# ESRS - Technology and Locational Diversity WG Report

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# 2 Introduction

The Electricity System Restoration Standard (ESRS) requires the Electricity System Operator (ESO) to have sufficient capability and arrangements in place to restore 60% of regional demand within 24hrs and 100% of Great Britain's electricity demand within 5 days. ESO must ensure that everything is in place to comply with this standard by no later than 31st December 2026.

Whilst our current approach plans to achieve restoration of 60% of national demand within 24 hours, there are regional variations and the estimation of time taken for full system restoration is based on a probabilistic assessment of shutdown scenarios, reflecting the range of severity of events, to determine likely timescales for differing stages of restoration.

The Technology and Locational Diversity Work Group is one of seven working groups established to understand and recommend changes required to achieve the ESRS standard. The working group comprised of stakeholders from across the industry, Electricity System Operator, Generation companies, Energy consultancy companies, Transmission Owners, Distribution Network Operators and other stakeholders. The working group provided regular progress updates to coordination team and steering committee, which sits above this working group.

In accordance with the terms of reference, the purpose of this working group was to assess how different technologies could contribute to faster restoration times and an enduring supply of demand to meet the ESRS.

The inputs to the working group include:

- ESO Strawman
- Relevant consultation responses
- Relevant codes
- Glossary & definitions

The outputs from the working group include:

- List of current/future challenges per technology discussed including advantages, limitations and proposed mitigations, technical and commercial drivers
- Recommendation on the minimum number of service provider technologies in each zone
- Risks and mitigations

The working group in coordination with other industry working groups assessed the impact of the outcomes on industry codes, including mapping of changes in relevant regulatory frameworks, initial draft of the proposed changes and a route to change.

# 3 Electricity Restoration Reporting Regions

The following 7 reporting regions have been proposed for electricity system restoration:

- North Scotland Restoration Region
- South Scotland Restoration Region
- North East Restoration Region
- North West Restoration Region
- Midlands Restoration Region
- South East Restoration Region
- South West Restoration Region

These regions were deduced from the original 6 restoration regions with the Scotland regions split into 2 to separate the 2 transmission networks in Scotland.

