

Potential Impacts of GFM BESS Technology on Power Grids and Energy Market

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Vision and mission

Bring digital to every person, home and organization for a fully connected, intelligent world



213,000
employees

53.7%
of employees work in R&D

63.8%
of employees outside China hired locally

170+
countries and regions

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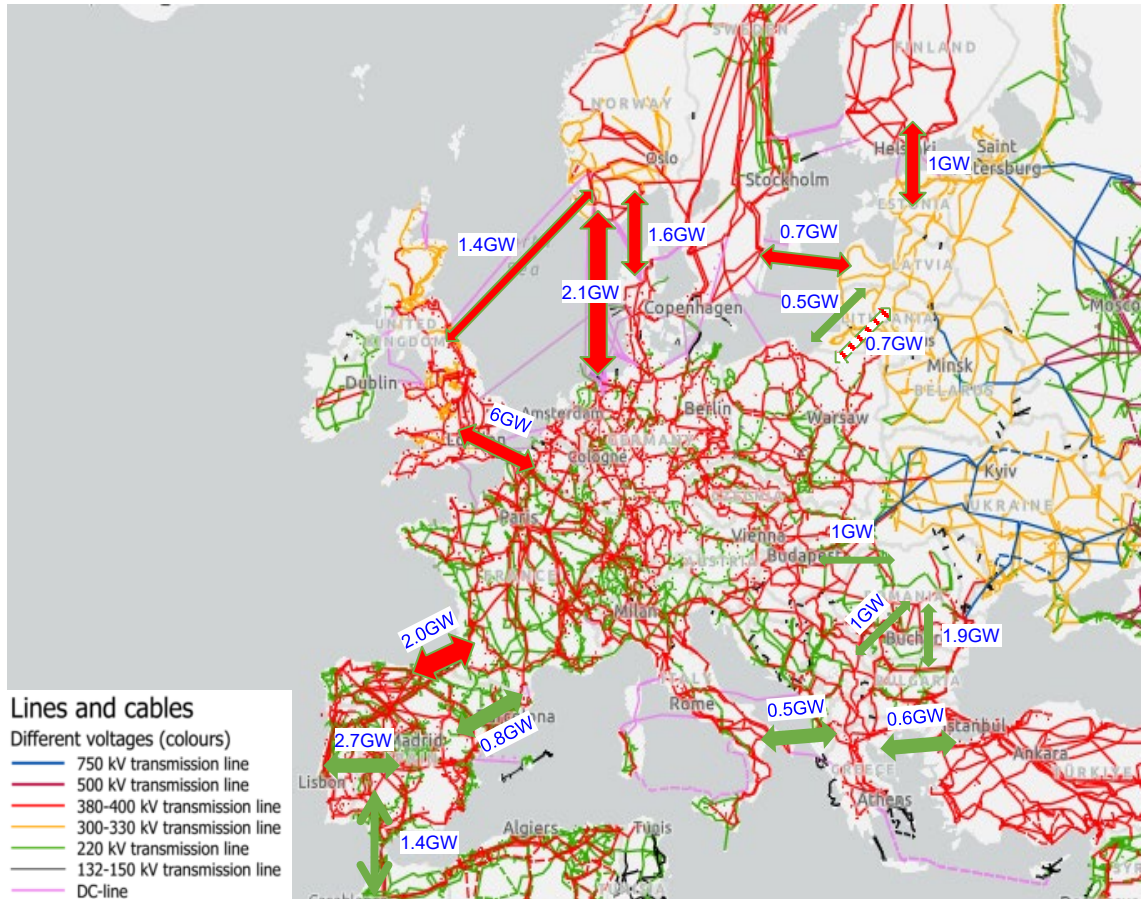
Cross-border connection bottlenecks and renewable energy transition reshape the stability of European power system

