RWE

Grid-Forming BESS Deployment in Germany

IERE Webinar · Grid-Forming Inverters

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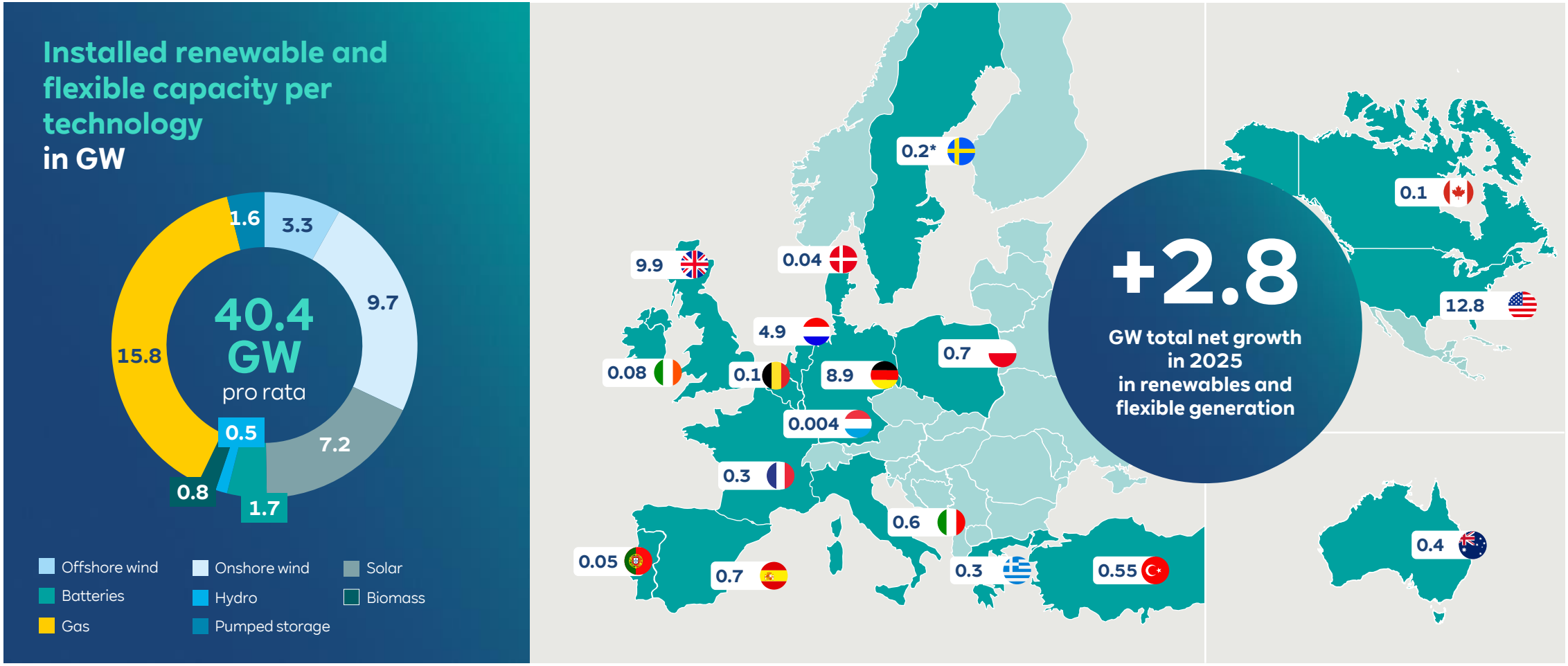
RWE business model is fully aligned with our strategic focus on tomorrow's energy.

Offshore Wind	Onshore Wind/Solar	Flexible Generation	Regulated Grid Infrastructure	Supply & Trading	Phase-out Technologies
• Offshore wind in Europe, Japan and Korea	• Onshore wind, solar and storage activities in Europe, North America and APAC • Development of US FlexGen solutions	• Hydro, biomass, gas-fired power plants and storage solutions in GER, UK, NL and TR • Hydrogen projects	• German electricity TSO Amprion Reported as a separate segment from FY 2027 onwards	• Trading/origination • Gas & LNG • Commodity solutions • Gas storage	• German lignite operations (planned exit by 2030) • German nuclear power plants (exit in 04/2023, currently being dismantled)

~40.4 **GW of installed renewable and flexible generation capacity[1]**

[1] Installed renewable and flexible generation capacity in a pro-rata view | Note: figures as of December 2025

RWE are in an excellent position for the new energy world.



