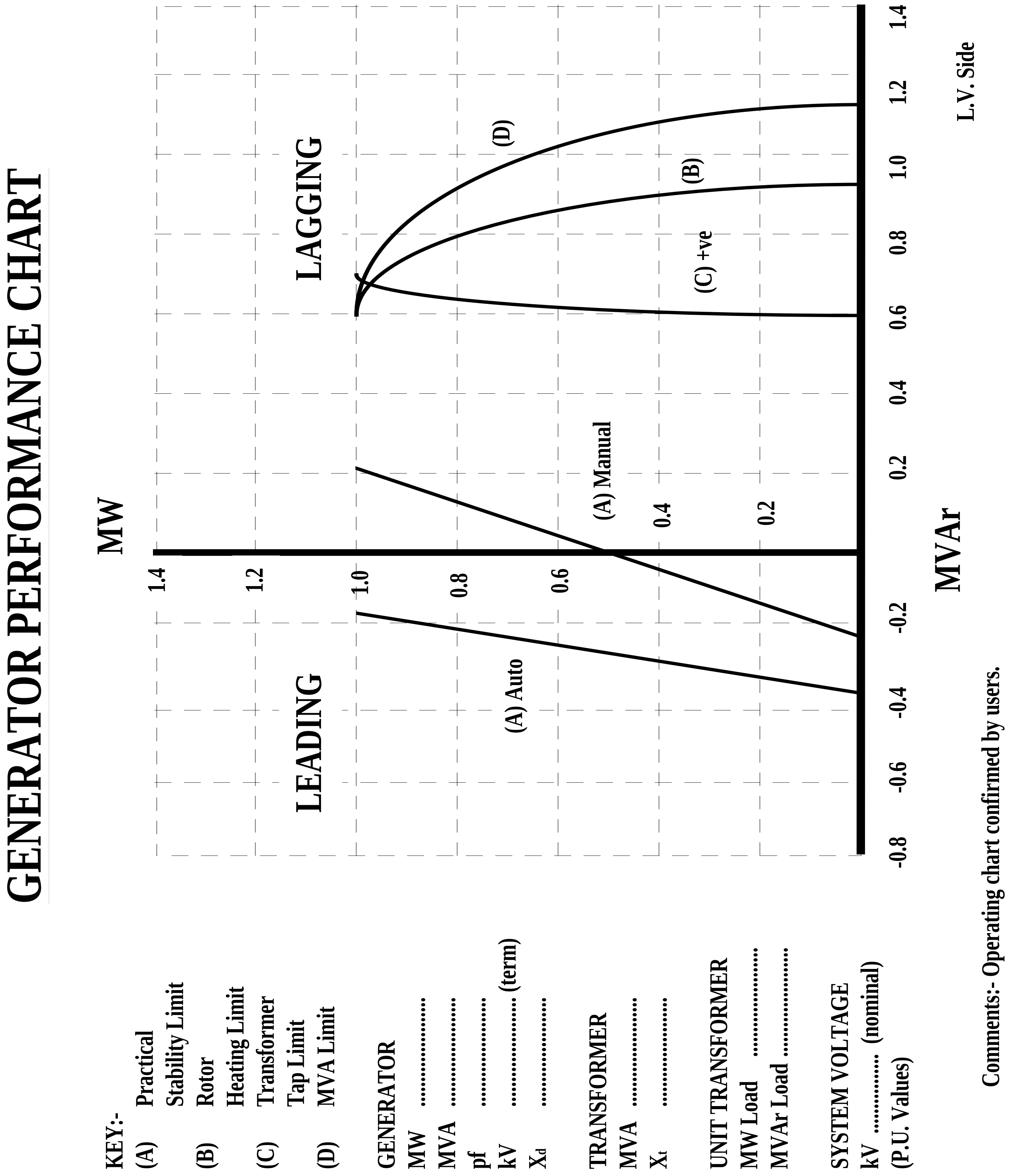
DPC7.5.4.1 The technical designs and parameters of the **Embedded Medium Power Stations** will comply with the relevant Connection Conditions of the **Grid Code**. A statement to this effect, stating compliance with OC5.8 of the **Grid Code** is required to be presented to the **DNO**, for onward transmission 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.

DPC7.5.4.2 Should the **Generator** make any material change to such designs or parameters as will have any effect on the statement of compliance referred to in DPC7.5.4.1, the **Generator** must notify the change to the **DNO**, as soon as reasonably practicable, who will in turn notify **NGC**.

DPC7.5.4.3 Tests to ensure **Grid Code** compliance may be specified by **NGC** in accordance with the **Grid Code**. It is the **Generator's** responsibility to carry out these tests

DPC7.5.4.4 Where NGC 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 DPC7.5.4.4.

FIGURE 1


GENERATOR PERFORMANCE CHART
MW
MVAr
LAGGING
LEADING
(A) Auto
(A) Manual
(B)
(C) +ve
(D)
L.V. Side
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.2
-0.4
-0.6
-0.8
KEY:-
(A) Practical Stability Limit
(B) Rotor Heating Limit
(C) Transformer Tap Limit
(D) MVA Limit
GENERATOR
MW ....
MVA ....
pf ....
kV .... (term)
Xd ....
TRANSFORMER
MVA ....
Xt ....
UNIT TRANSFORMER
MW Load ....
MVAr Load ....
SYSTEM VOLTAGE
kV .... (nominal)
(P.U. Values)
Comments:- Operating chart confirmed by users.

DISTRIBUTION PLANNING AND CONNECTION CODE 8

DPC8 TRANSFER OF PLANNING DATA

DPC8.1 Introduction

DPC8.1.1 **Distribution Planning and Connection Code** DPC8 details information to be exchanged between the **DNO** and **Users** that are connected at **High Voltage** including **Embedded Generators** and **Other Authorised Distributors**.

It includes data that is necessary in order for the **DNO's Distribution System** to be developed in an efficient, co-ordinated and economic manner, and to enable the **DNO** to comply with the conditions contained in its **Distribution Licence.**

DPC8.2 Planning Information to be Provided by Users

DPC8.2.1 Prospective and existing **Users** of the **DNO's Distribution System** must provide sufficient planning data/information as can reasonably be made available, when requested by the **DNO** from time to time to enable the **DNO** to comply with the requirements under its **Distribution Licence**. For those **Users** from whom **Demand** forecasts are required under **DOC1**, there will be a requirement to prepare an annual submission to the **DNO**. This submission, which is to be in accordance with **DOC1**, should include a development plan covering at least the subsequent 3 years and, where the **User** holds planning data or information relating to subsequent years up to 7 years ahead that data or information, including changes either increasing or decreasing in **Demand**, transfer requirements or generating capacity as appropriate.

DPC8.2.2 In addition to periodic updates of planning information a **User** should give adequate notice of any significant changes to the **User's System** or operating regime to enable the **DNO** to prepare its development plan, budget for, and implement any necessary **System** modifications. Such information should include any changes either increasing or decreasing in **Demand**, transfer requirements or generating capacity as appropriate. In the event of unplanned changes in a **User's System** or operating regime a **User** shall notify the **DNO** as soon as is practically possible to ensure any contingency measures, as necessary, can be implemented by the **DNO**.

DPC8.2.3 The **DNO** has an obligation under the **CUSC** to submit certain planning data/information relating to **Existing Offshore Generators** to **NGC**. Any **Existing Offshore Generators** will be required to cooperate with the **DNO** to contribute to the full and timely completion of the **Offshore Transmission Implementation Plan.**

DPC8.3 Information to be Provided to Users

DPC8.3.1 Where the **DNO** has received from a **User** any information or data under DPC8.3 or where the **DNO** proposes to make modifications to the **DNO's Distribution System** which, in either case, in the reasonable opinion of the **DNO**, may have an impact upon the **System** of any other **User,** the **DNO** will notify that **User** of the proposals subject to any constraints relating to the timing of release of information or confidentiality provisions.

DPC8.4 **Reactive Compensation Plant**

DPC8.4.1 A **User** shall provide the **DNO** with information on any reactive compensation **Plant** directly or indirectly connected to a **DNO's Distribution System**, other than at **Low Voltage**, including:-

(a) The MVAr capacitive or inductive rating of the **Equipment** and operating range if variable;

(b) Details of any automatic control logic such that the operating characteristics can be determined; and

(c) The point of connection to the **DNO's Distribution System**.

DPC8.5 **Lumped Network Susceptance**

DPC8.5.1 Under certain circumstances it will be necessary for the **User** to provide, at the request of the **DNO**, details of the equivalent lumped network susceptance at **Normal Frequency** of the **User's System** at nominal **Frequency** referred back to the connection with the **DNO's Distribution System**. This should include any shunt reactors which are an integrated part of a cable system and which are not normally in or out of service independent of the cable (ie. they are regarded as part of the cable).

DPC8.5.2 It should not include:-

(a) Independently switched reactive compensation plant connected to the **User's System** (covered in DPC8.4.1)

(b) Any susceptance of the **User's System** inherent in the **Reactive Power Demand**.

DPC8.6 **Short Circuit Infeed to the DNO's Distribution System**

DPC8.6.1 Information shall be exchanged between the **DNO** and the **User** on fault infeed levels at the point of connection with the **DNO's Distribution System** in the form of:-

(a) The maximum and minimum 3-phase symmetrical and phase earth short circuit infeed.

(b) The X/R ratio under short circuit conditions.

(c) In the case of interconnected **Systems**, adequate equivalent network information.

DPC8.7 **Interconnection Impedance**

DPC8.7.1 For **User** interconnections that operate in parallel with the **DNO's Distribution System** details of the interconnection impedance shall be exchanged between the **DNO** and the **User.** This information shall include an equivalent single impedance (resistance, reactance and shunt susceptance) of the parallel **User** or **DNO's Distribution System**.

DPC8.8 **Demand Transfer Capability**

DPC8.8.1 Information shall be exchanged on **Demand** transfer capability where the same **Demand** may be supplied from alternative **DNO** or **User** points of supply. This shall include the proportion of **Demand** normally fed from each point of supply and the arrangements (manual or automatic) for transfer under planned/fault outage conditions.

DPC8.9 **Other Authorised Distributor's Distribution System Data**

DPC8.9.1 **Other Authorised Distributors** shall provide the **DNO** with detailed data relating to the interface between their **Distribution System** and that of the **DNO**, covering circuit parameters, switchgear and **Protection** arrangements of equipment directly connected to or affecting the **Distribution System** to enable the **DNO** to assess any implications associated with these points of connection. Reciprocal arrangements will apply between the **DNO** and its **Users**.

DPC8.10 **Transient Overvoltage Effects**

DPC8.10.1 For **User's** busbars connected to the **DNO's Distribution System** sufficient details may need to be exchanged with respect to the **User/DNO Ownership Boundary** to enable an assessment, where necessary, of transient overvoltage effects to be made. This information may relate to physical and electrical layouts, parameters, specifications and **Protection** details.

DPC8.11 **More Detailed Information**

In certain circumstances more detailed information may be needed and will be provided upon the reasonable request of the **DNO**.

DISTRIBUTION OPERATING CODE **(DOC)**

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 1

DOC1 DEMAND FORECASTS

DOC1.1 **Introduction**

DOC1.1.1 In order for the **DNO** to operate the **DNO's Distribution System** efficiently and to ensure maximum **System** security and **System Stability**, there is a need for those **Users** specified in DOC1.3 to provide loading and generation output information to the **DNO**.

DOC1.1.2 The **Grid Code** specifies **NGC's** requirements for **Demand** forecasting for **Generation Sets** which constitute or contain **BM Units** which are active (ie. submitting bid-offer data) in the **Balancing Mechanism**. This **Distribution Operating Code** DOC1 specifies the information to be provided by other **Generation Sets** and all **Users** of the **DNO's Distribution System** specified in DOC1.3 below.

DOC1.1.3 This **Demand** forecasting information is required to enable the **DNO** to maintain the integrity of the **DNO's Distribution System**. The **Licensee** under its **Distribution Licence** has an obligation under the **Grid Code** to provide **Demand** forecast information to **NGC** in order that generation output can be matched with **Demand**. The information, required to be provided by **Users** (specified in DOC1.3 below) under this **Distribution Operating Code,** will enable the **Licensee** to comply with these requirements of the **Grid Code**.

DOC1.1.4 Where **Demand** data is required from the **User,** this means the MW **Demand** of electricity at the **DNO** point of supply to the **User.** The **DNO** may, in certain cases, specify that the **Demand** data shall include the MVAr **Demand**.

DOC1.1.5 The information to be provided to the **DNO** shall be in writing as specified in DGD2 (vi).

DOC1.1.6 In this **Distribution Operating Code** Year 0 means the current calendar year at anytime, Year 1 means the next calendar year at anytime, Year 2 means the calendar year after Year 1, etc

DOC1.1.7 References in this **Distribution Operating Code** to data to be supplied on a half-hourly basis refers to it being supplied for each period of 30 minutes ending on the hour and half-hour in each day.

DOC1.2 **Objectives**

The objectives of this Distribution Operating Code **DOC1 are to**:-

(a) Set out the **Demand** forecast and **Embedded Generating Plant Output** or **Embedded Transmission System** output information required to be provided by **Users** to enable the **DNO** to operate the **DNO's Distribution System**.

(b) Specify the information required to be provided by **Users** to the **DNO** to enable it to comply with its obligations under the **Grid Code**.

DOC1.3 **Scope**

This **Distribution Operating Code** applies to the following **Users** of the **DNO's Distribution Systems** which are connected at **HV**:-

(a) **Customers** with a **Demand** greater than 5 MW.

(b) **Embedded Generators** whose output is greater than 1MW where the **DNO** reasonably considers it appropriate.

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System**.

(d) **Suppliers**, at the request of the **DNO**, on behalf of their **Customers**.

DOC1.4 **Information Flow and Co-ordination**

DOC1.4.1 **Demand Forecast Information**

The **DNO** will co-ordinate all **Demand** forecast information for each **Grid Supply Point** to meet the requirements of the **Grid Code**. The **DNO** will aggregate forecast information provided by **Users,** where appropriate, and provide forecast information to **NGC** where the **Demand,** or change in **Demand,** is equal to or greater than the **Demand Control Notification Level** at any **DNO Connection Point**.

DOC1.4.2 **Generation Output Information**

Information relating to **Generating Plant Embedded** in the **DNO's Distribution System** or in the network of an **Other Authorised Distributor or any Embedded Transmission System** shall, where specified be provided to the **DNO** in writing. A **Customer With Own Generation** may be required to furnish such information should the **DNO** reasonably consider that it would affect its **Demand** forecasts.

DOC1.4.3 **Information to be Provided by the DNO**

Where reference is made to "as specified by the **DNO"** or "the **National Electricity Transmission System** days or times of **Peak Demand** or minimum **Demand"**, the **DNO** will provide each **User**, from whom **Demand** forecasts are required, with such information.

DOC1.5 **Demand Forecast Data**

DOC1.5.1 **Planning Periods**

Information shall be supplied by **Users** to the **DNO** for the following rolling timescales is required by the **DNO**:-

(a) Operational Planning Phase – next three years ahead

(b) Programming Phase – 24 hours to 8 weeks ahead

(c) Control Phase – 0 to 24 hours ahead

The information supplied will be as specified below and as set out in the Schedules of the **Distribution Data Registration Code.**

DOC1.5.2 **Operational Planning Phase (next 3 years ahead).**

DOC1.5.2.1 The information required to be provided to the **DNO** during the **Operational Planning Phase** is specified in Appendix 1 of this **Distribution Operating Code**, DOC1.

DOC1.5.2.2 The information shall be provided to the **DNO** by Calendar week 35 each year.

DOC1.5.3 **Programming Phase (24 hours to 8 weeks ahead inclusive).**

DOC1.5.3.1 The information required to be provided by the **User** to the **DNO** during the **Programming Phase** is specified in Appendix 2 of this **Distribution Operating Code,** DOC1.

DOC1.5.3.2 For the period 2 to 8 weeks ahead the information shall be supplied to the **DNO** by 1600 hours each Friday.

DOC1.5.3.3 For the period 2 to 13 days ahead the information shall be updated and supplied to the **DNO** by 0900 hours each Wednesday.

DOC1.5.3.4 The **DNO** may require the information specified in Appendices 1 and 2 of this **Distribution Operating Code** to be updated if it reasonably considers it necessary and to be supplied to the **DNO** by 0800 hours each day (or such other time as specified by the **DNO** from time to time) for the next day (except that it may be for the next 3 days on Fridays and 2 days on Saturdays) and may be longer (as specified by the **DNO** at least one week in advance) to cover holiday periods.

DOC1.5.4 **Control Phase (0 to 24 hours ahead)**

The following information shall be supplied to the **DNO** at reasonable times to be specified by the **DNO** for the unexpired period covered by the **Control Phase:-**

(a) Details of any differences of greater than 5MW from the schedules of operation of any **Embedded Generating Plant** or **Embedded Transmission System** on a half hourly basis which were supplied under DOC1.5.3.3;

(b) Details from **Suppliers** of any differences of the amount and duration of their proposed use of **Customer Demand Control** aggregated to 5MW or more (averaged over any half-hour period) on a half-hourly basis which were supplied under DOC1.5.3.4.

(c) Details from each **User** connected to the **Distribution System** of any change in aggregated **Demand** at the point of supply of greater than 5MW of the **Demand**.

DOC1.5.5 **Post Control Phase**

The following shall be supplied to the **DNO** by 0300 hours each day:-

(a) Details of half-hour **Active Power** and **Reactive Power** output sent out to the **DNO's Distribution System** by **Embedded Generating Plant** or any **Embedded Transmission System** where the **DNO** reasonably considers it appropriate during the previous day on a half-hourly basis.

(b) **Suppliers**, and **Other Authorised Distributor** connected to the **DNO's Distribution System** will provide details of the amount and duration of **Demand Control** at the **DNO Connection Point** aggregated to 5MW or more (averaged over any half-hour) which was implemented during the previous **Operational Day**

DOC1.6 **Forecast Factors**

DOC1.6.1 The following factors will be taken into account by the **DNO** and **Users** when conducting **Demand** forecasts in the **Operational Planning Phase:-**

(a) Historic **Demand** data and trends.

(b) Weather forecasts (responsibility for weather correction of **User's Demand** rests with the **User.**)

(c) Incidence of major events or activities

(d) **Embedded Generation Set** or **Embedded Transmission System** Schedules.

(e) **Demand** transfers.

(f) Interconnection with adjacent **Other Authorised Distributors**.

(g) **Demand Control** proposed to be operated by **Suppliers.**

(h) Any other factor reasonably considered necessary.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 1

DOC 1 - APPENDIX 1

Demand Forecasts Operational Planning Phase (3 years ahead)

EACH CALENDAR YEAR BY WEEK 35:

For each of the next 3 years forecast information for:

(a) Half-hour **Active Power** and **Power Factor** (or **Reactive Power**) at **Annual ACS Conditions** for the specified time of the annual peak half-hour at the associated **Grid Supply Points** and at the specified time of the **National Electricity Transmission System Peak Demand**.

(b) Half-hour **Active Power** and **Power Factor** (or **Reactive Power**) at **Average Conditions** at the specified half-hour of the **National Electricity Transmission System** minimum **Demand**.

(c) Half-hour **Active Power** output of **Embedded Generating Plant** or any **Embedded Transmisison System** at the specified half-hour of the **National Electricity Transmission System Demand**.

In addition, where the loading or the generation output of a **User** may have a particular impact on the security or stability of the **System** then the **DNO** may on request require the following information from a **User**.

(a) **Weekly ACS Conditions** and **Average Conditions Active** and **Reactive Power Demand** at the time of the specified **National Electricity Transmission System Peak Demand** each week together with forecasts of **Demand** to be met and relieved by **Embedded Generating Plant Output** and planned **Demand Control** by other **Users.**

(b) **Weekly ACS Conditions Active** and **Reactive Power Demand** at the time of the specified **Grid Supply Point Peak Demand** each week.

This additional information will, where requested by the **DNO**, be updated throughout the current year (Year 0) in the **Programming Phase**, the times to be notified by the **DNO** where this is necessary.

Where reference is made to “specified” or **“National Electricity Transmission System Demand”**, the information will be provided by the **DNO** following the receipt of information provided by **NGC** in accordance with OC1 of the **Grid Code**.

DOC 1 - APPENDIX 2

Demand forecasts - Programming Phase (24 hours to 8 weeks ahead inclusive)

The following information shall be provided to the **DNO** in the timescales specified in DOC1.5.3:-

(a) Schedules for the operation of **Embedded Generation Set** or any **Embedded Transmission System** whose output is greater than 1MW on a half-hourly basis where the **DNO** reasonably considers it appropriate

(b) From **Suppliers**, details of their proposed use of **Demand Control** measures aggregated to 5MW or more (averaged over any half-hour) on a half hourly basis for each of the **DNO's Connection Points**;

(c) From **Customers** and **Other Authorised Distributors** connected to the **DNO's Distribution System** whose operations are likely to result in an aggregated change in **Demand** at the **DNO's Connection Point** of supply of greater than 5MW of the **Demand** at that time on a half-hourly basis.

(d) Any other relevant **Demand** forecast information reasonably required by the **DNO**.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 2

DOC2 OPERATIONAL PLANNING

DOC2.1 **Introduction**

DOC2.1.1 **Operational Planning** within the terms of the **Distribution Code** comprises the co-ordination through various timescales, of planned outages of **Plant** and **Apparatus** which affect the **Operation** of the **DNO's Distribution System** or require the commitment of the **DNO's** resources.

DOC2.1.2 This **Distribution Operating Code** also enables the **DNO** to meet its **Distribution Licence** obligation to provide certain information specified in the **Grid Code** and establishes procedures to enable the collection of such data from **Users** specified in DOC2.3 below.

DOC2.1.3 Information to be provided to the **DNO** shall be in writing as specified in DGD2f).

DOC2.1.4 In order for the **DNO** to fulfil the requirements of this DOC2 it should be noted that the information set out in the **Grid Code** OC2, to be provided by **NGC**, will form the basis of **Operational Planning** under this DOC2.

DOC2.1.5 In this **Distribution Operating Code** Year 0 means the current calendar year at any time, Year 1 means the next calendar year at any time, Year 2 means the calendar year after Year 1, etc. Where Week 52 is specified read Week 53 in appropriate years.

DOC2.2 **Objectives**

The objectives of this **Distribution Operating Code** are:

(a) To set out the **DNO's Operational Planning** procedure and a typical timetable for the co-ordination of outage requirements of **Plant** and **Apparatus** to be provided by **Users** to enable the **DNO** to operate the **DNO's Distribution System.**

(b) To specify the information to be provided by **Users** to the **DNO** to enable the **DNO** to comply with its obligations under the **Grid Code**.

(c) To provide guidance for **High Voltage Customer** on how to comply with their obligations under Article 7 of the European Transparency Regulations (The European Commission Regulation No 543/2013) to provide information to **NGC** in their role as Transmission System Operator.

DOC2.3 **Scope**

This **Distribution Operating Code** applies to the **DNO** and the following **Users** of the **DNO's Distribution System** which are connected at **HV**:-

(a) **HV Customers** where the **DNO** considers it appropriate.

(b) **Customer With Own Generation** where the **DNO** reasonably considers it appropriate.

(c) **Embedded Generating Plant** in the **DNO's Distribution System** whose **Registered Capacity** is greater than 1MW and any **Embedded Transmission System** where the **DNO** reasonably considers it appropriate.

(d) Any **Other Authorised Distributor** connected to the **DNO's Distribution System**.

DOC2.4 **Information Flow and Co-ordination**

DOC2.4.1 **Embedded Generators**

Information relating to **Embedded Generating Plant** where the **DNO** reasonably considers it appropriate whose **Registered Capacity** is greater than 5MW, or 1MW in the case of renwable generating plant in Scotland and **Embedded Transmission System** shall where reasonably required by the **DNO** be provided by the **User** directly to the **DNO**. This may include a **Customer With Own Generation** where the **DNO** considers it appropriate.

DOC2.4.2 **High Voltage Customers**

In the event that:

a) a **High Voltage Customer** experiences the planned unavailability of its **Apparatus** resulting in the reduction of **Demand** of 100MW or more, or a change to the planned unavailability of its **Apparatus** resulting in a change in **Demand** of 100MW or more, for one settlement period or longer; or

b) a **High Voltage Customer** experiences a change in the actual availability of its **Apparatus** resulting in a change in **Demand** of 100MW or greater, such a **High Voltage Customer** shall provide **NGC** with the information required from a Non-Embedded Customer specified in **Grid Code** OC2.4.2.3 and **Grid Code** DRC Schedule 6 in a format and timescales agreed with **NGC**.

DOC 2.4.3 **Other Plant and Apparatus**

Information relating to all **Plant** and **Apparatus** connected to the **DNO's Distribution System**, or that which may affect its **Operation**, shall be co-ordinated with the **DNO**.

DOC2.5 **Timescales and Data**

DOC2.5.1 Detailed implementation of data gathering and timescales will be agreed between the **DNO** and each **User**. Due recognition will be given by the **DNO** to voltage levels and capacities of **Plant** and **Apparatus** when assessing information requirements.

DOC2.5.2 All information shall be provided in **Decimal Weeks** as a minimum, where Week 1 commences in the first week of January as published from time to time.

DOC2.5.3 The rolling timescales involved in **Distribution Operating Code** DOC2 are illustrated in Figure 1 of this **Distribution Operating Code** and are as follows:-

(a) **Operational Planning Phase**

Long Term Planning Phase - Calendar year 3 ahead.

Medium Term - Calendar years 1 and 2 ahead.

Short Term - The current calendar year 52 weeks ahead down to 9 weeks ahead.

(b) **Programming Phase**

24 hours to 8 weeks ahead inclusive

(c) **Control Phase**

0 to 24 hours ahead

DOC2.6 **Operational Planning**

DOC2.6.1 **Long Term Programme** (Calendar Year 3 ahead - Appendix 1).

DOC2.6.1.1 Each year, the **DNO** will prepare a Long Term Programme covering year 3 ahead which will include those **Distribution System** outages, **Embedded Transmission System** outages and **Embedded Generating Plant** outages, where the **DNO** reasonably considers it appropriate, which may affect the performance of the **Total System**.

DOC2.6.1.2 **Users** and **Embedded Generators** where the **DNO** reasonably considers it appropriate will provide the **DNO** with information in accordance with Appendix 1. This information will be requested by the **DNO** in order to satisfy the requirements of DOC2.6.1.1.

DOC2.6.2 **Medium Term Programme** (Calendar years 1 - 2 ahead Appendix 2)

DOC2.6.2.1 The previous Long Term Programme will be updated to form the basis of the Medium Term Programme. The availability of **Embedded Generating Plant** and any **Embedded Transmission System** will also be updated.

DOC2.6.2.2 **Users** and **Embedded Generators** will provide the **DNO** with information in accordance with Appendix 2.

DOC2.6.3 **Short Term Programme** (Current year 52 weeks ahead down to 9 weeks ahead - Appendix 3).

DOC2.6.3.1 The previous Medium Term Programme will be updated to form the basis of the Short Term Programme. The **DNO** will continually review this programme as necessary and periodically discuss it with the relevant parties as appropriate.

DOC2.6.3.2 It will take account of such review and discussions and any additional outages and the following further details of each outage proposed will be notified at this stage by the appropriate party:-

(a) Return to service times of circuits (if different from programme).

(b) Specific **Plant** and **Apparatus** to be worked upon.

(c) Any other information that may be reasonably specified by the **DNO** from time to time.

DOC2.6.3.3 At any time and from time to time during the current calendar year up to the **Programming Phase** (8 weeks ahead), **Users** may notify reasonable changes and additions to the outages previously notified during the Medium Term planning process. The **DNO** will consider whether the changes will adversely affect **System** security, stability or other parties, and will discuss with the party in question. Where the change is so discussed the **DNO** will inform the other affected **Users**.

