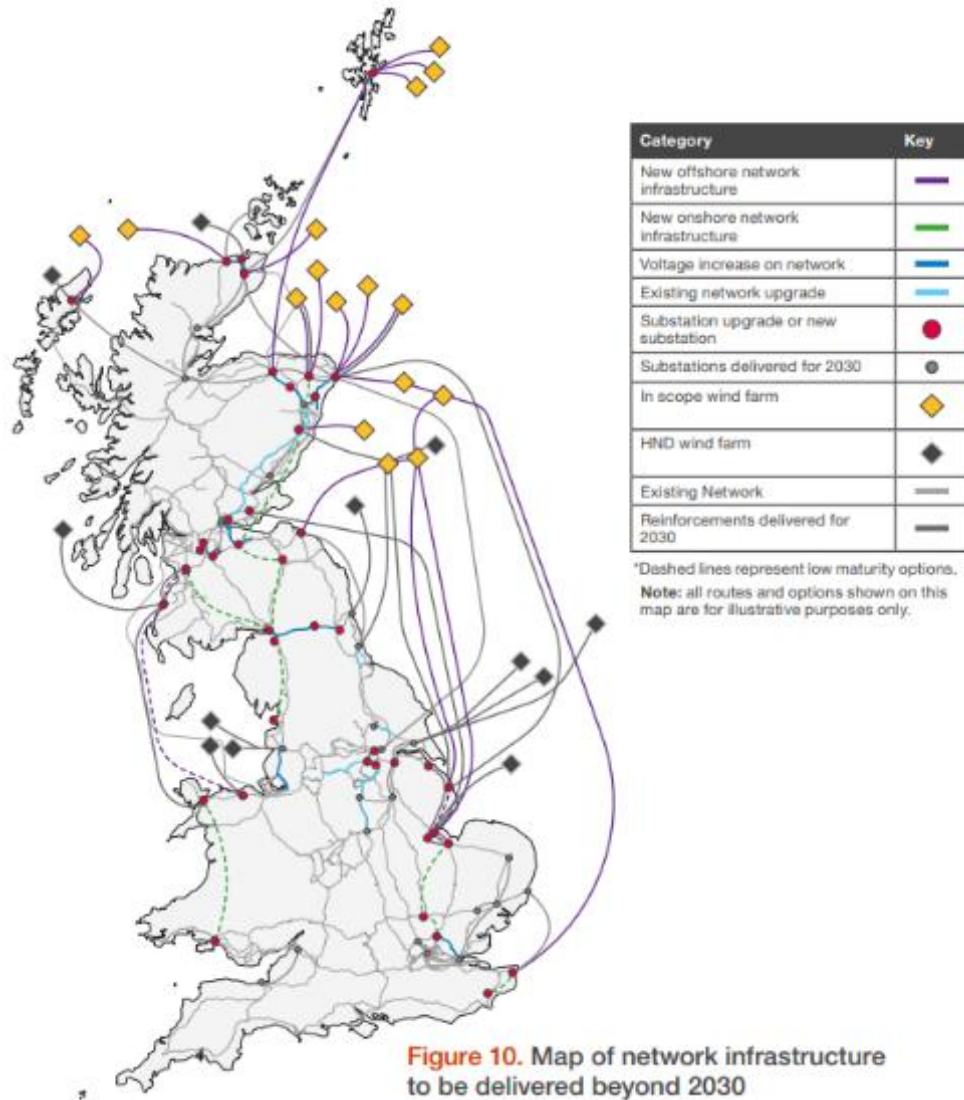


Public

# GB Grid-Forming Deployments Experience

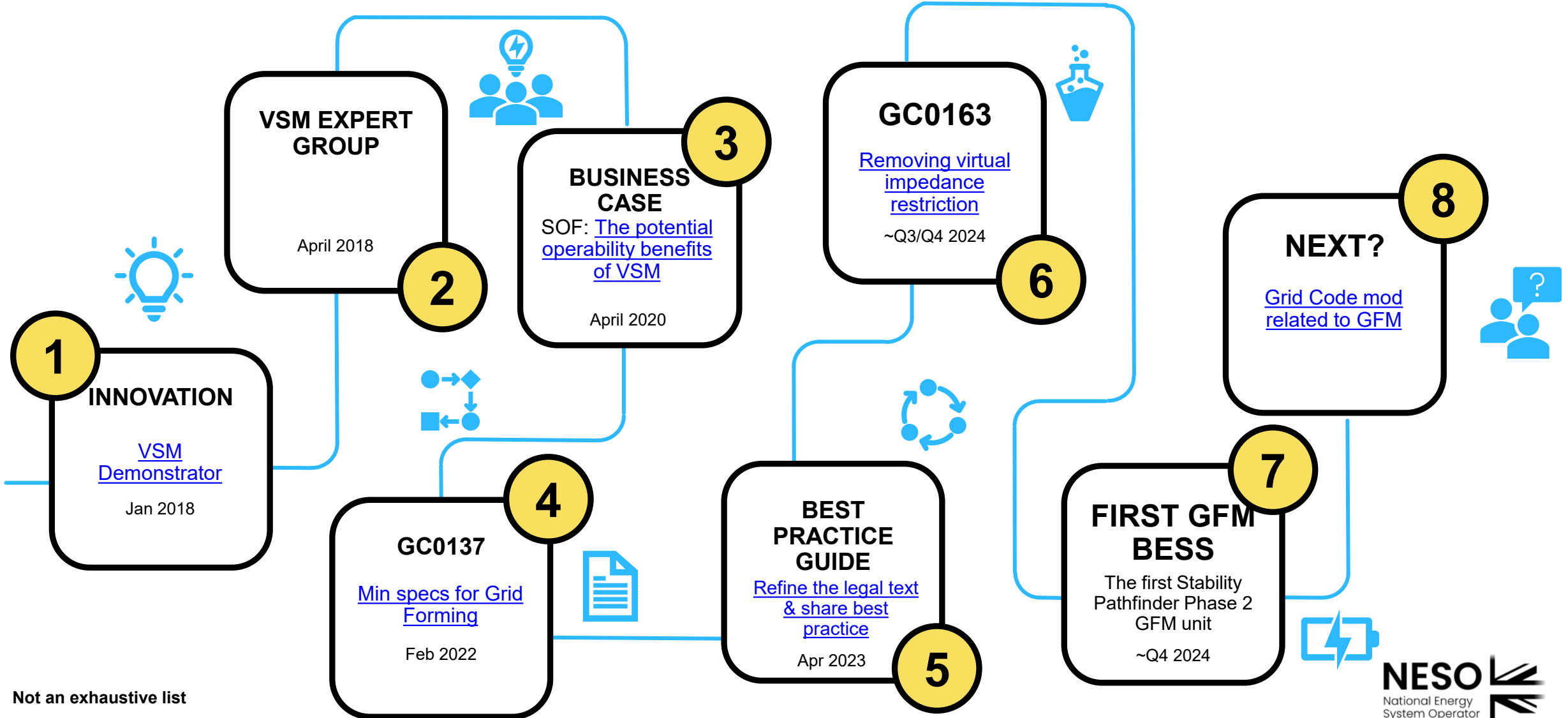
Dr Xiaoyao Zhou

# How GB system evolves



Technology	Installed Capacities (GW)		
	2023	2030 Further Flex and Renewables	2030 New Dispatch
Offshore wind	14.7	50.6	43.1
Onshore wind	13.7	27.3	27.3
Solar	15.1	47.4	47.4
Nuclear	6.1	3.5	4.1
Biomass/BECCS	4.3	4.0	3.8
Low carbon dispatchable power	0	0.3	2.7
Other renewables	4.7	5.7	5.7
Batteries	4.7	27.4	22.6
LDES	2.8	7.9	4.6
Interconnectors	8.4	12.5	12.5
Unabated gas	37.4	35.0	35.0

