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NCER: System Restoration Plan

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Contents

NCER: System Restoration Plan

1 Introduction

The *Network Code on Emergency & Restoration*[1] (***NCER***) came into force on 18 December 2017. Pursuant to the provisions in Chapter 3 below is the proposed System Restoration Plan on behalf of the GB National Electricity Transmission System Operator (NETSO).[2]

As provided for in the NCER Article 23, this System Restoration Plan will be designed in consultation with relevant Distribution System Operators (DSOs), Significant Grid Users (SGUs), National Regulatory authorities, neighbouring Transmission System Operators (TSOs) and other TSOs in the GB synchronous area.

This Plan is not intended to replace any provisions currently in place in the GB Codes nor to amend the Operational Security Limits[3], it is a summary of how the requirements for System Restoration specified in NCER will be satisfied. Many of the provisions contained within this System Defence Plan are already described in the GB national codes (Grid Code, CUSC, BSC, etc.). Where there are new mandatory requirements for GB Parties then these will be included in relevant GB Codes as appropriate.

This System Restoration Plan will impact all TSOs, and DSOs in Great Britain, SGUs identified in Appendices A to B and Restoration Service Providers (RSPs) identified in Appendix D, who have obligations under this plan.

This System Restoration Plan has been developed taking the following into account:

- The behaviour and capabilities of load and generation
- The specific needs of the high priority significant grid users detailed in Appendix C
- The characteristics of the National Electricity Transmission System and of the underlying DSO systems.
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[1] *Network Code on Emergency and Restoration* http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.312.01.0054.01.ENG&toc=OJ:L:2017:312:TOC

[2] *National Electricity Transmission System Operator – this term is used to incorporate all communication routes – specific procedures and platforms will channel communications to the appropriate teams, e.g. National Grid ENCC in real time or National Grid Network Access Planning team, ahead of time.*

[3] *Article 25 System Operations Guideline* *http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.220.01.0001.01.ENG*

2 System Restoration Plan Overview

The EU Network Code on Emergency and Restoration (NCER) aims to ensure security and continuity of electricity supply across Europe by creating harmonised standards and procedures to be applied in the Emergency, Blackout and Restoration system state(s). This code requires the development of a System Restoration Plan in advance of such an event specifying measures related to information exchange, operational procedures and post-event analysis.

NCER sits alongside the Transmission System Operation Guideline[4] (SOGL) which sets out harmonised rules on system operation and identifies different critical system states (Normal State, Alert State, Emergency State, Blackout State and Restoration).

This System Restoration Plan consists of the technical and organisational measures necessary for the restoration of the electricity system in Great Britain from a Partial or Total Shutdown to the defined Normal State, taking into account Significant Grid Users (SGU) capabilities (including Embedded SGUs), External Interconnections and the operational constraints of the Total System.

The main objectives of this plan include

1. To achieve the Re-Synchronisation of parts of the Total System which have become Out of Synchronism.
2. To ensure that communication routes and arrangements are available to enable representatives of the TSOs, DSOs and SGUs, who are authorised to make binding decisions on behalf of the TSO, DSO or the relevant SGU, as the case may be, to communicate with each other when this System Restoration Plan is active.
3. To describe the role that in respect of TSOs, DSOs, RSPs and/or SGUs may have in the restoration processes as detailed in the relevant De-Synchronised Island Procedures (DIP's) and Local Joint Restoration Plans (LJRPs).
4. To identify and address as far as possible the events and processes necessary to enable the restoration of the Total System in GB to a Normal State, after a Total Shutdown or Partial Shutdown. This is likely to require the following key processes to be implemented, typically, but not necessarily, in the order given below:

    - Selectively implement Local Joint Restoration Plans;
    - Expand Power Islands to supply non Black Start Power Stations;
    - Selectively reconnect demand;
    - Expand and merge Power Islands leading to Total System energisation;

[4] *https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1485&from=EN*

- Facilitate and co-ordinate returning the Total System back to normal operation; and
- Resumption of the market arrangements if suspended in accordance with the relevant codes.

