

# Grid Forming Technology Overview Webinar

# Webinar Content

- What is Grid Forming and why it is needed.
- Our GFM Policy and Requirements in the GB Grid Code (ECC.6.3.19)
- Key Performance Criteria
  - Active RoCoF Response Power
  - Active Phase Jump Power
  - Fault current Injection
- Commercial Aspects
  - Tender Requirements
  - Example Tender Process
- Modelling and Data Requirements
  - RMS and EMT Models
  - DRC Schedule 20
- Compliance Process
  - BCA Process (EON-FON) Including FAT requirements
  - Commercial Services go live process
- Future Developments of Grid Forming Requirements

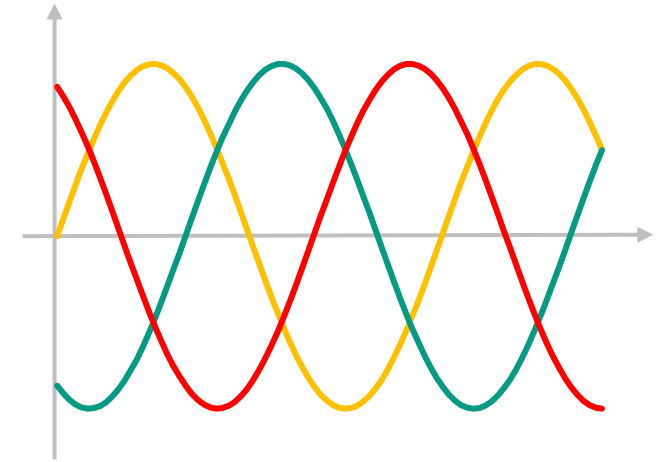
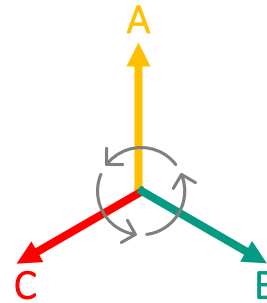
# What Grid Forming Is and Why We Need It

# What is Grid-Forming (GFM)?

## Common understanding

**GFM behaviour** refers to the inherent operational behaviour of a power system resource as a **controlled positive-sequence voltage source behind an impedance**, autonomously establishing and regulating system voltage and frequency.

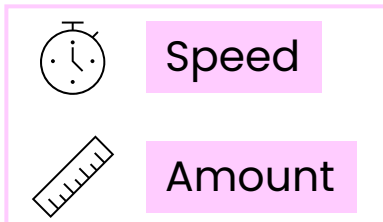
It maintains a nearly constant internal voltage phasor in normal operation and remains largely unchanged at and immediately following the instant of system disturbances, providing an instantaneous stabilizing response in voltage and frequency.



# GFM Behaviour

## Inherent response before reaching current limits

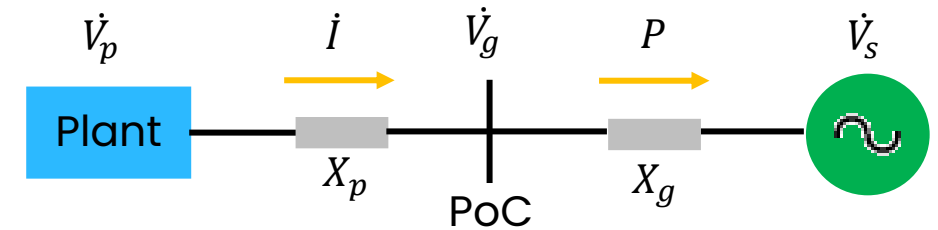
**Inherent response from GFM behaviour** refers to the physics-driven current response that arises solely from the voltage phasor difference between the internal voltage source and the grid voltage across the coupling impedance in between, with the current phasor magnitude and angle determined in accordance with Ohm's law, independent of any artificial control interventions or prioritization schemes.



