DOE i2X FIRST Grid-Forming Workshop

# GFM Experiences

16 March 2026

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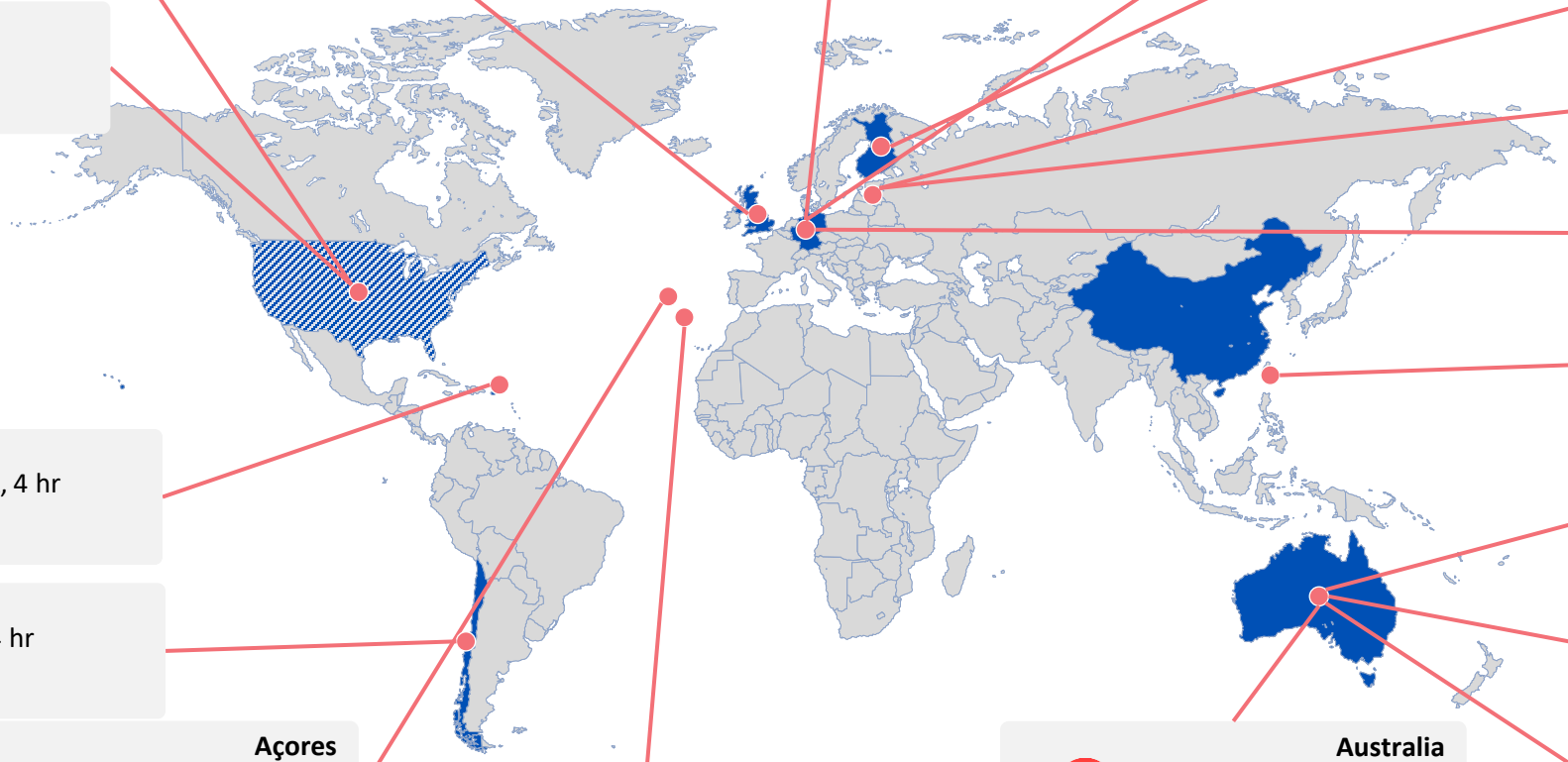
# Grid-Forming Projects Increase in Size and Number