DOC2.6.4 **Programming Phase** (24 hours to 8 weeks ahead inclusive)

DOC2.6.4.1 The Short Term Programme will form the basis of the **Programming Phase** and a rolling suggested programme for the following week and subsequent 7 week period respectively will be prepared weekly by the **DNO**.

DOC2.6.4.2 The **DNO** will update the programme each week and take account of any additional or varied outages.

DOC2.6.4.3 Any decision to depart from the outages and actions determined during this phase will immediately be notified to the **DNO**, who will inform other affected parties.

DOC2.6.5 **Generation Scheduling Information** (**Programming Phase** 24 hours to 8 weeks ahead inclusive).

DOC2.6.5.1 The **DNO** will obtain **Scheduling** information from **Embedded Generators** for **Embedded Generating Plant** and any **Embedded Transmission System** which <u>do not</u> constitute or contain **BM Units** which are active (ie submitting bid-offer data) where it considers it appropriate.

DOC2.6.5.2 The **Scheduling** information will specify the following on an individual **Generation Set** or **Embedded Transmission System** basis:

(a) The period the set or system is required.

(b) The planned half hourly output.

(c) Any other information the **DNO** reasonably considers necessary.

DOC2.6.6 **Control Phase** (0 to 24 hours ahead)

During the real time **Operation** any changes to the outage programme for the day shall be at the discretion of the **DNO**.

DOC2.7 **Nuclear Generating Plant**

DOC2.7.1 The **DNO** will endeavour to give as much notice as possible to a **Generator** with Nuclear **Generating Plant** which may be operationally affected by an outage which is to be included in a programme referred to in DOC2.6.4.1.

DOC2.7.2 Where a **Generator** with Nuclear **Generating Plant** which may be operationally affected by the **DNO's Distribution System** outage programme referred to in DOC2.6.4.1 (acting as a reasonable operator) is concerned on grounds relating to safety about the effect which an outage within such outage programme might have on one or more of its Nuclear **Generating Plant**, it may contact the **DNO** to explain its concerns and discuss whether there is an alternative way of taking that outage (having regard to technical feasibility). If there is such an alternative way, but the **DNO** refuses to adopt that alternative way in taking that outage, the **Generator** may involve the **Electricity Supply Industry (ESI)** disputes resolution procedure to decide on the way the outage should be taken. If there is no such alternative way, then the **DNO** may take the outage despite that **Generator's** concerns.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 2

DOC 2 - APPENDIX 1

OPERATIONAL PLANNING - LONG TERM PLANNING PHASE (YEAR 3 AHEAD)

The requirements of the Long Term Programme apply to Embedded Generating Plant and Embedded Transmission System connected to the DNO's Distribution System specified in DOC2.3.

EACH CALENDAR YEAR BY:-

WEEK 2 **Embedded Generators** provide the **DNO** with a provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme for Year 3 ahead specifying the **Generation Set** and MW concerned, the preferred date for each proposed outage, and where there is a possibility of flexibility, the earliest start date and latest finishing date where applicable.

WEEK 12 The **DNO** will provide the **Embedded Generators** with details of constraints on the **DNO's Distribution System** and potential **DNO's Distribution System** requirements during each week of Years 3 ahead for an outage together with their perceived **Output Usable** requirements for Year 3 ahead.

WEEK 25 **Embedded Generators** will provide the **DNO** with updated provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programmes together with the **Registered Capacity** and neutral weekly **Output Usable** forecasts in both cases for Year 3 ahead.

WEEK 28 The **DNO** after discussion with the **Embedded Generator** will notify each **Embedded Generator** with details of any suggested revisions the **DNO** proposes to the provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme previously supplied and the reasons for such proposed revisions including such information as provided in week 12.

Users will provide the **DNO** with details of proposed outages in Year 3 ahead which may affect the performance of the **DNO's Distribution System**. This information need not be limited to **Plant Apparatus** and **System** at the **DNO** interface**.** Details will comprise general outage requirements, start and end dates.

WEEK 42 The **DNO** after discussions with the **Embedded Generator** will notify each **Embedded Generator** with details of any suggested revisions necessary to maintain **DNO System** security to the updated provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme previously supplied.

WEEK 43 Following consultation with **Users**, the **DNO** will include these outage proposals in the Long Term Programme.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 2

DOC 2 - APPENDIX 2

OPERATIONAL PLANNING - MEDIUM TERM PROGRAMME (YEARS 1 & 2)

The requirements of the Medium Term Programme apply to **Embedded Generating Plant and Embedded Transmission System** connected to the **DNO's Distribution System** as specified in DOC2.3.

EACH CALENDAR YEAR BY:-

WEEK 2 — **Embedded Generators** not included in the Long Term Programme shall provide the **DNO** with a provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme for Years 1 and 2 specifying the **Generation Set** and MW concerned, the preferred date for each proposed outage, where applicable earliest start date and latest finishing date.

WEEK 10 — **Embedded Generators** provide the **DNO** with estimates of **Output Usable** for each **Embedded Generating Plant** or **Embedded Transmission System** for Year 1 and 2 (weeks 1 to 52) and its proposed **Generation Set** and/or **System** outage programme for Years 1 and 2.

WEEK 12 — The **DNO** will after discussion with the **Embedded Generator** provide the appropriate **Embedded Generator** with details of **DNO's Distribution System** constraints and potential **DNO's Distribution System** requirements during each week of Years 1 and 2 for an outage together with any suggested changes to its proposed **Generation Set** or **Embedded Transmission System** outage programme.

The **DNO** will notify each **Embedded Generator** of **Output Usable** requirements for Years 1 and 2 (weeks 1to 52).

WEEK 28 — **Users** within the **DNO's** distribution services area will provide the **DNO** with details of outages due to take place during the Years 1 and 2 which may affect the performance of the **DNO's Distribution System**. This will comprise updating the programme for Years 3 ahead where appropriate and including any subsequent requests.

In addition to outage proposals, the programme shall include Trip Testing, Risks of Trip, and other information where known which may affect the security and stability of the **DNO's Distribution System**.

WEEK 41 — Each **Embedded Generator** will provide the **DNO** with revised estimates of the **Output Usable** of each **Embedded Generating Plant** or **Embedded Transmission System** for Year 1 and 2 (weeks 1 to 52).

WEEK 48 — Following consultation with **Users**, the **DNO** will include their proposals in the Medium Term Plan.

DISTRIBUTION OPERATING CODE 2

DOC 2 - APPENDIX 3

OPERATIONAL PLANNING - SHORT TERM (CURRENT YEAR 52 WEEKS AHEAD DOWN TO 9 WEEKS AHEAD)

The Short Term Plan will be an update of the Medium Term Plan and comprise a receding period as the **Programming Phase** (24 hours to 8 weeks ahead inclusive) evolves through the current year.

EACH CALENDAR YEAR

WEEK 2 **Embedded Generators** not included in the Medium Term Plan will provide the **DNO** with a provisional **EmbeddedGenerating Plant** or **Embedded Transmission System** outage programme for the current calendar year specifying the **Embedded Generating Plant** or **Embedded Transmission System** and MW concerned, duration of the outage, earliest start date and latest finishing date where applicable. **Embedded Generators** will also provide the **DNO** with revised estimates of **Embedded Generating Plant** or **Embedded Transmission System Output Usable** for weeks 9 - 52.

WEEK 4 **DNO** will inform **Embedded Generators** of **Output Usable** requirements for weeks 9 - 52.

WEEK 10 **Embedded Generators** will provide the **DNO** with estimates of each **Embedded Generating Plant** or **Embedded Transmission System Output Usable** for weeks 18 - 52.

WEEK 12 The **DNO** will inform **Embedded Generators** of their desired changes **Embedded Generator** to **Output Usable** requirements for weeks 18 - 52 and will provide details of **DNO's Distribution System** constraints and **DNO's Distribution System** requirements.

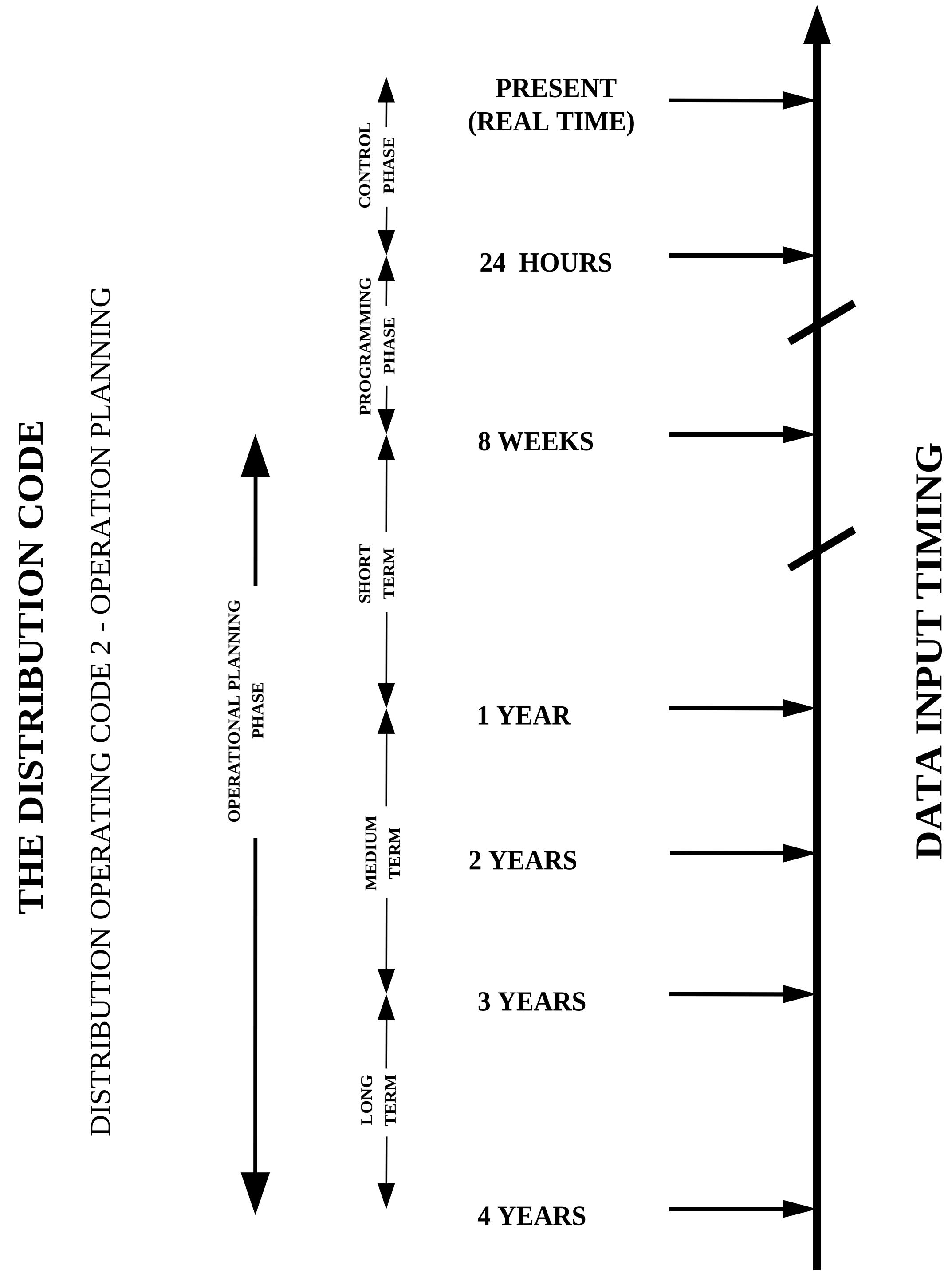
WEEK 25 **Embedded Generators** will provide the **DNO** with estimates of each **Embedded Generating Plant** or **Embedded Transmission System Output Usable** for weeks 28 - 52.

WEEK 27 The **DNO** will inform **Embedded Generators** of changes to **Output Usable** requirements for weeks 31 - 52.

WEEK 41 **Embedded Generators** will provide the **DNO** with estimates of each **Embedded Generating Plant** or **Embedded Transmission System Output Usable** for weeks 44 - 52.

WEEK 43 The **DNO** will inform **Embedded Generators** of changes to **Output Usable** requirements for weeks 44 - 52.

An update of **Users** proposals agreed in the Medium Term Plan will be included in the Short Term Programming Phase.


THE DISTRIBUTION CODE
DISTRIBUTION OPERATING CODE 2 - OPERATION PLANNING
OPERATIONAL PLANNING PHASE
CONTROL PHASE
PROGRAMMING PHASE
SHORT TERM
MEDIUM TERM
LONG TERM
PRESENT (REAL TIME)
24 HOURS
8 WEEKS
1 YEAR
2 YEARS
3 YEARS
4 YEARS
DATA INPUT TIMING

<u>Figure 1</u>

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 5

DOC5 TESTING AND MONITORING

DOC5.1 **Introduction**

DOC5.1.1 To ensure that the **DNO's Distribution System** is operated efficiently and within its licence standards and to meet statutory actions the **DNO** will organise and carry out testing and/or monitoring of the effect of **Users**' electrical apparatus on the **DNO's Distribution System**.

DOC5.1.2 The testing and/or monitoring procedures will be specifically related to the technical criteria detailed in the **Distribution Planning and Connection Code**. They will also relate to the parameters submitted by **Users** in the **Distribution Data Registration Code.**

DOC5.1.3 This DOC5 also covers the testing requirements that might be imposed from time to time on **Embedded Medium Power Stations** owned by a **Generator** who is not party to the **CUSC**

DOC5.1.4 The testing carried out under this **Distribution Operating Code** (DOC5) should not be confused with the more extensive **System Test** outlined in DOC12.

DOC5.2 **Objective**

DOC5.2.1 The objective of this **Distribution Operating Code** is to specify the **DNO's** requirement to test and/or monitor its **DNO's Distribution System** to ensure that **Users** are not operating outside the technical parameters required by the **Distribution Planning and Connection Code** and/or the **Distribution Operating Codes**.

DOC5.3 **Scope**

DOC5.3.1 This Distribution Operating Code applies to the following **Users** of the **DNO's Distribution System**:-

(a) **Customers** (it is not intended that the **Distribution Code** will necessarily apply to small **Customers** individually - their obligations will generally be dealt with on their behalf by their **Supplier**).

(b) **Embedded Generators.**

(c) **Other Authorised Distributor** connected to the **DNO's Distribution System.**

(d) **Suppliers**.

(e) **Meter Operators.**

DOC5.4 **Procedure Related to Quality of Supply**

DOC5.4.1 The **DNO** will from time to time determine the need to test and/or monitor the quality of supply at various points on its **DNO's Distribution System**.

DOC5.4.2 The requirement for specific testing and/or monitoring may be initiated by the receipt of complaints as to the quality of supply on the **DNO's Distribution System**.

DOC5.4.3 In certain situations the **DNO** may require the testing and/or monitoring to take place at the point of connection of a **User** with the **DNO's Distribution System**.

DOC5.4.4 Where testing and/or monitoring is required at the **Connection Point**, the **DNO** will advise the **User** involved and will make available the results of such tests to the **User**.

DOC5.4.5 Where the results of such tests show that the **User** is operating outside the technical parameters specified in the **Distribution Planning and Connection Code**, the **User** will be informed accordingly.

DOC5.4.6 Where the **User** requests, a retest will be carried out and the test witnessed by a **User** representative.

DOC5.4.7 A **User** shown to be operating outside the limits specified in **Distribution Planning and Connection Code** will rectify the situation or disconnect the **Apparatus** causing the problem from its electrical **System** connected to the **DNO's Distribution System** immediately or within such time as is agreed with the **DNO**.

DOC5.4.8 Continued failure to rectify the situation will result in the **User** being disconnected or de-energised in accordance with the **Connection Agreement** from the **DNO's Distribution System** either as a breach of the **Distribution Code** or through the authority of the **ESQCR**, where appropriate.

DOC5.5 **Procedure Related to Connection Point Parameters**

DOC5.5.1 The **DNO** from time to time will monitor the effect of the **User** on the **DNO's Distribution System**.

DOC5.5.2 The monitoring will normally be related to amount of **Active Power** and **Reactive Power** transferred across the **Connection Point**.

DOC5.5.3 Where the **User** is exporting to or importing from the **DNO's Distribution System Active Power** and **Reactive Power** in excess of the parameters in the **Connection Agreement** the **DNO** will inform the **User** and where appropriate demonstrate the results of such monitoring.

DOC5.5.4 The **User** may request technical information on the method of monitoring and, if necessary, request another method reasonably acceptable to the **DNO**.

DOC5.5.5 Where the **User** is operating outside the specified parameters, the **User** will immediately restrict the **Active Power** and **Reactive Power** transfers to within the specified parameters.

DOC5.5.6 Where the **User** requires increased **Active Power** and **Reactive Power** in excess of the physical capacity of the **Connection Point** the **User** will restrict power transfers to those specified in the **Connection Agreement** until a modified **Connection Agreement** has been applied for from the **DNO** and physically established.

DOC5.6 Grid Code Compliance for Medium Power Stations not subject to an embedded generation agreement

DOC5.6.1 Procedure For Compliance

DOC5.6.1.1 **NGC** may, from time to time, but generally not more than twice in any calendar year, request that the **DNO** procure from the **Generator** a statement confirming compliance with the relevant **Grid Code** Connection Conditions at the **Embedded Medium Power Station** not subject to an embedded generation agreement in question. Such requests will generally, but not necessarily, be contingent on the issues raised in DOC6.5.3.3 below.

DOC5.6.1.2 On request from the **DNO**, in furtherance of DOC5.6.1.1 above or at other times not generally more than twice per calendar year, the **Generator** will provide to the **DNO** a statement with appropriate supporting evidence of compliance with the relevant **Grid Code** requirements. The **DNO** will immediately submit this information to **NGC**. The **Generator** is at liberty to submit the data directly to **NGC**, but a copy must be submitted in parallel to the **DNO**.

DOC5.6.1.3 In the event that in **NGC's** view an **Embedded Medium Power Station** fails persistently to comply with the **Grid Code** Connection Conditions **NGC** shall notify the **DNO** giving details of the failure and of the monitoring that **NGC** has carried out.

DOC5.6.1.4 The **DNO** will notify the **Generator** responsible for the **Embedded Medium Power Station** in question as soon as possible, and in any case within 2 working days of all the facts contained in the **NGC** notice.

DOC5.6.1.5 The **Generator** responsible for the **Embedded Medium Power Station** in question will, as soon as possible, provide the **DNO** with an explanation of the reasons for the failure and details of the action that it proposes to take to comply with the **Grid Code** Connections Conditions within a reasonable period.

DOC 5.6.1.6 **NGC**, the **DNO** and the **Generator** will then discuss the action the **Generator** proposes to take and will endeavour to reach agreement as to:

(a) any short term operational measures necessary to protect other **Users**; and

(b) the parameters which are to be submitted for the **Generation Set** and the effective date(s) for the application of the agreed parameters.

DOC5.6.2 Procedure for Testing

DOC5.6.2.1 Subject to the provisions of DOC5.6.1 should the **DNO** fail to procure a notice of compliance to **NGC's** reasonable satisfaction**, NGC** may at any time (although not normally more than twice in any calendar year in respect of any particular **Embedded Medium Power Station** not subject to an embedded generation agreement issue an instruction requiring the **DNO** to facilitate a test, provided **NGC** has reasonable grounds of justification based upon:

(a) a submission of data in respect of the relevant **Embedded Medium Power Station** indicating a change in performance; or

(b) a statement from the **DNO** or **Generator** indicating a change in performance; or

(c) monitoring by **NGC**, whether or not carried out in accordance with DOC5.6.1.3 above; or

(d) notification from the **DNO** of completion of an agreed action from DOC5.6.1 above.

DOC5.6.2.2 The test referred to in DOC5.6.2.1 on any one or more of the **Generation Sets** comprising part of the relevant **Embedded Medium Power Station** should only be to demonstrate that:

(a) the relevant **Generation Set** meets the requirements of the paragraphs in the **Grid Code** Connection Conditions which are applicable to such **Generation Sets** or **Power Station**; or

(b) the relevant **Generation Set** meets the requirements for operation in **Limited Frequency Sensitive Mode** in accordance with CC.6.3.3, BC3.5.2 and BC3.7.2,

DOC5.6.2.3 The instruction referred to in DOC5.6.2.1 may only be issued where, following consultation and the preparation of a mutually agreed testing plan (to include prevailing economic conditions etc) and timetable between the **DNO**, **Generator** and **NGC**, **NGC** has:

(a) confirmed to the **DNO** and **Generator** the manner in which the test will be conducted, which shall be consistent with the principles established in DOC5.6.3; and

(b) received confirmation from the **DNO** that the relevant **Generation Set** would not then be unavailable by reason of forced outage or **Planned Outage** expected prior to the instruction.

DOC5.6.3 Conduct of Test

DOC5.6.3.1 The **Generator** is responsible for carrying out the test when requested by the **DNO** following a valid request from **NGC** in accordance with DOC5.6.2.1 and the **Generator** retains the responsibility for the safety of personnel and plant during the test.

DOC5.6.3.2 The performance of the **Generation Set** concerned will be recorded at **NGC** and/or **DNO Control Centres** with monitoring at site as and when necessary during the test.

DOC5.6.3.3 If monitoring at site is undertaken, the performance of the **Generation Set** will be recorded on a suitable recorder (with measurements taken as appropriate on the **Generation Set** Stator Terminals / on the LV side of the generator transformer) in the relevant **User's Control Centre**, in the presence of a reasonable number of representatives appointed and authorised by **NGC**. If **NGC** or the **DNO** or the **Generator** requests, monitoring at site will include measurement of the following parameters during the test.:

(a) for Steam Turbines: governor pilot oil pressure, valve position and steam pressure; or

(b) for Gas Turbines: Inlet Guide Vane position, Fuel Valve positions, Fuel Demand signal and Exhaust Gas temperature; or

(c) for Hydro Turbines: Governor Demand signal, Actuator Output signal, Guide Vane position; and/or

(d) for Excitation Systems: Generator Field Voltage and Power System Stabiliser signal where appropriate.

DOC5.6.3.4 The relevant test parameters and the pass/fail criteria shall be drawn from Section OC5.5.3 of the **Grid Code**.

DOC5.6.4 Test Failure/Re-test

DOC5.6.4.1 If the **Generation Set** concerned fails to pass the test the **Generator** must provide the **DNO** and **NGC** with a written report specifying in reasonable detail the reasons for any failure of the test so far as they are then known to the **Generator** after due and careful enquiry.

DOC5.6.4.2 The **DNO** has the responsibility under the **Grid Code** to forward the report of DOC5.6.4.1 above to **NGC.** This report must be provided within five Business Days of the test. If a dispute arises relating to the failure, **NGC**, the **DNO** and the **Generator** shall seek to resolve the dispute by discussion, and, if they fail to reach agreement, either of the **DNO** or **Generator** may by notice respectively:

(a) require **NGC** to initiate a re-test on 48 hours' notice which shall be carried out following the procedure set out in OC5.5.2 and OC5.5.3 and subject as provided in OC5.5.1.3, as if **NGC** had issued an instruction at the time of notice from the relevant **User**; or

(b) confirm that it (or they) will exercise its right to carry out a re-test on 48 hours' notice which shall be carried out following the procedure set out in **Grid Code** Sections OC5.5.2 and OC5.5.3 and subject as provided in **Grid Code** Sections OC5.5.1.6, as if **NGC** had issued an instruction at the time of notice from the **DNO**.

DOC5.6.5 Dispute following Re-test

DOC5.6.5.1 If the **Generation Set** in **NGC's** view fails to pass the re-test and a dispute arises on that re-test, **NGC**, the **DNO** and the **Generator** may use the **CUSC Disputes Resolution Procedure**, (which embodies the ESI disputes resolution procedure) for a ruling in relation to the dispute, which ruling shall be binding.

DOC5.6.6 Dispute Resolution

DOC5.6.6.1 If following the procedure set out in DOC5.6.5 it is accepted that the **Generation Set** has failed the test or re-test (as applicable), the **Generator** shall within 14 days, or such longer period as **NGC** may reasonably agree, following such failure, submit in writing to the **DNO** for submission to **NGC** for approval the date and time by which the **Generator** shall have brought the **Generation Set** concerned to a condition where it complies with the relevant requirement.

DOC5.6.6.2 Should **NGC** not approve the **Generator's,** proposed date or time (or any revised proposal), the **Generator** shall amend such proposal having regard to any comments **NGC** and/or **the DNO** may have made and re-submit it for approval.

DOC5.6.6.3 If the **Generation Set** fails the test the **Generator** shall resubmit to the **DNO** the relevant registered parameters of that **Generation Set** for the period of time until the **Generation Set** can achieve the parameters previously registered, as demonstrated (if required by **NGC** in accordance with DOC5.6.6.4) in a re-test. The **DNO** will submit these parameters to **NGC** as required by the **Grid Code**.

DOC5.6.6.4 Once the **Generator,** has indicated to **NGC** via the **DNO** the date and time that the **Generation Set** can achieve the parameters previously registered or submitted, **NGC** shall either accept this information or require the **Generator** to demonstrate the restoration of the capability by means of a repetition of the test referred to in DOC5.6.7 by an instruction requiring the **DNO** to ensure on 48 hours' notice that such a test is carried out by the **Generator**.

DOC5.6.6.5 The provisions of this DOC5.6.6 will apply to such further test.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 6

DOC6 DEMAND CONTROL

DOC6.1 **Introduction**

DOC6.1.1 This **Distribution Operating Code** DOC6 is concerned with the provisions to be made by the **DNO** and **Users** with **Systems** connected to the **DNO's Distribution System** in certain circumstances, to permit reductions in **Demand** in the event of insufficient **Generating Plant,** and transfers from **External Interconnections** being available to meet **Demand** or to avoid disconnection of **Customers** or in the event of breakdown and/or operating problems (such as in respect of **System Frequency**, **System** voltage levels or **System** thermal overloads) on any part of the **National Electricity Transmission System** and/or the **DNO's Distribution System**.

DOC6.1.2 This **Distribution Operating Code** deals with the following methods of **Demand Control**:-

(a) **Customer Demand** reduction, including **Voltage Reduction**, initiated by the **DNO**.

(b) **Customer Demand** reduction instructed by **NGC**.

(c) Automatic low frequency **Demand** disconnection.

(d) Emergency manual **Demand** disconnection.

The term "Demand Control" is used to describe any or all of these methods of achieving a Demand reduction.

Data relating to Demand Control should be expressed in MW.

DOC6.1.3 The situation where it is necessary to reduce **Demand** due to Civil Emergencies is dealt with in **Distribution Operating Code**, DOC9.

The Electricity Supply Emergency Code issued by the lead government department for energy emergencies (as amended from time to time) provides that in certain circumstances consumers are given a certain degree of "protection" when rota disconnections are implemented pursuant to a direction under the Energy Act 1976. No such protection can be given under the **Grid Code** or this section of the **Distribution Code.**

DOC6.1.4 Connections between **Power Stations** comprising **Generation Set(s)** which comprise or contain **BM Units** which are active (ie. submitting bid-offer data) in the **Balancing Mechanism** and a **DNO's Distribution System** will not, as far as is possible, be disconnected by a **DNO** pursuant to the provisions of DOC6 insofar as that would interrupt supplies.

(a) For the purpose of operation of the **Power Station** (including start-up and shutting down).

(b) For the purposes of keeping the **Power Station** in a state that it could be started-up when it is off–load for ordinary operational reasons.

(c) For the purpose of compliance with the requirements of a Nuclear Site Licence.

Demand Control pursuant to this **DOC6** therefore applies subject to this exception.

DOC6.1.5 The control of **Demand Control** between the **DNO's Distribution System** and the **National Electricity Transmission System** will be carried out in accordance with Operating Code of the **Grid Code** and is outwith the scope of this **Distribution Operating Code**.