# GB Grid Forming History



Not an exhaustive list

# GB Grid Forming Development

## ESO

### Grid Code Modification Proposal Form

**GC0XXX:**  
**GB Grid Forming (GBGF) - capability mandate, clarity on definitions, changes to performance requirements and changes to compliance tests and simulations.**

**Overview:** This modification aims to mandate Grid Forming Capability on certain types and sizes of plants. This modification also aims to update the Grid Code in respect of the Grid Forming requirements arising from i) the Great Britain Grid Forming Best Practice Guide, ii) Stakeholder comments, iii) the industrial experience gained from the Stability Pathfinder work / Compliance Process, iv) developments in Europe.

**Status summary:** The Proposer will be setting up an Expert Group which aims to develop recommendations ahead of a formal Grid Code Modification.

**This modification is expected to have a: High impact**

Manufacturers, Generators, the ESO, Transmission Owners, Offshore Transmission Owners.

**Modification drivers:** Harmonisation, New Technologies, System Operability, System Planning, System Security, Net Zero

**Proposer's recommendation of governance route** Standard Governance modification with assessment by a Workgroup

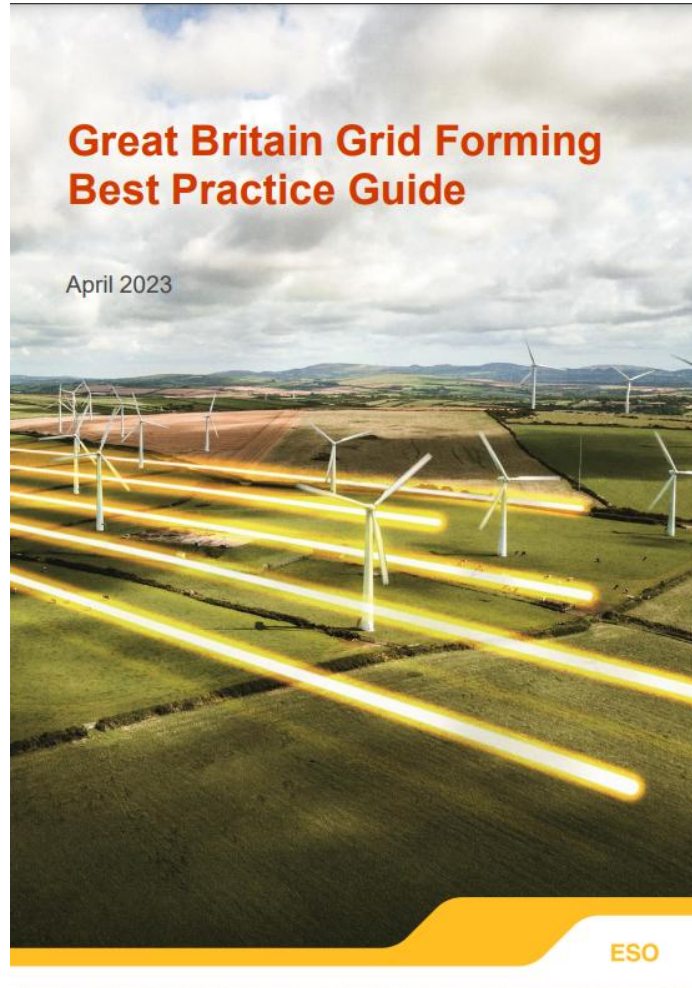
#### Modification process & timetable

TBD

nationalgridESOWorkgroup Consultation GC0137  
Published on 31 March 2021

Workgroup Consultation	Modification process & timetable														
<p><b>GC0137:</b>                      Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine/VSM Capability)</p> <p><b>Overview:</b> This modification proposes to add a non-mandatory technical specification to the Grid Code, relating to GB Grid Forming Capability (which was formerly referred to as a Virtual Synchronous Machine ("VSM") capability. The detail pertaining to its creation may be found in Section 3 "Why Change?" but the high-level overview is that the specification will enable parties to offer an additional grid stability service. This will be fundamental to ensuring future Grid Stability, facilitating the target of zero carbon System operation by 2025 and providing the opportunity to take part in a commercial market which would sit alongside other market arrangements such as the stability pathfinder work and dynamic containment.</p> <p><b>Have 5 minutes?</b> Read our <a href="#">Executive summary</a></p> <p><b>Have 20 minutes?