$$\dot{V}_p = V_p \angle \theta_p$$

$$\dot{V}_g = V_g \angle \theta_g$$

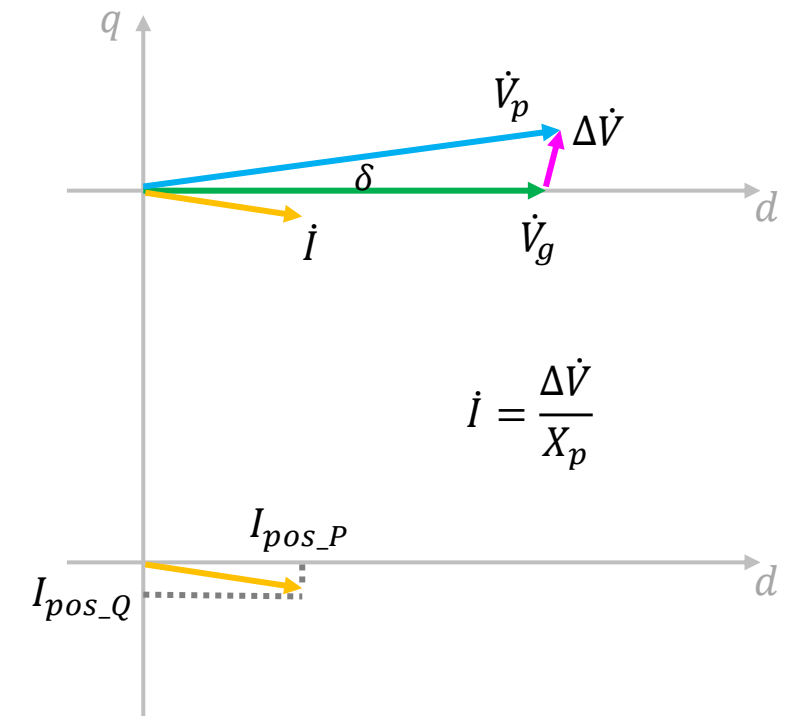
$$\dot{V}_s = V_s \angle \theta_s = 1 \angle 0^\circ$$



$$I_{pos\_P} \approx \frac{V_p \sin \delta}{X_p}$$

$$I_{pos\_Q} \approx \frac{V_p \cos \delta - V_g}{X_p}$$

$$I \approx \sqrt{I_{pos\_P}^2 + I_{pos\_Q}^2}$$



# System Needs

## GFM capabilities

### System transition



IBR (wind/PV/BESS/HVDC)



Synchronous generation (decommissioning)



System inertia  
System strength

### System needs

- Maintain frequency stability
- Maintain voltage stability & strength
- Disturbance ride-through (faults, phase jumps, etc.)

### GFM capabilities matter

- Inertial response
- Voltage establishment & control
- FRT capability & current contribution

GFM capabilities are not optional add-on benefits – they become a core part of maintaining a secure and stable grid in a high-IBR future.

# Our GFM Requirements and Policy

# GFM Requirements in the GB Grid Code

ECC.6.3.19

## Applicability & Market

### 1. Market Procurement:

- Non-mandatory requirements
- Market arrangements

### 2. Technology-Agnostic Scope:

- Requirements apply to:

- Power-electronic converters
- Synchronous generating units
- Or combination of both

## Transient & Dynamic Stability

### 4. Active Power Responses:

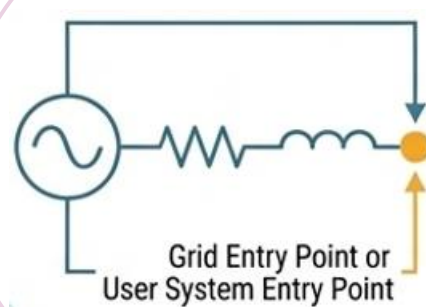
- |  |  |
|--|--|
|  Active ROCOF Response Power |  Active Phase Jump Power     |
|  Active Damping Power       |  Active Control Based Power |

