

Generator Connection Requirements – a review of Engineering Recommendation G59/2-1 (2011)

A consultation paper by the Great Britain Distribution Code Review Panel

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1. BACKGROUND

Engineering Recommendation (EREC) G59/2-1 (Recommendation for the connection of generating plant to the distribution systems of the licensed distribution network operators) 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 and with a minor revision in 2011.

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 G59/2 provision was made for the Type Testing of Generating Units of up to 50kW or 17kW per phase generally in line with ER G83/1-1. In practice this process has not been particularly helpful as the requirements for site testing and witnessing of these on site tests in G59/2 were common across all Generating Unit sizes.

The publication of EREC G59/2 introduced new protection settings which were out of line with those in EREC G83/1-1, particularly the over and under frequency settings and hence there was a discrepancy between the requirements of EREC G59/2 and the suggested Type Testing in the same document. It was recognized that EREC G83/1-1 would need to be revised to meet the request from National Grid Electricity Transmission (NGET) to raise the over frequency settings for all embedded generators. In addition this discrepancy between the requirements of ERECs G59 and G83 caused difficulties where installations comprised several small Generating Units which if installed singly came under EREC G83 but when combined at a single site fell under EREC G59. It was apparent that aligning the protection requirements of ERECs G83 and G59 would be advantageous and a working group was set up and has produced a revised document EREC G83/2 which was published on the 1st December 2012.

In developing EREC G83/2 most of the protection settings were taken directly from EREC G59/2-1 however the over and under voltage protection settings in EREC G59/2-1 allowed some leeway in selection of the nominal voltage ie between 230V and 240V. While calculation to match the site voltage is possible when using protection relays which can be set on site it causes difficulties with Type Tested Generating Units where it is preferable that they installed without modification on site. The G83/2 working group dealt with this problem by basing the LV voltage protection settings at a fixed value of 230V to match the nominal system voltage which is common across Europe. In order to prevent issues with Generating Units tripping, due to high voltages caused by voltage rise within the customers own installation in addition to the maximum voltage at the supply terminals of 230V +10% the overvoltage setting range was increased to 230V plus 14% for stage one and 230V plus 19% for stage two. In order to finally bring together the protection settings for ERECs G59 and G83 a corresponding change is required in EREC G59.

EREC G83/2 also improved the Type Testing requirements to include stability tests for voltage, frequency, rate of change of frequency and voltage vector shift. These stability tests give a better assurance that the Generating Units will stay connected to the System during voltage and frequency disturbances which may be caused by faults on adjacent circuits or due to the loss of large amounts of generation or load on the GB grid. In this respect EREC G83/2 went ahead of the EREC G59/2-1 requirements but fulfilled the requirements of NGET more effectively than EREC G59/2-1

The Distribution Code Review Panel agreed at the Panel meeting of 3 March 2011 that the review of EREC G59/2-1 should be undertaken and the agreed terms of reference are attached as annex 1. For a period of time the G83 revision working group worked in parallel with the G59 revision working group and many organizations had the same representative on both working groups.

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

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

Further explanation and reasoning for the changes from EREC G59/2-1 to EREC G59/3 can be found in Appendix 4.

2.1. Clarification of the defined terms with EREC G59

A new defined term “Installer” has been added to section 4 Terms and definitions. In addition further clarification of “Generating Unit” and “Power Station” has been provided and the term “Type Tested” has replaced “Type Verified”. These changes bring EREC G59 into line with EREC G83/2

2.2. Connection application and commissioning procedures

In section 6 there is a table which was un-identified in EREC G59/2-1 which split Generating Units in to 3 categories. This has been extended to 5 categories which are easier to follow and comprise sub 16A both EREC G83/2 compliant and not EREC G83/2 compliant. A Power Station of above 16A per phase but under 17kW per phase or 50kW Type Tested. Power Stations above 50kW using Type Tested Generating Units, and above 16A per phase not using Type Tested Generating Units. This table is now identified as section 6.1.0

2.3. 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

In order to simplify the connection and commissioning procedure for Power Stations in this range which fall in general under the same envelope as EREC G83/2 Power Stations in terms of the Micro-generation Certification Scheme (MCS) requirements a simplified application form has been produced which allows the Installer to make the application for connection and to complete the commissioning. This means that the process can be carried out without the active engagement of the Customer who will become a Generator at the end of the process. This is in line with the procedure under EREC G83/2 and is the primary change which helps to meet parts 1 to 7 of the terms of reference.

2.4. Connection and Commissioning Procedure for Power Stations above 50kW which use Type Tested Generating Units only

The connection procedure for power stations of this size has not changed. However a simplified Commissioning procedure has been identified which reduces the need for on-site testing but which ensures that the other commissioning requirements are carried out correctly. This is the primary means to meet part 8 of the terms of reference.

2.5. Voltage Unbalance

In EREC G59/2-1 the requirements to consider voltage unbalance was referenced in 9.6.5 of the document. This requirement remains but in order to give guidance to Installers about how to achieve this, an additional section 7.5 has been added in EREC G59/3 defining the maximum amount of unbalance which can be accepted in the output of a Power Station of 50kW or less at any time. This has been set at 16A as the difference between the highest and lowest rated output at any time. In order to give examples of the required calculations a new Appendix 13.10 has been added. It is expected that Power Stations above 50kW will use balanced 3 phase Generating Units

2.6. Generation capacity for single and split phase supplies

EREC G59/2-1 did not specify what could be connected on single and split phase connections on LV networks, though it did imply that 17kW per phase was acceptable. While the value will vary with the network an upper limit has been given in section 7.6 of 17kW for single phase connections and 34kW for split phase connections. Provision has been made for a DNO to relax these requirements in areas where the provision of a three phase supply would be more expensive than normal. This will prevent the

installation of very large Generating Units at single phase which could cause problems with unbalanced loading of LV networks. This aligns with the 17kW limit that had already been introduced in EREC G59/2.

