Network Challenges as we Progress to Net Zero

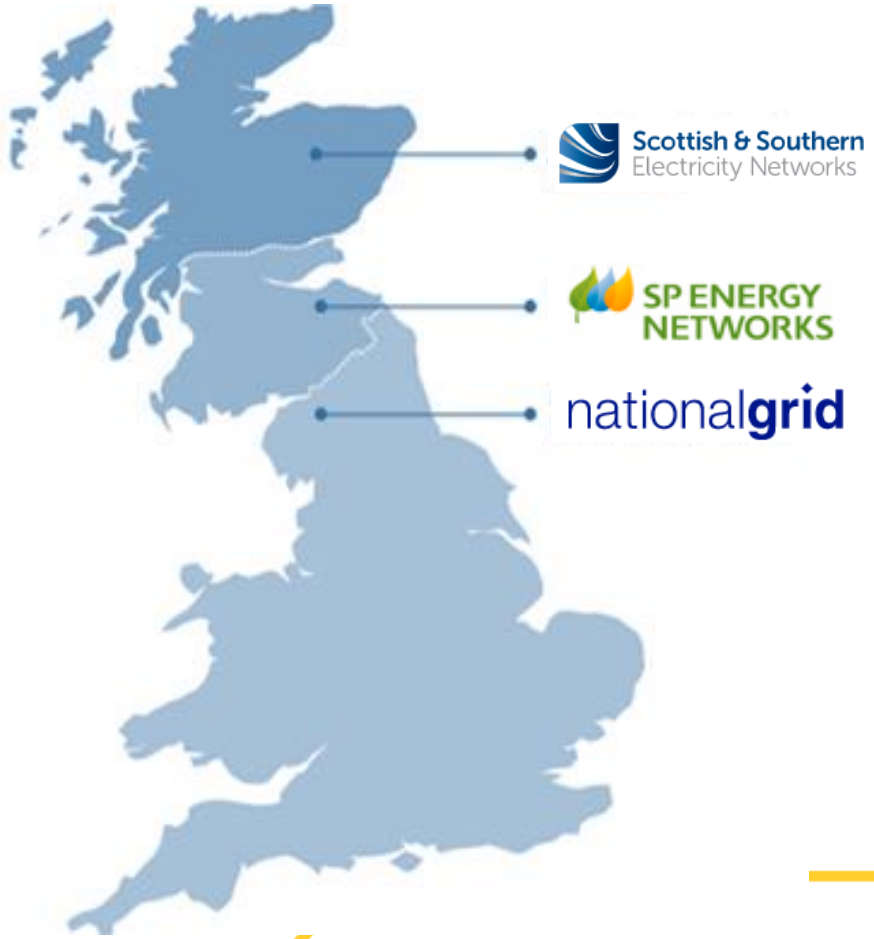
HVDC Operators' Forum
June 2023

Shurooque Baloch
Operability Product Manager

National Grid ESO's role

- Operates and balances the system
- Widens access, promotes competition
- Network recommendations
- Operational planning
- Connection agreements
- GB charging and billing

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



nationalgridESO

Zero carbon operation

- Government ambition
  - 100% zero carbon 100% of the time by 2035
  - 50GW offshore wind by 2030
  - 10GW of H2 by 2030

Our plan for 2025:

- For short periods we can operate the transmission system carbon free and can accommodate all the zero carbon generation the market provides

Our plan for 2035:

- Zero carbon operation all the time
- Manage new challenges of flexibility and adequacy

Operability Strategy Report 2023

Reliable Network

102GVAs
The level that system inertia must remain above for secure zero carbon operation in 2025

2200MVAr
The volume of new reactive capability needed to economically maintain a compliant network in 2025

2030
When we expect GB to be a net annual exporter of electricity by

100%
Of national demand restored, within 5 days, under the new restoration standard in the event of a power outage

Stability

Operationally, this level of inertia can be maintained via existing system behaviour and our stability pathfinders. Future procurement of stability services will be to ensure economic system operation.

We are working to ensure our policy on managing low fault infeed levels is fit for purpose for the future system.

