A landscape photograph featuring snow-capped mountains in the background and a valley in the foreground. Several bright, glowing yellow light trails curve across the valley floor, suggesting a path or a digital overlay. The sky is filled with dramatic, cloudy light.

# ESO Grid Forming (GFM) Specification Best Practice Application Guide

Nicholas Harvey, ESO

ESIG Event; 28, 02, 2023

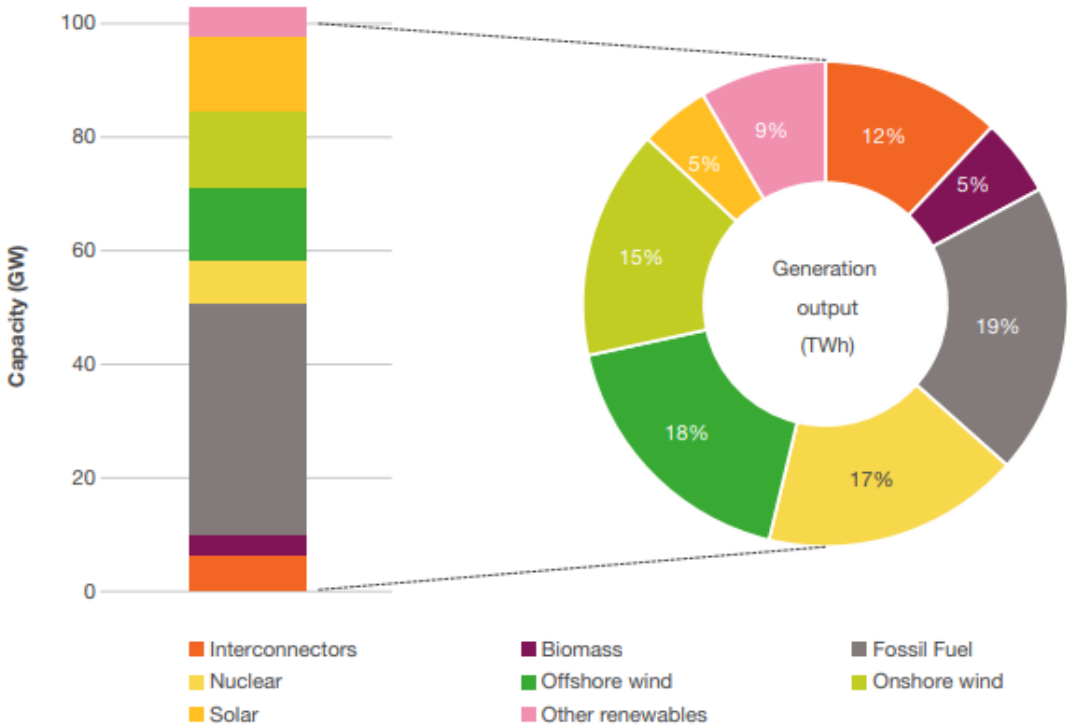
## National Grid ESO's role

- Operates and balances the system
- Widens access and promotes competition
- Provides network recommendations
- Operational planning
- Connection agreements
- Responsible for GB transmission charging and billing