2.7. Generating Unit performance requirements for Type Tested Units

EREC G59/2-1 had requirements for Generating Units to stay on line during certain conditions. However the Type Testing procedure which had been copied from EREC G83/1-1 did not include any tests to ensure that Generating Units would achieve this. A series of performance requirements have been added in EREC G59/3, section 9.3.7 and these are in line with the performance requirements included in EREC G83/2

2.8. Over and Under Voltage Stability Tests

These are specified to ensure stable operation within the specified ranges and with tolerance margins to cover measurement errors. The tests are in line with EREC G83/2

2.9. Frequency Drift and Step Change Stability Test.

EREC G59/2-1 did not specify a requirement for the Frequency Drift and Step Change Stability Test but attempted to ensure that Generation Units would not trip by defining protection settings. Under normal operation of the network, the frequency changes over time due to changes in load, or a step change can result due to the loss of a network component which does not cause a loss of supply. In order to ensure that these conditions do not cause un-necessary tripping of Type Tested Generating Units, a stability test is required to be carried out. This test has now been included in the main text of EREC G59/3 and the relevant Appendix 13.1 Type Test documentation and is in line with EREC G83/2.

2.10. Requirements to comply with ERECs G5/4 and P28

The working group noted that these are Planning standards for use by the DNOs. In order to define what can be Type Tested equipment standards are needed and for Flicker and Harmonics the relevant standards are BS EN 61000-3-11 and BS EN 61000-3-12 and these have been incorporated into the Type Test requirements and the Type Test documentation in such a way that the data is presented in a suitable format for DNOs to complete their studies using ERECs G5/4 and P28. This is in line with EREC G83/2. It should be noted that both EREC G5/4 and P28 are undergoing revision at the moment and that P28 published in 1989 is in some respects out of line with the BS EN 61000 series documents in terms of flicker measurements.

2.11. DC injection requirements

These have been moved to the Power Quality section of the document. They were in the Type Testing section only but with no reference to the requirement elsewhere.

2.12. Protection Settings

In EREC G59/2-1 the voltage protection settings did not align with the two stage protection settings prescribed in EREC G83/2. EREC G59/3 protection settings are now aligned with EREC G83/2 and they are based on a nominal voltage of 230V with stage 1 over voltage set at 230v plus 14% and stage 2 set at 230v plus 19%. In order to tie in with EREC G83/2 the overvoltage stage 2 setting may operate quickly to protect the device and if the voltage returns to within the protection setting before a trip signal is initiated then generation can resume immediately.

2.13. Under and Over frequency requirements

The references about these requirements were erroneously to the Grid code, however these requirements are specified in the Distribution Code for Small Power Stations and therefore the reference has been changed and now identifies the section of the Distribution code which applies DPC7.4.1.3

2.14. Guidance on the selection of LV settings for non-standard LV networks

It became clear as the work progressed that some private LV networks were not run to the same standards

as DNO networks which are normally run with the aim of keeping the voltage as high as possible within the allowable operating range. In these cases the standard LV settings were not suitable and a method of calculating alternative settings based on the HV settings has been set out to deal with this. Typical non-standard LV networks are where they are designed for 220V operation or where they have 340V phase to phase balanced LV networks with no neutrals.

2.15. Requirement to see the protection settings on site

A new section 10.5.17 has been added to EREC G59/3 to define how the manufacturer of a Type Tested product must show the protection settings for inspection. This is in line with EREC G83/2

2.16. Short Circuit Current Contribution

EREC G59/2-1 prescribed a single generic approach for the testing requirements for Short Circuit Current Contribution. EREC G59/3 now prescribes separate tests for directly connected Generation Units in line with EREC G59/2-1 requirements but also a separate test for Inverter connected Generating Units recognizing that they operate in a different manner to directly connected machines and that the conventional model cannot be used for Inverter connected machines.

2.17. Requirements for a Responsibility Schedule

These have been eased for Power Stations of up to 50kW or 17kW per phase so that all the data required is captured in the application and commissioning forms, and the requirements for a system drawing to be left onsite and sent to the DNO. There is therefore no need for a separate Site Responsibility schedule.

2.18. Changes to the Commissioning process

These are detailed above in points 2.2 to 2.4 but if reading the document then the changes are apparent in section 12 as well as in section 6

2.19. Revised Forms

Following feedback from stakeholders that the ENA common application form could be improved, and included many items which were not appropriate or relevant to small scale inverter connected generators, the WG has developed a new form for Application for Connection for Power Stations of less than 50kW, Commissioning Confirmation and Commissioning test recording, and Decommissioning. A new Type Testing Verification Sheet has also been developed which now includes a Manufacturers declaration that all products supplied to the same specification will meet the requirements of EREC G59/3. This is in line with the requirements of EREC G83/2.

2.20. Type Testing Annexes

The Annexes A13.1 and A13.2 have been removed and replaced with three new Annexes covering Type Testing, Commissioning of all Generating Units and additional site testing required for Generating Units which are not type tested.

2.21. Simplified application form

A simplified application form has been created for Power Stations of up to 50kW or 17kW per phase.

2.22. Ride through or Stability tests for Generating Units above 50kW

Currently there is a practical cut off for type testing at around a unit size of [50]kW. Test laboratories in general do not have facilities to test larger unit sizes. It might be that this is fertile future work, particularly following the introduction of the European Network Codes which will also require type testing regimes for generators.

3. REVISION TO THE GREAT BRITAIN (GB) DISTRIBUTION CODE

As a consequence of the revision to G59/2-1 there has been a need to also revise sections DPC7.4.3.4 and DPC7.4.3.9 of the GB Distribution Code. An amendment has been made to the definition of Registered Capacity to include clarification of inverter ratings. A copy of the revised GB Distribution Code v20 is available for comment as part of this G59/3 public consultation pack.