</b> Read the full <a href="#">Workgroup Consultation</a></p> <p><b>Have 60 minutes?</b> Read the full <a href="#">Workgroup Consultation and Annexes</a>.</p> <p><b>Status summary:</b> The Workgroup are seeking your views on the work completed to date to form the final solution(s) to the issue raised.</p> <p><b>This modification is expected to have a: High impact</b> - National Grid ESO – successful implementation of this specification and the subsequent launch of a commercial market would result in the provision of additional stability services. The primary aim being the ability to run the entire electricity transmission system on low carbon generation sources that include nuclear power, whilst at the same time ensuring a safe, secure and economic system. Consequently, the likelihood would be a net-positive in terms of the ESO's ability to balance the GB electrical grid and respond to unplanned interruptions to electricity supply. <b>Medium impact</b> - Generators and Interconnectors – successful implementation of this specification and the subsequent launch of a commercial market would provide generators and Interconnectors with a potential new revenue stream. In order to take part in such a market, Generators and Interconnectors may wish to amend/modify their plant.</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center;">1</td><td>Proposal Form 12 December 2019</td></tr> <tr><td style="text-align: center;">2</td><td>Workgroup Consultation 31 March 2021 – 30 April 2021</td></tr> <tr><td style="text-align: center;">3</td><td>Workgroup Report 27 May 2021</td></tr> <tr><td style="text-align: center;">4</td><td>Code Administrator Consultation 01 June 2021 - 22 June 2021</td></tr> <tr><td style="text-align: center;">5</td><td>Draft Modification Report 21 July 2021</td></tr> <tr><td style="text-align: center;">6</td><td>Final Modification Report 29 July 2021</td></tr> <tr><td style="text-align: center;">7</td><td>Implementation 01 October 2021</td></tr> </table>	1	Proposal Form 12 December 2019	2	Workgroup Consultation 31 March 2021 – 30 April 2021	3	Workgroup Report 27 May 2021	4	Code Administrator Consultation 01 June 2021 - 22 June 2021	5	Draft Modification Report 21 July 2021	6	Final Modification Report 29 July 2021	7	Implementation 01 October 2021
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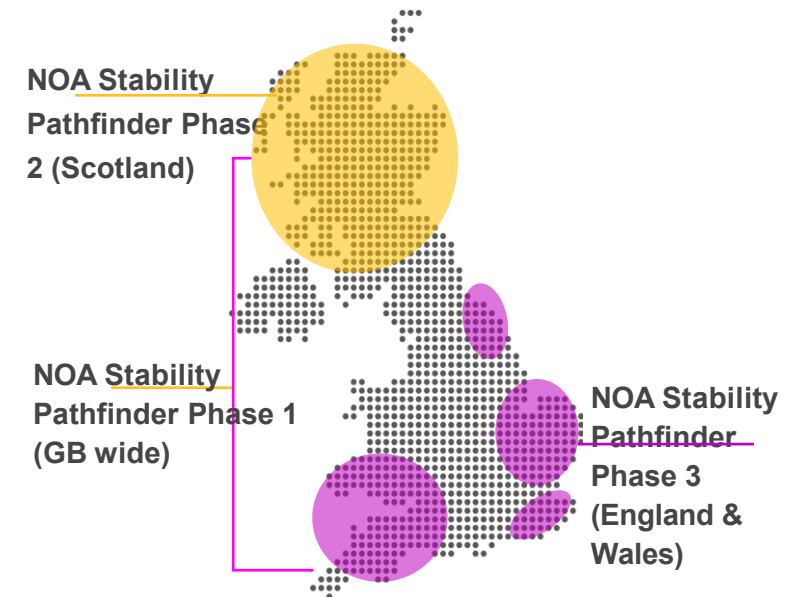
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# Stability Market Development