Voltage

Our need to absorb reactive power continues to increase, driven by decarbonisation of the electricity system and continual decline in reactive power demand.

We are exploring options to access new sources of reactive power, reduce voltage costs in the short term and define long term future reactive needs.

Thermal

Significant growth in renewable generation and interconnection continues to drive a need for more network capacity.

We are enabling the transition to Net Zero by mitigating rising constraint costs, contributing to network planning reviews and enabling the connection of renewable generation and new technologies.

Restoration

The new Electricity System Restoration Standard also requires 60% of regional demand to be restored within 24 hours (in all regions).

We are beginning to use learnings from Distributed Restart to enable DER such as solar, wind and hydro to provide restoration services and reduce our reliance on fossil fuel generators.

Balancing the System

2500MW
The maximum requirement for Balancing Reserve by 2025

46GW
Volume of expected Within-day flexibility from storage and demand by 2030 in Leading the Way

>50%
By 2035 in leading the way, there will be surplus generation in more than half of the year.

Frequency

More variable sources of generation, increasing volumes of demand flexibility and price driven coordinated behaviour of assets, such as EV's and interconnectors, create more challenging balancing conditions for the ESO.

New services such as Balancing Reserve and Static Recovery will help us manage these new challenges.

Within-day Flexibility

Changing the timing of demand, mainly with smart appliances and storage, will become the main source of within-day flexibility in the 2030s.

Understanding the contribution of this to system needs, starting with peak demand, will be critical for efficient zero carbon operation.

Adequacy

There is no trade-off between adequacy and net zero. We can deliver adequacy in a fully decarbonised power system.

Investment in at least one new reliable low carbon technology such as nuclear, carbon capture storage (CCS), hydrogen or long-duration storage will be needed.

https://www.nationalgrideso.com/research-and-publications/system-operability-framework-sof

nationalgridESO

What are we doing?

- Development of markets
- System strength management
- Inertia monitoring
- GB grid forming

Markets Roadmap

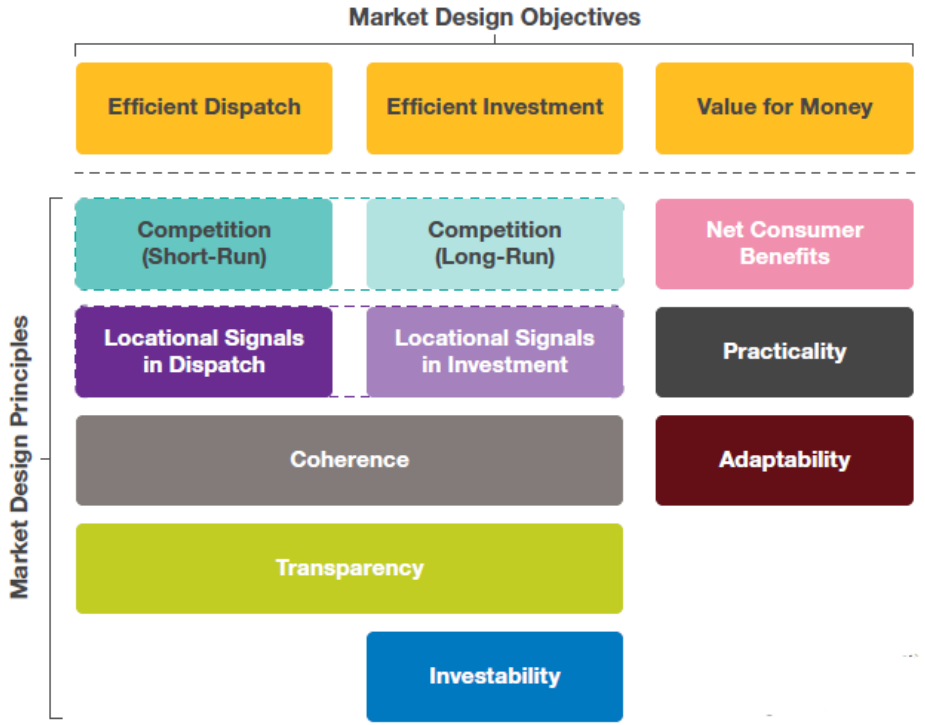
The Markets Roadmap outlines the ESO's plans to reform our markets to enable zero-carbon operation by 2025 and fully decarbonise by 2035

The markets roadmap also:

- Provides key insights into the different ESO markets as well as the key drivers for reform.
- Gives stakeholders confidence that we are making the right market reform and design decisions.
- Shares strategic questions we are currently tackling and signposts how industry can work with us to answer them.