4. DEVELOPMENT OF REVISED APPROACH

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

4.1. Establishment of WG

As explained in section 1.1 *Drivers for Change* this work originally started as a ENA ENFG project to review the Type Testing aspect of G59/2-1 and to develop a separate ENA Type Testing Guide. This guide would be provided as an addendum to G59. In parallel a DCRP WG was reviewing EREC G83. Most of the members of the DCRP G83/2 WG were members of the ENA Type Testing WG who were also working on the G59/2 Type Testing Guide.

The first meeting of the Type Testing WG was held in September 2011. At that first meeting it became fairly obvious that to produce a Type Testing guide some minor revision was certainly needed to G59/2. In addition as a consequence of the G83/1-1 revision work there was a need to align G59 to G83/2 as explained above in section 2. Effectively the G59/2 Type Testing WG morphed into a full EREC G59/2 revision group.

The Type Testing/G59/2 WG comprised of all the DNOs and also includes one representative of the independent DNOs who is also ensuring that his IDNO colleagues are fully aware of the work. The WG has also included direct representation from the Renewable Energy Industry including installers and manufacturers through Envance Wind, Froinius, Gendrive, Gaia Wind, Renewable UK, SMA and Sundog Energy.

The DCRP has been regularly kept informed of progress during the revision work and the progress recorded in the minutes of the DCRP meetings which are available on the DCode website.

A full list of all the organisations represented on the WG, can be found in appendix 2.

The development of the draft G59/3 commenced in September 2011 and following six WG meetings was completed in October 2012.

5. CONSULTATION

- 5.1. Published with this consultation paper are drafts of ER G59/3 and the revised Distribution Code.
- 5.2. Comments are welcome on any aspect of the new G59/3 or, of the modified Distribution Code, or on this consultation paper. Comments should be returned on the MS Word proforma "1001 comment table.doc" which is available on the DCRP website (www.dcode.org.uk).
- 5.3. Comments should be sent to DCRP Secretary, David Spillett at the ENA (david.spillett@energynetworks.org) **by Tuesday 7th May 2013**. 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

G59/2 working group on type testing of generators up to 50kW three phase or up to 17kW per phase for single and split phase applications.

Terms of Reference

Background

G59/2 issued in August 2010 and updated as G59/2-1 in April 2011 makes provision in chapter 12 sub section 2 for the development of type testing to be undertaken for machines up to 50kW three phase and up to 17kW per phase for single and split phase supplies.

Representatives of the DNO's met in October 2010 at the ENA offices in London and agreed to proceed with a working group to develop a Type Testing Guide along with generator manufacturers. A meeting was held with generator manufacturers and installers on the 22nd December 2010 but no further direct work has been carried out since then. A DCRP working group is now working on a revision of G83/1-1, with a view to producing G83/2 by the spring of 2012. It has made progress on many of the related issues which will need to be tackled in developing type testing for G59/2.

Proposal

A working group has been set up with members drawn from the following interested parties.

DNO's, including IDNO's

Micro generator manufacturers, including inverter manufacturers

Micro generator installers, specifically wind and PV need to be represented though installers of other technologies could provide useful insights into their particular issues.

Terms of Reference

The working group will review G59/2-1 chapter 12 section 2, Appendices A13.1, A13.2, A13.7 and protection settings in table 10.5.7.1 to ensure that they meet the following objectives, and where required provide additional guidance to manufacturers, installers and DNO's on best practice in type testing and the use of type tested products up to 50kW three phase and 17kW per phase for single and split phase supplies. Where identified by the WG recommendations may be requested of the DCRP to consider revision to other documents such as D Code or other annexed/appendix documents e.g G59/2 .

1/ The working group will work with the G83 revision group to ensure that where an installation under G59/2-1 comprises multiple machines type tested to G83/2 no additional type testing will be required.

2/ Work with the G83 revision group to establish a system of recording of type testing results and the provision of these to interested parties.

3/ Allow the generator manufacturers to produce products which can be installed by competent persons but which do not require significant testing, or any modification of protection settings on site.

4/ Allow the installer to provide data to DNOs, in a straight forward and relevant format that is sufficient for the DNO to assess the application for connection of a generator at a particular site.

5/ Allow DNOs to quickly assess the impact of the proposed generator on the network and produce a connection offer to the customer who will operate the generation once it is installed.

6/ Allow the installer to install, commission and place in to service, the generating plant provided that it meets with the requirements of the connection offer, and confirmation has been received from the DNO that any reinforcement work required and specified in the connection offer has been completed.

7/ Ensure that the DNO is made aware of the commissioning and placing in to service of the generating plant, within an appropriate time scale.

8/ Identify if the type testing approach can be extended above 50kW, or if alternative arrangements to ensure the quality, and adequacy of an installation above 50kW would be more appropriate. An alternative way forward would be to authorize individuals to manage the installation and testing of an

installation, possibly in two stages, LV only up to 1000kVA, HV up to 33kV. If alternative means of ensuring quality and adequacy of installations are thought more appropriate to recommend a way forward. This might require the establishment of a further working group to allow this groups recommendations to be put in place as soon as is practicably possible.

In addition the working group will provide guidance on allowable unbalance in generation output as the current G59/2-1 and the distribution code imply, but do not state an absolute requirement to balance generation equally across all available phases. While this is good engineering practice, is not practicable in some cases, for example where there are two areas available for PV and it would be uneconomic to provide balanced 3 phase inverters for both areas.

