

# ESRS - Future Networks WG Report

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## 1 Introduction

The ESO have a licence requirement to meet the Electricity Supply Restoration Standard (ESRS) by 31 December 2026. This new Electricity System Restoration Standard will require ESO to have sufficient capability and arrangements in place to restore 100% of Great Britain's electricity demand within 5 days. It will be implemented regionally, with an interim target of 60% of regional demand to be restored within 24 hours. The Electricity System Restoration Standard will reduce restoration time across Great Britain and ensure a consistent approach across all regions.

ESO commenced work on this requirement by creating industry working groups to understand more about the changes that were needed. This Future Networks working group is part of a series of 7 working groups, discussing different aspects of a restoration. The Future Networks working group includes members of the National Grid Electricity System Operator (ESO), GB Transmission Owners (TOs), Distribution Network Operators (DNOs) and Generator Owners, with other subject matter experts from across the industry brought in as required. The purpose of this working group was

*“To identify the development needs of networks to accommodate the changes in the generation mix across GB required to implement the Electricity System Restoration Standard”*

To commence the working group ESO completed

**Strawman** initial proposal to prompt discussion

**Consultation** with industry

**Codes** Review with glossary and definitions.

The following outputs were delivered by this working group. These are summarised below and presented within the body of this report.

**System Requirements** needed to facilitate restoration based on the future generation mix and the required technical capabilities

**Network Capabilities** required for restoration and changes needed to address gaps.

**Restoration Regions** proposal for boundaries

**Commercial Services** options

The report concludes with an implementation plan, identifies risks and mitigations and impact on industry codes.

The working group also worked collaboratively with other ESO ESRS working groups to contribute to the development of commercial services.

The ESO led working groups have provided a prompt start to achieving the ESRS requirements. Meanwhile, formal processes were commenced to undertake associated code changes. This has now been raised as GC0156 and the work from this working group will transfer across. This report documents current progress and thoughts to enable the transfer into the formal governance process of GC0156.

## 2 System Requirements for the Future Generation Mix

The GB generation mix is predicted to change considerably by 2030 and onwards, with increasing amounts of intermittent energy sources providing the electricity that we use. It is essential for an efficient and economical restoration that meets the ESRS that the generation is utilised optimally. This is effective because it drives competition for the consumer and provides resilience across different technologies.

To achieve the ESRS of restoring 60% of demand within 24 hours, and 100% within 5 days, there will need to be 60% of connected generating capacity synchronised within 24 hours of the National Power Outage. This will enable sufficient electrical energy to be available to connect the demand required. For this we can infer that changes need to be made for sufficient generation to be available within the timescales.

Peak demands increasing in the future mean that greater amounts of generation will be needed to achieve this level of restoration. By 2030 the lowest predicted Future Energy Scenarios (FES) ACS Peak System Demand will be 64.6GW (System Transformation), compared to 58.2GW in 2020. With more of this generation being intermittent, more generating units will need to be included in the restoration to achieve the same electrical energy output.