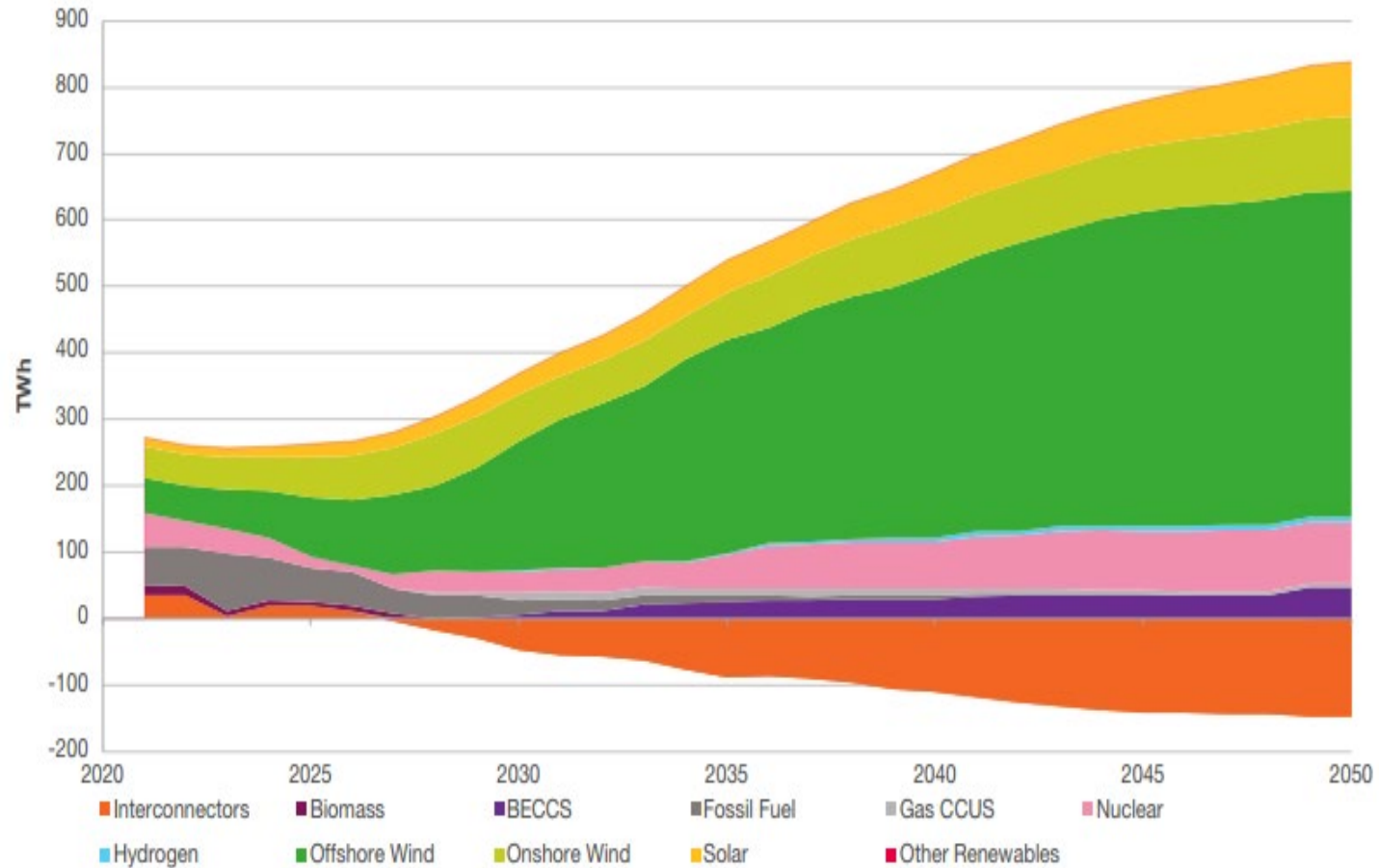
The **transmission operators (TOs)** own, build and maintain Britain's transmission infrastructure.



# Background: Generation Mix – Roadmap from 2020 to 2050



Electricity Generation Capacity (GW) and Output (TWh) in 2021



## Key Messages

Evolution of GB electricity system towards 2050

- Decarbonised
- Decentralised
- IBR-Dominant
- Significant decline in thermal power plants