The output from the working group to be made available for consideration by the DCRP on the 31st March 2012 to allow implementation at the same time as the revised G83/2

APPENDIX 2 - G59/2 TYPE TESTING WORKING GROUP MEMBERSHIP

Ceres Power Ltd – CHP Installer

Electricity North West – DNO

Evance Wind – Turbine Manufacturer

Fronius – Inverter Manufacturer

Gaia Wind – Turbine Manufacturer

Gendrive – Inverter Manufacturer

Inexus – IDNO

G59 Testing (Inspection/Testing Certification/Inspection)

Intertek - (Inspection/Testing Certification/Inspection)

Northern Powergrid – DNO

Power One

ScottishPower – DNO

Scottish & Southern Energy Power Distribution– DNO

Solarcentury - Installer

Sundog Energy – Installer

UK Power Networks – DNO

Western Power Distribution – DNO

APPENDIX 3 – FURTHER EXPLANATION AND REASONING FOR THE CHANGES FROM EREC G59/2-1 TO EREC G59/3

Page 4	Contents	New sections added at 7.5 and 7.6 details in main text figures 8.1 to 8.9 and 10.1 to 10.6 removed from title page they are still In the document ~Section 12 titles changed and section 13 number and titles of appendixes changed
Page 5	Foreword	New forward added to G59/3
Page 6	Scope 2.1	Updated to reflect update of G83 including note 1
Page 7	Scope 2.3	Updated to reflect update to G83/2 this applies to all references to G83 in the rest of the document.
Page 7	Scope 2.9	New section added to point out that Shetland grid is not the same as the GB grid
Page 8	Normative references	New paragraph added
Page 8	Statutory requirement	Added to meet ENA standard document template requirement
Page 8	Standards publications	Added to meet ENA standard document template requirement
Page 9	EREC G5 (Currently under revision)	Added to point out that this may change during the consultation period for the revised G59
Page 9	EREC G83/2	Updated Reference
Page 10	Terms & Definitions	Modified to meet ENAs new document template style.
Page 12	New Definition – Generating Unit	Generating Unit and Power station are used in preference to Generating Plant within

		<p>the updated sections of G59/3 rather than the use of Generating Plant.</p> <p>The definition has been expanded by adding the section in brackets.</p>
Page 12	New Definition - Installer	This new definition is required to keep compatibility with the wording in G83/2 and allow the document to be read more easily. It is used in the sections applying to type tested generators.
Page 13	Definition - Power Station	Power Station and Generating unit are used in preference to the term Generating Plant in all updated sections. Sentence added to the definition to make it clear that a single Generating Unit counts as a Power Station.
Page 14	Definition – Type Tested	New definition to replace the previous definition entitled Type Verified. This has been done to tie together the procedures in G83/2 with those for type tested equipment in G59/3
Page 17	Connection Application 6.1 General	Significant re-arrangement of this section has taken place it is not always possible to identify new from altered or moved sections it is recommended that the whole section is considered as a whole new section.
Page 18	Connection Application 6.1 General – Reference to Power Station Capacity	Makes it clear that aggregate capacity defines the requirements not what is being added
Page 18	Connection Application 6.1 General – Reference to only new plant that will be required to meet the current standards	Avoids retrospective upgrading of plant.
Page 18	Table – Power Station capacity	The table has been expanded to 5 columns to cover all possibilities
Page 18	Table – Power Station capacity – Reference to section 12.1.4	<p>Section 12.1.3 states what the installer has to do to commission the equipment and Section 12.1.4 states that normally the DNO would not wish to witness the commissioning of the plant.</p> <p>Text of Section 12.1.4 is repeated here “ The DNO will not normally choose to witness the commissioning tests. Where they do choose to witness the commissioning</p>

		<p>they will advise this as part of the connection offer and may make a charge for this. Possible reasons for witnessing may include:</p> <p>a) A new installer with no track record.</p> <p>b) Check on quality of installation either on a random basis or as a result of problems which have come to light from previous installations.”</p>
Page 19	Section 6.1.1 Less than 16A per phase and ER G83 compliant Generating Unit(s)	Essentially the same as the old Section 6.1.3 but renumbered to bring the document in to line with the table ie this is first in the table. Then the next sections follow on in order with the last two columns covered by 6.1.4.
Page 19	Section 6.1.4 Not Type Tested or larger than 50kW 3 phase (or 17kW 1 phase Generating Unit)	<p>The old sections 6.1.4 and 6.1.5 have been changed to reflect the new table and sections 6.1.2 to 6.1.4 cover the new arrangements. The old section 6.1.6 with regards Amalgamations and additions has been moved to the 4th paragraph of section 6.1 as it fitted better there than where it was.</p> <p>The WG have also made a significant change in that DNOs only require the new plant to meet the new requirements ie there is no need to upgrade existing plant. This is important as we have included some new stability tests for new type tested plant so just changing protection setting would not bring the generating plant up to standard</p>
Page 19	Section 6.2 Application for Connection	Significant re arrangement of this section has taken place it is not always possible to identify new from altered or moved sections. It is recommended that the whole section is considered as a whole new section.
Page 20	Section 6.2.2 Less than 16A per phase and ER G83 Compliant Generating Unit	G83 referred to rather than a particular version of G83 as the existing reference to G83/1-1 would strictly be out of date when G83/2 was published.
Page 20	Section 6.2.4 Power Stations >16A per phase but ≤ 50kW 3 phase (or 17kW 1 phase) comprised of Type Tested Generating Units to G59 or G83/2 or later versions of G83 but not G83/1-1.	Sections 6.2.4 and 6.2.5 replace the old section 6.2.4 and expand on the requirements for type tested equipment in the new section 6.2.4 Note that it also allows the use of multiple G83 type tested units. This was on the basis that G83/2 would have been published in April 2012 but G83/1-1 is excluded as the protection settings are unsuitable for a G59 installation.
Page 21	Section 6.3 - System Analysis for Connection Design	No change to section 6.3