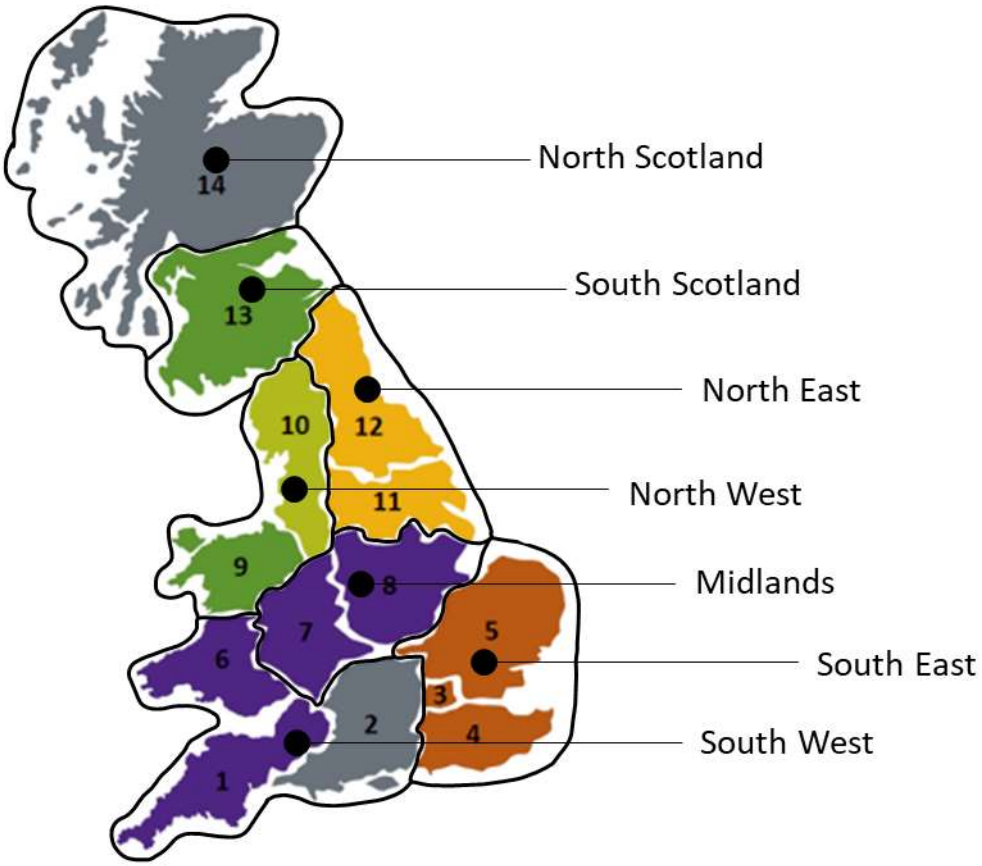



Figure 1: Electricity Restoration Reporting Regions

# 4 Minimum Number of Service Provider Technologies in Each DNO licence area

## 4.1 Reasoning for a minimum number of technologies

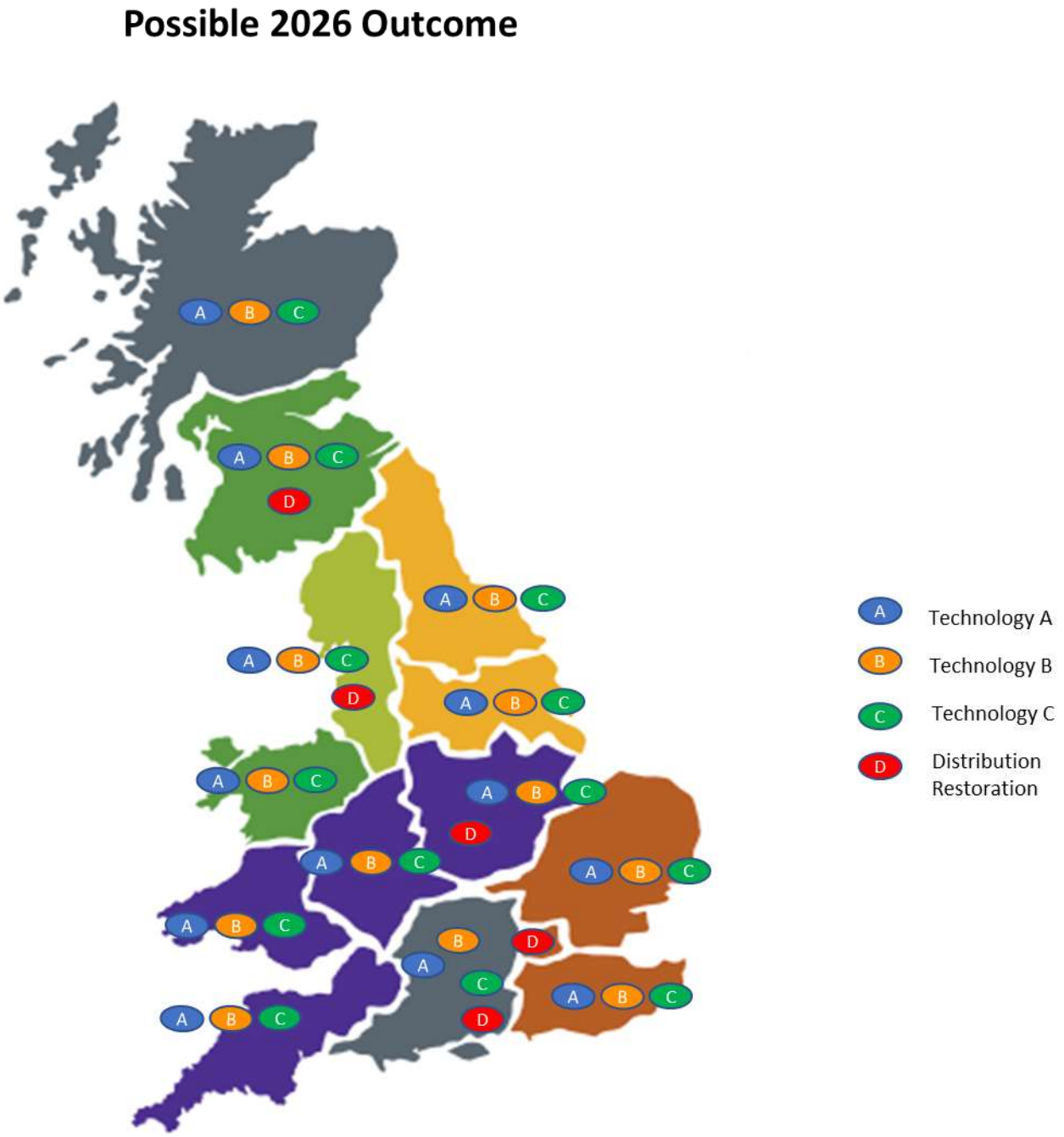
It was decided that each DNO licence area requires diverse technologies to mitigate against the risk of one type of technology being unavailable or a common source of failure. It was also suggested in working group meetings that technologies should not be shifted in and out of the licenced area but instead a licenced area should rely on what technology is present in that area. This will also go to mitigate against large scale change in the market, such as happened with coal generation.