### 8. Fault Ride-Through:

- Execute Fast Fault Current Injection



## GFM Plant



## Voltage Source Characteristics

### 3. Physical Emulation:

- Must act as an internal voltage source behind an impedance

### 7. Extreme Robustness:

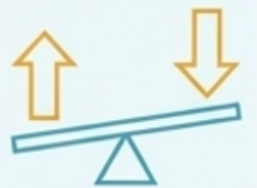
- Operate at a minimum short circuit level of zero MVA



## Operating Envelope

### 5. Symmetrical Ability:

- Both export and import if not limited by its asymmetry in energy availability



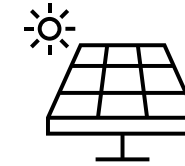
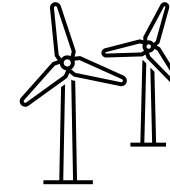
### 6. Damping Factor:

- Between 0.2 and 5

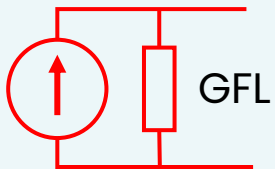
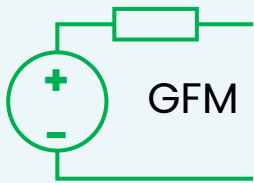


# GFM Policy

## GFM Inverter-Based Resources (GBGF-I)



### Control modes



### Compliance testing



GFM

- Single mode operation:
  - Compliance testing required only for the intended mode



GFL

- Dual mode operation:
  - Separate compliance testing required for each mode
- Compliance approval is mode-specific

### Operation & market



- Even if compliant in both modes:
  - **No** free switching between GFL and GFM
  - Mode changes must be notified to NESO in advance



- A plant may:
  - Complete GFM compliance testing only without holding a commercial GFM contract

Grid Code compliance, operational control, and commercial arrangements are treated separately.

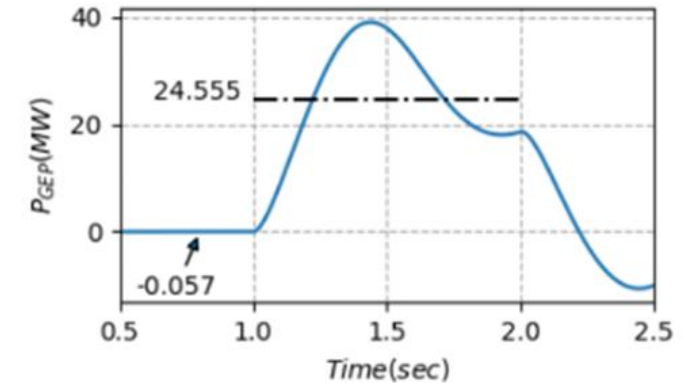
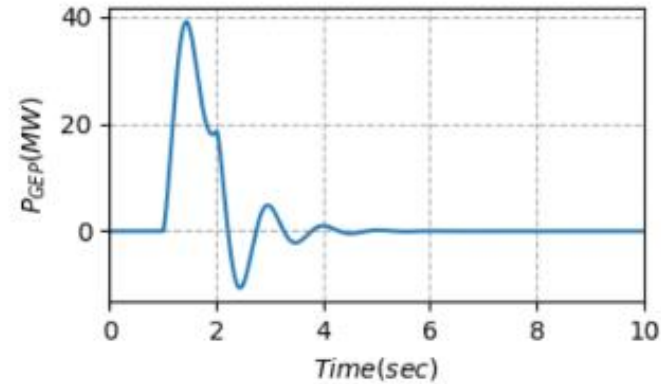
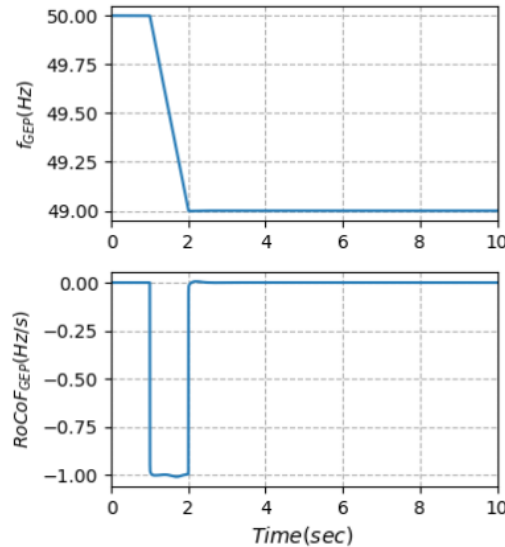
# Key Performance Criteria