2.1 Activation of System Restoration Plan

In Accordance with NCER Article 25:

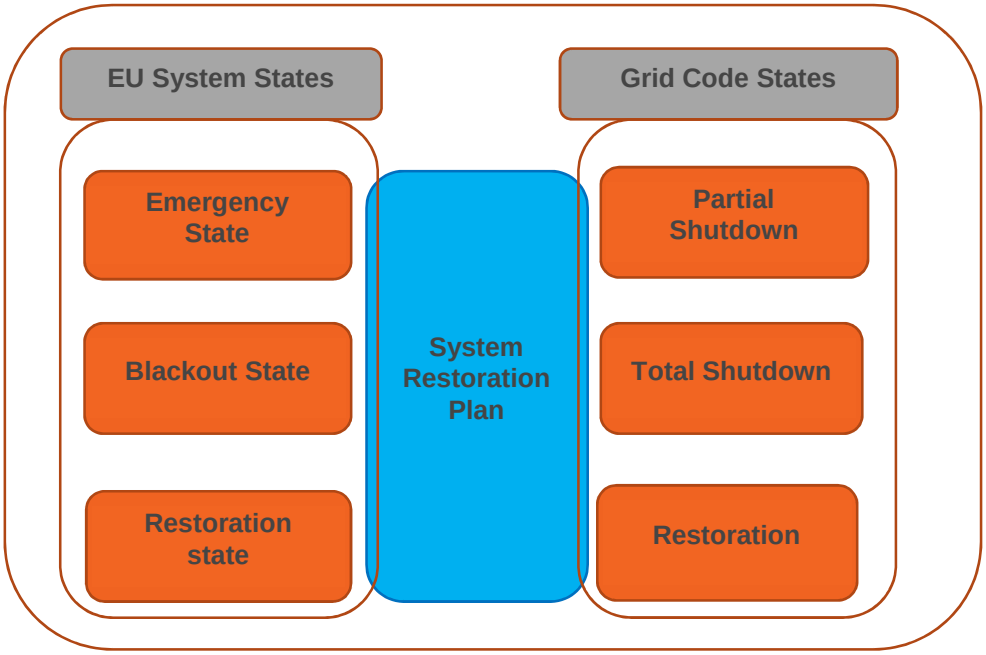
2.1.1 Procedures in this System Restoration Plan can be activated when the System is in Emergency state and activated procedures of the System Defence Plan have taken place, or will be activated when the System is in the Blackout state.

2.1.2 Procedures in this System Restoration Plan will be activated by the NETSO in coordination with DSOs, SGUs and Restoration Service Providers.

2.1.3 All instructions issued by the NETSO under this System Restoration Plan must be executed by each DSO, SGU and Restoration Service Provider without undue delay.

2.1.4 The NETSO will manage remedial actions that involve actions from other TSOs.

2.1.5 The SRP can be activated, and remain active, through the Emergency, Blackout and Restoration states as shown below.



2.1.6 Activation of the SRP in GB will occur once the NETSO determines and informs the BSCCo that either a Total Shutdown or a Partial

Shutdown exists and subsequent Black Start instructions are required for restoration.

2.1.7 Market Suspension (*NCER Article 35 part 1*) does not occur in GB during a Partial Shutdown (*GC OC9.4.1*) where the Market Suspension threshold as detailed in *BSC G-3.1.5* (that is, under 5% of demand having been lost) has not been met. If the Market Suspension threshold has been met, then Market Suspension will occur in GB. Both scenarios can occur within the Emergency State.

2.1.8 The trigger threshold for the GB system Blackout State shall be maintained as per the current definition of a Partial or a Total System Shutdown *Grid Code OC9.4.1*.

3 System Restoration Plan Procedures

Grid Code OC9.4. documents the procedure of recovery from a Total or Partial Shutdown. This allows for a top-down (energisation from other TSOs) and bottom-up (within TSO area energisation) restoration approach strategies. Detailed within this are the specific procedures referenced in NCER as:

- Re-energisation procedure *(NCER Article 26 Section 2)*
- Re-synchronisation procedure *(NCER Article 33 Section 4)*
- Frequency management procedure

3.1 Re-energisation procedure

3.1.1 The *Grid Code OC 9.2.5* identifies the key processes to be implemented in GB to enable the restoration of the Total System following a Total or Partial Shutdown as:

- Selectively implement Local Joint Restoration Plans;
- Expand Power Islands to supply Power Stations;
- Selectively reconnect Demand;
- Expand and merge Power Islands leading to Total System energisation;
- Facilitate and co-ordinate returning the Total System back to normal operation; and
- Resumption of the Balancing Mechanism if suspended in accordance with the provisions of the BSC.

