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BESS IN GERMANY: 2024 REVIEW AND 2025 OUTLOOK

R² ADVISORS – INDUSTRY INSIGHTS

BESS: Enabling Germany's Energy Transition

Battery Energy Storage Systems are positioned to play a crucial role in Germany's pursuit of a Carbon-Neutral Economy and ambitious Renewable Energy goals

Introduction to BESS

Battery Energy Storage Systems (BESS) are advanced technologies designed to store energy generated from various sources, such as solar and wind, for later use. They operate by charging during periods of surplus electricity generation and discharging during periods of high demand or low generation.

Energy storage is vital for integrating renewable energy, ensuring reliability, and reducing greenhouse gas emissions. BESS stands out for its affordability, driven by technological advances and economies of scale. Its modular design offers scalability and flexibility, balancing grid supply-demand, stabilizing the system, and enabling consistent energy delivery regardless of weather conditions.

The Role of BESS in Germany's Energy Transition

As the global leader in energy transition, Germany's commitment to **achieving a carbon-neutral economy by 2045** necessitates innovative solutions to integrate renewable energy into its power grid.

Additionally, the significant growth of renewable energy in Germany, covering **52% of power consumption by 2023**, underscores the nation's commitment to achieving an **ambitious 80% renewable energy share by 2030.**

With plans to **double onshore wind capacity to 115 GW**, expand **offshore wind to 30 GW**, and **boost solar capacity to 215 GW by 2030**, the **integration of Battery Energy Storage Systems (BESS) are critical in this mission,** offering a reliable, efficient, and flexible means to manage energy supply and demand in the era of renewable dominance.

Germany's Energiewende Strategy has driven exponential growth in renewable energy capacity, especially wind and solar. However, these **energy sources are inherently variable, creating challenges for grid stability and energy reliability. This is where BESS steps in, by providing:**

- Grid Stability
- Energy Storage
- Peak Load Management
- Renewable Integration

Battery Energy Storage Systems (BESS) are the backbone of Germany's energy transition. By ensuring energy resilience, reliability, and sustainability, BESS aligns with Germany's vision for a carbon-neutral future and sets a benchmark for the global energy transition.

"Germany's success in behind-the-meter storage is a testament to its long-standing commitment to the Energiewende," *says Dr. Andreas Müller, energy economist at the German Institute for Economic Research (DIW Berlin).* ***"The combination of high electricity prices, falling battery costs, and supportive policies has created a perfect storm for BESS adoption."***

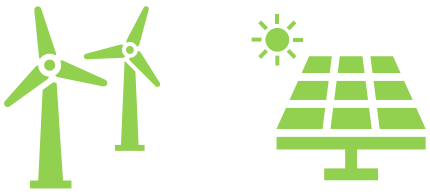
Source(s): Clean Energy Wire, Green Dealflow and Secondary Research

Unlocking the Potential Applications of BESS

Exploring Key Use-Cases of BESS to Maximize Energy Efficiency and Operational Impact

BESS is used Across the Entire Energy Landscape

Front of the meter (FTM)



Electricity Generation & Distribution

Behind the meter (BTM)

Commercial and Industrial | **Residential**

Energy Storage Applications

Generation Support and Bulk Storage Services

- Storage Services for RES Support
- Arbitrage
- RES Curtailment Minimisation
- Conventional Generation Support
- Capacity Firming
- Seasonal Arbitrage
- System Electricity Supply Capacity

Services to Support Transmission Infrastructure

- Transmission Investment Deferral
- Transmission Support
- Angular Stability

Services to Support Distribution Infrastructure

- Distribution Grid Upgrade Deferral
- Dynamic Local Voltage Control
- Reactive Power Compensation
- Contingency Grid Support
- Intentional Islanding
- Cross Sectoral Storage

Generation Support and Bulk Storage Services

- Frequency Containment Reserve (FCR)
- Frequency Stability of Weak Grids
- Automatic Frequency Restoration Reserve (aFRR)
- Black Start
- Manual Frequency Restoration Reserve (mFRR)
- Voltage Support
- Replacement Reserve (RR)
- Load Following