# Active RoCoF Response Power

- One of the basic performance characteristics is the inertia response of the plant

## Inertia Response

The inherent injection or absorption of active power in response to frequency change



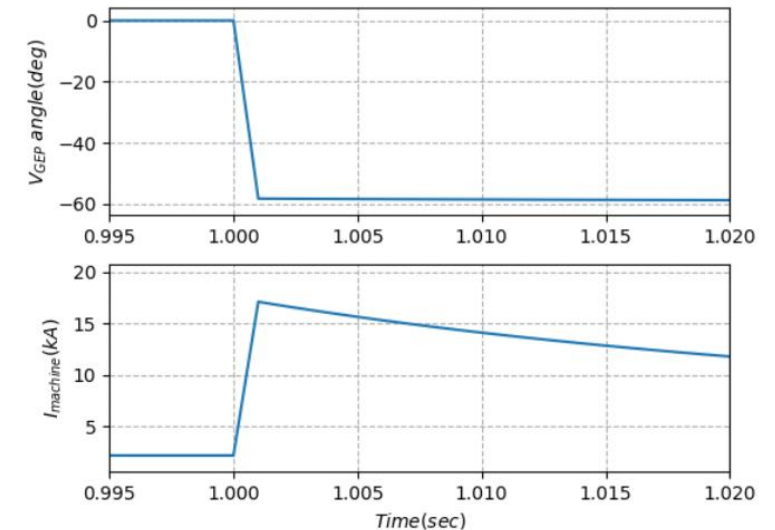
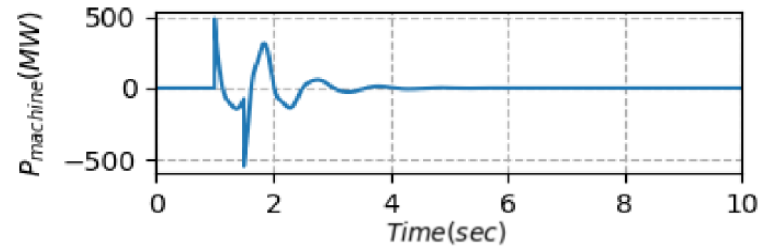
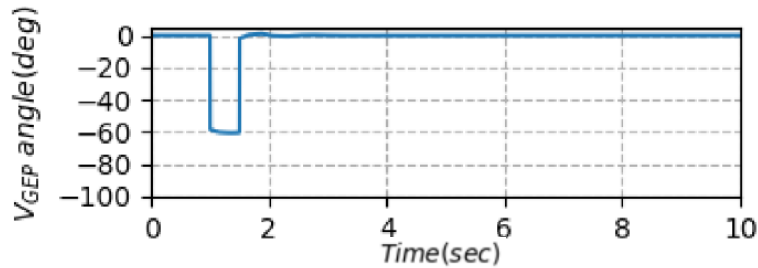
- The response of the plant can be seen, when a Rate of Change of Frequency event occurs the plant counters this by injecting active power.

# Active Phase Jump Power

- One of the basic performance requirements of plant is the response to phase angle jumps

Active Phase Jump Power

The inherent transient injection or absorption of active power in response to a phase angle change.



