

ENA and Department for Business, Energy and Industrial Strategy (BEIS) Distributed Energy Resources (DER) – Cyber Security Connection Guidance

Guidance to support users in the design, development, deployment, connection and maintenance of new and existing DERs to the distribution networks to improve their cyber security.

Publicly Available Specification (PAS) 1879

Energy smart appliances – Demand side response operation – Code of practice.

4. Terms and definitions

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

Active Power (P)

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).

Active Power Frequency Response

An automatic response of **Active Power** output, from a **Power Generating Module**, to a change in system frequency from the nominal system frequency.

Assimilated Law

Has the same meaning as that given by section 6(7) of the European Union (Withdrawal) Act 2018.

Authority

The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000 The Gas and Electricity Markets Authority established under Section 1 of the Utilities Act 2000.

Automatic Voltage Regulator or AVR

The continuously acting automatic equipment controlling the terminal voltage of a synchronous **Generating Unit** by comparing the actual terminal voltage with a reference value and controlling by appropriate means the output of an **Exciter**, depending on the deviations.

Anchor Plant Capability

An ability in respect of an **Anchor Power Station**, for at least one of its **Generating Units** to start-up from shutdown and to energise a part of the **Distribution Network** and be synchronised to the **Distribution Network** upon instruction from the **ISOP**, or instruction or signal from the **DNO**, within a time period defined in the **System Restoration** contract, without an external electrical power supply.

Anchor Power Station

A **Power Generating Facility** which is recognized by the **ISOP** or **DNO**, as having **Anchor Plant Capability**.

Combined Cycle Gas Turbine Module or CCGT Module

A collection of **Generating Units** comprising one or more Gas Turbine Units (or other gas based engine units) and one or more Steam Units where, in normal operation, the waste heat from the Gas Turbines is passed to the water/steam

system of the associated Steam Unit(s) or Steam Units and where the component units within the **CCGT Module** are directly connected by steam or hot gas lines which enable those units to contribute to the efficiency of the combined cycle operation of the **CCGT Module**.

Connection Agreement

A contract between the **Distribution Network Operator** and the **Generator**, which includes the specific technical requirements for the **Power Generating Module** and the relevant requirements for the **Power Generating Facility**.

Connection Point

The interface at which the **Power Generating Module** or **Generator's Installation** is connected to a **Distribution Network**, as identified in the **Connection Agreement**. For the avoidance of doubt, two or more connection circuits constitutes a single **Connection Point** for the purposes of EREC G99.

Controller

A device for controlling the functional operation of a **Power Generating Module**.

CUSC

Has the meaning set out in the **Transmission Licence**.

Customer

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

Customer's Installation

The electrical installation on the **Customer's** side of the **Connection Point** together with any equipment permanently connected or intended to be permanently connected thereto.

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 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 Network

An electrical network for the distribution of electrical power from and to a third party[s] connected to it, a **Transmission System** or another **Distribution Network**.

Distribution Network Operator (DNO)

The person or legal entity named a **Distribution Licence** and any permitted legal assigns or successors in title of the named party. A distribution licence is granted under Section 6(1)(c) of the **Electricity Act 1989**.

Droop

The ratio of the per unit steady state change in speed (or frequency), to the per unit steady state change in **Active Power** output. Whilst not mandatory, it is often common practice to express **Droop** in percentage terms.

Electricity Act

The **Electricity Act** 1989.

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 **Electricity Act** 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004) in relation to the distribution of electricity.

Electricity Storage

Electricity Storage in the electricity system is the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy. Pumped storage **Power Generating Modules** are not considered to be **Electricity Storage** devices unless they are declared to be so by the **Generator**.

Embedded Medium Power Station

A **Power Generating Facility** in England and Wales of 50MW or greater **Registered Capacity** but less than 100MW **Registered Capacity** connected to a **DNO's Distribution Network**.

Energisation Operational Notification (EON)

A notification issued by the **DNO** to a **Generator** prior to energisation of its internal network.

Excitation System

The equipment providing the field current of a machine, including all regulating and control elements, as well as field discharge or suppression equipment and protective devices.

Exciter

The source of the electrical power providing the field current of a synchronous machine.

Fast Fault Current

A current injected by a **Power Park Module** during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault, supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance.

Fault Ride Through

The capability of **Power Generating Modules** to be able to remain connected to the **Distribution Network** and operate through periods of **Low Voltage** at the **Connection Point** caused by secured faults on the **Transmission System**.

Final Operational Notification (FON)

A notification issued by the **DNO** to a **Generator**, who complies with the relevant specifications and requirements in this EREC G99, allowing them to operate a **Power Generating Module** by using the **Distribution Network** connection.

Frequency Response Deadband

An interval used intentionally to make the frequency control unresponsive.

Frequency Response Insensitivity

The inherent feature of the control system specified as the minimum magnitude of change in the frequency or input signal that results in a change of output power or output signal.

Frequency Sensitive Mode (FSM)

The operating mode of a **Power Generating Module** in which the **Active Power** output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency.

Fully Type Tested

A **Power Generating Module** with an **Intrinsic Design Capacity** ≤ 50 kW which has been tested to ensure that the design meets the relevant technical and compliance requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar **Power Generating Modules** supplied will be constructed to the same standards and will have the same performance. In the case where **Interface Protection** functionality is included in the tested equipment, all similar products will be manufactured with the same protection settings as the tested product.

Generating Unit

Any apparatus which produces electricity. This includes micro-generators and controllable **Electricity Storage** devices. A **Vehicle to Grid Electric Vehicle** is considered as an **Electricity Storage** device. Where an electric vehicle and/or its charger have been configured such that the electric vehicle cannot operate as a **Vehicle to Grid Electric Vehicle**, then it shall be considered as a load and is not included in the requirements of this EREC G99.

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) and whose **Power Generating Facility** is directly or indirectly connected to a **Distribution Network**. For the 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**.

Generator Performance Chart

A diagram showing the **Active Power** (MW) and **Reactive Power** (MVar) capability limits within which a **Synchronous Power Generating Module** or **Power Park Module** at the **Generating Unit** terminals or the **Connection Point** as appropriate for the **Power Generating Facility** will be expected to operate under steady state conditions.

Generator's Installation

The electrical installation on the **Generator's** side of the **Connection Point** together with any equipment permanently connected or intended to be permanently connected thereto.

Great Britain or GB

The landmass of England & Wales and Scotland, including internal waters.

Grid Code

The code which the **ISOP** is required to prepare under its 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 1000 V AC or 1500 V DC between conductors, or 600 V AC or 900 V DC between conductors and earth.

Installer

The person who is responsible for the installation of the **Power Generating Module(s)**.

Interface Protection

The electrical protection required to ensure that any **Power Generating Module** is disconnected for any event that could impair the integrity or degrade the safety of the **Distribution Network**. **Interface Protection** may be installed on each **Power Generating Module** or at the **Connection Point** for the **Power Generating Facility**.

Interim Operational Notification (ION)

A notification from the **DNO** to a **Generator** acknowledging that the **Generator** has demonstrated compliance, except for the **Unresolved Issues** with this EREC G99 or with specific items in the **Connection Agreement** in respect of the plant and apparatus specified in such notification.

Intermittent Power Source

The primary source of power for a **Generating Unit** that cannot be considered as controllable, eg wind, wave or solar.

Intrinsic Design Capacity

The designed maximum **Active Power** capacity of a **Generating Unit** or a **Power Generating Module**. In general this will be identical to the **Registered Capacity**, but can be a higher value where the **Manufacturer** has made specific provision for the maximum **Active Power** output to be limited to a defined value less than the designed maximum **Active Power** capacity. Such a limitation will be semi-permanent and designed in by the **Manufacturer**. It will not be amenable to adjustment by the **Generator**; any such adjustment shall be undertaken by personnel specifically empowered and equipped for that task by the **Manufacturer**. Where a **Manufacturer** offers a **Generating Unit** or **Power Generating Module** with a **Registered Capacity** that is less than the **Generating Unit's** or **Power Generating Module's Intrinsic Design Capacity**, all certification, especially type testing, must be done at the **Registered Capacity** (or fractions of it as required by the various tests) and not the **Intrinsic Design Capacity**.

Inverter

A device for conversion from Direct Current to nominal frequency Alternating Current.

IP Completion Day

As defined in section 39 of the European Union (Withdrawal Agreement) Act 2020.

ISOP

A person designated by the Secretary of State under section 162 of the Energy Act 2023 as the holder of the ESO Licence. For the time being that person is the National Energy System Operator.

Limited Frequency Sensitive Mode

A mode whereby within a range of system frequency the operation of a **Power Generating Module** is frequency insensitive.

Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)

A **Power Generating Module** operating mode which will result in **Active Power** output reduction in response to a change in system frequency once the system frequency exceeds a certain value.

Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)

A **Power Generating Module** operating mode which will result in **Active Power** output increase in response to a change in system frequency once the system frequency falls below a certain value.

Limited Operational Notification (LON)

A notification issued by the **DNO** to a **Generator** who had previously attained **FON** status but is temporarily subject to either a significant **Modification** or loss of capability resulting in non-compliance with the relevant specifications and requirements.

Low Voltage (LV)

A voltage normally exceeding extra-low voltage (50 V) but not exceeding 1000 V AC or 1500 V DC between conductors or 600 V AC or 900 V DC between conductors and earth.

Manufacturer

A person or organisation that manufactures **Generating Units**.

Manufacturer's Data & Performance Report

A report submitted by a **Manufacturer** to the **DNO** relating to a specific version of a **Generating Unit** demonstrating the performance characteristics of such **Generating Unit** in respect of which the **DNO** has evaluated its relevance for the purposes of compliance.

Manufacturers' Information

Information in suitable form provided by a **Manufacturer** in order to demonstrate compliance with one or more of the requirements of this EREC G99. Where Equipment Certificate(s) as defined in **Assimilated Law** (Commission Regulation (EU) 2016/631 (Network Code on the Requirements for Connection of Generators)) cover all or part of the relevant compliance points, the Equipment

Certificate(s) demonstrate compliance without the need for further evidence for those aspects within the scope of the Equipment Certificate.

Minimum Regulating Level (MRL)

The minimum **Active Power** output down to which the **Power Generating Module** can control **Active Power**.

Minimum Stable Operating Level (MSOL)

The minimum **Active Power** output at which the **Power Generating Module** can be operated stably for an unlimited time.

Modification

Any actual or proposed replacement, renovation, modification, alteration or construction by a **Generator** to any **Power Generating Module**, or the manner of its operation.

Over-Excitation Limiter

Shall have the meaning ascribed to that term in IEC 34-16-1.

Phase (Voltage) Unbalance

The ratio (in percent) between the root mean square (RMS) values of the negative sequence component and the positive sequence component of the voltage.

Point Of Common Coupling

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

Power Factor

The ratio of **Active Power** to apparent power.

Power Generating Facility (PGF)

A facility that converts primary energy into electrical energy and which consists of one or more **Power Generating Modules** connected to a **Network** at one or more **Connection Points**.

Power Generating Module (PGM)

Either a **Synchronous Power Generating Module** or a **Power Park Module**.

Power Generating Module Document (PGMD)

A document provided by the **Generator** to the **DNO** for a **Type B, Type C or Type D Power Generating Modules** which confirms that the **Power Generating Module's** compliance with the technical criteria set out in this EREC G99 has been demonstrated and provides the necessary data and statements, including a statement of compliance.

Power Park Module (PPM)

A **Generating Unit** or ensemble of **Generating Units** (including **Electricity Storage** devices) generating electricity, which is either asynchronously connected to the network or connected through power electronics, and that may be connected through a transformer and that also has a single **Connection Point** to a **Distribution Network**.

Power System Stabiliser (PSS)

Equipment controlling the output of a **Power Generating Module** 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.

Q/P_{max}

The ratio of **Reactive Power** to the **Registered Capacity**. The relationship between **Power Factor** and **Q/P_{max}** is given by the formula:-

$$\text{Power Factor} = \cos[\arctan [\frac{Q}{P_{max}}]]$$

Rapid Voltage Change (RVC)

The change in RMS voltage over several cycles.

Rated Field Voltage

Shall have the meaning ascribed to that term in IEC 34-16-1:1991 [equivalent to British Standard BS4999 Section 116.1: 1992].

Rated Import Power

The normal maximum **Active Power** capacity of a **Power Generating Module** incorporating **Electricity Storage**, ie the maximum possible flow of **Active Power** into the **Power Generating Module** terminals when replenishing its energy store.

Reactive Power (Q)

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 (P_{max})

The normal maximum **Active Power** capacity of:

- A **Generating Unit**; or
- A **Power Generating Module** (in the case of a **Power Park Module**, the lesser of the **Inverter(s)** rating or the rating of the energy source); or
- A **Power Generating Facility**,

as declared by the **Generator** taking into account the **Active Power** consumed when producing the same and the production of the required **Reactive Power** at the **Connection Point**. For the purposes of the **Small Generation Installation** procedure the **Registered Capacity** of a **Power Generating Module** can be a limited (eg by software) to be less than the **Intrinsic Design Capacity** of the **Power Generating Module**.

Small Generation Installation

A **Generator's Installation** that comprises one or more **Low Voltage Power Generating Modules**⁴ each with an **Intrinsic Design Capacity** of no more than

⁴ In EREC G98 a **Power Generating Module** with nominal current up to and including 16 A per phase is known as a Micro-generator.

32 A and where the aggregate **Registered Capacity** of all the **Power Generating Modules** is no more than 60 A.

Slope

The ratio of the steady state change in voltage, as a percentage of the nominal voltage, to the steady state change in **Reactive Power** output, in per unit of **Reactive Power** capability. For the avoidance of doubt, the value indicates the percentage voltage reduction that will result in a 1 per unit increase in **Reactive Power** generated.

Standard Planning Data (SPD)

General information required by the **DNO** under the Distribution Planning Code.

Station Transformer

A transformer supplying electrical power to the auxiliaries of a **Power Generating Facility**, which is not directly connected to the **Power Generating Module** terminals (typical voltage ratio being 132/11 kV).

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 **Power Generating Module Automatic Voltage Regulator (AVR)** and static VAR compensator (SVC) actions, and transient decay (typically 5 s after the fault clearance or system switching have taken place), but before any other automatic or manual tap-changing and switching actions have commenced.

Supplier

- (a) A person supplying electricity under an Electricity Supply Licence; or
 - (b) A person supplying electricity under exemption under the **Electricity Act 1989** (as amended by the Utilities Act 2000 and the Energy Act 2004); or
- in each case acting in its capacity as a **Supplier** of electricity to **Customers**.

System Restoration

The procedure necessary for a recovery from a situation where all electricity supplies have been interrupted and all generation has ceased in that part of the Distribution Network. In these cases, there is no immediate prospect of external electricity supply being available to that part of the Distribution Network from the Transmission System or any other source, and therefore electricity supplies cannot be restored without recourse to the System Restoration Capability of an Anchor Power Station.

System Stability

The ability of the system, for a given initial operating condition, to regain a state of operating equilibrium, after being subjected to a given system disturbance, with most system variables within acceptable limits so that practically the whole system remains intact.

Synchronous Power Generating Module

Means an indivisible set of **Generating Units** (ie one or more units which cannot operate independently of each other) (including **Electricity Storage** devices) which can generate electrical energy such that the frequency of the generated

voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in **Synchronism**. Each set of **Generating Units** which cannot run independently from each other (such as those **Generating Units** on a common shaft or as part of an integrated **CCGT Module**), but can run independent of any other generating equipment, form an individual **Synchronous Power Generating Module**. Any prime mover and alternator combination that can run as an independent unit (irrespective of normal operating practice) is a **Synchronous Power Generating Module**.

This is illustrated in Figure 4.1a and b.

Synchronism

The condition under which a **Power Generating Module** or system is connected to another system so that the frequencies, voltage and phase relationships of that **Power Generating Module** 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 **Power Generating Modules**, **Transmission System**, **Distribution Networks** and associated electrical demand.

Transmission Licence

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

Transmission System

A system of **High Voltage** lines and plant owned by the holder of a **Transmission Licence** and operated by the **ISOP**, which interconnects **Power Generating Facilities** and substations.

Type A

A **Power Generating Module** with a **Connection Point** below 110 kV and a **Registered Capacity** of 0.8 kW or greater but less than 1 MW.

Type B

A **Power Generating Module** with a **Connection Point** below 110 kV and **Registered Capacity** of 1 MW or greater but less than 10 MW.