Note: pro rata capacities as of December 2025; rounding differences may occur | RES & Flexible Generation only, excluding lignite, hard coal & other | *Please note: Sweden portfolio sell-down completed in Q1 2026

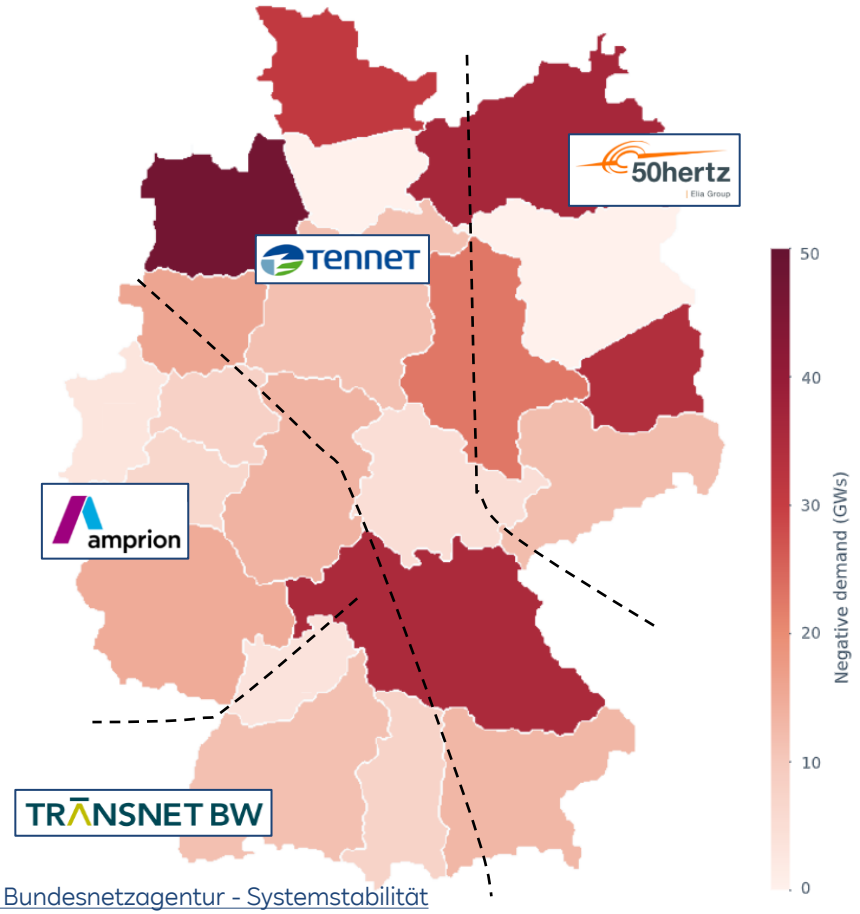
Grid-Forming BESS Deployment in Germany

Germany's inertia need is substantial, spatially structured & directional

Germany Outlook 2030 - Regional positive Momentanreserve demand

LA2030 scenario · Underfrequency

88 most critical hours excluded (~1% of the year)



Source: Bundesnetzagentur - Systemstabilität

TSO	2030 Momentanreserve requirement	
	Positive	**Negative**
amprion	53.8 GW·s	55.8 GW·s
TRANSNET BW	19.8 GW·s	14.6 GW·s
TenneT	140 GW·s	259.9 GW·s
50hertz	100.4 GW·s	231.6 GW·s
Sum	**314 GW·s**	**561.9 GW·s**

Spatial concentration of Momentanreserve requirement

- High renewable generation in northern Germany, combined with strong north–south power transfers and credible network-separation scenarios, creates large regional power imbalances and particularly high Momentanreserve requirements in the north.

Directional asymmetry in the north

- A northern island can become generation-rich after north–south separation, leading to over-frequency and therefore a significantly higher requirement for negative Momentanreserve in the TenneT and 50Hertz areas.

System need is no longer theoretical:
Germany has defined regional Momentanreserve requirements and started market-based procurement in January 2026.

Grid-Forming BESS Deployment in Germany

Germany: system need becomes an investable service

Technical rule-setter	Energy regulator	TSO	Asset owner & operator
VDE	BNetzA	Amprion, 50hertz, etc	RWE, EnBW, Vattenfall, etc
VDE FNN Forum Netztechnik/Netzbetrieb im VDE	Bundesnetzagentur	amprion, TRANSNET BW, TenneT, 50hertz	RWE, VATTENFALL, EnBW
Set the technical boundary	**Define the market framework**	**Procure & use the service**	**Deploy & optimise the asset**
Grid connection and GFM technical requirements	Regulatory and inertia procurement framework	Regional inertia procurement & system operation	Plant operation and commercial optimization
Jan 2026 | FNN GFM V2.1	**Apr 2025 | Inertia Market framework approved**	**Jan 2026 | Inertia Market launched**	**June 2025 | 1st Inertia BESS in Operation**

Germany now has the full chain

technical framework → regulatory framework → live market → operational GFM assets..

