GC0156 Future Networks Subgroup Report

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# Executive Summary

The ESO has been directed by the Secretary of State that in accordance with Special Condition 2.2 of the National Grid Electricity System Operator’s Transmission Licence, The Electricity System Restoration Standard is set at –

1. 60% of electricity demand being restored within 24 hours in all regions, and
2. 100% of electricity demand being restored with 5 days nationally.

It is an essential requirement for the NETS to have electricity system restoration capability. The ESO delivers this requirement by determining and procuring sufficient system restoration capability for the NETS on an ongoing basis.

The purpose of this direction is to require that the ESO –

1. Ensures and maintains an electricity restoration capability; and
2. Ensures and maintains the restoration timeframe.

*Note: In accordance with the advice from BEIS- at GC0156 “electricity demand” will be calculated by way of the forecast of the next peak transmission demand.*

**Objective**

The objective of this report is to cover at an appropriate level of detail the enhancements required for Transmission & Distribution Networks, Transmission Licensees, Network Operators, CUSC Parties and the ESO in the future to facilitate the ESRS particularly on:

* Resilience
* Network Design
* Operational Capability
* Protection Systems

Within the body of the report, each topic reflects the proposals, dissention and alternatives where applicable.

# Introduction

Secretary of State Direction

The ESO has been directed by the Secretary of State that in accordance with Special Condition 2.2 of the National Grid Electricity System Operator’s Transmission Licence, The Electricity System Restoration Standard is set at –

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The purpose of this direction is to require that the ESO –

1. Ensures and maintains an electricity restoration capability; and
2. Ensures and maintains the restoration timeframe.

*Note: “electricity demand” will be calculated by way of the forecast of the next peak transmission demand.*

GC0156 & Future Networks Subgroup

The ESO has raised Grid Code modification GC0156 to ensure that the industry is aware of what requirements are necessary to ensure and maintain an electricity restoration capability, and restoration timeframes.

This document presents the needs identified by the Future Networks Subgroup and their suggested implementation routes together with the relevant changes to Codes.

**Terms of** References

Purpose/Scope

To determine further future network requirements that may have implications for network operators, transmission owners, offshore transmission owners and competitively appointed transmission owners to facilitate how the industry can meet the requirements of the Electricity Supply Restoration Standard (ESRS).

Assess and accept, or modify, the recommendations in the ESRS working group report (including any unresolved ESRS WG comments) and create proposals to the GC0156 working group.

Inputs

* ESRS Future Network Workgroup Report and the associated recommendations
* Relevant codes
* An understanding of the restoration process, demand restoration requirements, service provider (volumes, geographic distribution), and how these may change in the future.

Outputs

A report, to be delivered by 20 October 2022, covering all the below aspects and including at an appropriate level of detail, the enhanced functionality required from networks in the future to facilitate the ESRS:

* Proposals from the GC0156 Future Networks subgroup to the GC0156 working group
  + Outline of any changes necessary to the Grid Code
  + Outline of any changes necessary to the Distribution Code
  + Identification of likely necessary actions and/or changes beyond the scope of GC0156
* An indication of how the above changes affect the ESO, TOs, OFTOs, CATOs, DNOs, restoration service providers, and any other users, including timescales and costs for the adoption of any proposals where this is available from subgroup members. Note – potential cost impacts will be forwarded to the Markets and Funding Mechanism Subgroup.

Provide regular progress updates to the GC0156 WG.

Propose initial draft legal text for Grid Code and Distribution Code.

Members (Update based on Nominations list)

*Role Name Organization*

Chair NGESO

Technical secretary NGESO

Generator rep

TO Rep

DNO Rep

Other

Etc

Standing Agenda

1. Safety/Wellbeing/inclusion moment
2. Actions update
3. Progress/project update
4. Analysis and discussion of issues within scope
5. Decisions/actions
6. Risk/Issues for escalation to GC0156
7. AOB

Logistics

* **Cadence** –Meetings scheduled bi-weekly.
* **Duration** – 4 hours
* **Location** – Teams Meeting
* **Submissions** due and pre-read – slides/papers with clear confirmation of input/decisions needed 5 business days prior. Papers are to be read ahead of the meeting.
* **Minutes –** to be taken and circulated with the Action/Decision Log
* **Quorum** – All standing members to attend. Deputies can attend with full decision-making authority delegated.
* **Dissention** - Proposals will be based on majority decisions. Dissention from the proposals shall be recorded.