Limited cross-border transmission capacity



Source: ENTSO-E

Changing Generation Distribution Patterns

Past → Now

Big synchronous generators

High Inertia and

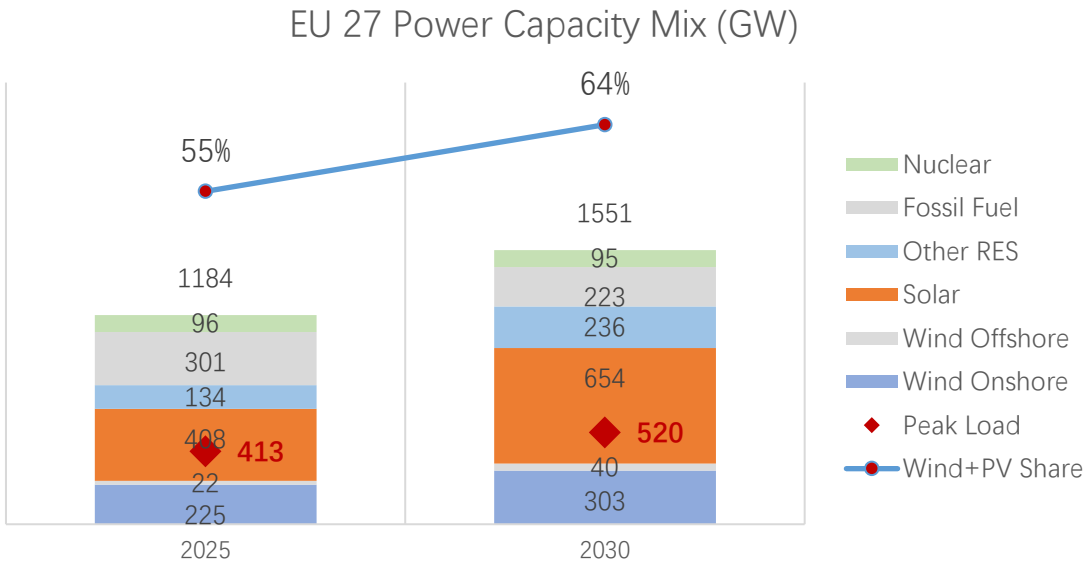
Short Circuit Power

Renewable energy are **Distributed**

Inverter Based

PV+Wind share:

55%@2025 → **64%**@2030



Source: energy-chart, ERAA 2025, Wind Europe

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Grid-forming requirements are being established across EU, but regulatory progress is slow

RfG2.0 will be published in 2026, and GFM requirements will be implemented in member states

ENTSO-E

- **2025.10: Report on GFM technical requirements**
- **2025.12: Recommended all TSOs to update the GCs ASAP**

ENTSO-E recommends TSOs to take actions to update national technical connection requirements as soon as possible to support EU-wide power system stability needs identified by ACER[6], the Grid Connection European Stakeholder Committee, and the EC-organized "roundtable discussions on sustainable integration of data centres in the energy system".
As this action may include involving the National Regulatory Authorities, Member States, and Distribution System Operators, **ENTSO-E encourages ACER and the Council of European Energy Regulators to convey this message towards the National Regulatory Authorities and - where needed - to ask them to support the TSOs for the above.**



CENELEC
Drafting the new EU standards

CLC/prTS 50744-1

Electrical characteristics of grid-forming generating and storage units to be connected in parallel with electrical networks - definitions and tests

prEN 50744-2

Electrical characteristics of grid-forming generating and storage units to be connected in parallel with electrical networks - functional requirements