Markets Roadmap webpage

Market Design Framework



Markets Roadmap – Voltage

We are developing our procurement strategy as our voltage management requirements continue to rise

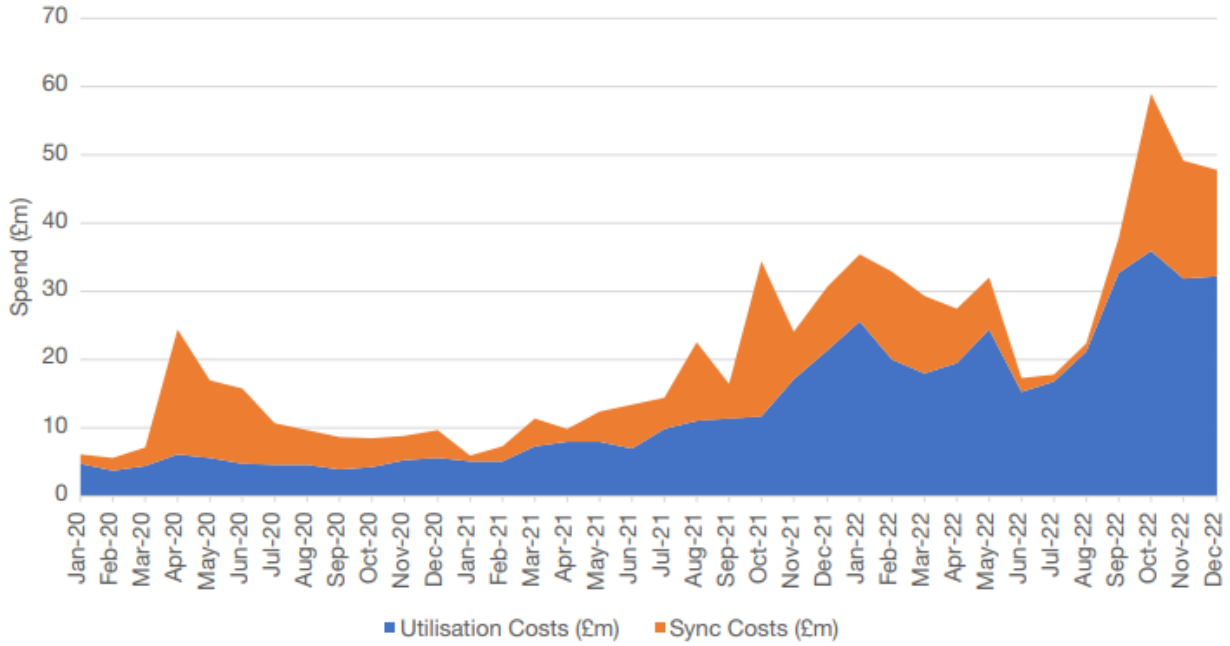
What happened in 2022:

- Voltage management requirements continued to grow
- The default payment rate increased due to gas prices
- We identified an estimated 3.4GVar of capacity from existing units
- Our Mersey Pathfinder delivered £12.6million in savings and is forecast to save £25.3m across 2023/24.

What is happening 2023 and beyond:

- Exploring how to harness this additional 3.4GVar
- Pennines New Services Procurement go-live in 2024
- Continue to develop our enduring market design

VT Figure 3: The utilisation and synchronisation costs between 2020-2022



Note: revenue recovered by the Transmission Owners related to their reactive compensation equipment cannot be identified within their overall Regulated Asset Base (RAB). The above chart, therefore, does not represent the full cost to consumers of voltage management in 2022.