*Note: CATOs are not yet defined in the Grid Code, hence are not referenced in the draft legal text for GC0156, however, the subgroup considered CATOs and once implemented via GC0159, the legal text will be amended to include CATOs.*

# Resilience

Transmission Network Resilience

**Proposal**

The transmission network, where necessary, will need to be operable remotely during a System shutdown to be able to switch sufficient equipment to achieve the restoration standard.

For the Onshore TOs and Offshore TOs it will be required to ensure that substations they own/operate can be operated in a restoration situation for up to 72 hours following a Total or Partial Shutdown. This shall involve providing mains independent back up power supplies sufficient for a minimum of 72 hours, or the provision of alternative solutions, to enable plant and primary equipment to operate without normal site supplies.

**Dissentions**

None

**Legal Text References**

CC/ECC.7.10.1 and CC/ECC.7.11.1/2

STC to follow

**Alternatives**

None

Transmission Network Switching Speed

**Proposal**

The onshore TOs / offshore TOs (including TOs HVDC networks) shall have a capability to energize all transmission substations within 24 hrs. This means there should be no transmission substation that cannot be energized, if required, within 24 hours of a restoration event, provided that there is an energised section of the transmission system to which it can be energised. In practice, the TOs will need to have the capability to perform faster switching, allowing time for other parties e.g. Network Operators to discharge their obligations.

Transmission network switching:

* Gives access to generation and demand
* Migrates away from “resilient” auxiliary supplies to normal auxiliary supplies
* Facilitate creation of a single Power Island system that can be more easily managed

Operational capability and specific network design functionality will be needed to enable this speed of energisation.

**Dissentions**

See below

**Legal Text References**

ECC.7.11.3, OC9.4.7.10, OC9.2.1 and OC9.1.1

STC to Follow

**Alternatives**

It was proposed to limit this requirement to “Core” substations for the operational capability to energise within 24 hours.

Priority would need to be given to the core substations referenced within the System Restoration Plan to be energised first [within 24hours, or a shorter period as required].

Core substations to be defined to allow for flexibility (for example, substations within the skeleton network, referenced in a LJRP or DRZP etc) to cater for a credible range of restoration scenarios.

Migration from Resilient Auxiliary Supplies at TO Substations to Normal Auxiliary Supplies

**Proposal**

Onshore TOs, OFTOs, DNOs & IDNOs need to work collaboratively to understand which circuits supply the transmission substations normal auxiliary supplies and to be able to energise these circuits as soon as reasonably possible within 72hrs hence migrating from the resilient auxiliary supplies.

This will maintain the operability of the transmission substations from (or before) 72hrs onwards by Network Operators. Where the network quickly returns to serviceability, the need of fuel for auxiliary supplies is reduced.

All new design builds and refurbishments of transmission substations should consider a standardised approach for normal auxiliary LVAC power, such as from a SGT tertiary winding such that there is no reliance on supplies from another Network Operator’s system. This would aid resilience of changing back to the normal auxiliary supply from the resilient supply.

**Dissentions**

None

**Legal Text References**

CC/ECC.7.10.4

STC for Transmission Licensees’

**Alternatives**

None

Distribution Resilience

**Proposal**

DNOs shall ensure that the distribution substations that the DNO needs to operate during an Electricity Restoration event for System Restoration purposes have 72-hour electricity supply resilience.  This is supported by the planning assumption that all such distribution substations will be re-energised within 72 hours.  This will ensure that there are auxiliary supplies to provide sufficient protection to facilitate the clearance of faults when the distribution system is re-energised.  Where auxiliary supplies to the DNO’s relevant substations are supplied from the DNO’s system, this may require some limited additional parts of the DNO system to be energised early.

Critical systems e.g., Control Centres, shall have 72-hour resilience to enable the DNO to switch demand (i.e., switching demand on and potentially off) on the distribution system in accordance with a pre-established Restoration Plan that is sufficiently flexible.  Such a Restoration Plan will set out a plan to restore customer supplies in a range of credible scenarios of:

1. transmission and distribution connected generation resynchronisation,
2. transmission switching; and
3. distribution switching

to restore 60% of electricity transmission system demand in 24 hours.  To achieve this co-ordinated transmission and distribution switching will be required within 24 hours.