DOC6.2 **Objective**

To establish procedures to enable the **DNO**, following an instruction of **NGC** or otherwise, to achieve reduction in **Demand** that will either avoid or relieve operating problems on the **National Electricity Transmission System** and/or the **DNO's Distribution System**, in whole or in part in a manner that does not discriminate against or unduly prefer any one or any group of **Suppliers** or their **Customers** or **Other Authorised Distributors** in accordance with the **Distribution Licence**.

DOC6.3 **Scope**

This **Distribution Operating Code** will apply to the **DNO** and to **Users** which in this **Distribution Operating Code** means:

(a) **Customers** (it is not intended that the **Distribution Code** shall apply to small **Customers** individually).

(b) **Embedded Generators**.

(c) **Other Authorised Distributor** connected to the **DNO's Distribution System**.

DOC6.3.2 Implementation of **Demand Control** by the **DNO** may affect all **Suppliers' Customers** and where applicable, contractual arrangements between **Suppliers** and their **Customers** may need to reflect this.

DOC6.4 **Operational System Load Reduction Arrangements**

DOC6.4.1 The **DNO** will arrange within its **DNO's Distribution System** a scheme to reduce load in a controlled manner by reducing voltage and/or by disconnecting **Customers** and/or **Users**.

DOC6.4.2 A **System** of warnings will be contained within the load reduction arrangements to give notice, wherever practical, of impending implementation.

DOC6.4.3 The **DNO** will arrange to have available within the **DNO's Distribution System**, four stages of **Demand Control** in integral multiples of between four and six per cent. These stages may include the use of **Voltage Reduction** and/or other forms of **Demand Control** determined by the **DNO.**

DOC6.4.4 The groups will be arranged so that disconnection can take place uniformly across the **DNO's Distribution System**, and as far as practicable uniformly between **Grid Supply Points.**

DOC6.4.5 The **DNO** will arrange to have available a scheme to implement a further four 5% stages of **Demand Control** upon receipt of a suitable warning from **NGC** which will be issued by 1600 hrs on the previous day.

The **DNO** will arrange to have available a scheme to implement further twelve 5% stages of **Demand Control.**

DOC6.4.6 **Embedded Generators**, **Suppliers**, **Customers** and **Other Authorised Distributors** connected to the **DNO's Distribution System** will need to be considered in the preparation of **DNO's Demand Control** schemes.

DOC6.4.7 The **DNO** shall issue instructions to such **Users** of the **DNO's Distribution System** who are required to disconnect or reconnect and the **User** shall carry out the instructions without delay.

DOC6.4.8 Once a disconnection has been applied at the instruction of the **DNO**, the **User** shall not reconnect until the **DNO** instructs the **User** to do so in accordance with this **Distribution Operating Code.**

DOC6.4.9 The **Users** shall abide by the instructions of the **DNO** with regard to reconnection under this **Distribution Operating Code** without delay.

DOC6.4.10 Where disconnection is envisaged by the **DNO** to be prolonged, the **DNO** may utilise disconnection rotas where 5 per cent groups are interchanged to ensure (so far as practicable) equitable treatment of **Customers**, provided that the proportion of total **Demand** disconnected at all times does not change.

DOC6.5 **Automatic Low Frequency Demand Disconnection**

DOC6.5.1 The **DNO** shall provide automatic low frequency disconnection in stages by tripping relays to disconnect at least 40% of the **DNO's Distribution System Peak Demand** in Scotland and 60% of the **DNO's Distribution System Peak Demand** in England and Wales (based on the winter peak value), in order to seek to limit the consequences of the loss of a major source of generation or an **Event** on the **National Electricity Transmission System** which leaves part of the **Total System** with a generation deficit.

DOC6.5.2 The **Demand** subject to automatic low frequency disconnection shall be split into discrete blocks. The number, location and size of the blocks and the associated low frequency settings will be as specified by the **DNO.** The intention is that the distribution of the blocks will be such as to give a reasonably uniform application throughout the **DNO's Distribution System**, but may take into account any operational requirements and the essential nature of certain **Demand.**

DOC6.5.3 Where conditions are such that, following automatic low frequency disconnection, it is not possible to restore all or a great proportion of those **Customers** so disconnected within a reasonable period of time, the **DNO** may instruct, at any time, further manual load disconnection and instruct a portion of the **Customers** which were disconnected by automatic low frequency disconnection to be restored in order that any further fall in **Frequency** will be contained by operation of automatic low frequency disconnection.

DOC6.5.4 Once an automatic low frequency disconnection has taken place, it shall not be reconnected until the **DNO** instructs to do so in accordance with this **Distribution Operating Code**.

DOC6.5.5 Each **Supplier** and **Other Authorised Distributor** shall abide by the instructions of the **DNO** with regard to reconnection under this **Distribution Operating Code** without delay.

DOC6.5.6 In addition, **Embedded Generators** may wish to disconnect, automatically or manually, their plant from the **System** to which it is connected at certain frequency levels. Any such disconnection will be agreed with the **DNO** on connection to the **DNO's Distribution System** in accordance with the **Distribution Planning and Connection Code**.

DOC6.6 **Emergency Manual Disconnection of Demand**

DOC6.6.1 The **DNO** shall make such arrangements as are necessary to enable it to disconnect **Customers** under emergency conditions irrespective of frequency.

DOC6.6.2 The **DNO** shall annually, by the end of September, prepare schedules with details, on a **Grid Supply Point** basis and including arrangements with **Users**, of the percentage block of **Demand** at that **Grid Supply Point** available for manual disconnection, the method of disconnection to be used and the timescale of the implementation of disconnection of each block.

DOC6.6.3 The scheme will be designed to be called into operation irrespective of **System Frequency**, and to be implemented in predetermined timescales to disconnect **Demand** progressively.

DOC6.6.4 **Customers** and **Other Authorised Distributors** may be required to provide manual disconnection facilities. Where required by the **DNO** to disconnect load, each **Customer** or **Other Authorised Distributor** shall abide by the instructions of the **DNO** with regard to disconnection under this **Distribution Operating Code** without delay and the instructed disconnection must be completed without undue delay.

DOC6.6.5 Once a disconnection has been applied at the instruction of the **DNO** reconnection shall not be applied until the **DNO** instructs it to be done in accordance with this **Distribution Operating Code**.

DOC6.6.6 Each **Customer** and **Other Authorised Distributor** shall abide by the instructions of the **DNO** with regard to reconnection under this **Distribution Operating Code** without delay.

DOC6.7 **Co-ordination of Actions**

DOC6.7.1 Where **Demand Control** is exercised by the **DNO** in order to safeguard the **DNO's Distribution System** the **DNO** will liaise with and inform **Users** accordingly so far as is practical.

DOC6.7.2 Where **Demand Control** is exercised by the **DNO** on instruction or request from **NGC** in order to safeguard the **Total System** then the **DNO** is required to respond to these requests promptly but will liaise with and inform other **Users** so far as is practical.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 7

DOC7 OPERATIONAL LIAISON

DOC7.1 **Introduction**

DOC7.1.1 This **Distribution Operating Code** DOC7sets out the requirements for the exchange of information in relation to **Operations** and/or **Events** on the **DNO's Distribution System** and on the immediately adjacent parts of adjoining **Systems** which have had (or may have had), or will have (or may have) an **Operational Effect**.

(a) on the **DNO's Distribution System** or on the **System** of any other **User** in the case of an **Operation** and/or **Event** occurring on the **System** of a **User**, and

(b) on the **System** of a **User** in the case of an **Operation** and/or **Event** occurring on the **DNO's Distribution System** or the **National Electricity Transmission System,**

where no requirement for liaison is specified in any other section of the **Distribution Code.**

DOC7.1.2 The requirement to notify in DOC7 relates generally to communicating what has happened or what is to happen and not the reasons why. However, DOC7 provides, when an **Event** has occurred on the **DNO's Distribution System** which itself has been caused by (or exacerbated by) an **Operation** or **Event** on a **User's System**, the **DNO** in reporting the **Event** on the **DNO's Distribution System** to a **User** can pass on what it has been told by the **User** in relation to the **Operation** on that **User's System**.

DOC7.2 **Objective**

To provide for the exchange of information so that the implications of the **Operation** and/or **Event** can be considered and the possible risks arising from it can be assessed and appropriate action taken by the relevant party in order to maintain the integrity of the **Total System** and the **User's System**. This **Distribution Operating Code** does not seek to deal with any actions arising from the exchange of information, but merely with that exchange.

DOC7.3 **Scope**

This Distribution Operating Code applies to the **DNO** and to Users, which in this Distribution Operating Code means:-

(a) **High Voltage Customers.**

(b) **Embedded Generators** connected to the **DNO's Distribution System** at **HV.**

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System** at **HV.**

(d) **Suppliers** on behalf of their **Customers** where appropriate.

DOC7.4 **Communications**

DOC7.4.1 The **DNO** and each **User** connected to the **DNO's Distribution System** will establish communication channels to make effective the exchange of information required by DOC7.

DOC7.4.2 Communication should, as far as possible, be direct between the **User** and the operator of the network to which that **User** is connected.

DOC7.4.3 Information between a **DNO** and **Users** will be exchanged on the reasonable request of either party. The request may follow a specific **Operation** or **Event**, or be in accordance with a prior agreement to exchange information on particular types of **Operation** or **Event**.

This does not preclude the voluntary exchange of information which may be perceived as being relevant to the operation of the **DNO** or **User System**, in accordance with good operating practice.

DOC7.5 **Requirement to notify Operations**

DOC7.5.1 **Notification Requirements**

DOC7.5.1.1 In the case of an **Operation** on the **DNO's Distribution System** or on receipt of notification of an **Operation** on the **National Electricity Transmission System**, which will have or may, in the opinion of the **DNO**, have an **Operational Effect** on the **System** of a **User** connected to the **DNO's Distribution System**, the **DNO** will notify the **User** in accordance with DOC7.

DOC7.5.1.2 In the case of an **Operation** on the **System** of a **User** connected to the **DNO's Distribution System**, which, in the opinion of the **User,** will have or may have an **Operational Effect** on the **DNO's Distribution System**, the **User** will notify the **DNO** in accordance with DOC7.

DOC7.5.1.3 An **Operation** may be caused by another **Operation** or an **Event** on another's **System** and in such situations the information to be notified is different from that where the **Operation** arose independently of any other **Operation** or **Event**.

DOC7.5.1.4 Whilst in no way limiting the general requirement to notify in advance as set out in this part of this **Distribution Operating Code**, DOC7.5, the following are examples of circumstances where notification may be required in accordance with this **Distribution Operating Code**:-

(a) The implementation of a scheduled outage of **Plant** and/or **Apparatus** which has been arranged pursuant to **Distribution Operating Code** DOC2.

(b) The **Operation** (other than, in the case of a **User**, at the instruction of the **DNO**) of a circuit breaker or isolator or any sequence or combination of the two, including any temporary over-stressing, **System** parallels, or **Generation Set** synchronising.

(c) Voltage control.

DOC7.5.2 **Form of Notification**

DOC7.5.2.1 A notification under DOC7.5.1 will be of sufficient detail to describe the **Operation**, although it need not state the cause, and to enable the recipient of the notification reasonably to consider and assess the implications and risks arising and will include the name of the individual reporting the **Operation** on behalf of the **DNO** or the **User**, as the case may be. The recipient may seek clarification of the notification.

DOC7.5.2.2 The notification may be written or oral. Written notification must be of an immediate form such as electronic mail. Where the notification is oral, it shall be written down by the sender and be dictated to the recipient who shall write it down and repeat each phrase as received and on completion shall repeat the notification in full to the sender and check that it has been accurately recorded.

DOC7.5.3 **Timing**

A notification under DOC7.5.12 shall be given in sufficient time as will reasonably allow the recipient to consider and assess the implications and risks arising, and to undertake mitigating actions.

DOC7.6 **Requirement to Notify Events**

DOC7.6.1 **Notification Requirements**

DOC7.6.1.1 In the case of an **Event** on the **DNO's Distribution System** or on receipt of notification of an **Event** on the **National Electricity Transmission System**, which, in the opinion of the **DNO**, might have had or will have an **Operational Effect** on the **System** of a **User** connected to the **DNO's Distribution System**, the **DNO** will notify the **User** in accordance with this DOC7. This does not preclude any **User** asking the **DNO**, to whose **System** he is connected, for information regarding the **Event** which has affected the **User's System**.

DOC7.6.1.2 In the case of an **Event** on the **System** of a **User** connected to the **DNO's Distribution System**, which has had or may have had an **Operational Effect** on the **DNO's Distribution System** or on the **National Electricity Transmission System**, the **User** will notify the **DNO** in accordance with this DOC7.

DOC7.6.1.3 An **Event** may be caused by (or exacerbated by) another **Event** or by an **Operation** on another's **System** and in that situation the information to be notified is different from that where the **Event** arose independently or any other **Event** or **Operation**.

DOC7.6.1.4 Whilst in no way limiting the general requirement to notify set out in this part of this **Distribution Operating Code**, DOC7.6, the following are examples of circumstances where notification may be required in accordance with this **Distribution Operating Code**:-

(a) Where **Plant** and/or **Apparatus** is being operated in excess of its capability or may present a hazard to personnel.

(b) The actuation of an alarm or indication of an abnormal operating condition.

(c) Adverse weather conditions being experienced or forecast.

(d) Breakdown of, or faults on, or temporary changes in the capabilities of, **Plant** and/or **Apparatus** including **Protection** control, communications and metering equipment.

(e) Increased risk of inadvertent **Protection** operation.

DOC7.6.2 **Form of Notification**

DOC7.6.2.1 A notification under DOC7.6.1of an **Event,** although it need not state the cause, shall be of sufficient detail to enable the recipient of the notification to reasonably consider and assess the implications and risks arising. Details of the **Event** should include the timescale and the probability of repeat occurrences within a period. The recipient may seek clarification of the notification.

DOC7.6.2.2 The notification may be written or oral. Written notification must be of an immediate form such as electronic mail. Except in an emergency situation any oral notification shall, be written down by the sender and dictated to the recipient who shall write it down and repeat each phrase as received and on completion shall repeat the notification in full to the sender and check that it has been accurately recorded.

DOC7.6.3 **Timing**

A notification under DOC7.6.1 shall be given as soon as practicable after the occurrence of the **Event**, or time that the **Event** is known of or anticipated by the giver of the notification under this **Distribution Operating Code** DOC7.

DOC7.7 **System Control**

DOC7.7.1 Where a part of a **DNO's Distribution System** is, by agreement, under the **System Control** of the **National Electricity Transmission System Control Centre** then the requirements and provisions of the **Grid Code** shall apply to that situation as if that **DNO's Distribution System** was the **National Electricity Transmission System**

DOC7.7.2 Where a part of a **User's System** is, by agreement, under the **System Control** of a Distribution **Control Centre** the **DNO,** then the requirements and provisions of this **Distribution Operating Code** shall apply to that situation as if that **System** was part of the **DNO's Distribution System**.

DOC7.8. **Significant Incidents**

DOC7.8.1 Where an **Event** on the **DNO's Distribution System** or the **National Electricity Transmission System** or the **System** of a **User**, in the opinion of the **DNO**, has had or may have had a significant effect on the **System** of any of the others, the **Event** shall be reported in writing to the owner of the **System** affected in accordance with the provisions of **Distribution Operating Code** DOC10. Such an **Event** will be termed a "**Significant Incident**".

DOC7.8.2 Where the **DNO** notifies a **User** of an **Event** under DOC7, which the **User** considers has had or may have a significant effect on that **User's System**, that **User** will require the **DNO** to report that **Event** in writing and will notify the **DNO** accordingly. Such an **Event** will also be termed a "**Significant Incident**".

DOC7.8.3 Without limiting the general description set out in DOC7.8.1 or DOC7.4.10.2 a **Significant Incident** will include **Events** which result in, or may result in, the following:

(a) Voltage outside statutory limits.

(b) **System Frequency** outside statutory limits.

(c) **System** instability.

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DOC8 SAFETY CO-ORDINATION

DOC8.1 **Introduction**

DOC8.1.1 This **Distribution Operating Code** DOC8 specifies the **Safety Management System** criteria to be applied by the **DNO** and **Users** for the co-ordination, establishment and maintenance of necessary **Safety Precautions** when work or testing is to be carried out on **Plant** and/or **Apparatus** of **the DNO** or a **User** and where for this to be done safely, isolation on and/or earthing of the other's **System** is needed. This **Distribution Operating Code** does not apply to the situation where **Safety Precautions** need to be agreed solely between **Users**.

DOC8.1.2 This **Distribution Operating Code** does not seek to impose a particular set of **Safety Rules** on the **DNO** and **Users**. The **Safety Rules** to be adopted and used by the **DNO** and each **User** shall be those chosen by each.

DOC8.2 **Objectives**

To lay down requirements with a view to ensuring safety of persons working at or across Operational and Ownership Boundaries between the **DNO's Distribution System** and Users' Systems.

DOC8.3 **Scope**

This Distribution Operating Code **DOC8** specifies the **Safety Management System** criteria to be applied by the **DNO** and all **Users** of the **DNO's Distribution System** at or across an **Operational Boundary, Users** for the purposes of this **Distribution Operating Code** being**:-**

(a) **High Voltage Customers.**

(b) **Embedded Generators,** but excluding the **OTSO.**

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System.**

(d) **Meter Operators.**

(e) Any other party reasonably specified by the **DNO** including **Users** with **Unmetered Supply** and those connected at **Low Voltage** for appropriate sections of DOC8 where necessary.

DOC8.4 **Operational Safety**

DOC8.4.1 **Approved Safety Management Systems**

DOC8.4.1.1 At each site or location where an **Operational Boundary** exists, a **Safety Management System** specifying the principles and procedures to be applied so as to ensure the health and safety of all who are liable to be working or testing on the **DNO's Distribution System**, or on **Plant** and **Apparatus** connected to it, will be established by the **DNO** and **Users**. For interfaces involving **HV Systems** this shall include the provision for **Control Person(s)**, a system of documentation and the establishment of **Safety Precautions.**

DOC8.4.2 **Authorised Persons**

DOC8.4.2.1 The **DNO** and every **User** shall at all times have nominated a person or persons to be responsible for the co-ordination of safety pursuant to this **Distribution Operating Code**, those persons being referred to in this **Distribution Operating Code** as **Control Persons.** (Under the conditions of the **DNO's Safety Rules** a **Control Person** may either be at the **DNO's Distribution Control Centre** or be a person authorised in accordance with DOC8.4.2.2, who is at the site or location of the **Operational Boundary**).

DOC8.4.2.2 **Control Persons** and persons concerned with the carrying out of **Safety Precautions** and work on or testing of **Plant** and **Apparatus** forming part of, or connected to, the **DNO's Distribution System** shall have a written authorisation designating their role in implementing the **Safety Management System.**

DOC8.4.2.3 The written authorisation shall indicate the class of **Operation** and/or the class of work permitted and the parts of the **System**, **the DNO** and/or **Users**, to which the written authorisation shall apply.

DOC8.4.3 **System of Documentation**

DOC8.4.3.1 A system of documentation shall be maintained by the **DNO** and the appropriate **Users** which will record the inter-system **Safety Precautions** taken when:-

(a) Work and/or testing is to be carried out on **HV Plant** and/or **Apparatus** across the **Operational Boundary**.

(b) Isolation and/or earthing of the other's **System** is required.

DOC8.4.3.2 Where relevant, copies of the **Safety Management Systems** and related documentation shall be exchanged between the **DNO** and **Users** for each **Operational Boundary.**

DOC8.4.3.3 The **DNO** and **Users** shall maintain a suitable system of documentation which records all relevant operational events that have taken place on the **DNO's Distribution System** or any other **System** connected to it and the co-ordination of relevant **Safety Precautions** for work.

DOC8.4.3.4 All documentation relevant to the **Operation** of the **Distribution System**, and **Safety Precautions** taken for work or tests, shall be held by the **DNO** and the appropriate **User** for a period of not less than six months.

DOC8.4.4 **Safety Precautions**

The establishment of **Safety Precautions** involves:-

(a) the isolation from the remainder of the **System** of **Plant** and/or **Apparatus**, including from **Low Voltage** infeeds, either by an **Isolating Device** in the isolating position and immobilised and locked or by other means of rendering the **Plant** or **Apparatus Isolated**, and/or

(b) the earthing by way of providing a connection between a conductor and earth by using an **Earthing Device** which is applied and where reasonably practicable, immobilised and locked, the extent of the **Safety Precautions** required being determined pursuant to this **Distribution Operating Code**.

DOC8.5 **Environmental Safety**

DOC8.5.1 **Site Safety and Security**

DOC8.5.1.1 Arrangements shall be made by the **DNO** and **Users** to ensure site safety and security as required by statutory requirements.

DOC8.5.1.2 Suitable arrangements shall be agreed between the **DNO** and the relevant **Users** to provide free and unrestricted access to the **DNO's Plant** and **Apparatus** at substations or similar by the **DNO's** personnel or their designated representatives at all times.

DOC8.5.2 **Site Specific Hazards**

Suitable arrangements shall be made by the **DNO** and/or the relevant **Users** to ensure that personnel are warned by an appropriate means of hazards specific to any site, before entering any area of the site. This shall include hazards that may be temporary or permanent. Where these risks include contamination or similar, suitable decontamination facilities and procedures shall be provided.

DOC8.6 **Information Flow and Co-ordination**

DOC8.6.1 **Schedules of Responsibility**

DOC8.6.1.1 The **DNO** and **Users** shall jointly agree and set down in writing schedules specifying the responsibilities for **System Control** of **Equipment**. These shall ensure that only one party is responsible for any item of **Plant** or **Apparatus** at any one time.

DOC8.6.1.2 Pursuant to the **Distribution Planning and Connection Code**, **Site Responsibility Schedules** specifying the responsibilities for ownership, operation and maintenance shall be jointly agreed by the **DNO** and the appropriate **User(s)** for each site or location where an **Operational Boundary** or joint responsibility exists. This will include **Operation Diagrams** illustrating sufficient information for **Control Persons** to carry out their duties which shall be exchanged by the **DNO** and the appropriate **User**.

DOC8.6.1.3 A copy of the **Site Responsibility Schedules** and **Operation Diagrams** shall be retained by the **DNO** and the appropriate **User(s). Site Responsibility Schedules** and **Operation Diagrams** shall be maintained by the **DNO** and the appropriate **User(s)** and exchanged as necessary to ensure that they reflect the current agreements.

DOC8.6.2 **Outage Co-ordination**

DOC8.6.2.1 For those **Users** connected at **HV** and having firm supply connections (provided by more than one circuit) and where the **User** so requests the **DNO**, these schedules shall identify those specified **DNO** circuits on which **Planned Outages** by the **DNO** shall be notified to the **User**. These specified circuits will be those where the **DNO** and the **User** have agreed that during outages of the specified circuits the **User** can introduce measures to manage critical processes or safety aspects. These specified circuits will usually operate at the voltage level at which the supply is provided and will have a significant effect on the security level of the **User's** supply.

DOC8.6.2.2 Those **Users** connected at **HV** and not having firm supply connections (provided by more than one circuit) may seek to obtain outage planning information through arrangements with the **DNO**.

DOC8.6.3 **Nomination of Control Persons**

The **DNO** and each **User** shall at all times have nominated a **Control Person** or **Control Persons** responsible for co-ordination of **Safety From The System** pursuant to this **Distribution Operating Code.**

DOC8.6.4 **Communications**

DOC8.6.4.1 Where the **DNO** reasonably specifies the need, suitable communication systems shall be established between the **DNO** and other **Users** to ensure the control function is carried out in a safe and secure manner.

DOC8.6.4.2 Where the **DNO** reasonably decides a back up or alternative routing of communication is necessary to provide for the safe and secure **Operation** of the **DNO's Distribution System** the means shall be agreed with the appropriate **Users**.

DOC8.6.4.3 Schedules of telephone numbers/call signs shall be exchanged by the **DNO** and appropriate **User** to enable control activities to be efficiently co-ordinated.

DOC8.6.4.4 The **DNO** and appropriate **Users** will establish 24-hour availability of personnel with suitable authorisation where the joint operational requirements demand it.

DOC8.7 **Procedures**

DOC8.7.1 Pursuant to this **Distribution Operating Code** the **Control Person** and/or Authorised Persons for each of the **DNO** and a **User** relating to the place where **Safety Precautions** are required will contact each other to coordinate the **Safety Precautions,** and the **Control Person** requesting **Safety Precautions** shall be referred to as the **"Requesting Control Person"** and the **Control Person** being requested and implementing the **Safety Precautions** shall be referred to as the **"Implementing Control Person".**

DOC8.7.2 Procedures shall be maintained by the **DNO** and the appropriate **Users** which clearly specify the responsibility for **System Control** of **Plant** and **Apparatus** and these shall ensure that only one **Control Person** is responsible for any item of **Plant** and **Apparatus** at any one time.

DOC8.7.3 The operational procedures shall be in accordance with the **Safety Management System** agreed between the **DNO** and the **User(s).**

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DOC9 CONTINGENCY PLANNING

DOC9.1 Introduction

This **Distribution Operating Code** DOC9 sets out requirements and procedures relating to the following planning procedures for abnormal situations:

DOC9.1.1 Black Start

This **Distribution Operating Code** DOC9 covers the requirements for the implementation of **Black Start** recovery procedures following a **Total Shutdown** or **Partial Shutdown** of the **Total System** as recognised by **NGC.** The **Black Start** procedure provides for the recovery of the **Total System** in the shortest possible time taking into account **Power Station** capabilities and the operational constraints of the **Total System,** in accordance with the **Grid Code** and the requirements of **NGC.**

DOC9.1.2 Re-synchronising Islands

The requirements for re-synchronising parts of the **Total System** where there is no **Total Shutdown** or **Partial Shutdown** but parts of the **Total System** are out of synchronism with each other.

DOC9.1.3 Joint System Incident Procedure

The requirements for the establishment of a communication route and arrangements between responsible representatives of the **DNO** and **Users** involved in, or who may be involved in, an actual or potential serious or widespread **Total System** disruption which requires or may require urgent managerial response, day or night.

DOC9.1.4 Civil Emergencies

The requirements for dealing with a Civil Emergency which under the **Act** is any natural disaster or other emergency which, in the opinion of the **Secretary of State**, is or may be likely to disrupt electricity supplies. The procedures may be similar to, or separate from, the **Demand** reduction schemes in **Distribution Operating Code** DOC6.

DOC9.2 Objectives

This **Distribution Operating Code** sets out Contingency Planning procedures to enable co-ordination between all **Users** with a common approach to give uniformity of priorities to restart or to operate the **Total System** in abnormal situations. It also specifies requirements to be met during periods of declared civil emergencies.

DOC9.3 Scope

This Distribution Operating Code applies to the **DNO** and to Users which in this Distribution Operating Code means, the Users specified below with a High Voltage connection to the **DNO's Distribution System**:

(a) **Customers** (it is not intended that the **Distribution Code** shall apply to small **Customers** individually).

(b) **Embedded Generators**, but excluding the **OTSO.**

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System.**

Any actions required of **Users** connected at **HV** will be identified by the **DNO** and discussed with **Users**.

DOC9.4 **Black Start**

DOC9.4.1 **Shutdown**

DOC9.4.1.1 During a **Total Shutdown** or **Partial Shutdown** and during the subsequent recovery the Security Standards set out in, or deriving authority pursuant to, the **Transmission Licence** and the **Distribution Licence** may not apply and the **Total System** may be operated outside normal voltage and **Frequency** standards.

DOC9.4.1.2 In a **Total Shutdown** or **Partial Shutdown**, it may be necessary for **NGC** to issue Emergency Instructions and it may be necessary to depart from the normal **Balancing Mechanism** operation in issuing Bid-Offer Acceptances.