## Fluence Contracted Projects Exceed 3000 MVA



**USA**
Microgrid Portfolio
*GFL/GFM-Droop*

**USA**
Multiple Industrial
*GFL/GFM-Black-Start*

**Puerto Rico**
2*100MW/125MVA, 4 hr
*GFM-Inertia+SCL*
*GFM-Black-Start*

**Chile**
250MW/260MVA, 4 hr
*GFM-Inertia+SCL*
*GFM-Black-Start*

**Açores**
15MW/18.75MVA, 1 hr
20MW/25MVA, 1 hr
*GFM-Droop*

**Madeira**
15 MW/18.75MVA, 1 hr
*GFL/GFM-Droop*

**UK**
50MW/60MVA, 2 hr
*GFM-SCL*

**Germany**
2*100MW/108MVA, 1 hr
*GridBooster*

**Germany**
250MW/350MVA, 1 hr
*GridBooster*

**Australia**
300MW/320MVA, 2 hr
*GFM-System Strength*
*GFM-Black-Start*

**Finland**
55MW/60MVA, 2hr
*GFM-System Strength*

**Lithuania**
1 MW, 1hr
*GFL-Advanced*
*GFM-Back-Up*

**Lithuania**
4*50MW/65MVA, 1hr
*GFL-Advanced*
*GFM-Black-Start*

**Germany**
Multiple Industrial
*GFL/GFM-Black-start*

**Taiwan**
10MW/15MVA, 5hr
*GFL/GFM-Black-Start*

**Australia**
50MW/66MVA, 1 hr
*GFM-System Strength*

**Australia**
500MW/540MVA, 2 hr
*GFM-System Strength*

**Australia**
500MW/540MVA, 4 hr
*GFM-System Strength*

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# Key Drivers for Grid-Forming BESS

## Physics + Operating Risk

Local system strength constraints (fault current availability, voltage stiffness) are becoming binding constraints for renewable connections.

## Regulatory Response & Standards Evolution

Grid codes worldwide are being updated to require more from inverter assets — not just “ride-through” but *active support functions.*

Grid-Forming Requirements for Different Countries

## Economic Imperative & Multi-Service Value

GFM-capable assets can provide traditional functions (frequency response, GFM-inertia, voltage support, black start) *and* participate in energy arbitrage and capacity markets — improving economics.