Page 23	Section 7.1.1 - Operating Modes – New reference to Voltage Management Unit	New requirement not apparent at the time G59/2 was written. Use of voltage management units could allow generating units to stay on line even with very high voltages being fed back in to DNO networks section 7.7 outlines why but the reference here in section 7.1.1 is to make sure that it is identified early on.
Page 23	Section 7.3 - Infrequent Short-Term Parallel Operation	No changes made to any part of section 7.3
Page 25	Section 7.4 - Switched Alternative-Only Operation	No changes made to any part of section 7.4
Page 27	Section 7.5 - Balance of Generating Unit Output at LV	This is a new section and while some parts have been moved from elsewhere most of it is new in order to clarify the requirements to balance the generation to within reasonable limits. G59/2-1 could be read as requiring only balanced 3 phase generators or could be read that the DNO must always be approached and carry out a study. Both DNO and installer sides thought that these options were too onerous and that guidance should be given to what would normally be acceptable to DNOs so that the installer could make sensible decisions before approaching the DNO and the DNO could in most cases avoid having to carry out expensive studies the costs of which are then passed to installers.
Page 27	Section 7.6 - Generation capacity for single and split phase supplies at LV	This is a new section again to give installers information about what is likely to be acceptable to DNOs in terms of connection options in section 7.6.1.
Page 28	7.6.2	New section to allow the use of single phase inverters without requiring expensive intertripping should there be a single phase fault.
Page 28	7.6.3	Covers the requirement for a three phase inverter to disconnect all phases for a fault on one phase. Allows DNOs and installers to negotiate the use of single or split phase networks for higher capacity generation if studies shown that it will not be detrimental to total system operation and that three phase is an expensive option, without implying a right to connect large generators as single or split phase.
Page 28	7.7 - Voltage Management Units in Customers premises	This is a new clause which is self-explanatory. It was inserted due to concerns that the inappropriate use of Voltage Management Units could negate the over voltage protection settings on a Generating Unit and result in the unit continuing to operate

		with very high voltages on the DNOs LV networks.
Page 29	Section 8 - EARTHING	No change to this section or its associated drawings.
Page 41	Section 9 - NETWORK CONNECTION DESIGN AND OPERATION	Change in title to represent that this section covers the design of network connections and ongoing operation of the connection.
Page 41	Section 9.2 - Network Connection Design for Generating Plant	Title changed to more accurately reflect what the section covers.
Page 44	Section 9.3.7 - Performance Requirements for Type Tested Generating Units	<p>New section to define the required range of operation for G59 type tested devices. This lines up with the requirements in G83/2. These performance requirements are not the same as protection settings.</p> <p>Requirement to operate in a particular range of power factors allows this to be tested during Type Testing and is compatible with G83/2.</p>
Page 45	Section 9.4 - Fault Contributions and Switchgear Considerations	No changes have been made to this section but it should be noted that 9.4.4 makes particular reference to infeeds from rotating machines and does not reference the contribution from inverter connected machines. For Type Tested Generating Units an alternative description of fault contribution has been defined in line with the requirements of G83/2 but no attempt has been made to define how this should be used by DNOs as this will require further work to be carried out.
Page 48	Section 9.5.7 - 2 nd Paragraph	Note that no change has been made to this text but European standards allow 3.3% changes in steady state level and 4% step changes during the switching. These European levels have been used in the type testing for Generating Units of up to 50kW as they tie in with the requirements set out in G83/2. Relevant documents are BS EN 61000-3-3 for sub 16A and BS EN 61000-3-11 for 16A to 75A
Page 48	Section 9.5.9	Again no change has been made to this paragraph but a step change of up to 4% and of at least 3.3% would be allowed in European regulations. EREC P28 is currently undergoing revision.
Page 49	Section 9.6.2 - Flicker	Title added to aid location of section.

		All of section 9.6.2 after first paragraph is new. A small section about wind turbines referencing IEC61400-21 has been removed as its requirement is included in the new section. It has been added to clarify the requirements for Type Tested equipment and to line these up with G83/2
Page 50	Sections 9.6.2.1 & 9.6.2.2	New sub heading to aid location of text when referenced in relevant appendix.
Page 50	Section 9.6.3 – Harmonic Emissions	Title added All of section 9.6.3 after second paragraph has been added and is new to reflect the requirements for Type Tested equipment
Page 51	Section 9.6.5 - Voltage Imbalance	Title Added
Page 51	Section 9.6.6.1	New clause to make it clear that compliance with section 7.5 requirements removes the need for any further action by a Generator with a Power Station of less than 50kW. This is in line with G83/2 where it is up to the DNO to balance the network not the Customer.
Page 51	DC Injection	Moved here from testing appendix with a new section number as it is an actual power quality requirement for all generators.
Page 52	Section 9.7 – System Stability	No Change
Page 55	Section 10.1.2 – 2 nd Paragraph	New paragraph to make it clear that type tested does not apply to a protection only. Type tested units need to meet other standards with regards power quality etc. This is stated elsewhere but many people are under the impression that G59 is a protection standard.
Page 55	Section 10.1.3	New section to state in general terms that DNO may also need to fit protection.
Page 55	Section 10.2.1	Effectively from bullet “undervoltage (2stage)” to end of section 10.2.1 has been re-written with exception of last paragraph.