Type C

A **Power Generating Module** with a **Connection Point** below 110 kV and a **Registered Capacity** of 10 MW or greater but less than 50 MW.

Type D

A **Power Generating Module** with a **Connection Point** at or greater than 110 kV, and/or with a **Registered Capacity** of 50 MW or greater.

Type Tested

A product which has been tested to ensure that the design meets the relevant requirements of this EREC G99, and for which the **Manufacturer** has declared that all similar products supplied will be constructed to the same standards and will have the same performance. The **Manufacturer's** declaration will define clearly the extent of the equipment that is subject to the tests and declaration. In the case where **Interface Protection** functionality is included in the tested equipment, all

similar products will be manufactured with the same protection settings as the tested product.

Examples of products which could be **Type Tested** include **Generating Units**, **Inverters** and the **Interface Protection**.

Unresolved Issues

Any relevant EREC G99 requirements identified by the **DNO** with which the **Generator** has not demonstrated compliance to the **DNO's** reasonable satisfaction at the date of issue of the **Interim Operational Notification** and/or **Limited Operational Notification** and which are detailed in such **Interim Operational Notification** and/or **Limited Operational Notification**.

Under-excitation Limiter

Shall have the meaning ascribed to that term in IEC 34-16-1.

Vehicle to Grid Electric Vehicle

An electric vehicle and any associated internal or external charging devices forming part of a **Customer's Installation** that can import electricity from and export electricity to that **Customer's Installation**.

4.2. Illustrative examples of **Power Generating Module** types and categorisation

Figures 4.2 to 4.6 illustrate examples of different **Power Generating Modules** comprising **Power Park Modules** and **Synchronous Power Generating Modules** to assist with the interpretation of **Power Park Module** categorisation.

Figure 4.7 illustrates an example of a **Small Generation Installation**.

Key to following Figures:

ST: Steam Turbine

GT: Gas Turbine

HR: Heat Recovery Unit

CP: **Connection Point**

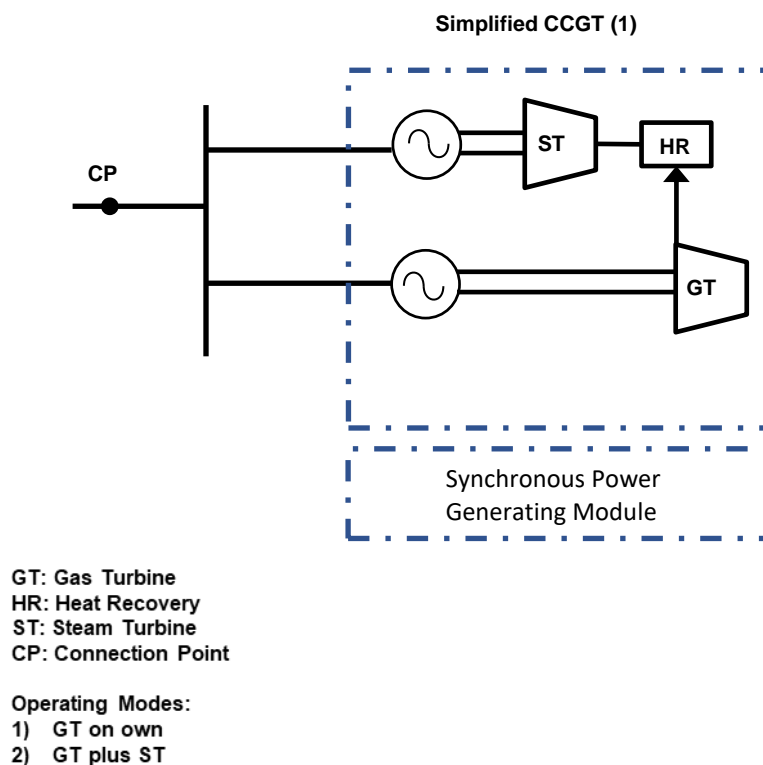
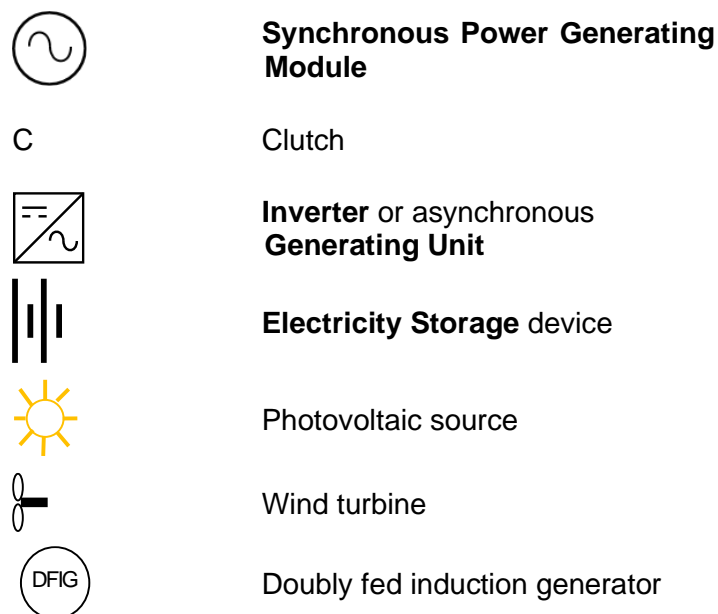


Figure 4.1a Example of a Synchronous Power Generating Module comprising a gas turbine (GT) with a steam turbine (ST) on a separate shaft (simplified diagram)

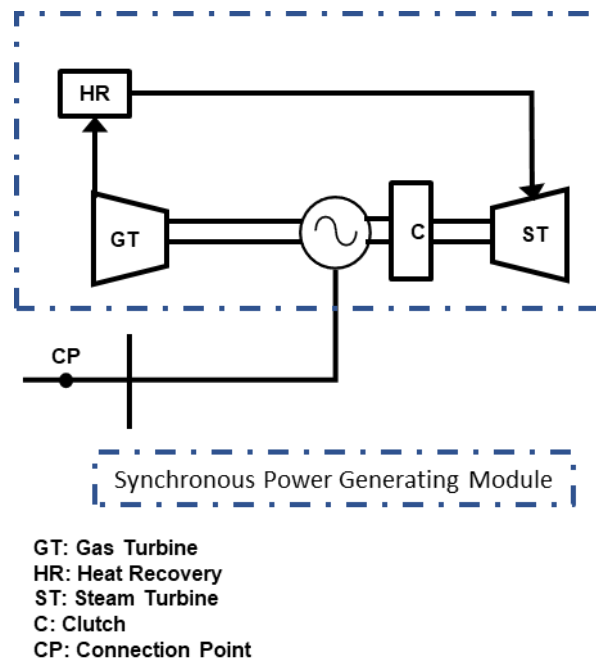
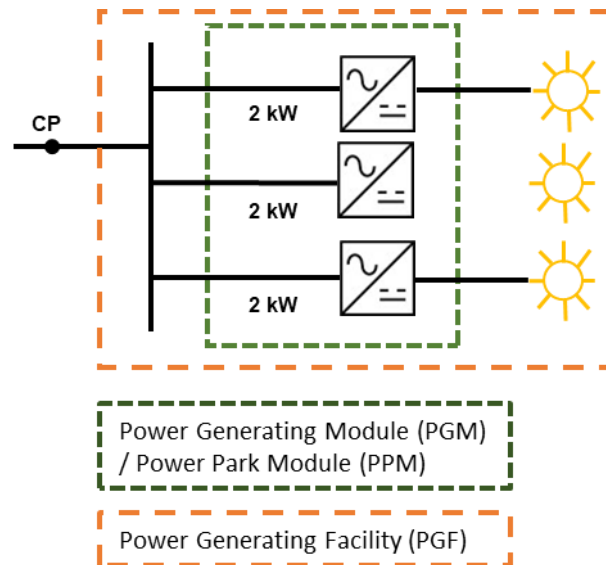
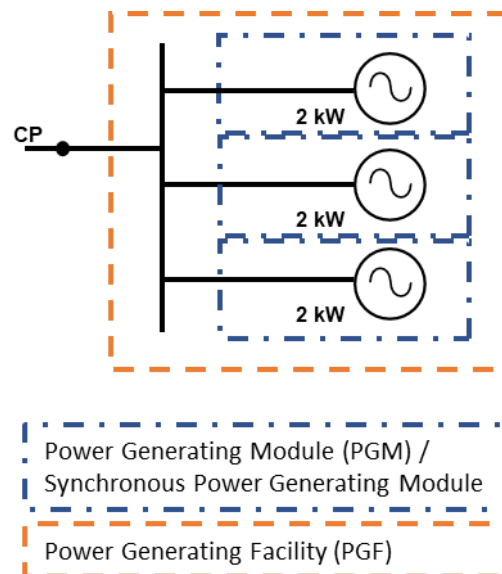


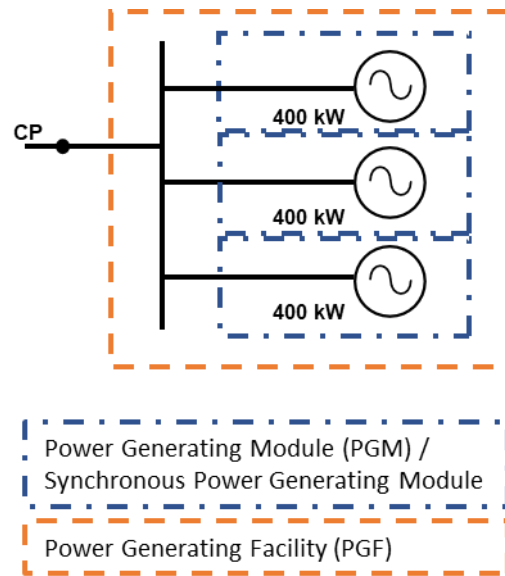
Figure 4.1b Example of a Synchronous Power Generating Module comprising a gas turbine (GT) with a steam turbine (ST) on the same shaft (simplified diagram)



- a) 3 x 2 kW **Inverter** connected **Generating Units**
 = 6 kW **Type A Power Park Module**
 = 6 kW **Power Generating Facility**

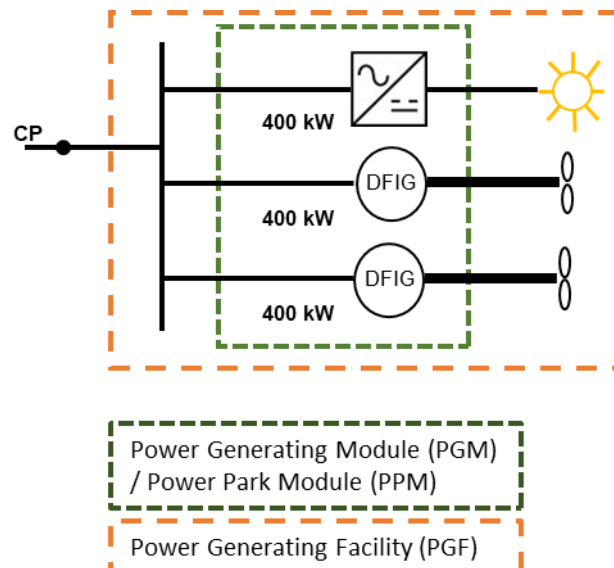


- b) 3 x 2 kW **Type A Synchronous Power Generating Modules**
 = 6 kW **Power Generating Facility**



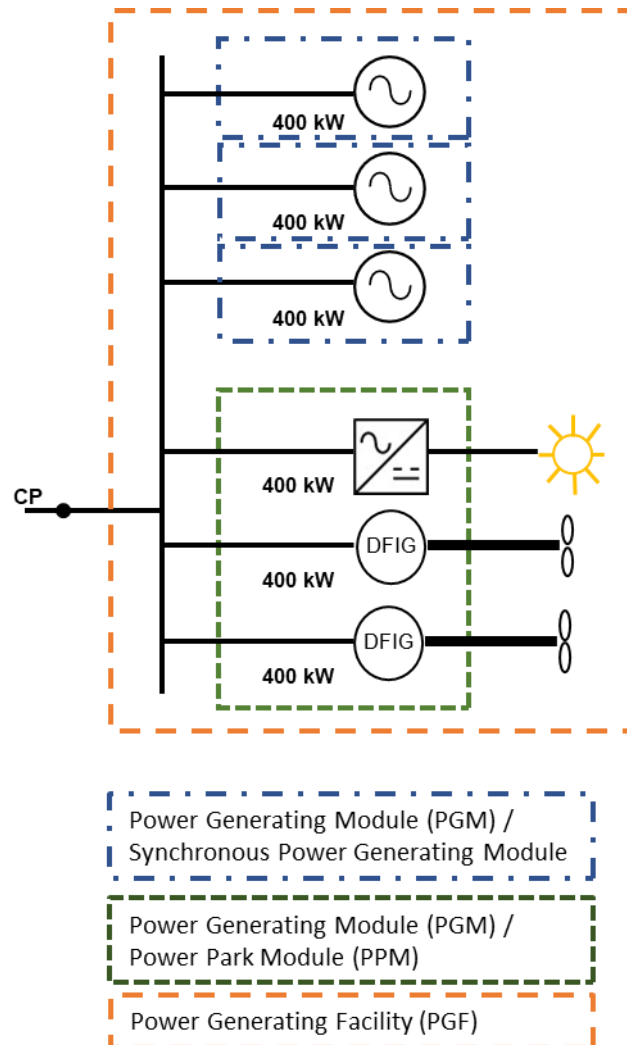
- c) 3 x 400 kW **Type A Synchronous Power Generating Modules**
= 1.2 MW **Power Generating Facility**

Figure 4.2 Examples of Type A Power Generating Modules



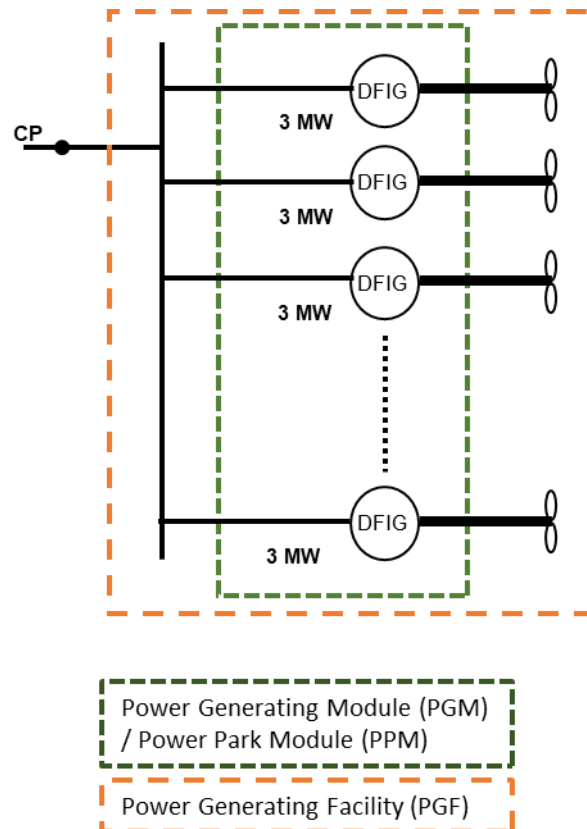
- 1 x 400 kW **Inverter** connected plus 2 x 400 kW asynchronous **Generating Units**
= 1.2 MW **Type B Power Park Module**
= 1.2 MW **Power Generating Facility**

Figure 4.3 Example of Type B Power Generating Modules



3 x 400 kW **Type A Synchronous Power Generating Modules** plus 1 x 400 kW **Inverter** connected and 2 x 400 kW asynchronous **Generating Units**
 = 3 x 400 kW **Type A Synchronous Power Generating Modules** plus 1 x 1.2 MW **Type B Power Park Module**
 = 2.4 MW **Power Generating Facility**

Figure 4.4 Example of combination of Type A and Type B Power Generating Modules in same Power Generating Facility