The system will be restored by DNO licence areas and the rationale being that the GB demand will be restored quicker with a smaller restoration zone. It was also noted that DNO licence areas provide a good demarcation point for demands, moreover it provides the control demarcation required for distribution restoration using Distribution Restoration Zone Controllers (DRZC).

Figure 2. below shows the possible view in 2026 with regards to technologies in each DNO licence area. Potentially there could be 39 Transmission Restoration Service Providers and 5 Distribution Restoration Zone Controllers. These numbers are based on indicative analysis using demand and generation data noting that other factors will need to be considered before a definitive figure can be concluded.

The figures are based on having 3 technologies as transmission Restoration Service Providers per 13 DNO licenced area (excluding UKPN London where there are no transmission generations) to give 39 transmission Restoration Service Providers. The 5 Distribution Restoration Zone Controllers are based on choosing 4 areas where there are negative generation imblance or tight margin between the transmission generation and total demand within the DNO licence area and adding the Scottish Power TO area, as this area would also benefit from Distribution Restoration.

The Technology A, B, or C in this context could be any technology and the idea being that they are different to provide diversity, and the relevant letter may be different across DNO licence areas.




**Potentially 39 Transmission Restoration service Providers & 5 Distribution Restoration Zone Controllers**

*Figure 2 – Different types of technologies in each DNO licence area*

Figure 3 below presents a representation of the potential generation aligning to DNO licence areas for year 2026 and the associated winter demand. This is aimed at identifying capacities of potential Restoration Service Providers to balance the demand in each DNO licence area. It should be noted that this does not necessarily mean the generators would be capable to support restoration, but where there is a transmission generation versus total demand imbalance, it immediately shows a shortfall and a potential need to source for other options such as distributed restoration providers.