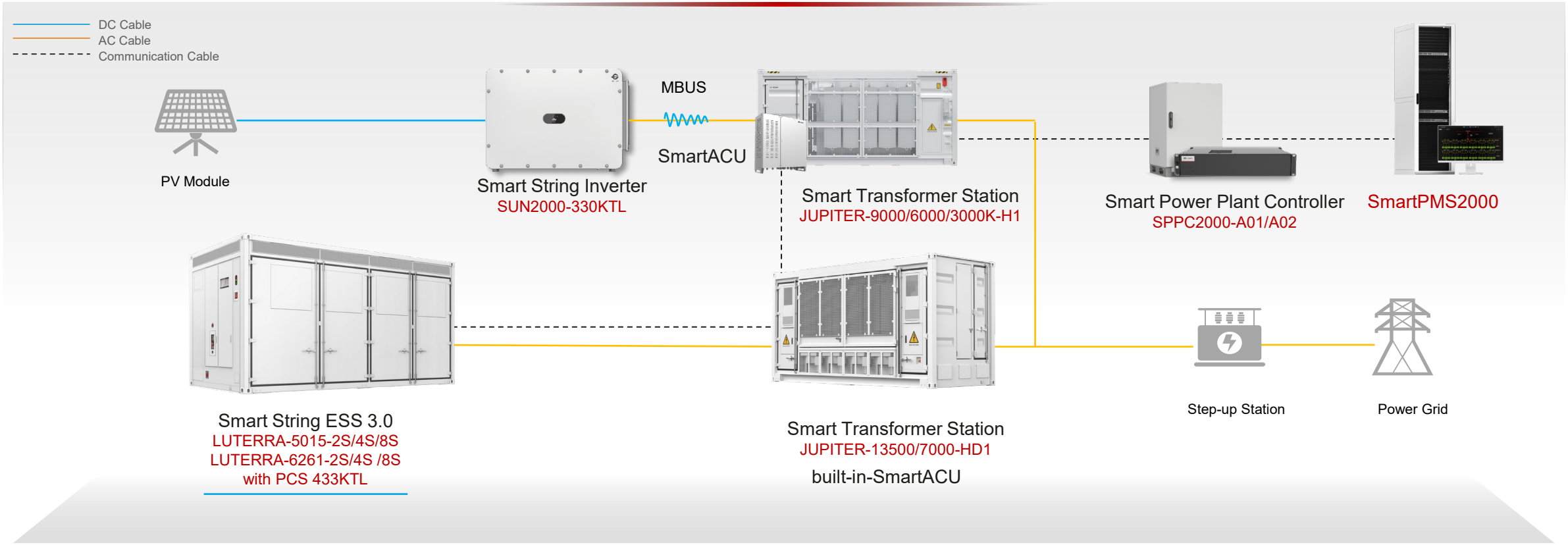
15+ Countries will publish the GFM requirements by the end of 2026

Great Britain 2023	Finland 2025.01	Italy 2025.05	Cyprus 2025.07	Spain 2025.11
Switzerland 2025.11	Germany 2026.01	Denmark 2026.02	Turkey 2026.02	France 2026.05
Belgium 2026	Ireland 2026	Netherlands 2026	Poland 2026	Portugal 2026

Red: Mandatory

End-to-end Utility Smart PV Solution to Bring Four Major Benefits

Complete Solution Ecosystem: Smart PV Solution



All-architecture safety
Proactive safety from cell to grid

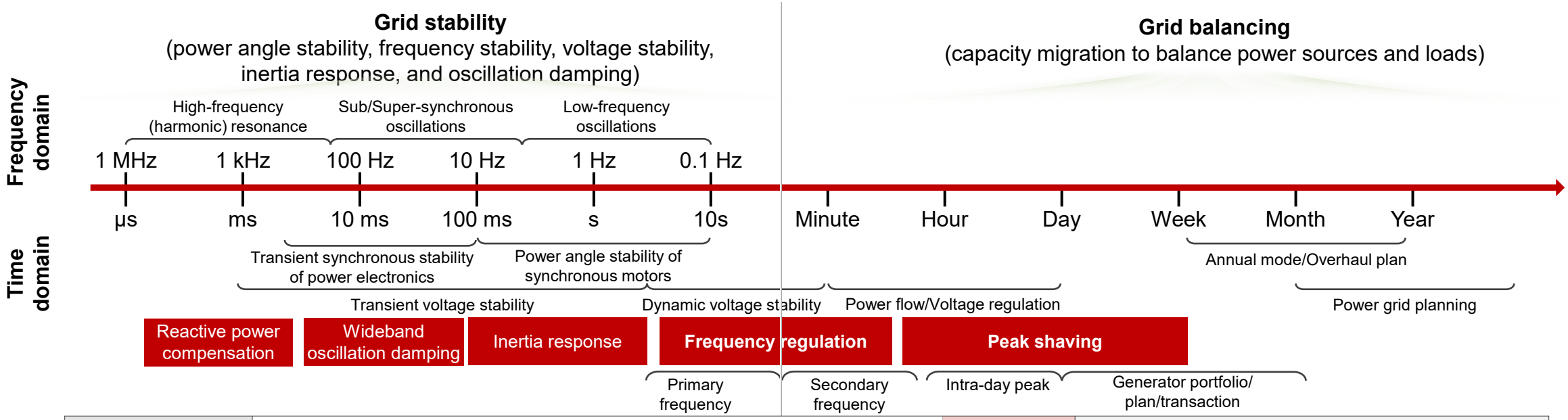
All-scenario Grid Forming
Increasing the proportion of new energy access by 40%+