25 x 3 MW asynchronous **Generating Units**

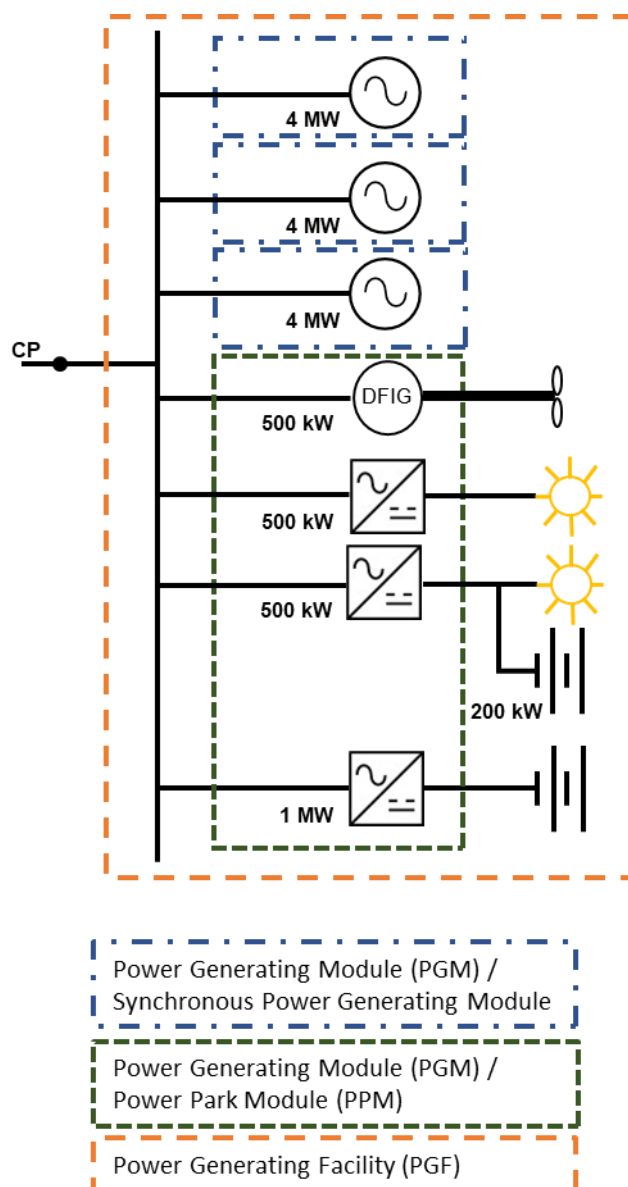
= 1 X 75 MW **Type D Power Park Module**

= 1 x 75 MW **Type D Power Generating Module**

= 75 MW **Power Generating Facility**

(**Embedded Medium Power Station** in England and Wales, large power station in Scotland)

Figure 4.5 Example of Type D Power Generating Facility comprised of a number of Generating Units



3 x 4 MW **Type B** Gas Engines plus 1 x 500 kW asynchronous **Generating Unit** plus 1 x 500 kW **Inverter** plus 1 x 500 kW **Inverter** with 200 kW Integral **Electricity Storage** plus 1 MW **Electricity Storage** device

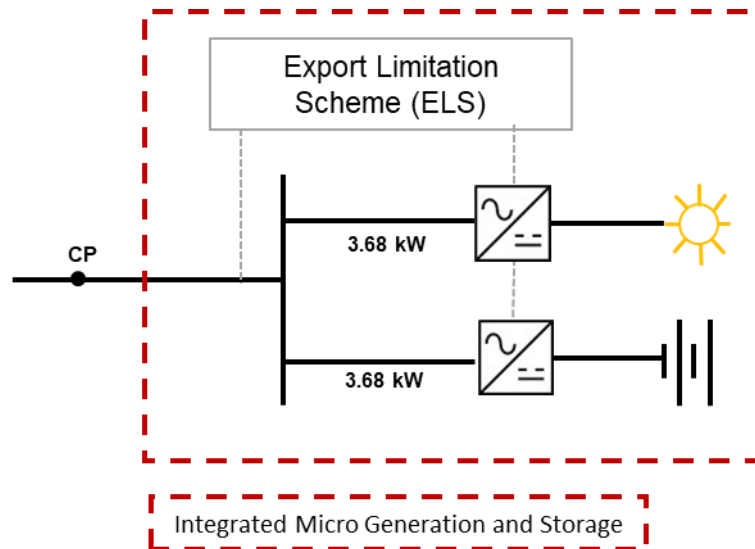
= 3 x 4 MW **Type B** **Synchronous Power Generating Modules** plus (1.5 MW + 1 MW) 2.5 MW **Type B** **Power Park Module**

= 14.5 MW **Power Generating Facility** (Large power station in North of Scotland)

Note the **Electricity Storage** device using the same **Inverter** as the PV does not contribute to the **Power Park Module Registered Capacity**, because the **Registered Capacity** is based on the **Inverter** rating. The **Electricity Storage** device using a dedicated **Inverter** is included in the **Power Park Module**⁵ and **Power Generating Facility Registered Capacity**.

Figure 4.6 Example of Connection of Electricity Storage devices

⁵ For storage commissioned before 01 September 2022 please see Annex A4.2.



1 x 3.68 kW PV **Inverter** plus 1 x 3.68 kW **Electricity Storage** device
= 7.36 kW **Power Park Module**
= 7.36 kW **Power Generating Facility**

Figure 4.7 Example of a Small Generation Installation

5. Legal Aspects

- 5.1 The operation and design of the electricity system in **Great Britain** is defined principally by Directive 2009/72/EC as it has effect immediately before **IP Completion Day**, the Electricity Act 1989, 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 **DNOs**, **Generators** and **Customers** is included as Annex D.4.
- 5.2 This EREC has been written to comply with the requirements of **Assimilated Law** (Commission Regulation (EU) 2016/631 (Network Code on the Requirements for Connection of Generators)), referred to as the RfG, and to include other requirements required for connection to the **GB** power system.
- 5.3 Under Section 21 of the **Electricity Act**, **Generators** may be required to enter into a bespoke **Connection Agreement** with the **DNO**. Such a **Connection Agreement** will specify the terms and conditions including technical, operating, safety and other requirements under which **Power Generating Modules** are entitled to remain connected to the **Distribution Network**. It is usual to include site specific commercial issues, including recovery of costs associated with the connection, GDUoS (Generator Distribution Use of System) charges and the applicable energy loss adjustment factors, in **Connection Agreements**. It is also common practice by some **DNOs** to collect the technical issues into a subordinate

6.1.6 Interaction with the **ISOP**

- 6.1.6.1 It should be noted that if the aggregate **Registered Capacity** of all **Power Generating Module(s)** (synchronous together with asynchronous) on one or more sites in common ownership is >50 MW, then the **Generator** becomes licensable.
- 6.1.6.2 **Generators** with an agreement with the **ISOP** may be required to comply with applicable requirements of the **Grid Code**. Where **Grid Code** requirements apply, it is the **Generator's** responsibility to comply with the relevant parts of both the **Distribution Code** and **Grid Code**.
- 6.1.6.3 In the case where the **Generator** has a Bilateral Embedded Generation Agreement (BEGA) with the **ISOP**, the **Generator** shall demonstrate compliance with this EREC G99 to the **DNO**, and any additional **Grid Code** compliance requirements shall be demonstrated by the **Generator** to the **ISOP**. In these cases the **Generator** will make the **Generator's** interim and final **PGMD**, and/or the **Generator's FON**, available to the **ISOP** on request. The **ISOP** may seek confirmation from the **DNO** of the compliance status of the **Power Generating Module** as recorded on the **Generator's PGMD**.
- 6.1.6.4 In some cases the Grid Code requirements may be different to those in Sections 12-13 of this EREC G99. In these cases the **DNO** and the **ISOP** may agree to apply the Grid Code requirements in substitution for the G99 requirements. In these cases, the **DNO** will record these exceptions in the **Connection Agreement**, and the compliance with those requirements will be assessed by the **ISOP**.
- 6.1.6.5 In the case of an embedded large power station, the **ISOP** will be responsible for confirming the **Generator's** compliance with all **Grid Code** requirements. In general this will mean that the requirements of Sections 12-13, 17, 18 and parts of Section 19 of this EREC G99 will be superseded by the equivalent requirements in the **Grid Code**. The **DNO** will remain responsible for ensuring the **Generator's** compliance with the remaining parts of this EREC G99.
- 6.1.6.6 See also section 6.2.4.6 regarding the issuing of **FONs**

6.2. Application for Connection

- 6.2.1. Information about the **Power Generating Module(s)** is needed by the **DNO** so that it can assess the effect that a **Power Generating Facility** may have on the **Distribution Network**. This EREC G99 details the parameters to be supplied by a **Generator** wishing to connect **Power Generating Module(s)** that do not comply with EREC G98 to a **Distribution Network**. This EREC G99 also enables the **DNO** to request more detailed information if required.
- 6.2.2. Small Generation Installation procedures
 - 6.2.2.1. Where, typically in a domestic, or similarly small **Low Voltage** installation, the **Generator** wishes to install one or more small **Generating Units** where the **Intrinsic Design Capacity** of all existing and intended **Generating Units** is not greater than 32 A per phase, the provisions of the appropriate **Small Generation Installation** procedure can be followed provided that the **Generator's Installation** meets the appropriate conditions set out below. Different connection procedures

apply depending on the exact capacities and capabilities of the **Generating Units** and control equipment installed, as summarised in the table below:

Application Procedure	All individual Intrinsic Design Capacities	All individual Registered Capacities	Aggregate of Registered Capacities	EREC G100 limitation scheme required?
EREC G98	-10	≤ 16 A	≤ 16 A	No
EREC G99 SGI-1	≤ 32 A	≤ 16 A	≤ 16 A	No
EREC G99 SGI-2	≤ 32 A	≤ 16 A	≤ 32 A	16 A
EREC G99 SGI-3	≤ 32 A	≤ 32 A	≤ 60 A	32 A

6.2.2.2. Small Generation Installation Procedure-1

(a) This procedure SGI-1 applies where the following conditions are met:

1. The new and existing **Generating Units** are located in a single **Generator's Installation**;
2. All of the **Generating Units** (including **Electricity Storage** devices) are connected via EREC G98 or G99 **Fully Type Tested** inverters;¹¹
3. The Intrinsic Design Capacity of each Generating Unit is no more than 32 A;
4. Any Generating Unit with an Intrinsic Design Capacity of greater than 16 A has its Registered Capacity limited to 16 A; and
5. The total aggregate Registered Capacities of all Generating Units (including **Electricity Storage** devices) is no more than 16 A per phase;

(b) If all the conditions above are satisfied, the **Generator** can install and commission all the **Power Generating Modules** and shall submit notification in the format as shown in Form A3-3 (Annex A.1). Note that the **DNO** may provide a method of submitting this information electronically on line etc.

(c) If the **Generator** wishes to increase the **Active Power** output of one or more **Generating Units** comprising the **Power Generating Module** from its current **Registered Capacity** such that condition 4 above is no longer satisfied, ie to change or remove the limitation on output, an application in a format as shown in Form A1-1 or Form A1-2 (as applicable and included in Annex A.1) shall be submitted to the **DNO**.

¹⁰ G98 does not include the concept of **Intrinsic Design Capacity**.

¹¹ Or **Type Tested** to EREC G83 or G59 where the **Power Generating Module** was connected prior to 27 April 2019.

6.2.2.3. Small Generation Installation Procedure-2.

- (a) This procedure SGI-2 applies where the **Generator** wishes to install one or more **Generating Units** and the following conditions, which are essentially the conditions that were applicable for the “Integrated Micro Generation and Storage” procedure in previous versions of EREC G99, are met:
1. The new and existing **Generating Units** are located in a single **Generator’s Installation**;
 2. All of the **Generating Units** (including **Electricity Storage** devices) are connected via EREC G98 or G99 **Fully Type Tested** inverters;¹²
 3. The **Intrinsic Design Capacity** of each new and existing **Generating Unit** is no more than 32A per phase;
 4. The **Registered Capacity** of each new and existing **Generating Unit** is no more than 16A per phase;
 5. The total aggregate **Registered Capacities** of all the **Generating Units** (including **Electricity Storage** devices) is less than 32 A per phase; and
 6. An EREC G100 **Fully Type Tested** export limitation scheme is present that limits the export from the **Generator’s Installation** to the **Distribution Network** to no more than 16 A per phase.
- (b) If all the conditions above are satisfied, the **Generator** should complete an application in a format as shown in Form A1-2 (Annex A.1). Note that the **DNO** may provide a method of submitting this information electronically on line etc.
- (c) The **DNO** will assess the application. No **Power Generating Modules** should be installed or commissioned before this **DNO** assessment is complete and the **Generator** has been advised of the outcome of this assessment. The **DNO** will provide the results of the assessment within 10 working days of receiving the application in (b) above. Given the lower limit of **Registered Capacities** allowed in this procedure SGI-2 compared to that of SGI-3, the **DNO** will generally apply less complex checks than in procedure SGI-3.
- (d) The planned commissioning date stated on the application form shall be between 10 working days and 3 months from the date that the application is submitted to the **Distribution Network Operator**. Confirmation of the commissioning of each **Power Generating Module** shall be made no later than 28 days after commissioning (where tests and checks are not witnessed in accordance with 16.3.1). Confirmation shall be provided in a format as shown in Form A3-2 (Annex A.3).

¹² Or **Type Tested** to EREC G83 or G59 where the **Power Generating Module** was connected prior to 27 April 2019.

- (e) If, at (c) above, the **DNO** determines that further analysis is required before a connection offer can be made, the **DNO** will confirm this. This confirmation ends the SGI-2 process for this application which will then be progressed in line with the **DNO's** standard application process. No **Power Generating Modules** should be installed or commissioned before the standard application process completes.

6.2.2.4. Small Generation Installation Procedure-3.

- (a) This procedure SGI-3 applies where the following conditions are met:
 - 1. The new and existing **Generating Units** are located in a single **Generator's Installation**;
 - 2. All of the **Generating Units** (including **Electricity Storage** devices) are connected via EREC G98 or EREC G99 **Fully Type Tested** inverters;¹³
 - 3. The **Intrinsic Design Capacity** of each new and existing **Generating Unit** is no more than 32 A.
 - 4. The total aggregate **Registered Capacities** of all the **Generating Units** (including **Electricity Storage** devices) is less than 60 A per phase; and
 - 5. An EREC G100 **Fully Type Tested** export limitation scheme is present that limits the export from the **Generator's Installation** to the **Distribution Network** to 32 A per phase.
 - 6. Condition 5 above can be waived if the aggregate of the **Registered Capacities** of the **Power Generating Units** is no more than 32 A.
- (b) If all the conditions above are satisfied, the **Generator** should submit an application in a format as shown in Form A1-2 (Annex A.1). Note that the **DNO** may provide a method of submitting this information electronically on line etc.
- (c) The **DNO** will make an initial assessment of the application. No **Power Generating Modules** should be installed or commissioned before this initial **DNO** assessment is complete and the **Generator** has been advised of the outcome of this initial assessment. The **DNO** will confirm within 10 working days of the submission whether it is necessary for the **DNO** to undertake site specific analysis of the application, taking into account the **Intrinsic Design Capacities**, the aggregated **Registered Capacities** of the **Generating Units** and the local network conditions. Where the **DNO** has identified there is a need for further analysis, no further submission of information is required, but installation and commissioning must not proceed until the **DNO** has established if it is necessary to upgrade the network, and whether such work

¹³ Or **Type Tested** to EREC G83 or G59, where the **Power Generating Module** was connected prior to 27 April 2019.

may be chargeable to the **Generator**, if the **Generator** wishes to go ahead with the installation.

- (d) The planned commissioning date stated on the application form shall be between 10 working days and 3 months from the date that the application is submitted to the **DNO**. Confirmation of the commissioning of each **Power Generating Module** shall be made no later than 28 days after commissioning (where tests and checks are not witnessed in accordance with 16.3.1). Confirmation shall be provided in a format as shown in Form A3-2 (Annex A.3).

6.2.3 Power Generating Facilities which include Type A Power Generating Modules

- 6.2.3.1 For **Type A Power Generating Modules** the compliance, testing and commissioning requirements are detailed in Section 16 of this EREC G99.

- 6.2.3.2 The **Generator** should apply to the local **DNO** for connection using the **DNO's** Standard Application Form (available from the **DNO's** website). On receipt of the application, the **DNO** will assess whether any **Distribution Network** studies are required and whether there is a requirement to witness the commissioning tests. In some cases studies to assess the impact on the **Distribution Network** may need to be undertaken before a firm quotation can be provided to the **Generator**. On acceptance of the quote, any works at the connection site and any associated facilitating works will need to be completed before the **Power Generating Module** can be commissioned. On successful completion of the commissioning tests, the **DNO** will sanction permanent energisation of the **Power Generating Module** in accordance with Section 16 of this EREC G99.