Source: VDE FNN V2.1 (Jan/May 2026) · BNetzA BK6-23-010 (22 Apr 2025) · Netztransparenz / 4 TSOs (market launch 22 Jan 2026) · RWE Moerdijk (16 Jun 2025).

Grid-Forming BESS Deployment in Germany

GFM technical requirements by VDE and qualification challenges

Six capability areas — from voltage-source behaviour to certified, repeatable system response

Voltage-source behaviour

- Voltage source with defined effective impedance, i.e.
- Phase jump power
- Fast voltage/current response

⚠ **Stable voltage-source behaviour across weak-grid conditions**

Inertia / transient response

- Extreme RoCoF ride-through
- Phase-jump power response
- Inertia power & energy & overload
- Start-up time constant TA
- Positive / negative direction

⚠ **Fast, quantified response with defined limits**

Damping & interactions

- Synchronization / angular stability
- Damping
- Parallel operation with GFM/GFL/Type-1

⚠ **Stable interaction across grid conditions & converter mix**

Fault response & current limits

- OVRT / UVRT
- Current limiting and transition out
- Protection coordination
- Maintain GFM behavior during limitations

⚠ **Preserve GFM while protecting HW**

Control & coordination

- P / Q setpoints
- PCNB / frequency control
- Gradients / actuator response
- Prioritization

⚠ **Correct prioritisation across competing grid-support functions**

Measurement, models & evidence

- Unit-level disturbance recording
- HIL and lab test
- EMT/RMS model and validation
- Plant verification
- Certification

⚠ **Reproduce dynamic behaviour consistently across test, model & plant**

From "GFM capable" to "GFM proven": requirement → measurement → model → certification

Source: VDE FNN V2.1 (Jan/May 2026)

Grid-Forming BESS Deployment in Germany

From qualified GFM capability to long-term, availability-based revenue

Market Product Options

Basic – minimum availability 30%	Basic positive	Basic negative
Premium – minimum availability 90%	Premium positive	Premium negative

Entry / Qualification

Valid VDE FNN GFM / Momentanreserve certificate

⟶ defines certified Momentanreserve capability and dynamic operating limits

Contract & Commitment

2–10 year contracted service period, fixed price secured

Up to 3 years lead time for project implementation

Monitoring & Assessment

Availability ⟶ quarter-hourly assessment based on unit-level measurements

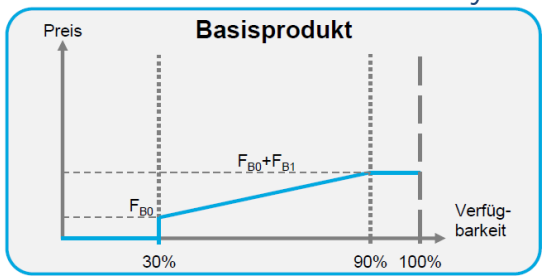
Data exchange ⟶ monthly operational / measurement data

Quality assurance ⟶ additional unit-level measurements & logs may be requested

Payment & Risk

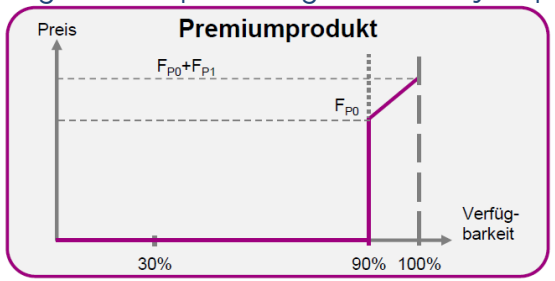
Basic: 30–90% availability

remuneration increases linearly



Premium: ≥90% availability

higher fixed price + high availability req.



Remuneration

Contracted Momentanreserve × fixed price × availability

The value is not just "€/MWs", but also availability, power reserve and opportunity costs.

Source: BNetzA BK6-23-010 (22 Apr 2025)

Grid-Forming BESS Deployment in Germany

Momentanreserve: continuously available, but physically event-driven

Event Driven

an availability product

- Severe system split = design-relevant case and is described as occurring extremely rarely but unpredictably.