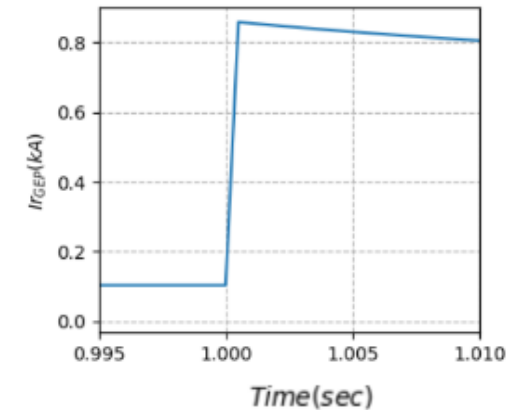
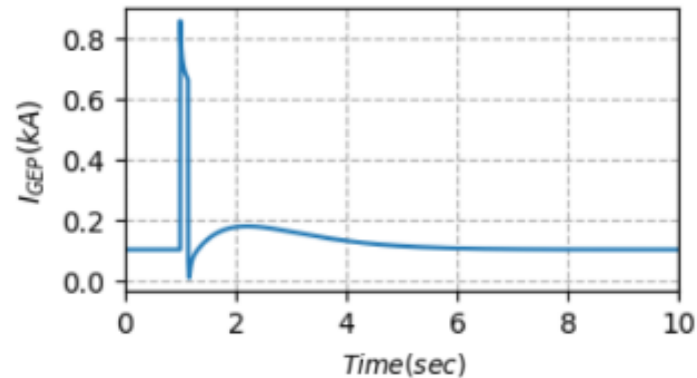
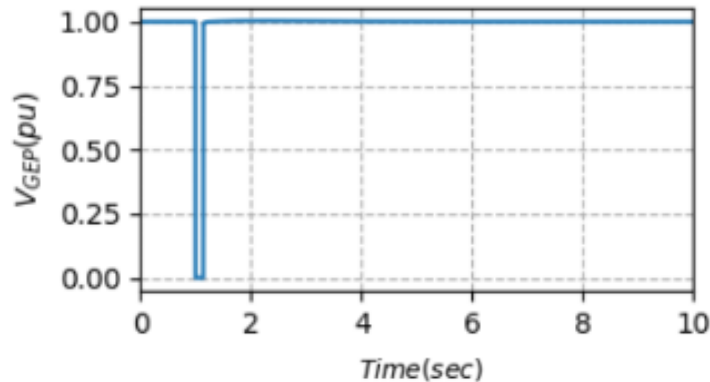
- The response of the plant can be seen, when a phase angle jump event occurs the plant counters this by injecting active power in anti-phase.

# Fault Current Injection

- One of the basic performance characteristics is the response of the plant to faults

## Fault Current Injection

The inherent injection of reactive current to the system when the voltage drops below 0.9 p.u.