Generation Support and Bulk Storage Services

- End-User Peak Shaving
- Continuity of Energy Supply
- Time-Of-Use Energy Cost Management
- Limitation of Upstream Disturbances
- Particular Requirements in Power Quality
- Reactive Power Compensation
- Maximising Self-Production & Self-Consumption of Electricity
- EV Integration

Source(s): McKinsey & Company Report, European Association for Storage of Energy Activity Report 2023 and Secondary Research

Exploring the Diverse BESS Solutions in the Market

A Comprehensive Overview of the Diverse Approaches being Explored to Enhance Energy Storage Capabilities

Based on Battery Technologies

- **Lithium-ion:** Lithium iron phosphate (LFP) and nickel manganese cobalt oxide (NMC) are popular Li-ion chemistries, offering high energy density, lightweight design, rapid charging, and long lifespan.
- **Sodium-ion:** Sodium-ion batteries are a promising alternative to lithium-ion, offering cost advantages (up to 20% cheaper than LFP), improved safety, and greater sustainability, despite lower cycle life and energy density.
- **Lead Acid Batteries:** Lead-acid batteries, common in automotive and UPS applications, are affordable, recyclable, and temperature-tolerant but have lower energy density, efficiency, and shorter lifespan.
- **Flow Batteries:** Flow batteries, like vanadium redox, store energy in liquid electrolytes, offering long lifespans, quick response, low fire risk, and suitability for extended durations up to 8 hours.
- **Flywheels:** Flywheels store and release energy using kinetic motion, ideal for short-term applications like load leveling and backup power, offering quick response and high efficiency.

Sodium-ion batteries are gaining traction in the BESS market due to lower costs, improved safety, and sustainability, offering a smoother transition as lithium mining concerns and costs rise.

Based on Location of the BESS

Co-located BESS

- Lower Grid Connection cost
- Deployment near generation site
- Focus on Renewable Energy Optimisation
- Simple Integration (single-site)

Decentralised BESS

- High Grid Connection cost
- Deployment near Demand centers or grid weak points
- Focus on Grid services and flexibility
- Complex Integration (multi-site)

Based on Voltage and Power of BESS

Category	Power Range	Voltage Range	Applications	Examples
Low Voltage, Low Power	<100 kW	<1kV	Residential systems, Small commercial setups and Off-grid and backup power	TESLA POWERWALL, RESU LG Chem
Low Voltage, Medium Power	100 kW to 1 MW	<1kV	Microgrids, Small industrial applications and Local renewable integration	sonnen
Medium Voltage, Medium Power	100 kW to 10 MW	1kV to 36kV	Commercial and industrial (C&I) setups, Community storage and Renewable integration	FLUENCE Gridstack
Medium Voltage, High Power	>10 MW	1kV to 36kV	Regional grid support, Utility-scale load shifting and Ancillary services	TESLA MEGAPACK, WÄRTSILÄ
High Voltage, High Power	>10 MW	>36kV	Bulk energy storage, Renewable energy plants and Grid-scale ancillary services	FLUENCE Ultrastack

Source(s): McKinsey & Company Report, Carbon Collective and Secondary Research

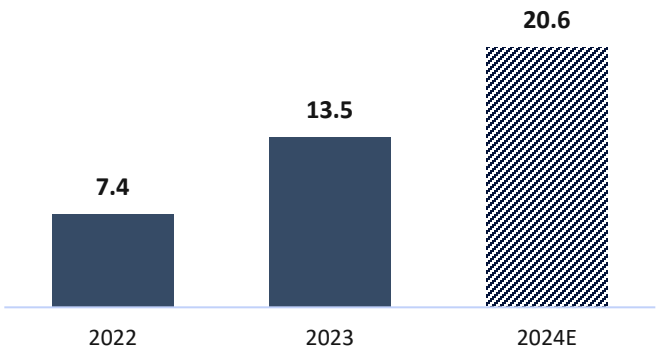
BESS Capacity across Germany and Projected Growth

Germany's BESS Capacity is Largely Dominated by Residential/Self-Consumption segment, but Grid-Scale BESS segment is Poised to See Large Growth until 2031