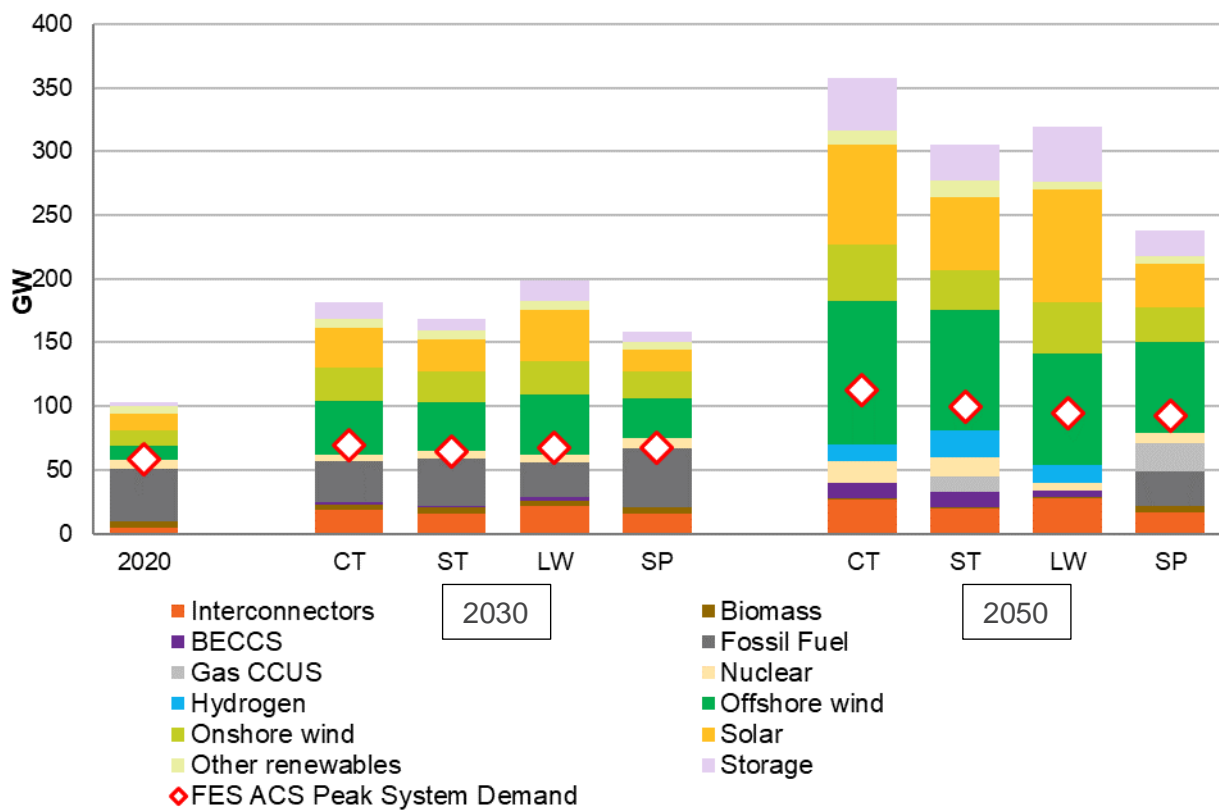


Figure 1: FES 2021 Chart SV.22 Installed electricity generation capacity, plus storage and interconnection (No vehicle-to-grid)

Where possible, renewables (such as onshore/offshore wind and solar) will need to be utilised in the first 24 hours of system restoration, either as Primary Restoration Service Providers or Secondary

Restoration Service Providers. Of the 58.5GW of continuous output generation connected that could meet 60% demand restoration, there will be long periods where this is cold and take too long to join a restoration. To achieve the timescales, it would be advantageous to look to the shorter start up times of the 93GW of renewables connecting by 2030 in System Transformation which remove the need for warming costs.

Network modifications presented in the Electricity Network Ten Year Statement to deliver the changing energy mix will also need to complement the restoration. For example, if network electrical gain is too high it may not be possible for a single generating unit to energise a circuit. This demonstrates that it is equally important to have networks and generation that are designed for restoration.