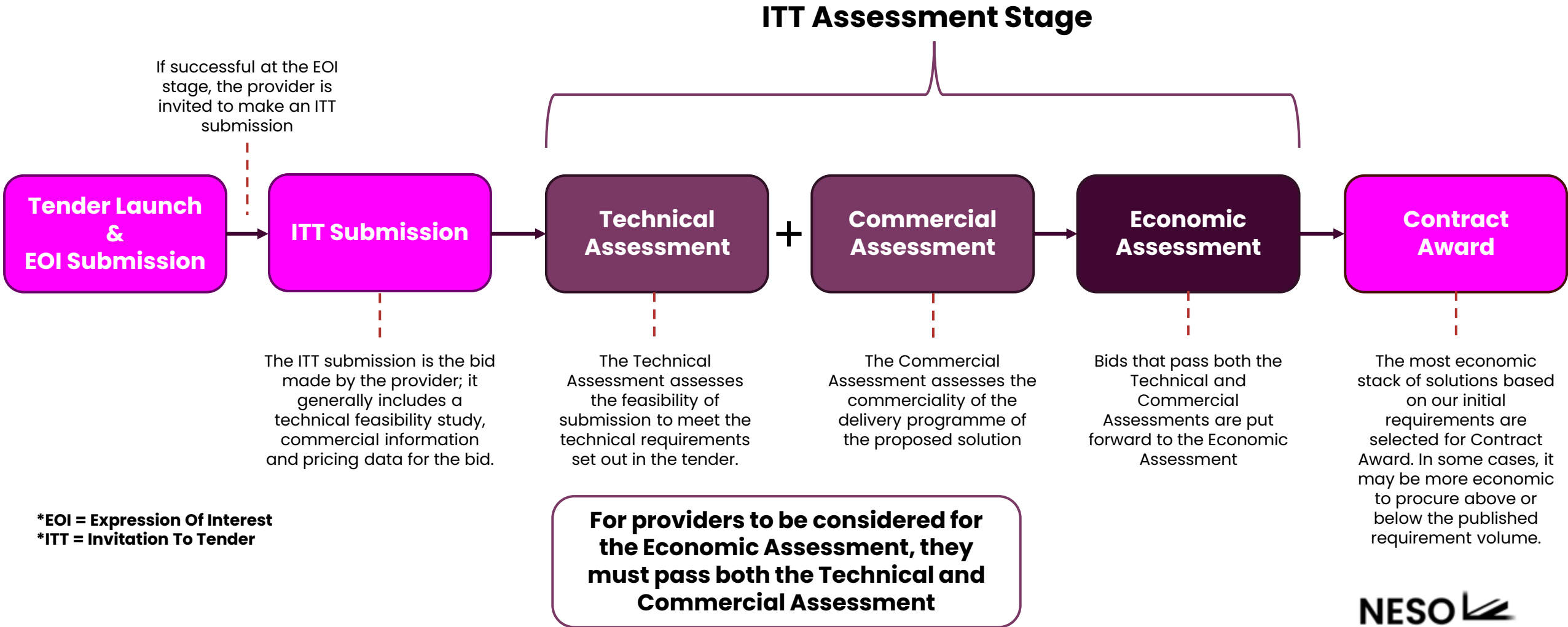
- The response of the plant can be seen, when a fault occurs and the voltage dips the plant injects current into the system.

# Commercial Services

# Tender Requirements

- Certain system services must be provided by Grid Forming Plant, these include:
  - Inertia Services (Stability Market)
  - System Strength Services (Stability Market)
  - Primary Restoration Services (Electricity System Restoration tenders)
- These services, are paid-for services that are optional and not mandated to be provided by plant.
- As, such these contracts are awarded on a competitive basis through our Network Services Procurement programme.
- These services are essential to the safe, secure and economic operation of the Electricity System and as such may carry more onerous requirements than the minimum requirements in the Grid Code.

# Example Tender Process



# Modelling and Data Registration Code Requirements

# RMS and EMT Models

- **RMS models** shall be **unencrypted** and fulfil the Performance Specification of PC.A.9.8. Use of standard open-source models (IEC or WECC) is also acceptable. **EMT models** can be **encrypted** and shall fulfil the Performance Specification of PC.A.9.9.
- Models must accompany their supporting documentation/User Guides that clearly explains the structure and functionalities of all the control blocks
- Where a User provides both **Grid Forming** and **Grid Following** modes, **a representative model** incorporating the two modes of operation along with clear guidance on mode selection shall be submitted, in **both RMS and EMT domain**
- Models must accurately reflect the real plant behaviour. This includes but not limited to all relevant electrical, mechanical, control and protection functionalities: Voltage, Frequency, Grid Forming converter control with adjustable parameters (setpoints, limits, thresholds etc.)
- The **Detailed Modelling Guidance** explaining the key performance criterion can be found on [NESO Compliance Website](#). Furthermore, NESO has recently published an **FAQ guide** to address some of the frequently asked modelling questions