3.1.2 In order to deliver this restoration contractual arrangements for Restoration Service Providers and documented restoration plans are in place as permitted through *Grid Code OC9* provisions.

3.1.3 The bilateral procurement of Black Start service provision is carried out by the NETSO. Following a commercial contract being established and commenced, the RSP, relevant TSO, local DSO and NETSO create, in line with *Grid Code OC9.4.7.12*, an LJRP.

3.1.4 Operation of these LJRPs follows *Grid Code OC9.4.7.6*. Each individual LJRP document provides specific details of how an individual RSP is to be started and block loaded to create a stable Power Island. These plans provide guidance to TSO staff to assess the status of operational equipment and systems, within a shutdown situation, and identify the organisational and process changes necessary to enable an effective restoration. They also identify the split in responsibilities between the relevant TSO(s) and relevant DSO, together with the appropriate communication channels.

3.1.5 Changes, amendments and the creation of new LJRPs is detailed in *Grid Code OC9.4.7.12* including the exercising of these plans.

3.1.6 In the LJRP stage of restoration the voltage and frequency management is undertaken by the specific RSP within that Power

Island. Once an additional party (either another provider or DSO) is involved in the Power Island the voltage and frequency management control reverts to the NETSO. At this point the NETSO directs the relevant TSO to expand the network in line with routes identified in the Skeleton Network.

3.1.7 The Skeleton Network indicates key routes for growing individual power islands, once stable and having developed a level of circuit security, to enable supplies to be given to further SGUs, other Power Islands and subsequently to create a single, synchronous power system.

3.1.8 During the re-energisation process the resynchronisation and frequency management procedures detailed within this System Restoration Plan are adhered to.

3.2 Re-synchronisation procedure

3.2.1 NCER Article 33 Section 4 requires the appointment of a resynchronisation leader. For the purpose of GB NETS restoration, the NETSO takes on this role as overall coordinator of the restoration procedure. *Grid Code OC9.5.6* outlines the requirements for the Re-synchronisation of De-Synchronised Islands following a Total or Partial Shutdown.

3.2.2 Following any shutdown, the re-energisation procedure requires that several Power Islands are created and expanded with the objective of creating the Skeleton Network to grow to reach available generation and demand. The Skeleton Network is then expanded until all demand, generation and appropriate circuits have been restored. It will, therefore, be necessary to interconnect Power Islands. The complexities and uncertainties of recovery from a Total or Partial Shutdown requires that provisions under this section to be flexible, however, the actions taken when Re-synchronising De-synchronised Islands following any Total Shutdown or Partial Shutdown, will include the following: (a) the provision of supplies to appropriate Power Stations to facilitate their synchronisation as soon as practicable; (b) energisation of a skeletal National Electricity Transmission System; and (c) the strategic restoration of Demand in co-ordination with relevant DSOs.

3.2.3 Re–synchronisation of a Power Island is performed by arming and closing a synchronising breaker at the substation joining both Power Islands. The Power System Synchroniser setting is in place to ensure safe closure of the open circuit breaker which is live on both sides. This is designed to synchronise two electrically separate systems which are running at slightly different frequencies with the two voltages across the open circuit breaker contacts cyclically passing in and out of phase with each other.

3.2.4 The requirement for the Power System Synchroniser is to ensure the phase angle between voltages is practically zero and the voltage

magnitudes and difference in frequency or slip is within pre-set limits. Once the synchronisation command has been executed, the Power System Synchroniser circuit breaker will remain armed for a period of time to allow system conditions to be suitably altered (one frequency driven towards the other by issuing Target Frequency instructions to generators within one power island) to allow the synchronising relay to close the selected circuit breaker. Should the conditions not be met then the instruction will time out and circuit breaker re-selection and execution of the instruction must be repeated.

3.2.5 The location of Power System Synchroniser circuit breaker facilities are documented within the relevant TSO's internal procedures and are indicated on NETSO's situational awareness displays.

3.2.6 The setting policy for synchronising relays is common across all three onshore TSO areas in GB, and are:

System synchronising slip 0.125Hz

System synchronising closing angle 10deg

Under voltage setting 0.85pu

3.2.7 During a Total Shutdown or Partial Shutdown and during the subsequent recovery, the (Transmission) Licence Standards may not apply and the Total System may be operated outside normal Voltage and Frequency standards.