Page 56	Section 10.2.2	Was previously section 10.2.3 as old section 10.2.2 removed from here and located at section 10.4 where it fits in with NVD protection provided by the DNO the old section 10.2.2 covered other DNO protection.
Page 56	Section 10.2.3 & 10.2.4 & 10.2.5	Renumbered only no change.
Page 57	Section 10.2.5 sub clause d	new sub clause to ensure that Type Tested Generating Units do not need to be retested on site to confirm that all the connections have been made correctly.
Page 58	Section 10.3.7	Existing text split out into its own section and subsequent sections renumbered.
Page 59	Sections 10.3.8, 10.3.9, 10.3.10, 10.3.11, 10.3.12	Renumbered only no change.
Page 60	Section 10.3.13	Text added to clarify position with respect to type tested units and requirement for the no trip test. Note also added to advise readers that RoCoF is not a viable long term solution.
Page 60	Section 10.3.14	Renumbered and final sentence added to cover Type Tested Generating Units .
Page 60	Section 10.3.15	Renumbered only no change.
Page 61	Section 10.3.16	Renumbered and final sentence added to cover Type Tested Generating Units .
Page 61	Section 10.3.17 & 10.3.18	Renumbered only no change.
Page 61	Section 10.4 – Additional DNO Protections	Title changed to cover all protection which may be provided by the DNO in one section. Text is the former section 10.2.2 Penultimate paragraph is new.
Page 62	Section 10.4.1 - Neutral Voltage Displacement Protection	Title moved from 10.4 to 10.4.1 The section 10.4.1. and 10.4.2 have been amalgamated and added to making reference to other sections so as to more fully explain the need for NVD in some cases.

Page 62	Section 10.4.2	Renumbered only no change until final paragraph which is new. The new paragraph has been added to point out that different DNOs have different network designs and may interpret the rest of the section above differently because of this.
Page 63	Section 10.4.3	Renumbered only no change.
Page 63	Section 10.5.1	Final sentence <i>For Type Tested Generating Units etc</i> is new.
Page 63	Section 10.5.2	Final sentence - <i>See note in section 10.3.13 about the future long term unsuitability of RoCoF protection</i> is new.
Page 64	Section 10.5.3 – Under Voltage	No change has been made to the text of this section though in practice the under voltage settings on some LV networks will be lower due to the adoption of 230v as the only voltage from which the settings can be calculated from.
Page 64	Section 10.5.4 – Over Voltage	This section has been re written to take account of the fact that the LV settings are based solely on the nominal voltage of 230v phase to neutral where the previous version of G59 allowed settings to be selected based on any chosen voltage in the range 230V to 240V phase to neutral. This change is in line with G83/2 and allows the selection of a single setting for Type Tested Generating Units .
Page 65	Section 10.5.5 – Over Frequency	New reference to the Distribution Code requirement. This was not in G59/2-1 but was included in the Distribution code version 17 or possibly earlier Version 17 was dated October 2011.
Page 65	Section 10.5.5 – Over Frequency (2 nd bullet)	Change from within 0.5 seconds to tie up with G83/2 and the settings described earlier in the sentence.
Page 65	Section 10.5.6 – Under Frequency	The reference to the distribution code is a change from a reference to the Grid code but the requirement could not be found in the latest grid code but is in the Distribution code. The Distribution code requirements only apply to small power stations. Perhaps these needs to be looked in to by the Grid Code review panel.

Page 67	Section 10.5.7.1 – Settings for long term parallel operation	<p>(1) New General note.</p> <p>† One LV voltage reference only in line with G83/2.</p> <p>\$ New note to deal with Inverter manufactures concerns about very short term over voltages which can be caused by switching which they need to protect against by shutting down with no time delay. If the voltage is restored to normal within 0.5 seconds then the unit can restart immediately.</p>
Page 68	<p>Paragraph 1</p> <p>Paragraph 2</p> <p>Paragraph 3</p>	<p>*New sentence to cover Type Tested Generating Units.</p> <p>*Last part of sentence added.</p> <p>Accuracy requirement for Type Tested Generating Units to match the requirements of G83/2.</p>
Page 68	Section 10.5.7.2 – Settings for Infrequent Short-Term Parallel Operation	† Changed in line with the settings for long term parallel operation.
Page 69	Sub-Section 10.5.12	Re written to reflect the use of 230V as the voltage for calculation of LV protection settings on DNO networks. Section 10.5.16 added to cover none standard LV network where it is not appropriate to use the standard settings.
Page 69	Sub-Section 10.5.14	Last sentence added to cover compatibility with G83/2.
Page 69	Sub-Section 10.5.16	New section to deal with the installation of embedded generation at Factories with private HV networks running none standard LV networks and the use of balanced three phase inverters with no neutral connection.
Page 70	Sub-Section 10.5.17	New section to maintain compatibility with G83/2 Applies to all G59 installations so that settings can be checked.

Page 71	Sub-Section 10.6 - Typical Protection Application Diagrams	No change to any part of section 10.6
Page 79	Sub-Section 11.1.5	<p>Sentence added to to make it clear that a separate document is not required to comply with this clause.</p> <p>The Application form in section 13.5, the Type Test document in section 13.1 along with the connection offer made by the DNO and the Customers' acceptance of this should include sufficient information to cover these requirements.</p>
Page 82	<p>Section 11.3 Site Responsibility Schedule</p> <p>Sub-Section 11.3.1</p>	<p>New sentence saying that only 11.3.3 is required for sub 50kW power stations, this is in line with the requirements of G83/2.</p>
Page 85	Section 12 – TESTING AND COMMISSIONING	Note that a change in philosophy with regards testing has taken place in order to align the sub 50kW power station installation with G83/2 and this has meant a significant re-writing of this section . The paragraph explaining that section 12 included an overview of the G83/1-1 requirements has been removed from here as the requirements for all generating units connected under G59 have been described in further parts of section 12 from here on section 12 does not align with the old section 12 and should be read in its entirety as a new section. Notes are added to explain the thinking behind some points.
Page 85	Sub-Section 12.1 Power Stations >16A per phase but ≤ 50kW 3 phase (or 17kW 1 phase) comprised of type tested Generating Units to G59 or G83/2 or later version	This section covers Power Stations up to 50kW with a process that is in most respects the same as that for installations under G83/2 The differences are that firstly DNO agreement for the connection must be sought first and that in some instances the DNO will request to witness the commissioning but will in most cases chose not to do so. A DNO wishing to witness the commissioning must notify the installer or customer at the time of making a connection offer. This section replaces the old section 12.2 for Type Tested Generating Units used in Power Stations of 50kW or less. The old section 1 which dealt with G83/1-1 has been dropped. The alignment of G83/2 and G59 allows Power Stations under G59 to comprise multiple G83/2 units. It does not allow use of G83/1-1 units as these are not compatible.