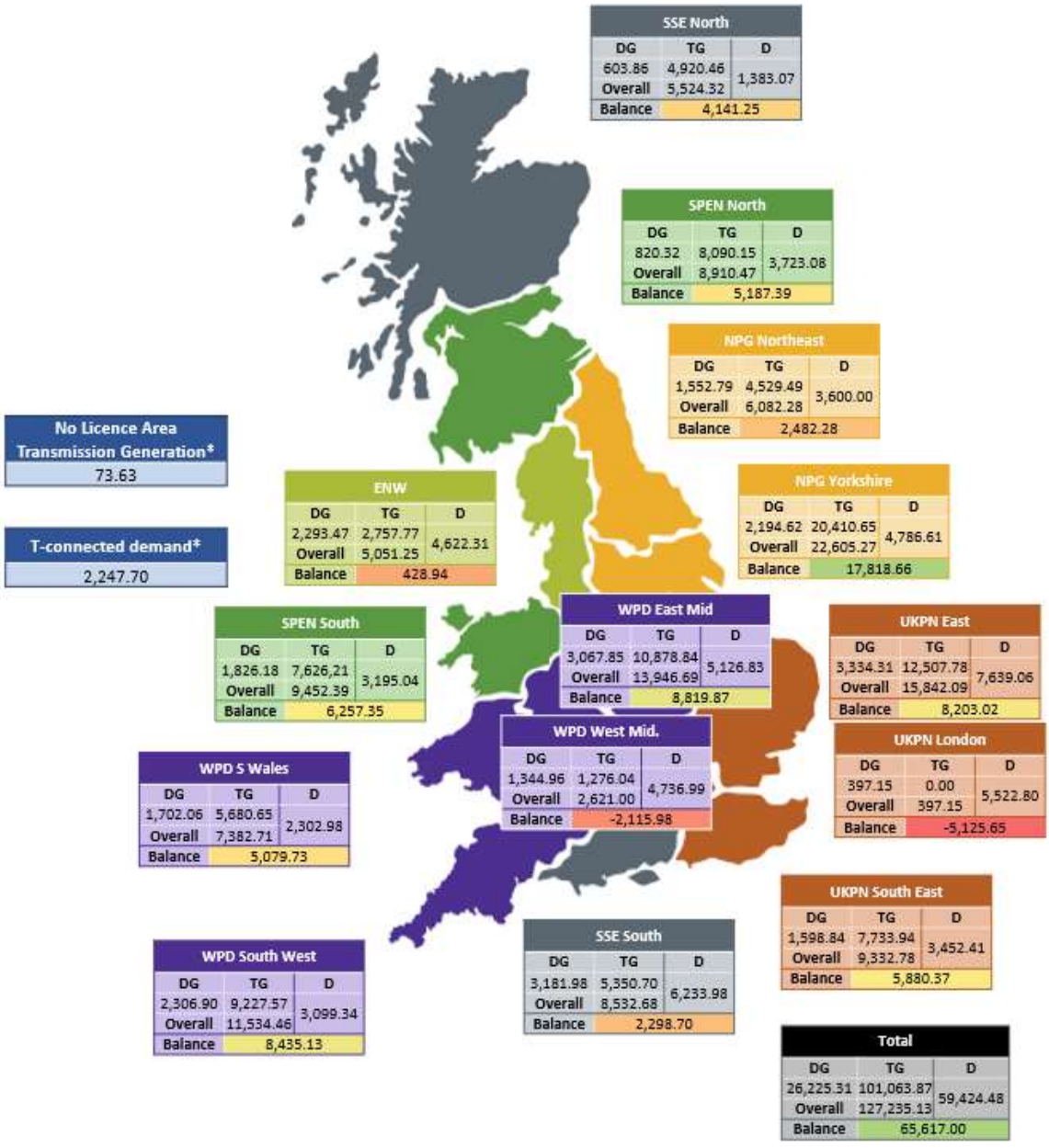



*Figure 3 - 2026 Forecast Generation – transmission and distributed generation against winter demand (in MW)*

Note, the generation and demand that cannot be allocated to a DNO licence area is captured in the blue box above and included in the overall total.

# 5 Attributes and Proposed Mitigations of Technologies for Restoration

This section will examine the suitability of current technologies and how some limitations can be mitigated against. It assesses the technologies in their default or inherent state.

## 5.1 Attributes and mitigations of the Technologies

| Attributes/Technology | Wind | Pump Storage | Solar | Batteries | Demand Side Response | Biomass | Electric Vehicle/ V2G | Nuclear | Interconnectors | Hydro | Gas Plant | Mitigations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Infinite fuel source | Yes | No | Yes | No | No | No | No | No | No | No | No | |
| Available across diverse areas | Yes | No | Yes | Yes | Yes | No | Yes | No | No | No | No | |
| Large sources of renewable electricity | Yes | No | Yes | No | No | Yes | No | No | No | Yes | No | |
| Potential to accelerate the overall restoration with fast start times | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | |
| Diversity of services- generating, pumping, spinning, generation or load | No | Yes | No | Yes | Yes | No | Yes | No | Yes | Yes | No | |
| | | | | | | | | | | | | |

| Attributes/Technology | Wind | Pump Storage | Solar | Batteries | Demand Side Response | Biomass | Electric Vehicle/ V2G | Nuclear | Interconnectors | Hydro | Gas Plant | Mitigations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Full Grid Forming capability including fault infeed and inertia | No | Yes | No | No | No | Yes | No | Yes | Yes | Yes | Yes | The framework laid out in GC0137 will make it clear what is required. |
| Inherent self-start capability without auxiliary unit | No | No | No | Yes | No | No | Yes | No | Yes | No | No | |
| Rapid active power frequency control and voltage regulation capability. | Yes | Yes | Yes | Yes | No | Yes | Yes | No | No | Yes | Yes | |
| Manage impact of intermittency of other technologies during restoration | No | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |
| High block load capability | No | Yes | No | No | No | Yes | No | No | Yes | Yes | Yes | |
| Intermittency of supply | Yes | No | Yes | No | No | No | No | No | No | No | No | Forecasting, Co-location with storage |
| Potential cause of Sub-synchronous Torsional Interaction issues (SSTI) | Yes/ Offshore Wind farm | No | No | No | No | No | No | No | Yes | No | No | |
| Controls or communications Available. | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Controls with resilient comms |

| Attributes/Technology | Wind | Pump Storage | Solar | Batteries | Demand Side Response | Biomass | Electric Vehicle/ V2G | Nuclear | Interconnectors | Hydro | Gas Plant | Mitigations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Likelihood of feasibility for Grid Re-energisation due to size | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | |
| Capability to trip to house load. | Yes | Yes | Yes | Yes | No | Yes | Yes | No | Yes | Yes | Yes | Capability for a new nuclear generator to trip to house load as specified in (Art 15(5) and ECC.6.3.5.6 (b)(i) |
| Long start up time | No | No | No | No | No | No | No | Yes | No | No | No | Use for later stage of restoration |
| Need to involve another System Operator/Dependent on other countries | No | No | No | No | No | No | No | No | Yes | No | No | Multiple links to reduce risk |