3.2.8 In a Total Shutdown and during the subsequent recovery, all instructions issued by the relevant TSO (unless specified otherwise) are deemed to be Emergency Instructions under *BC2.9.2.2 (iii)* and need not be prefixed with the words "This is an Emergency Instruction".

3.2.9 In a Partial Shutdown and during the subsequent recovery, all instructions issued by the relevant TSO in relation to RSPs and DSOs which are part of an invoked LJRP will (unless specified otherwise) are deemed to be Emergency Instructions under *BC2.9.2.2(iii)* and need not be prefixed with the words "This is an Emergency Instruction".

3.3 Frequency management procedure

3.3.1 NCER Section 3 Article 29 requires the appointment of a frequency leader during system restoration when a synchronous area is split in several synchronised regions. For the purpose of GB NETS restoration, the NETSO takes on the role of frequency leader.

3.3.2 Frequency management during system restoration falls into two phases; the LJRP phase and the Skeleton Network phase. NETSO remains the frequency leader in both these phases and both phases can be in force simultaneously as new LJRPs are instructed and form power islands whilst the Skeleton Network is being restored.

3.3.3 Frequency Management during LJRP Phase

During the LJRP phase, the NETSO will instruct the implementation of required LJRPs and the required Target Frequency. As detailed within the LRJP; demand blocks will be added in line with the requirements of the RSP to establish a power island. The RSP's will configure their governor to act in "free governor action" mode to aid in frequency control. During the period when only one RSP is connected to the Power Island the frequency is controlled by the RSP in co-ordination with the relevant TSO and or relevant DSO who will also add or remove demand as the RSP requires to maintain Target Frequency.

During this period, the RSP will be required to regulate their output in co-ordination with the relevant TSO and /or relevant DSO to the existing and newly connected demand in the Power Island. The relevant TSO and /or relevant DSO and RSP will communicate so demand and generation are matched to maintain (where practicable) the Target Frequency. Demand will be added to the Power Island as more generation becomes available.

3.3.4 Frequency Management during the Skeleton Network Phase

The Skeleton Network phase begins when a second or subsequent SGUs are added to the Power Island and the direction of frequency control passes to the relevant TSO. The relevant TSO may issue new Target Frequency instructions to RSPs and in co-ordination with available generation informs the relevant TSO and/or relevant DSO of the size of power blocks required to be added or removed from the Power Island to maintain generation stability.

Power Islands will be synchronised to each other using suitable system synchroniser circuit breakers. The frequency of each Power Island will be matched (both controlled by the relevant TSO), the power system synchroniser breaker will automatically synchronise the power island. Subsequent Power Island will be synchronised in a similar way.

The relevant TSO will determine power block size to be added or removed from the power island to maintain energy balancing and power island frequency. Power Stations & RSPs will be instructed by the relevant TSO. All Power Stations who resume operation in a Restoration State will remain in Frequency Sensitive Mode until Normal State is achieved, or instructed otherwise by NETSO.

4 System Restoration to Normal State operation

4.1 In GB a Black Start restoration will be deemed to be completed when either:

Normal Market operations have resumed and the Market Suspension is no longer in force (the Balancing Mechanism resumes normal operation) as determined by the BSC Panel;

or

The end of the settlement period when NETSO determines (and notifies BSCCo that the system is back in normal operation).

4.2 *Grid Code OC9.4.7.9* describes the considerations to be made by NETSO before declaring that the Total System could return to normal operation:

- the extent to which the GB NETS is contiguous and energised;
- the integrity and stability of the GB NETS and its ability to operate in accordance with the (Transmission) Licence Standards;
- the impact that returning to a Normal State may have on transmission constraints and the corresponding ability to maximise the Demand connected;
- the volume of Generation or Demand not connected to the GB NETS; and
- the functionality of normal communication systems (i.e. electronic data communication facilities, Control Telephony, etc.).

4.3 Once NETSO deems that sufficient confidence in the Transmission System, connected generation and demand and appropriate systems are in place to return to normal operation they will inform BSCCo of this development.

5 System Restoration Plan Implementation

5.1 Article 24 of *the NCER,* provides for the implementation of the **System Restoration Plan** and requires that by the 18 December 2018 the NETSO will notify all DSOs, SGUs and Restoration Service Providers of their obligations.