Figure C3: GB Power Flow Diagram Leading the Way 2025/26

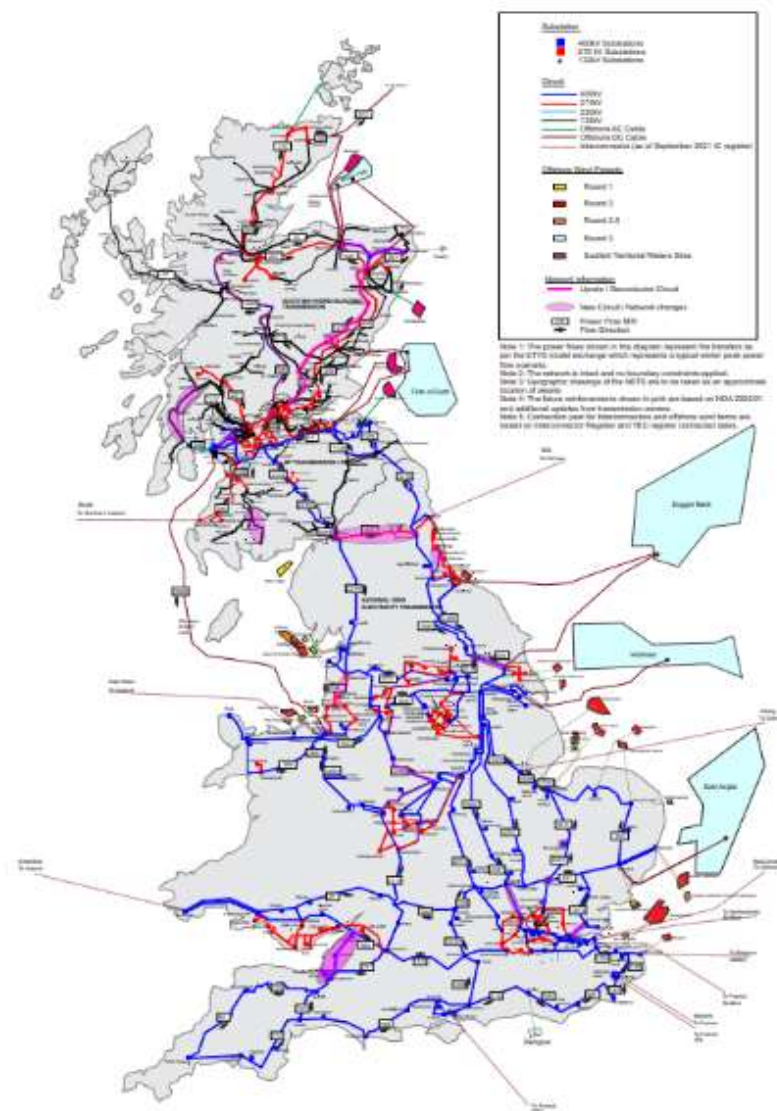


Figure 2: Electricity Ten Year Statement 2021, GB Power Flow Diagram Leading the Way 2025/26

The needs of the restoration strategy could be applied via the Network Options Assessment. For example, this process has been expanded to not only consider thermal constraints, but also voltage constraints. This shows that the process could be used to also consider restoration requirements for the network.

For the Distribution Network, we will need to look at what frameworks can be used to ensure that the designs work for restoration. This will include alignment between the Transmission and Distribution systems.

Pathfinders have been an economic and technically successful way of finding solutions to challenges identified in the near future. These on a day-to-day basis make it possible to operate the system. This is effective because it considers innovative options and the best economic solution. It follows that the need for these services within a restoration should be considered, and resilience specified as appropriate.

In conclusion, the future generation mix, network changes and tools to operate the system provide a need to change how we restore and what tools we use. For example, where we have utilised the reactive capability of a conventional generator, it may be that we now utilise a piece of reactive equipment. This shows whilst there is new capability required, it is possible to maintain and increase restoration performance.

### 3 Network Capabilities

This section details the required technical capabilities of DNOs and TOs to support restoration.

#### 3.1 Requirements on DNOs

Requirements for DNOs may include (but is not limited to):

- Resilience
  - Have in place at substations the required infrastructure, regardless of route chosen for restoration, to remain available for a minimum of 3 days (e.g. Backup auxiliary power, such as diesel generators or alternative technology)
- Network Design
  - Consideration of design for a restorable network (e.g. reactive gain, or network arrangements)
  - The ability to change protection and control settings as required
  - The ability to provide slow balancing to support block loading and enable maximum demand to be restored while retaining sufficient resources in reserve to respond to generation/balance mismatches.
  - The ability to segregate its network to allow block loads of a maximum of 20MW or 2-10MW for Anchor Generators and Top up service providers.
  - The ability to initiate fast control of available resources to balance the system (frequency and voltage) and minimise the stress on the anchor generator
  - Ability to synchronize power islands in at least 50% of the installed circuit breakers at the highest DNO Voltage.
- Operability
  - The ability to block load every 3 minutes

#### 3.2 Requirements for TOs (Onshore and Offshore)

Requirements for TOs may include (but is not limited to):

- Resilience – the transmission system needs to be visible and operable.
  - All substations should have resilient auxiliary power sources to remain functionally available for a minimum of 72 hours.
- Network Design – the design of the network needs to be able to facilitate a restoration, Local Joint Restoration Plans (LJRP) and Skeleton Network
  - No Load Gain between adjacent substations to not exceed 50Mvar.
  - The ability to deliver reactive compensation in steps of up to 60Mvar

- The ability to change protection and control settings as required to ensure correct operation at low fault levels in an LJRP and skeleton network.

### 3.3 Requirements for iDNOs

iDNO's are currently treated as DNO's within the codes. We do not envisage any specific changes being required, over and above that detailed in the DNO section.