# DRC Schedule 20 – Plant Capability Data

## ▪ Modelling Data

- Grid Forming Plants must provide a representation of their Plant in a Grid Code specified format (e.g. Laplace domain block diagram)
- Submit the RMS and EMT models of the Grid Forming Plant

- **Key Technical Information\***: Submit all necessary data as outlined in the PC.A.5.8.1. This includes but not limited to information about,
  - Inertia, Short Circuit Infeed and Damping
  - Plant impedance/reactance, rated angle etc.
  - Key performance aspects such as Maximum Capacity, RoCoF, Phase Jump and Damping Power etc.

\*The detailed explanation of the data in Schedule 20 can be found under Appendix A of the Grid Forming Guidance Notes-Issue 3 published by NESO

# Compliance Process for a Grid Forming Plant

# Grid Code Compliance Process

Compliance Inauguration Meeting



Share Compliance Statement



Comprehensive list of requirements from Grid Code and Connection Agreement

Pre-ION Compliance Submissions



- ✓ FAT Reports (GBGF-I)
- ✓ Simulation Studies
- ✓ RMS and EMT Models
- ✓ Connection Data etc.
- ✓ Schedule 20 (GBGF-I)

EON/ION



Synchronise to the Total System

Post-ION Compliance Submissions



- ✓ Onsite Test Results
- ✓ Model Validation
- ✓ MSA etc.



Commercial Contract

FON



12-18 months

24 months

# Pre-ION Compliance Submissions



## Factory Acceptance Tests (FAT)

- In order to demonstrate key Grid Forming functionality of the Grid Forming Converters, NESO expects the User to undertake the FAT in early compliance stage
- Actual scope of tests to be agreed with NESO generally including but not limited to the Grid Code Grid Forming tests (Fault Ride Through, RoCoF, Phase Jump etc.)
- The test results along with the formal assessment report shall be submitted to NESO
- The control parameters demonstrating acceptable FAT results shall be used for all the subsequent pre-ION compliance submissions



## Simulation Studies\*

- Voltage Control and Reactive Capability
- Frequency Response
- Fault Ride Through and Fast Fault Current Injection
- Sub-Synchronous Oscillations
- RoCoF, Phase Jump and Damping Performance

\*A User intending to operate in both Grid Forming and Grid Following mode shall submit the compliance studies in both the operating modes. These studies shall be done regardless of export and import operation for Electricity Storage Modules

# Pre-ION Compliance Submissions



RMS and EMT Model

- Shall be submitted at least 3 months prior to an expected ION date
- Models fulfilling the requirements of the Planning Code Appendix 9
- Validation report with respect to the results from Factory Acceptance Tests
- Where a User submits different model to NESO than the one used for carrying out compliance simulations, a model verification report comparing the two models shall also be submitted



DRC Data (Schedule 20)

- Submission of data associated with the Grid Forming plant as per Planning Code
- Obligation on the User to ensure that the data submitted shall be consistent with the rest of the compliance submissions