All-lifecycle cost-effectiveness
Better investment, ROI increased by 3% to 8%

All-rounder Smart O&M
O&M efficiency increased by > 50%

Grid-forming ESS can resolve balancing and stability issues, ensuring grid safety and stability

As renewables develop, grid stability and renewables integration (grid balance) have become major challenges for the power system.



Solution

Pumped storage						Intra-day peak shaving	➢ Construction period ≥ 7 years; natural endowment constraints
Thermal power (peak shaving/frequency regulation)	Reactive power compensation		Inertia response	Primary frequency regulation (partial)	Secondary frequency regulation	Intra-day peak shaving	➢ Retired for carbon reduction; reserved and high cost
Condenser	Reactive power compensation		Inertia response				➢ High cost, requiring 24-hour attendance
Conventional SVG	Reactive power compensation						➢ Supports voltage regulation only, but not frequency regulation or peak shaving
Grid-forming SVG	Reactive power compensation	Supercapacitor required	Supercapacitor required				➢ Supports voltage regulation only, but not frequency regulation or peak shaving
Grid forming wind power	Reactive power compensation		Negative inertia only	Primary frequency regulation (partial)	Secondary frequency regulation	Intra-day peak shaving	➢ Few wind turbine rotational potential energy (inertia), and secondary frequency drop
Grid-forming PV	Reactive power compensation		Negative inertia only	Primary frequency regulation (partial)	Secondary frequency regulation	Intra-day peak shaving	➢ A small amount of capacitor energy storage. Power can be reduced but cannot be increased.
Conventional ESS					Secondary frequency regulation	Intra-day peak shaving	➢ Solves the grid balance problem but does not solve the grid stability problem.
Grid-forming ESS	Reactive power compensation	Wideband oscillation damping	Inertia response	Primary frequency regulation	Secondary frequency regulation	Intra-day peak shaving	➢ Large energy storage capacity, instantaneous natural discharge ➢ Provides a wider power regulation range and a longer adjustment time range.

Grid-forming ESS balances energy and capacity, ensuring grid safety and stability.

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Three Countries Already Launched Inertia Market, and More Countries Are Following

Countries Already Launched Inertia Market

Country	Market	Products	Key design elements for inertia / stability procurement

Ireland	LCIS (Low Carbon Inertia Service)	• Sync Inertia
		• Reactive Power
		• Short-Circuit Contribution
			• **Fixed term competitive procurement**
			• **Contract Duration:**
			  • 6 years for phase 1
			  • 8 years for phase 2

Great Britain	Stability Market	• Inertia
		• Short-Circuit Level
			• **Three Markets: Competitive Tender**
			  • Long Term Market: 10 Years
			  • Mid Term Market: 1 Year
			  • Short Term Market: 4 hours

Germany	Inertia Market	• Basic Inertia • Premium Inertia	• **Remuneration system with fixed prices** • **Long Term Contract:** 2 to 10 years (to be determined by the provider)

Countries Planned Inertia Market



Netherlands

Plan In 2026

- **Technical requirements** for inertia delivery
- Prepare for **the first phase of market-based inertia product**

Hybrid approach

TSO-Owned Assets
(Baseload Inertia)
- Guaranteed minimum inertia
- Overall grid stability and system security (not only inertia)
- Trade-offs:
  - → Capital-intensive, if all demand is covered that way
  - → Limited innovation