Markets Roadmap – Stability

Two more stability pathfinders concluded in 2022 whilst costs associated with increasing system inertia trebled in comparison with 2021.

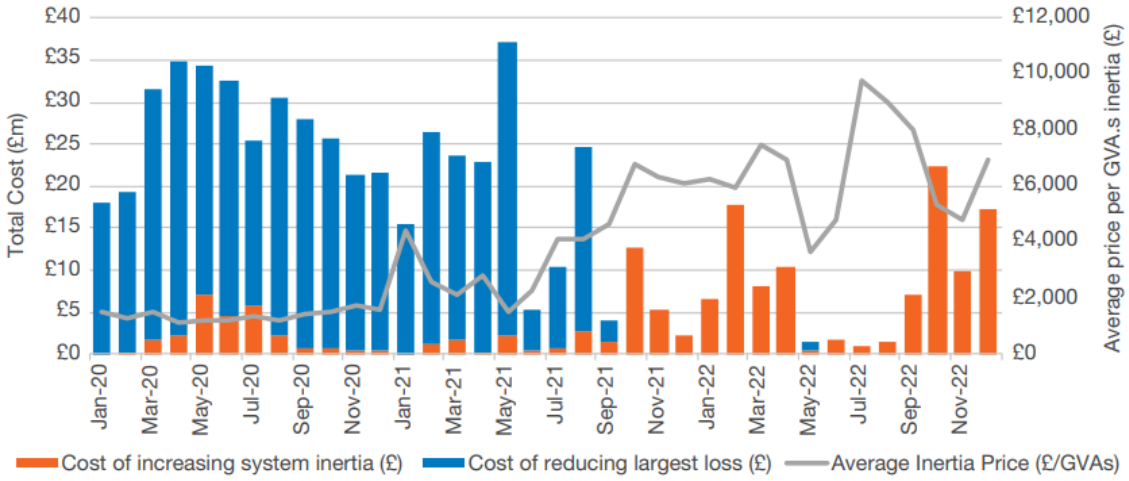
What happened in 2022:

- Actions taken to reduce the size of the largest loss decreased very significantly.
- Actions to increase system inertia doubled in volume and trebled in cost (£104m) due to greater penetration of renewables and high gas costs.
- Stability Pathfinders 2 and 3 secured >20GVA.s inertia and >23GVA effective SCL, including the first grid-forming battery storage solutions.

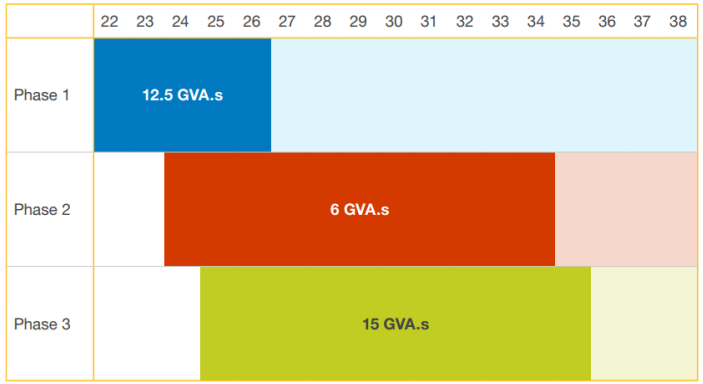
What's happening in 2023 and beyond:

- Lowering the minimum inertia threshold via FRCR (120GVA.s) will reduce the costs associated with managing system inertia.
- The Stability Market Design innovation project recommends three discrete markets – a long-term (Y-4), mid-term (Y-1) and short-term (D-1).
- A mid-term Y-1 stability market will be initiated in 2023 to access high-availability inertia as a cheaper alternative to the Balancing Mechanism.
- D-1 and Y-4 markets will be developed in parallel.