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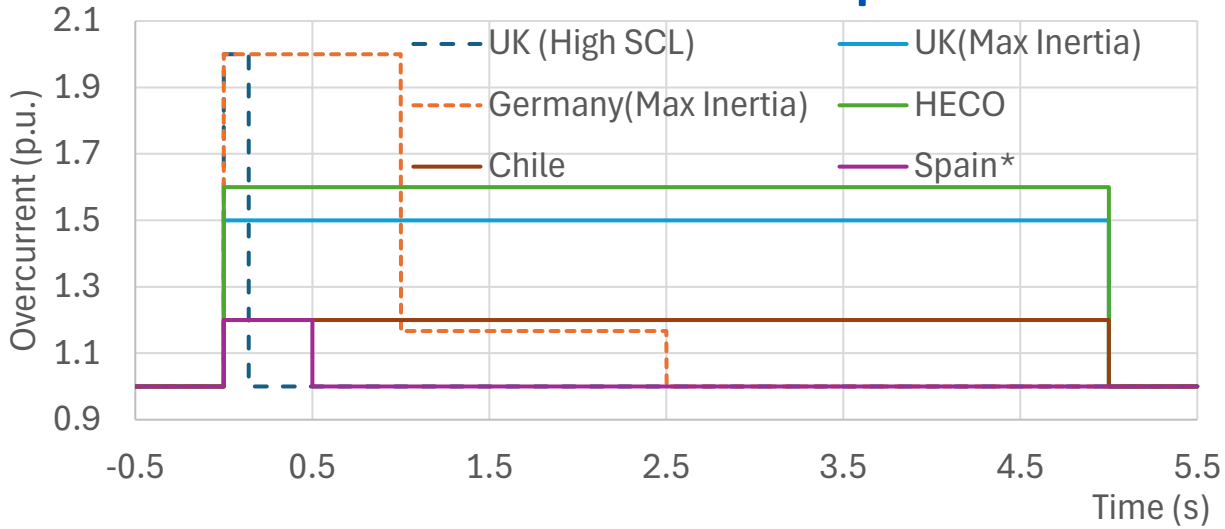
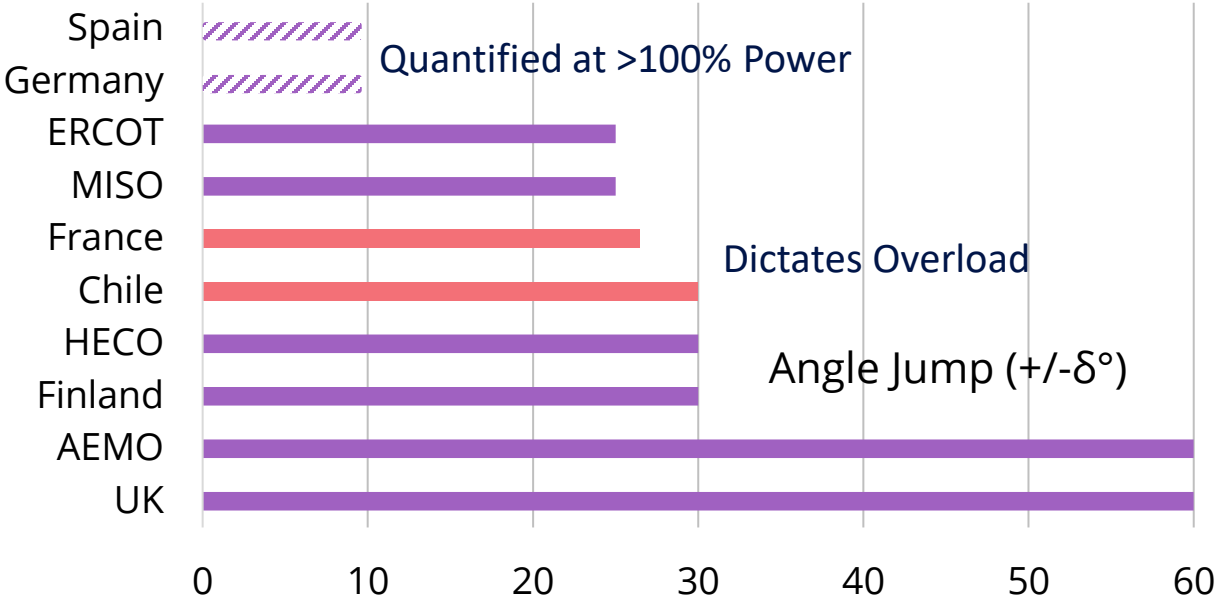
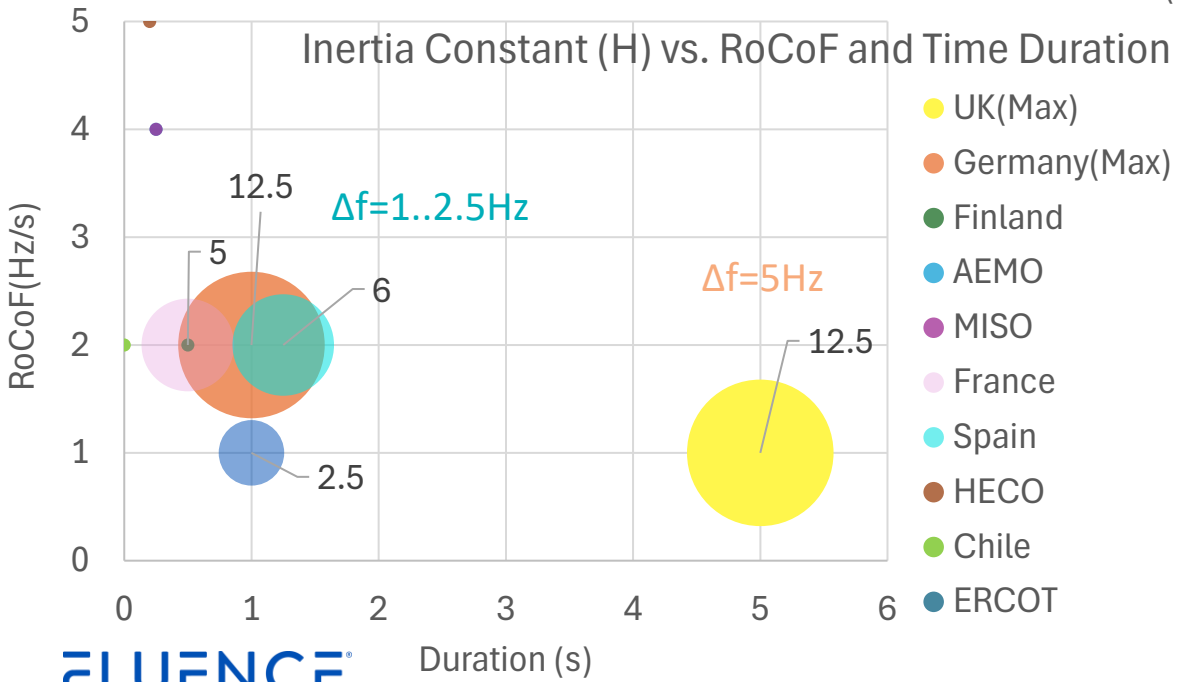
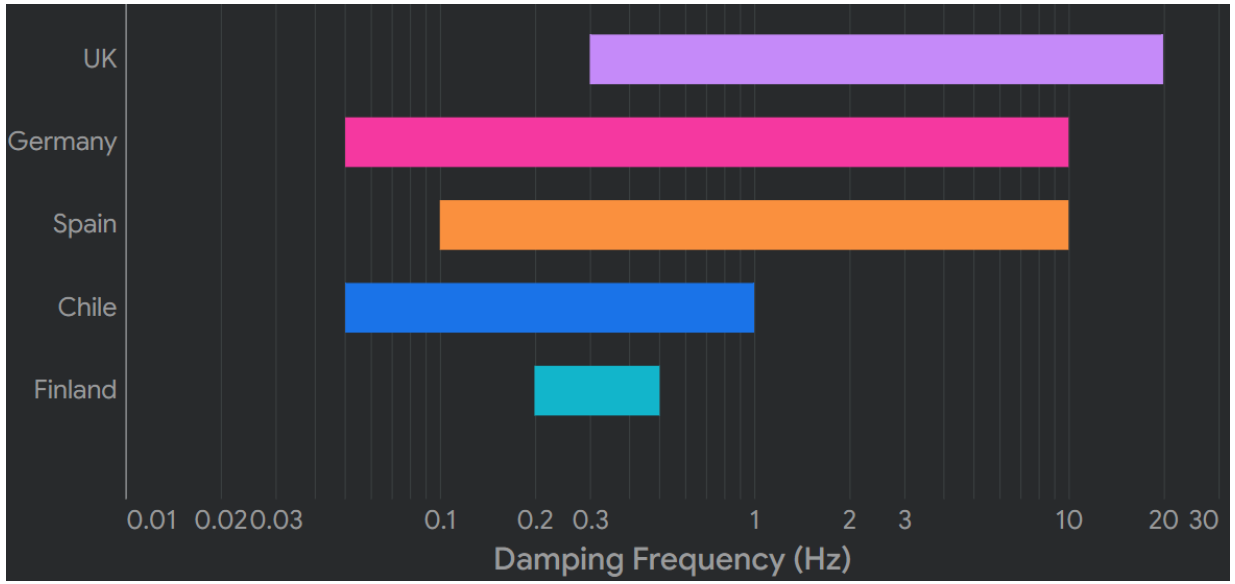
# GFM ≠ GFM ≠ AGS: Requirements & Testing Vary Greatly