# 6 Risks & Mitigations

## 6.1 Table of Risks

| Risk Number | Description of Risk | Cause of Risk | Consequence of Risk | Risk Mitigation |
|---|---|---|---|---|
| 001 | Unable to get required technology capacity in each DNO licenced area to meet the ESRS standard | Insufficient number of generators of specific technologies are not located in the DNO licenced area | Insufficient generation to meet ESRS standard and in some cases where this is met, there is no technology diversity. | Early market notification and incentives to encourage investment in certain technologies in certain areas |
| 002 | Some of the technologies may not meet the specifications to support restoration | The technologies do not meet the restoration functional specifications due to its inherent capabilities or it will need enhanced capability installed. | The generator will be unable to participate as a restoration provider | Early market notification of restoration requirements and incentives to enable upgrades to generators and feed into new builds. |
| 003 | Some of the technologies may not be available in a DNO licenced area to provide technology diversity | Unavailability of diverse technology generators in DNO licenced areas. | Non diverse restoration provision which may introduce a common point of failure for restoration providers leading to ESRS standard not met. | Create incentives for investment opportunities for diverse restoration provisions in DNO areas. |
| 004 | There may not be a resilient network to the generators to support restoration | Unavailability of independent power resilient network from Network Operator to generator | No communication to facilitate restoration therefore ruling out the generator as restoration provider | Investment in independent power resilient network |
| 005 | The risks and mitigations listed may be more severe as original thought as some of the technologies haven't been assessed fully for restoration capabilities | The risk identified may be underestimated and more severe than articulated. | Point of failure as a Restoration Service Provider and not meeting ESRS standard | Site trials to check suitability should be done as early as possible |

# 7 Impact on Industry

## 7.1 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. There are likely to be numerous changes to ensure that the capability required for ESRS is implemented appropriately. There will also be related changes to the Connection and Use of System Code (CUSC) and Balancing and Settlement Code (BSC).

## 7.2 Changes on Regulatory Frameworks

Changes made to the industry codes will place additional requirements on the Restoration Service Providers. It is currently understood that there are potential reopeners within the ESO, TO and DNO 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. It is also possible that changes will be required in the secondary (non-commercial) generator providers. Funding mechanisms for secondary restoration activities will be investigated under a separate BSC code panel.

## 7.3 Route to Change

The ESO have raised Grid Code Modification GC0156 to implement the necessary changes to the Grid Code. The Technology and Locational Diversity Working Group will transfer into GC0156, to formalise the process. It is proposed this is a joint Grid Code / Distribution Code Workgroup which will also develop Distribution Code Changes. There will however need to be separate workgroups under the auspices of the other industry code panels (STC, SQSS, CUSC and BSC) to implement the full suite of measures required. It has been proposed that the combined Grid Code / Distribution Code should be the first formal Code modification established and the other industry code changes will then follow. This will enable the coordination of the Restoration Methodology.