# Stability Pathfinder




	Stability Pathfinder Phase 1	Stability Pathfinder Phase 2	Stability Pathfinder Phase 3
Requirement	Inertia and dynamic voltage GB wide	Inertia, SCL and dynamic voltage	Inertia, SCL and dynamic voltage
Status	All Synchronous compensators most units now live	5 GFM BESS 5 SynComp Go-live from Apr 24	29 Synchronous compensators Go-live expected from 2025
Participating technology	0MW Synchronous Compensators only	Synchronous and Grid Forming Converter based	Synchronous and Grid Forming Converter based
Procurement regions	GB wide	Scotland	England and Wales
Procurement volume	12.5 GW.s of inertia	8.4 GVA of SCL 6 GW.s of inertia	7.5 GVA of SCL 15 GW.s of inertia
Contract Detail	Up to 6 years	End of Mar 2034	End of Mar 2035 £1.35b
Contract payments	Availability payments for SCL& Inertia Utilisation payments for reactive power		



<https://www.neso.energy/industry-information/balancing-services/network-services-procurement/stability-network-services-procurement>

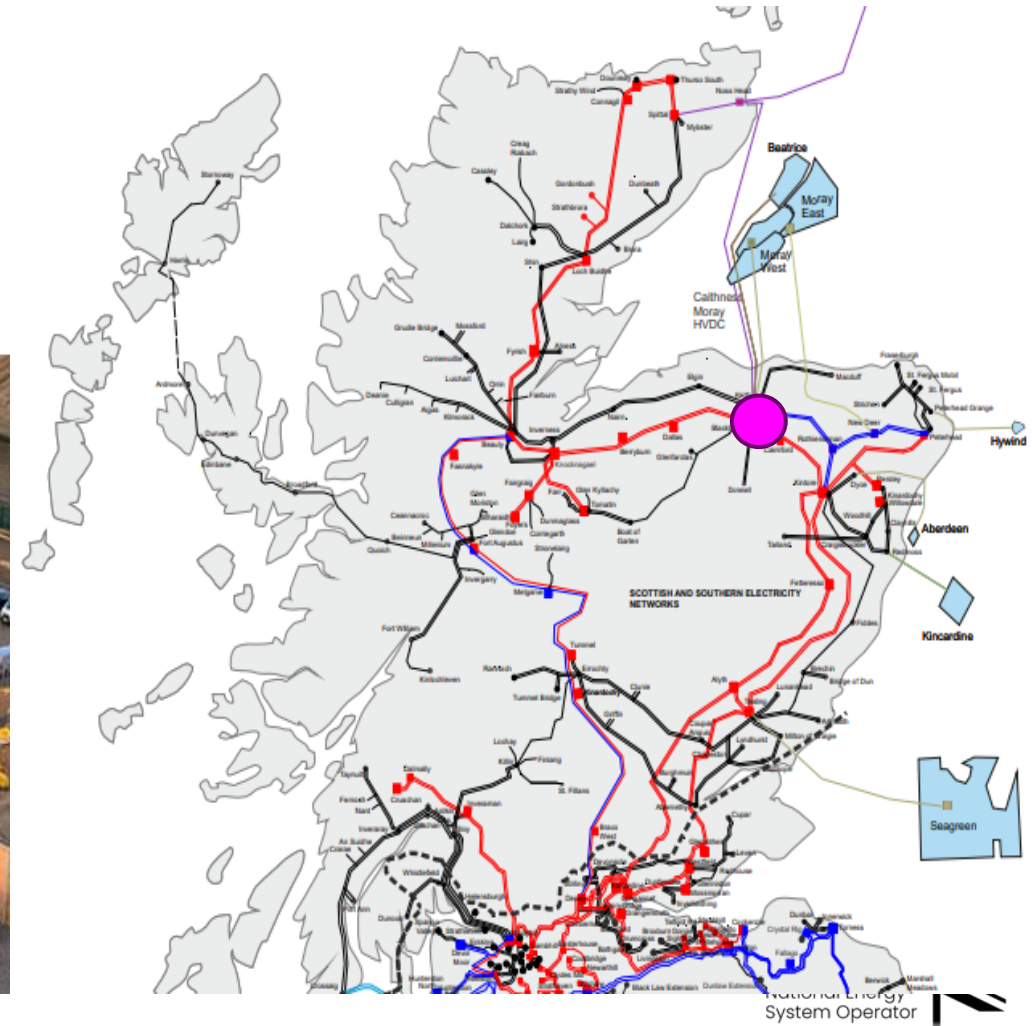
# Stability Market Overview

To maintain compliance and reduce costs associated with managing stability, we have concluded an innovation project to explore designing new markets to procure stability services.

		Long Term (Y-4)	Mid Term (Y-1)	Short Term (D-1)