Page 86	Subsection 12.1.5	Section 10.5.17 covers how the parameters should be made available and is the same as the agreed text in G83/2.
Page 87	Subsection 12.2	This section 12.2 covers all power stations which do not come under the sub 50kW or 17kW per phase and type tested requirements in 12.1. Where type tested generating units of up to 50kW are installed then the simpler commissioning process defined in section 12.1 is in general followed but the DNO will always have the right to witness the commissioning and does not have to specifically request this in the connection offer. Much of section 12.2 has been rewritten and covers the old sections 12.2 for non-type tested generating units and 12.3 for above 50kW. The following sections have been renumbered.
Page 87	Subsection 12.2 1	Self-explanatory but worth reading through carefully to understand what is required.
Page 88	Subsection 12.2.3	Again self-explanatory but worth reading through to understand what is required.
Page 90	Subsection 12.2.3 bullet e)	New requirement to tie in with G83/2.
Page 90	Subsection 12.2.3 bullet f)	Testing for loss of a single phase is done as part of the Type Testing process and is therefore not required on site for Type Tested Equipment. This test was included originally in Appendix A 13.3 section 8.2.2 but this has been extensively rewritten to cover the use of Type Tested equipment and the clause inserted here.
Page 91	Subsections 12.2.4,	Renumbered only no change ex 12.3.9.
Page 91	Subsections 12.2.5	Renumbered and simplified ex 12.3.10.
Page 91	12.3 Changes in the Installation Subsections 12.3.1	Number change only was previously 12.4.1.
Page 91	Subsections 12.3.2	Number change only was previously 12.4.2.
Page 91	Subsections 12.3.3	New section to allow continued use of G83/1-1 equipment if installation extended.

Page 92	Subsections 12.3.4	New section to allow use of modified G83/1-1 equipment if installation extended.
Page 92	Subsections 12.3.5	New section to require replacements to faulty equipment to be to current standards.
Page 93	13 APPENDICES	The appendices have been renumbered to make them section 13 of the document without the prefix A as this seemed to add nothing and some appendices were internally numbered this has been dropped so that they all start with 13.
Page 95	Appendix 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 generally in line with that produced for G83 though some references are changed due to the size of the Generating Units. Note it does not apply to Generating Units above 50kW.
Page 95	Type Tested reference number	This ties in with the G83/2 Type Testing numbering system and will be recorded on the system provided by the ENA at the expense of the DNOs.
Page 96	System supplier declaration	This declaration is in line with that in G83/2.
Page 96	Section - Power Quality. Harmonics	BS EN 61000-3-2 is the standard for sub 16A equipment but if met means that the DNO does not have to establish a minimum fault level in relation to the generating unit size. This may allow generating units to be connected with existing transformers while those only complying with BS EN 61000-3-12 may require a change of transformer to a larger size. Therefore generators who purchase equipment to the tighter standard may save money in terms of connection costs.
Page 102	Power Quality. Voltage fluctuations and Flicker.	These tests are in line with G83/2 and ensure that the DNO has sufficient information to design a supply connection which will not cause a problem in terms of flicker to other customers. Previously G59/2-1 required compliance with P28 which was not appropriate for Type Tested equipment as P28 is a DNO planning standard and not an equipment standard.
Page 102	For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the	A simplified calculation has been given for units which operate at close to unity power factor. This will be the case for the majority of Generating Units.

	power factor of the generation output is 0.98 or above.	
Page 103	Power Quality. Power factor	Included to maintain compatibility with G83/2. This would preclude the use of G59 Type Tested units for many connections where the connection offer requires the generator to use voltage control. But dealing with this issue was outside the terms of reference of the working group.
Page 105	Protection. Loss of Mains test and single phase test. Sentence below title – <i>To be carried out at three output power levels plus or minus 5%, an alternative for inverter connected Generating Units can be used instead.</i>	Same test as in G83/1-1 and carried over into G83/2 as one option and always required for Rotating machines.
Page 106	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.	Alternative test not in G83/1-1 but included in G83/2. Strictly this is a test for PV inverters but it can be applied to any inverter. There are over 30 tests and we have asked for a sub set of the results only.
Page 106	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.	This Type Test removes the need to carry out a single phase test on site when using Type Tested Generating Units and only a three phase disconnection is required as an onsite functional test. This has been introduced because of the difficulties involved with removing a single phase to a generating unit where ganged three phase CBs or switch fuses are used to provide the circuit protection and doing the prescribed single phase test in G59/2-1 causes considerable difficulty. It should be noted that the single phase test is required to prevent a generator continuing to operate when a fuse has blown on one phase and the measured voltage and frequency produced by the generator have not changed sufficiently to cause operation due to under or over voltage or frequency.
Page 107	Fault level contribution For Inverter output	No change has been made to the requirements for directly connected machines however the requested values are meaningless with respect to inverter connected machines which do not follow the standard model of a voltage source in series with a bank of reactances which are switched out over time to leave only one reactance in circuit. Under the standard model a generator connected at half volts will preclude half the current that it would do for a short circuit. Inverter connected units may well