**Customer Transformation, ESO's Future Energy Scenarios, 2022**

# Grid Forming Capability to Meet GB Operability Challenges

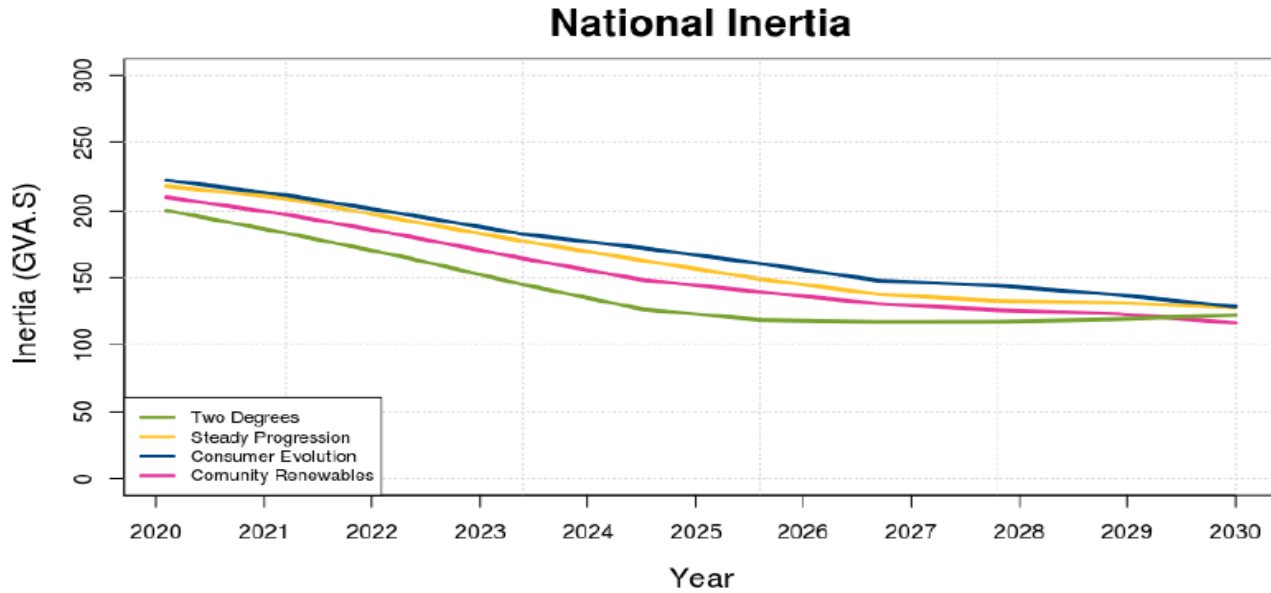


Figure 1: Inertia Trend to 2030, System Operability Framework (SOF): “Operating a Low Inertia System”, Feb 2020