6.2.4 Power Generating Facilities which include Type B, Type C or Type D Power Generating Modules

- 6.2.4.1 The connection process is similar to that described in paragraph 6.2.2 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 will generally be required is defined in the **Distribution Code**, Data Registration Code (DDRC), Schedules 5a, 5b and 5c.

- 6.2.4.2 For **Type B** and **Type C Power Generating Modules** the compliance, testing and commissioning requirements are detailed in Sections 17 and 18 respectively of this EREC G99. On successful completion of a **Type B** or **Type C Power Generating Module Document** the **DNO** will issue a **Final Operational Notification** to the **Generator**.

- 6.2.4.3 For a **Type D Generating Unit**, once all the relevant documents have been provided to the **DNO** to its satisfaction, the **DNO** will issue an **Energisation Operational Notification** to the **Generator** followed by an **Interim Operational Notification** and a **Final Operational Notification**. This staged process is described further in Section 19 of this EREC G99.

- 6.2.4.4 **Generators** who own **Type B** and **Type C Power Generating Modules** do not have permanent rights to operate their **Power Generating Modules** without a valid

- (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** shall be satisfied that any arrangement will be sufficient to fulfil the **Generator's** obligations under the **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** shall be satisfied that any arrangement will be sufficient to fulfil the **Generator's** obligations under the **ESQCR**.

- 7.4.3.3 The switchgear that is used to separate the two systems shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Facility**, from flowing into the **DNO's Distribution Network** when it operates as a switched alternative only supply.

7.5. **Phase Balance of Type A Power Generating Module output at LV**

- 7.5.1 Connection of single phase **Power Generating Modules** may require **Distribution Network** reinforcement and extension before commissioning for technical reasons (such as voltage issues and unacceptable phase imbalance) depending on the point of connection and **Distribution Network** design.

- 7.5.2 A solution to these voltage issues and phase imbalance issues may be to utilise three phase **Power Generating Modules** or to use multiple single phase **Power Generating Modules** connected across three phases. For this arrangement the same export power will result in lower voltage rises due to decreased line currents and a three phase connected **Power Generating Module** is likely to result in significantly lower voltage rises than those created by a single phase connected **Power Generating Module**. If the individual **Power Generating Modules** have different ratings, current and voltage imbalance may occur. To maintain current and voltage imbalance within limits the **Generator** shall consider the phase that each **Power Generating Module** is connected to in an installation. In addition the

DNO may define to a **Generator** the phases to which the **Power Generating Modules** in any given installation should be connected.

- 7.5.3 Where single phase **Power Generating Modules** are being used the **Generator** should design the installation on a maximum unbalance output of 32 A between the highest and lowest phase. Where there is a mixture of different technologies, or technologies which may be operational at different times (eg wind and solar) **Power Generating Modules** shall be connected to give a total imbalance of less than 32 A based on assumed worst case conditions, those being:

- (a) One **Power Generating Module** at maximum output with the other(s) at zero output – all combinations to be considered.
- (b) Both / all **Power Generating Modules** being at maximum output.

A **Power Generating Module** technology which operates at different times due to location eg east and west facing roofs for PV, shall 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 these requirements examples of acceptable and unacceptable connections have been given in Annex A.5.

7.6. **Type A Power Generating Module capacity for single and split LV phase supplies**

- 7.6.1 The maximum aggregate capacity of **Power Generating Modules** that can be connected to a single phase supply is 17 kW. The maximum aggregate capacity of **Power Generating Modules** that can be connected to a split single phase supply is 34 kW.

- 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 17 kW per phase (subject to the balance of site output as per Section 7.5). A single phase 17 kW connection may result in an imbalance of up to 17 kW following a **Distribution Network** or **Power Generating Module** outage. However the connection design should result in imbalance under normal operation to be below 32 A between phases as noted above.

- 7.6.3 **Power Generating Facilities** with a capacity above 17 kW per phase are expected to comprise three phase units. The requirement to disconnect all phases following a fault in the **Generator's Installation** or a **Distribution Network** outage applies to three phase **Power Generating Modules** only and will be tested as part of the compliance testing of the **Power Generating Module**. In some parts of the country where provision of three phase networks is costly then the **DNO** may be able to provide a solution using single or split phase networks for **Power Generating Facilities** above the normal limits as set out above.

7.7. **Voltage Management Units in Generator's Installation**

- 7.7.1 Voltage Management Units are becoming more popular and use various methods, in most cases, to reduce the voltage supplied from the **DNO's Distribution Network** before it is used by the **Generator**. In some cases where the **DNO's Distribution Network** voltage is low they may increase the voltage supplied to the

Generator. Some technologies are only designed to reduce voltage and cannot increase the voltage.

- 7.7.2 The use of such equipment has the advantage to the **Generator** 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 **Connection Point** and the **Power Generating Module** in a **Generator's Installation**, it may result in the voltage at the **Generator** side of the Voltage Management Unit remaining within the limits of the protection settings defined in Table 10.1 while the voltage at the **Connection Point** side of the unit might be outside the limits of the protection settings. This would negate the effect of the protection settings. Therefore, this connection arrangement is not acceptable and all **Power Generating Modules** connected to the **DNO's LV Distribution Network** under this Engineering Recommendation shall be made on the **Connection Point** side of any Voltage Management Unit installed in a **Generator's Installation**.
- 7.7.4 **Generators** should note that the over voltage setting defined in Table 10.1 is 4% above the maximum voltage allowed for the voltage from the **DNO's Distribution Network** under the **ESQCR** and that provided they have designed their installation correctly there should be very little nuisance tripping of the **Power Generating Module**. Frequent nuisance tripping of a **Power Generating Module** may be due to a fault in the **Generator's Installation** or the operation of the **DNO's Distribution Network** at too high a voltage. **Generators** should satisfy themselves that their installation has been designed correctly and all **Power Generating Modules** are operating correctly before contacting the **DNO** if nuisance tripping continues. Under no circumstances should they resort to the use of Voltage Management Units installed between the **Connection Point** and the **Power Generating Module**.
- 7.8. **Power Generating Module Sharing System**
- 7.8.1 This section describes the additional requirements where a **Generator** provides **Active Power** to two or more independent **Customers** connected at **Low Voltage** via equipment designed to share the power generated by **Power Generating Module(s)** under a sharing arrangement.
- 7.8.2 In such a sharing arrangement the **Power Generating Module(s)** are connected to each separate **Customers' Installation** and power flow through these connections is arranged such that output from the **Power Generating Module(s)** is shared between them.
- 7.8.3 The owner of the **Power Generating Module** is, for the purposes of this EREC G99, the **Generator**. The **Generator** need not have a direct electrical connection to the **DNO's Distribution Network**. In some cases the connection will only be via the relevant **Customers' Installations**. In all cases the **Generator** shall have a suitable contract with the **DNO** for the installation and operation of the **Power Generating Module**.
- 7.8.4 All **Customers** served by a **Power Generating Module** sharing arrangement must be connected to the same section of the **DNO's Distribution Network** (ie supplied

via a single set of **Low Voltage** fuses at the **DNO's** substation or equivalent) and also have the same earthing arrangements (eg all be PME or all be SNE). Normally all the **Customers' Installations** will be within a single building. Any use of a sharing arrangement outside of a single building must be specifically agreed with the **DNO**.

7.8.5 Where **Power Generating Module** output sharing is intended, the following requirements apply:

7.8.5.1 The **Generator** is responsible for ensuring compliance with all the relevant requirements of this EREC G99, including specifically the requirements of this section 7.8.5.

7.8.5.2 The equipment/installation shall be designed and constructed such that all protection in each **Customers' Installation** and the **Generator's Installation** will operate correctly by design for faults anywhere on the **Generator's Installation** and **Customers' Installations**. Such protection shall also comply with the requirements of BS 7671. Particular attention should be paid to ensure that all parts of the **Customer's Installation** and the **Generator's Installation** that are within the protection zone of the **DNO's** cut-out fuse are adequately protected.

7.8.5.3 The equipment/installation shall be designed such that no **Active Power** can flow from any **Customer's Installation** towards the **Power Generating Module**, ie to prevent **Active Power** flowing from one **Customer's Installation** to another or from one **Customer's Installation** to the **Generator's Installation**. This restriction does not include any **Active Power** flow that is used purely for maintaining the equipment implementing the sharing arrangement in an operational state when the **Power Generating Module** is generating insufficient **Active Power**, ie the sharing arrangement equipment's parasitic demand: for example that required by a PV sharing arrangement in its quiescent state at night.

7.8.5.4 An exception to section 7.8.5.3 is allowed where the **Generator** has incorporated **Electricity Storage** into the **Power Generating Module**. In this case the **Generator** will arrange, and demonstrate, that the **Active Power** flow into the **Electricity Storage** component matches the aggregate **Active Power** flowing from the **Generator's Installation** and all the relevant **Customer's Installations** at all times. Under these circumstances all **Active Power** flows between the components of the sharing arrangement and the **Customers' Installations** shall be in the same direction, ie towards the **Electricity Storage** component. If there is a mismatch in aggregate flows or direction the charging of the **Electricity Storage** shall cease immediately and an alarm raised.

7.8.5.5 If a **Customer's Installation** becomes de-energized from the **DNO's Distribution Network** the equipment shall detect this condition and disconnect the **Power Generating Module** from that **Customer's Installation**.

7.8.5.6 Synchronizing facilities shall be in place and synchronising checks carried out that check for correct phasing each and every time a **Customer's Installation** is to be connected to the **Generator's Installation**. The detection of incorrect phasing shall trigger an alarm.

7.8.5.7 In situations where the power sharing arrangement results in export of **Active Power** from the **Customers' Installations** to the **DNO's Distribution Network**, the exported **Active Power** flows to the **DNO's Distribution Network** shall be arranged to be balanced between the relevant **Customers' Connection Points**. The

characteristics of the distribution of exported **Active Power** shall be specified in the application, and the export per phase per **Customer** must not exceed 32A.

7.8.5.8 All communication channels, ie those between the components of the equipment used to implement the sharing arrangement, and between those components and any part of **Customers' Installations**, shall be actively monitored, and failure of communication channels shall lead to the appropriate failsafe action, ie disconnection of the **Power Generating Module** from the relevant **Customer's Installation** or the complete shut down of the **Power Generating Module** as appropriate, together with triggering an alarm.

7.8.5.9 If any of the following are detected:

- (a) An **Active Power** flow from any **Customer's Installation** towards the **Power Generating Module** (apart from the parasitic demand referred to in 7.8.5.3 above);
- (b) A mismatch between the aggregate **Active Power** flow from the **Generator's Installations** to the **Customers' Installation** and to any **Electricity Storage** component of the **Power Generating Module** as described in section 7.8.5.4;
- (c) An out of phase condition, as described in section 7.8.5.6; or
- (d) A failure of any communication channel as described in section 7.8.5.8

an alarm shall be raised and communicated to the **Generator**.

7.8.5.10 Earthing arrangements shall be in accordance with BS 7671.

7.8.5.11 The **Power Generating Module** sharing arrangement shall be capable of being switched off by the **Generator** and disconnected via lockable isolation devices from all **Customers' Installations**.

7.8.5.12 In addition to the requirements of Section 14 ownership and operational boundaries, and the means of isolation of the **Power Generating Module(s)** and the connections between the **Generator's Installation** and the **Customer's Installation**, shall be clear for every **Customer**, the **Generator**, the **DNO** and for any operator of the network in a shared building. Appropriate labels shall be affixed at each **Customer's** service position. A single line diagram of the overall installations shall be posted in the **Generator's Installation** and at each **Customer's** service position.

As well as the standard signage requirements of section 14.2 the following provisions shall apply:

- (a) The generation sharing equipment itself should be clearly labelled.
- (b) There should be a specific warning label affixed at each **Customer's** metering position, each **Customer's** consumer unit. These labels shall make it clear that the equipment is supplied from more than one source of energy.
- (c) Depending on the **Manufacturer's** instructions and installation design additional labels may be required to identify generation sharing neutral

connections and any current transformers installed for the generation sharing installation.

- (d) Where there is more than one set of generation sharing equipment within the installation, cross-referencing shall be used on relevant labels to identify which generation sharing equipment supplies each **Customer**.

8.3. **Power Generating Modules with a Connection Point at LV**

- 8.3.1 **LV Distribution Networks** are always solidly earthed, and the majority are multiple earthed. Design practice for protective multiple earthing is detailed in the Energy Networks Association publications including Engineering Recommendation G12, and in the references contained in those publications.
- 8.3.2 The winding configuration and method of earthing connection shall be agreed with the **DNO**.
- 8.3.3 In addition, where the **Power Generating Facility's Connection Point** is at **Low Voltage** the following shall apply:

Where an earthing terminal is provided by the **DNO** it may be used by a **Power Generation Facility** for earthing the **Power Generating Module**, provided the **DNO** earth connection is of adequate capacity. If the **Power Generating Module** is intended to operate independently of the **DNO's** supply, the **Power Generating Module** shall 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 shall be connected to the **Power Generating Modules** earthing system by means of a conductor at least equivalent in size to that required to connect the **DNO's** earthing terminal to the installation.

Where the **Power Generating Module** may be operated as a switched alternative only to the **DNO's Distribution Network**, the **Power Generation Facility** shall provide an independent earth electrode.

Where it is intended to operate in parallel with the **DNO's Low Voltage Network** with the star point connected to the neutral and/or earthing system, precautions will need to be taken to limit the effects of circulating harmonic currents. It is permissible to insert an impedance in the supply neutral of the **Power Generating Module** for this purpose, for those periods when it is paralleled with the **DNO's Distribution Network**. However, if the **Power Generating Module** is operating in isolation from the **DNO's Distribution Network** it will be necessary to have the **Power Generating Module** directly earthed.

Where the **Power Generating Modules** are designed to operate independently from the **DNO's Distribution Network** the switchgear that is used to separate the two systems shall break all four poles (3 phases and neutral). This prevents any phase or neutral current, produced by the **Power Generating Module**, from flowing into the **DNO's Distribution Network** when it operates as a switched alternative only supply.

The following Figures 8.7 to 8.15 show typical installations.