The above two items will facilitate the restoration of the remaining customer supplies within 5 days.

**Dissentions**

None

**Legal Text References**

CC/ECC.7.10.4

**Alternatives**

None

Distribution Operational Switching

**Proposal**

DNOs should have the capability to switch demand in at sufficient speed to achieve 60% electricity demand restoration in 24 hours in their respective Licence Areas. This will need to take account for the time taken by other parties to undertake their tasks e.g. TOs to energise the relevant GSPs.

DNOs should have the capability to switch demand on or off to help manage Power Island frequency throughout the duration of the restoration event.

**Dissentions**

None

**Legal Text References**

ECC 7.11.3

**Alternatives**

None

User Resilience

**Proposal**

All CUSC parties and Restoration Service Providers shall be able to operate normally once auxiliary supplies are returned from the system.

User’s plant and equipment will need to shutdown safely and enter a state of preservation that will facilitate them joining a power island within a reasonable time and at a reasonable run up rate, similar to a cold start. In particular, items, such as hydrogen cooling of generator windings, will need to be maintained during the shutdown.

**Dissentions**

Some stakeholders are concerned about the practicalities and cost of retrospective installation of resilience measures on existing plant and equipment.

**Legal Text References**

CC/ECC.7.10.1 and CC/ECC.7.11.1

DPC6.7.2, DPC6.8.3, DPC7.A

**Alternatives**

None

Network Operators & Users

**Proposal**

Visibility of TOs’, OFTOs’, DNOs’ Network to the ESO. For the DNO Network this is limited to assets within the DRZ as defined in the associated DRZP and any other assets as defined in the associated LJRP.

Communication between TOs’, OFTOs’ and the ESO

There is a need for resilience of assets required to facilitate visibility and communication of user control points to the ESO and user control points to their sites.

There needs to be operational capability resilience to any extended loss of supply within ESO, TOs’, OFTOs’, DNOs’ and Users’ control points.

The visibility and communication requirements above are required for restoration.

**Dissentions**

None

**Legal Text References**

CC/ECC.6.4.6.3c

DPC6.7.5

STC to follow

**Alternatives**

None

# Onshore TO, Offshore TO and Interconnectors

Network Design

**Proposal**

The network needs to be designed holistically, so that the capability of new generation connecting is matched against the transmission system.

Proposed changes to the TO’s and OFTO’s systems and the connection of new Users, should be designed and built to be able to operate in a restoration situation with an electrically weak network i.e., considering reactive gain, inertia, inrush and the ability to energise and operate these with limited generator capability.

These requirements partly exist within the existing frameworks for TOs, but the STC and SQSS requires further review to ensure requirements are fit for purpose. The framework needs developing/updating to ensure OFTOs have similar requirements to the onshore TOs.

Proposals for network design that may be included in the STC or SQSS (includes but are not limited to):

* *Each user connection point will have a network designed around it to be able to energise a 0MW output to sufficient demand to load the generator above SEL, with only the reactive power from that User.*
* *No Load gain between adjacent substations must be designed so that it can be energised within a restoration situation. (i.e., circuit busbars and associate reactive plant) This would include energising from Anchor Generator/ Top up services to demand, and then other CUSC Parties.*
* *Once a power island is created with RSP, Network and demand, it must be possible to energise to the next user on the network to either offer auxiliary supplies or to Synchronise Power Islands.*
* *The ability to deliver reactive compensation in steps of up to 60Mvar from a proportion of reactive equipment. Enabling utilisation of this equipment during a restoration.*
* *Compensation equipment, such as Static Compensators and SVCs should be energised and used within initial stages of a restoration.*
* *The ability to utilise Offshore Networks as part of the Restoration Process.*

**Dissentions**

None

**Legal Text References**

STC/SQSS To follow

**Alternatives**

None

Protection Systems

**Proposal**

Transmission systems owned/operated by TOs, OFTOs and Interconnectors should have the ability to change between predefined protection and control settings as required during the restoration, to align with the system strength.

For equipment and personnel safety, there needs to be the capability for protection to operate at different fault infeeds that could realistically be expected during the implementation of a LJRP or DRZP.

**Dissentions**

None

**Legal Text References**

STC to follow

**Alternatives**

None

Operational Capability

**Proposal**

Transmission systems owned/operated by TOs, OFTOs and Interconnectors should have sufficient operational capacity to energise a skeleton network across Great Britain, all substations energised by at least one transmission circuit within 24 hours. This will need to take account of the time taken by other parties undertaking their tasks, e.g. DNOs to switch to restore customer supplies.

