Update on Grid Forming Invertors and Stability Pathfinders – breaking the chicken and egg cycle

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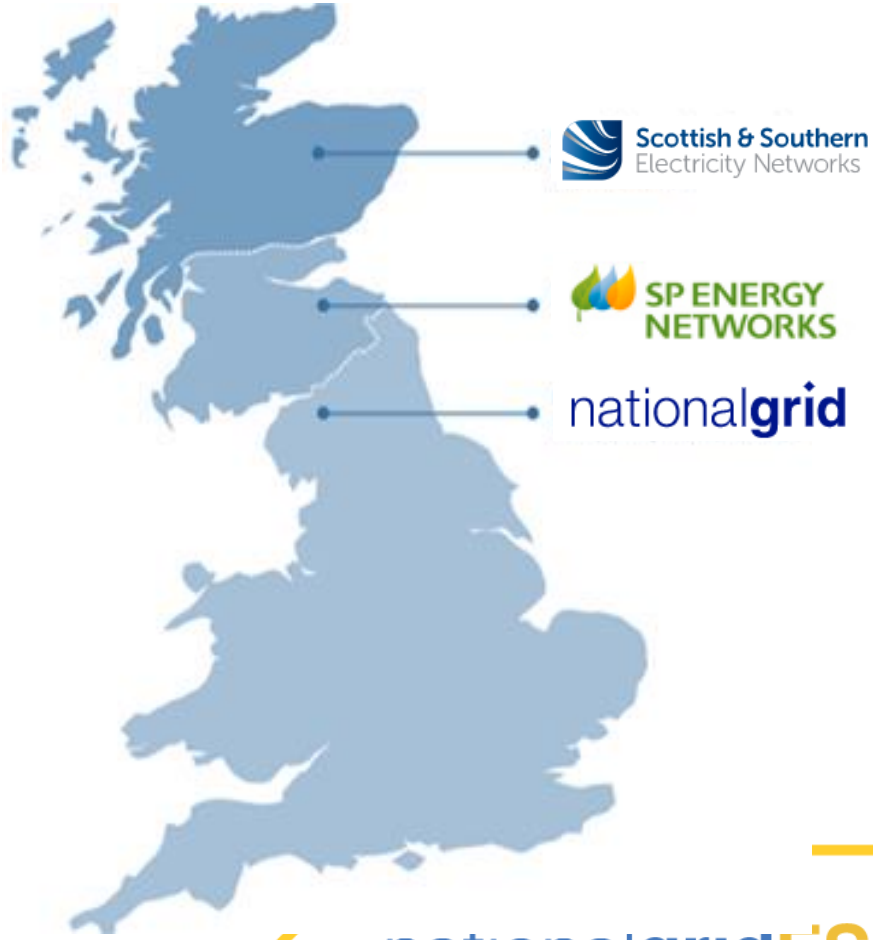
Agenda

- GB ESO Ambitions and Government targets
- System Trends across GB
- Ongoing Initiatives

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



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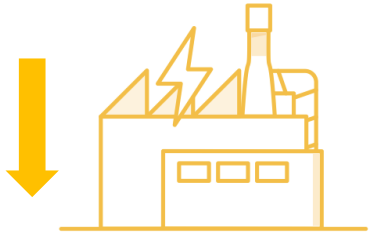
Environmental Targets

- Clear Government ambition over a sustained period
  - 15% of all generation to be renewable by 2020
  - All coal to be closed by 2024
  - 100% zero carbon 100% of the time
  - 40GW offshore wind by 2030
  - 5GW of H2 by 2030
- ESO ambition to have the ability to operate zero carbon in 2025

Engineering Challenges

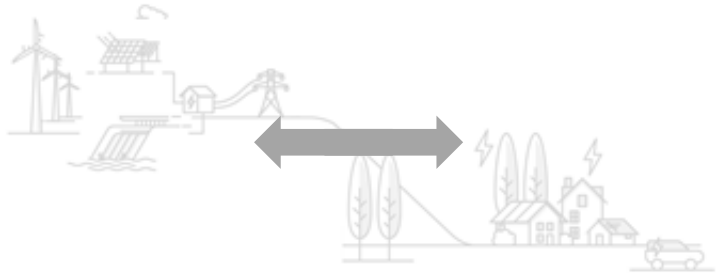
Decarbonisation of the GB power system has resulted in changes in four key areas:



Less dispatchable generation

More variable sources of generation

More asynchronous generation



Generation moving to different areas.