Instantaneous Response

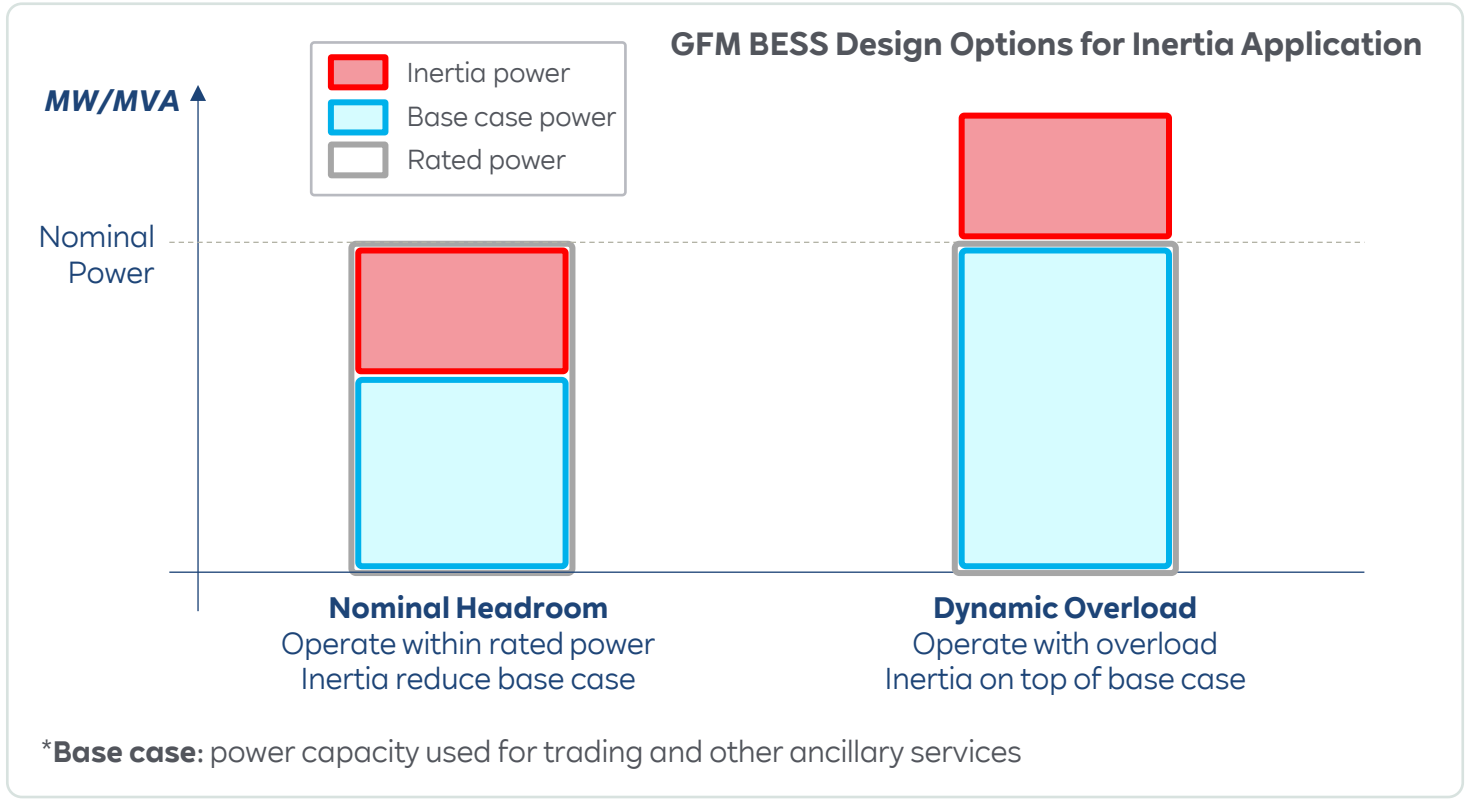
Power capability is critical

- GFM reacts inherently and without delay to changes in voltage angle / power imbalance.

Short Duration

Transient, not continuous

- The required excess power is transient, while the required energy is correspondingly small.