TOs, OFTOs and Interconnectors should:

* when considering resourcing and systems, have the ability to open switches to “clear circuits” prior to energisation over the first 24 hours.
* have operational support for LJRPs/DZRPs within each Region and undertake operational planning during a restoration process.
* Have the ability to manage and expand Power Islands, including synchronising Power Islands together.

**Dissentions**

None

**Legal Text References**

OC9.1.1, OC9.2.1

STC to follow

**Alternatives**

The alternative is to modify the proposed requirement from all substations to core substations at the request of the TO’s. The ESO has clarified that for those substations that are not core i.e., will not have normal LV auxiliary restored, the relevant TO will need to develop how they can maintain capability during the restoration.

New Connections

**Proposal**

TOs, OFTOs and Interconnectors should develop solutions to meet any reactive power requirements imposed by the STC, Bilateral Connection Agreement (BCA) with Users and the Grid Code (ECC.6.3). Need to add flexibility so that reactive power is able to be provided at 0MW active power output.

There should be the ability for users (including Offshore Wind Farms) to operate in islanded mode i.e. providing reactive power at 0MW, when the transmission system is not energised / available.

There should be the ability to operate in weak transmission system conditions expected during restoration.

**Dissentions**

None

**Legal Text References**

CC/ECC.6.3.2.5.3

STC to follow

**Alternatives**

None

# DNO and IDNO

Network design

**Proposal**

To develop a process to ensure that restoration is considered when designing the network, in partnership with TOs and ESO. This being for the initial restoration stages documented in an LJRP or DZRP, and later stages of restoration such as skeleton network and demand restoration.

DNO Network should be designed to have the:

* Ability to energise and block load, considering reactive gain between adjacent substations such that it can be energised within a restoration situation/ network arrangements.
* Ability to segregate areas of the network for LJRP and DRZPs.
* Ability to segregate block loads
* Ability to synchronise circuit breakers across the network
* Ability to manage embedded generation within a DRZs.

**Dissentions**

None

**Legal Text References**

OC9.4.7.5.1 (b)(x); OC9.4.7.5.1 (c)(xi); OC9.4.7.5.2 (a)(xii); OC9.4.7.5.2 (b)(xii); CC/ECC.6.4.6.3b

DOC9

**Alternatives**

None

Operation capacity

**Proposal**

DNOs should have the capability in operational timescale to:

* Switch their network to supply a minimum of 60% of electricity demand within 24 hours, in accordance with any agreed block loading requirements.
* Switch their network to supply 100% of electricity demand within 5 days.
* Estimate demand pick up (max and mins) associated with each block to help avoid going outside the capability of the Power Island.
* Provide support to demand balancing in a Power Island by switching on or off demand to maintain sufficient (head room / foot room between the demand and generator capability)
* Co-ordinate with a ESO led process of electricity sharing across GB, plus the DNO responding back to ESO for operations and reporting where applicable.

**Dissentions**

None

**Legal Text References**

OC9.1.1, OC9.2.1

**Alternatives**

None

Protection systems

**Proposal**

DNOs should have the capability to remotely switch between two protection and control setting groups on parts of their network referenced in a LJRP or DRZP (as required) during the restoration process.

For safe and efficient operation of the system, DNOs should have the capability for protection to operate at different fault infeeds that could realistically be expected during the implementation of a LJRP or DRZP.

**Dissentions**

None

**Legal Text References**

CC/ECC.6.2.3.7.2

DCode to follow

**Alternatives**

None

# CUSC Participants

Restoration Service Providers & all CUSC Parties – Starting point recap

**Proposal**

Future Networks subgroup meeting 1 covered resilience requirements. In summary the agreed principles are

* ESRS will need Users to be able to operate normally once auxiliary supplies are returned from the system.
* Operational capability resilient to a total shutdown across user control pointsand generation.

Added for clarity:

All CUSC Parties, including existing parties, will be required to ensure that their plant and apparatus has a resilience period of up to 72 hours such that when supplies are restored their plant and apparatus shall be returned to service in an equivalent time scale that would be expected from a cold plant

Their plant and apparatus should be such that their plant can be shutdown in a safe manner in a Partial or Total Shutdown and remain in a safe state without external supplies for up to 72 hours so there is some assurance that the plant will not have to be subject to major component replacement thereafter.