Each of these changes brings about new engineering challenges which have to be resolved to operate a zero carbon network.

- **Frequency** - As more non-synchronous generation connects, system inertia lowers requiring faster acting response. More variability in the system requires fast acting reserves. Large and small loss sizes require services which respond dynamically to the frequency.
- **Stability** - More non-synchronous generation is reducing the levels of stability capability provided to the network. To ensure the system is stable for faults on the network services to provide inertia and short circuit levels need to be procured.
- **Voltage** - Less dispatchable generation and changes to network flows brought about by generation moving away from demand is increasing the requirements to absorb reactive power on the GB network.
- **Thermal** – More variable sources of generation combined with generation moving to different areas are creating more thermal constraints on the network requiring more innovative solutions to manage congestion prior to network build

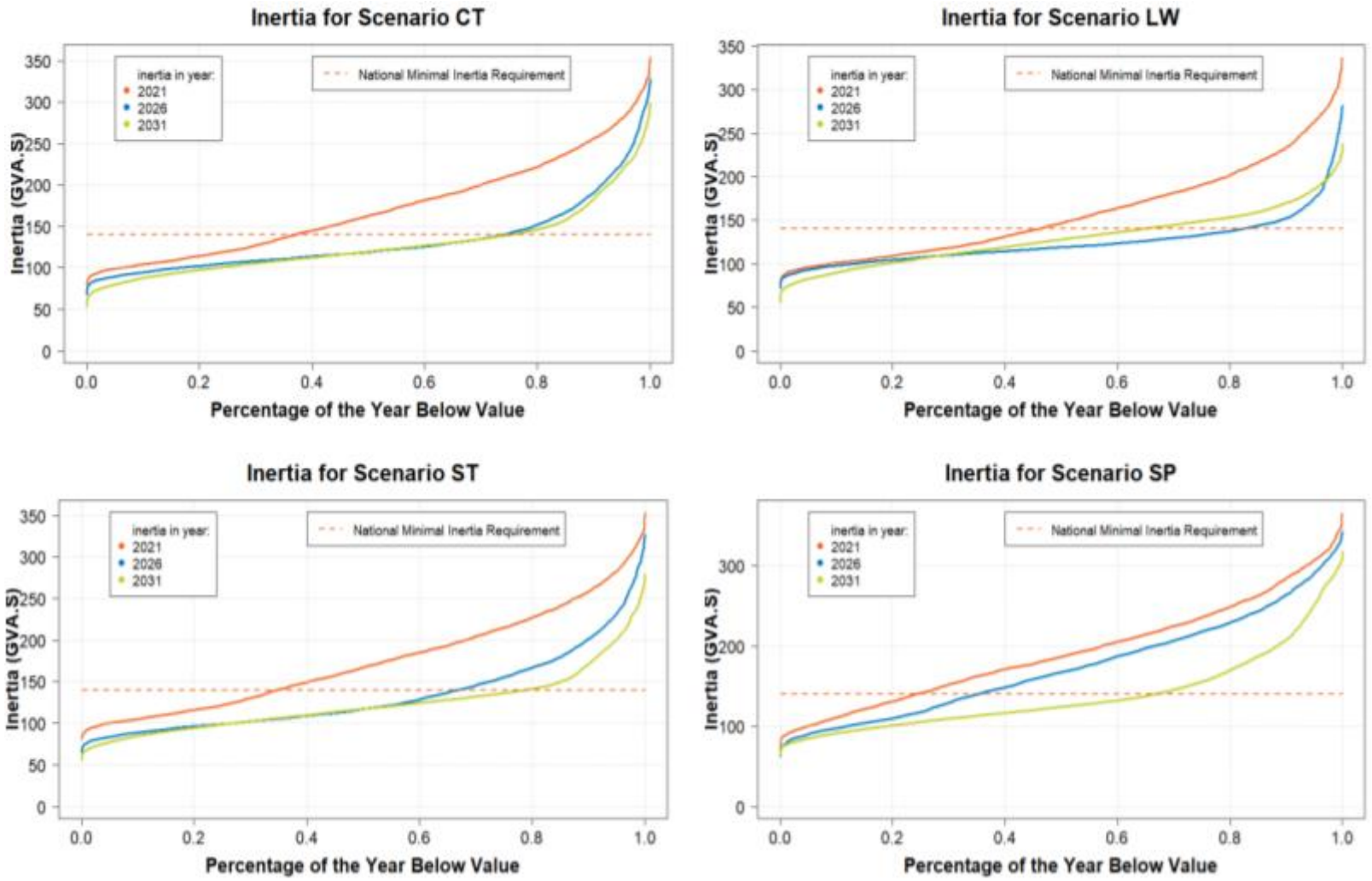
What the analysis told us:

System Performance Trends across GB

Declining inertia

- The rate at which frequency changes following a loss of generation or demand depends on the total system inertia.
- The declining trend of the inertia is across all scenarios.

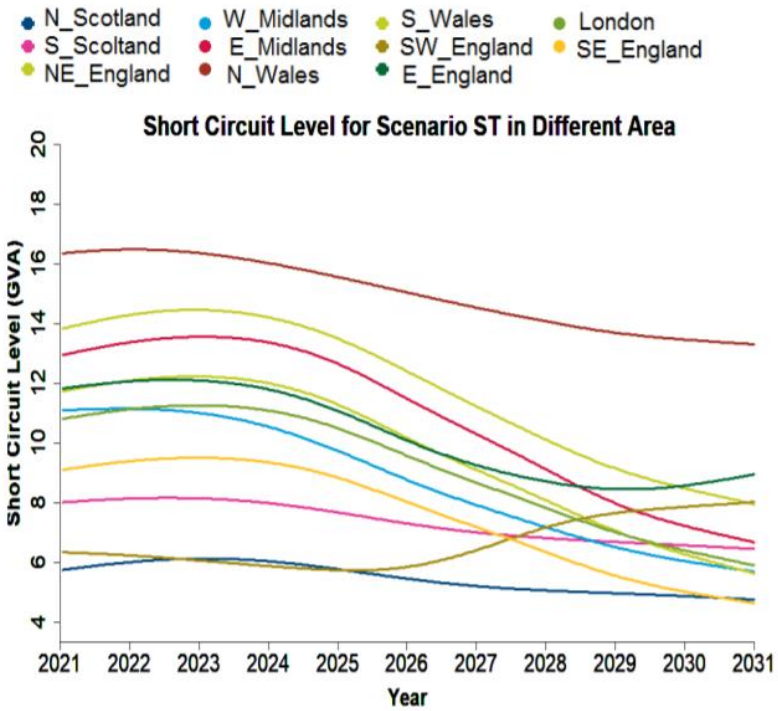
Annual distribution of inertia for four future energy scenarios

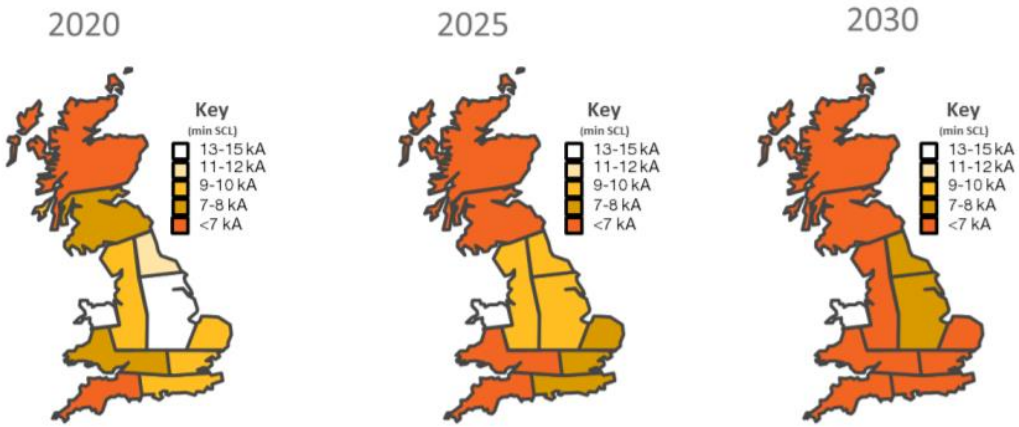


Declining Short Circuit Level (SCL)