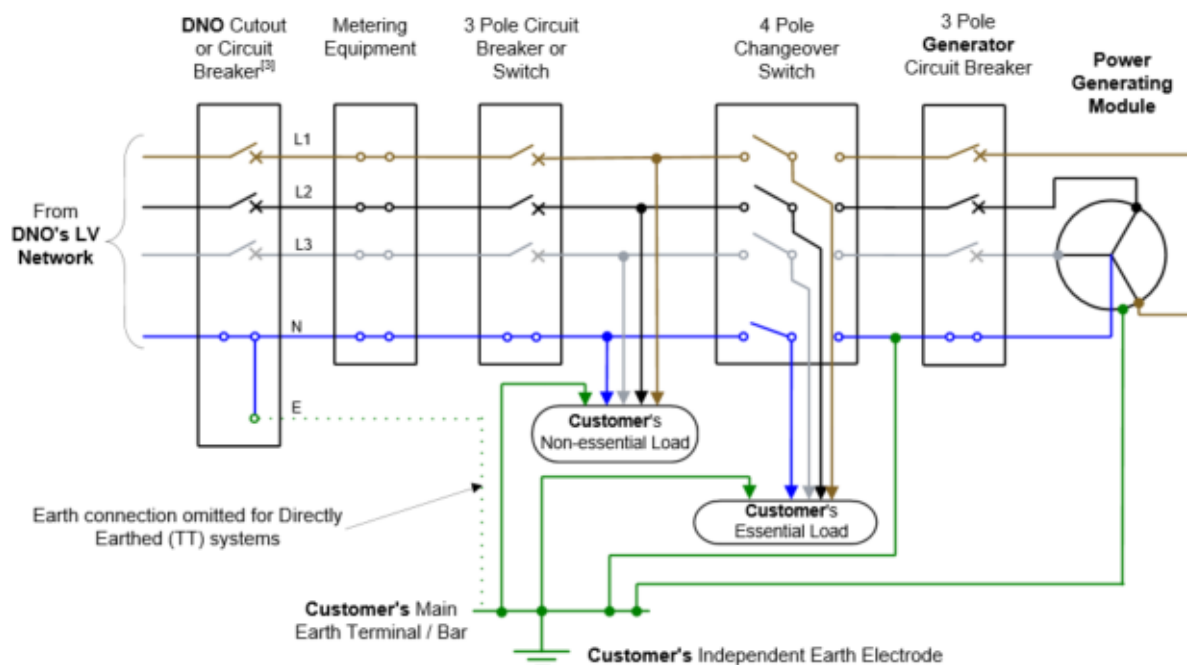


Figure 8.7 - Typical earthing arrangement for an LV Power Generating Module Embedded within a Generator's LV System and designed for Switched Alternative Only (OM4)

NOTE:

- (1) The **Power Generating Module** is not designed to operate in parallel with the **DNO's Distribution Network**.
- (2) The changeover switch shall disconnect each phase and the neutral (ie for a three phase system a 4 pole switch is required). This prevents current flowing and voltage being transferred between the **DNO's Distribution Network** and the **Customer's Installation** when operating in switched alternative mode.
- (3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

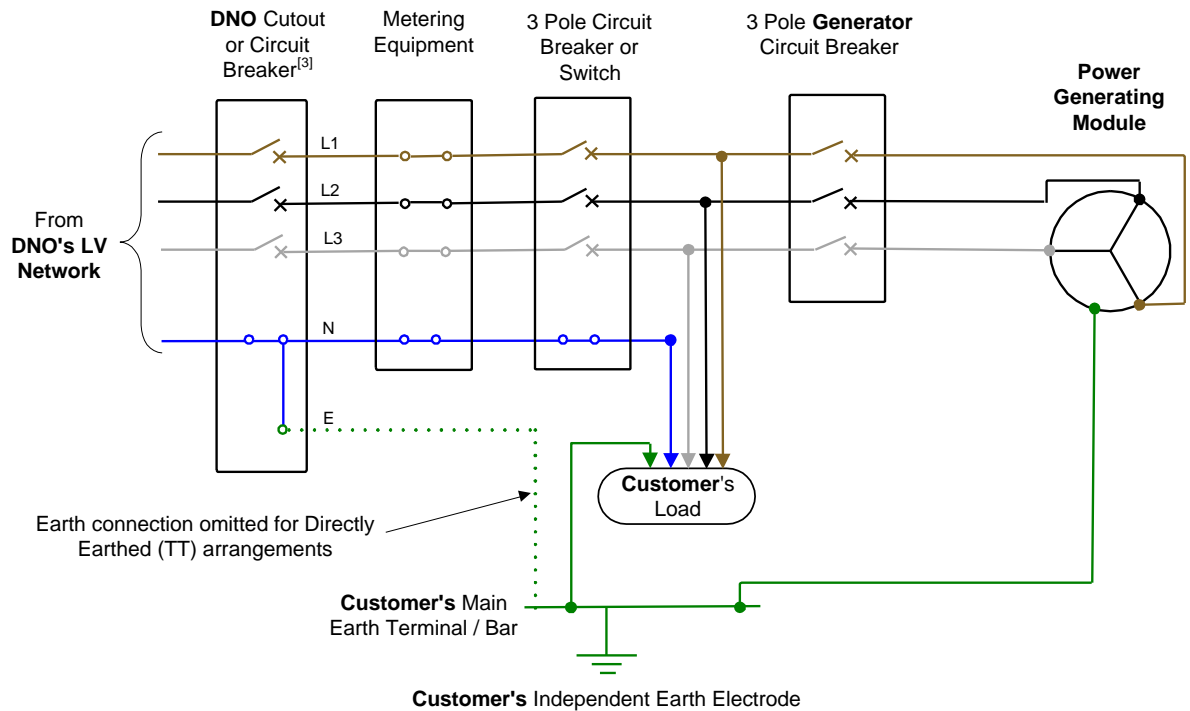


Figure 8.8 - Typical earthing arrangement for a three phase LV Power Generating Module Embedded within a Generator's LV System and designed for Long Term Parallel Operation without Islanding (OM1)

NOTE:

- (1) The **Power Generating Module** is not designed to operate in island mode, ie it can only operate in OM1.
- (2) The **Generator's** independent earth electrode is only required if the installation is Directly Earthed (TT).
- (3) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

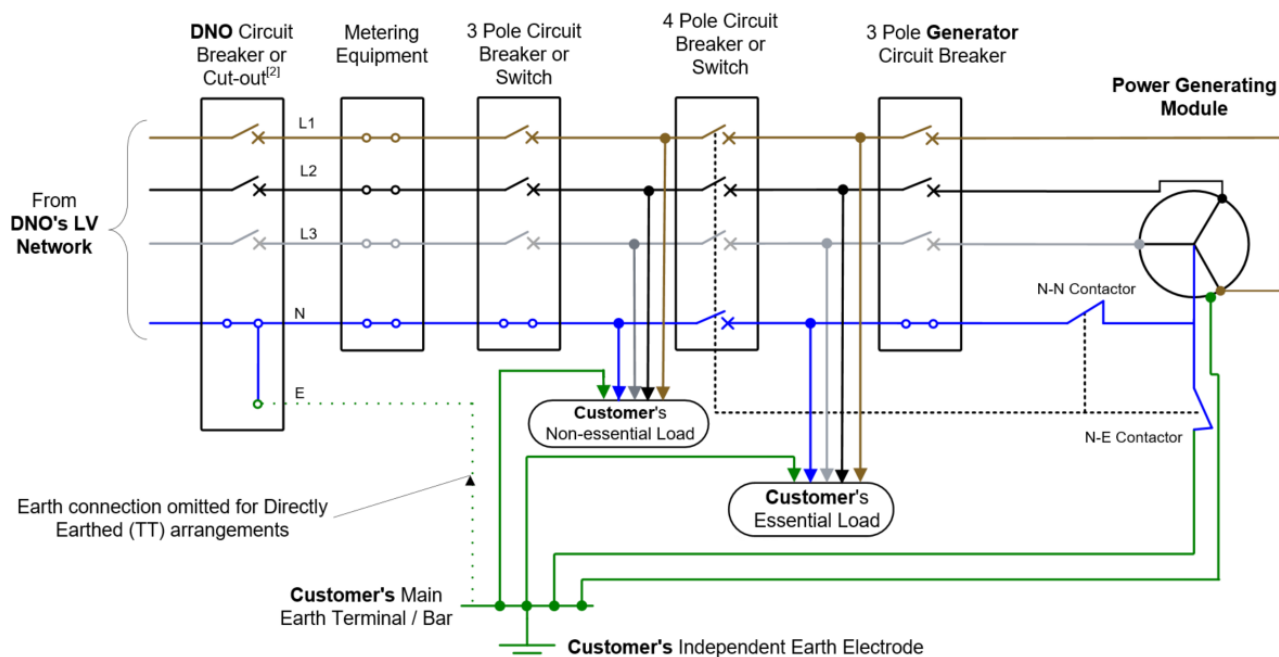


Figure 8.9 - Typical earthing arrangement for a three phase LV Power Generating Module Embedded within a Generator's LV System and designed for Long Term Parallel Operation with Islanding (OM2)

NOTE:

- (1) When the **Power Generating Module** operates in island mode, the switch that is used to provide isolation between these two systems shall disconnect each phase and neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Generator's Installation** that is not supported by the **Power Generating Module**. This switch should also close the **Power Generating Module** neutral and earth switches during island mode operation.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

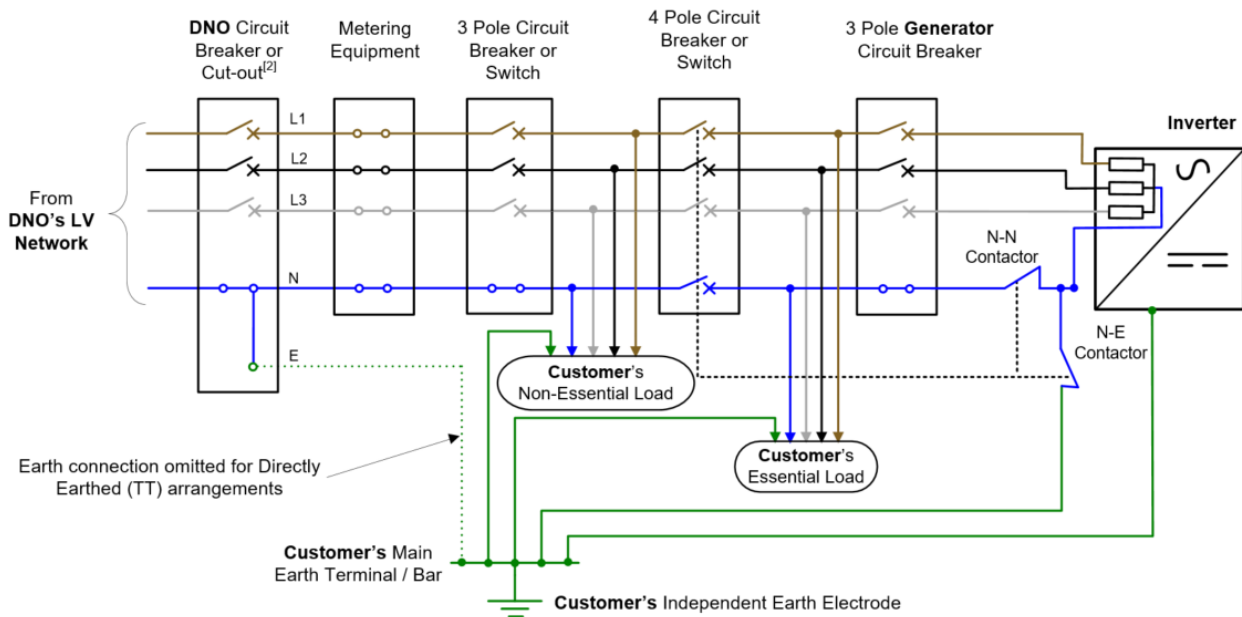


Figure 8.10 - Typical earthing arrangement for a three phase LV Power Park Module Embedded within a Generator's LV System and designed for Long Term Parallel Operation with Islanding (OM2)

NOTE:

- (1) When the **Power Generating Module** operates in island mode the switch that is used to provide isolation between these two systems shall disconnect each phase and neutral (ie for a three phase system a 4 pole switch is required). This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Generator's Installation** that is not supported by the **Power Generating Module**. This switch should also close the **Power Generating Module** neutral and earth switches during island mode operation.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements

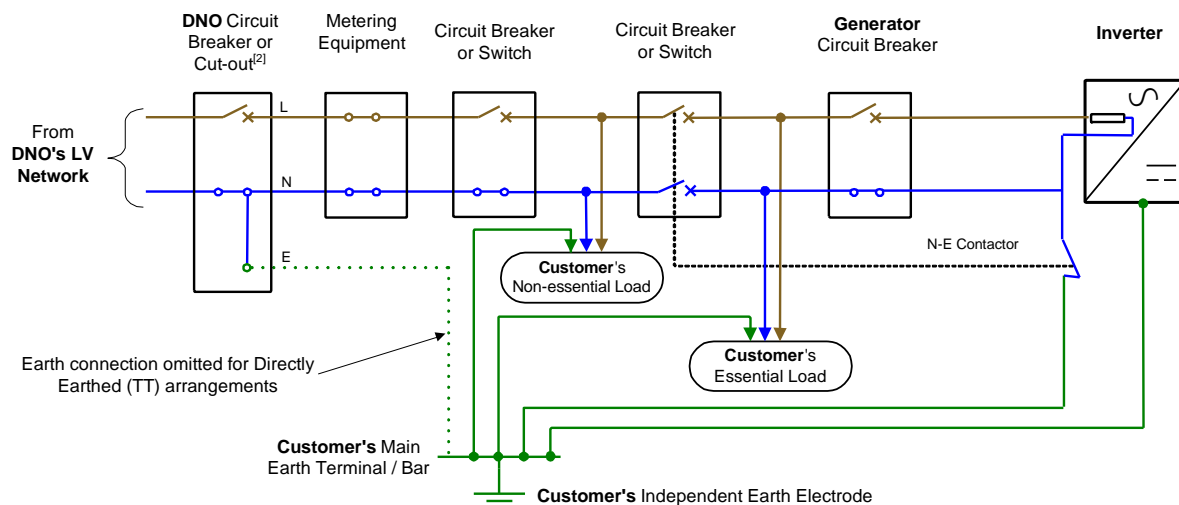


Figure 8.11 - Typical earthing arrangement for a single phase LV Power Park Module Embedded within a Generator's LV System and designed for Long Term Parallel Operation with Islanding (OM2)

NOTE:

- (1) When the **Power Generating Module** operates in island mode the switch that is used to provide isolation between these two systems shall disconnect both phase and neutral. This prevents **Power Generating Module** neutral current from inadvertently flowing through the part of the **Generator's Installation** that is not supported by the **Power Generating Module**. This switch should also close the **Power Generating Module** neutral and earth switches during island mode operation.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

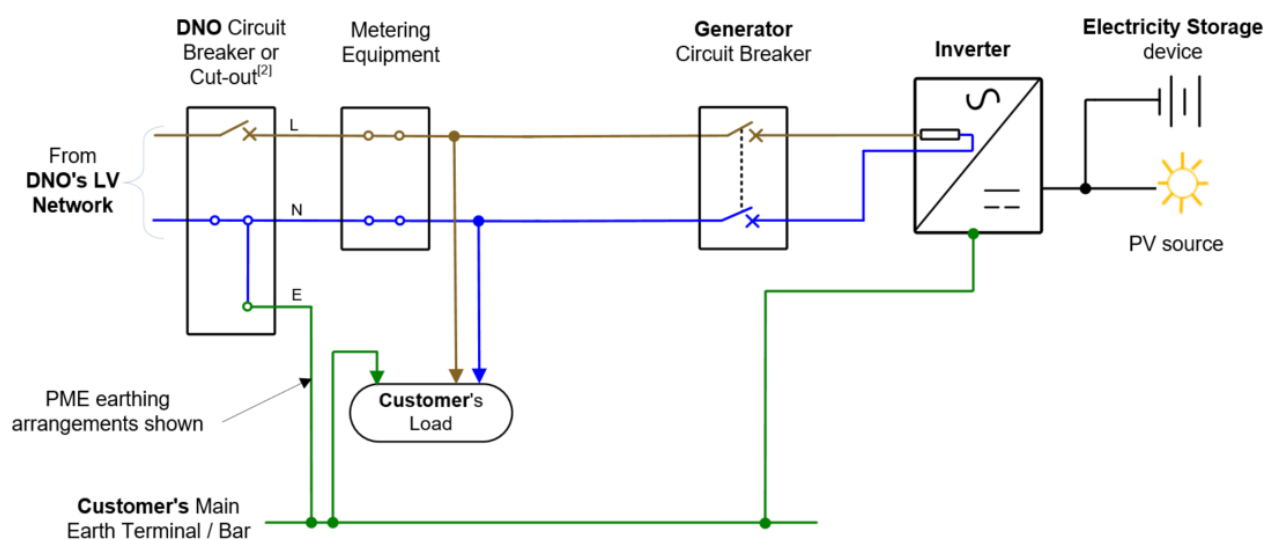


Figure 8.12 - Typical domestic earthing arrangement for a single phase LV Power Park Module Embedded within a Generator's LV System and designed for Long Term Parallel Operation without Islanding (OM1)

NOTE:

- (1) Domestic single phase premises may be supplied from a three phase cut out in certain circumstances.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

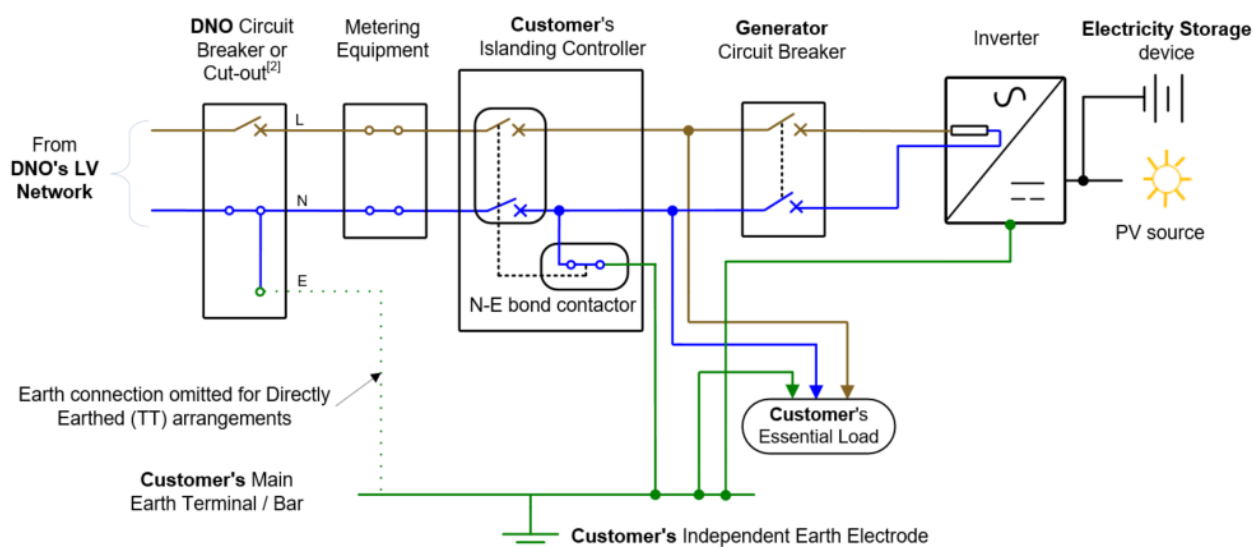


Figure 8.13 – Typical domestic earthing arrangements for Long Term Parallel Operation with Islanding supplying all loads (OM2)

NOTE:

- (1) Domestic single premises may be supplied from a three phase cut out in certain circumstances.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.
- (3) When the **Power Generating Module** operates in island mode the backup **Customer's** islanding controller interface used shall disconnect both phase and neutral. This prevents any current flow inadvertently feeding onto the **Distribution Network** when operating in island mode.
- (4) Manufacturer's instructions for the **Customer's** islanding controller and the design of the installation shall always be followed.