**Dissentions**

SSE Gen remains unclear on the requirement for the 72hrs resilience. ESO responded that the requirement is as stated above.

**Legal Text References**

CC/ECC.7.10.1 and CC/ECC.7.11

**Alternatives**

None

Restoration Service Providers & CUSC Parties – Annual Data

**Proposal**

The ESO needs to understand the status of whether ESRS is likely to be met, and the ESO is developing a tool to aid decision making during a restoration.

Based upon the capability to be resilient and the ability of a generator to join a power island, the ESO will need the following data to be provided:

* Confirmation that installed equipment has resilience, and plant would be able to be operated.
* Design duration of the resilience at site.
* Predicted duration from the return of auxiliary supplies from the system/power island to synchronisation.

It is envisaged that this would be an annual data submission to the ESO, with provider notifications for any changes via PC – Week 24 data submission.

This requirement forms part of the Assurance activity.

**Dissentions**

None

**Legal Text References**

Assurance activity is in OC5 and System Test Plan

**Alternatives**

None

Other Non-CUSC Users (including those connected to DNO networks)

**Proposal**

There needs to be clarity on how other users will act during a restoration and the scale of this interaction with the power Island. The ESO will review the Grid Code Week 24 submissions and propose a change to Schedule 11 to ensure that for each power station (including embedded power stations) the following information is provided to the ESO:

Embedded generation and capacity installed

* G99 and G98 reconnection arrangements
* Availability of Distribution Restoration Zones and critical equipment outages to be provided by the DNO as part of OC2 data submissions.

**Dissentions**

See below

**Legal Text References**

OC2 and PCA.5.7.2

**Alternatives**

As an alternative it would be reasonable to assume, for embedded generators connected after April 2019 that the default arrangements in EREC G99 and EREC G98 have been adopted by the Generator. Same applies for Embedded Generators caught by the requirements of G59.

# ESO and GB System

Management of Power Islands

**Proposal**

The ESO initiates the restoration process to form a Power Island and also manages the synchronisation between two or more Power Islands. This is the current arrangement.

**Dissentions**

None

**Legal Text Reference**

OC9.4.7.8, OC9.4.7.9, OC9.4.7.10, OC9.4.7.11, OC9.4.7.12, OC9.5

**Alternatives**

None

Regions Definition

**Proposal**

Within the drafting of the legal text, the definition of a Restoration Region will be codified aligning with the text below.

* Restoration Region – A single or number of DNO Licence Areas combined for reporting and process efficiencies.

**Dissentions**

None

**Legal Text Reference**

G&D

**Alternatives**

None

LJRP and DRZP Establishment

**Proposal**

The ESO leads the development of LJRPs and DRZPs in cooperation with prospective restoration service providers, TOs and DNOs. The ESOs’ control room uses these plans to speed up the decision-making process, avoid errors and optimise the restoration process as a whole.

* LJRP - Local Joint Restoration Plan
* DRZP - Distribution Restoration Zone Plan

A DRZP is distinct from and falls outside the provisions of a Local Joint Restoration Plan.

**Dissentions**

SSE Gen queries why Restoration Service Providers within LJRP have 2hrs to re-energise vs Restoration Service Providers within DRZP which have up to 8hrs to re-energise.

**Legal Text Reference**

OC9.4.5.1, OC9.4.5.2, OC9.4.7.5.1, OC9.4.7.5.2

DOC9.4.2; DOC9.4.2; DOC9.4.6

**Alternatives**

None

Electricity Sharing across regions

**Proposal**

To achieve the ESRS regionally there will be a need to determine electricity supplies available to each Restoration Region, and the demand connected in that Restoration Region.

During normal system operation

* Demand data will need to be collated for each Restoration Area via OC2.
* There will be a requirement codified for ESO to publish on a daily basis the 60% and 100% transmission demand forecasts that would feed into the ESRS regional restoration targets.

During a restoration event

* Current demand data will need to be collated and a forecast of demand made for each Restoration Region.
* There will be a codified requirement for the ESO to communicate the current and forecast demand required in each Restoration Region.

**Dissentions**

None

**Legal Text Reference**

OC9

OC2 To follow

**Alternatives**

None