5.2 This System Restoration Plan will be fully implemented by 18 December 2019.

6 Plan Review

6.1 NCER Article 51 requires the NETSO to review the measures of the System Restoration Plan using computer simulation tests to assess effectiveness at least every five years.

6.2 The review will cover:

- Simulating the establishment of the Skeleton Network using RSPs with Black Start capability;
- Demand reconnection process;
- Process for resynchronisation of Power Islands; and
- Learning from operational testing as per the testing procedure

6.3 Operational testing of the System Restoration Plan will be in line with the Assurance and Compliance Testing requirements within the System Defence Plan.

6.4 The NETSO will review the System Restoration Plan to assess its effectiveness at least every five years.

6.5 The NETSO will also review the relevant measures of the System Restoration Plan in advance of a substantial change to the configuration of the National Electricity Transmission System.

6.6 Any substantive changes identified in the review of the System Restoration Plan will be captured via published updates to this document.

Appendices

Appendix A: Criteria for the list of SGUs responsible for implementing measures that result from EU Code mandatory requirements or from national legislation

NCER Article 23.4(c) requires the System Restoration Plan to include a list of SGUs responsible for implementing on their installations the measures that result from mandatory requirements set out in Regulations (EU) 2016/631 [NC RfG], (EU) 2016/1388 [NC DCC] and (EU) 2016/1447 [NC HVDC] or from national legislation and a list of the measures to be implemented by those SGUs.

The list shall apply to the following Significant Grid Users (SGUs):

- existing and new power generating modules classified as type C and D in accordance with the criteria set out in Article 5 of Commission Regulation (EU) 2016/631 [NC RfG];
- existing and new transmission-connected demand facilities;
- existing and new transmission-connected closed distribution systems;
- providers of re-despatching of power generating modules or demand facilities by means of aggregation and providers of active power reserve in accordance with Title 8 of Part IV of Commission Regulation (EU) 2017/1485 {SOGL}; and
- existing and new high voltage direct current ('HVDC') systems and direct current-connected power park modules in accordance with the criteria in Article 4(1) of Commission Regulation (EU) 2016/1447 [NC HVDC]. (for the avoidance of doubt Article 4(1) only requires existing HVDC systems to comply with articles 26, 31, 33 and 50 of NC HVDC unless they undergo substantial modification.)

The NETSO will be responsible for producing the list in consultation with relevant DSOs and SGUs. DSOs will be responsible for notifying the NETSO of type C and D distribution-connected power generating modules. The NETSO will update the list annually as part of its review of the System Restoration Plan.

Appendix B: Measures to be implemented by SGUs that Result from EU Code Mandatory Requirements or from National Legislation

The list of SGUs responsible for implementing on their installations the measures that result from mandatory requirements set out in Regulations (EU) 2016/631 [NC RfG], (EU) 2016/1388 [NC DCC] and (EU) 2016/1447 [NC HVDC] or from national legislation and a list of the measures to be implemented by those SGUs is as follows: -

Restoration Service Providers have contractual and codified obligations that they shall meet.

For Transmission connected SGU, they shall comply with Grid Code BC2.9 – Emergency Circumstances.

For Distribution connected SGUs, they shall comply with Distribution Code DOC9.4 – Black Start

Appendix C: List of High Priority Significant Grid Users & Terms of Re-energisation

There are no High Priority Significant Grid Users that apply for the GB System Restoration Plan and/or System Defence Plan.

Appendix D: Current Restoration Plans & Restoration Service Providers

Due to the sensitive information held within these plans, these have been lodged with the Authority.

Appendix E: Substations Essential for Restoration Plan Procedures

Due to the sensitive information held within these plans, these have been lodged with the Authority.

Appendix F: List of TSOs & DSOs Responsible for Implementing System Restoration Plan Measures

The responsible companies are as follows:

- Electricity North West
- National Grid Electricity Transmission Plc
- Northern Powergrid (North East & Yorkshire)
- Scottish and Southern Energy Networks (Scottish and Southern Energy Power Distribution Ltd, Scottish Hydro Electric Transmission plc, Scottish Hydro Electric Power Distribution Plc, Southern Electric Power Distribution Plc)
- SP Energy Networks (SP Transmission Plc, SP Distribution Plc, SP Manweb Plc).
- UK Power Networks (Eastern Power Network, London Power Network, Southern Power Network)
- Western Power Distribution (Midlands, South Wales and West)
- All OFTOs
- HVDC Systems with cross border capability (and defined as TSOs)

All parties on this list are responsible for ensuring they have the resilience measures laid out in the System Defence Plan and are able to enact their System Restoration Plan responsibilities.