		produce the same current at half volts as for a short circuit and with no decay. Further work is required to determine fault contributions from inverter connected machines and the creation of suitable models. While a crude attempt at defining fault level contribution this is at least an acknowledgement that standard models are not applicable to this problem and suggests an alternative. This is in line with G83/2
Page 109	Appendix 13.2 Generating Plant Installation and Commissioning Confirmation – Form	This form is applicable to all installations under G59/3 and is a departure from the existing forms in that it ensures that the basic safety checks required of an installation are carried out without any actual testing of the installation. Where a Power Station is less than 50kW then an approved installer can carry out the checks and notify the DNO. Where the installation comprises Type Tested equipment and is over 50kW it carries out the same function but the responsibility for completion is passed to the Generator rather than the installer. This allows installers under the MCS scheme to carry out installations in much the same way as they do for G83/2 installations. Where the installation has Generating Units which are not Type Tested then the form still needs to be completed to ensure that the general safety issues have been checked but in addition protection settings need to be checked using the form in section 13.3
Page 109	Details of Generating Unit(s) - where applicable	This section only requires the notification of new Generating Units. The Application form has space to notify existing Generating Units. This is different to the G83/2 form which requires notification of new Generating Units and notification of existing Generating Units. This is because under G83/2 there is no application form for single Customer installations
Page 112	Appendix 13.3 Generating Plant Installation and Commissioning Tests - Additional commissioning test requirements for non-type tested Generating Units form.	This form covers the testing of protection for Generating Units which have not been type tested. It will be required for all Generating Units of above 50kW.
Page 112	Over and Under Voltage Protection Tests LV – Calibration & accuracy Tests	All based on a 230v nominal voltage and the revised LV over voltage settings adopted in G59/2-x and taken from G83/2
Page 114	Over and Under Voltage Protection Tests LV –	Note that stability tests have been introduced for all settings in line with those required for Type Tested Equipment under G59/2-x and that these are in line with

	Stability Tests	G83/2
Page 114	Over and Under Voltage Protection Tests HV - referenced to 110V ph-ph VT output	These are all based on the use of standard 110v ph-ph VT outputs. The use of 110v ph-ph outputs on VTs is almost universal within the UK. But alternatives could be used with care. The form indicates on the title line that it applies to 110v ph-ph VT outputs.
Page 122	Appendix 13.5 - Application for connection of Type Tested Generating Unit(s) with Total Aggregate Capacity < 50kW 3-Phase, or <17kW Single Phase – Form	This simplified form has been produced for Power Stations up to 50kW or 17kW per phase using Type Tested Equipment so as to enable Installers to follow a similar format to G83/2 when installing Power Stations in this range. In common with G83/2 it is designed to be customized by each DNO so as to get the information to the right place as quickly as possible.
Page 122	Installer or Generator Details :	It is assumed that most installations of this size will be carried out by installers under the MCS scheme but where a Generator does not want to apply for FIT payments then the Generator themselves may apply.
Page 123	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	A Customer may use load management devices to limit the export of energy to the DNOs system to allow a connection to take place without incurring reinforcement costs. For example a customer with a single phase supply may install a 6kW wind turbine but use a load management device to limit export to the DNO network to 3kW to avoid excessive voltage rise on the DNO's network
Page 124	Additional Information Relating to System Stability Studies	No change has been made to this section apart from renumbering it from A13.5 to 13.6.
Page 127	Loss of Mains (LoM) Protection Analysis	No change has been made to this section apart from renumbering it from A13.6 to 13.7. Recent information from National Grid Electricity Transmission indicates that this analysis is out of date with respect to RoCoF but the working groups were not asked to consider this issue.
Page 137	Type Testing of Generation Units of 50kW three phase, or 17kW per phase or less. Guidance for Manufacturers	This section replaces A13.7. It attempts where possible to follow the same format as the Type Testing annex in G83/2 however it was realized that much of the sections in G83/2 which were split into directly connected or inverter connect machines were duplicated. In this case they have been combined where possible and sections have been cross referenced to G83/2 to help suppliers who have already carried out Type

		Testing to G83/2 to understand what the same is and where there are some differences.
Page 137	<p>13.8.1 (A1.1,B1.1) General Arrangements</p> <p>Interface Protection must not rely on interconnection using cables which are capable of being 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)</p>	This allows the manufacturer to supply parts which need to be connected together but all the connections required for the protection functions must be pre tested prior to delivery to site and made with a plug and socket arrangement to ensure that they cannot be inadvertently reconnected incorrectly on site.
138	<p>13.8.2(A1.2,B1.2) CE Marking and Certification</p> <p>Third paragraph... <i>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 Annex, and recorded in format similar to that shown in section 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)</i></p>	This allows separate units to be Type Tested in order to achieve an overall Type Tested Generating Unit. There are requirements in the revised G59/3 which require that the supplier ensures that the supplied unit cannot be disconnected in terms of its protection functions. These are detailed in section 10.2.5.d)
Page 143	<p>13.8.3.4A(A.3.4) - Loss of Mains Protection, Inverter connected machines</p> <p><i>For Multi phase Generating Units they should be operated at part load while connected to a network running at about 50Hz etc etc</i></p>	including this test in the Type Testing allows it to be avoided during the site testing and this is an advantage in that making a single phase break is often difficult on site where ganged CBs or switch fuses do not allow the disconnection of one phase easily.

Page 144	13.8.3.6(A1.3.6,B1.3.6) - Frequency Drift and Step Change Stability test	A new test but in line with G83/2
Page 145	13.8.4.2(A1.4.2,B1.4.2) Power Factor <i>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 etc etc</i>	G59 does not specifically require a generating unit to operate within this range of power factors however it was felt sensible to define a range and to test to these values for Type Tested Generating Units which are generally in line with what a DNO would expect an embedded generator to be able to achieve and are in line with G83/2. The requirements are detailed in 9.3.7
Page 151	13.9 Main Statutory and other Obligations	No change from G59/2-1 except for a change in reference from A13.8 to 13.9

APPENDIX 4 - TIMETABLE TO PUBLICATION

Version 1