→ TSO assets **only fulfill part of the inertia needs** for 2035 and beyond

Market-Owned Assets
(How to unlock inertia in the market?)
1. By Legislation & Codes
   - **Enable** synthetic inertia
     - → Grid forming in grid code

2. By market-based inertia procurement
   - Competitive procurement
   - Investment & innovation signals
   - Technology-neutral access
     - → Preferably **no influence on Electricity market**

→ Required to **meet large future inertia needs**
→ Essential for providing **additional baseload and variable inertia needs** during the day

Other Countries





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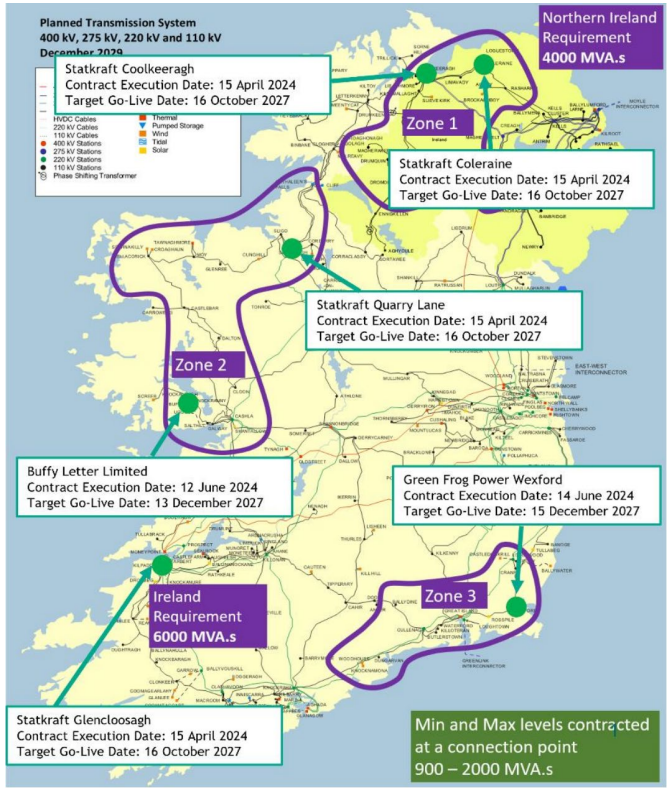
Ireland LCIS: Only Sync Technology, Annual Cost €17695.2/MWs in Phase 1

Phase 1: Annual Cost €17695.2/MWs/a



- On 23 April 2024, SONI published a Contract Award Notice, confirming the award of two contracts for a total volume of 4,000 MVA.s of LCIS.
- On 11 July 2024, EirGrid published a Contract Award Notice, confirming the award of four contracts for a total volume of 6,963 MVA.s. of LCIS.

	Inertia (MWs)	Go live date	Price	Contract (Years)
Ireland	6963	2027	€2.02/MWs/h	6
North Ireland	4000	2027	£1.79/MWs/h	6
Total	10963	2027		

Phase 2: Annual Cost Cap €15855.6/MWs/a

EirGrid and SONI will target the procurement of 14GWs in the Phase 2 LCIS (including Synchronous Inertia, Reactive Power support and Short-Circuit contribution) , and the contract award is Q3 2026.

	Inertia (MWs)	Price cap
Ireland	10000 (Max 12000)	€1.81/MWs/h
North Ireland	4000 (Max 6000)	£1.54/MWs/h
Total	14000 (Max 18000)	