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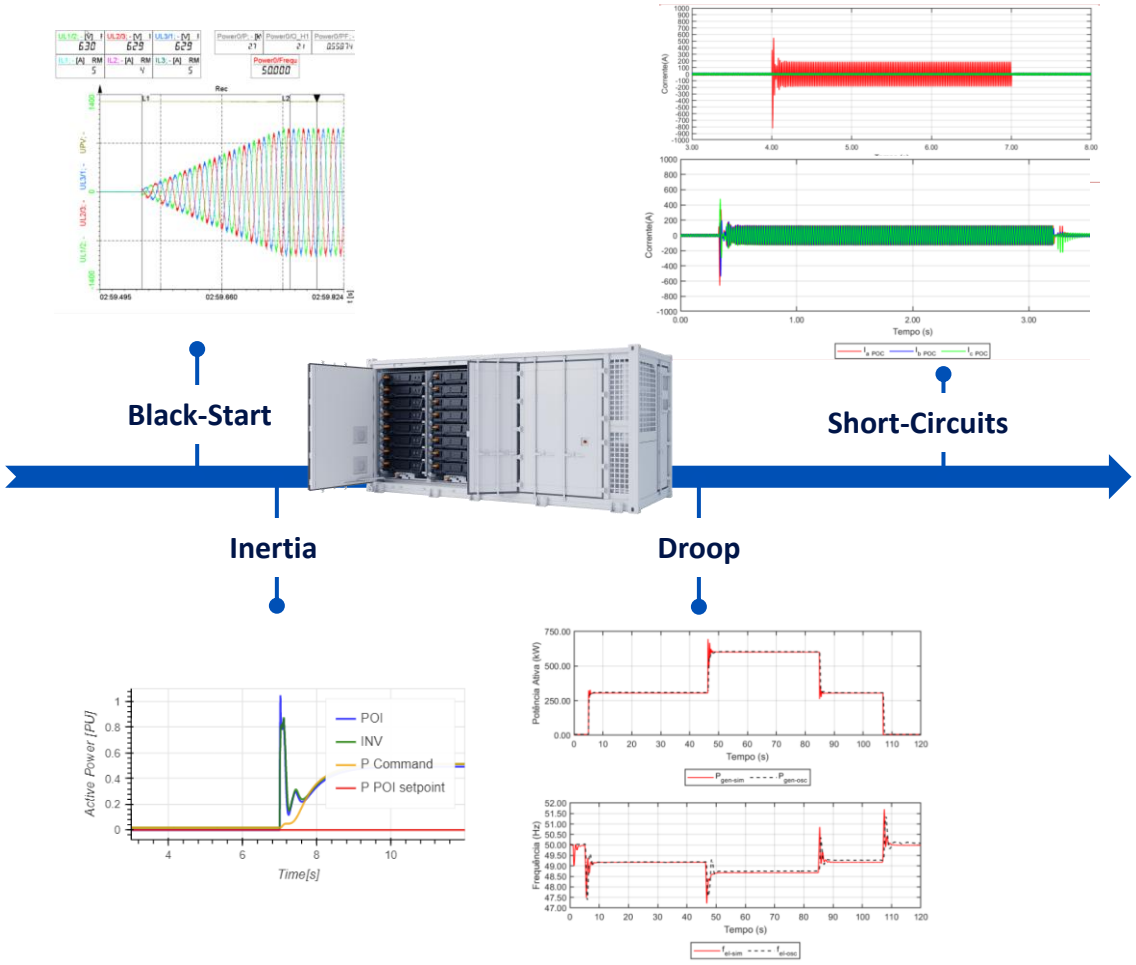
# Fluence Qualification & Integration Method