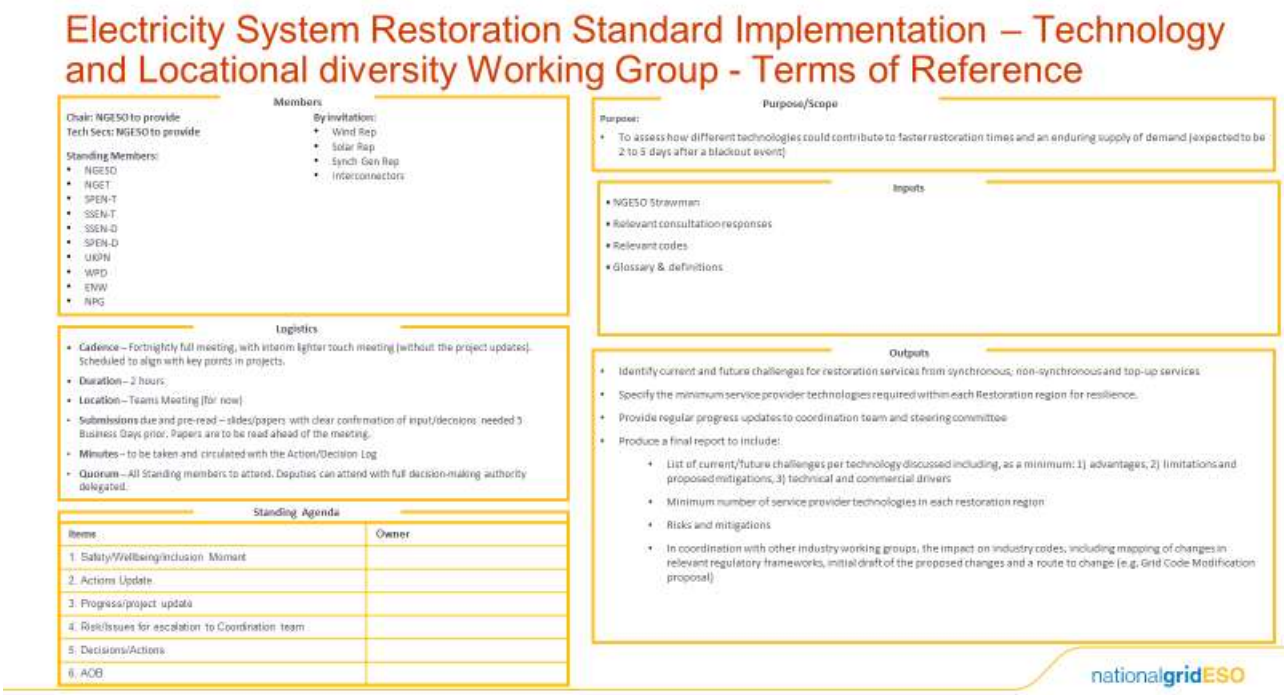
# 8 Conclusion

The Technology and Locational Diversity Working Group reported on key areas detailing the various technologies that could contribute to Electricity system restoration. The advantages, limitations and proposed mitigations were assessed and recorded in this report.

The working group also assessed and recommended a minimum of 3 different technologies in each DNO licenced area for electricity system restoration to create diversity.

A risk assessment was carried out and recorded in a risk table. These recommendations will feed into the Grid Code modification - GC0156.

# 9 Appendices



## Electricity System Restoration Standard Implementation – Technology and Locational diversity Working Group - Terms of Reference

**Members**

Chair: NGESO to provide
Tech Secs: NGESO to provide

Standing Members:
- NGESO
- NGET
- SPEN-T
- SSEN-T
- SSEN-D
- SPEN-D
- UKPN
- WPD
- ENW
- NPG

By invitation:
- Wind Rep
- Solar Rep
- Synch Gen Rep
- Interconnectors

**Logistics**

- **Cadence** – Fortnightly full meeting, with interim lighter touch meeting (without the project updates). Scheduled to align with key points in projects.
- **Duration** – 2 hours
- **Location** – Teams Meeting (for now)
- **Submissions** due and pre-read – slides/papers with clear confirmation of input/decisions needed 3 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.

**Standing Agenda**

| Items | Owner |
|---|---|
| 1. Safety/Wellbeing/Inclusion Moment | |
| 2. Actions Update | |
| 3. Progress/project update | |
| 4. Risk/Issues for escalation to Coordination team | |
| 5. Decisions/Actions | |
| 6. AOB | |

**Purpose/Scope**

Purpose:
- To assess how different technologies could contribute to faster restoration times and an enduring supply of demand (expected to be 2 to 5 days after a blackout event)

**Inputs**

- NGESO Strawman
- Relevant consultation responses
- Relevant codes
- Glossary & definitions

**Outputs**

- Identify current and future challenges for restoration services from synchronous, non-synchronous and top-up services
- Specify the minimum service provider technologies required within each Restoration region for resilience.
- Provide regular progress updates to coordination team and steering committee
- Produce a final report to include:
  - List of current/future challenges per technology discussed including, as a minimum: 1) advantages, 2) limitations and proposed mitigations, 3) technical and commercial drivers
  - Minimum number of service provider technologies in each restoration region
  - Risks and mitigations
  - In coordination with other industry working groups, the impact on industry codes, including mapping of changes in relevant regulatory frameworks, initial draft of the proposed changes and a route to change (e.g. Grid Code Modification proposal)

nationalgridESO

Figure 4 – Technology and Locational Diversity WG Terms of reference