DOC9.4.1.3 Certain **Embedded Power Stations** are registered by **NGC**, as having the ability of at least one of its **Generation Sets** to start up from shutdown without connections to external power supplies. Such **Power Stations** are to be referred to as **Black Start Stations**.

DOC9.4.1.4 For each **Black Start Station** plans will be put in place, in accordance with the **Grid Code**, which in the event of a **Partial Shutdown** or **Total Shutdown**, will provide for the establishment of a **Power Island**. These plans are known as Local Joint Restoration Plans produced jointly by **NGC** the **DNO** and **Generators** and may include **Embedded Generators. DNO**s will be party to these Plans irrespective of whether the **Black Start Station** is **Embedded.**

DOC9.4.1.5 In Scotland a Local Joint Restoration Plan may include more than one **Black Start Station** and may be produced with and include obligations on the relevant **Transmission Licensee**, **Generators** responsible for **Generation Sets** not at a **Black Start Station** and other **Users**.

DOC9.4.2 **Black Start Situation**

In the event of a **Total Shutdown** or **Partial Shutdown**, the **DNO** will, as soon as reasonably practicable, inform **Users** which, in the **DNO's** opinion, need to be informed that a **Total Shutdown** or, as the case may be, a **Partial Shutdown**, exists and that **NGC** intends to implement the **Black Start** procedure.

In Scotland, in exceptional circumstances, as specified in the Local Joint Restoration Plan, the relevant **Transmission Licensee** may invoke such Local Joint Restoration Plan for its own **Transmission System** and operate within its provisions.DOC9.4.3 **Black Start Recovery Procedure**

DOC9.4.3.1 The procedure necessary for a recovery from a **Total Shutdown** or **Partial Shutdown** is known as **Black Start,** the main objective of which is the restoration of the **Total System** as an integrated whole as soon as possible bearing in mind the restoration of **Customers**. The procedure for a **Partial Shutdown** is the same as that for a **Total Shutdown** except that it applies only to a part of the **Total System**. It should be remembered that a **Partial Shutdown** may affect parts of the **Total System** which are not themselves shut down.

DOC9.4.3.2 The complexities and uncertainties of recovery from a **Total Shutdown** or **Partial Shutdown** require that **Black Start** is sufficiently flexible in order to accommodate the full range of **Generation Set** and **Total System** characteristics and operational possibilities and this precludes the setting out of concise chronological sequences. The overall strategy will in general include the overlapping phases of establishment of isolated groups of **Power Stations** together with complementary local **Demand** termed **"Power Islands"**, step by step integration of these groups into larger sub-systems and eventually re-establishment of a complete **Total System**.

DOC9.4.3.3 Where there are no **Power Stations** with a contracted **Black Start** capability within the **DNO's Distribution System**, then restoration of supply may be substantially delayed while the relevant **Transmission Licensee** re-establishes the **National Electricity Transmission System** or part of the **National Electricity Transmission System** from a restored **Power Island** . The **DNO** shall re-appraise the priorities in these situations and restore supplies in accordance with such priorities.

DOC9.4.3.4 The procedure for a **Black Start** shall, therefore, be that specified by the **relevant Transmission Licensee** at the time. **Users** shall abide by the **DNO's** instructions during a **Black Start** situation, even if they conflict with the general overall strategy outlined in DOC9.4.3.2.

DOC9.4.3.5 The **DNO** may, in accordance with the relevant **Transmission Licensee's** requirements, be required to issue instructions (although this list should not be regarded as exhaustive) to a **Black Start Station** relating to the commencement of generation, to a **User** connected to the **DNO's Distribution System** or **Customers** in the **DNO's** authorised operating area, as appropriate, relating to the restoration of **Demand** and to an **Embedded Power Station** relating to their preparation for commencement of generation when an external power supply is made available to them, and in each case may include switching instructions.

DOC9.4.3.6 Where the **DNO**, as part of the **Black Start** procedure, has given an instruction to a **Black Start Station** to initiate startup the **Black Start Station** shall confirm to the **DNO** when the startup of a **Generation Set** has been completed. Following confirmation of startup, the **DNO** will endeavour to stabilise that **Generation Set** by the establishment of appropriate **Demand** following which the **DNO** may instruct the **Black Start Station** to start up the remaining available **Generation Sets** and auxiliary gas turbines if any at that **Black Start Station** and synchronise them to create a **Power Island.**

DOC9.4.3.7 **Interconnection of Power Islands**

In accordance with the requirements of the relevant **Transmission Licensee,** the **DNO** may be required to issue instructions to **Users** so as to establish, maintain and expand **Power Islands** and to interconnect **Power Islands** to achieve larger sub-systems and subsequently to form an integrated **System** and re-establishment of the **Total System**. **Users** shall at all times abide by the **DNO's** instructions in relation to interconnection of **Power Islands**.

DOC9.4.3.8 The conclusion of the **Black Start** situation and the time of the normal operation of the **Total System** will be determined by the relevant **Transmission Licensee** who shall inform the **DNO.** The **DNO** will inform **Users** of the **DNO's Distribution System** which in the **DNO's** opinion need to be informed that the **Black Start** situation no longer exists and that normal operation of the **Total System** has begun.

DOC9.5 **Re-synchronisation of De-synchronised Islands**

DOC9.5.1 Where parts of the **Total System** are out of synchronism with each other but there is no **Total Shutdown** or **Partial Shutdown NGC** will instruct **Users** to regulate generation or **Demand**, as the case may be, to enable the de-synchronised islands to be re-synchronised.

DOC9.5.2 **DNOs** may be involved in re-synchronising by issuing instructions to **Users** in accordance with the requirements of **NGC.** **Users** shall at all times abide by the **DNO's** instructions in relation to re-synchronising de-synchronised islands.

DOC9.5.3 The re-synchronising of de-synchronised islands are covered by De-synchronised Island Procedures agreed between **NGC** and the relevant **Transmission Licensee, DNO** and **Generators**.

DOC9.6 **Joint System Incident Procedure**

DOC9.6.1 A **Joint System Incident** is an **Event** (as referred to in **Distribution Operating Code** DOC7) wherever occurring which in the opinion of the **DNO** has or may have a serious and/or widespread effect on, in the case of an incident on a **User's System**, the **DNO's Distribution System** or the **National Electricity Transmission System** or, in the case of an incident on the **DNO's Distribution System** or the **National Electricity Transmission System,** on a **User's,** or **Users'**, **System(s)**. Where an incident on a **User's System** has or may have no effect on the **DNO's Distribution System** or the **National Electricity Transmission System**, then such an incident does not fall within this **Distribution Operating Code** and accordingly DOC9 shall not apply to it.

DOC9.6.2 Each **User** requested by the **DNO** in accordance with the **Distribution Planning and Connection Code**, shall provide in writing to the **DNO** and the **DNO** shall provide in writing to each such **User** a telephone number or numbers at which or through which responsible management representatives, who are fully authorised to take binding decisions on behalf of their appointers, can be contacted day or night when there is a **Joint System Incident**. The lists of telephone numbers shall be provided at the time that a **User** connects to the **DNO's Distribution System** and must be updated (in writing) as often as the information contained in them changes.

DOC9.6.3 On the occurrence of an **Event**, then pursuant to **Distribution Operating Code** DOC7:

(a) If it is on the **System** of a **User**, the **User** shall notify the **DNO** accordingly together with any other **User** who is or may be affected and will inform the **DNO** of which **Users** it has informed.

(b) If it is on the **DNO's Distribution System,** the **DNO** shall notify all **Users** who are or may be affected.

DOC9.6.4 Following notification by a **User** of an **Event**, the **DNO** will if it considers necessary, telephone the **User** on the telephone number referred to in DOC9.6.2 to obtain such additional information as it requires.

DOC9.6.5 Following notification of an **Event** in accordance with DOC9.6.3(a) or (b), and/or the receipt of any additional information requested pursuant to DOC9.6.4, the **DNO** will determine whether or not the **Event** is a **Joint System Incident**, and, if so, the **DNO** may set up a **System Incident Centre** in order to avoid overloading existing operational arrangements of the **DNO**.

DOC9.6.6 The **DNO** shall as soon as possible notify all relevant **Users** that a **System Incident Centre** has been established and the telephone number(s) of the **DNO's System Incident Centre** if different from those already supplied pursuant to DOC9.6.2.

DOC9.6.7 All communications between the responsible management representatives of the relevant parties with regard to the **DNO's** role in the **Joint System Incident** shall be made via the **System Incident Centre**, if it has been established.

DOC9.7 **Civil Emergencies**

DOC9.7.1 Directions under Section 96 of the **Act** place an obligation on the **DNO** to prepare and maintain plans for mitigating the effects of any civil emergency which may occur in accordance with the Electricity Supply Emergency Code. That Code describes the steps which Government might take to deal with an electricity supply emergency envisaged under Section 96(7) of the **Act** or Section 3(i)(b) of the Energy Act 1976 and sets down the actions which Companies in the Electricity Supply Industry should plan to take and which may be needed or required in order to deal with such an emergency.

DOC9.7.2 In an electricity emergency it may become necessary to restrict **Users' Demand** for and consumption of electricity and may be achieved by one or more of the following methods:

(a) Appeals by the Government to the public for voluntary restraint.

(b) The issue of Orders under the Energy Act 1976 requiring restrictions on consumption by industry and commerce.

(c) The issue of directions under the Energy Act 1976 requiring rota disconnections and associated restrictions.

DOC9.7.3 In the event that the **Secretary of State** issues directions to the **DNO** to implement rota disconnections, the **DNO** will establish an Emergency Co-ordinating Centre and as soon as possible establish communications with such relevant **Users** as is necessary to ensure operational liaison. The plans to be implemented will be similar or separate from the schemes outlined in **Distribution Operating Code,** DOC6.

DOC9.7.4 The plans make provision for the need to maintain supply, so far as practicable, to consumers in protected categories. For the purpose of the **Distribution Code** Nuclear **Generating Plant** shall be deemed to be a protected category in accordance with the provisions of DOC6.1.4.

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DOC10 OPERATIONAL EVENT REPORTING AND INFORMATION SUPPLY

DOC10.1 Introduction

DOC10.1.1 This **Distribution Operating Code** DOC10 sets out the requirements for reporting in writing and, where appropriate, more fully those **Events** termed **Significant Incidents** which were initially reported under **Distribution Operating Code** DOC7 and those statutory specified events to be reported under the **ESQCR**.

Information between a **DNO** and **Users** will be exchanged on the reasonable request of either party.

DOC10.1.2 DOC10 also provides for the joint investigation of **Significant Incidents** by the **Users** involved.

DOC10.2 Objectives

The objective of this **Distribution Operating Code** is to facilitate the provision of more detailed information in writing and, where agreed between the **DNO** and the **Users** involved, joint investigation of those **Significant Incidents** initially reported under DOC7.

DOC10.3 Scope

This Distribution Operating Code DOC10 applies to the **DNO** and to Users, which in this Distribution Operating Code means:-

(a) **High Voltage Customers.**

(b) **Embedded Generators** connected to the **DNO's Distribution System** at **HV**.

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System** at **HV.**

(d) Suppliers on behalf of their **Customers** where appropriate.

DOC10.4 Communications

DOC10.4.1. The **DNO** and **Users** connected to the **DNO's Distribution System** shall establish communication channels to ensure the effectiveness of this **Distribution Operating Code**. Communication should, as far as possible, be direct between the **User** and the operator of the network to which that **User** is connected. However, this does not preclude communication with the **User's** nominated representative.

DOC10.4.2 **Operational Event Reporting**

DOC10.4.2.1 **Written Reports of Events by Users to the DNO**

In the case of an **Event** which has been reported initially to the **DNO** under DOC7.6 and subsequently has been determined by the **DNO** to be a **Significant Incident**, a written report will be given to the **DNO** by the **User** in accordance with DOC10. The **DNO** will not pass this report on to other affected **Users** but may use the information contained therein in preparing a report under DOC10 to a **User** in relation to a **Significant Incident** on the **DNO's Distribution System** which has been caused by (or exacerbated by) the **Significant Incident** on the **User's System**.

DOC10.4.2.2 **Written Reports of Events by the DNO to Users**

In the case of an **Event** which has been reported initially to the **User** under DOC7.6 and subsequently has been determined by the **User** to be a **Significant Incident**, a written report will be given to the **User** by the **DNO** in accordance with DOC10. The **User** will not pass this report on to other affected **Users** but may use the information contained therein in preparing a report for another **Authorised Electricity Operator** connected to its **System** in relation to a **Significant Incident** which has been caused by (or exacerbated) the **Significant Incident** on the **DNO's Distribution System**.

DOC10.4.3 **Form of Report in Writing**

DOC10.4.3.1 A report under DOC10.4.2 will be in writing and shall be sent to the **DNO** or **User**, as the case may be, containing written confirmation of the initial notification given under DOC7 together with more details relating to the **Significant Incident**, although it need not state the cause of the **Event** save to the extent required under DOC7.6.2 and such further information which has become known relating to the **Significant Incident** since the initial notification under DOC7. The report should, as a minimum, contain those matters specified in the Appendix 1 of this DOC10 which is not intended to be exhaustive to this DOC10. The recipient may raise questions to clarify the notification, and the giver of the notification will, in so far as it is able, answer any questions raised.

DOC10.4.4 **Timing of the Report in Writing**

DOC10.4.4.1 A written report under DOC10.4.2 shall be given as soon as reasonably practicable after the initial notification under DOC7 and in any event a preliminary report shall normally be given within 24 hours of such time.

DOC10.4.5 **Statutory Reports of Specified Events**

DOC10.4.5.1 Nothing in this **Distribution Operating Code** shall be construed as relieving **DNOs** or **Users** from their duty to report events specified in the **ESQCR** in accordance with those **Regulations** in so far as they apply to **Users**.

DOC10.4.6 **Joint Investigation into Significant Incidents**

DOC10.4.6.1 Where a **Significant Incident** has been declared and a report submitted under DOC10 either party or parties may request in writing that a joint investigation be carried out.

DOC10.4.6.2 The composition of such an investigation panel will be appropriate to the incident to be investigated, and agreed by all parties involved.

DOC10.4.6.3 Where there has been a series of **Significant Incidents** (that is to say, where a **Significant Incident** has caused or exacerbated another **Significant Incident**) the parties involved may agree that the joint investigation should include some or all of those **Significant Incidents**.

DOC10.4.6.4 A joint investigation will only take place where all affected parties agree to it. The form and rules of, the procedure for, and all matters (including, if thought appropriate, provisions for costs and for a party to withdraw from the joint investigations once it has begun) relating to the joint investigation will be agreed at the time of a joint investigation and in the absence of agreement the joint investigation will not take place.

DOC10.4.6.5 Any joint investigation under **DOC10** is separate from any inquiry which may be carried out under the **Electricity Supply Industry (ESI)** disputes resolution procedure.

DISTRIBUTION OPERATING CODE 10

DOC 10 - APPENDIX 1

MATTERS, IF APPLICABLE TO THE SIGNIFICANT INCIDENT, TO BE INCLUDED IN A WRITTEN REPORT GIVEN IN ACCORDANCE WITH DOC10.4.2.

1. Time and date of **Significant Incident**.
2. Location.
3. **Plant** and/or **Apparatus** involved.
4. Brief description of **Significant Incident**.
5 Estimated time and date of return to service.
6 Supplies/generation interrupted and duration of interruption.
7 Set/Station frequency response achieved.
8 Set/Station MVAr performance achieved.
9 Ownership of the faulted **Plant** and/or **Apparatus**.
10 Estimated **Demand Control** relief undertaken.
11 Estimated **Demand** shed Automatic/Manual.
12 Time and date of **Demand** restoration.

DISTRIBUTION OPERATING CODE 11

DOC11 NUMBERING AND NOMENCLATURE OF ELECTRICAL APPARATUS AT OWNERSHIP BOUNDARIES

DOC11.1 **Introduction**

DOC11.1.1 This **Distribution Operating Code** DOC11 sets out the responsibilities and procedures for notifying the relevant owners of the numbering and nomenclature of **Apparatus** at **Ownership Boundaries**.

DOC11.1.2 The numbering and nomenclature of **Apparatus** shall be included in the **Operation Diagram** prepared for each site having an **Ownership Boundary**.

DOC11.2 **Objectives**

The prime objective embodied in this **Distribution Operating Code** is to ensure that at any site where there is an **Ownership Boundary** every item of **Apparatus** has numbering and/or nomenclature that has been mutually agreed and notified between the owners concerned to ensure, so far as is reasonably practicable the safe and effective **Operation** of the **Systems** involved and to reduce the risk of error.

DOC11.3 **Scope**

This **Distribution Operating Code DOC11** applies to the **DNO** and to **Users**, which in this **Distribution Operating Code** excludes **Users** connected **at Low Voltage** without **Generation** and protected by a fuse(s) or other device(s) rated at 100 amps or less, (except it may apply to such **Users** who are the sole **User** connected to an **HV/LV** transformer.), and otherwise includes:

(a) **Customers**.

(b) **Embedded Generators,** but excluding the **OTSO.**

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System.**

(d) **Meter Operators**.

DOC11.4 **Procedure**

DOC11.4.1 **New Apparatus**

DOC11.4.1.1 When the **DNO** or a **User** intends to install **Apparatus** having an interface at an **Ownership Boundary** the proposed numbering and/or nomenclature to be adopted for the **Apparatus** must be notified to the other owner(s).

DOC11.4.1.2 The notification shall be made in writing to the relevant owner(s) and will consist of **Operation Diagrams** incorporating the proposed new **Apparatus** to be installed and its proposed numbering and/or nomenclature.

DOC11.4.1.3 The notification shall be made to the relevant owner(s) at least eight months prior to the proposed installation of the **Apparatus**.

DOC11.4.1.4 The relevant owners shall respond in writing within one month of the receipt of the notification confirming both receipt and whether the proposed numbering and/or nomenclature is acceptable or, if not, what would be acceptable.

DOC11.4.1.5 In the event that agreement cannot be reached between the **DNO**, and the other owner(s), the **DNO**, acting reasonably, shall have the right to determine the numbering and nomenclature to be applied at that site.

DOC11.4.2 **Existing Apparatus**

DOC11.4.2.1 The **DNO** and/or every **User** shall supply the **DNO** and/or every other **User** on request with details of the numbering and nomenclature of **Apparatus** on sites having an **Ownership Boundary**.

DOC11.4.2.2 The **DNO** and every **User** shall be responsible for the provision and erection of clear and unambiguous labelling showing the numbering and nomenclature of its **Apparatus** on sites having an **Ownership Boundary.**

DOC11.4.3 **Changes to Existing Apparatus**

DOC11.4.3.1 Where the **DNO** or a **User** needs or wishes to change the existing numbering and/or nomenclature of any of its **Apparatus** on any site having **Ownership Boundary**, the provisions of DOC11.4.1 shall apply with any amendments necessary to reflect that only a change is being made.

DOC11.4.3.2 Where a **User** changes the numbering and/or nomenclature of its **Apparatus**, which is the subject of **DOC11**, the **User** will be responsible for the provision and erection of clear and unambiguous labelling.

DOC11.4.3.3 Where a **DNO** changes the numbering and/or nomenclature of its **Apparatus**, which is the subject of **DOC11**, the **DNO** will be responsible for the provision and erection of clear and unambiguous labelling.

DISTRIBUTION OPERATING CODE (DOC)

DISTRIBUTION OPERATING CODE 12

DOC12 SYSTEM TEST

DOC12.1 **Introduction**

DOC12.1.1 This **Distribution Operating Code** DOC12 sets out the responsibilities and procedures for arranging and carrying out **System Test** which have or may have an effect on the **Systems** of the **DNO** or **Users**. **System Test** are those tests which involve either simulating conditions or the controlled application of irregular, unusual or extreme conditions on the **Total System** or any part of the **Total System**, but do not include commissioning or recommissioning tests or any other tests of a minor nature.

DOC12.1.2 **System Test** which have a minimal effect on the **Distribution System** of the **DNO** or the **Systems** of others will not be subject to this procedure; minimal effect will be taken to mean variations in voltage, **Frequency** and waveform distortion of a value not greater than those figures which are defined in the **Distribution Planning and Connection Code**.

DOC12.1.3 If the **System Test** proposed by the **DNO** or **User** connected to the **DNO's Distribution System** will or may have an effect on the **National Electricity Transmission System** then the provisions of the **Grid Code** shall apply.

DOC12.1.4 A **System Test** proposed by **NGC** under the **Grid Code** will be treated by the **DNO** as a **System Test** under this DOC 12 if it is considered by the **DNO** to have any effect on **Users** as defined in DOC 12.3.1.

DOC12.2 **Objectives**

DOC12.2.1 The objectives of this **Distribution Operating Code** are to:-

(a) Ensure that the procedures for arranging and carrying out of **System Test** do not so far as practicable, threaten the safety of either personnel or the general public and cause minimum threat to the security of supplies, the integrity of **Plant** and/or **Apparatus** and cause minimum detriment to the **DNO** and **Users**.

(b) Set out procedures to be followed for establishing and reporting **System Test**.

DOC12.3 **Scope**

DOC12.3.1 This **Distribution Operating Code** applies to the **DNO** and to **Users**, which in this **Distribution Operating Code** means:-

(a) **High Voltage Customers.**

(b) **Embedded Generators** connected to the **DNO's Distribution System** at **HV.**

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System** at **HV**.

DOC12.4 **Procedure**

DOC12.4.1 **Proposal Notice**

DOC12.4.1.1 When the **DNO** or a **User** intends to undertake a **System Test** which will have or may have an effect on the **System** of others normally six months notice, or as otherwise agreed by the **DNO**, of the proposed **System Test** will be given by the person proposing the **System Test** (the **"**Test Proposer**"**) to the **DNO** and to those **Users** who may be affected by such a **System Test.**

DOC12.4.1.2 The proposal shall be in writing (the "Proposal Notice") and shall contain details of the nature and purpose of the proposed **System Test** and will indicate the extent and situation of the **Plant** or **Apparatus** involved.

DOC12.4.1.3 If in the view of the recipients the information set out in the Proposal Notice is considered insufficient by the recipients they shall as soon as is reasonably practicable contact the Test Proposer with a request in writing for further information which shall be supplied as soon as reasonably practicable. The **DNO** shall not be required to do anything under this **Distribution Operating Code** until it is satisfied with the details supplied in the Proposal Notice or pursuant to a request for further information.

DOC12.4.1.4 If the **DNO** wishes to undertake a **System Test** the **DNO** shall be deemed to have received a proposal of that **System Test**.

DOC12.4.2 **Preliminary Notice and Establishment of Test Panel**

DOC12.4.2.1 The **DNO** shall have overall co-ordination of the **System Test**. Using the information supplied to it under DOC12.4.1 the **DNO** shall determine in its reasonable estimation, which **Users** other than the Test Proposer may be affected by the proposed **System Test**.

DOC12.4.2.2 The **DNO** shall, with the agreement of the **Users** which it has identified may be affected, appoint a **Test Coordinator** as soon as reasonably practicable after it has received a Proposal Notice and in any event prior to the distribution of the Preliminary Notice referred to below.

(a) Where the **DNO** decides that the **DNO's Distribution System** will or may be significantly affected by the proposed **System Test**, then the **Test Coordinator** shall be a suitably qualified person nominated by the **DNO**.

(b) Where **the DNO** decides that the **DNO's Distribution System** will not be significantly affected by the proposed **System Test,** then the **Test Coordinator** shall be a suitably qualified person nominated by the proposer of the **System Test**, in consultation with the **DNO**.

(c) The **DNO** shall as soon as reasonably practicable after it has received a Proposal Notice contact the Test Proposer where the **Test Coordinator** is to be (pursuant to this **Distribution Operating Code**) a person nominated by the Test Proposer and invite him to nominate a person. If the Test Proposer is unable or unwilling to nominate a person within seven days of being contacted by the **DNO** then the proposed **System Test** will not take place.

DOC12.4.2.3 The **DNO** will notify all **Users** identified by it under DOC12.4.2.1 in writing of the proposed **System Test** which in this **Distribution Operating Code** shall be known as a Preliminary Notice. The Preliminary Notice will contain:

(a) The details of the nature and purpose of the proposed **System Test,** the extent and situation of the **Plant** and/or **Apparatus** involved and the **Users** involved.

(b) An invitation to nominate within fourteen days a suitably qualified representative (or representatives if the **Test Coordinator** informs the **DNO** that it is appropriate for a particular **User**) to be a member of a **Test Panel** for the proposed **System Test**.

(c) The name of the **DNO** representative (or representatives) on the **Test Panel** for the proposed **System Test**.

(d) The name of the **Test Coordinator** and whether he was nominated by the proposer of the **System Test** or by the **DNO**.

DOC12.4.2.4 The Preliminary Notice shall be sent within one month of the receipt by the **DNO** of the Proposal Notice or the receipt of any further information requested under DOC12.4.13, whichever is the later. Where the **DNO** is the Test Proposer the Preliminary Notice will be sent as soon as possible after the proposed **System Test** has been formulated.

DOC12.4.2.5 If replies to the invitation in the Preliminary Notice to nominate a representative to be a member of the **Test Panel** have not been received within fourteen days, the **User** which has not replied shall not be entitled to be represented on the **Test Panel**.

DOC12.4.2.6 The **DNO** shall as soon as possible after the expiry of that fourteen day period appoint nominated persons to the **Test Panel** and notify all relevant **Users -** of the composition of the **Test Panel**.

DOC12.4.3 **Test Panel**

DOC12.4.3.1 A meeting of the **Test Panel** shall take place as soon as possible after the **DNO** has notified relevant **Users** of the composition of the **Test Panel**, and in any event within one month of the appointment of the **Test Panel**.

DOC12.4.3.2 The **Test Panel** shall consider:-

(a) The details of the nature and purpose of the proposed **System Test** and other matters set out in the Proposal Notice (together with any further information requested under DOC12.4.2).

(b) The economic, operational and risk implications of the proposed **System Test**.

(c) The possibility of combining the proposed **System Test** with any other tests and with **Plant** and/or **Apparatus** outages which arise pursuant to the **Operational Planning** requirements of the **DNO**, **NGC** and **Users.**

(d) The implications of the proposed **System Test** on plant which comprise or contain **BM Units** which are active (ie. submitting bid-offer data) in the **Balancing Mechanism** insofar as it is able to do so.

DOC12.4.3.3 **Users** who received a Preliminary Notice concerning the proposed **System Test** (whether or not they are represented on the **Test Panel**) shall be obliged to supply that **Test Panel** upon written request with such details as the **Test Panel** reasonably requires in order to consider the proposed **System Test**.

DOC12.4.3.4 The **Test Panel** will meet as often as the **Test Co-ordinator** deems necessary to conduct its business and he shall be the person to convene a meeting.

DOC12.4.4 **Proposal Report**

(a) DOC12.4.4.1 Within two months of the first meeting, the **Test Panel** shall submit a report, which in this **Distribution Operating Code** shall be called a Proposal Report, which shall contain: **System Test** (including the manner in which the **System Test** is to be monitored).

(b) An allocation of costs (including unanticipated costs) between the affected parties, (the general principle being that the Test Proposer will bear the costs).

(c) Such other matters as the **Test Panel** consider appropriate.

The Proposal Report may include requirements for indemnities to be given in respect of claims and losses arising from the **System Test**. All **System Test** procedures must comply with all applicable legislation.

DOC12.4.4.2 If the **Test Panel** is unable unanimously to agree on any decision in preparing its Proposal Report the proposed **System Test** shall not take place and the **Test Panel** will be dissolved.

DOC12.4.4.3 The Proposal Report will be submitted to the **DNO** and to each **User** who received a Preliminary Notice under DOC12.4.2.

DOC12.4.4.4 Within fourteen days of receipt of the Proposal Report, each recipient shall respond to the **Test Coordinator** with its approval of the Proposal Report or its reason for non-approval.