## 4 Proposed Boundaries for each Electricity Restoration Region

This section analyses four different boundary options used for the demarcation of regions.

### 4.1 Option 1: Restoration Zones remains as it is

Features of Option 1:

- Existing restoration zones closely align to the geo political zones
- The use of existing Local Joint Restoration Plan (LJRP) per Restoration Service Provider
- A restoration zone may cut across 2 DNO licenced areas
- A restoration zone may cut across 2 different DNO companies
- Existing LJRP may not be consistent with Distributed ReStart Zone where you may have more than one DNO company in a LJRP

Pros and Cons of Option 1:

Pros	Cons
No administrative adjustment required on LJRPs and zones	Not easy to quantify the deliverables – where demand in a zone may cut across different DNO licenced area/different DNO company
This could easily fit into Ofgem restoration zone requirement	May not be straightforward to show restoration standard is met if the zones cut across DNO licenced area/DNO companies

### 4.2 Option 2: Restoration Zone as DNO licenced area

Features of Option 2:

- Create 14 zones to align with 14 DNO licenced areas
- Create 14 LJRPs to be consistent with the 14 DNO licenced areas
- The restoration zones to align with distributed Restart zones with a distributed controller in each licenced area
- 14 reporting zones to meet restoration standard – the licenced areas become the restoration zones.

Pros and Cons of Option 2:

Pros	Cons
Easy to implement with additional work	Cost to implement is higher than other options
Goes beyond Ofgem requirement and provide quicker restoration options (first 24 hrs)	Most onerous option to meet restoration standard – other options could pool demand to meet standard- larger area pooled to reach 60% demand in first 24 hours.



Easy to report as demarcations are clear	Administrative adjustment required on LJRP and zones
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### 4.3 Option 3: Restoration Zones as three GB Nations

Features of Option 3:

- The restoration zones to align with 3 GB nations (Scotland, England & Wales)
- LJRPs modified to align with the zones or multiple LJRPs per zone
- Zones modified to consist of multiple DNO licenced areas

Pros and Cons of Option 3:

Pros	Cons
Easy to implement with additional work	Does not fit into Ofgem requirement as it stands (3 zones instead of 6) and may attract challenge from Ofgem/BEIS
	Administrative adjustment required on LJRPs and zones

### 4.4 Option 4: Modify Existing Restoration Zone

Features of Option 4:

- LJRPs to align with 14 DNO licenced areas – 14 LJRPs
- Modify the restoration zones (closely aligning with the geo political zones) to follow DNO licenced area boundaries
- Restore demand per licenced area and this aligns with distributed Restart zones
- Collate licenced area into corresponding geo political zones for ESRS reporting

Pros and Cons of Option 4:

Pros	Cons
Easy to implement with additional work	Administrative adjustment required on LJRPs and zones
Easily fits into Ofgem requirement	
Deliverables can be quantified	

### 4.5 Conclusions

It is proposed that option 4 is taken forward. This will involve having 14 Restoration zones, each with an LJRP covering several Restoration Service Providers and accompanying DZRP. These restoration zones will be the same as the DNO licence area. This enables the safest and most efficient operation of a restoration, only communicating with a single DNO licence area.