- Protection on the transmission network relies on the large current flowing in the system during a system fault.
- During a fault, a lower SCL results in lower retained voltage levels across the network which can compromise a generator's ability to ride through the fault conditions.
- Lowering fault levels means that the voltage magnitude and angle will respond to a disturbance to a greater extent, there will be less dynamic damping available and voltage recovery will be slower.
- We see low SCL trend continuing in Scotland

Mean Short Circuit Level for System Transformation scenario in different area





Regional minimum short circuit level

Ongoing Initiatives to Enable a Stable GB Network

World's First Inertia Measurement System

reactive
technologies

New Services and Products

Need to manage the trade off and balance between frequency response and inertia

Faster acting frequency response products

- increasing over time FFR, EFR and now Dynamic Containment
- Dynamic Containment (DC) is a fast-acting post-fault service to contain frequency within the statutory range of +/-0.5Hz in the event of a sudden demand or generation loss. The service delivers very quickly and proportionally to frequency but is only active when frequency moves outside of operational limits (+/- 0.2Hz). With full delivery in 1second.

Stability Pathfinders

- Trail by doing – define the need, let the market innovate
- Phase 1 contracted January 2020 – 12GVAs equivalent to 5 to 8 machines £320M for 6 years
- Phase 2 – Scotland focus for Short Cct infeed and inertia (circa 12GVAs) – contracted spring 2022
- Phase 3 Nationwide inertia requirements – contract fall 2022

Grid Code Modification GC0137

- **Minimum non-mandatory specification** within the Grid Code for parties wishing to offer a Grid Forming capability –
- Such plant would support the Grid during unplanned events/faults particularly in respect of:
    - i) limiting the rate of change of system frequency following the loss of a generating unit or load;
    - ii) injecting instantaneous active power into the system at the time of a fault as a result of the corresponding phase change;
    - iii) injecting instantaneous Fast Fault Current into the system at the time of a fault as a result of the corresponding voltage change;
    - iv) Contributing to damping power;
    - v) Limiting vector shift;
    - vi) Contributing to synchronising torque;
    - vii) Contributing to the maintenance of an improved voltage profile during a fault
    - – a fundamental pre-requisite for fault ride through.
- This is a key step in opening up the stability/ short circuit infeed market to procuring 'traditional services' from renewables

Short Circuit Level (SCL) Management

- Grid “strength”, often measured as the short-circuit level is decreasing and we need to find the right strategy to manage the issue:
  - Developing right measure for system strength /SCL
  - Developing a suitable method to estimate the minimum SCL to maintain resilient system operation: ensure protection works, maintain system voltage etc
  - Understanding the IBR’s capability to remain stable in low SCL system
  - Determining the right balance on how much SCL provided by system / IBR SCL needs
  - Developing a process on how SCL requirements could be implemented in design and operation timescale
- Ultimately we expect to define SCL requirement in codes also

Summary

- Clear Government targets
- Clear analysis that shows the trends
- Create the markets and the revenue streams
- Work with OEMs
- Define the Grid Code requirements

Ongoing initiatives to meet stability challenges

- NOA Stability Pathfinder Projects
  - Phase 1 – awarded contracts in Jan 2020 for 12.5 GW.s of inertia
    https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-1
  - Phase 2 – will buy inertia of 6 GW.s and SCL of 8.4 GVA in Scotland
    https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-2
  - Phase 3 – will buy inertia of 15 GW.s and SCL of 7.5 GVA in areas of England & Wale
    https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-3
- Introducing GB Grid Code change for Grid Forming Technologies
  - Grid Code Working Group GC0137
    https://www.nationalgrideso.com/industry-information/codes/grid-code-old/modifications/gc0137-minimum-specification-required
- Stability Market development Innovation project
  - Aims is to understand if there is a need for a stability market
    https://www.nationalgrideso.com/future-energy/projects/stability-market-design
- Accelerated Loss of Mains Change Program (ALoMCP)
  - Under which initiative the electricity distribution companies are updating settings for the RoCoF loss of mains protection relays from 0.125 to 1Hz/s, with a definite time delay of 500ms
  - This will allow us to reduce spend on RoCoF related system constraints.