ST Figure 3: Inertia management costs: Jan 2020 - Dec 2022



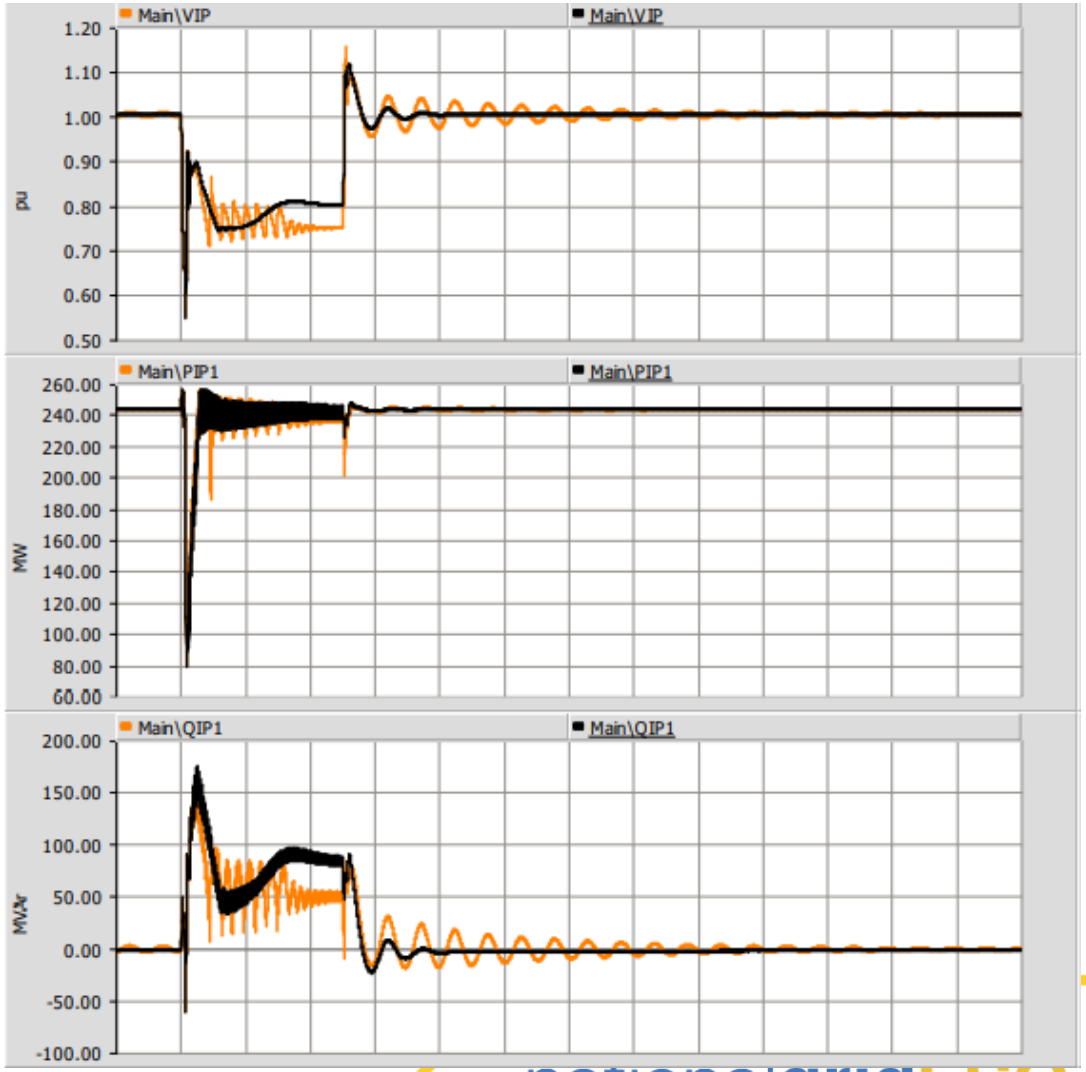
ST Figure 1: Total volume of contracted inertia (GVA.s) through stability pathfinder 1, 2 and 3.



ESO

System Strength Management

- Minimal SCR (MSCR) is the minimum SCR required for IBR to maintain stable operation.
- With reduction of system SCL, it becomes challenging for generators to meet the grid code requirements
- There is a risk that existing generators might not remain compliant with reduced SCL
- Tuning parameters may improve the performance under low SCR, however it is case by case and hard to determine the limit.