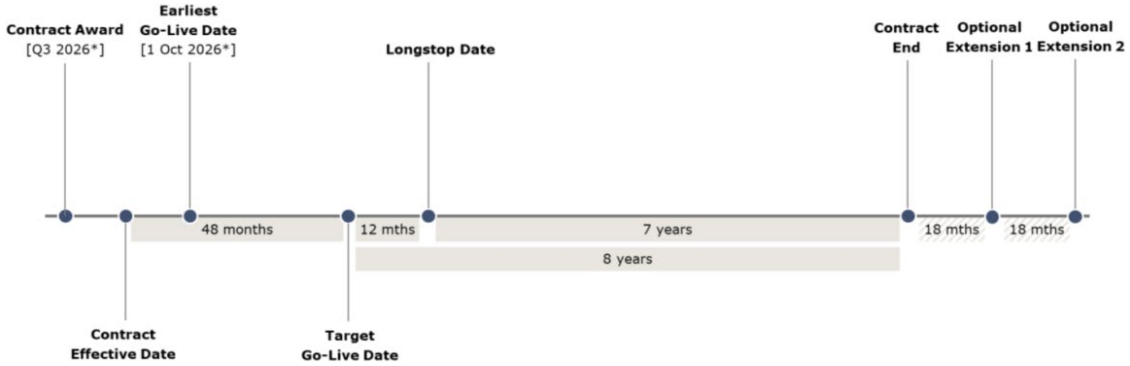


*Figure 3: Proposed LCIS Phase 2 timeline as per the LCIS Phase 2 Agreement. *Dates in square brackets are provisional.*

Source: Low Carbon Inertia Service Procurement – Phase 2 Consultation paper on the requirements, contractual and procurement arrangements

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GB Stability Market: 5 GFM BESS Were Selected, Average Cost is £1098.3/MWs/a

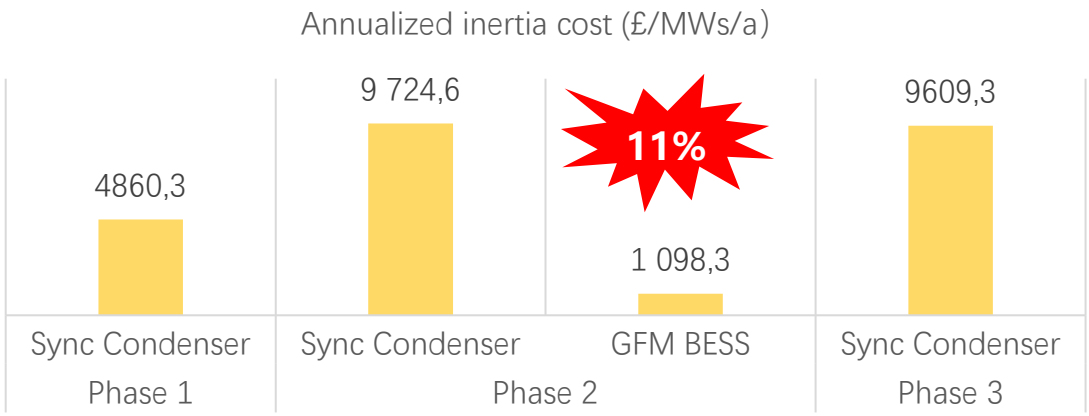
The upcoming LT and MT market with well-defined needs

		2019	2021	2022	2024	2025	2026
Pathfinder Inertia+SCL	Phase	Phase 1	Phase 2	Phase 3			
	Contract (Years)	6	10	10			
	Inertia (GVA.s)	12.5	6.7	17.1			
	SCL (GVA)		11.5	12.7			
	Awarded	12 SCs	5 SCs **5 GFM BESS**	29 SCs			
Long-term Inertia+SCL	Inertia (GVA.s)					10	
	SCL (GVA)					31.1	
Mid-term Inertia Only	Inertia (GVA.s)				5	7.3	11+
	Awarded				5 SCs	3 SCs 2 OCGT	

5 GFM BESS were selected, much cheaper than SCs

Company	Technology	SCL (MVA)	Inertia (MVA.s)	Start Date	Annual Cost (£/MWs/a)
TINZ	Sync Condenser	3168	549	2024/4/1	11198.7
WP Grid Services		1576	470	2024/10/31	10858.7
		2304	470	2024/5/31	10503.0
		817	454	2024/5/31	7532.8
		1078	454	2024/8/31	8154.3
STATKRAFT	GFM BESS	345	0	2025/4/30	/
		269	0	2024/4/29	/
Zenobe		210	333	2024/3/31	2321.4
		716	1341	2024/10/25	778.1
		1070	2686	2026/4/30	1106.3