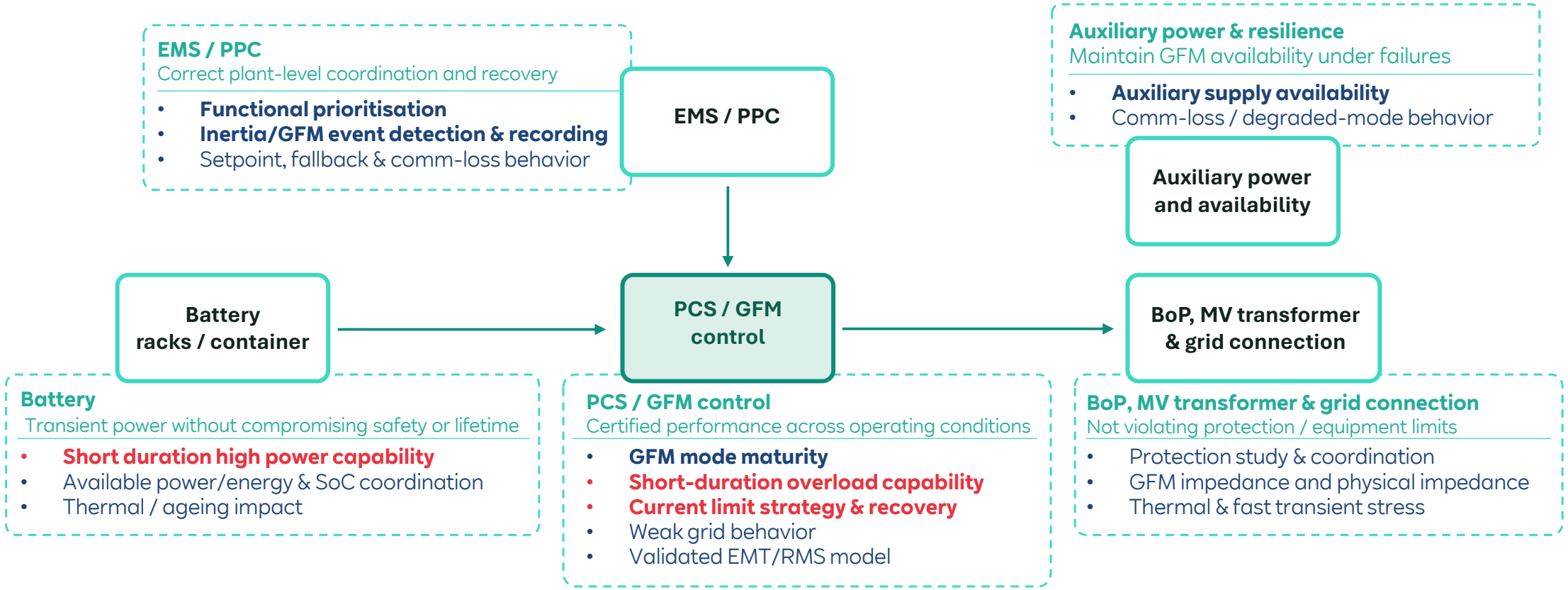
*__Base case__: power capacity used for trading and other ancillary services

Design Principle Preference

Use certified dynamic overload for Momentanreserve rather than unnecessarily sacrificing nominal BESS power.

Grid-Forming BESS Deployment in Germany

Project deployment: from “has GFM” to “can be integrated, qualified & operated”



Battery + PCS/GFM + EMS/PPC + BoP/grid interface must behave as one controllable system