## Picking Apart the PCS

- **Documentation Diligence**
- **Unit EMT Simulations** *(PSCAD, PF, PSSE, HiL)*
- **Factory Witnessed Test**
  - *Direct Controls/Sequences, Accuracy, Speed, CMV, Black-Start, Short-time >>*
- **Core Lab(s): Simulation & Validation**
  - *Fluence PPC/Enclosure, 1..2xPCS, MV Trafo, Grid and/or Grid Emulators, Load banks*
- **Power Plant Controls (PPC) Adaption & Tuning in EMT**
  - *PSCAD/PSSE/PowerFactory/EMTP*
  - *Project Specific HiL (DMAT)*
- **Project Execution**
  - *Island Testing*
  - *Grid Switching Events (Double line, Substation Transformer(s) or Compensation Equipment)*

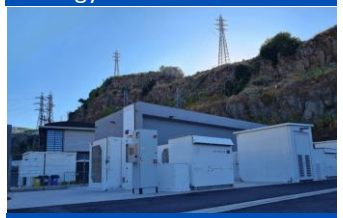




GridBooster – Germany


Terceira – Portugal


Energy Cells - Lithuania


Madeira – Portugal

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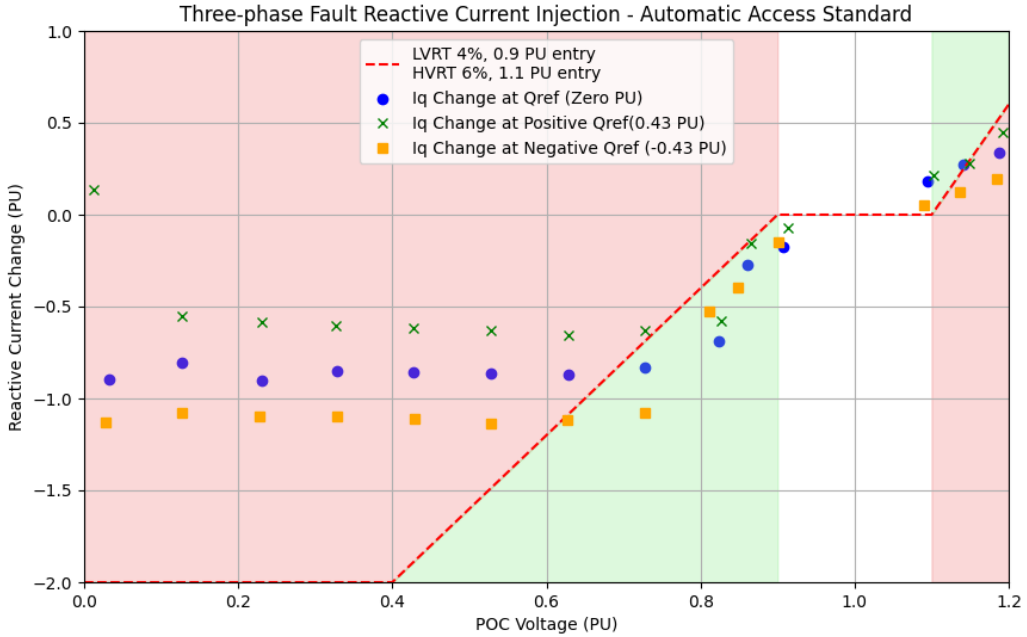
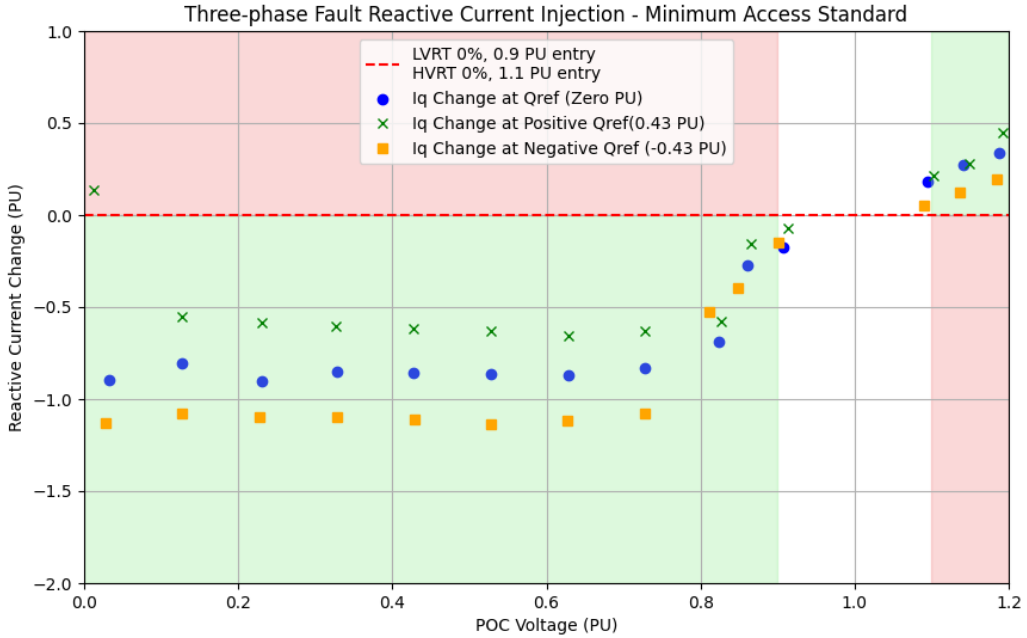