Appendix G: Glossary

Balancing Mechanism Participant	A person who is responsible for and controls one or more BM Units or where a Bilateral Agreement specifies that a User is required to be treated as a BM Participant for the purposes of the Grid Code. For the avoidance of doubt, it does not imply that they must be active in the Balancing Mechanism.
Balancing Service Provider	A Balancing Service Provider (BSP) is a market participant providing Balancing Services to its Connecting TSO.
BEIS	Her Majesty's Government Department for Business, Energy and Industrial Strategy.
Defence Service Provider	A Defence Service Provider is a legal entity with a legal or contractual obligation to provide a service contributing to one or several measures of the System Defence Plan.
DSO	A Distribution System Operator is a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
Frequency Sensitive Mode	A Genset, or Type C Power Generating Module or Type D Power Generating Module or DC Connected Power Park Module or HVDC System operating mode which will result in Active Power output changing, in response to a change in System Frequency, in a direction which assists in the recovery to Target Frequency, by operating so as to provide Primary Response and/or Secondary Response and/or High Frequency Response.
HVDC System	An electrical power system which transfers energy in the form of high voltage direct current between two or more alternating current (AC) buses and comprises at least two HVDC Converter Stations with DC Transmission lines or cables between the HVDC Converter Stations.
Local Joint Restoration Plans	NETSO Restoration plans agreed prior to a shutdown event between a Restoration Service Provider, relevant DSO and relevant TSO(s). These detail the agreed method and procedure of restoration from an individual Restoration Service Provider.

GB NETS	Great Britain National Electricity Transmission System
NETSO	The National Electricity Transmission System Operator is responsible for operating the Onshore Transmission System and, where owned by Offshore Transmission Licensees, Offshore Transmission Systems. The NETSO for Great Britain is currently National Grid Electricity System Operator.
Non-Embedded Customer	A Customer in Great Britain, except for a Network Operator acting in its capacity as such, receiving electricity direct from the Onshore Transmission System irrespective of from whom it is supplied.
Partial Shutdown	A Partial Shutdown is the same as a Total Shutdown except that all generation has ceased in a separate part of the Total System and there is no electricity supply from External Interconnections or other parts of the Total System to that part of the Total System. Therefore, that part of the Total System is shutdown with the result that it is not possible for that part of the Total System to begin to function again without TSO's directions relating to a Black Start.
Power Generating Module	Either a Synchronous Power-Generating Module or a Power Park Module owned or operated by an EU Generator or a GB Generator.
Power Island	One or more Power Stations, together with complementary local demand.
Power System Synchroniser	Equipment which synchronises two electrically separate synchronous areas together to create one synchronous area.
Restoration Service Provider	A restoration service provider refers to “a legal entity with a legal or contractual obligation to provide a service contributing to one or several measures of the restoration plan”
Skeleton Network	The detailed restoration plan for restoring a skeletal GB NETS
Target Frequency	That Frequency determined by The Company, in its reasonable opinion, as the desired operating Frequency of the Total System or Power Island. This will normally be 50.00Hz plus or minus 0.05Hz, except in exceptional circumstances as determined by The Company, in its reasonable opinion when this may be 49.90 or 50.10Hz. An example of

	exceptional circumstances may be difficulties caused in operating the System during disputes affecting fuel supplies.
Total System	The National Electricity Transmission System and all User Systems in the National Electricity Transmission System Operator Area.
Total Shutdown	A Total Shutdown is the situation existing when all generation has ceased and there is no electricity supply from External Interconnections. Therefore, the Total System has shutdown with the result that it is not possible for the Total System to begin to function again without TSO's directions relating to a Black Start.
TSO	A Transmission System Operator is a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity.
Type C Power Generating Module	A Power-Generating Module with a Grid Entry Point or User System Entry Point below 110 kV and a Maximum Capacity of 10 MW or greater but less than 50 MW.
Type D Power Generating Module	A Power-Generating Module: with a Grid Entry Point or User System Entry Point at, or greater than, 110 kV; or with a Grid Entry Point or User System Entry Point below 110 kV and with Maximum Capacity of 50 MW or greater.

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