# Post-ION Compliance Submissions



## Onsite Compliance Testing

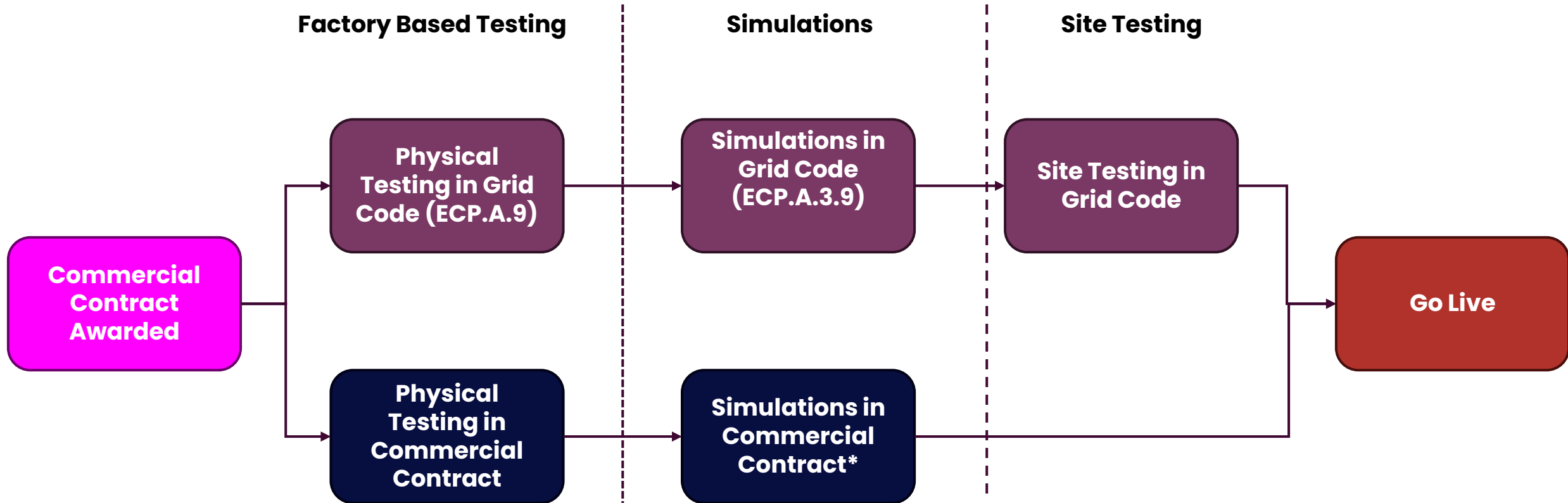
- Pre 20% Voltage Control and Full Voltage Control Tests
- Pre 70% Frequency Response (only required for Plants with Max. Capacity  $\geq 100\text{MW}$ )
- Full Frequency Response Tests
- Reactive Capability



## Model Validation

- The RMS and EMT models shall be validated with respect to the measured performance during onsite testing for Voltage and Frequency Controller and re-submitted if required
- Validation report shall be done by overlaying the simulated performance onto measurement data

# Typical Service Compliance Process



Any successful provider must follow the process above to achieve Go-Live; this is compliance against both the requirements of the bilateral connection agreement and the commercial service agreement. This is illustrative only and the process may change from tender to tender.

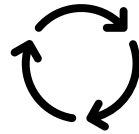
\*For the Stability Mid-Term Market, providers may complete Service Compliance prior to having a contract awarded. Providers should contact [box.stability@neso.energy](mailto:box.stability@neso.energy) for more information.

# Future Developments of GFM Requirements

# Future GFM Requirements

## Engagement & Collaboration

- GFM Expert Group established (Sep. 2024)
- Regular engagement with industry stakeholders
  - monthly meetings (Sep 24 – Apr 25)
- Feedback gathered from:
  - Stability pathfinder experience
  - Compliance testing experience
  - Wider stakeholder input
- International developments monitored
  - E.g., ENTSO-E RfG 2.0/HVDC 2.0
- Last Expert Group meeting: 10 Dec 2025



Expert Group-led,  
evidence-based  
development

## Expert Group Development

- Defining the minimum GFM capability
- Assessing whether a GFM mandate should apply to all Type-D PPMs & HVDC
- Technology-specific considerations
  - Less certainty for other technologies than BESS
  - Possible role of (E-)STATCOM solutions
- Ongoing assessment of potential damping and oscillatory issues from high penetration of GFM resources
- Awaiting finalisation of RfG 2.0 and HVDC 2.0

## Status & Next Steps

- Expert Group Report and legal text proposed for circulation in Q2/Q3 2026
- Formal Grid Code Mod expected to be raised Q3/Q4 2026 (technical requirements + mandate)
- Timelines remain indicative and subject to change