 Purpose		<ul style="list-style-type: none"> <li>Procure capacity in advance (LT), to signal the need for new assets</li> <li>Allow financing of new build capacity (and enhanced capability, TBD) through LT contracts</li> </ul>	<ul style="list-style-type: none"> <li>Procure capacity in advance (MT), to adjust LT procurement in case necessary</li> <li>Allow MT financing of new, incremental and existing capability able to provide stability</li> </ul>	<ul style="list-style-type: none"> <li>Procure capacity to fulfil residual of total requirements for Stability closer to real time (ST)</li> <li>Allow remuneration of marginal costs for providing Stability.</li> </ul>
 Timeline	Procurement lead time	- Y-4	- Y-4	- Y-1
	Contract duration	- 10+ years	- 3 years	- 1 year
 Product	Contract type	- Baseload availability	- Baseload availability	- 4 h (EFA blocks)
	Contract obligations	- e.g. 90% availability	- e.g. 90% availability	- 100% availability
Payment Design		- Availability only	Synchronous Machines – Availability and Utilisation Inverter Based Generation – Availability Only.	- Utilisation Only.

# Blackhillock GFM project

- The Blackhillock BESS has a 200MW / 400MWhr capacity
- The contracted level of inertia response is 380MWs. For a 1Hz/s Rate of Change of Frequency (RoCoF)
- In operation since March 2025