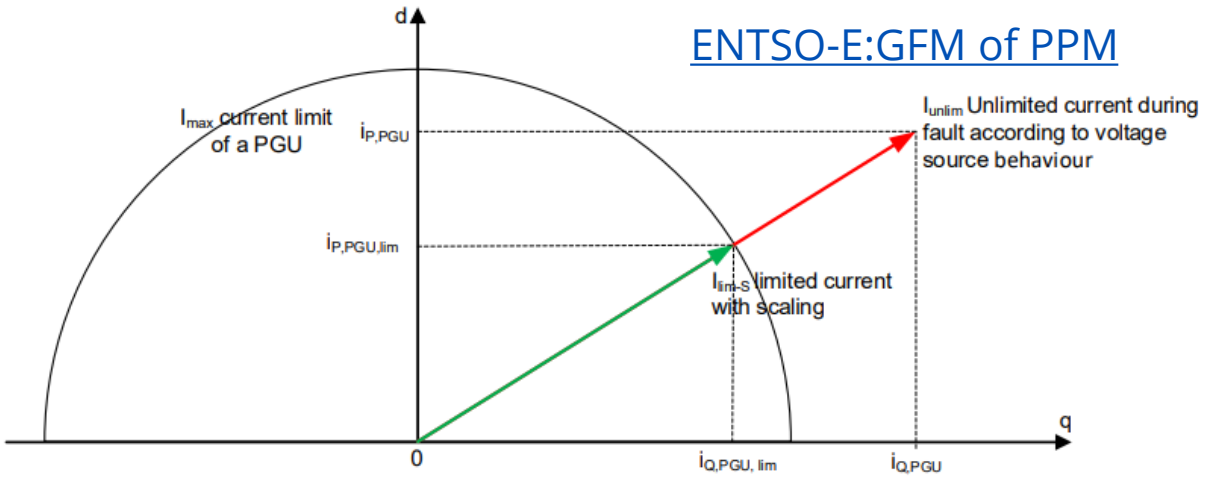




| Remaining voltage level (in pu) | Three phase fault | Phase to phase fault | Two phase to ground | Single phase to ground |
|---|---|---|---|---|
| 0.9 | PASS | PASS | FAIL | FAIL |
| 0.85 | FAIL | FAIL | FAIL | FAIL |
| 0.8 | PASS | FAIL | FAIL | FAIL |
| 0.7 | PASS | FAIL | FAIL | PASS |
| 0.6 | PASS | FAIL | FAIL | PASS |
| 0.5 | PASS | FAIL | PASS | FAIL |
| 0.4 | PASS | FAIL | PASS | FAIL |
| 0.3 | FAIL | FAIL | PASS | FAIL |
| 0.2 | PASS | FAIL | FAIL | FAIL |
| 0.1 | PASS | FAIL | PASS | FAIL |
| 0.05 | PASS | FAIL | PASS | PASS |

