UK Stability Pathfinder Provider – Grid Forming BESS

Xiaoming Li

For power system expertise

Next Generation Network

Who we are

Zenobē designs, finances, builds and operates battery-based services.

Our purpose:

Making clean power accessible

How?

Through the innovative use of battery storage:

- + Network Infrastructure
- + Electric Fleets
- + Second-life Batteries

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Agenda

- GB transmission system operability challenges
- NGESO requirement
- Solutions
- Future development

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GB transmission system operability challenges

- The transition to a decarbonized electricity system creates new operability challenges that require novel solutions

NGESO Operability Strategy Report 2023:

- *"Falling inertia levels, increasing largest loss size and high RoCoF levels are driving many of the current and future frequency challenges."*

- *"In addition to declining inertia, we are also starting to observe challenges with low short circuit levels"*

"Grid forming technology will be a significant, contributing factor to future stability of the system."

NGESO requirements

- NGESO has undertaken a series of novel tender exercises to procure key system support services – known as "Pathfinders"
- These exercises seek to procure services that are beyond the standard mandatory Grid Code performance requirements
- Stability Pathfinder Phase 2 sought to procure Short Circuit Level and Inertia services in Scotland
- 10-year contracts could be secured
- Main technical challenges anticipated:
  - Could GFM inverters respond in time?
  - Could they respond appropriately to RoCoF?
  - Operation during severe Voltage depression
  - Operation under severe phase angle jump
  - Meeting short term over-load capability of both battery and inverters
  - Monitoring of performance

Service Category	Network Condition	Service Description
Short Circuit Level (MVA)	Contingency (Voltage Drop)	Fast fault current injection during system fault, to maintain low SCL at the grid BESS is designed to provide higher SCL with grid forming inverter
Inertia (MVA.s)	Contingency (Frequency Ramp)	Instantaneous MW response from frequency ramp within 5ms, proportional to RoCoF Inertia value is adjustable and designed to provide target values at any operational conditions

Site by Site SCL Requirements

Location	Ref	Requirement (MVA)
Spittal	1	600
Blackhillock	2	1,300
Peterhead	3	1,300
Longannet area	4	600
Hunterston	5	1,200
Mark Hill/ Coylton area	6	400
Moffatt/ Elvanfoot area	7	1,800
Eccles area	8	1,200
Total		**8,400**

Regional Inertia Requirements

	Requirement (MVA.s)
Inertia	6,000
Total	**6,000**

Source: NGESO NOA Stability Pathfinder Phase 2 EOI

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Preferred solutions

Point of Stability Substation	Overall BESS Rating	Duration	Tendered Service Rating (MVA)	De-rated Inertia* (MVA.s)	Service Start Date
Project B 275kV	200MW**	2hr	61	333	31/03/2024
Project KS 400kV	300MW	2hr	244	1341	25/10/2024
Project E 400kV	400MW	2hr	488	2686	30/04/2026

- The rating of the actual project delivered might exceed the contracted stability service
- Projects should be designed to ensure that the contracted service can be provided even when the BESS is operating at full import or export
- This allows BESS projects to provide other services vital supporting a low carbon network, including:
  - ✓ short circuit level / inertia /frequency response / constraint management / reactive power / system restoration / energy trading / network balancing / capacity markets
- The ability to stack these services and create multiple revenue streams is critical to the business case for these projects

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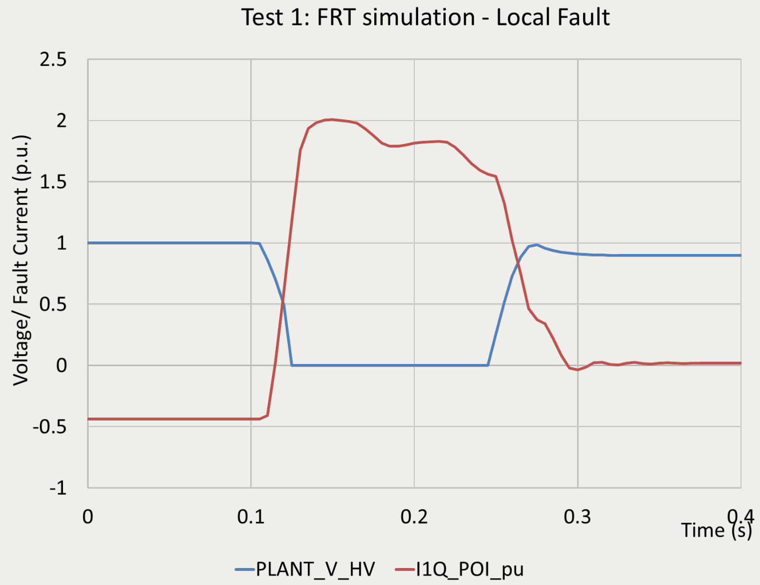
Short Circuit Level capability

- Developers should have worked closely with energy storage integrators to ensure that the Pathfinder technical requirements were understood and tailored solutions for each project could be developed
- SCL capability should be enhanced by optimizing inverter and plant design
  - Can achieve 1.5 - 2.0 p.u. fault current at the HV terminal via simulation/factory test was achieved
- “Traditional” solutions to achieve required fault current would be to include more inverter units – increasing CAPEX and creating issues with land requirements
- GFM capability was verified through EMT simulation during feasibility stage of development

NGESO definition of SCL:

$$\textbf{Short circuit level (MVA)} = \sqrt{3} * \textbf{Rated voltage (kV)} * \textbf{Fault current(kA)}$$

Where:
the fault current is defined as the instantaneous positive sequence RMS fault current seen at 100ms after a 3-phase symmetrical fault at the point of stability; and Rated voltage is defined as the voltage of first busbar at the point of stability.