# GFM modelling and Compliance approach

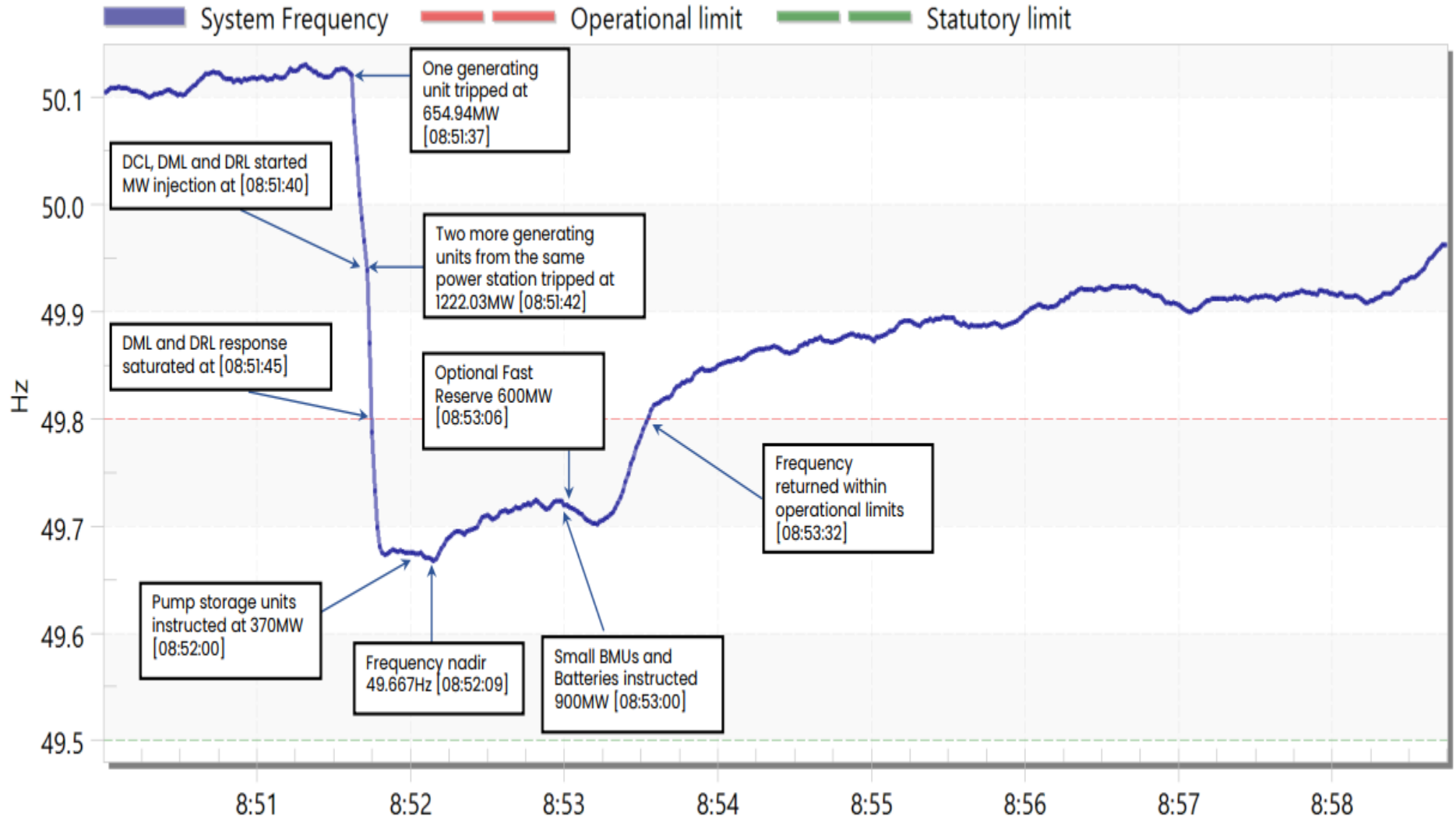
## Model Requirement

- RMS
- EMT

## Compliance

- Offline model simulation
- FAT
- On site Commissioning test

# 14/March 2025 Event



- Cascading trips within 15 sec. Total infeed loss ~ 1876MW.
- Total contracted Dynamic Response Services, i.e. DC, DR and DM volume = 1683MW
- System behaved as expected has been replicated using the NESO frequency simulation model.

# Operation Experience

From one frequency event data in March 2025, NESO has done comparison studies between the actual GFM BESS site performance, the Electromagnetic Transient (EMT) model of the plant and an idealised swing equation representing the plant's inertia.