System Strength Management

- Many TSOs have attempted to apply a consistent assumption for MSCR across their network. Examples are shown in the table.
- If the SCR is above these levels, the likelihood of instability is low. However, there is no clear cut without a detailed EMT study.
- Generally, controllers could be retuned to reduce the minimum SCR for an IBR. However, there are cases when this was not successful.
- Additional challenge of control interaction under low SCR
- SCR method works better for single IBR connection, when rest of system can be represented as an equivalent voltage source
- More work needs to be done for multiple IBRs connection

	MSCR at TIP	Connection type
AEMO	3	AC
EirGrid	2	HVDC
VDE	2	HVDC
GB experience	3	AC

Inertia Monitoring

Implemented two new “first-of their-kind” inertia monitoring tools

- GE Digital solution providing:
  - Regional based
  - Real-time monitoring based on Phasor Measurement Units (PMUs)
  - Day ahead forecasting per settlement period using operating data (demand, wind, solar & synchronous inertia)
  - Verified against loss of load events
  - Operating since late 2021, currently Scotland only based on PMU availability
  - Full GB availability limited by NGET PMU rollout
- Reactive Technologies solution:
  - GB wide 5 minute real-time monitoring
  - Uses ultra capacitor to provide “controlled” signal onto frequency
  - Measured across GB in distribution network
  - Operating since July 2022, mainly over periods of high renewables

Inertia Monitoring – Data Verification

- Internal review of data
- Data Analysis being undertaken independently by National Physical Laboratory (NPL*) to:
  - Assess both products alongside internal evaluation
  - Establish regional representation
  - Establish standardisation for measurements
- Comparison of 6 months data
  - Strong correlation with synchronous inertia (>0.85)
  - Confidence values within 10% for 95% of measurements
  - Initial indication of regional variations
  - Detailed analysis of periods of high renewables ongoing
- Incorporate into ENCC situational awareness summer 2023
- Potential data publication (depending on commercial agreements)

* NPL is an institute developing and maintaining the national primary measurement standards. It is a Public Corporation owned by the Department of Business, Energy and Industrial Strategy (BEIS)

Future of GB Grid Forming

The penetration and proportion of Grid Following (GFL) based IBRs on the GB energy system will increase hugely into the foreseeable future.

A number of challenges are foreseen below. How best can we address these issues?

- Q1: How much Grid Forming (GFM) capability will be required on the system to manage operability issues?
- Q2: Should GFM capability be mandated?
- Q3: How can we assess interoperability issues between GFL/GFM-based IBRs and Synchronous Machines?

ESO's Future Strategic Roadmap for GB Grid Forming Development

GBGF Best Practice Group: Nov, 2021 to Mar, 2023 → Complete

Milestone: Legal Text update for Virtual Impedance and other quick changes as commonly agreed during BPG and Quick-Win Stages

2nd GC0137 Mod. – Quick Win (Without Expert Group): Q2, 2023 → No Start

NIA Strength To Connect Project which was kicked off in Oct, 2022 for 18 months → On-going → **2nd GC Mod. WG from Q3, 2023** → No Start

Milestone: Legal Text update for more challenging topics e.g. Compliance Testing Pass Criteria, GBGF relevant definitions/tools

New SOF on GBGF: Mar-Nov, 2023 → On-going

Milestone: New SOF on GBGF can be published after wider consultations from Int./Ext. Stakeholders

Milestone: Further Legal Text update for GC0137 Mandatory GBGF requirements

Feasibility Studies of Transition from Market-driven to Mandatory requirements → On-going

NIA project – Shaping any Minimum Mandatory GB GFM Requirements: Sept 2023 to Apr, 2025 as planned → No Start

- Direct Policy Development
- Network Innovation
- External Engagement

Wider Engagement with OEMs/Developers and Industrial Engagements such as ENTSO-E, G-PST and CIGRE B4/C4 JWG from 2023 to 2025 → On-going

Evolution of GC0137 Legal Text and relevant ESO's capability (knowledge, models) in support to massive implementation of GBGF applications for facilitating UK's net zero energy transitions.

nationalgridESO


Q&A