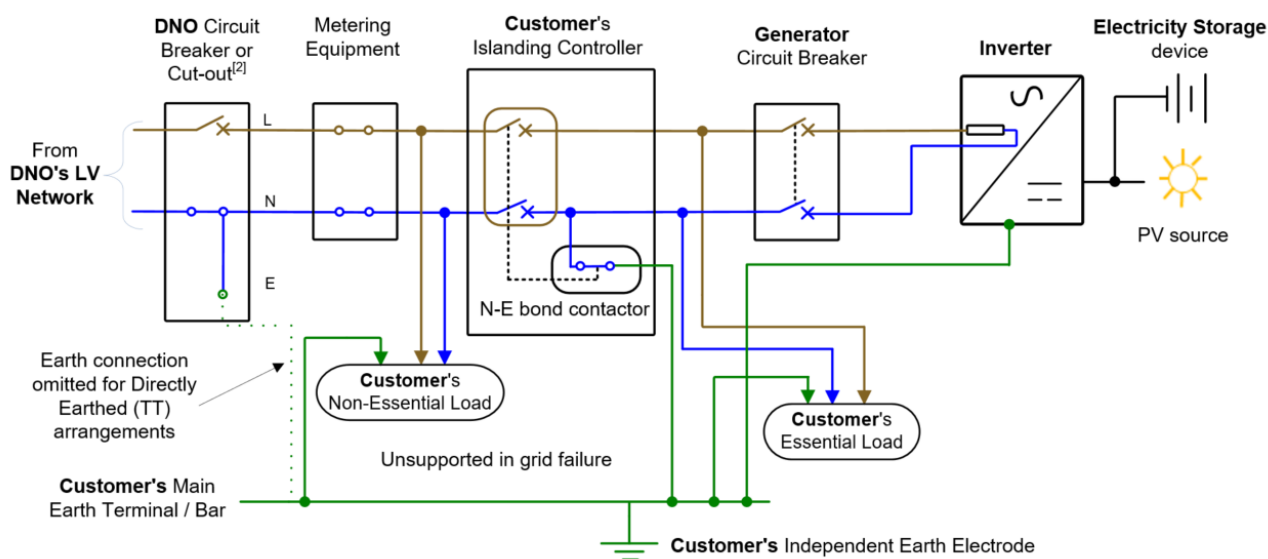


Figure 8.14 – Typical domestic example of earthing arrangements for Long Term Parallel Operation with Islanding supplying only essential loads (OM2)

NOTE:

- (1) Domestic single premises may be supplied from a three phase cut out in certain circumstances.
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.
- (3) When the **Power Generating Module** operates in island mode the **Customer's** islanding controller used shall disconnect all phases and neutral. This prevents any current flow inadvertently feeding onto the **Distribution Network** when operating in island mode.
- (4) Manufacturer's instructions for the **Customer's** islanding controller and the design of the installation shall always be followed.

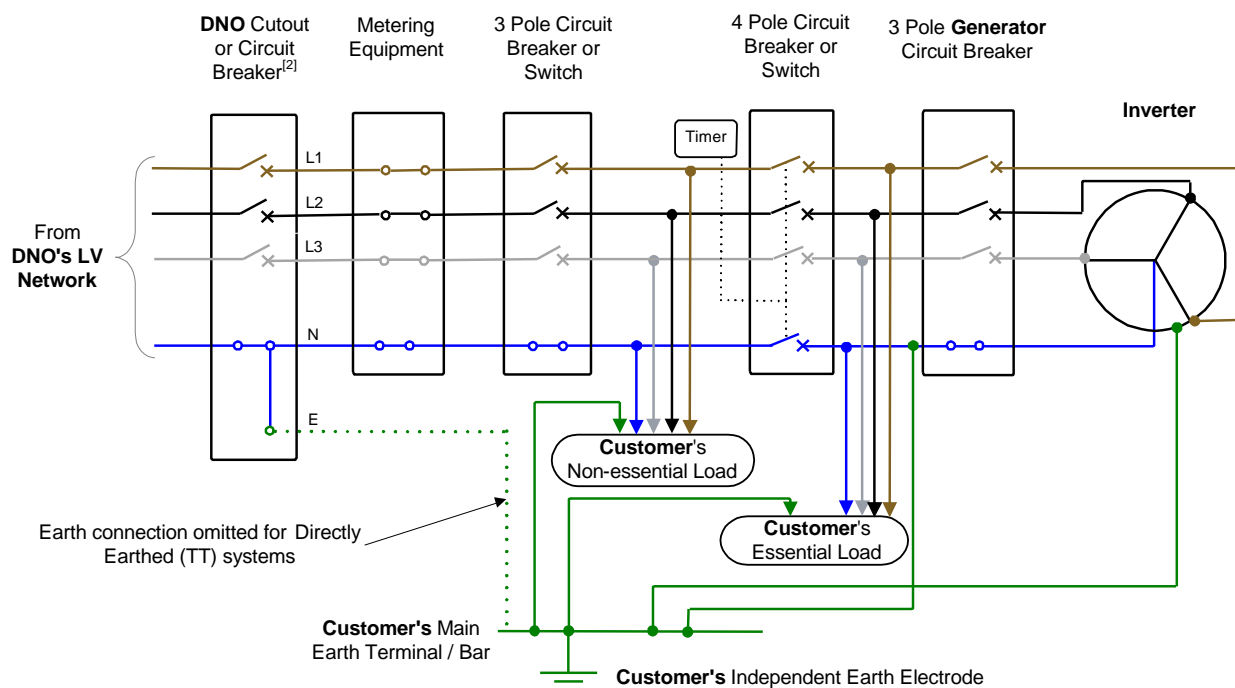


Figure 8.15 – Typical example of earthing arrangements for Short Term Parallel Operation with Islanding supplying only essential loads (OM3)

NOTE:

- (1) It is expected that the earthing of the **Power Generating Module** star point would be solid, ie there will not generally be a neutral/earth contactor for three phase installations – see 9.6.3.4(b)
- (2) The **DNO** cut-out / circuit breaker shows a PME (TN-C-S) connection, however, the **Power Generating Module** earthing arrangement is also applicable to SNE (TNS) and direct earthing (TT) arrangements.

10.6.7. Protection Settings

10.6.7.1

Table 10.1 Settings for Long-Term Parallel Operation

Protection Function	Type A, Type B and Type C Power Generating Modules				Type D Power Generating Modules and Power Generating Facilities with a Registered Capacity > 50 MW	
	LV Protection(1)		HV Protection(1)			
	Trip Setting	Time Delay Setting	Trip Setting	Time Delay Setting	Trip Setting	Time Delay Setting
U/V	$V\phi\text{-}n^{\dagger}$ -20%	2.5 s*	$V\phi\text{-}\phi^{\ddagger}$ -20%	2.5 s*	$V\phi\text{-}\phi^{\ddagger}$ -20%	2.5 s*
O/V st 1	$V\phi\text{-}n^{\dagger}$ + 14%	1.0 s	$V\phi\text{-}\phi^{\ddagger}$ + 10%	1.0 s	$V\phi\text{-}\phi^{\ddagger}$ + 10%	1.0 s
O/V st 2	$V\phi\text{-}n^{\dagger}$ + 19%\$	0.5 s	$V\phi\text{-}\phi^{\ddagger}$ + 13%	0.5 s		
U/F st 1	47.5 Hz	20 s	47.5 Hz	20 s	47.5 Hz	20 s
U/F st 2	47.0 Hz	0.5 s	47.0 Hz	0.5 s	47.0 Hz	0.5 s
O/F	52.0 Hz	0.5 s	52.0 Hz	0.5 s	52.0 Hz	0.5 s
LoM (RoCoF)#	1 Hzs ⁻¹ time delay 0.5 s		1 Hzs ⁻¹ time delay 0.5 s		Intertripping expected	

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

If the EREC G99 protection takes its voltage reference from an **LV** source then **LV** settings shall be applied. Where a private non-standard **LV** network exists the settings shall be calculated from **HV** settings values as indicated by Section 10.6.14;

If the EREC G99 protection takes its voltage reference from an **HV** source then **HV** settings shall be applied.

[†]A value of 230 V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network** ie the U/V **LV** trip setting is 184 V, the O/V stage 1 setting is 262.2 V and the O/V stage 2 setting is 273.7 V.

[‡]A value to suit the nominal voltage of the **HV Connection Point**.

* Might need to be reduced if auto-reclose times are <3 s. (see 10.2.1).

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

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

The required RoCoF protection requirement is expressed in Hertz per second (Hzs^{-1}). The time delay should begin when the measured RoCoF exceeds the threshold expressed in Hzs^{-1} . The time delay should be reset if measured RoCoF falls below that threshold. The relay shall not trip unless the measured rate remains above the threshold expressed in Hzs^{-1} continuously for 500 ms. 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 500 ms if the system RoCoF was significantly higher than the threshold.

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

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

10.6.7.2

Table 10.2 – Settings for Infrequent Short-Term Parallel Operation

Protection Function	Type A, Type B and Type C Power Generating Module			
	LV Protection		HV Protection	
	Trip Setting	Time Delay Setting	Trip Setting	Time Delay Setting
U/V	$V\phi\text{-}n^{\dagger} -10\%$	0.5 s	$V\phi\text{-}\phi^{\ddagger} -6\%$	0.5 s
O/V	$V\phi\text{-}n^{\dagger} + 14\%$	0.5 s	$V\phi\text{-}\phi^{\ddagger} + 6\%$	0.5 s
U/F	49.5 Hz	0.5 s	49.5 Hz	0.5 s
O/F	50.5 Hz	0.5 s	50.5 Hz	0.5 s

\dagger A value of 230 V shall be used in all cases for **Power Generating Facilities** connected to a **DNO's LV Distribution Network** (ie the U/V LV trip setting is 207 V and the O/V trip setting is 262.2 V).

\ddagger A value to suit the voltage of the **HV Connection Point**.

- 10.6.8. Over and Under voltage protection shall operate independently for all three phases in all cases.
- 10.6.9. The settings in Table 10.1 should generally be applied to all **Power Generating Modules**. In exceptional circumstances **Generators** have the option to agree alternative settings with the **DNO** if there are valid justifications in that the **Power Generating Module** may become unstable or suffer damage with the settings specified in Table 10.1. The agreed settings should be recorded in the **Connection Agreement**.
- 10.6.10. Once the settings of relays have been agreed between the **Generator** and the **DNO** they shall not be altered without the written agreement of the **DNO**. Any

11. Type A Power Generating Module Technical Requirements

11.1. Power Generating Module Performance and Control Requirements – General

11.1.1. The requirements of this Section 11 do not apply in full to:

- (a) **Power Generation Facilities** that are designed and installed for infrequent short-term parallel operation only; or
- (b) **Electricity Storage Power Generation Modules** within the **Power Generating Facility** commissioned before 01 September 2022.

Refer to Annex A.4 for details.

11.1.2. The **Active Power** output of a **Power Generating Module** should not be affected by voltage changes within the statutory limits declared by the **DNO** in accordance with the **ESQCR**.

11.1.3. **Power Generating Modules** connected to the **DNO's Distribution Network** shall be equipped with a logic interface (input port) in order to cease **Active Power** output within 5 s **following** an instruction being received at the input port.

11.1.3.1. By default the **DNO** logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor. When the switch is closed the **Power Generating Module** can operate normally. When the switch is opened the **Power Generating Module** will reduce its **Active Power** to zero within 5 s. The signal from the **Power Generating Module** that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V). If the **DNO** wishes to make use of the facility to cease **Active Power** output the **DNO** will agree with the **Generator** how the communication path is to be achieved.

11.1.4. Each item of a **Power Generating Module** and its associated control equipment shall be designed for stable operation in parallel with the **Distribution Network**.

11.1.5. When operating at **Registered Capacity** the **Power Generating Module** shall be capable of operating 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**.

11.1.6. As part of the connection application process the **Generator** shall agree with the **DNO** the set points of the control scheme for voltage control, **Power Factor** control or **Reactive Power** control as appropriate. The control scheme, the settings, and any changes to the settings, shall be agreed with the **DNO** and recorded in the **Connection Agreement**. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.

11.1.7. Load flow and **System Stability** studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The **Connection Agreement** should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels

leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module**.

11.2. Frequency response

11.2.1. Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the **DNO's Distribution Network** could rise above 50.5 Hz. Therefore all **Power Generating Modules** shall be capable of continuing to operate in parallel with the **Distribution Network** in accordance with the following:

- (a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range.
- (b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.
- (c) 49.0 Hz – 51.0 Hz Continuous operation of the **Power Generating Module** is required.
- (d) 51.0 Hz – 51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.
- (e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.

11.2.2. With regard to the rate of change of frequency withstand capability, a **Power Generating Module** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the **Power Generating Module's** own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.

11.2.3. Output power with falling frequency

11.2.3.1. Each **Power Generating Module**, shall be capable of:

- (a) continuously maintaining constant **Active Power** output for system frequency changes within the range 50.5 to 49.5 Hz; and
- (b) (subject to the provisions of paragraph 11.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 11.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25°C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%. In the case of a **CCGT Module** this requirement shall be retained down to 48.8 Hz, which reflects the first stage of the automatic Low Frequency Demand Disconnection scheme. For system frequency below 48.8 Hz, the existing requirements shall be retained for a minimum period of 5 minutes while system frequency remains below 48.8Hz, and any special measure(s) that may be required to meet this requirement shall be kept in service during this period. After that 5 minute period, if system frequency remains below the 49.5 Hz threshold, the special

measure(s) must be discontinued if there is a materially increased risk of the Gas Turbine tripping. The need for special measure(s) is linked to the inherent Gas Turbine **Active Power** output reduction caused by reduced shaft speed due to falling system frequency. Where the need for special measures is identified in order to maintain output in line with the level identified in Figure 11.1 these measures should still be continued at ambient temperatures above 25°C maintaining as much of the **Active Power** achievable within the capability of the plant.

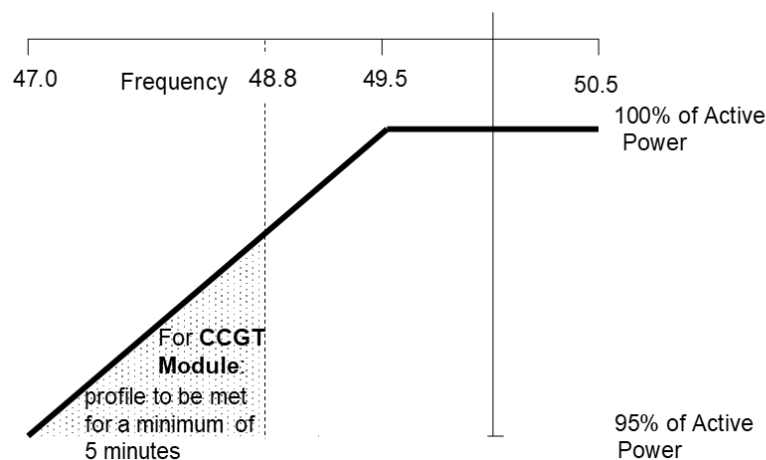


Figure 11.1 Change in Active Power with falling frequency

11.2.3.2. For the avoidance of doubt, in the case of a **Power Generating Module** using an **Intermittent Power Source** where the power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.