GFM BESS inertia cost is only 11% of sync condensers



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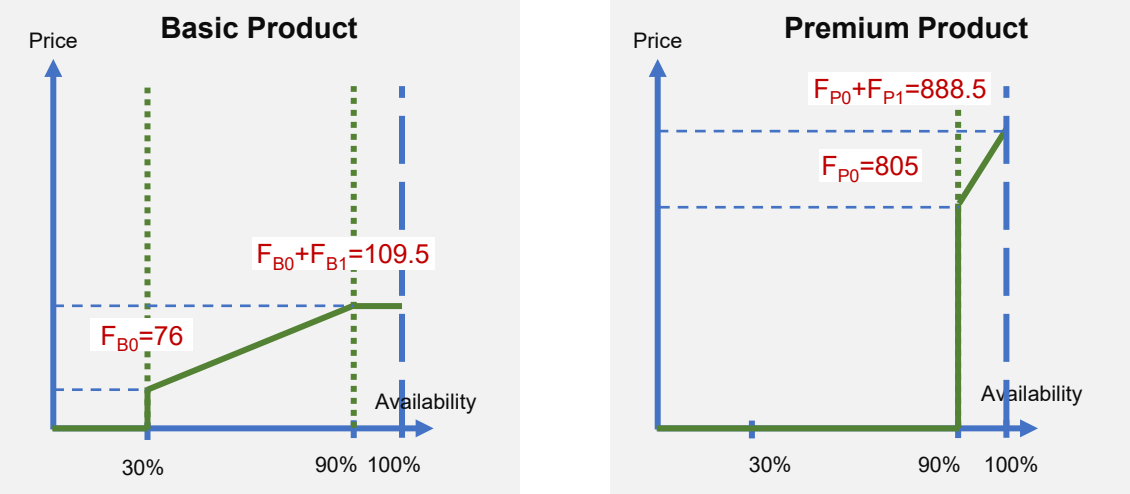
German Inertia Market: Fixed Prices, Average Cost is €1777/MWs/a in Sheet 1

Prices and Remuneration



* The price in the figure is the Price Sheet 1, unit: €/MWs/a

- Maximum contractable inertia energy: $E_{inertia,Contractible}=0.5 \cdot T_A \cdot P_{rE}$
- Remuneration is determined by three factors:
  - the chosen product
  - the fixed price components
  - the annual availability achieved.
- **Price Determination:** Initial fixed price components for 2026 and 2027 are determined by an expert appraisal.

The pricing framework uses secure, fixed prices published in advance

2025	2026	2027	2028	2029	2030	2031
Price Sheet 1: Published in 13th Nov. 2025	valid from January 2026 to December 2027					
		Price Sheet 2: Published by July 2027	valid from January 2028 to December 2029			
				Price Sheet 3: Published by July 2029	valid from January 2030 to December 2031	

amprion verbindet
Positiv: 53,8 GWs
Negativ: 55,8 GWs

TRANSNET BW
Positiv: 19,8 GWs
Negativ: 14,6 GWs

TenneT
Positiv: 140 GWs
Negativ: 259,9 GWs

50hertz | Elia Group
Positiv: 100,4 GWs
Negativ: 231,6 GWs

- **Price Sheet Period:** The price sheet is published for a **two-year** preview period.
- **Publication Timing:** New price sheets are published **at least six months before** the current sheet expires.
- **Contract Security:** The fixed price secured at the time of bid submission applies for **the entire contract term**.