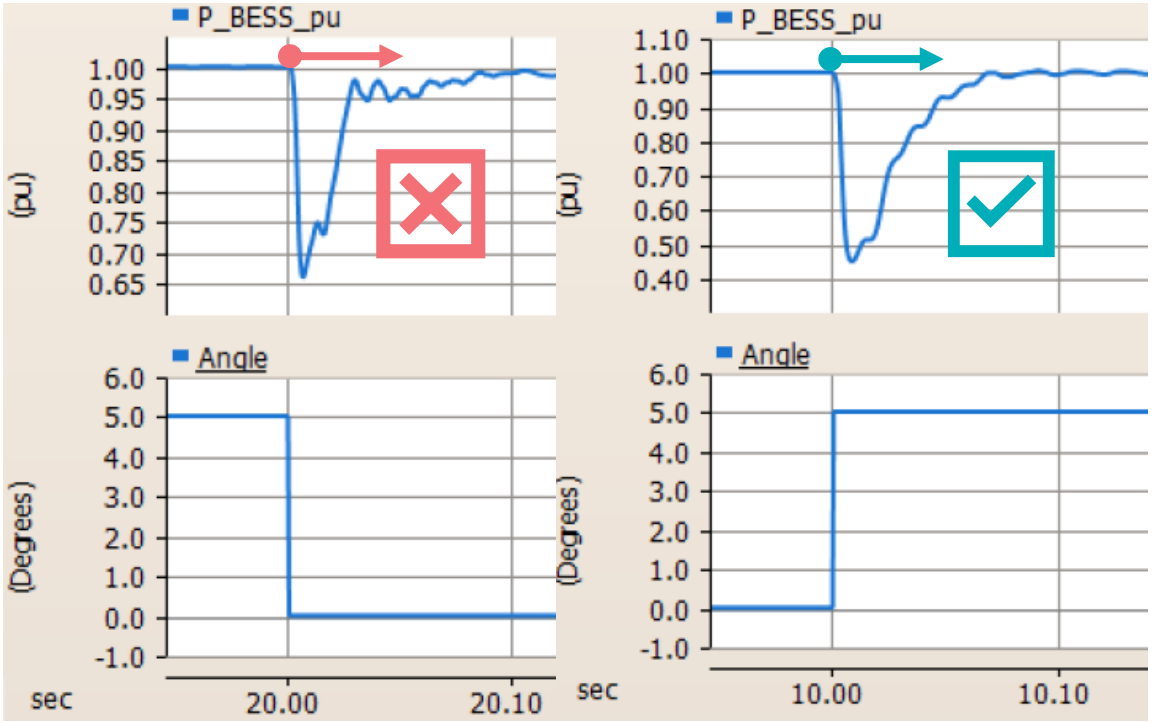
# Short Overload is Obligatory

**Even if not explicitly required per code, de-facto for stable controls**




## Inconsistent Control Response w/o >>I

- OEM Controls often fail on
  - Asymmetric conditions
  - Non-Prioritization of Current
  - Edge of Current Capability Curve → -δ° at 1p.u.
- Many GFM Codes do not:
  - Prescribe asymmetric fault tests
  - Detail prioritization of current
  - Prescribe testing at current limits

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# What Makes Grid-Forming Possible in a Fluence BESS System

**Batteries**

System Design and Integrated Fluence BMS to ensure GFM-PCS respect DC limits

**Power Conversion System (PCS)**

Voltage-forming converter controls (droop, inertia).

**Plant Design, Protection, Operation**

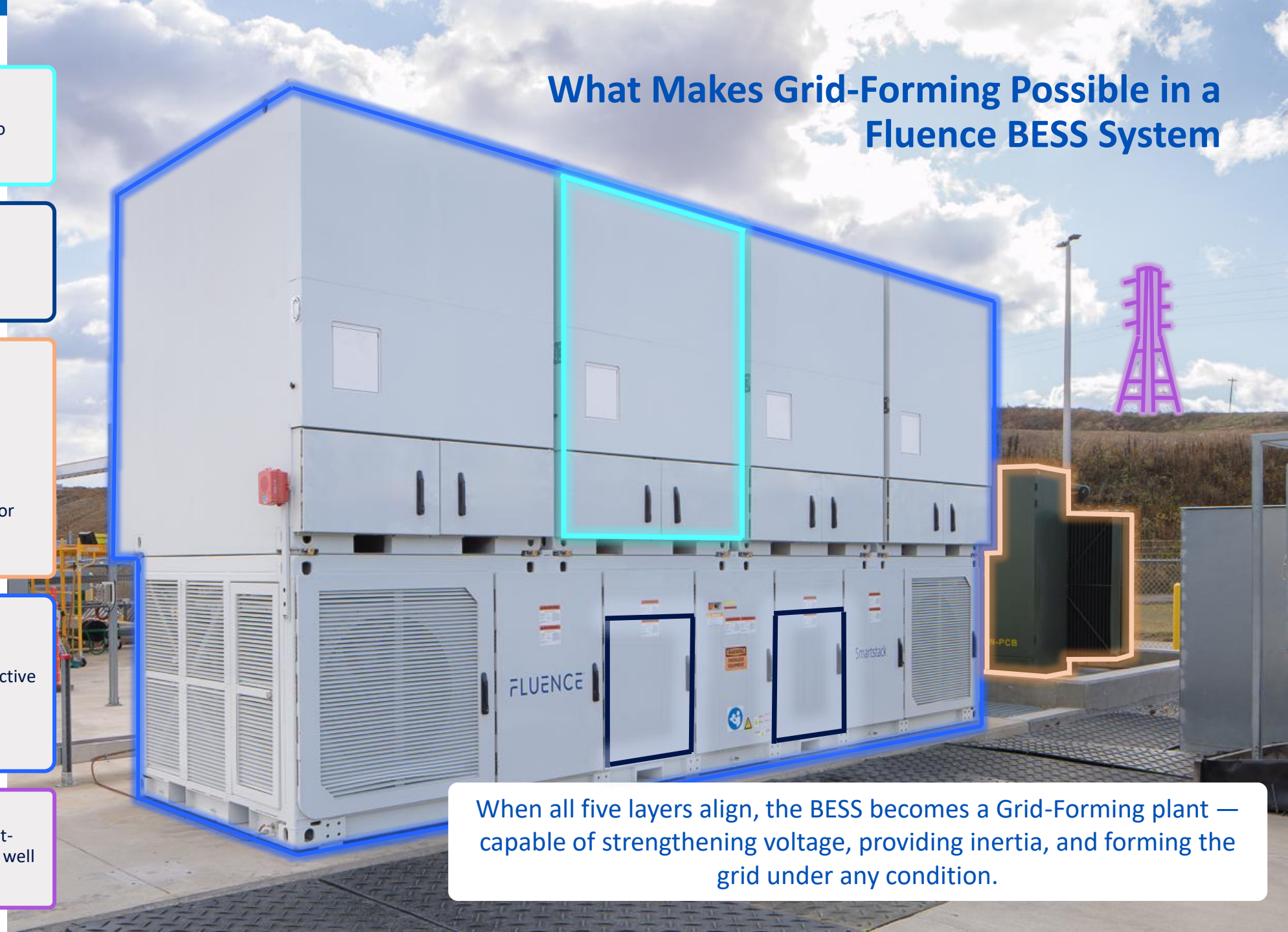
- Design ensures maximum performance without compromising safety.
- High-speed metering and redundancy to maintain real-time visibility.
- Advanced BMS calibration and balancing for “always-on” nature of GFM