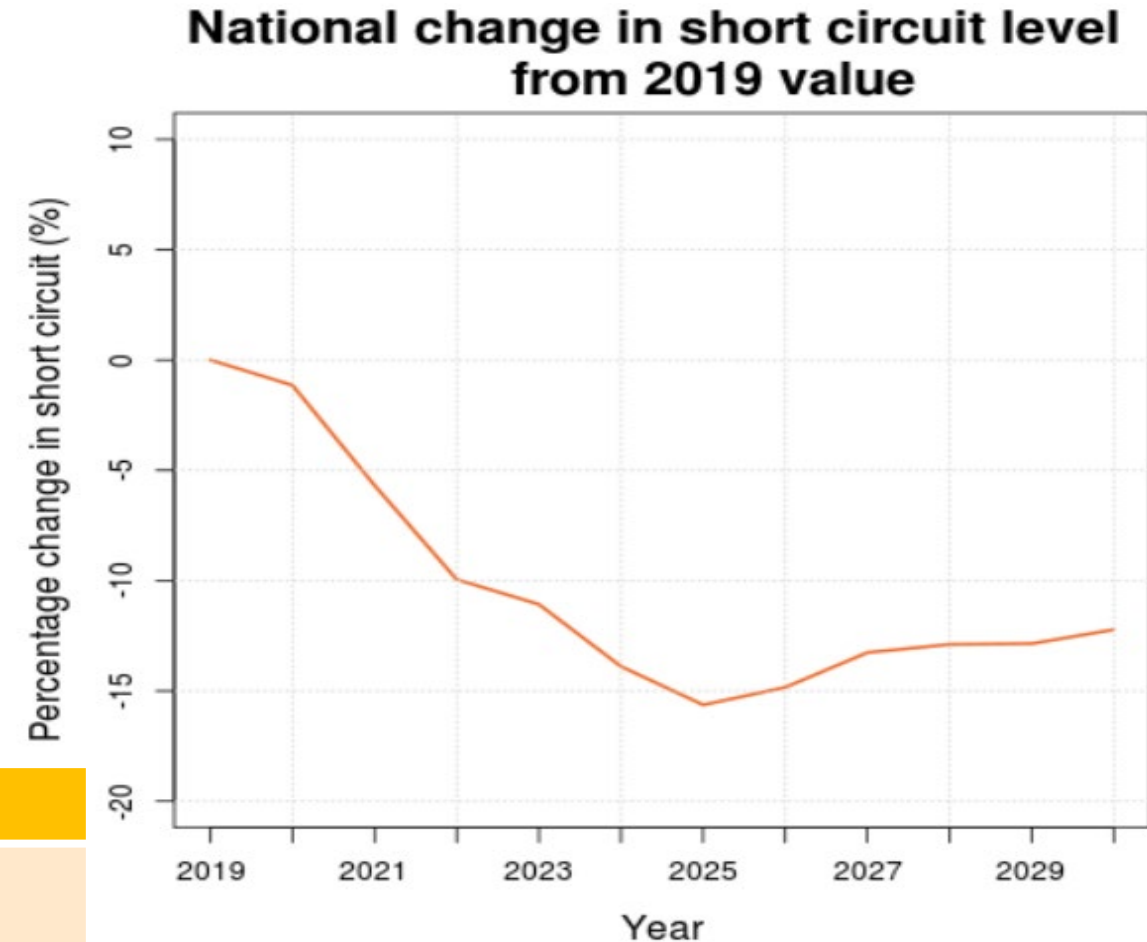


Figure 2: National Short Circuit Level 2019- 2030, SOF: “Impact of Declining Short Circuit Levels”, Dec 2018

## Key Messages

1. Key Challenges for Future IBR-Dominant GB Electricity Tx System:
  - Declining Inertia
  - Declining System Strength
2. As suggested in ESO’s Operability Strategy - Grid Forming capability is considered to meet these operability challenges.

# ESO's Current Strategic Roadmap for GB Grid Forming Development

## Business Case

- ESO Operability Strategy Report
- System Operability Framework (SOF) Article on GFM/VSM

## Collaboration with External Stakeholders

- VSM Expert Group (Completed).
- [GC0137 GB Grid Forming Working Group \(Completed\).](#)
- [GB Grid Forming Best Practice Group \(Completed\)](#)

SOF “The Potential Operability Benefits of Virtual Synchronous Machines and Related Technologies”, Apr, 2020

Share insight

Tech Spec & Best Practice

Feasibility Studies

GC0137: Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine/VSM Capability), implemented in Feb, 2022

## Innovation Projects:

- Virtual Synchronous Machine (VSM) Demonstrator (Completed)
- Hybrid Grid Forming Converter (Completed)
- Demonstration of Virtual Synchronous Machine Control of a Battery System (Completed)

# Technical Specification for GB Grid Forming Capability - GC0137

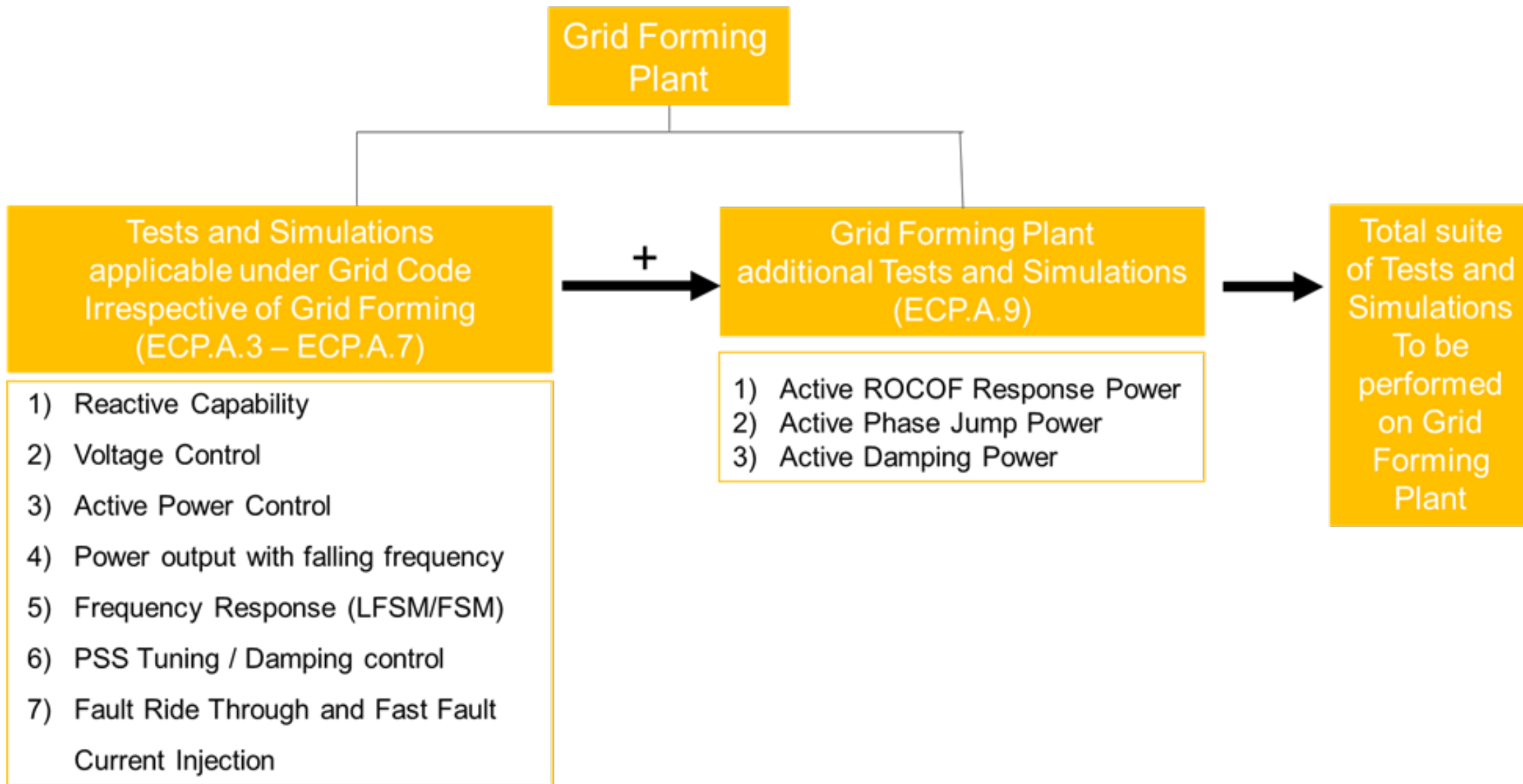
- Provide a high-level overview of Grid Forming and the Transmission System Need.
- The GC0137 “Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability”, as world’s first Grid Code specification for Grid Forming capability, was approved in early 2022 by the Ofgem.
- Develop a high-level flexible specification which would be Non-Mandatory and provide the necessary framework so the specification can be used in a future market:
  - 1) Technical Specification of Plant Requirements
  - 2) Data and Model Submission
  - 3) Compliance Simulation and Testing
- The GC0137 Minimum Specification is **NOT** as detailed Technical Specification.