DOC12.4.4.5 In the event of non-approval by one or more recipients, the **Test Panel** shall as soon as practicable meet in order to determine whether the proposed **System Test** can be modified to meet the objection or objections.

DOC12.4.4.6 If the proposed **System Test** cannot be so modified, then the **System Test** will not take place.

DOC12.4.4.7 If the proposed **System Test** can be so modified, the **Test Panel** shall as soon as practicable, and in any event within one month of meeting to discuss the responses to the Proposal Report, submit a revised Proposal Report and the provisions of DOC12.4.4.3 and DOC12.4.4.4 will apply to that submission.

DOC12.4.4.8 In the event of non-approval of the revised Proposal Report by one or more recipients, the **System Test** will not take place and the **Test Panel** will be dissolved.

DOC12.4.5 **Final Test Programme**

DOC12.4.5.1 If the Proposal Report (or, as the case may be, the revised Proposal Report) is approved by all recipients, the proposed **System Test** can proceed and at least one month prior to the date of the proposed **System Test**, the **Test Panel** shall submit to the **DNO** and all recipients of the Proposal Notice a programme which in this **Distribution Operating Code** shall be called a "Final Test Programme" stating the switching sequence and proposed timings, a list of those staff involved in the carrying out of the **System Test** (including those responsible for site safety) and such other matters as the **Test Panel** deem appropriate.

DOC12.4.5.2 The Final Test Programme shall bind all recipients to act in accordance with the provisions contained within the programme in relation to the proposed **System Test**.

DOC12.4.5.3 Any problems with the proposed **System Test** which arise or are anticipated after the issue of the Final Test Programme and prior to the day of the proposed **System Test** must be notified to the **Test Coordinator** as soon as possible in writing. If the **Test Coordinator** decides that these anticipated problems merit an amendment to or postponement of the **System Test**, he shall notify any party involved in the proposed **System Test** accordingly.

DOC12.4.5.4 If on the day of the proposed **System Test** operating conditions on the **System** are such that any party involved in the proposed **System Test** wishes to delay or cancel the start or continuance of the **System Test**, they shall immediately inform the **Test Coordinator** of this decision and the reasons for it. The **Test Coordinator** shall then postpone or cancel, as the case may be, the **System Test** and shall if possible, agree with all parties involved in the proposed **System Test** another suitable time and date or if he cannot reach such agreement, shall reconvene the **Test Panel** as soon as practicable which will endeavour to arrange another suitable time and date and the relevant provisions of the **Distribution Operating Code** shall apply.

DOC12.4.6 **Final Report**

DOC12.4.6.1 At the conclusion of the **System Test**, the Test Proposer shall be responsible for preparing a written report (the "Final Report") of the **System Test** for submission to the **DNO** and other members of the **Test Panel**.

DOC12.4.6.2 The Final Report shall include a description of the **Plant** and/or **Apparatus** tested and of the **System Test** carried out, together with the results, conclusions and recommendations for submission to other members of the **Test Panel**.

DOC12.4.6.3 The Final Report shall not be distributed to any party which is not represented on the **Test Panel** unless the **Test Panel**, having considered the confidentiality issues, shall have unanimously approved such distribution.

DOC12.4.6.4 When the Final Report has been submitted under DOC12.4.2.1 the **Test Panel** shall be dissolved.

DISTRIBUTION DATA REGISTRATION CODE **(DDRC)**

DDRC1 INTRODUCTION

DDRC1.1 The various sections of the **Distribution Code** require the **DNO** and **Users** to exchange and update data from time to time. The data which is specified in each section of the **Distribution Code** is summarised in the **Distribution Data Registration Code (DDRC)**.

DDRC1.2 The **Distribution Data Registration Code ("DDRC")** provides a series of schedules summarising all requirements for information of a particular type. Each class of **User** is then referred to the appropriate schedule or group of schedules for a statement of the total data requirements in his case.

DDRC1.3 The **DDRC** specifies procedures and timings for the supply of data and subsequent updating, where the timings are covered by detailed timetables laid down in other sections of the **Distribution Code** they are not necessarily repeated in full in the **DDRC**.

DDRC1.4 In the case of an **Embedded Generator** seeking a connection to the **DNO's Distribution System** then irrespective of its potential involvement in the **Balancing Mechanism,** discussions on connection will be with the **DNO** concerned with the connection arrangements, in addition to any discussions required with **NGC** under the **Grid Code**. References to "**Embedded Generator**" in the DDRC shall include existing and prospective **Embedded Generators**.

DDRC2 OBJECTIVE

The objective of the **DDRC** is to collate and list in a readily identifiable form all the data to be provided by:

(a) Each category of **User** to the **DNO** under the **Distribution Code**.

(b) The **DNO** to each category of **User** under the **Distribution Code.**

DDRC3 SCOPE

The **DDRC** will apply to the **DNO** and to all **Users** which for the purpose of the **DDRC** are listed below:

(a) **Customers** It is not intended that the **Distribution Code** shall generally apply to small **Customers** individually; their obligations will be dealt with on their behalf by their **Supplier**.

(b) **Embedded Generators**.

(c) **Other Authorised Distributors** connected to the **DNO's Distribution System.**

(d) **Suppliers**

(e) Any other person who is making application for use of or connection to the **DNO's Distribution System**.

DDRC4 DATA CATEGORIES

DDRC4.1 **Categories of Data**

Within the **DDRC** the data required by the **DNO** is allocated to one of the following three categories:

(a) **Standard Planning Data (SPD)**

(b) **Detailed Planning Data (DPD)**

(c) **Operational Data (OD)**

DDRC4.2 **Standard Planning Data (SPD)**

DDRC4.2.1 **Standard Planning Data** is that data listed in the **Distribution Planning and Connection Code** which is required to be supplied by all **Users** when making application for connection to and/or use of the **DNO's Distribution System** in order that the **DNO** may assess the implications for making the connection.

DDRC4.2.2 **Standard Planning Data** will be provided to the **DNO** in accordance with Section DPC6 and DPC7 of the **Distribution Planning and Connection Code**.

DDRC4.2.3 Following an agreement for connection/use of **System**, it is a requirement of the **Distribution Planning and Connection Code** that estimated data supplied by **Users** should be replaced by actual values prior to connection which will be referred to as **Registered Data.**

DDRC4.3 **Detailed Planning Data (DPD)**

DDRC4.3.1 **Detailed Planning Data** is that data listed in the **Distribution Planning and Connection Code** which is required to be supplied by the **Users** specified for connection to and/or use of the **DNO's Distribution System**.

DDRC4.3.2 **Detailed Planning Data** will be provided to the **DNO** in accordance with Section DPC6 and DPC7 of the **Distribution Planning and Connection Code**.

DDRC4.3.3 Following an agreement for connection/use of **System**, it is a requirement of the **Distribution Planning and Connection Code** that estimated data supplied by **Users** should be replaced by measured values prior to connection.

DDRC4.4 **Operational Data (OD)**

DDRC4.4.1 **Operational Data** is data, which is required by the **Distribution Operating Codes**.

DDRC4.4.2 **Operational Data** is required to be supplied in accordance with timetables set down in the relevant **Distribution Operating Codes** and is repeated in tabular form in the schedules attached to this **DDRC**.

DDRC5 PROCEDURES AND RESPONSIBILITIES

DDRC5.1 **Responsibility for Submission and Updating of Data**

In accordance with the provisions of the various sections of the **Distribution Code** and unless otherwise agreed or specified by the **DNO,** each **User** is required to submit data as defined in DDRC6 following and the attached schedules.

DDRC5.2 **Methods of Submitting Data**

DDRC5.2.1 Data must be submitted to the **DNO** in writing and where possible in the format specified by the **DNO** and must indicate the name of the person who is submitting those schedules.

DDRC5.2.2 If a **User** wishes to change any data item then this must first be discussed with the **DNO** concerned in order for the implications to be considered and the change if agreed (such agreement not to be unreasonably withheld), should be confirmed by the submission of a revised data scheduler by verbal means with confirmation in writing if short timescales are involved.

DDRC5.2.3 The **DNO** will supply data as requested by **Users** and as agreed by the **DNO** where no obligation of confidentiality exists.

DDRC5.3 **Changes to User's Data**

Whenever a **User** becomes aware of a change to an item of data, which is registered with the **DNO** the **User**, must notify the **DNO** in accordance with the appropriate section of the **Distribution Code**. The method and timing of the notification to the **DNO** is set out in the appropriate section of the **Distribution Code**.

DDRC5.4 **Data Accuracy and Data not Supplied**

DDRC5.4.1 The **User** is solely responsible for the accuracy of data (or of changes to data) supplied to the **DNO**.

DDRC5.4.2 Any data which the **User** fails to supply when required by any section of the **Distribution Code** may be estimated by the **DNO** if and when, in the **DNO's** view, it is necessary to do so. Such estimates will be based upon data supplied previously for the same **Plant** or **Apparatus** or upon corresponding data for similar **Plant** or **Apparatus** or upon such other information as the **DNO** deems appropriate.

DDRC5.4.3 The **DNO** will advise a **User** in writing of any estimated data it intends to use pursuant to DDRC5.4.2 relating directly to that **User's Plant** or **Apparatus** in the event of data not being supplied. The **DNO** will not be liable as a result of using that estimated data; the responsibility for the accuracy of that data will rest with the **User** as if the data has been supplied by that **User**.

DDRC5.4.4 It is a requirement of the **Distribution Planning and Connection Code** that Registered Project Planning Data is updated by the **User** annually.

DDRC6 DATA TO BE REGISTERED

DDRC6.1 Schedules 1-4 are not used within the **Distribution Code**.

DDRC6.2 Schedules 5a, 5b and 5c - **Embedded Generating Plant** Technical Information.

DDRC6.3 Schedule 5e - **Embedded Transmission System**

DDRC6.4 Schedule 6 - **Demand** forecasts - as described in DOC1, time varying output/generation forecasts for the **Users** defined in the scope.

DDRC6.5 Schedule 7 - **Operational Planning** - as described in **DOC2**, outage planning information.

DDRC6.6 Schedule 8 - **System** Design Information - comprising **System** technical data.

DDRC6.7 Schedule 9 - Load Characteristics - comprising the forecast data for load points indicating for example, the maximum load, the equipment that comprises the load, and the harmonic content of the load.

DDRC6.8 The schedules applicable to each class of **User** are as follows:-

Schedule Number:-	**Title**	**Applicable to:-**
Schedule 5a	**Power Station Data**	All **Power Stations**
Schedule 5b	**Generation Set Data**	All **Embedded Generation Sets**
Schedule 5c	**Generation Set Data**	For specified types of **Generation Set** and ancillary **Plant and Apparatus** (i) Synchronous **Generation Set** (ii) Fixed speed induction **Generation Set** (iii) Doubly fed induction **Generation Set** (iv) Series Converter Connected **Generation Set** (v) Transformers
Schedule 5d	**DNO** Network Data	**DNO's Distribution System**
Schedule 5e	All **Embedded Transmission System**	All **Embedded Transmission System**
Schedule 6	**Demand** Forecasts	All **Embedded Generators** greater than 1MW; Any **Other Authorised Distributor** connected to the host **DNO System**; All **Suppliers**; All **Customers** connected at **HV**_whose **Demand** is greater than 5MW

Schedule Number:-	**Title**	**Applicable to:-**
Schedule 7a	**Operational Planning**	All **Embedded Generators** greater than 1MW; Any **Other Authorised Distributor** connected to the host **DNO System**; All **Suppliers**; All **Customers** connected at **HV**_whose **Demand** is greater than 5MW
Schedule 8 Schedule 9	**System** Design Information and Load Characteristics	**Embedded Generators**; Any **Other Authorised Distributor** connected to the host **DNO's Distribution System**; All **Suppliers**; All **Customers**

Schedule 5a

DATA REGISTRATION CODE

POWER STATION DATA FOR ALL EMBEDDED POWER STATIONS EXCLUDING THE OTSO

DATA DESCRIPTION **5a Power Station Data**	**UNITS**	**DATA CATEGORY**
APPLICANT'S DETAILS		
Customer's Details		
Company name	Text	**SPD**
Company registered number	Text	**SPD**
Postal address	Text	**SPD**
Contact name	Text	**SPD**
Email address	Text	**SPD**
Telephone number	Text	**SPD**
Facsimile number	Text	**SPD**
Consultant's Details (if applicable)		
Consultant's name	Text	**SPD**
Postal address	Text	**SPD**
Contact name	Text	**SPD**
Email address	Text	**SPD**
Telephone number	Text	**SPD**
Facsimile number	Text	**SPD**
POWER STATION LOCATION AND OPERATION		
Power Station name	Text	**SPD**
Details of any existing **Connection Agreements** for this **Power Station**	Text	**SPD**
Target date for the provision of the connection / commissioning of the **Power Station**	Text	**SPD**
Postal address or site boundary plan (1/500)	Text / Plan	**SPD**
Connection Point (OS grid reference or description)	Text	**SPD**
Connection Point voltage	V	**SPD**
Single line diagram of any on-site existing or proposed electrical plant or, where available, **Operation Diagrams**	Diagram	**SPD**
What security is required for the connection? (see note 1)	Text	**SPD**
Number of **Generation Sets** in **Power Station**	Number	**SPD**

DATA DESCRIPTION **5a Power Station Data**	**UNITS**	**DATA CATEGORY**
Are all **Generation Sets** of the same design/rating? (If not complete the relevant Schedules 5b and 5c for each type)	Y/N	**SPD**
Will the **Power Station** operate in islanded mode?	Y/N	**SPD**
Will **Generating Plant** supply electricity to on-site premises?	Y/N	**SPD**
POWER STATION STANDBY IMPORT REQUIREMENTS (see note 2)		
Maximum **Active Power** import	MW	**SPD**
Maximum **Reactive Power** import (lagging)	MVAr	**SPD**
Maximum **Reactive Power** export (leading)	MVAr	**SPD**
POWER STATION TOP-UP IMPORT REQUIREMENTS (see note 3)		
Maximum **Active Power** import	MW	**SPD**
Maximum **Reactive Power** import (lagging)	MVAr	**SPD**
Maximum **Reactive Power** export (leading)	MVAr	**SPD**
POWER STATION EXPORT REQUIREMENTS **(see note 4)**		
Total **Power Station** output at **Registered Capacity** (net of auxiliary loads)		
Registered Capacity (maximum **Active Power** export)	MW	**SPD**
Maximum **Reactive Power** export (lagging)	MVAr	**SPD**
Maximum **Reactive Power** import (leading)	MVAr	**SPD**
Total **Power Station** output at **Minimum Generation** (net of auxiliary loads)		
Minimum Generation (minimum **Active Power** export)	MW	**DPD**
Maximum **Reactive Power** export (lagging)	MVAr	**DPD**
Maximum **Reactive Power** import (leading)	MVAr	**DPD**
Power Station performance chart (net, at **Connection Point**, as per DPC7 Figure 1)	Figure	**DPD**
POWER STATION MAXIMUM FAULT CURRENT CONTRIBUTION (see note 5)		
Peak asymmetrical short circuit current at 10ms (i_p) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**
RMS value of the initial symmetrical short circuit current (I_k”) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**
RMS value of the symmetrical short circuit current at 100ms ($I_{k(100)}$) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**

DATA DESCRIPTION **5a Power Station Data**	**UNITS**	**DATA CATEGORY**
Short circuit time constant T”, corresponding to the change from I_k” to $I_{k(100)}$	s	**DPD**
Positive sequence X/R ratio at the instant of fault	-	**DPD**
POWER STATION INTERFACE ARRANGEMENTS (see note 6)		
Means of connection, disconnection and synchronising between **DNO** and **User**	Method statement	**SPD**
Site protection / co-ordination arrangements with DNO	Report	**DPD**
Precautions should neutral become disconnected from earth (LV only see ER G59/3-2~~1~~)	Report	**DPD**
Site communications, control and monitoring (HV / LV)	Report	**DPD**

DATA DESCRIPTION **5a continued**	**Units**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
POWER STATION G59 PROTECTION – see note 7			
U/V Stage 1	V and s	**SPD**	**SPD**
U/V Stage 2	V and s	**SPD**	**SPD**
O/V Stage 1	V and s	**SPD**	**SPD**
O/V Stage 2	V and s	**SPD**	**SPD**
U/F Stage 1	Hz and s	**SPD**	**SPD**
U/F Stage 2	Hz and s	**SPD**	**SPD**
O/F Stage 1	Hz and s	**SPD**	**SPD**
O/F Stage 2	Hz	**SPD**	**SPD**
LoM (RoCoF)	Hzs^{-1} and s	**SPD**	**SPD**
LoM (Vector Shift)	degrees	**SPD**	**SPD**
LoM - other		**SPD**	**SPD**

Notes:

1. The **DNO** will assume a single circuit connection to the **Power Station** is required unless stated otherwise. Options include:-
    a. Single circuit connection
    b. Manually switched alternative connection
    c. Automatic switched alternative connection
    d. Firm connection (secure for first circuit outage)
2. This section relates to operating conditions when the **Power Station** is importing **Active Power**, typically when it is not generating. The maximum **Active Power** import requirement and the associated maximum **Reactive Power** import and/or export requirements should be stated.
3. This section relates to operating conditions when the **Power Station** is importing **Active Power**, typically when it is generating, but is not generating sufficient power to cater for all the on-site demand. The maximum **Active Power** import requirement and the associated maximum **Reactive Power** import and/or export requirements should be stated.
4. This section relates to operating conditions when the **Power Station** is exporting **Active Power**. The **Active Power** export and associated maximum **Reactive Power** range should be stated for operation at **Registered Capacity** and for operation at **Minimum Generation**.
5. See ER G74, ETR 120 and IEC 60909 for guidance on fault current data. Additionally, fault current contribution data may be provided in the form of detailed graphs, waveforms and/or tables. This information need not be provided where detailed fault level contribution / impedance data is provided for each **Generation Set** in Schedules 5b or 5c.
6. The interface arrangements need to be agreed and implemented between the **User** and the **DNO** before energisation and consideration should be given to addressing the Distribution Code requirements including DGC5, DGC8, DPC6.7, DPC7.2.6, DOC5, DOC7.4, DOC8.6.3, DOC8.6.4, DOC9 and DOC10. For example DOC7 requires that up to date contact details are provided and procedures are agreed to establish an effective means of communication between the **Generator** and the **DNO**.
7. This information need not be provided where the G59 interface protection is provided on each individual **Generation Set**. In such cases the information should be provided in Schedule 5b.

Schedule 5b

DATA REGISTRATION CODE

GENERATION SET DATA FOR ALL EMBEDDED GENERATION SETS

DATA DESCRIPTION **5b Generation Set Data**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
GENERATION SET GENERAL DATA			
Number of **Generation Sets** to which this data applies	Value	**SPD**	**SPD**
Type of **Generation Set**: Synchronous Generator, Fixed Speed Induction Generator, Double Fed Induction Generator, Series Convertor Connected Generator, Other (provide details)	Text	**SPD**	**SPD**
Technology/Production type (see note 1)	Text	**SPD**	**SPD**
Operating regime – intermittent or non-intermittent (see note 2)	Text	**SPD**	**SPD**
GENERATION SET OUTPUT DATA			
Rated terminal voltage (generator)	V	**SPD**	**SPD**
Rated terminal current (generator)	A	**SPD**	**SPD**
Generation Set Registered Capacity	MW	**SPD**	**SPD**
Generation Set apparent power rating (to be used as base for generator parameters)	MVA	**SPD**	**SPD**
Generation Set rated **Active Power**	MW	**SPD**	**SPD**
Maximum measured **Active Power** P_{60} (see note 3)	MW	**DPD**	**DPD**
Maximum measured **Active Power** $P_{0.2}$ (see note 3)	MW	**DPD**	**DPD**
Minimum Generation (set connected; net of auxiliary loads)	MW	**DPD**	**DPD**
Generation Set Reactive Power capability at rated **Active Power** (gross, at generator terminals)			
Maximum **Reactive Power** export (lagging)	MVAr	**DPD**	**SPD**
Maximum **Reactive Power** import (leading)	MVAr	**DPD**	**SPD**
Generation Set performance chart (gross, at generator terminals, as per DPC7 Figure 1)	Figure	**DPD**	**DPD**

DATA DESCRIPTION **5b Generation Set Data**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
GENERATION SET MAXIMUM FAULT CURRENT CONTRIBUTION (see note 4)			
Peak asymmetrical short circuit current at 10ms (i_p) for a 3φ short circuit fault at the **Generation Set** terminals	kA	None	**SPD**
RMS value of the initial symmetrical short circuit current (I_k") for a 3φ short circuit fault at the **Generation Set** terminals	kA	None	**SPD**
RMS value of the symmetrical short circuit current at 100ms ($I_{k(100)}$) for a 3φ short circuit fault at the **Generation Set** terminals	kA	**SPD**	**SPD**
Short circuit time constant T", corresponding to the change from I_k" to $I_{k(100)}$	s	None	**DPD**
Positive sequence X/R ratio at the instant of fault	-	None	**DPD**
GENERATION SET VOLTAGE CONTROL			
If operating in **Power Factor** control mode, allowable **Power Factor** range		**SPD**	**SPD**
If operating in **Power Factor** control mode, target **Power Factor**		**SPD**	**SPD**
If operating in voltage control mode, voltage set point	V	**SPD**	**SPD**
If operating to any other control mode, description of parameters and set points.	Text	**SPD**	**SPD**
GENERATION SET INSTALLED G59 PROTECTION (see note 5)			
U/V Stage 1	V and s	**SPD**	**SPD**
U/V Stage 2	V and s	**SPD**	**SPD**
O/V Stage 1	V and s	**SPD**	**SPD**
O/V Stage 2	V and s	**SPD**	**SPD**
U/F Stage 1	Hz and s	**SPD**	**SPD**
U/F Stage 2	Hz and s	**SPD**	**SPD**

DATA DESCRIPTION **5b Generation Set Data**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
O/F Stage 1	Hz and s	**SPD**	**SPD**
O/F Stage 2	Hz	**SPD**	**SPD**
LoM (RoCoF)	Hzs^{-1} and s	**SPD**	**SPD**
LoM (Vector Shift)	degrees	**SPD**	**SPD**
LoM - other	Text	**SPD**	**SPD**

Notes:

1. The Production Type should be quoted for all new connections on or after 1 January 2015 and selected from the list below derived from the Manual of Procedures for the ENTSO-E Central Information Transparency Platform:
   - Biomass;
   - Fossil brown coal/lignite;
   - Fossil coal-derived gas;
   - Fossil gas;
   - Fossil hard coal;
   - Fossil oil;
   - Fossil oil shale;
   - Fossil peat;
   - Geothermal;
   - Hydro pumped storage;
   - Hydro run-of-river and poundage;
   - Hydro water reservoir;
   - Marine;
   - Nuclear;
   - Other renewable;
   - Solar;
   - Waste;
   - Wind offshore;
   - Wind onshore; or
   - Other.

   For connections made before 1 January 2015, the technology type(s) used, selected from the list set out at paragraph 2.23 in Version 2 of the Regulatory Instructions and Guidance relating to the distributed generation incentive, innovation funding incentive and registered power zones, reference 83/07, published by Ofgem, in April 2007, may be submitted as an alternative to the production type.

2. Intermittent and Non-intermittent Generation is defined in ER P2/6 as follows:
    - Intermittent Generation: Generation plant where the energy source for the prime mover can not be made available on demand
    - Non-intermittent Generation: Generation plant where the energy source for the prime mover can be made available on demand
3. For wind turbines only - IEC 61400-21 (P_{60} and $P_{0.2}$)
4. See ER G74, ETR 120 and IEC 60909 for guidance on fault current data. Additionally, fault current contribution data may be provided in the form of detailed graphs, waveforms and/or tables. This information need not be provided where detailed fault level contribution / impedance data is provided for the site in Schedule 5a or for each **Generation Set** in Schedules 5c.
5. This information need not be provided where the G59 interface protection is provided on a per **Power Station** basis. In such cases the information should be provided in Schedule 5a.

Schedule 5c (i)

DATA REGISTRATION CODE

GENERATION SET DATA FOR EMBEDDED GENERATION SETS

DATA DESCRIPTION **5c (i) Synchronous Generation Sets (or Equivalent Synchronous Generation Sets – see note 1)**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
GENERATION SET MODEL DATA			
Generation Set identifier	Text	**SPD**	**SPD**
Type of **Generation Set** (round rotor, salient pole or asynchronous equivalent – see note 1)	Text	**SPD**	**SPD**
Positive sequence (armature) resistance	per unit	**DPD**	**SPD**
Short circuit ratio (see note 2)	Number	**DPD**	**DPD**
Inertia constant (**Generation Set** and Prime Mover)	MWsec/ MVA	**DPD**	**SPD**
Direct axis reactances:			
Sub-transient (X''_d) – unsaturated / saturated	per unit	**SPD / SPD**	**SPD / SPD**
Transient (X'_d) – unsaturated / saturated	per unit	**DPD / DPD**	**SPD / SPD**
Synchronous (X_d) – unsaturated / saturated	per unit	**DPD / DPD**	**SPD / SPD**
Quadrature axis reactances:			
Sub-transient (X''_q) – unsaturated / saturated	per unit	None	**DPD / DPD**
Transient (X'_q) – unsaturated / saturated	per unit	None	**DPD / DPD**
Synchronous (X_q) – unsaturated / saturated	per unit	None	**DPD / DPD**
Time constants:			
State whether time constants are open or short circuit	Text	**DPD**	**SPD**
D-axis sub-transient – unsaturated / saturated	s	**DPD / DPD**	**SPD / SPD**
D-axis transient – unsaturated / saturated	s	**DPD / DPD**	**SPD / SPD**
Q-axis sub-transient – unsaturated / saturated	s	None	**DPD / DPD**
Q-axis transient – unsaturated / saturated	s	None	**DPD / DPD**
Stator leakage reactance (unsaturated)	per unit	None	**DPD**
Zero sequence resistance (earthed star only, including any neutral earthing resistance)	per unit	**DPD**	**DPD**
Zero sequence reactance (earthed star only, including any neutral earthing reactance)	per unit	**DPD**	**DPD**
Negative sequence resistance	per unit	**DPD**	**DPD**
Negative sequence reactance	per unit	**DPD**	**DPD**

DATA DESCRIPTION **5c (i) Synchronous Generation Sets (or Equivalent Synchronous Generation Sets – see note 1)**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
Rated field current	A	**DPD**	**DPD**
Field current open circuit saturation curve (from 50% to 120% of rated terminal voltage)	Graph	**DPD**	**DPD**
Potier reactance (if saturation factor available – see note 3)	per unit	**DPD**	**DPD**
Saturation factor (pu field current to produce 1.2pu terminal voltage on open circuit)	per unit	**DPD**	**DPD**
GENERATION SET MODELS			
Governor and prime mover model (see note 4)	Model	**DPD**	**DPD**
AVR / excitation model (see note 4)	Model	**DPD**	**DPD**

Notes:

1. Asynchronous generators may be represented here by an equivalent synchronous generator data set
2. The short circuit ratio (SCR) of a **Generation Set** is one measure of the performance of a machine under short circuit conditions and is important in determining the unit's stability performance. The reciprocal of the per unit on rating saturated synchronous reactance, Xd(sat), is equal to the SCR.
3. The Potier reactance is only required if the saturation factor is available. The saturation factor is defined as the pu value of field current required to generate 1.2pu stator terminal voltage on open circuit.
4. **SPD** will normally be sufficient, except where the **DNO** considers that the stability and security of the network is at risk. Sufficient **DPD** should then be provided in order to build up a suitable **Generation Set** dynamic model for analysis. Alternatively a 'Black Box' dynamic model of the **Generation Set** may be provided. All models should be suitable for the software analysis package used by the **DNO**.