**F.OS Power Plant Control (PPC)**

Manages multiple converters and their respective DC sources, coordinates transitions between modes (GFM-Inertia ↔ GFM-Droop).

**Grid Compliance and Market**

Designed for seamless integration into market-based inertia and system strength services as well as connection requirements.




When all five layers align, the BESS becomes a Grid-Forming plant — capable of strengthening voltage, providing inertia, and forming the grid under any condition.

# Fluence Grid Forming

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FLUENCE BY THE NUMBERS

# Innovation, problem-solving, and real-world deployment experience

## Energy Storage Solutions

**46**
TOTAL GWh

**273+**
PROJECTS

## Optimization Software
Renewables and Storage

NISPERA

**18**
GW OF UNDER MANAGEMENT

Mosaic

**16**
GW OF AI-OPTIMIZED BIDDING

## Services

**13**
TOTAL GW

*Data from Sept 30, 2025*

STORAGE AS A TRANSMISSION ASSET

# European grid interconnection and renewables transition in the Baltics

**EPSO-G** (Lithuania)
Litgrid – 1 MW/ 1 MWh demonstration project
Energy Cells – 200 MW / 200 MWh (50 MW per site)

## SERVICES

- Instantaneous Power Reserve
- Frequency and Voltage Regulation
- Black start
- Virtual Inertia Contribution
- Enables Isolated Mode Operation for Baltic Grid
- Renewable Integration

## IMPACTS

- Increase Grid Resilience today
- Ensure stable operation during synchronization with Continental European Grid Area
- One of the largest energy storage project of its' kind

# Coal-to-Clean

## Liddell Battery (AGL)

Hunter Energy Hub, Muswellbrook, NSW (former Liddell coal power station site)
500 MW / 1,000 MWh

**SERVICES**

- Designed for energy shifting/firming, Ancillary Service Markets, GFM-inertia, and system strength

**IMPACT**

- Coal-to-clean transformation: Reuses the decommissioned Liddell coal site
- Backed by ARENA grid-forming grant funding and a NSW LTESA, aligning with state/federal clean-energy targets.

# ISLANDS

## Electricidade dos Açores (EDA)

Terceira, Azores, Portugal

15 MW/15 MWh

**SERVICES**

- Frequency regulation
- Spinning reserve
- Peak shaving

**IMPACT**

- One of the largest stand-alone (island) battery-based energy storage systems in Europe
- Increases renewables and decreases fossil fuels, limiting GHG emissions
- Strengthens energy independence by providing more flexibility, capacity and resilience

 

# Fluence Track Record in Delivering Grid Forming BESS – Australia

**True grid forming capability in Australia, tested and verified by AEMO and ARENA**

## Broken Hill BESS (2023)

50 MW / 50 MWh

Customer: AGL

## Liddell BESS (2026)

500 MW / 1,000 MWh

Customer: AGL

## Mortlake BESS (2026)

300 MW / 650 MWh

Customer: Origin Energy

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