# Key Messages from GB Grid Forming Specification GC0137:

## Basic Definition and System Service

- Definition of GB Grid Forming Capability: GBGF Plant can be represented as an equivalent Synchronous Internal Voltage Source behind an Impedance (to mimic a Synchronous Generator to some extent).
- Capable of contributing to:
  - 1) Active Phase Jump Power (Instantaneous contribution to System Disturbances)
  - 2) Active Inertia Power (Contribution to System Inertia)
  - 3) Active Damping Power (Contribution to Damping)

# Key Messages from GB Grid Forming Specification: Scope of Work for Compliance Testing



Typical Suite of Tests for Generic GBGF Plants

# GB Grid Forming Best Practice Guide – Background

## Overview:

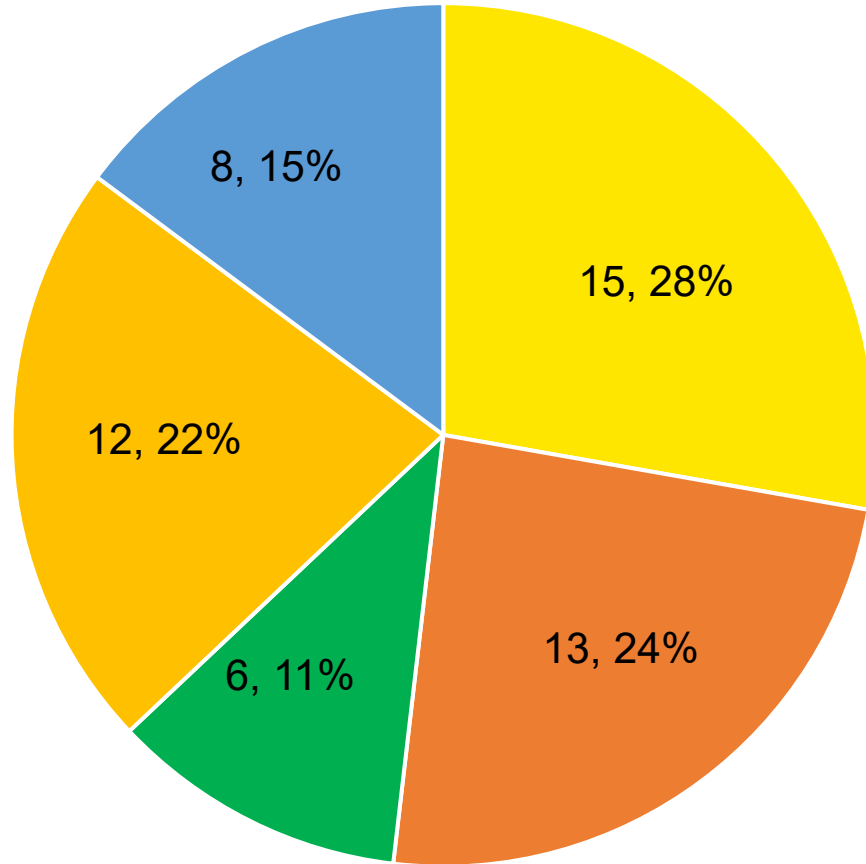
The **GB Grid Forming Best Practice Guide** has been well co-developed by the ESO and a large group of international experts in the ESO's **GB Grid Forming Best Practice Group (GBGF BPG)**. This is to ensure workable guidance for all parties can be created to facilitate future grid forming applications within GB energy markets.