Schedule 5c (ii)

DATA REGISTRATION CODE

GENERATION SET DATA FOR EMBEDDED GENERATION SETS

DATA DESCRIPTION **5c (ii) Fixed Speed Induction Generation Sets**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
GENERATION SET MODEL DATA (see notes 1 and 2)			
Magnetising reactance	per unit	**DPD**	**SPD**
Stator resistance	per unit	**DPD**	**SPD**
Stator reactance	per unit	**DPD**	**SPD**
Inner cage or running rotor resistance	per unit	**DPD**	**SPD**
Inner cage or running rotor reactance	per unit	**DPD**	**SPD**
Outer cage or standstill rotor resistance	per unit	**DPD**	**SPD**
Outer cage or standstill rotor reactance	per unit	**DPD**	**SPD**
State whether data is inner-outer cage or running-standstill	Text	**DPD**	**SPD**
Number of pole pairs	number	**DPD**	**DPD**
Gearbox ratio	number	**DPD**	**DPD**
Slip at rated output	%	**DPD**	**SPD**
Total effective inertia constant (generator and prime mover)	MWsec/ MVA	**DPD**	**SPD**
Inertia constant of the generator rotor	MWsec/ MVA	**DPD**	**DPD**
Inertia constant of the prime mover rotor	MWsec/ MVA	**DPD**	**DPD**
Equivalent shaft stiffness between the two masses	Nm/ Electrical radian	**DPD**	**DPD**
Describe method of adding star capacitance over operating range (see notes 3 and 4)	Text	**DPD**	**DPD**

DATA DESCRIPTION **5c (ii) Fixed Speed Induction Generation Sets**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
Shunt capacitance connected in parallel at % of rated output Starting 20% 40% 60% 80% 100%	kVAr or Graph	**SPD**	**SPD**
Active Power and **Reactive Power** import during start-up **Active Power** and **Reactive Power** import during switching operations eg '6 to 4 pole' change-over	MW-MVAr / Time Graphs	**SPD** **DPD**	**SPD** **SPD**
Under voltage protection setting & time delay	puV, s	**SPD**	**SPD**
Governor and prime mover model (see note 5)	Model	**DPD**	**DPD**

Notes:

1. Asynchronous generators may be represented by an equivalent synchronous data set
2. The **User** will need to provide the above data for each asynchronous **Generation Set** based on the number of pole sets (ie two data sets for dual speed 4/6 pole machines).
3. LV connected generators may just have a simple fixed capacitor bank.
4. If electronic power factor control (e.g. SVC) is installed, provide details of the operating range and characteristics e.g. pf or MVAr range - operating regime: constant or voltage set-point / slope and response times.
5. **SPD** will normally be sufficient, except where the **DNO** considers that the stability and security of the network is at risk. Sufficient **DPD** should then be provided in order to build up a suitable **Generation Set** dynamic model for analysis. Alternatively a 'Black Box' dynamic model of the **Generation Set** may be provided. All models should be suitable for the software analysis package used by the **DNO**.

Schedule 5c (iii)

DATA REGISTRATION CODE

GENERATION SET DATA FOR EMBEDDED GENERATION SETS

DATA DESCRIPTION **5c (iii) Doubly Fed Induction Generation Sets**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
Generation Set maximum fault current contribution data (see note 1)	Schedule	**SPD**	**SPD**
GENERATION SET MODEL DATA (see note 2)			
Magnetising reactance	per unit	**DPD**	**SPD**
Stator resistance	per unit	**DPD**	**SPD**
Stator reactance	per unit	**DPD**	**SPD**
Running rotor resistance	per unit	**DPD**	**SPD**
Running rotor reactance	per unit	**DPD**	**SPD**
Standstill rotor resistance	per unit	**DPD**	**SPD**
Standstill rotor reactance	per unit	**DPD**	**SPD**
Rotor current limit	A	**DPD**	**DPD**
Number of pole pairs	number	**DPD**	**DPD**
Gearbox ratio	number	**DPD**	**DPD**
Generator rotor speed range (minimum to rated speed)	rpm	**DPD**	**SPD**
Electrical power output versus generator rotor speed	Graph / Table	**DPD**	**DPD**
Total effective inertia constant (generator and prime mover) at rated speed	MWsec/ MVA	**DPD**	**SPD**
Inertia constant of the generator rotor at rated speed	MWsec/ MVA	**DPD**	**DPD**
Inertia constant of the prime mover rotor at rated speed	MWsec/ MVA	**DPD**	**DPD**
Equivalent shaft stiffness between the two masses	Nm/ Electrical radian	**DPD**	**DPD**
DFIG unit models including excitation and prime mover control systems (see note 2)	Models	**DPD**	**DPD**

Notes:

1. Fault current contribution data should be provided under Schedule 5b.

2. **SPD** will normally be sufficient, except where the **DNO** considers that the stability and security of the network is at risk. Sufficient **DPD** should then be provided in order to build up a suitable **Generation Set** dynamic model for analysis. Alternatively a ‘Black Box’ dynamic model of the **Generation Set** may be provided. All models should be suitable for the software analysis package used by the **DNO**.

Schedule 5c (iv)

DATA REGISTRATION CODE

GENERATION SET DATA FOR EMBEDDED GENERATION SETS

DATA DESCRIPTION **5c (iv) Series Converter Connected Generation Sets**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
Generation Set maximum fault current contribution data (see note 1)	Schedule	**SPD**	**SPD**
GENERATION SET MODEL DATA (see note 2)			
Gearbox ratio	number	**DPD**	**DPD**
Generator rotor speed range (minimum to rated speed)	rpm	**DPD**	**SPD**
Electrical power output versus generator rotor speed	Graph / Table	**DPD**	**DPD**
Total effective inertia constant (generator and prime mover)	MWsec/ MVA	**DPD**	**SPD**
Inertia constant of the generator rotor at rated speed	MWsec/ MVA	**DPD**	**DPD**
Inertia constant of the prime mover rotor at rated speed	MWsec/ MVA	**DPD**	**DPD**
Equivalent shaft stiffness between the two masses	Nm/ Electrical radian	**DPD**	**DPD**
SCCG unit models including excitation, voltage/**Reactive Power** and prime mover control systems (see note 2)	Models	**DPD**	**DPD**

Notes:

1. Fault current contribution data should be provided under Schedule 5b.
2. **SPD** will normally be sufficient, except where the **DNO** considers that the stability and security of the network is at risk. Sufficient **DPD** should then be provided in order to build up a suitable **Generation Set** dynamic model for analysis. Alternatively a 'Black Box' dynamic model of the **Generation Set** may be provided. All models should be suitable for the software analysis package used by the **DNO**. Where required by the **DNO,** generator electrical parameters should be provided based on Schedule 5c (i) or 5c (ii), according to the type of machine used.

Schedule 5c (v)

DATA REGISTRATION CODE

GENERATION SET DATA FOR EMBEDDED GENERATION SETS

DATA DESCRIPTION **5c (v) Transformers**	**UNITS**	**Data Category for Generators connected at LV**	**Data Category for Generators Connected at HV**
Transformer identifier	Text	**SPD**	**SPD**
Transformer type (Unit/Station/Auxiliary)	Text	**SPD**	**SPD**
Number of identical units	Number	**SPD**	**SPD**
Type of cooling	Text	**SPD**	**SPD**
Rated (apparent) power	MVA	**SPD**	**SPD**
Rated voltage ratio (on principal tap)	kV/kV	**SPD**	**SPD**
Positive sequence resistance on principal tap	per unit	**DPD**	**SPD**
Positive sequence reactance at principal tap	per unit	**SPD**	**SPD**
Positive sequence reactance at minimum tap	per unit	None	**DPD**
Positive sequence reactance at maximum tap	per unit	None	**DPD**
Zero sequence resistance	per unit	**DPD**	**DPD**
Zero sequence reactance	per unit	**DPD**	**DPD**
Winding configuration (eg Dyn11)	Text	**DPD**	**SPD**
Type of tap changer (on load / off circuit)	Text	**SPD**	**SPD**
Tap step size	%	**SPD**	**SPD**
Maximum ratio tap	%	**SPD**	**SPD**
Minimum ratio tap	%	**SPD**	**SPD**
Tap position in service (for off load tapchangers only)	%	**DPD**	**DPD**
Method of voltage control	Text	**DPD**	**SPD**
Method of earthing of high-voltage winding	Text	**SPD**	**SPD**
Method of earthing of low-voltage winding	Text	**SPD**	**SPD**

Schedule 5d

DATA REGISTRATION CODE

DNO NETWORK DATA

(Data indicative of that which may be requested by Users for parts of the Distribution System)

<u>**DATA DESCRIPTION**</u> **5d DNO Network Data (see note 1)**	<u>**UNITS**</u>
Fault Level at Connection Point prior to Power Station connection.	
Peak asymmetrical short circuit current at 10ms (i_p) for a 3φ short circuit fault at the **Connection Point**	kA
RMS value of the initial symmetrical short circuit current (I_k") for a 3φ short circuit fault at the **Connection Point**	kA
RMS value of the symmetrical short circuit current at 100ms ($I_{k(100)}$) for a 3φ short circuit fault at the **Connection Point**	kA
Peak asymmetrical short circuit current at 10ms (i_{p-e}) for a 1φ-E short circuit fault at the **Connection Point**	kA
RMS value of the initial symmetrical short circuit current (I_{k-e}") for a 1φ-E short circuit fault at the **Connection Point**	kA
RMS value of the symmetrical short circuit current at 100ms ($I_{k-e(100)}$) for a 1φ-E short circuit fault at the **Connection Point**	kA
Circuit Data	
Circuit schematic diagram and geographic diagram showing normal open points	Diagram
Circuit impedances (R, X, B positive & zero sequence)	Specify
Circuit ratings and any seasonal variations	Specify
Is the network operated radial or non-radial?	Text
Circuit transformer voltage ratios eg HV/433/250	kV/V/V
Are circuit transformers zoned by applying the progressively higher tap settings for each group of transformers in zones along the circuit to optimise voltage regulation?	Y/N
Transformer Data (for each transformer)	
Transformer identifier	Text
Rated voltage ratio (on principal tap)	kV/kV
Winding configuration eg Dyn11	Text
Rated (apparent) power	MVA
Type of tap changer (on load / off circuit)	Text
Tap changer rating (forward and reverse power)	MVA / MVA
Tap step size	%
Maximum ratio tap	%

DATA DESCRIPTION **5d DNO Network Data (see note 1)**	**UNITS**
Minimum ratio tap	%
Normal tap position	%
Method of voltage control (voltage / LDC / NRC / other)	Text / Report
Controlled busbar (high-voltage side / low-voltage side / remote busbar)	Text
Target voltage and limits	kV, ±%
Normal system voltage on the high-voltage side	kV
Normal system voltage on the low-voltage side	kV
Positive sequence resistance	% on rating
Positive sequence reactance at principal tap	% on rating
Zero sequence resistance	% on rating
Zero sequence reactance	% on rating
Method of earthing of the high-voltage winding	Text
Method of earthing of the low-voltage winding	Text

Notes:

1. **Users** are advised to refer to network data items published in the **DNO's** Long Term Development Statement.

Schedule 5e

DATA REGISTRATION CODE

DATA FOR EMBEDDED TRANSMISSION SYSTEMS

DATA DESCRIPTION **5e Embedded Transmission System Data**	**UNITS**	**DATA CATEGORY**
EMBEDDED TRANSMISSION SYSTEM LOCATION & OPERATION		
Embedded Transmission System name	Text	**SPD**
Postal address or site boundary plan (1/500)	Text / Plan	**SPD**
Connection Point (OS grid reference or description)	Text	**SPD**
Connection Point voltage	V	**SPD**
Single line diagram of existing and proposed connections or **Operation Diagrams** when available	Diagram	**SPD**
Number of **Power Stations** and/or **Generation Sets** connected to the **Embedded Transmission System**	Number	**SPD**
Operating regime of **Power Station** and/or **Generation Sets** – intermittent or non-intermittent (see note 1)	Text	**SPD**
Means of carrying out voltage control and/or power factor control at the **Connection Point**	Report	**SPD**
Embedded Transmission System performance chart (net, at **Connection Point**, as per DPC7 Figure 1)	Figure	**DPD**
EMBEDDED TRANSMISSION SYSTEM IMPORT REQUIREMENTS (see note 2)		
Maximum **Active Power** import	MW	**SPD**
Maximum **Reactive Power** import (lagging)	MVAr	**SPD**
Maximum **Reactive Power** export (leading)	MVAr	**SPD**
Requirements for **Top - Up** and / or **Standby** supplies	Text	**SPD**
EMBEDDED TRANSMISSION SYSTEM EXPORT REQUIREMENTS (see note 3)		
Total **Embedded Transmission System** output at **Registered Capacity** (net of auxiliary loads)		
Registered Capacity (maximum **Active Power** export)	MW	**SPD**
Maximum **Reactive Power** export (lagging)	MVAr	**SPD**
Maximum **Reactive Power** import (leading)	MVAr	**SPD**

DATA DESCRIPTION **5e Embedded Transmission System Data**	**UNITS**	**DATA CATEGORY**
Total **Embedded Transmission System** output at **Minimum Generation** (net of auxiliary loads)		
Minimum Generation (minimum **Active Power** export)	MW	**DPD**
Maximum **Reactive Power** export (lagging)	MVAr	**DPD**
Maximum **Reactive Power** import (leading)	MVAr	**DPD**
Embedded Transmission System MAXIMUM FAULT CURRENT CONTRIBUTION (see note 4)		
Peak asymmetrical short circuit current at 10ms (i_p) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**
RMS value of the initial symmetrical short circuit current (I_k”) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**
RMS value of the symmetrical short circuit current at 100ms ($I_{k(100)}$) for a 3φ short circuit fault at the **Connection Point**	kA	**SPD**
Short circuit time constant T”, corresponding to the change from I_k” to $I_{k(100)}$	s	**DPD**
Positive sequence X/R ratio at the instant of fault	-	**DPD**
Embedded Transmission System INTERFACE ARRANGEMENTS (see note 5)		
Means of connection, disconnection and synchronising between **DNO** and **User**	Method statement	**SPD**
Site protection / co-ordination arrangements with DNO	Report	**DPD**
Site communications, control and monitoring (HV / LV)	Report	**DPD**

Notes:

1. Intermittent and Non-intermittent Generation is defined in ER P2/6 as follows:
    - Intermittent Generation: Generation plant where the energy source for the prime mover can not be made available on demand
    - Non-intermittent Generation: Generation plant where the energy source for the prime mover can be made available on demand
2. This section relates to operating conditions when the **Embedded Transmission System** is importing **Active Power**, typically when it is not generating. The maximum **Active Power** import requirement and the associated maximum **Reactive Power** import and/or export requirements should be stated.
3. This section relates to operating conditions when the **Embedded Transmission System** is exporting **Active Power**. The **Active Power** export and associated maximum **Reactive Power** range should be stated for operation at **Registered Capacity** and for operation at **Minimum Generation**.
4. See ER G74, ETR 120 and IEC 60909 for guidance on short-circuit current data. Additionally, fault current contribution data may be provided in the form of detailed graphs, waveforms and/or tables.

5. The interface arrangements need to be agreed and implemented between the **User** and the **DNO** before energisation and consideration should be given to addressing the Distribution Code requirements including DGC5, DGC8, DPC6.7, DPC7.2.6, DOC5, DOC7.4, DOC8.6.3, DOC8.6.4, DOC9 and DOC10. For example DOC7 requires up to date contact details and procedures are required to establish an effective means of communication between the **Generator** and the **DNO**.

Schedule 6

DATA REGISTRATION CODE

DEMAND FORECASTS

DATA DESCRIPTION	**UNITS**	**TIME PERIOD COVERED**	**UPDATE TIME**	**DATA CATEGORY**
1. Half hour **Active Power** and **Power Factor** at **Annual ACS Conditions** for specified time of the annual peak half hour at the associated **Grid Supply Points** and at the specified time of the annual peak half-hour of the **National Electricity Transmission System Demand**	MW/ MVAr	8 weeks - 3 years	Week 35	**OD**
2. Half hour **Active Power** and **Power Factor** at **Average Conditions** at the specified half hour of the annual minimum **National Electricity Transmission System Demand.**	MW/ MVAr	8 weeks - 3 years	Week 35	**OD**
3. Half hour Power output of **Embedded Generating Plant** and/or **Embedded Transmission System** at the specified half hour of the annual peak half hour of the **National Electricity Transmission System**	MW	8 weeks - 3 years	Week 35	**OD**
4. Schedules for the operation of **Embedded Generation Sets** and/or **Embedded Transmission Systems** whose output is greater than 5MW on a half-hourly basis	MW Date Time	2 weeks to 8 weeks ahead	1600 hrs Friday	**OD**

DATA DESCRIPTION	UNITS	TIME PERIOD COVERED	UPDATE TIME	DATA CATEGORY
5. **Supplier**s will provide details of their proposed use of **Demand Control** measures aggregated to 5MW or more (averaged over any half hour) on a half hourly basis for each **DNO Connection Point**.	MW Date Time	2 weeks to 8 weeks ahead	1600 hrs Friday	**OD**
6. **Customers**, **Suppliers,** Other Network Operators and other **DNOs** connected to the **DNO's Distribution System** shall notify the **DNO** where their or their **Customers** operations are likely to result in an aggregated change in **Demand** at the **DNO Connection Point** of supply of greater than 5MW of the **Demand** at that time on a half hourly basis.	MW Date Time	2 weeks to 8 weeks ahead	1600 hrs Friday	**OD**
7. Items 5, 6 and 7 above updated.		2 days to 12 days ahead	0900 hrs each Wednesday	**OD**
8. Details of differences greater than 5MW from the schedules of operation of any **Embedded Generating Plant** and/or **Embedded Transmission System** on a half-hourly basis submitted under item 5 above.	MW Date Time	0 - 24 hrs ahead	As specified	**OD**
9. Details from **Supplier**s of any differences of the amount and donation of their proposed use of **Customer Demand Control** (aggregated over any half hourly basis submitted under item 6 above).	MW Date Time	0 - 24 hrs ahead	As specified	**OD**

DATA DESCRIPTION	**UNITS**	**TIME PERIOD COVERED**	**UPDATE TIME**	**DATA CATEGORY**
10. Details from each **User** connected to the **DNO's Distribution System** of any change in aggregate **Demand** at the point of surplus of greater than 5MW of the **Demand**.	MW Date Time	0 - 24 hrs ahead	As specified	**OD**
11. Details of half hour **Active Power** and **Reactive Power** output sent out to the **DNO's Distribution System** by **Embedded Generating Plant** and/or **Embedded Transmission System** during the previous day on a half hourly basis.	MW MVAr	Previous day	0300	**OD**
12.**Supplier**s, Other Network Operators and other **DNOs** connected to the **DNO's Distribution System** will provide details of the amount and duration of **Demand Control** at the **DNO Connection Point** aggregated to 5MW or more (arranged over any half hour) which was implemented during the previous **Operational Day**.	MW Time	Previous day	0300	**OD**

Schedule 7a

OPERATIONAL PLANNING - LONG TERM

YEARS 3 AHEAD-

EMBEDDED GENERATORS CONNECTED TO THE DNO'S DISTRIBUTION SYSTEM AS SPECIFIED BY THE DNO

DATA DESCRIPTION	UNITS	TIME PERIOD COVERED	UPDATE TIME	DATA CATEGORY
1. For individual **Generation Sets** or **Embedded Transmission Systems** the Set/**System** number and **Generation Set/ Embedded Transmission System** capacity. Preferred outage dates earliest start date latest finish date.	MW Date	Years 3 ahead	Week 2	**OD**
2. **DNO** advise **Embedded Generators** of:-				
(a) details of **Embedded Generating Plant** or **Embedded Transmission System** they may withdraw from service.	Date	Years 3 ahead	Week 12	**OD**
(b) **Output Usable** requirements.	MW Date	Years 3 ahead	Week 12	**OD**
3. **Embedded Generators** provide **DNO** with				
(a) update of provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme.	Date	Years 3 ahead	Week 12	**OD**
(b) **Registered Capacity**.	MW			
(c) Neutral weekly **Output Usable** forecasts.	Date			
4. **DNO** following discussion with **Embedded Generator** will notify, with reason, revision to the provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme.	Date	Years 3 ahead	Week 28	**OD**

DATA DESCRIPTION	UNITS	TIME PERIOD COVERED	UPDATE TIME	DATA CATEGORY
5. **DNO** following discussion with **Embedded Generator** will notify, with reason, revisions to the provisional **Embedded Generating Plant** or **Embedded Transmission System** outage programme. (This taking into account **User** outages received in Week 28).	Date	Years 3 ahead	Week 42	**OD**
6. **DNO** following discussion with **Users** agree **Users** outages.	Date	Years 3 ahead	Week 43	**OD**

Schedule 7b

OPERATIONAL PLANNING - MEDIUM TERM

YEARS 1-2

EMBEDDED GENERATORS CONNECTED TO THE DNO'S DISTRIBUTION SYSTEM AS SPECIFIED BY THE DNO

DATA DESCRIPTION	**UNITS**	**TIME PERIOD COVERED**	**UPDATE TIME**	**DATA CATEGORY**
1. For individual **Generation Sets** or **Embedded Transmission System** the Set/**System** numbers and **Embedded Generating Plant/ Embedded Transmission System** capacity. Preferred outage dates earliest start date latest start date.	MW Date	Years 1 - 2	Week 2	**OD**
2. **Embedded Generators** provide the **DNO** with estimates of:-				
(a) **Output Usable**	MW Date	Years 1 - 2	Week 10	**OD**
(b) outage programme	Date	Year 1		
3. **DNO** following discussion with **Embedded Generator** provide:-	Date	Years 1 - 2	Week 12	**OD**
(a) Details of **Embedded Generating Plant** or **Embedded Transmission System** they may withdraw from service for an outage				
(b) Update of **Embedded Generator** outage programme.				
4. **DNO** notify each **Embedded Generator** of **Output Usable** requirements.	MW Date	Years 1 - 2	Week 12	**OD**
5. **Embedded Generator** provides estimates of **Output Usable** of each **Embedded Generating Plant** or **Embedded Transmission System**	MW Date	Years 1 - 2	Week 41	**OD**

Schedule 7c

OPERATIONAL PLANNING - SHORT TERM

EMBEDDED GENERATORS CONNECTED TO THE DNO'S DISTRIBUTION SYSTEM AS SPECIFIED BY THE DNO

DATA DESCRIPTION	UNITS	TIME PERIOD COVERED	UPDATE TIME	DATA CATEGORY
1. For individual **Generation Sets** or **Embedded Transmission Systems** the Set/**System** number and **Embedded Generating Plant/ Embedded Transmission System** capacity. Duration of outage earliest start date latest finishing date.	MW Date	Weeks 9 - 52		
Output Usable estimates.	MW Date	Weeks 9 - 52	Week 2	**OD**
2. **DNO** informs **Embedded Generators** of **Output Usable** requirements.	MW Date	Weeks 9 - 52	Week 4	**OD**
3. **Embedded Generators** provide **DNO** with **Embedded Generating Plant** or **Embedded Transmission System Output Usable** estimates.	MW Date	Weeks 18 - 52	Week 10	**OD**
4. **DNO** informs **Embedded Generators** of change to **Output Usable** requirements.	MW Date	Weeks 18 - 52	Week 12	**OD**
5. **Embedded Generators** provide **DNO** with **Embedded Generating Plant** or **Embedded Transmission System Output Usable** estimates.	MW Date	Weeks 28 - 52	Week 25	**OD**
6. **DNO** informs **Embedded Generators** of changes to **Output Usable** requirements.	MW Date	Weeks 31 - 52	Week 27	**OD**

7. **Embedded Generators** will provide estimates of **Embedded Generating Plant or Embedded Transmission System Output Usable** .	MW Date	Weeks 44 - 52	Week 41	**OD**
8. **DNO** inform contracted **Embedded Generators** of changes to **Output Usable** requirements.	MW Date	Weeks 44 - 52	Week 43	**OD**

Schedule 7d

DATA REGISTRATION CODE

OPERATIONAL PLANNING - USER PLANT, APPARATUS AND SYSTEMS

DATA DESCRIPTION	UNITS	TIME PERIOD COVERED	UPDATE TIME	DATA CATEGORY
Users provide the **DNO** with details of proposed outages which may affect the performance of the **DNO's Distribution System**. Details of trip testing, risks of trip and other information where known which may affect the security and stability of the **DNO's Distribution System** shall also be included.	Dates	Years 1 - 2 and Years 3 ahead	Week 28	**OD**
Update of previously submitted data for year 3 ahead.				
Following consultation with **Users** and **DNO** will include agreed outage proposals in the programme.	Date	Years 3 ahead Years1 - 2	Week 43 Week 48	**OD** **OD**
As changes occur.	Update of **Users** proposals agreed in the Medium Term Plan.			

Schedule 8

DATA REGISTRATION CODE

SYSTEM DESIGN INFORMATION

DATA DESCRIPTION	UNITS	DATA CATEGORY
General Information: Type of load and control arrangements Maximum load on each phase at time of **Peak Demand**		**DPD**
Fluctuating Loads:		
Rate of change of **Demand – Active Power** and **Reactive Power** increasing and decreasing	MW/s MVAr/s	**DPD**
Shortest repetitive time intervals between fluctuations in **Demand Active Power** and **Reactive Power**	s	**DPD**
Largest step change **Active Power** and **Reactive Power** increasing and decreasing	MW/s MVAr/s	**DPD**
Maximum energy **Demand** per half hour	MWh	**DPD**
Steady state residual **Demand** (MW) between **Demand** fluctuations	MW	**DPD**
Reactive Compensation		
Rating of individual shunt reactors (not associated with cables)	MVAr	**DPD**
Rating of individual capacitor banks	MVAr	**DPD**
Details of any automatic control logic such that operating characteristics can be determined.	Text/ Diagrams	**DPD**
Point of connection to the **System**	Diagram	**DPD**
Lumped Network Susceptance		
Details of the equivalent lumped network susceptance of the **User System** referred back to the connection with the **DNO's Distribution System**.	MVAr	**DPD**

DATA DESCRIPTION	**UNITS**	**DATA CATEGORY**
Including shunt reactors which are an integrated part of a cable system and which are not normally in or out of service independent of the cable. Excluding independently switched reactive compensation connected to the **User System** and any susceptance of the **User System** inherent in the active and reactive **Demand**.		**DPD**
Fault Infeeds		
Maximum and minimum short circuit infeeds into the **DNO's Distribution System**	MVA	**DPD**
X/R ratio under maximum and minimum short circuit conditions		**DPD**
[Contribution from rotating plant]		**DPD**
Equivalent network information at the request of the **DNO**		**DPD**
Interconnection Impedance		**DPD**
For **User** interconnections that operate in parallel with the **DNO's Distribution System** details of the interconnection impedance shall be exchanged between the **DNO** and **User**, including Positive Sequence Resistance Zero Sequence Resistance Positive Sequence Reactance Zero Sequence Reactance Susceptance	% on 100 % on 100 % on 100 % on 100 % on 100	**DPD** **DPD** **DPD** **DPD** **DPD**
If the impedance in the view of the **DNO** is low then more detailed information will be requested.		
Demand Transfer Capability		**DPD**
Information shall be exchanged on **Demand** transfer capability where the same **Demand** may be supplied from alternative **DNO** or **User** points of supply including the proportion of **Demand** normally fed from each point of supply	MW	**DPD**

DATA DESCRIPTION	**UNITS**	**DATA CATEGORY**
The arrangements for manual/automatic transfer under planned/outage conditions should be provided		**DPD**
Non - **DNO System** Data		
The **DNO** will request information on circuit parameters, switchgear and **Protection** arrangements	Text/ Diagrams	**DPD**
Transient Overvoltages		**DPD**
Demand Profile For Day Of **Exit Point Peak Demand**		**DPD**
Demand Profile For Day Of **Exit Point** Minimum **Demand**		**DPD**

Schedule 9

DATA REGISTRATION CODE

LOAD CHARACTERISTICS

DATA DESCRIPTION	UNITS	DATA CATEGORY
Geographical and electrical point of connection and date connection required Diagrams existing and proposed connections	Text	**SPD**
Types of **Demand**:-		
Maximum **Active Power Demand Registered Capacity**	MW	**SPD**
Maximum and minimum **Reactive Power** requirement	MVAr	**SPD**
Type of load and control arrangements. Eg variable speed motor type of starter employed	Text	**SPD**
Maximum **Phase Voltage Unbalance**	Ratio/ Phase at the time	**SPD**
Maximum harmonic content	% THVD	**SPD**
Fluctuating Loads:- Graphical indication of typical cycle variation of **Demand** (Active / Reactive)	Graphical	**SPD**
Load Management Data	Text	
Maximum short circuit infeed based on **Generation Set** subtransient reactance	MVA	**SPD**
Maximum zero phase sequence impedance of the **User's System** at the connection point	% on 100 MVA	**SPD**
2 hour **Demand** profiles for **Peak Demand**	MW and MVAr	**SPD**
Monthly **Peak Demand** variation	MW and MVAr	**SPD**

GUIDE TO THE DISTRIBUTION CODE OF GREAT BRITAIN

Issue 25 of The Distribution Code of Licensed Distribution Operators of Great Britain

01 November 2014

GUIDE TO THE DISTRIBUTION CODE OF GREAT BRITAIN

NOTE - This Guide is provided to prospective Users of the **DNO's Distribution System** for their information only and does not constitute part of the Distribution Code. Terms defined in the Distribution Code have initial capitals.