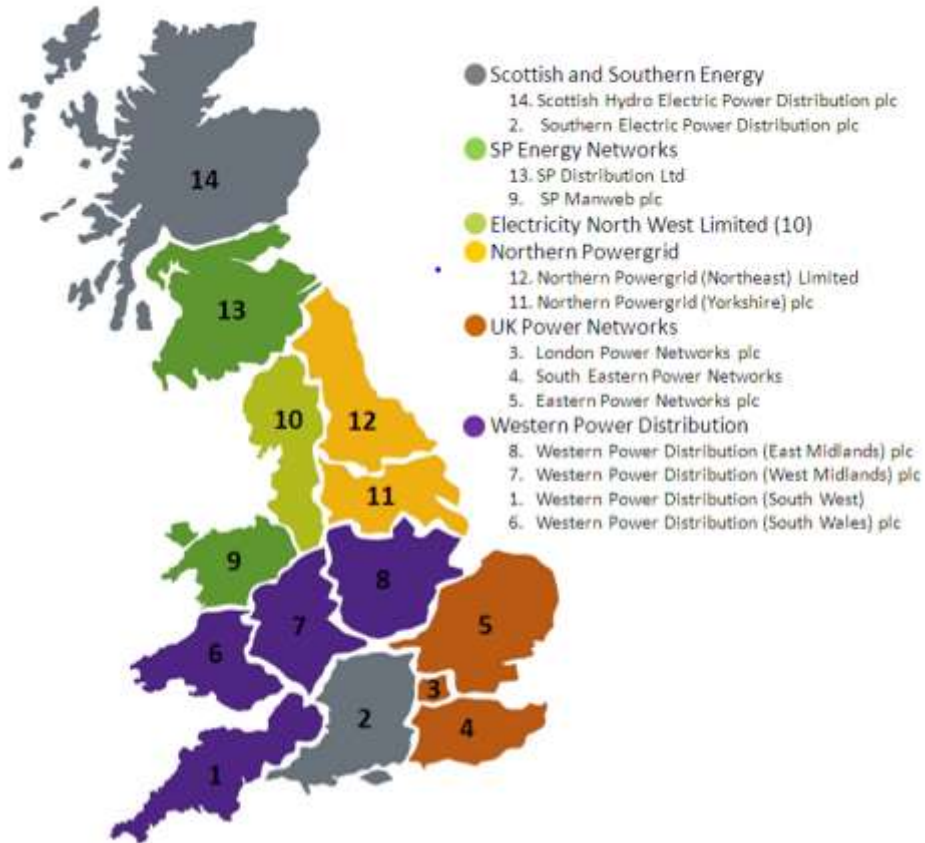


Figure 3: DNO Licence Areas / Restoration Zones

There will then be 7 Electricity Restoration Regions, grouping zones together for reporting of demand restored within the region.

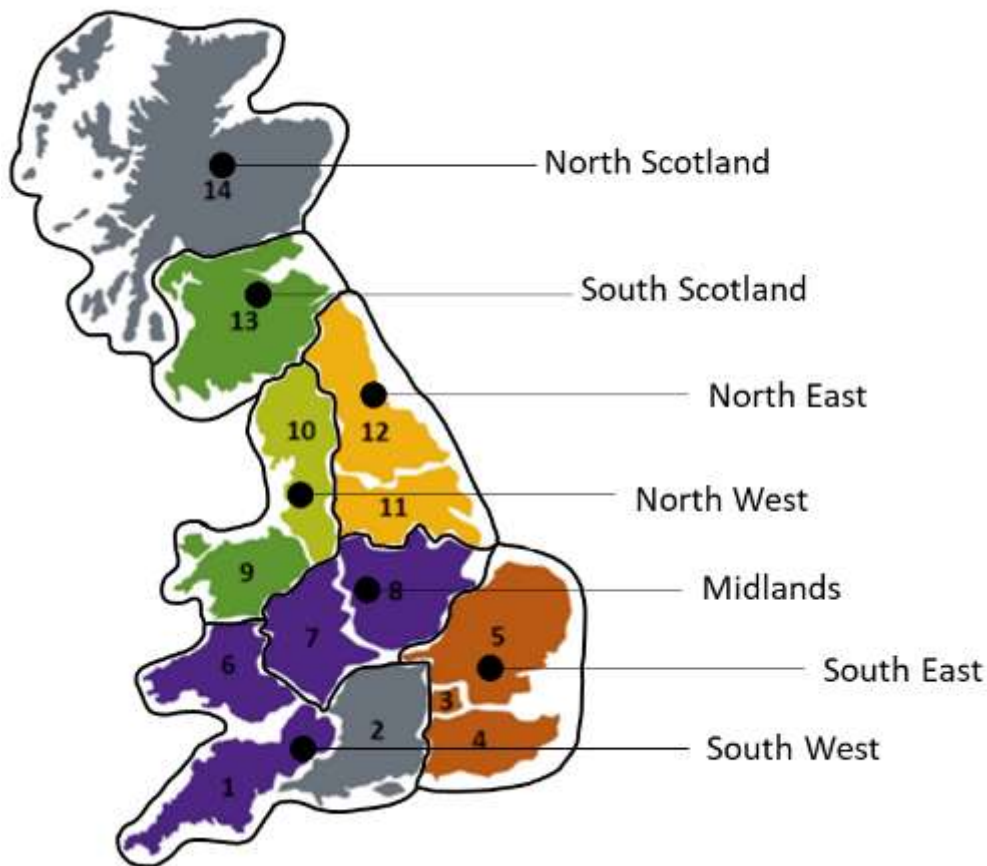


Figure 4: Restoration Regions overlaid onto DNO Licence areas.