11.2.3.3. **Electricity Storage Power Generating Modules** when operating in an importing mode of operation:

11.2.3.3.1 Each **Generator** in respect of an **Electricity Storage Power Generating Module** is required to meet the requirements of 11.2.3.3.1 (a) – (f):

- (a) Be capable of automatically maintaining its **Active Power** output within the shaded operating region shown in Figure 11.2 until the stored energy has been depleted. The **Electricity Storage Power Generating Module** could initially be operating at any level of import between zero **Active Power** and the **Rated Import Power** within a system frequency range of 50 Hz and 49.5 Hz as shown in Figure 11.2. The **Electricity Storage Power Generating Module** is only required to reach its **Registered Capacity** if the **Electricity Storage Power Generating Module** has headroom and the ability to increase **Active Power** output. A typical value of the **Droop** would be 0.6% where this does not result in control system instability or plant difficulties. In all cases the **Droop** shall be between 0.6% and 1.2% and shall be agreed with the **DNO**.
- (b) Automatically respond in accordance with the characteristic of Figure 11.2 when the system frequency falls to 49.5 Hz and below.

- (c) The reduction in **Active Power** import (during an import mode of operation), and the transition to the final value of **Active Power** output shall be continuously and linearly proportional, as far as is practicable, to the reduction in frequency below 49.5 Hz. **Active Power** output must be provided increasingly with time as required by 11.2.3.3.1 (d) below.
- (d) As much as possible of the proportional reduction in **Active Power** import must result from the frequency control device (or speed governor) action and must be achieved within 10 s of the time of the frequency decreases below 49.5 Hz. The **Electricity Storage Power Generating Module** shall be capable of initiating a power frequency response with an initial delay that is as short as possible. Delays that exceed 2 s shall be justified by the **Generator** providing technical evidence to the **DNO** and in any event as much as possible of the proportional reduction in **Active Power** import shall be achieved within 10 s. This performance requirement is to be maintained when the **Electricity Storage** device makes the transition to an **Active Power** export mode of operation unless the energy store is depleted, in which case it shall be required to operate at zero **Active Power** output.
- (e) Where the **Electricity Storage Power Generating Module** is not capable of making a transition from import operation to export operation within 20 s of the frequency falling to 49.2 Hz, then it shall immediately reduce its **Active Power** import to zero.
- (f) If the **Electricity Storage Power Generating Module** has not achieved at least a zero **Active Power** import when the system frequency has reached 48.9 Hz, it shall be instantaneously tripped. Where an **Electricity Storage Power Generating Module** trips, it shall not reconnect to the system until the conditions of 10.3.3 to 10.3.5 are met.

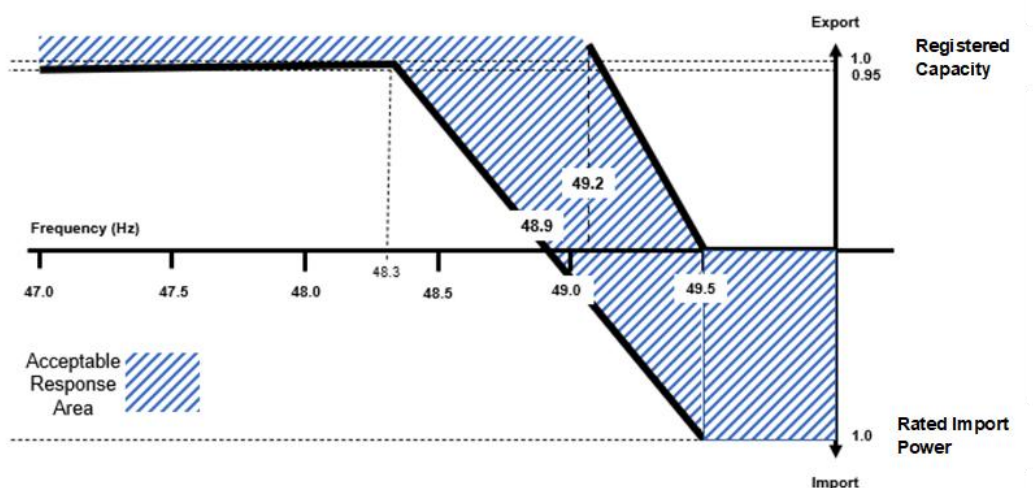


Figure 11.2 Active Power performance with falling frequency

11.2.3.3.2 Where an **Electricity Storage Power Generating Module** was importing before the fall in frequency and has responded in accordance with the requirements of 11.2.3.3.1, its performance, once the system frequency starts to rise above the minimum reached, shall be in accordance with Figure 11.3 in respect of the **Active Power** output and **Active Power** import. For example, Figure 11.3, illustrates the four operating points W, X, Y and Z. If points W, X,

Y and Z denotes the minimum frequency that the **Total System** reached during a particular low system frequency event, as the system frequency starts to rise, the **Active Power** output of the **Electricity Storage Power Generating Module** should remain at a constant level (where the energy source has not been depleted) until 49.5 Hz is reached as denoted by the dashed black lines. Once the system frequency has risen above 49.5 Hz the **Electricity Storage Power Generating Module** is permitted to reduce **Active Power** output so long as it is operating within the shaded area above 49.5 Hz shown in Figure 11.3, unless the **Electricity Storage Power Generating Module** has insufficient capability in which case it shall operate at zero **Active Power**.

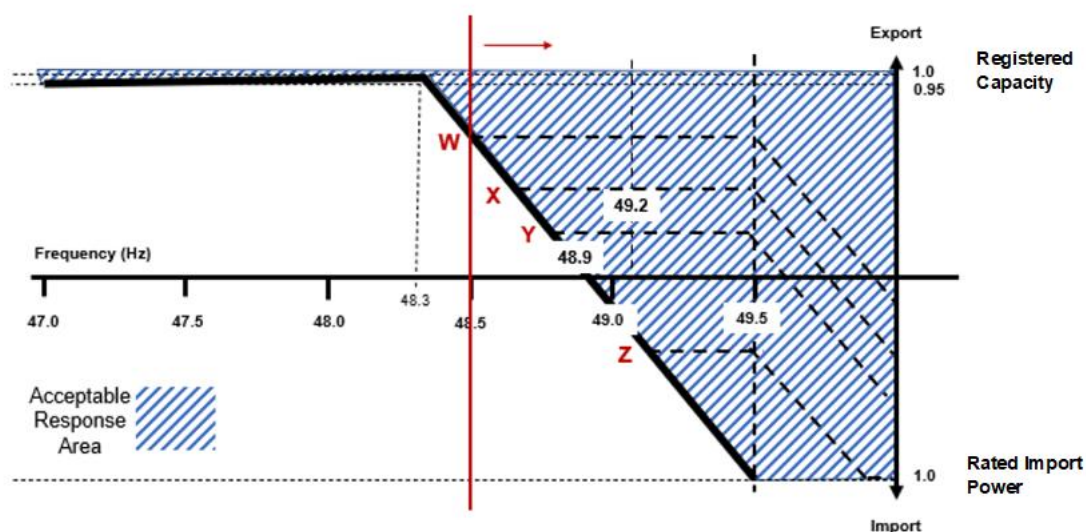


Figure 11.3 Active Power performance with increasing frequency

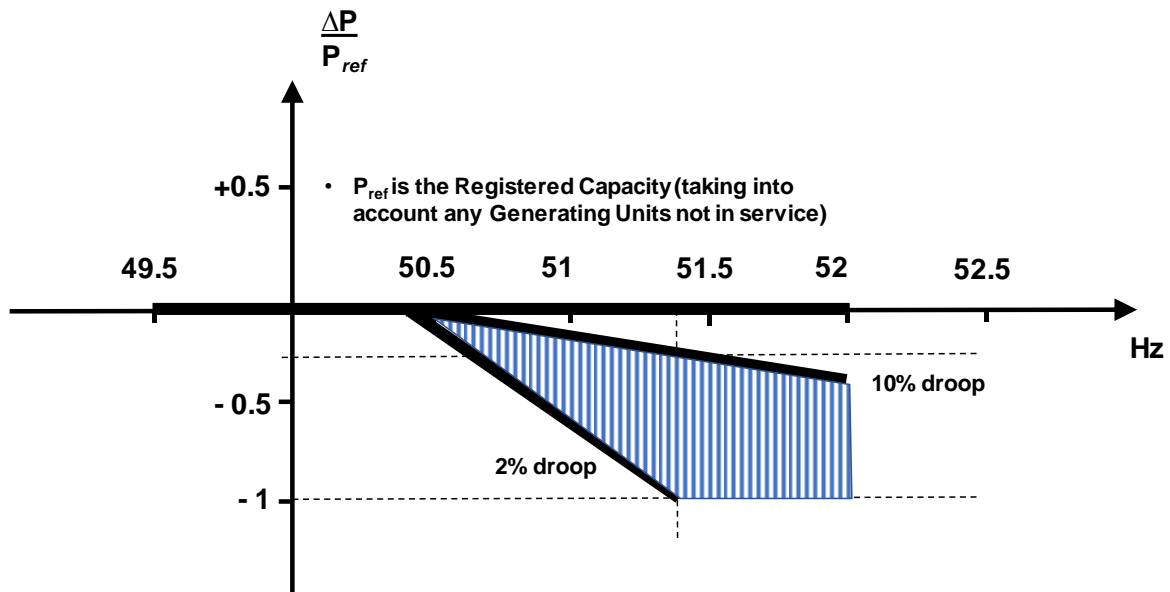
11.2.3.3.3 Where an **Electricity Storage Power Generating Module** is exporting **Active Power** (including zero) to the **Total System** and the system frequency falls below 49.5 Hz the requirements of 11.2.3.3.1 and 11.2.3.3.2 shall apply.

11.2.4. Limited Frequency Sensitive Mode – Overfrequency

11.2.4.1. Each **Power Generating Module** shall be capable of reducing **Active Power** output in response to the frequency on the **Total System** when this rises above 50.4 Hz. The **Power Generating Module** shall be capable of operating stably during **LFSM-O** operation. If a **Power Generating Module** has been contracted to operate in **Frequency Sensitive Mode** the requirements of **LFSM-O** shall apply when the frequency exceeds 50.5 Hz.

- (a) The rate of change of **Active Power** output shall be at a minimum rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a **Droop** of 10%) as shown in Figure 11.4. For the avoidance of doubt, this would not preclude a **Generator** from designing the **Power Generating Module** with a **Droop** of less than 10%, but in all cases the **Droop** should be 2% or greater.

- (b) The **Power Generating Module** shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the **Generator** shall justify the delay, providing technical evidence to the **DNO**, who will pass this evidence to the **ISOP**.
- (c) For deviations in frequency up to 50.9 Hz at least half of the proportional reduction in **Active Power** output shall be achieved within 10 s of the time of the frequency increase above 50.4 Hz. Refer to Figure A.7.10 for details.
- (d) For deviations in frequency beyond 50.9 Hz the measured rate of change of **Active Power** reduction shall exceed $0.5\% \text{ s}^{-1}$ of the initial output. Refer to Figure A.7.9 for details.
- (e) The **LFMS-O** response shall be reduced when the frequency subsequently falls again and, when to a value less than 50.4 Hz, at least half the proportional increase in **Active Power** shall be achieved in 10 s. For a frequency excursion returning from beyond 50.9 Hz the measured rate of change of **Active Power** increase shall not exceed $0.5\% \text{ s}^{-1}$.
- (f) If the reduction in **Active Power** is such that the **Power Generation Module** reaches its **Minimum Stable Operating Level**, it shall continue to operate stably at this level.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 11.4 Active Power Frequency Response capability when operating in LFSM-O

- 11.2.4.2. When the **Power Generating Module** is providing **Limited Frequency Sensitive Mode Overfrequency (LFSM-O)** response it shall continue to provide the frequency response until the frequency has returned to, or is below, 50.4 Hz.
- 11.2.4.3. Steady state operation below **Minimum Stable Operating Level** is not expected but if system operating conditions cause operation below **Minimum Stable Operating Level** which give rise to operational difficulties then the **Generator** shall be able to return the output of the **Power Generating Module** to an output of not less than the **Minimum Stable Operating Level**.
- 11.3. **Fault Ride Through and Phase Voltage Unbalance**
- 11.3.1. Where it has been specifically agreed between the **DNO** and the **Generator** that a **Power Generating Facility** will contribute to the **DNO's Distribution Network** security, (eg for compliance with EREC P2) the **Power Generating Module(s)** 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 **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.
- 11.3.2. In the case of phase to phase faults on the **DNO's Distribution Network** that are cleared by system back-up protection which will be within the plant short time rating

on the **DNO's Distribution Network** the **DNO**, on request during the connection process, will advise the **Generator** of the expected **Phase (Voltage) Unbalance**.

11.4. Voltage Limits and Control

- 11.4.1. Where a **Power Generating Module** is remote from a **Network** voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the **DNO** should agree with the **Generator** the declared voltage and voltage range at the **Connection Point**. Immunity of the **Power Generating Module** to voltage changes of $\pm 10\%$ of the declared voltage is recommended, subject to design appraisal of individual installations.
- 11.4.2. The connection of a **Power Generating Module** to the **Distribution Network** shall be designed in such a way that operation of the **Power Generating Module** does not adversely affect the voltage profile of and voltage control employed on the **Distribution Network**. EREP 126 provides **DNOs** with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the **DNO** if requested by the **Generator**.
- 11.4.3. The final responsibility for control of **Distribution Network** voltage does, however, remain with the **DNO**.
- 11.4.4. Automatic Voltage Control (AVC) schemes employed by the **DNO** often assume that power flows from parts of the **Distribution Network** operating at a higher voltage to parts of the **Distribution Network** operating at lower voltages. Export from **Power Generating Modules** in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the **Low Voltage** side may not operate correctly without an import of **Reactive Power** and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of **Power Generating Modules** becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.
- 11.4.5. **Power Generating Modules** can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in **Active Power** and **Reactive Power** flows. EREP 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.

15.5. Compliance of Vehicle to Grid Electric Vehicles

- 15.5.1. The owner of the installation where a **Vehicle to Grid Electric Vehicle** is connected to the **Distribution Network** is a **Generator** and is responsible for compliance of the **Vehicle to Grid Electric Vehicle** with this EREC G99.

15.6. Family approach to Type Testing

- 15.6.1. A family approach to type testing is acceptable, whereby **Generating Units** that are the same model and produced by the same **Manufacturer** but vary in electrical output can be considered to be **Type Tested** once one **Generating Unit** in the family has been shown to be compliant.¹⁹ The approach is permissible in the following range of **Generating Unit** electrical output:

- For **Synchronous Generating Units**:
 - Lower limit: $1/\sqrt{10}$ (0.3162) times the tested **Generating Unit** nameplate rating (W)
 - Upper limit: $\sqrt{10}$ (3.162) times the tested **Generating Unit** nameplate rating (W)
- For all other **Generating Units**:
 - Lower limit: $1/\sqrt{10}$ (0.3162) of tested **Generating Unit** nameplate rating (W)
 - Upper limit: 2 times tested **Generating Unit** nameplate rating (W)

- 15.6.2. All absolute values (e.g. operating range tests) shall be transferred directly in the compliance forms of an assumed compliant **Generating Unit** of the same family. All relative results related to design **Active Power** or current (e.g. power quality fluctuation and flicker) from the tested **Generating Unit** shall be transferred to the compliance form of a **Generating Unit** in the same family according to the ratio of the respective nameplate rating (W) of the tested **Generating Unit** and the assumed compliant **Generating Unit**. For the avoidance of doubt, the **Manufacturer** shall register each **Generating Unit** in the family on the Energy Networks Association **Type Test** register.