Grid-Forming BESS Deployment in Germany

RWE GFM deployment pathway: from pilot to German scale-up & retrofit

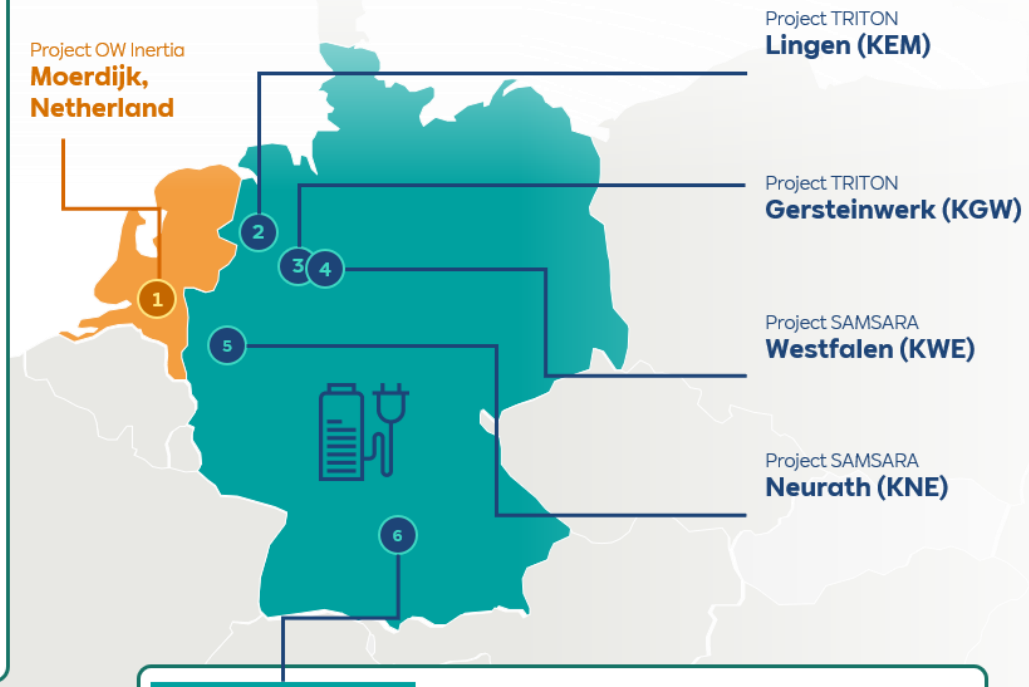
1. PROVE

Inertia Pilot

Oranjewind / Moerdijk



- 7.5 MW / 11 MWh Inertia BESS
- 2-year pilot with TenneT
- German VDE FNN based GFM learning and qualification



2. RETROFIT

Retrofit GFL BESS to GFM BESS

Triton & Samsara

- Identify necessary changes
- Software / control update
- Safety loop
- Updated New plant certificates and operating permits

Availability requirement

- Maintenance plan
- Operation team awareness

3. SCALE

Gundremmingen

400 MW / 700 MWh

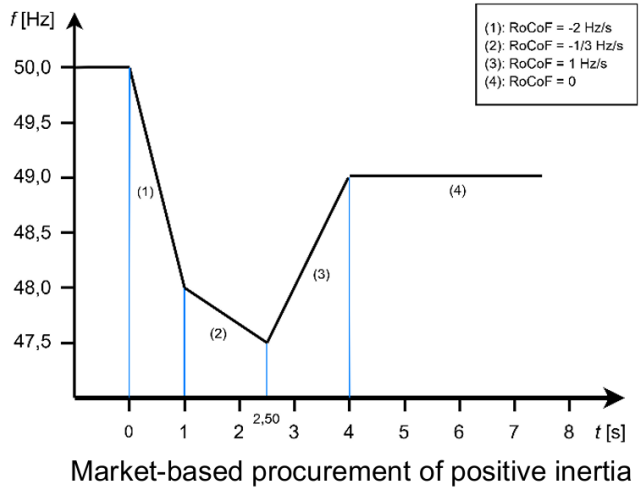
German new-build portfolio example: **Gundremmingen**

GFM capability embedded in new-build design
One example of RWE's growing German BESS deployment

Grid-Forming BESS Deployment in Germany
RWE Oranjewind Inertia BESS - real-site demonstration

VDE FNN V2.1 reference

The GFM BESS must deliver the specified inertial active-power response within the defined frequency/RoCoF envelope.