This applies the concept of resilience of services across GB to prevent against storm damage. Restoration efforts and progress can then be balanced across GB to ensure a fair approach to all via the Restoration Zones. These aligning with electrical boundary, rather than geopolitical boundaries for safety and efficiency reasons, but achieving the same goal.

Sharing of available electrical supplies across GB will be enacted as soon as it is practicable to do so. It is easier to manage one larger system, once established, as more generators will be available to react to any change. It therefore follows that targeted demand loads per DNO licence area or Restoration Zone, based upon available generation should be communicated in Realtime. This will minimise the risk of a Power Island collapsing because of imbalance.

To clarify, this section presents a current proposal on the approach via Zones and Regions. It maybe that boundaries may change over time, for example due to Restoration Service Providers changing.

## 5 Commercial service options

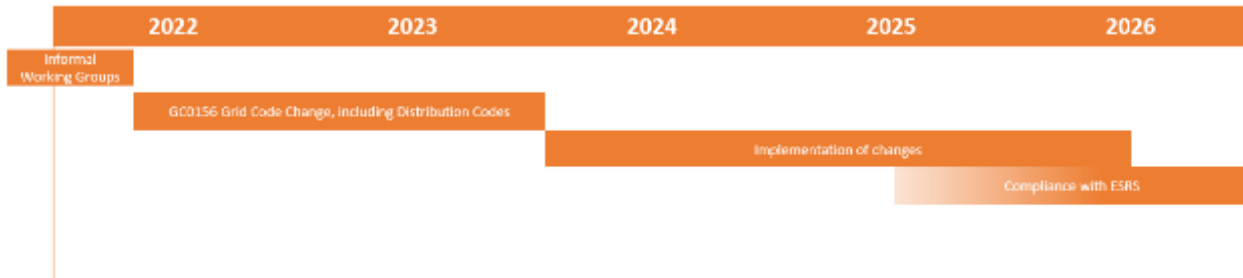
The Electricity System Restoration Assurance Framework 22/23 sets out the approach to procuring commercial services for Restoration Service Providers. This framework will be followed, except for removing Phase 4 services, as the timescale of 72-120 hours is outside that of the resilience being asked for under ESRS.

The phase approach for commercial services enables sites with longer start up times than 2 hours to join and contribute to a restoration process. For clarity it is not delaying capability from joining a restoration rather, Phases 2 and 3 empower more generators to offer the service and join the restoration in a timely manner that supports resource capabilities for ESO and Network Operators.

Commercial Service	Restart Time
Phase 1 Electricity System Restoration	Within 2hrs
Phase 2 Electricity System Restoration	2-24hrs
Phase 3 Electricity System Restoration	24-72hrs

## 6 Implementation plan

The plan below presents the high-level implementation plan for changes associated with ESRS.



## **7 Risks & Mitigations**

2030 Offshore Wind targets of 40GW of installed capacity are currently being designed, with their associated Offshore Transmission. Many of these sites are approaching their design fix dates, where there will be no more alterations to the design, to enable manufacture and build. For ESRS this is a key milestone to enable a significant amount of generation to join the restoration strategy.

Transmission Owners and Distribution Network Operators may need to make numerous changes to plant and equipment on their network, both for resilience and operability. Whilst there are funding routes available for this, resource with skills and expertise are limited, along with access to the network. It is a possibility that the priority of the ESRS will need to be balanced with work already committed to.

Reporting of demand restored will rely on metering accuracy across all networks. We are aware that whilst this is operationally sufficient at present, it does have limitations. Therefore, to enable accurate reporting of demand restored within each region, further work will need to be done around metering across the GB Network.

A working group member shared that there are c1 million G99 connections on the network in 2022. This including Solar and Vehicle 2 Grid connections. Inhibiting these is unrealistic within a restoration setting. Further, if brief Voltage variations were to take place, G99 would disconnect for 20 seconds and return, possibly destabilising a restoration.