The Guide describes the provisions of the Distribution Code, which are mainly of a technical nature, in the context of the overall commercial and administrative arrangements for connection to the Distribution System covered in the Distribution Licence.

1. ELECTRICITY SUPPLY INDUSTRY

The principal functions within the Electricity Supply Industry are Generation, Transmission, Distribution, Supply and Metering.

1.1 Generation

Electricity is generated from a number of fuels, principally from nuclear energy, natural gas, coal, and water. A number of renewable sources are under continual development and output from wind, waste and biomass sources is expected to increase.

1.2 Transmission

The major Power Stations are connected to the Transmission System (The Grid) which operates as a fully interconnected system within Scotland, England and Wales. The Grid operates at 275kV and 400kV. The 132kV network in Scotland is also classed as part of the Transmission System but this is not the case in England and Wales. The Transmission System provides a secure supply of electricity to Grid Supply Points, ie the Grid Exit Points, which are also the Entry Points to the Distribution System, and also to the Exit Points for Customers with large or special Demands.

1.3 Distribution

The Distribution System operates at nominal voltages of 66kV, 33kV and 22kV (EHV), 11kV and 6.6kV (HV) and 400 volts and 230 volts (LV). The 132kV network in England and Wales is also classed as part of the Distribution System but this is not the case in Scotland. The Distribution System provides a supply to the Exit Points to all remaining Customers for industrial, commercial and domestic purposes. The voltage of the connection depends on Demand, the purpose for which the supply is used and the local technical requirements of the Distribution System. An increasing output from small Generators is connected directly to the Distribution System and these are termed Dispersed, Distributed or Embedded, Generators. The terms are synonymous and Embedded will be used throughout the Distribution Code.

1.4 Supply

The Supply Function deals with the marketing of electricity, billing and commercial aspects of the use of electricity.

1.5 Metering

Metering is used to measure real time power flows within the various Systems to allow them to be operated within ratings and to match supply with Demand. Metering is also used to record the amount of electrical energy produced by Generators, transferred over the grid and onto the Distribution System. Metering also records the amount of energy consumed by Customers and Suppliers for billing purposes.

2 PRINCIPAL ORGANISATIONS

The following outlines the principal organisations involved in fulfilling the functions described above.

(a) The DNOs, as holders of Distribution Licences under the Electricity Act 1989 as amended, who own and operate the Distribution System, and who are under a statutory duty to provide a connection to the Distribution System and to distribute electricity on request.

(b) Generators who are licensed under the Electricity Act 1989 as amended or licence exempt and who are independent of the DNOs.

(c) Suppliers who supply electricity under licence or exemption under the Electricity Act 1989 as amended. There is only one class of licensed Supplier and the term “Public Electricity Suppliers (PES)” is now defunct. However certain Suppliers including the supply businesses of the former PESs continue to have a statutory obligation to supply electricity on request.

(d) Customers with Own Generation who have Generating Plant for supplying their own needs, although they may sell a certain amount of electricity without a licence.

(e) The Licensed Meter Operator who owns metering assets and provide metering services. The Licensed Meter Operator may be a subsidiary of the DNO, or an independent provider of metering services.

3 **PRINCIPLES OF AN INTERCONNECTED** SYSTEM

3.1 General

The benefits of the interconnection of individual generating stations and the supply of electricity from such interconnected systems to discrete load centres have long been recognised worldwide. High Voltage interconnected systems confer on electricity supply the advantages of increased security of supply and greater economy arising from the immediate accessibility of the required mix of generation at any time.

3.2 Demand **Forecasting**

Since electricity cannot be stored in bulk until it is needed it has to be generated in the correct quantities at virtually the instant it is required, otherwise the supply voltage and frequency will deviate outside fairly narrow statutory limits with both undesirable and possibly harmful effects. Because of this property it is necessary to forecast total Demand from all Suppliers on a daily basis so that the minute-by-minute operation of Power Stations can be scheduled. A mismatch will immediately affect the quality of supply to Suppliers' Customers and can arise from unexpected occurrences like sudden changes in weather leading to large swings in the Demand for electricity or breakdowns on the interconnected system or on Generating Plant. It normally takes several hours for Generation Sets to become available. Therefore to offset the effect of any occurrences a reserve or security margin of Generating Plant is required to be available to provide electricity at very short notice. It is also necessary to forecast Demand in the longer term to programme the reinforcement of the interconnected network.

3.3 System **Security**

Standard procedures are necessary to ensure that the interconnected system is developed, operated, maintained and used to transmit and distribute supply to the load centres and Suppliers' Customers in a secure and efficient manner during normal and abnormal conditions. It is necessary to specify the technical requirements for the development of the interconnected system and the technical requirements for connection to it. Any failure to meet with these minimum requirements can lead to reduced security and efficiency or to disturbances or events causing undesirable effects on the System. It is also necessary to plan outages of Generation Sets and of the interconnected system to preserve Demand Control and match generation to Demand.

3.4 **Industry Structure**

In Scotland, electricity transmission is owned by SP Transmission Ltd and Scottish Hydro-Electric Transmission Ltd. They are responsible for the planning and development of their transmission systems. In England and Wales, the National Grid Company owns the transmission system, and is responsible for its planning and development. NGC is also responsible for the day to day control of the whole GB Transmission System (ie the transmission systems of NGC, SPT and SHETL taken together) as the GB System Operator. In this role they are also responsible for offering connections to the GB Transmission System to Users. NGC has no interests in generation or supply.

DNOs own and operate the Distribution Systems in both Scotland and in England and Wales. In Scotland, the two DNOs are affiliated to the respective Scottish transmission companies. Some DNOs have affiliates which are involved in generation and the supply of electricity. Generation and supply are fully competitive activities. Licence obligations on DNOs and the Scottish transmission licensees require the distribution businesses to be operated separately from the competitive businesses, that they facilitate competition, that they do not discriminate between different users, and that they maintain confidentiality of information.

In addition there is the opportunity for competition in the construction of connections to the transmission and distribution systems.

The electricity market now also operates across Scotland and Enngland and Wales under the arrangements established under the Energy Act 2004 and the BETTA trading arrangements. The historic differences in structure and market operation lead to some minor differences in terminology and information exchange requirements. However the technical requirements of Distribution Systems are identical and a common Distribution Code has been adopted for Great Britain as a whole, with a small number of alternative provisions for Scotland and England and Wales.

4 GRID AND DISTRIBUTION CODES

It is a requirement of the Licences that Codes be prepared and at all times be in force covering all technical aspects relating to connection to and the planning, operation and use of the interconnected system, and the operation of electrical lines and electrical Plant and Apparatus connected to that System. There are two such Codes which will apply to the appropriate parts of the System and to those who are connected to it.

(a) The Grid Code which is a condition of the Transmission Licence and relates to the Transmission System and connections to it.

(b) The Distribution Code which is a condition of the Distribution Licence and relates to the Distribution System and connections to it.

The Grid Code and the Distribution Code are approved by the Authority. The Office of Gas and Electricity Markets (Ofgem fulfils the function of the Authority) and are essential to ensure that the total electricity supply System operates efficiently, so as to provide, as far as is reasonably practicable, a secure high quality supply to Customers.

The relationship between the Grid Code and the Distribution Code is shown diagrammatically in the relevant Figure 1 to this Guide.

5 DISTRIBUTION CODE

5.1 General

The Distribution Code covers all material technical aspects relating to connections to and the operation and use of the Distribution Systems of the DNOs. However, it is not exhaustive as to the requirements to be complied with by those connected to the Distribution System who must also comply with the requirements of the Electricity Act 1989, the Electricity Safety, Quality and Continuity Regulations and all other relevant legislation which from time to time comes into force.

The principles contained in the Distribution Code shall apply to all Users, ie all persons and companies connected to the Distribution System:

(a) Customers, classified by Demand and connection voltage. (It is not intended that the Distribution Code should generally apply to small Customers individually; their obligations will be dealt with on their behalf by their Suppliers.

(b) Suppliers.

(c) Embedded Generators classified by output and connection voltage.

(d) Other Authorised Distributors connected to the System.

(e) Meter Operators, via Suppliers.

The Distribution Code does not deal with charges and other commercial terms relating to

(a) A connection to the System.

(b) Supplies of electricity.

(c) The use of the Distribution System for the transport of electricity.

Statements setting out the principles of connection to and use of the Distribution System are covered in the Distribution Licence and summarised in this Guide. Further details and the calculation of such charges, together with current prices, are available from the DNOs.

5.2 Distribution Code Review Panel

The DNOs are required to maintain a Distribution Code Review Panel comprising representatives of the DNOs, Ofgem and Users. The Panel maintains an ongoing review of the Distribution Code and its workings.

Users can pass to the Panel suggestions for changes to the Distribution Code at any time. Users can also ask the Panel to issue guidance in relation to the implementation, performance and interpretation of the Code.

5.3 Distribution Code **Sections**

The Code is prepared by the DNOs and is specifically designed to:

(a) Permit the development, maintenance and operation of an efficient co-ordinated and economic system for the distribution of electricity.

(b) Facilitate competition in the generation and supply of electricity.

The Code covers the Distribution Systems of the DNOs which are defined so as to include Equipment at 33kV and below in Scotland and 132kV and below in England and Wales.

The Code comprises several sections which identify the responsibilities of both the host DNO and Users with regard to connection to and use of the Distribution System:

(i) **Glossary and Definitions**, defines terms used in the Distribution Code.

(ii) **Introduction** to the Distribution Code.

(iii) **General Conditions**, apply to all aspects of the Distribution Code and are intended to ensure that the Code works to the benefit of all Users**.**

(iv) **Planning and Connection Code**, specifies technical, design and operational criteria and procedures applied by DNOs in planning and developing the Distribution System and with which Users must comply when seeking a connection.

(v) **Operating Code**, sets out operating procedures at the interface with Users and requires Users of the Distribution System to provide load and/or generation output information to the DNOs.

(vi) **Data Registration Code**, provides guidelines for the collection and assembly of information exchanged between Users and DNOs under the various sections of the Distribution Code.

Subsequent sections of this Guide consider in turn the main Distribution Code sections.

5.4 Distribution Planning and Connection Code

The Distribution Planning and Connection Code specifies technical and design criteria and the procedures to be applied by DNOs and Users in the planning and development of the Distribution System, including information exchange.

In the event that reinforcement or extension of the Distribution System is required, the Distribution Licence imposes an appropriate timescale for the exchange of information between the DNO and Users subject to all parties observing, where appropriate, the confidentiality of such information.

5.4.1 Design Principles and Standards (DPC4)

The characteristics of the Distribution System which must be provided by the **DNO** are specified in DPC 4.2, including security of supply and voltage and frequency limits.

The technical requirements for small Customers taking low voltage supplies of 100 amps and less are specified in DPC 4.3. Installations complying with BS7671 Requirements of Electrical Installations (wiring regulations) are deemed to comply with the Distribution Code.

The general technical requirements for larger installations are specified in DPC 4.4 which makes reference to Electricity Supply Industry Standards covering earthing arrangements. More complex requirements for High Voltage Customers, are specified in DPC 6 and DPC 8.

Industry interface standards are open to collective governance by the Panel. This is explained in Section 7 of this Guide.

5.4.2 Network Statements (DPC4.5)

The DNO is required by the Authority (Ofgem) to prepare a Long Term Development Statement, for the whole of the DNO's Distribution System, which gives information to assist prospective and existing Users when developing their distribution arrangements with the DNO.

In addition to this, prospective or existing Users can request a more detailed statement from the DNO showing its best estimate and forecast of the present and future circuit capacity, power flow and loading on the part or parts of the relevant Distribution System specified in the request.

This requested statement must be prepared as soon as practicable and in any event within 28 days of the requester agreeing to meet the cost of providing the information (see below), unless due to the complexity of the request, a longer timescale is sought by the DNO within 10 days of the request and agreed by Ofgem.

The Code makes it clear that the requested statement shall include:

(a) Such further information as the DNO considers necessary to the requester in the assessment of opportunities available for connection to or use of the Distribution System specified in the request.

(b) If so requested, a commentary setting out the DNO’s view as to the suitability of that part of the System for the purpose specified in the request.

The DNO will only omit supporting information from the statement on the grounds of confidentiality as required by the Distribution Licence. The omission of information will not invalidate the conclusions of the statement.

5.4.3 Charges for Information

A provision in the Distribution Licence allows the DNO to charge for providing such Planning Statements. These charges relate to reasonable costs in providing the statement. The exact procedure is as follows:

(a) The DNO may within 10 days of receipt of a request provide an estimate of its reasonable costs in preparing any statement.

(b) Provision of the requested information is conditional on the requester agreeing to pay the amount estimated or such other amount as Ofgem may direct, on application of the DNO or the person requesting such statement. on payment of the DNO's estimated costs or, such other amount as Ofgem may direct.

(c) The DNO must provide the information within 28 days of the date of the request, or if the DNO has provided an estimated cost for providing data, within 28 days of the date on which agreement to pay the charge is received.

5.4.4 Exchange of Information (DPC5)

DPC 5 (General Requirements for Connection) specifies the connection arrangements, and information requirements, in separate sections for small and large Users. The information required includes Active Power and Reactive Power requirements and information about disturbing loads to ensure that they comply with the standards referred to in DPC4 (5.4.1 above).

5.4.5 Embedded Generator**s (DPC7)**

Embedded generation, that is generation directly connected to the Distribution System or Customers With Own Generation, can have a significant effect on Distribution Systems and the DNO will need to assess the impact of specific projects. Generators are classified by voltage and output power and the detailed technical standards to be applied and information required from Embedded Generators is set out in a composite section of the Planning and Connection Code (DPC7).

In England and Wales embedded generators of size between 50MW and 100MW, although generally exempt from being licensed, nevertheless are bound by some Grid Code requirements. However, as they have no relationship with NGC, these Grid Code requirements are reflected in Distribution Code requirements in Sections DPC7.5 and also in DOC 5.6. In Scotland, in SP Transmission's area, these Grid Code requirements may apply to generators in the 5MW to 30MW range.

Customers who have domestic or micro generation complying with Engineering Recommendation G83/2 – "Recommendations For The Connection of Type Tested Small-Scale Embedded Generators (Up To 16A Per Phase) In Parallel With Public Low-Voltage Distribution Networks" are not classed as Generators for the purposes of the Distribution Code.

5.4.6 Application for Connection Procedures

Any person seeking to establish new or modified arrangements for connection to and/or use of the Distribution System must make their application to do so on standard forms provided by the DNO. However, in the case of large or technically complex connections full details appropriate to the scheme should be provided. The DNO will provide guidance in cases where the standard forms are not appropriate and full details are required.

Under the Competition in Connections policy applicants for new or modified connections may wish to take responsibility for some aspects of the associated work. The DNO will provide details of the scope and implications of contestable work on request.

5.4.7 Typical Areas for Discussion

During the Application Process the following is typical of the issues to be discussed.

(a) Will the System take X amount of additional power without upgrading? If not, how much will it take before a major upgrade is required?

(b) If there are network constraints, what are they? Are they acceptable? A constraint may reflect a system capacity limit which requires the System to be switched off for maintenance work. This may be for as little as one day per annum, or substantially longer and more frequent.

(c) Are there any major upgrading works scheduled in the area over the next 5 years which will reduce any connection costs?

(d) Can the amount of power required be provided by the local System without major upgrading, and at reasonable cost?

(e) By how much can the required supply capacity be increased without necessitating major upgrading? If a System upgrade is required what are the mechanisms for allocating the costs and benefits associated with the upgrade?

(f) What will be the supply voltage? Are there other options and what are the implications of the other options?

(g) How reliable is the supply (in statistical terms)? How will the supply be provided? Will it be mainly by overhead line, or by underground cable?

5.4.8 Requirement to Offer Terms

DNOs are required by the Distribution Licence to offer terms under which they are prepared to enter into an agreement with the applicant for establishment of the proposed new or modified connection to and/or use of the DNO's Distribution System.

The offer will be made as soon as is practicable after receipt of an application containing all such information as the DNO may reasonably require for the purposes of formulating an offer and (save where the Authority (Ofgem) consents to a longer period) in any event not more than 28 days in the case of an application for use of System only or not more than 3 months in the case of an application for connection or use of System with connection. The offer shall specify, and the terms shall take account of, any works required for the extension or reinforcement of the DNO's Distribution System or the Transmission System necessitated by the applicant's proposed activities and for the obtaining of any consents necessary for such purposes.

The extension or reinforcement required to the DNO's Distribution System or the Transmission System to accommodate an application may be of such magnitude or complexity that the DNO considers that analysis of the proposal cannot reasonably be concluded within the specified timescale. In such circumstances, the Authority may agree to an extension, in which case the DNO shall, within the original timescale, provide a preliminary offer, indicating those areas which require more detailed analysis. On receipt of the preliminary offer, the User shall indicate whether it wishes the DNO to undertake the work necessary to proceed to a firm offer within a timescale to be specified by the Authority.

Where an offer made has lapsed or has been rejected by the applicant, the DNO shall refer to the Authority for his consideration, any further application received from that applicant within twelve months of the original application if, in the view of the DNO, the further application does not represent a significant change from the original application. The DNO shall not proceed with consideration of the further application unless and until the Authority confirms he considers the applicant to be acting reasonably under the terms of the Distribution Code.

5.4.9 Right to Reject an Application

The DNO shall reject an application for connection to or use of the DNO's Distribution System only if it considers that any offer of terms for establishment of the proposed arrangements would place the DNO in breach of statutory obligations or other regulatory or licence conditions or if the applicant does not agree to comply with the Distribution Code.

5.4.10 Information Provided by the DNO

Once committed by signature the Connection/Use of System Agreement constitutes a contract between the DNO and the User. A signed contract may (but not always) reduce the scope for referring areas of dispute to Ofgem for determination. Users may wish to discuss these issues with Ofgem to satisfy themselves in this respect before signing a contract.

The contract includes a condition requiring both parties to comply with the Code. In particular for connection at High Voltage, both parties are required to sign a site responsibility schedule detailing the division of responsibility in relation to ownership, control, operation and maintenance of Plant and Apparatus. The Connection/Use of System Agreement requires the DNO to provide:

(a) Details of any capital related payments arising from necessary reinforcement or extension to the company's Distribution System or Transmission System, and if required.

(b) Detailed costing arrangements for the supply of Standby and Top-up facilities.

5.4.11 Information Required From Users

Prospective and existing Users are required to provide sufficient Planning Data as requested by the DNO to allow compliance with its Distribution Licence. The required Planning Data is allocated to one of two categories, Standard Planning Data and Detailed Planning Data. The DNOs can provide proforma schedules for the submission of both Standard and Detailed Planning Data, although every effort will be made to minimize the complexity and detail of the data requested.

These schedules are included in the Distribution Data Registration Code section of the Distribution Code.

Standard Planning Data include items such as:

(a) The location of the connection and the date when connection is required.

(b) A requirement for diagrams (single line) of Plant and Apparatus and the type and electrical loading of equipment.

(c) Maximum and minimum parameters for Active Power Demand, Reactive Power etc. and details of any load management scheme adopted by the Active Power.

Detailed Planning Data, when required, includes data relating to Demand and load fluctuation. In some cases detailed information may need to be provided to allow a full assessment of the effect of the Users load on the Distribution Systems.

5.4.12 Status of Planning Data

For Distribution Planning and Connection Code purposes, planning data supplied by Users may be allocated to one of three status levels which provided a progression related to degrees of commitment and validation, as follows:

(a) **Preliminary Project Planning Data** - Data supplied by a User in conjunction with an application for connection or use of System shall be considered as Preliminary Project Planning Data until such time as a binding Connection/Use of System Agreement is established between the DNO and the applicant. This data shall be treated as confidential by the DNO.

Preliminary Project Planning Data will normally contain only Standard Planning Data, unless Detailed Planning Data is required to permit more detailed System studies by the DNO.

(b) **Committed Project Planning Data** - When a Connection/Use of System Agreement is established, the data relating to the User's development, and subsequent data required by the DNO under the Distribution Planning and Connection Code, shall have the status of Committed Project Planning Data. This data shall form the background against which any further applications from other Users shall be considered and against which planning of the DNO's Distribution System shall be undertaken. Committed Project Planning Data may contain both Standard Planning Data and Detailed Planning Data.

(c) **Registered Project Planning Data** (For Users other than at Low Voltage) - The Distribution Planning and Connection Code requires that, before an agreed connection may be physically established, any estimated values contained within the Committed Project Planning Data shall be replaced, where practicable, by validated actual values and as appropriate by updated forecasts for future data items such as Demand. Data provided at this stage is termed Registered Project Planning Data. Registered Project Planning Data may contain both Standard Planning and Detailed Planning Data.

5.5 Distribution Operating Code

The objective of the Operating Code is to set out operating procedures at the interface with Users and to facilitate the exchange of information necessary to allow the DNO to operate the System so as to ensure maximum security and stability.

The Operating Code covers a number of specific aspects for which information and detailed procedures are required. Categories of information are identified by schedules in the Distribution Data Registration Code that are designed for the provision of the specific information:

(a) **Demand Forecasts (**DOC1**)** Generators and Customers whose Demand is greater than 5MW are required to provide information of their Demand as specified in DOC1.

(b) **Operational Planning** (DOC2**)** This section covers information intended mainly for Embedded Generators although operational procedures will need to be agreed with High Voltage Customers regarding planned plant maintenance which may affect the Customer's operations.

(c) **Testing and Monitoring** (DOC 5) To ensure that the Customer is not operating outwith the parameters of the Connection Agreement, the DNO has the right to test and monitor the Customer's supply at the Connection Point. The DNO must advise the Customer that tests are to be carried out and will make results available. The Customer may witness any of the tests carried out. Should the DNO establish that the Customer is operating outwith the agreed parameters the Customer faces the ultimate possibility of being disconnected from the Distribution System.

(d) **Demand Control** (DOC 6) In cases of extreme emergency, due to plant breakdown for example, where available Generating Plant is insufficient to meet the total Demand of Customers, it will be necessary to reduce the load on parts or all of the Distribution System. This section sets out the alternative methods which may be applied. Until the emergency has passed, Customers may be subject to rota disconnections.

(e) **Operational Liaison (**DOC 7**)** The Customer must nominate a person to be contacted and advised by the DNO's nominated person of the possible risk of System disturbance or System security caused by Operations or Events on the Distribution System.

(f) **Safety Co-ordination (**DOC 8) This section sets out the responsibilities and requirements when working at or across the Operational and Ownership Boundaries.

(f) **Contingency Planning (**DOC 9**)** This section describes procedures to be undertaken following a complete or partial failure of the Distribution and Transmission Systems or civil emergency.

(h) **Event Reporting (**DOC 10**)** Any major incident, such as a fault on a Customer's System, must be reported by the Customer to the DNO. Any oral report must be confirmed by a full written report as soon as possible after the incident.

(i) **Numbering and Nomenclature (**DOC 11**)** The DNO will be responsible for providing the Customer with circuit/apparatus, numbering/nomenclature at own ownership boundaries in accordance with agreed standards. Such information for new installations will be provided on an Operation Diagram as soon as possible.

(j) **System Test (**DOC 12**)** When the DNO or User intends to carry out a System Test which may affect supply to other Customers the DNO must inform all affected Customers in writing, giving details of the nature and purpose of the proposed System Tests. There are laid down time periods within the Code for giving Customers prior warning of any tests.

5.6 Distribution Data Registration Code

The Distribution Data Registration Code collates in a readily identified form the information exchanged between the DNO and Users under the various sections of the Code.

Data required by the DNO is allocated to one of three categories:

(a) **Standard Planning Data** is that data listed in the Planning and Connection Code which is required to be supplied by all Users when making application for connection to and/or use of the DNOs' Distribution System.

(b) **Detailed Planning Data** is that data listed in the Planning and Connection Code which is required to be supplied by the User. This is more specific data relating to Demand, fluctuating loads etc. which could adversely affect the Distribution System. There may be some relaxation of the requirement to provide detailed planning data in the case of small Embedded Generators.

(c) **Operational Data** is data which is required by the Distribution Operating Code and should be supplied in accordance with the timetables set down in the relevant operating codes.

5.6.1 Procedures and Responsibilities

Data must be submitted to the DNO in writing and, where required, in the format of the schedules included in the Distribution Data Registration Code. These schedules are structured to serve as standard formats for data submission.

The registration code identifies procedures in the event that Users may wish to change data submitted or already registered with the DNO.

There is provision for the DNO to estimate data which Users have failed to supply. However, DNOs must notify Users in writing of any estimated data it intends to use.

A specific requirement of the Planning Code is that Registered Data is updated by Users on an annual basis.

6 CONNECTION TO THE DISTRIBUTION SYSTEM

6.1 Electricity Suppliers

Supplies of electrical energy to Customers within the DNO's authorised supply area will be made by the licensed Suppliers or exempted Suppliers. Each will be entitled, under a specific Agreement(s), to use both the Transmission and Distribution Systems for the transport of electrical energy from the Generating Plant to Customers.

By virtue of the conditions of its Distribution Licence, the DNO is obliged to offer use of its Distribution System to all Supply Businesses. The Licence provides that in doing so the DNO must not discriminate in favour of any Supply Business.

6.2 Connection Types

There are two types of connection to the DNO’s Distribution System, namely:

(a) Entry Point: That is the connection between the DNO’s Distribution System and the point where electricity enters the System, usually the Transmission System or an Embedded Generator.

(b) Exit Point: That is the connection between the DNO’s Distribution System and either the premises where the electricity is consumed or, in some cases, another Distribution System (owned, for example, by another Distributor and termed Other Authorised Distributor).

Note:- A connection may be an Entry and an Exit Point (Customer With Own Generation)

The DNO’s Distribution System may also be used

(a) To transport electricity between Entry and Exit Points.

(b) For the provision of Standby and/or Top-up supplies of electricity.

6.3 Connection Agreements and Use of System Agreements

Use of the Distribution System may require a Customer to sign a specific agreement(s) with the DNO. The following is given as a guide and is not intended to be exhaustive.

(a) Large power Customers shall be required to sign a Connection Agreement. In most cases low voltage Customers will only be required to sign a Supply Agreement with their Supplier.

(b) Embedded Generators shall be required to sign an Embedded Generator Connection Agreement, including specific technical and operating requirements, and may also require a Use of System Agreement.

(c) Suppliers shall be required to sign a Use of System Agreement.

(d) Top up and Standby agreements may be required by:

(i) A Supplier.