## Drivers:

- To provide necessary **Guidance** on existing GC0137 Legal Text.
- To capture any **Good Practices** in GB and wider, as well as comprehensive valuable **Suggestions** for future development of GB Grid Forming where appropriate.
- To identify any future **Grid Code Modifications** that may be required to facilitate massive roll-outs of GB Grid Forming applications within GB energy markets.

# GB Grid Forming Best Practice Group – Scope of Work

Total 54 External Organisations in Contribution to GBGF BPG at Different Stages



■ Developer ■ OEM ■ TSO ■ Academia/R&D/Industrial Forum ■ Consultant/Contractor

A good mix of Subject-Matter Experts from GB and wider provided their contributions into the following four Subgroups:

- Subgroup 1: **Definition** of GB Grid Forming Plant and its functionality
- Subgroup 2: **Analysis** Tools for Compliance Testing Purpose
- Subgroup 3: **Modelling** Requirement for GB Grid Forming Plant
- Subgroup 4: **Compliance** Testing for GB Grid Forming Plant

# GB Grid Forming Best Practice Group – Key Findings/Suggestions\*

Subgroup No.	Key Suggestions	Further Grid Code Mod.	
		Importance	Urgency
SG1 - Definition	From the ESO's position, a GBGF Inverter Plant is only represented as a <b>Grey Box</b> where only its Functionality, Performance, Inputs/Outputs are regulated by ESO.	High	High
SG2 - Tools	Detailed guidance on deployment of <b>new Linear Analysis Tools</b> e.g. Impedance Scan to assist with non-linear time-domain RMS/EMT simulation tools e.g. PowerFactory, PSCAD.	Medium	Medium
SG3 - Modelling	Key considerations for a GBGF-I Plant's <b>Control System model (functions and elements) during Normal/Abnormal Operational Conditions</b> e.g. fault conditions.	Medium	Medium
SG4 - Compliance	Evaluation of <b>more Practical Pass Criteria</b> for Compliance Test of Active Phase Jump Power under extreme conditions (Abnormal but not fault conditions)	High	Medium

**Note\*:** Compressive discussions on topics with intensive interest (As listed in table above) were held in the ESO's GBGF Best Practice Group monthly discussions and a series of small external stakeholders engagements in 2021/2022.

## Further Plan\* after Publication of GBGF Best Practice Guide around early March, 2023

### 2<sup>nd</sup> GC Mod. - “Quick Win” Stage (To be kicked off in Q2, 2023)

- Will be primarily focusing on certain urgent changes in GC137 Legal Text as agreed during the GBGF BPG Stage e.g. Definition of GBGF Inverter Plant using Grey Box rather than White Box with transparent equivalent impedance definition and limitation (SG1 topic).
- New Expert Working Group is **NOT NEEDED** for extra effort

### 2<sup>nd</sup> GC Mod. “Expert Working Group” Stage (To be kicked off in Q3, 2023)

Will be mainly focusing on the more challenging topics as concluded and agreed during the GBGF Best Practice Group including

- Detailed Guidance of Linear Analysis Tools for Compliance Testing Purpose (SG2);
- GBGF-related new definitions and quantifications if applicable (SG3);
- Re-evaluation of Pass criteria for certain compliance tests (SG4).

Note\*: Time-scale and Scope of Work of those two Grid Code modification workstreams mentioned above could be further clearly defined when those agreed dates are approaching.

Q&A

Thanks for your attention!

Any Question?