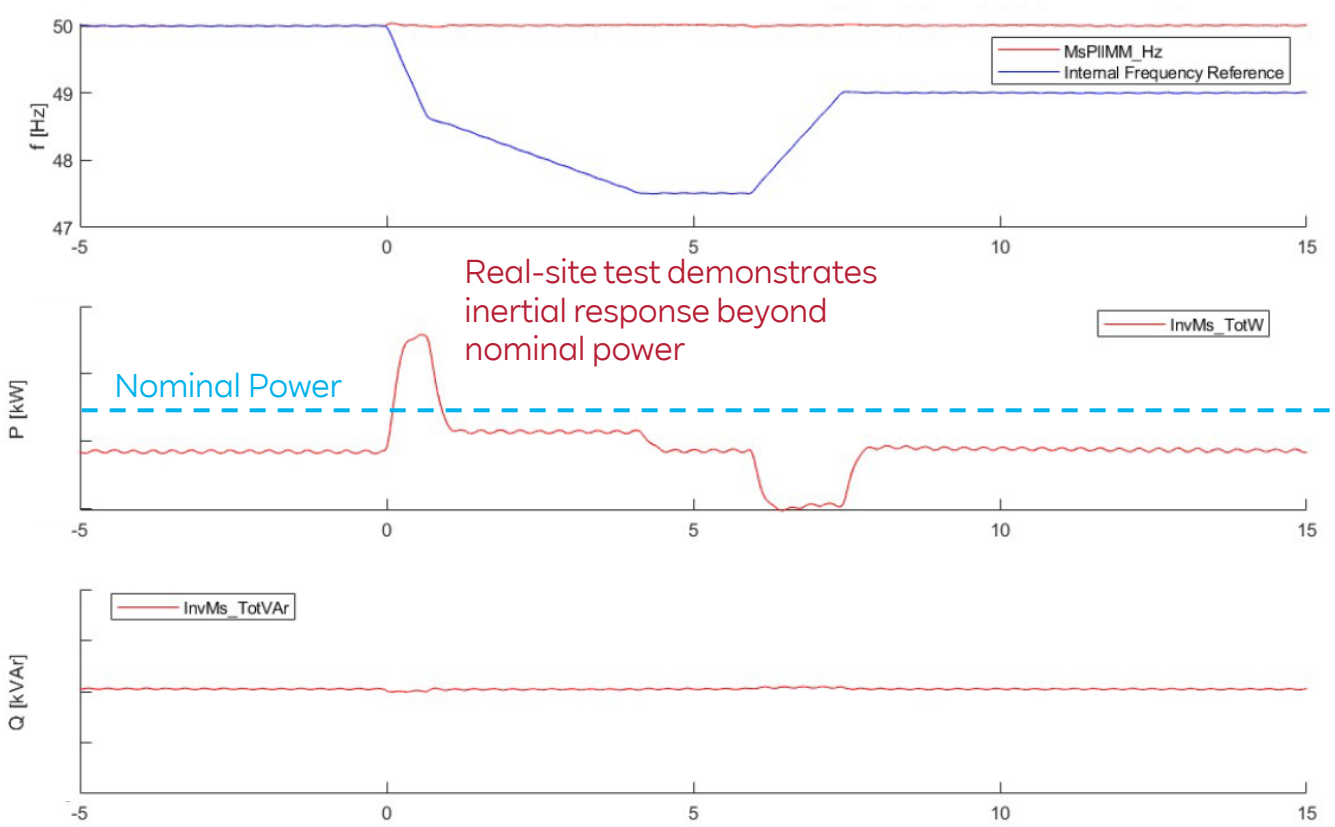


Source: VDE FNN V2.1 (Jan/May 2026)

- **High instantaneous power is required only during the disturbance**
- **Certified short-time overload can provide it above nominal rating.**

Real-site test demonstrates inertia response beyond nominal power

Site test confirms response tracking and transient overload capability.



Source: SMA Solar Technology AG | RWE OranjeWind site test, 28 Apr 2025

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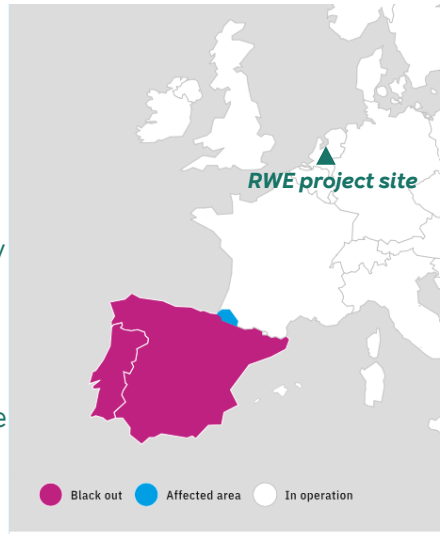
RWE Oranjewind Inertia BESS - real response to a major grid disturbance

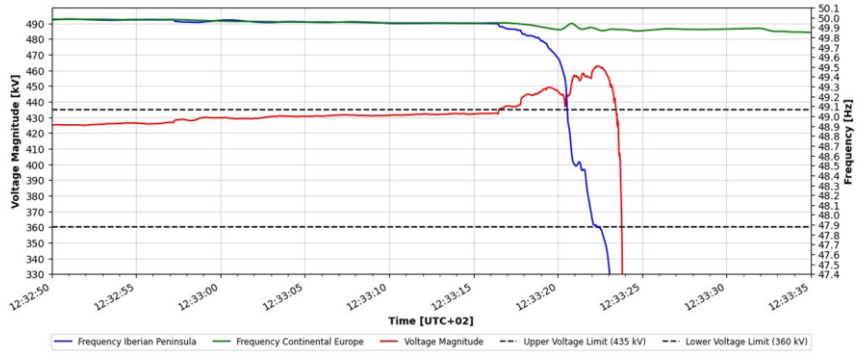
Iberian system blackout

28 Apr 2025 | ~12:33 CEST

- **Iberian system blackout**
  Total blackout in Spain & Portugal following cascading generation disconnections, voltage escalation and stability deterioration. entsoe.eu

- **RWE Moerdijk site – Netherlands**
  Site remained connected, while the disturbance was clearly visible in local measurements:



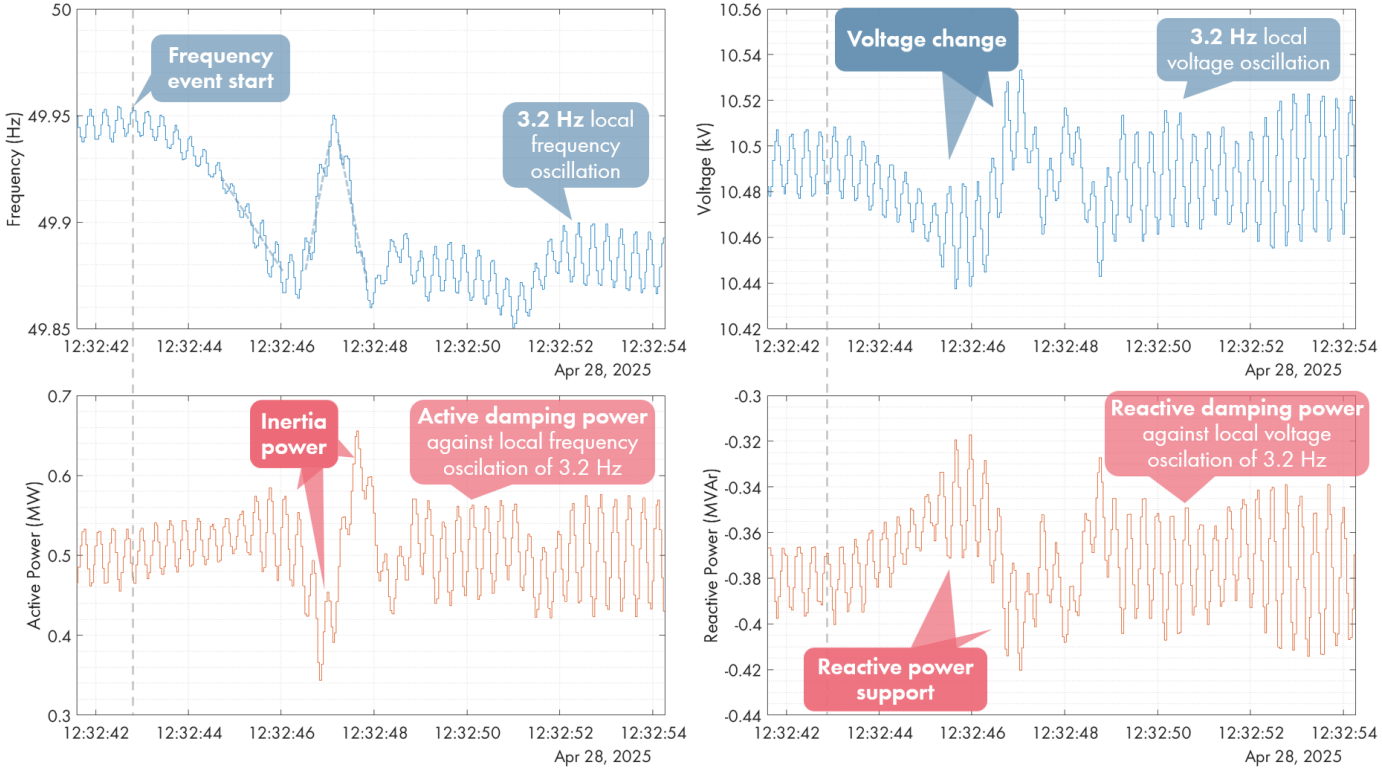


Source: ENTSO-E 28 April 2025 Blackout

Oranjewind site record

Frequency: rapid deviation plus 3.2 Hz local oscillation
Voltage: pronounced transient deviation + local oscillation
GFM response: inertial active-power response + active/reactive damping

✓ Real disturbance
✓ Real response
✓ Real stabilisation



Source: SMA Solar Technology AG | RWE OranjeWind site test, 28 Apr 2025

Grid-Forming BESS Deployment in Germany

Germany has moved from GFM need to a real, investable service

1 SYSTEM NEED

Substantial, spatially structured & topology-driven

N–S topology and credible separation scenarios drive local/directional requirements

2 MARKET

Need is now a live market service

VDE ⟶ BNetzA ⟶ TSO: rules, procurement & system operation

3 ENGINEERING

“Has GFM” ≠ “works as one plant”

All equipment and coordinated engineering

4 QUALIFICATION

“GFM capability” must become certified plant evidence

Measurement + EMT/model validation + plant-level verification + certification

5 RWE POSITION

Real-world GFM experience

OranjeWind / Moerdijk
Real disturbance ⟶ measured response ⟶ operational evidence