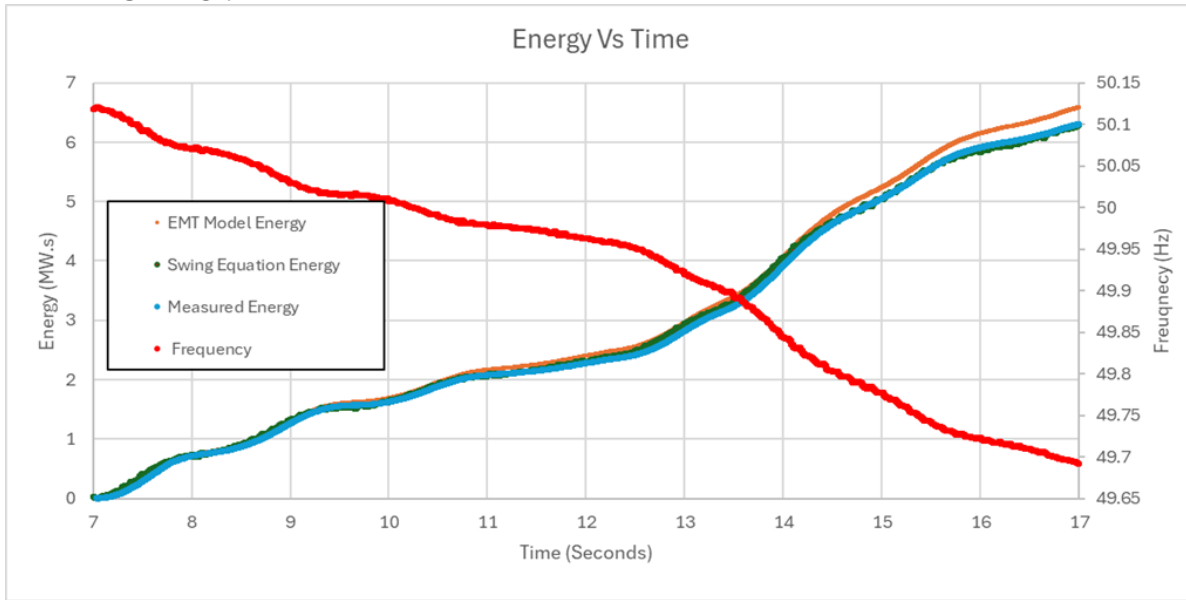


Figure 1 Energy vs Time

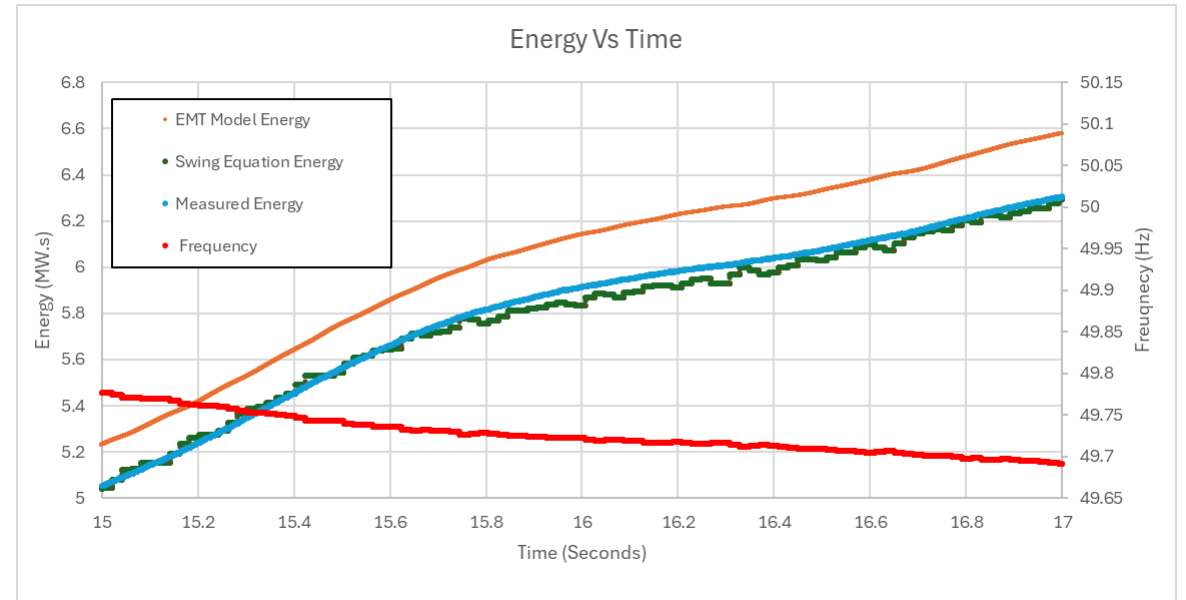


Figure 2 Energy vs Time (Zoomed)

# Thank You!

Questions?