## **8 Impact on Industry**

### **8.1 Impact on Industry Codes**

It is envisaged that code changes will be required to the Grid Code, Distribution Code and System Operator Transmission Owner Codes. These are likely to be numerous changes to ensure that the capability required for ESRS is detailed appropriately.

### **8.2 Changes on Regulatory Frameworks**

Changes to be made to the industry codes will place additional requirements on the TO and DNOs. It is currently understood that there are potential reopeners within their regulatory frameworks for changes associated with ESRS.

For Restoration Service Providers, these will be procured via a tendering process. It follows that costs will be included in their service provision.

### **8.3 Route to Change**

NGESO have raised GC0156 Grid Code change to implement this work. It has been agreed with the Grid Code and Distribution Code Panels that GC0156 will be the vehicle for code changes with the Distribution Code. This will enable the coordination of the Restoration Methodology.

The Future Networks Working Group will transfer into GC0156, to avoid duplication and formalise the process.

## **9 Conclusion**

The generation mix is changing significantly by 2030, and to ensure that ESRS can be complied with by 31 December 2026 it is important to facilitate as many different technologies providing the Restoration Service as possible. This is likely to mean changes to designs and installations to build the capability required.

DNOs and iDNOs will need to assess resilience and network operability for both Distribution Restoration Zones and for wider ESRS requirements. This is likely to involve changes to network equipment, plant resilience and systems.

Transmission Owners will need also to assess resilience and network operability for ESRS. This will involve bolstering resilience and increasing flexibility of assets such as reactive equipment.

Offshore Transmission Owners will need to be brought into the restoration, to enable access to renewable energy sources. This will require capability increases on their networks, and changes to designs for those sites yet to be built.

Restoration Service will be procured in 14 Restoration Zones (DNO License Areas) across Great Britain. This will increase the fleet provision, contributing to the ability to restore 60% of demand in 24 hours. Reporting of demand restored will then be based on the 7 Electricity Restoration Regions, ensuring a regional approach to restoration.

Commercial services will be aligned with available resilience on the networks to optimise performance for ESRS.

## 10 Appendix A – Next steps (To be discussed)

Restoration Service Provider resilience to the loss of external site supplies will be needed until auxiliary supplies are returned from the Skeleton Network. This being the ability to power any essential services that are required to protect the integrity of the generator, e.g., lubrication systems. It is not the ability to self-start, but to prevent damage to generators. This is to ensure that the generation is kept in an operable and safe state, until the site is energised during the restoration and can then contribute.

For DNO's it will be necessary to have:

- The ability to operationally switch 60% of demand within 24 hours, 100% in 5 days, in coordination with ESO and available generation.
- The ability to manage demand connected to assist in balancing the Frequency and working to ESO provided demand limits to aid management of the emerging system.
- Calculation of maximum loads on load pick up.
- DNO in partnership with TO and ESO include restoration in their network designs, for long term, planning and operational timescales.

For the TO it will be necessary to have:

- TO in partnership with ESO, and DNO include restoration plan designs within the long term, planning and operational timescales.
- The ability to energise and load Type D and C generators, this meaning that there are suitable network routes between generators and sufficient demand to load generator to stable export limit, should be able to be energised by a single unit of the generator at 0MW output.
- The ability to extend Power Islands after reaching stable export limit with demand, the generator should be able to energise to a neighbouring generator to provide supplies.
- The ability to synchronise Power Islands at all substations across the Transmission Network (Couplers and Section Circuit Breakers).
- When considering resourcing and systems, the ability to open switches to “clear circuits” prior to energisation over the first 24 hours.
- The ability to operationally support LJRPs within the TO area, over c4 hours.
- The ability to operationally support the establishment and synchronisation of the system, energising every substation within 24 hours. Noting that this maybe at single circuit and will make available supplies to generation and demand groups when ready.
  - Need for offline teams to support the strategy and analysis (similar to outage plan) as the restoration progress.
  - TO and ESO evaluation of outages and their effect on Restoration timings

- For Regulatory Frameworks funding may be needed to make changes that are not covered by current regulatory frameworks. Specifically, it is possible that changes will be required in the Secondary (non-commercial Restoration Service Providers) fleet. There may be the need for funding mechanisms to be provided and this can be discussed when the need is more clearly defined.