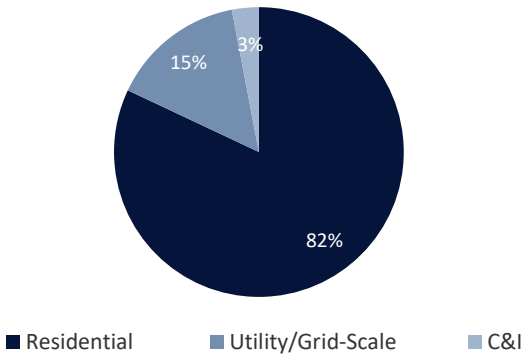
Overview

- **In 2023, Germany doubled its BESS capacity and total BESS installations hit 13.5 GWh**, a 93% rise. Residential storage led with 9.5 GWh, surging 109%, representing 70% of the total.
- **Germany led the European BESS market** in 2023, **with a 34% share**, followed by Italy at 22% and the UK at 15%.
- Germany **added 6.1 GWh of installations, in 2023** and **for 2024,** new installations are projected to grow by 17%, reaching **approximately 7.1 GWh.**
- Additionally, **Germany led Europe in residential energy storage**, installing 555,000 units (5.0 GWh) in 2023: a 166% YoY growth—**accounting for 52.6% of Europe's new installations**.
- In 2024**, Germany's four major transmission operators registered 161 GW of storage projects**, excluding distribution system operator requests, which manage electricity delivery from substations to consumers.

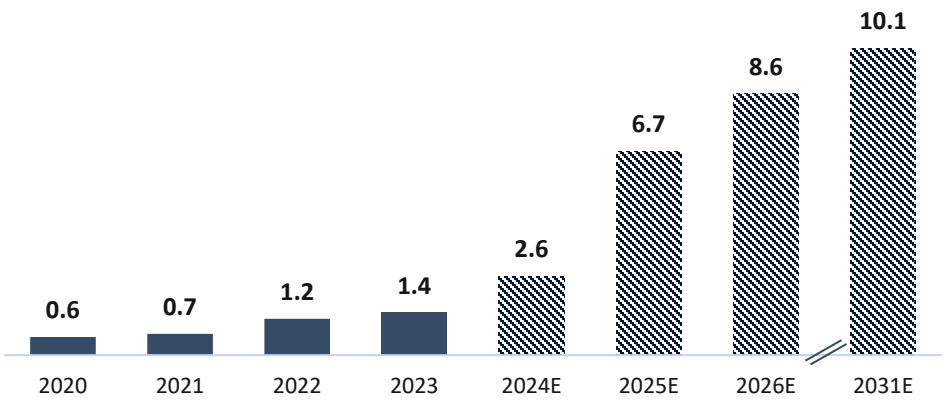
Total Installed BESS Capacity (in GWh)



Germany's BESS Installations Types (as of 2023)



Total Grid-Scale BESS Capacity and Forecast (in GWh)



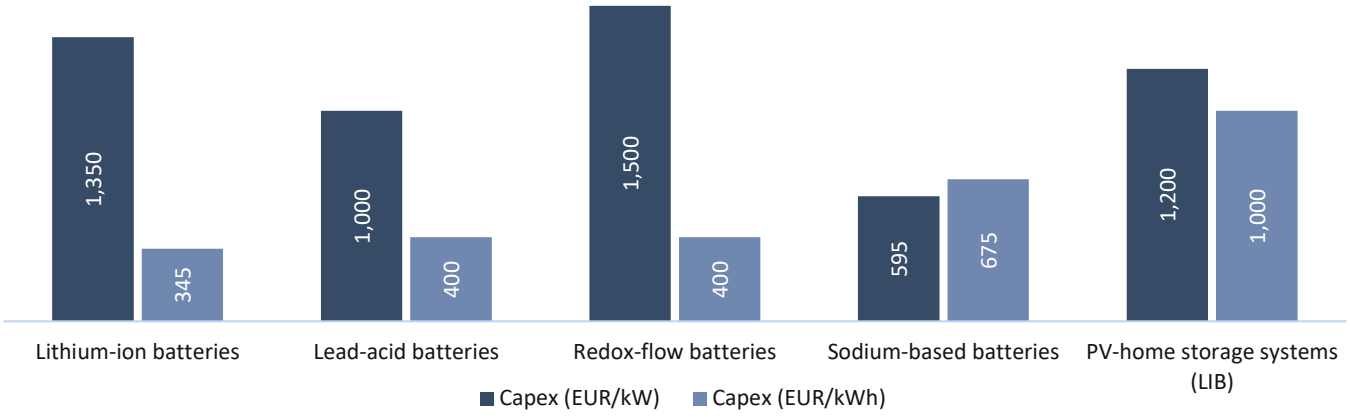
- BSW-Solar forecasts additional 7 GWh of grid-scale BESS capacity by 2026, building on 1.4 GWh installed in 2023, as per Enervis analysis
- Supported by strong EU policies, Germany will rank third in grid-scale energy storage additions (8.81 GWh) by 2031, per Wood Mackenzie.