Generic simulation indicating the short circuit current contribution

Short circuit current contribution

- Have investigated solutions using Synchronous Condenser (SC), BESS and hybrid designs
- Performance advantages for BESS during faults were identified

Fault contribution characteristics by technology

	SC	BESS
Fault current retention at 100ms after the fault	LOW	HIGH
Fault current dependency to pre-fault Q dispatch	HIGH	LOW
Fault current contribution to remote fault	LOW	HIGH
Positive sequence RMS fault current at 100ms after 3-phase symmetrical fault at HV terminal	2.5 – 3.5 pu	1.0 – 2.0 pu

Note: Fault current is measured at 100ms after a 3-phase symmetrical fault at HV terminal based on NGESO's specification

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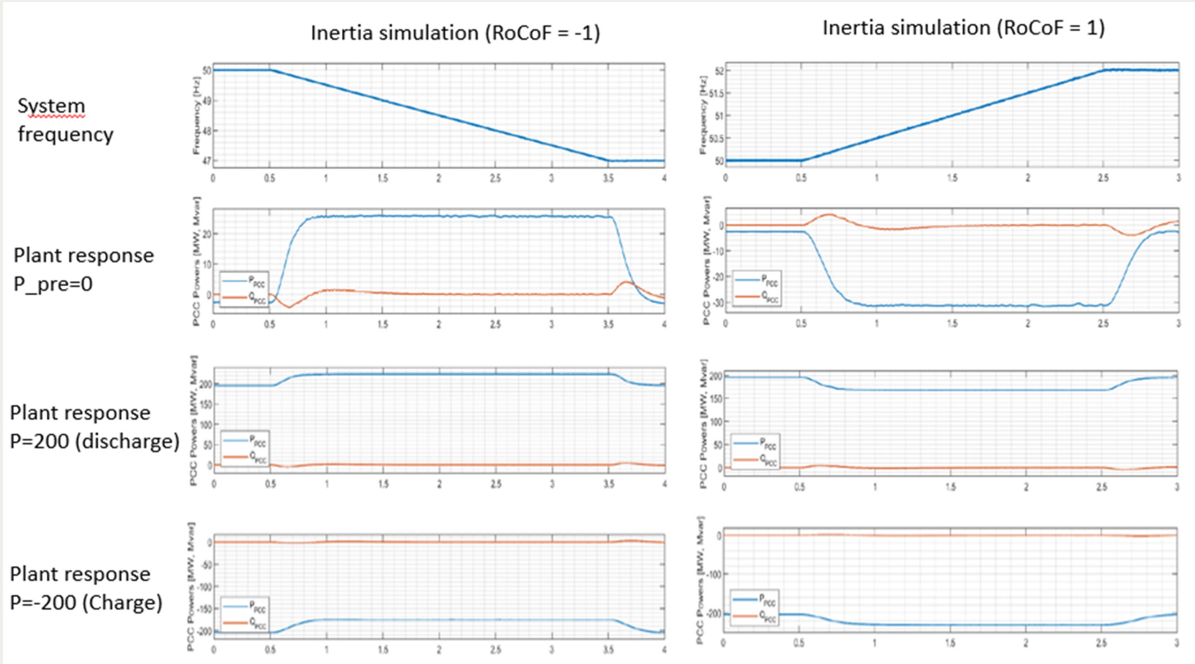
Inertia capability

- Deliver inertia response by using the overcurrent capability of the PCS (no interaction with other services)
- Inertia constant (H) is adjustable between 1 – 30 depending on the short-time overcurrent capability of PCS
- Battery components are designed to provide overcurrent capability to meet the target inertial MW (ΔP) by using short-term high C-rate which is controlled by Battery Management System.

NGESO definition of Inertia:

$$\mathbf{Inertia} = \boldsymbol{H} \times \boldsymbol{S_{rating}}$$

$$\boldsymbol{H} = \frac{\Delta P\, f_0}{2\, S_{rating} RoCoF}$$



Generic simulation indicating the Inertia service can be provided at any operation condition

Future development

- Bring the solutions to grids with similar characteristics - grid forming technologies will have an important role to play wherever renewable energy penetration is high
- Pathfinder process in GB worked well by allowing developers to propose innovative solutions to a functional need – requires forward thinking system operators willing to consider innovative solutions
  - The structured process (separate feasibility and commercial stages) allowed new concepts to be proven and only credible solutions to progress to tender
  - NGESO ran a highly collaborative process – this is vital to allow innovation and maximize value for consumers, system operators, and developers
- NGESO understood that "bankability" was key to bring forward a range of solutions. The availability of contracts and opportunity to stack services is key to the business case of GFM BESS projects and allows services to be provided on a lower pound for pound CAPEX basis than traditional solutions (e.g. Sync Comps)
- Development of strong and flexible markets and contract opportunities will drive further development and innovation and allow the fully capability of BESS solutions to be utilized

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Thank You!

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