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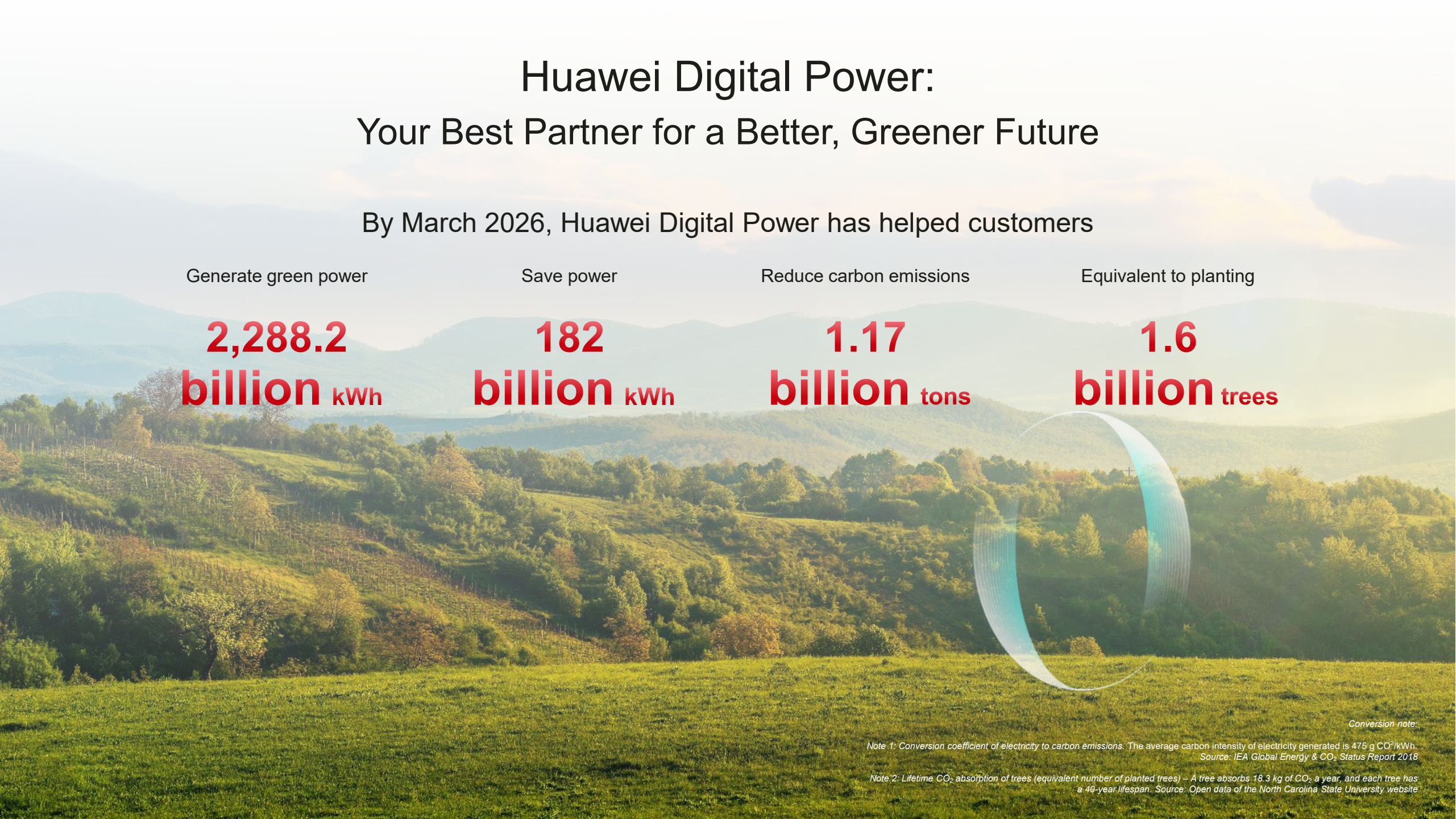
Huawei Digital Power:

Your Best Partner for a Better, Greener Future

By March 2026, Huawei Digital Power has helped customers

Generate green power	Save power	Reduce carbon emissions	Equivalent to planting
2,288.2 billion kWh	**182 billion kWh**	**1.17 billion tons**	**1.6 billion trees**



Conversion note:

Note 1: Conversion coefficient of electricity to carbon emissions. The average carbon intensity of electricity generated is 475 g CO^2/kWh.
Source: IEA Global Energy & CO_2 Status Report 2018

Note 2: Lifetime CO_2 absorption of trees (equivalent number of planted trees) – A tree absorbs 18.3 kg of CO_2 a year, and each tree has a 40-year lifespan. Source: Open data of the North Carolina State University website