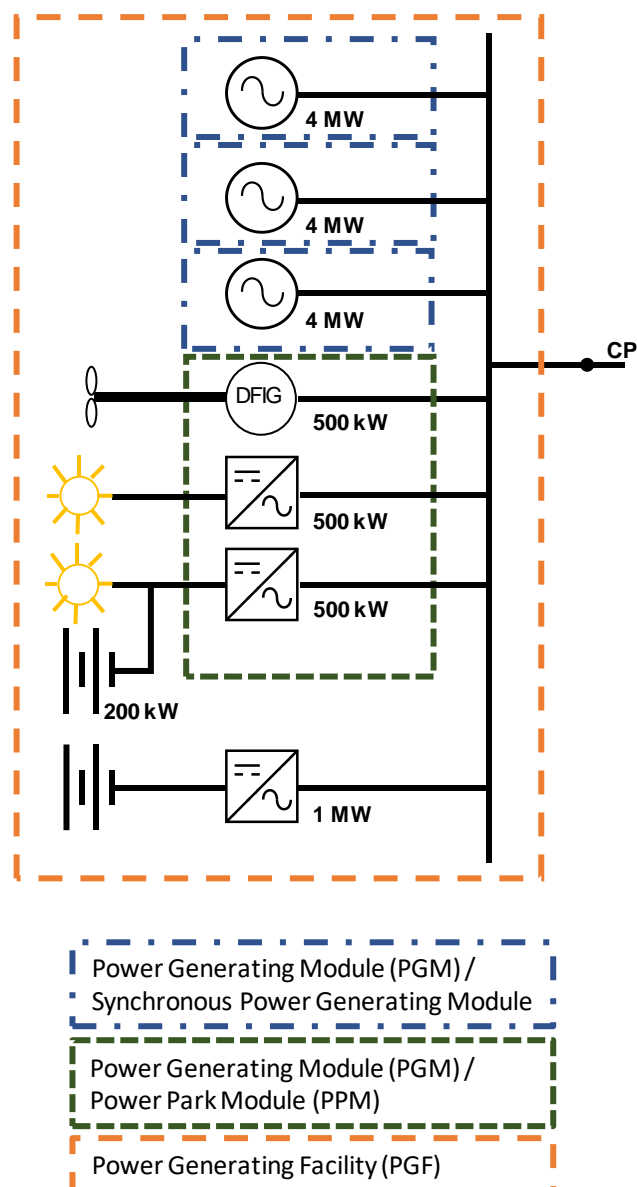
- 15.6.3. It is the responsibility of the **Manufacturer** to provide technical justification that the results are transferable. For example, the **Generating Units** have the same control systems.

15.7. Compliance demonstration for Infrequent Short-Term Parallel Power Generating Modules

- 15.7.1. Compliance of a **Power Generating Module** designed to operate in infrequent short-term parallel operation mode should be demonstrated for the applicable requirements and design variations as detailed in Section 7.3. As a minimum this shall include:

- Provision of a Standard Application Form;
- Compliance with Section 8 (Earthing);

¹⁹ This approach is taken in Germany by VDE, a standards, testing and certification institution.



3 x 4 MW **Type B** Gas Engines plus 1 x 500 kW asynchronous **Generating Unit** plus 1 x 500 kW **Inverter** plus 1 x 500 kW **Inverter** with 200 kW Integral **Electricity Storage** plus 1 MW **Electricity Storage** device

= 3 x 4 MW **Type B** **Synchronous Power Generating Modules** plus 1.5 MW

Type B Power Park Module plus 1 MW **Electricity Storage**

= 14.5 MW **Power Generating Facility** (Large power station in North of Scotland)

Note the **Electricity Storage** device using the same **Inverter** as the PV does not contribute to the **Power Park Module Registered Capacity**, because the **Registered Capacity** is based on the **Inverter** rating. The **Electricity Storage** device using a dedicated **Inverter** is also a **Power Generating Module** but is excluded from some of the requirements of this EREC G99, but included in the **Power Generating Facility**.

Figure A.4.1 Example of Connection of Electricity Storage with Type A and Type B Power Generating Modules in the same Power Generating Facility

A.4.2.4 For **Electricity Storage** devices commissioned before 01 September 2022 the connection scenario examples detailed below have a different interpretation or applicability to that detailed in Section 6:

A.4.2.4.1 Scenario 7 and Figure 6.7: The **Electricity Storage** devices are not included in the **Power Park Module** in this example, hence this example is a 60 kW **Power Park Module** and a 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.2.

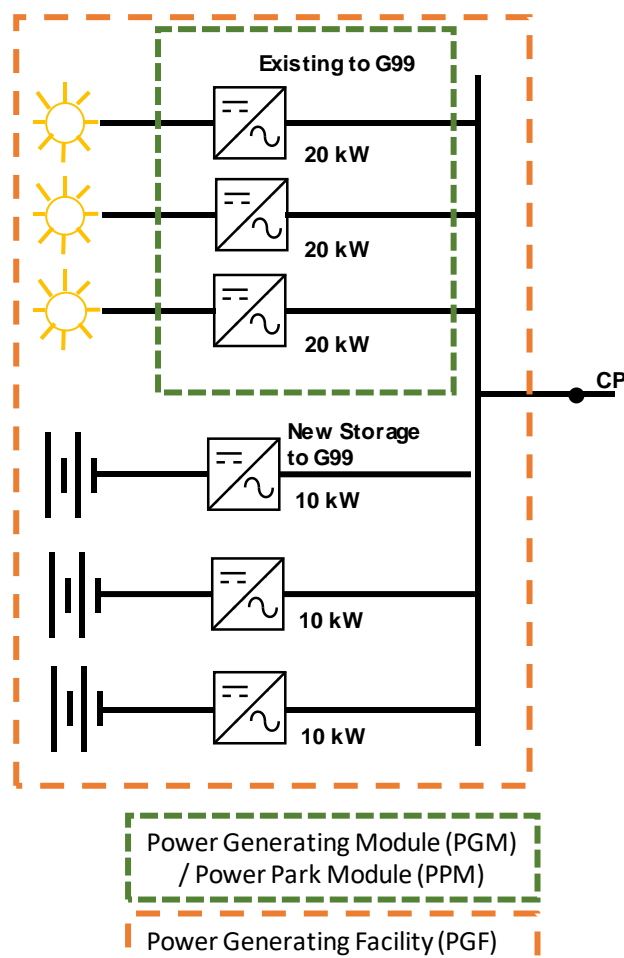


Figure A.4.2. Example: Existing 60 kW Type A Power Park Module to EREC G99 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters

= 60 kW Type A Power Park Module plus 30 kW Electricity Storage (exempt from certain Type A requirements)

= 90 kW Power Generating Facility

A.4.2.4.2 Scenario 8 and Figure 6.8: The later addition of 3 x 10kW **Electricity Storage** devices do not form a **Type A Power Park Module** and hence this example is 60 kW **Electricity Storage** + 30 kW **Electricity Storage** = 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.3.

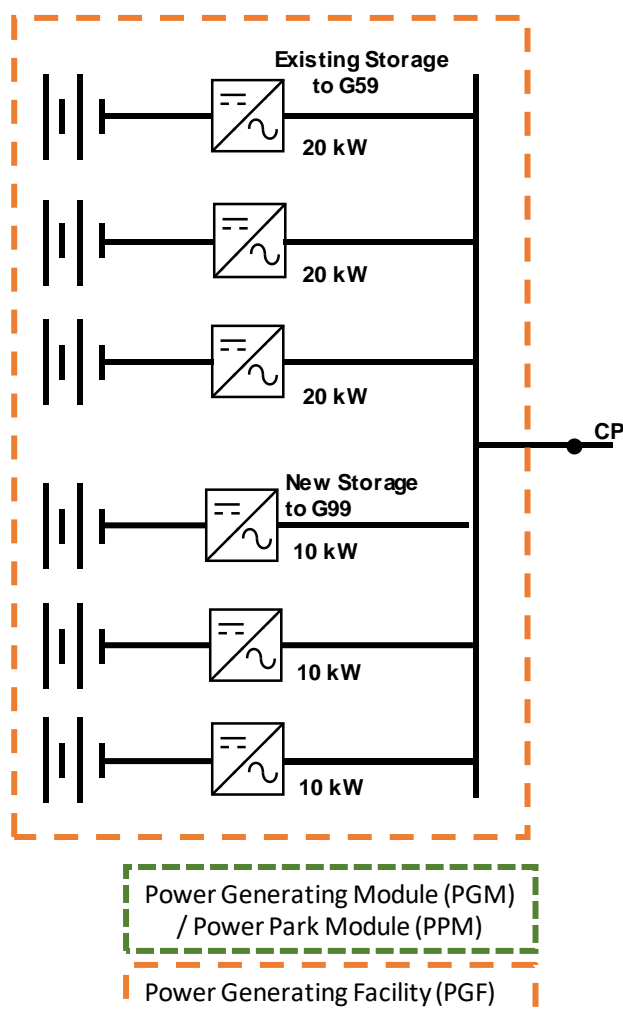


Figure A.4.3. Example: Existing 3 x 20 kW Electricity Storage devices to EREC G59 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters

= 60 kW Electricity Storage + 30 kW Electricity Storage (exempt from certain Type A requirements)

= 90 kW Power Generating Facility

A.4.2.4.3 Scenario 9 and Figure 6.9: The existing **Electricity Storage** devices and the later addition of 3 x 10kW **Electricity Storage** devices do not form a **Type A Power Park Module** and hence this example is 60 kW **Electricity Storage** + 30 kW **Electricity Storage** = 90 kW **Power Generating Facility**. This is illustrated in Figure A.4.4.

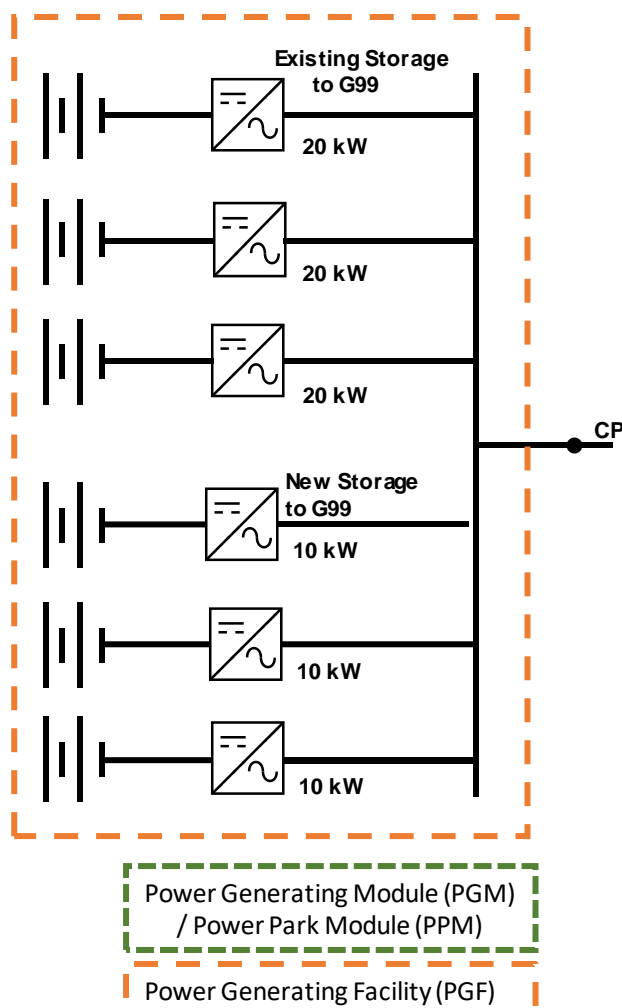


Figure A.4.4. Example: Existing 3 x 20 kW Electricity Storage devices to EREC G99 plus later addition of 3 x 10 kW Electricity Storage devices with own Inverters

**= 60 kW Electricity Storage (exempt from certain Type A requirements) +
30 kW Electricity Storage (exempt from certain Type A requirements)**

= 90 kW Power Generating Facility

A.4.2.4.4 Scenario 10 and Figure 6.10; This example is not applicable, however it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.

A.4.2.4.5 Scenario 11 and Figure 6.11: This example is not applicable it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.

A.4.2.4.6 Scenario 12 and Figure 6.12: This example is not applicable however it should be noted that before a **Vehicle to Grid Electric Vehicle** is connected to the fixed installation the **Customer** must ensure there is an appropriate **Connection Agreement** with the **DNO** and that the **Power Generating Module** is compliant with this EREC G99 ie compliant with all the requirements in this document except the exclusions stated in this Annex A.4.2.

A.4.3 Infrequent Short-Term Parallel Operation

For **Power Generating Modules** that operate in parallel with the **Distribution Network** under an infrequent short-term parallel operation mode the following sections of EREC G99 do not apply:

Type A - Less than 1 MW:

- All of Section 11

Type B - 1 MW or greater but less than 10 MW:

- All of Section 12

Type C and Type D - 10 MW or greater and / or with a Connection Point at greater than 110 kV:

- All of Section 13

•
A.5 Example calculations to determine if unequal generation across different phases is acceptable or not

A **Generator Installation** might have 15 kW of PV and a 6 kW CHP plant. Due to the areas of roof available the PV plant comprises two by 4.5 kW **Inverters** and two by 3 kW **Inverters**, all of these devices being single phase.

(a) The following connection would be deemed acceptable:

- Ph 1 4.5 kW PV
- Ph 2 3 kW PV plus 6 kW CHP
- Ph 3 3kW + 4.5 kW PV

This would lead to:

- 4.5 kW imbalance with CHP at zero output
- 4.5 kW imbalance with CHP and PV at maximum output
- 6 kW imbalance with CHP at maximum output and PV at zero output.

All of which are below the 32 A imbalance limit.

(b) The following alternative connection for the same plant would be deemed unacceptable:

- Ph1 4.5 kW PV plus 6 kW CHP
- Ph 2 3 kW PV
- Ph3 4.5 kW PV plus 3 kW PV

This is not acceptable as at full output Ph 1 would have 7.5 kW more output than Ph 2 and this exceeds the 32 A limit described above even though on an individual technology basis the limit of 16 A is not exceeded.

If a **Generator Installation** has a single technology installed which has **PGMs** 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 6 kW east roof 6 kW west roof
- Ph 2 6 kW east roof 6 kW west roof
- Ph 3 5 kW east roof 5 kW west roof

(b) The following alternative connection for the same plant would be deemed unacceptable.

- Ph1 12 kW east roof
- Ph2 5 kW east roof 5 kW west roof
- Ph 3 12 kW 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 32A.

A.6 Significant Modification – application of EREC G99 to generation equipment commissioned before EREC G99 was published

These scenarios present examples in respect of connection to new sites or modifications to existing sites, as well as considering whether a modification to an existing **Power Generating Module** would be considered to be substantial and therefore compliance with this EREC G99 would be required. Note that this table is applicable to **Type A, B, C and D Power Generating Modules**.

A ✓ indicates that the example triggers full compliance of the **Power Generating Module** with the latest version of EREC G99, whereas a ✗ indicates that full compliance with the latest EREC G99 is not required.

	Scenario	DNO position	EREC G99?	Rationale
1	Existing EREC G59 PPM installation (eg solar PV or wind)– the Generator replaces a failed Generating Unit (ie Inverter or turbine) at a PPM comprising multiple Generating Units .	Like-for-like replacements do not immediately lead to EREC G99 compliance for the whole module. The new Inverter or Turbine does need to be compliant with the latest EREC G99.	✗	This is a maintenance issue – the overall characteristics of the PPM are essentially unchanged – at least until 80% of the capacity of the PGM is replaced.
2	Existing EREC G59 PPM installation (eg solar PV or wind)– the Generator operates a planned replacement programme of Generating Units (ie Inverter or turbine) of the same capacity at a PPM comprising multiple Generating Units .	Like-for-like replacements do not immediately lead to EREC G99 compliance for the whole module, until 80% of the capacity of the PGM has been replaced. The new Inverter does need to be compliant with the latest EREC G99.	✗	This is a maintenance issue – the overall characteristics of the PPM are essentially unchanged – at least until 80% of the capacity of the PGM is replaced.
3	Existing EREC G59 PPM installation (eg solar PV or wind)– the Generator <u>completes</u> 80% (by capacity) of planned replacement programme of Generating Units (ie Inverter or turbine) of the same capacity at a PPM comprising multiple Generating Units .	On completion, the PPM must comply fully with the latest version of EREC G99 by the date agreed with the DNO.	✓	The Generator has made a capital investment in the site and as the whole of the PPM has been replaced, it must now comply with the latest version of EREC G59.
4	Existing EREC G59 PPM site, the Generator adds an additional PPM after 27/4/19.	The new PPM to be compliant with EREC G99.	✓	This is a new capital investment but cannot sensibly be integrated with the existing module (see figure 6.4 in EREC G99).