(ii) A Customer With Own Generation.

(iii) A Customer with an alternative supply not provided via the DNO's Distribution System.

A prospective User, once committed by signature of a Connection/Use of System Agreement, is termed a "Committed User".

A Connection/Use of System Agreement will constitute a contract between the DNO and the User, including as appropriate within its terms and conditions:

(a) A condition requiring both parties to comply with the Distribution Code.

(b) Details of the rates forming the basis of Use of System Charges.

(c) Details of capital related payments arising from necessary reinforcement or extension of the Distribution or Transmission System.

(d) Details of any ongoing charges for special services such as regular ongoing System studies or abnormal System management requirements.

(e) A condition requiring both parties to sign a Site Responsibility Schedule, detailing the divisions of responsibility at interface sites in relation to ownership, control, operation, maintenance of Plant and Apparatus and to safety of persons.

Detailed costing arrangements for the supply of standby and top-up facilities, if required, to cover any shortfall in contract quantities of electricity delivered by a Generator to a Supplier under a Connection/Use of System Agreement shall be the subject of a top-up and standby supply agreement.

6.4 Consents and Statutory Obligations

Depending on the size and type of a User's installation which is to be connected to the DNO's Distribution System, a User may have obligations in connection with obtaining consents and satisfying statutory obligations associated with the connection referred to in DPC1.5.

6.4.1 An offer by the DNO to a User for connection or use of the DNO's Distribution System may be conditional upon the outcome of any or all of the following procedures relating to an extension or reinforcement of the DNO's Distribution System or the Transmission System to permit a development by the User:

(a) An application for planning consent.

(b) Negotiations with landowners or occupiers for consent to place Plant and Apparatus on or across their land.

(c) The submission of an environmental assessment statement.

(d) A Public Inquiry.

6.4.2 A User whose development requires the DNO to engage in any of the procedures referred to in 6.4.1 or any other statutory procedure which would not otherwise be necessary shall:

(a) Provide any necessary supporting information or evidence.

(b) Ensure attendance at a Public Inquiry by such witness as the DNO may reasonably request.

(c) Bear the cost incurred in compliance with 6.4.2 (a) and (b).

6.4.3 If planning consent is granted, but is conditional upon a change in the design arrangements originally offered by the DNO (eg undergrounding), then the DNO shall make a revised offer to the User, including revised terms and timing. This revised offer shall form the basis of any Connection Agreement/Distribution Use of System Agreement.

6.4.4 If any necessary consent is not granted, the DNO shall not be obliged to fulfil any Connection Agreement/Distribution Use of System Agreement

6.5 Approval to Connect

Depending on the size and type of a User’s installation which is to be connected to the DNO’s Distribution System a DNO may specify procedures to approve the technical compliance of the User’s installation and commissioning procedures to energise the connection, as provided for in DPC5.3.3. These procedures may have some or all of the typical features specified below:

6.5.1 Readiness to Connect

6.5.1.1 A User, whose development is under construction in accordance with a Connection Agreement and who wishes to establish connection with the DNO’s Distribution System, shall apply to the DNO by submitting a standard connection card or otherwise in writing, stating readiness to connect and giving the following:

(a) Confirmation that the User's installation complies with the principles outlined in Regulation 25(2)(a) of the Electricity Safety, Quality and Continuity Regulations.

(b) Where appropriate update the Distribution Planning and Connection Code data based on actual values.

(c) Where appropriate update forecasts for future operational data as listed in the Distribution Data Registration Code.

(d) A proposed connection date.

6.5.1.2 The DNO may request a User to provide, in addition to his written application to the DNO for connection in accordance with 6.5.1.1, a report certifying to the DNO that all matters required by DPC4 have been considered and that DPC5 to DPC8 inclusive have been complied with by the User and incorporating:

(a) Type test reports and test certificates produced by Nationally Accredited Laboratories showing that the Plant and/or Apparatus specified in the Distribution Planning and Connection Code meet the criteria specified.

(b) Copies of the manufacturers' test certificates relating to Plant and/or Apparatus referred to in the Distribution Planning and Connection Code, including measurements of positive and zero sequence impedance of Apparatus which will contribute to the fault current at the point of connection.

(c) Details of Protection arrangements and settings under DPC6.3.

(d) A certificate declaring the maximum short circuit current in Ampere which the User's System would contribute to a three- phase short circuit at the point of connection, and the minimum zero sequence impedance of the User's System at the Connection Point and taking into account the contributions of any Generation Set or Power Station motors.

(e) Confirmation that design conforms with the standards referred to in DPC4.

(f) A list of persons appointed by the User to undertake, and to be responsible for, the application and removal of **Safety Precautions** on those parts of the User's System which are directly connected to the DNO’s Distribution System.

(g) A list of names and telephone numbers of responsible management representatives in accordance with Distribution Operating Code DOC.9.

(h) Site Common Drawings as specified in the Connection Agreement.

(i) A single line diagram of the User's Apparatus showing all items to which the Distribution Planning and Connection Code applies.

(j) Information to enable the DNO to prepare a Site Responsibility Schedule as DPC5.4.3.

6.5.1.3 For connections at High Voltage, the User shall provide a proposed commissioning programme, giving at least six weeks notice of the proposed connection date, and detailing all proposed site testing of main and ancillary Equipment, together with the names of the organisations who are to carry out such testing.

6.5.1.4 The DNO shall be entitled to witness site testing of Equipment whose performance can reasonably be regarded as affecting the integrity of the DNO’s Distribution System. The User shall provide the DNO with certified results of all such tests and the DNO may withhold agreement to energise the User's Equipment where test results indicate that the Distribution Planning and Connection Code have not been satisfactorily complied with.

6.5.1.5 Where in advance of the proposed connection date, a Generator requires connection to the DNO Distribution System for the purpose of testing, the Generator will require satisfying the DNO of the following:

(a) Compliance with the requirements of the Connection Agreement.

(b) Provision of a commissioning programme supplied by the Generator and agreed with the DNO to allow commissioning tests to be co-ordinated in a manner detailed in Distribution Operating Code DOC-12 – “System Tests”.

6.5.2 Confirmation of Approval to Connect

6.5.2.1 The DNO shall inform the User whether or not the DNO considers the requirements of 6.4.1 and requirements of the Distribution Planning and Connection Code are satisfied and the making of the connection is approved subject to satisfactory results of those tests which cannot be performed prior to energization of the User's Plant and Apparatus. Where approval is withheld, detailed reasons shall be stated.

6.5.2.2 When indicating agreement to the energization of a connection, the DNO shall specify the contents and sequence of the energization programme and associated testing and shall be entitled to postpone or suspend the programme where, due to circumstances which could not reasonably have been foreseen by the DNO, continuation of the programme would impose an unacceptable level of risk to the integrity of the DNO's Distribution System.

6.5.2.3 Detailed costing arrangements for the supply of standby and top-up facilities, if required, to cover any shortfall in contract quantities of electricity delivered by a Generator to a Supplier under a Connection Agreement /Distribution Use of System Agreement shall be the subject of a top-up and standby supply agreement.

7 GOVERNANCE OF TECHNICAL STANDARDS

7.1 General

7.1.1 The Panel maintains a Standard Procedure detailing the governance arrangements. This procedure can be found on the Distribution Code Website along with the Panel Constitution and Rules: www.dcode.org.uk.

7.1.2 Industry interface standards are open to collective governance by the Panel. There are three broad classes of standards as detailed below.

7.2 Distribution Code Standards

Some standards impose Distribution Code obligations, and these are listed in Annex 1 of the Distribution Code. These standards implement Distribution Code requirements and these standards are cited in preference to stating the detail of the requirements in the Distribution Code itself. The content of these standards is subject to the governance of the Panel which will consult publicly on them, although ownership of the standards rests with the DNOs. Ofgem has to give final approval to any changes.

7.3 Other Industry Standards

There are other standards that do not impose direct Distribution Code obligations, but are nevertheless considered to be material and binding on DNOs and Users and are subject to governance by the Panel. These are listed in Appendix 2 of this Guide. These standards are governed in a similar manner to Annex 1 standards. The salient difference is that Ofgem does not need to formally approve changes to these standards. However Ofgem may approve them should the Panel fail to agree on changes to them.

7.4 Individual DNO’s standards.

These are not directly governed by the Panel, but by exception the Panel can review an individual DNO standard if the Panel’s advice is sought by Ofgem following a referral to Ofgem of an issue with an individual DNO standard by a User. Ofgem may then take the Panel’s advice into account when resolving the User’s complaint.

FIGURE 1A - GRID CODE **&** DISTRIBUTION CODE **BOUNDARIES (SCOTLAND)**

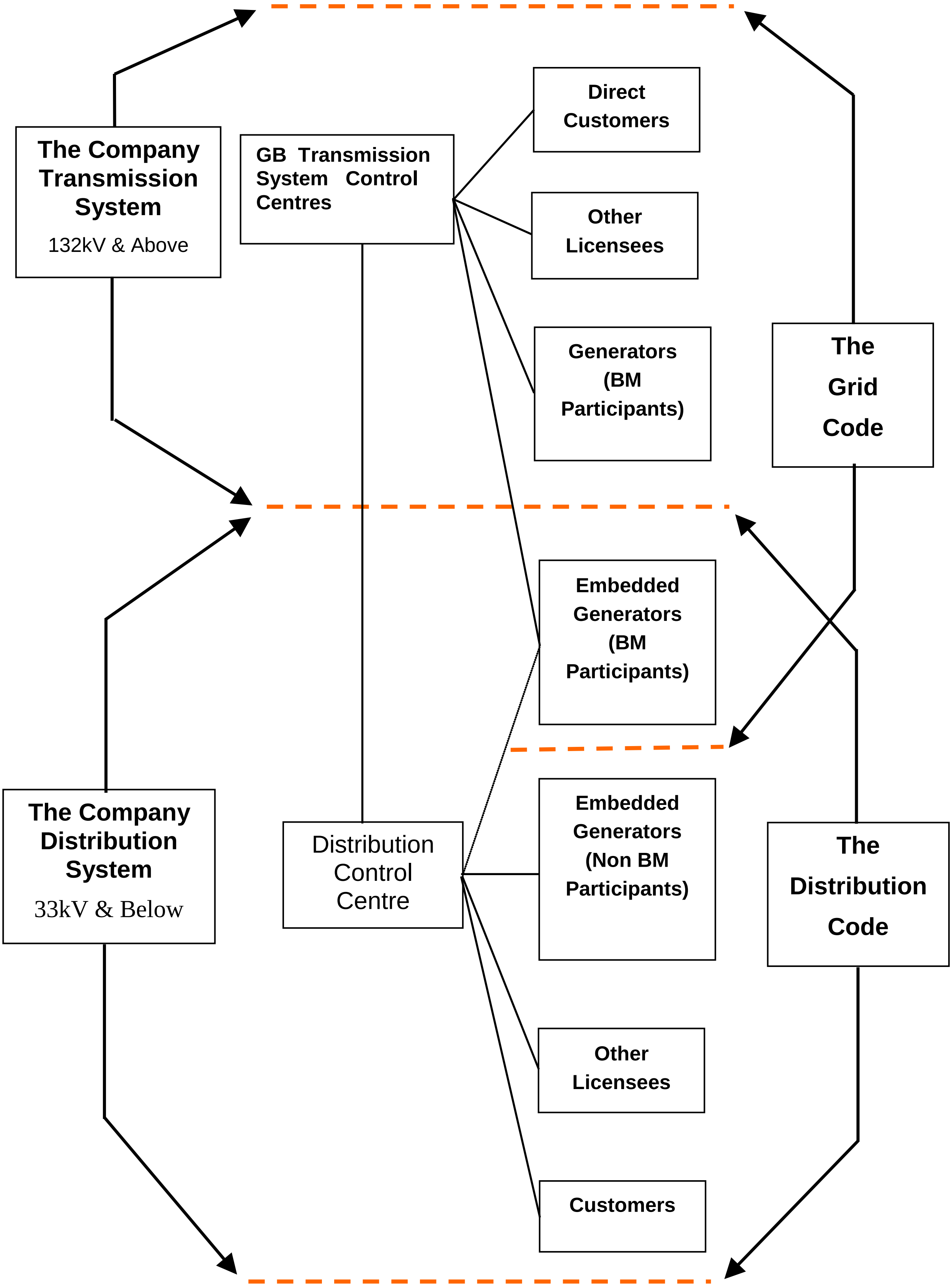
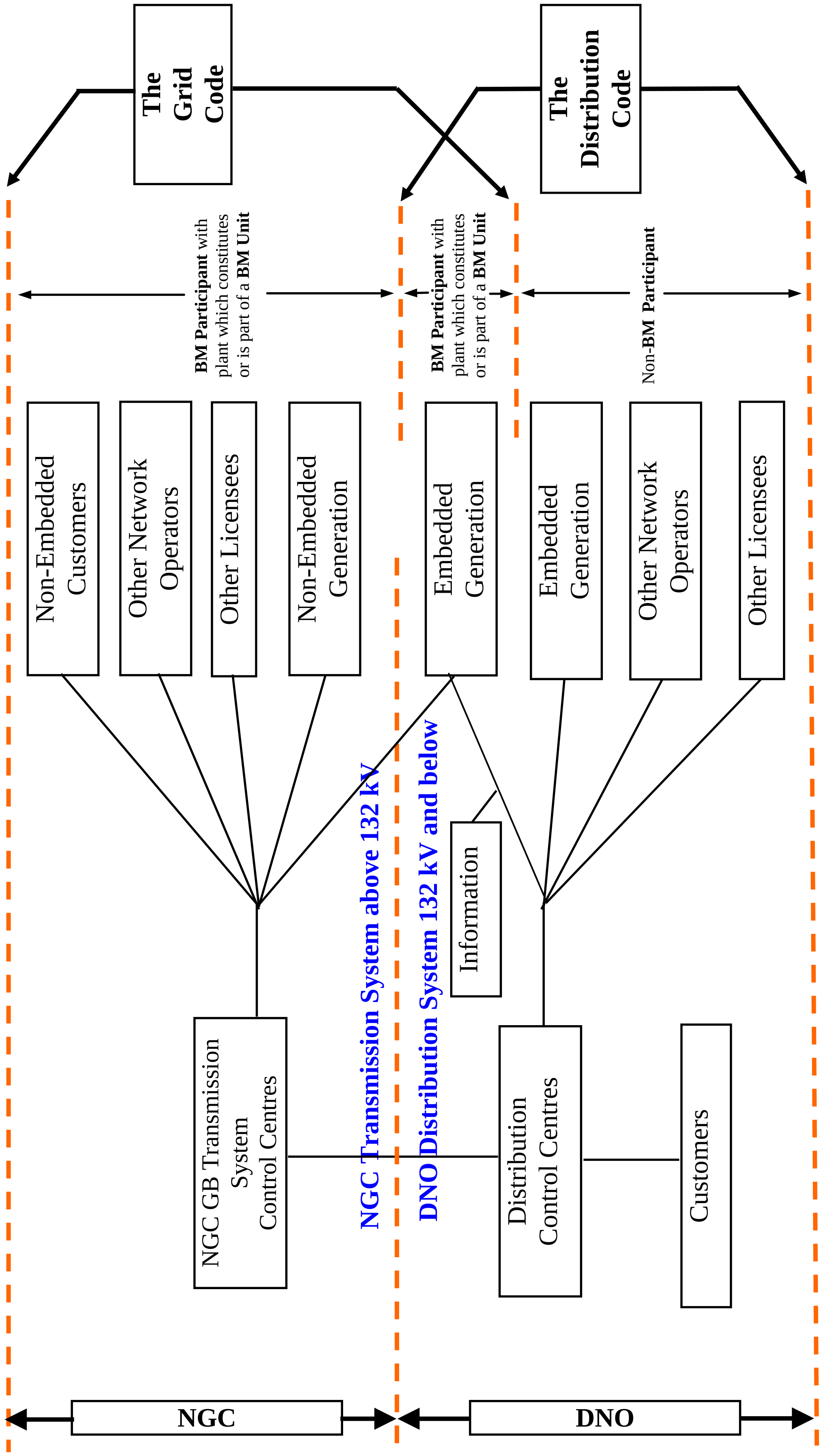


FIGURE 1B - GRID CODE **&** DISTRIBUTION CODE **BOUNDARIES (ENGLAND AND WALES)**



APPENDIX 1 - CATEGORIES OF USERS OF THE DISTRIBUTION SYSTEM

Category A Users are those having a connection at 1 kV or above (HV)

A1. Embedded Generators including CWOGs having an output capacity of 1 MW and above.

A2. Embedded Generators including CWOGs having an output capacity of less than 1 MW.

A3. Customers without generation having a Demand of 5 MW and above.

A4. Customers without generation having a Demand of less than 5 MW.

The classification threshold of 5 MW is related to the obligations that a **DNO** has for providing aggregated **Demand** information to NGC. Generators are further classified by voltage of connection and capacity for the purposes of technical standards.

Category B Users are those having a connection at below 1 kV (Low Voltage)

B1. Embedded Generators (including CWOGs) irrespective of capacity of fuse(s) or other Protection device(s).

B2. Customers who are the sole Customer with a connection to the Low Voltage side of a High Voltage to Low Voltage transformer, irrespective of the capacity of fuse(s) or other protection device(s).

B3. Customers without generation and having a single or three phase supply protected by fuse(s) or other device(s) rated at more than 100 amps.

B4. Customers without generation having a single phase or three phase supply protected by a fuse(s) or other device(s) rated at 100 amps or less.

B5. Customers with Unmetered Supplies.

B6. Customers who have connected a Generation Set in accordance with ER G83/2 and where this is their only Generation Set.

C. Suppliers including licence exempt Suppliers, unless otherwise stated.

D. Other Authorised Distributors connected to the DNO’s Distribution System, being licensed or licence exempt Distributors.

E. Meter Operators (This Distribution Code does not place any direct obligation on Meter Operators other than through the appointment by either a Supplier or a Customer.)

SECTIONS OF THE DISTRIBUTION CODE APPLYING TO PARTICULAR CATEGORIES OF USERS OF THE DNO'S DISTRIBUTION SYSTEM

CATEGORY OF USERS

D Code Ref	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	C	D	E
DGC	D	D	D	D	D	D	D	D	D	D	D	D	D
DPC1	R	R	R	R	R	R	R	R	R	R	R	R	R
DPC2	R	R	R	R	R	R	R	R	R	R	R	R	R
DPC3	R	R	R	R	R	R	R	R	R	R	R	R	R
DPC4	D	D	D	D	D	D	D	D	D	D	R	D	D
DPC5	D	D	D	D	D	D	D	D	D	D	R	D	D
DPC6	D	D	D	D	D	D	D	X	X	R	R	D	D
DPC7	D	D	X	X	D	X	X	X	X	R	R	D	X
DPC8	D	D	D	D	X	X	X	X	X	X	R	D	X
DOC1	D	X	D	X	X	X	X	X	X	X	D	D	X
DOC2	D	X	D	X	X	X	X	X	X	X	D	D	X
DOC5	D	D	D	D	D	D	D	D	D	R	D	D	D
DOC6	D	D	D	D	R	R	R	R	R	R	D	D	X
DOC7	D	D	D	D	X	X	X	X	X	R	D	D	X
DOC8	D	D	D	D	D	D	D	D	D	R	R	D	D
DOC9	D	D	D	D	R	R	R	R	R	R	R	D	R
DOC10	D	D	D	D	X	X	X	X	X	R	D	D	X
DOC11	D	D	D	D	D	D	D	X	D	X	X	D	D
DOC12	D	D	D	D	D	D	X	X	X	R	R	D	X
DDRC	D	D	D	D	D	X	X	X	X	R	D	D	X

X Not applicable.
D Applicable with specific obligations.
R Relevant for information but no specific obligations.

APPENDIX 2 – ELECTRICITY SUPPLY INDUSTRY STANDARDS NOT IMPLEMENTED VIA THE DISTRIBUTION CODE BUT HAVING A MATERIAL AFFECT ON USERS

Copies of the Engineering Recommendations and Technical Specifications and other documents in this Appendix are available from the Energy Networks Association, 6th Floor, Dean Bradley House, 52 Horseferry Road, London SW1P 2AF, **www.energynetworks.org**.

1 **Engineering Recommendation G81** Framework for design and planning, materials specification and installation and record for Greenfield low voltage housing estate installations and associated, new, HV/LV distribution substations.

2 Energy Networks Association – Distributed Generation Connection Guide, (Parts 1, 2 and 3).

3 Engineering Technical Report 130-1

Application Guide for assessing the Capacity of Networks Containing Distributed Generation

4 **Engineering Technical Report 131**

Analysis Package for Assessing Generation Security Capability – Users' Guide

5 **Engineering Recommendation P18**

Complexities of 132kV circuits.

5 **Engineering Recommendation G87**

Guidelines for the Provision of Low Voltage Connections to Multiple Occupancy Buildings

ISSUE SUMMARY

No.	Date	Details of Change
1	01/10/02	This is the **first issue** of the Distribution Code for Great Britain. The D Code has been formed from an amalgamation of the pre-existing Scottish (Issue 4), and England & Wales (Modification 13) D Codes. There are no deliberate policy changes introduced in this first issue of the GB code: the drafting reflects the requirements existing in both forerunner codes. However there are changes to the wording from both codes necessary in adopting a common text. These changes have been kept to a minimum consistent with developing a common Distribution Code for Great Britain. The detail of these changes from the forerunner codes was publicly consulted on as part of the process of introducing the Distribution Code for Great Britain. Where there are technical, regulatory or institutional differences between Scotland and England & Wales the drafting has preserved these differences in the combined code where necessary.
2	01/03/03	Annex 1 amended to recognize that ER G75 has been re-issued as ER G75/1.
3	01/09/03	Modifications in respect of data requirements for **Embedded Generator**s **–** particularly: • the addition of new DPC1.6 and DPC1.7; • additions to DPC4.5.1; • new DPC5.1.2; • modified DPC7.3 and new DPC7.3.4 Modifications to the **Distribution Data Registration Code**
4	01/03/04	Introduction of ER G83/1 governing the connexion of small scale generation. Minor changes to definitions of **Embedded Generator** and **Generator**, plus new note in DPC7.1.3 and minor explanatory notes in 5.4.5 and Appendix 1 of the Guide. Rationalization of use of **Embedded Generator** and **Generator** throughout the text. Modification to the following clauses for the consequential changes attendant on the replacement of the Electricity Supply Regulations with the Electricity Safety, Quality and Continuity Regulations: DPC4.2.2.1; DPC4.2.2.2; DPC4.4.2; DPC4.4.4; DPC5.2.1; DPC5.3.4; DPC5.4.3; DOC5.4.8; DOC10.1.1; DOC10.4.5.1
5	01/08/04	Governance of Standards Modification to: Glossary and Definitions: addition of Annex 1 Standard; Appendix 1 Standard; Individual DNO Standard; Qualifying Standard. new DGC 4.2 (g) & (h) DGC 4.4

		House keeping Changes to: DPC 5.4.1 (and Guide 2(e)) and DPC 5.4.3

6	01/04/06o	Modifications for BETTA and LEEMPS Significant definitional and consequential changes to harmonize with BETTA and GB Grid Code drafting. Licence Exempt Embedded Medium Power Station drafting including: • New definition of a DC Converter • Modifications to DPC7.3.3 in relation to data requirements • Addition of new section DPC7.5 relating to data and connexion requirements • Addition of new Section DOC 5.6 in relation to compliance testing of Medium Power Stations
7	01/07/06	Replace ER P2/5 with ER P2/6 and the following consequential changes: • Addition of ETRs 130 and 131 to Appendix 2. • Harmonization of lower limit for DDRC Schedules 6 & 7 at 1MW Replace ER G5/4 with ER G5/4-1 in Annex 1 and in DPC 4.2.3(b)
8	01/11/06	Modify the definitions of Large, Medium and Small Power Stations to align with changes to the GB Grid Code.
9	01/06/08	Minor housekeeping corrections to DGC6.1 and DOC 1.1.5 to point to DGD 2(vi). Replace references to G83/1 with references to G83/1-1
10	15/12/08	Modified to include IDNOs in governance of the D Code. Primarily mods to DGC4. Gas and Electricity Consumers's Committee changed to NCC in accordance with Ofgem directive of 1 October 2008.
11	24/06/09	Modified for Offshore Transmission. New definitions of : Embedded Transmission Licensee Embedded Transmission System Existing Offshore Generators Great Britain National Electricity Transmission System National Electricity Transmission System Demand Offshore Offshore Transmission Implementation Plan Offshore Transmission System Operator Offshore Transmission Licensee Offshore Transmission System

		Onshore Transmission Licensees Onshore Transmission System SHETL SPT and consequential amendments. Various changes to the code to ensure that conceptually an embedded transmission system, ie an offshore transmission system connecting to a DNO network is treated like a Large Power Station for planning and operating purposes. Note that for safety interfaces etc, the offshore transmission network is treated in the code in the same way as an existing onshore transmission interface.
12	01/02/10	Addition of revised ENA TS 41-24 to Annex 1
13	01/08/10	Revised for updated requirements for the connexion of embedded generation. Revision to the definition of **System Stability** Replacement of Annex 1 Item 3 with ER G59/2 Removal of Annex 1 Item 4 ER G75/1 Addition of new document to Appendix 2 - ER P18. New section DGC11 DPC4.2.3 re-organized and amended to include the treatment of voltage step changes. New DPC4.4.1(f) citing ER P18 as a limit on 132kV system design complexity. New DPC 7.1.4 dealing with short term paralleling requirements New DPC7.2 section dealing with operational requirements transferred from G59 New DPC7.4.3section dealing with protection requirements, mainly transferred from G59 Modified DPC7.4.4 for fault ride through requirements New DPC 7.4.5 for system stability requirements mainly transferred from ER G75/1 New DPC 7.4.6 on earthing, largely incorporating requirements from G59 New DPC7.4.9.2 detailing requirements for commissioning tests Review and updating of DDRC schedules.
14	01/02/11	Changes to DGC4.5 and Constitution and Rules to require consideration of greenhouse gas emissions. Update to Appendix 2 Item 2, the Distributed Generation Connexion

		Guide
15	12/04/11	Inclusion of Guidance Note 2 in the published version of the D Code Revision of G59/2 to G59/2-1 in Annex 1
16	01/08/11	Addition of ER G87 Guidelines for the Provision of Low Voltage Connections to Multiple Occupancy Buildings to Appendix 2 of the Guide to the Distribution Code
17	07/10/11	Minor amendments to Guidance Note 2.
18	29/03/12	Minor amendments to Guidance Note 2.
19	01/11/12	Replace G83/1-1 with G83/2 and update Guidance Note 2. Add Guidance Note 3
20	01/09/13	Modifications to the protection requirements in 7.4.3.4 to align with G59/3
21	01/01/14	Modifications to DGC to implement the Code Adminstrators' Code of Practice. Modification to DIN 2.1 to implement EU Third Package requirements. Minor housekeeping changes to definitions of Distribution Data Registration Code and Distribution Code Review Panel to correct typographical errors.
22	01/02/14	Modification to Annex 1 to note the change from ER G12/3 to ER G 12/4
23	01/08/14	Modification to DPC 7.4.3.3 and DPC 7.4.3.4 to increase RoCoF protection settings to provide greate Total System stability
24	21/08/14	Modfications to DPC 7.4.2 and Schedules 5a and 5b to accommodate additional reporting of Small Generator data to National Grid
25	21/08/14	Modfications to DOC2.2 and DOC2.4 to relect EU Transparency Regulations on demand customers >100MW Housekeeping amendments to: • DOC 6.1.3 (Electricity Supply Emergency Code nane change) • Amended DGC 4.3(d) to replace National Consumers' Council with Citizens Advice. • Update of reference to ETR130-1
26	31/07/15	Replace EREC G59/3-1 with EREC G59/3-2 in Annex 1

END