Source(s): Green Dealflow, Solar Power Europe Report, Tamarindo Global Insights, Press Releases and Secondary Research

Economic Assessment of BESS across Europe (1/2)

Understanding the Cost Dynamics and Future Outlook of CAPEX and OPEX for BESS in Europe

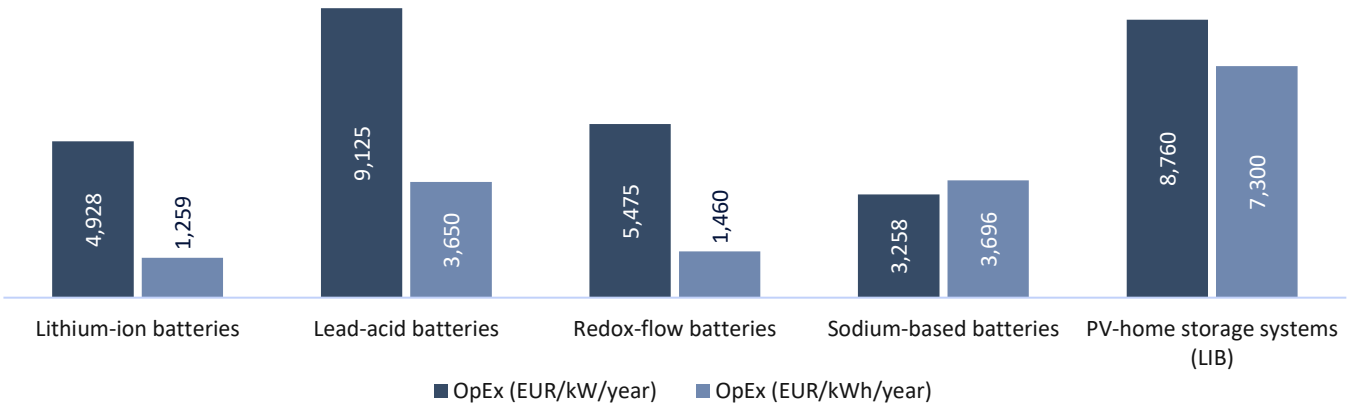
Capital Expenditures (Capex)



Battery Technology	Lithium-ion	Lead-acid	Redox-flow	Sodium-based	PV-home storage
2030 Target	240 EUR/kWh or less	250 EUR/kWh or less	100-370 EUR/kWh	< 450 EUR/kWh	250-350 EUR/kWh

- Components of Capex include Electrical Infrastructure, Generation Equipment & Infrastructure, Grid Connection costs, Installation and indirect costs, and Balance of System costs.

Operation and Maintenance (O&M) Costs



Battery Technology	Lithium-ion	Lead-acid	Redox-flow	Sodium-based	PV-home storage
2030 Target	Slight decrease	Slight decrease	Slight decrease	Slight decrease	Slight decrease
Round-trip efficiency (%)	88%	85%	70%	85%	88%

- Components of O&M costs include Fixed costs, Insurances & Taxes, General Maintenance costs, Replacements costs and Battery Augmentation costs.

Source(s): NREL, ENTEC - Energy Transition Expertise Centre Study, and Secondary Research

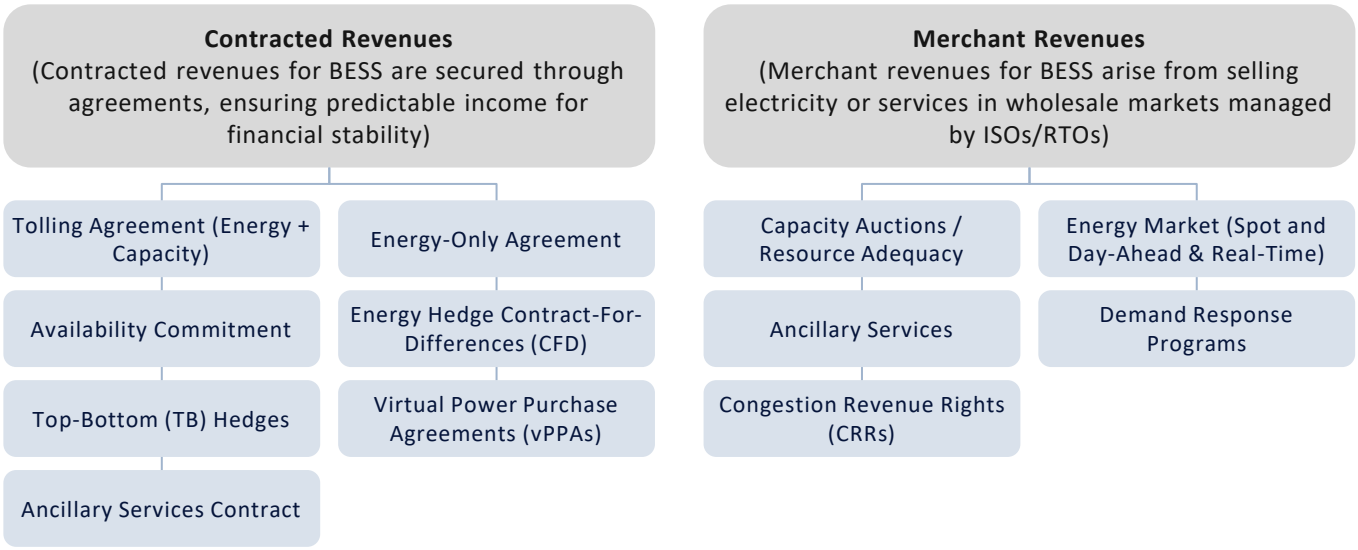
Economic Assessment of BESS across Europe (2/2)

Understanding the Revenue Models for BESS and the Importance Of Optimisers in Europe's Energy Storage Landscape

BESS Revenue Models

- **Energy Arbitrage:** BESS generates revenue by exploiting electricity price differentials: charging when prices are low (off-peak hours like 2:00–5:00 AM) and discharging during high-demand periods (7:00–8:00 PM).
- **Ancillary Services:** BESS supports grid stability through frequency regulation, voltage control, and spinning reserves, contributing to renewable energy integration. These services are traded with grid operators or platforms like PICASSO.
- **Capacity Payments:** BESS earns revenue by ensuring power availability during peak demand or grid stress. Recent auctions awarded large contracts to energy storage systems, underscoring the critical role BESS plays in bolstering energy security and market efficiency.

Based on how BESS sells its services to the market, it can be broadly divided into following 2 types:



Role of Optimisers in Ensuring Peak BESS Efficiency and Maximizing BESS Revenues

A BESS optimiser is a software or a set of tools that optimise the operation and profitability of energy storage systems. The primary goal of a BESS optimiser is to enhance the economic performance of the system by using advanced algorithms and data analytics to determine the best operational strategy in real time.

BESS optimisers use sophisticated data and algorithms to make real-time operational decisions that improve both the financial returns and technical performance of energy storage systems.

Key Functions include Energy Arbitrage, Ancillary Services, Market Participation and Bidding, Performance Efficiency, Integration with Renewable Energy, System Health Monitoring, Grid Stability and Profit Maximization

Key European BESS Optimiser Solution Providers

FLUENCE A Siemens and AES Company Mosaic™
FLUENCE A Siemens and AES Company Nispera™
AutoGrid
Entrix
enspired
athena powered by stem
enel X

Source(s): Green Dealflow, and Secondary Research