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# **BESS in Germany 2025 and Beyond:** Use Cases, Business Models and Financing Considerations

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 of power supply, 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 **55% of power consumption by 2024**, underscores the nation's commitment to achieving an **ambitious 80% renewable energy share by 2030.**

Germany's Energiewende Strategy has driven exponential growth in renewable energy capacity, especially wind and solar, 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.**

However, these **energy sources are inherently variable, creating challenges for grid stability and energy reliability.** This is why **integration of BESS are critical in this mission.**

**By providing**

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

BESS offer a reliable, efficient and flexible means to optimize energy systems, increasing the efficiency of electricity markets and contributing to smoother and more predictable electricity prices.

**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.**

**Enabling Germany's Energy Transition requires an economically sustainable model to attract necessary private capital. The following pages shall provide an overview of various technologies, use cases, revenue strategies, and how the necessary CapEx for BESS can be funded.**

*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)**

**Grid Scale Renewable Energy (RE)**

**Behind the meter (BTM)**

**C&I RE**

**Residential RE**

### Energy Storage Applications

**Renewable Integration**

- **Energy Smoothing:** BESS smooths out fluctuations from renewable energy sources (e.g., solar or wind), ensuring a steady power supply.
- **Storage for Excess Generation:** BESS stores surplus energy generated during high renewable output periods for use when renewable generation is low.
- **Microgrids and Off-Grid Systems:** Combined with renewables, BESS provides stable, continuous power in remote areas or microgrid setups.

**Energy Storage**

- **Load Shifting:** Storing energy during low-demand periods and releasing it during high-demand periods optimizes grid efficiency.
- **Backup Power:** BESS provides reliable energy storage for critical facilities during grid outages.
- **Energy Arbitrage:** Energy is stored when electricity prices are low and sold back when prices are high.

**Grid Stability**

- **Frequency Regulation:** BESS can quickly respond to fluctuations in the power grid to maintain a stable frequency.
- **Voltage Support:** By supplying or absorbing reactive power, BESS helps maintain grid voltage stability.

**Peak Load Management**

- **Demand Response:** During peak demand periods, BESS supplies stored energy to the grid, reducing the need for additional generation capacity.
- **Peak Shaving:** Reduces the load on the grid by supplying energy from the BESS during high consumption periods, lowering energy costs and demand charges for users.

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

# Exploring BESS Solutions in the Market

## An Overview of Technologies and Approaches for Application of BESS

### Based on Battery Technologies

- **Lithium-ion:** Lithium iron phosphate (LFP) and nickel manganese cobalt oxide (NMC) are li-ion chemistries, offering high energy density, lightweight design, rapid charging, and long lifespan.
- **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 a 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.
- **Sodium-ion:** Sodium-ion batteries are a promising alternative to lithium-ion and gaining traction, offering cost advantages (up to 20% cheaper than LFP), improved safety, and greater sustainability.

**With a 72.3% market share, lithium-ion batteries dominate grid scale BESS applications and are set to remain the top choice for future needs.**

### 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*

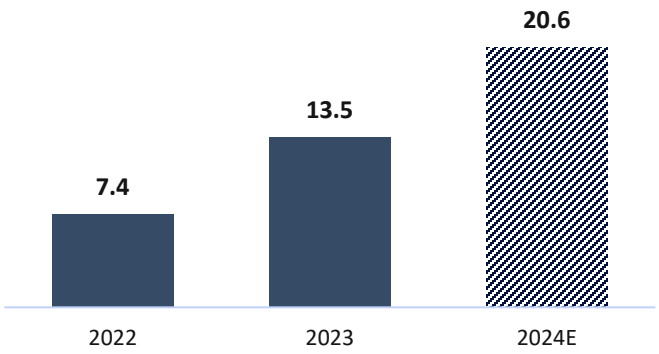
# BESS Capacity across Germany and Projected Growth

## Germany's Grid-Scale BESS segment is Poised to See Large Growth until 2031

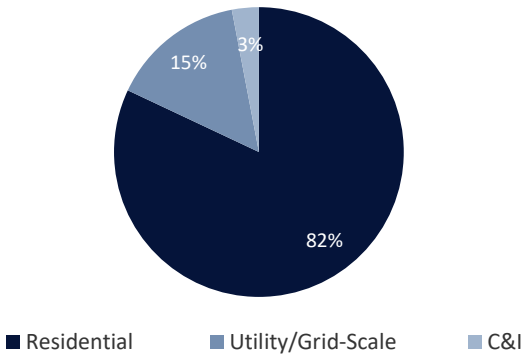
### Overview

- **By mid-2024, Germany's total BESS capacity reached 16 GWh,** which included:
  - 13 GWh residential
  - 1.1 GWh commercial
  - 1.8 GWh large-scale systems
- **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.

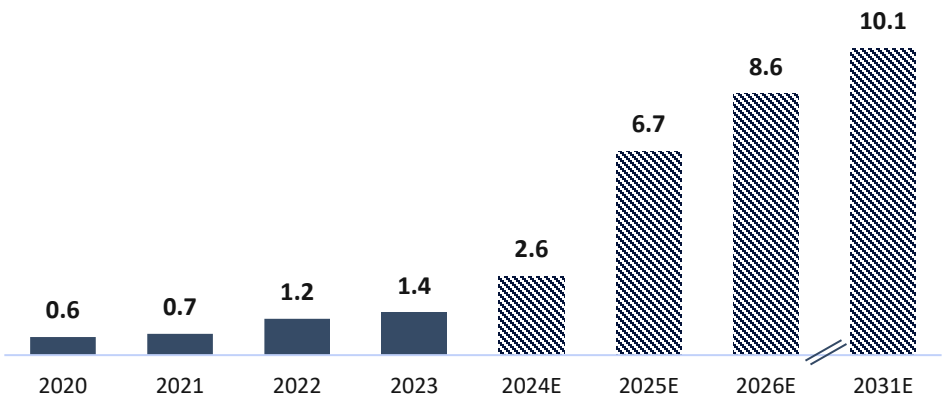
### Total Installed BESS Capacity (in GWh)




### Germany's BESS Installations Types (as of 2023)




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




- Bundesverband Solarwirschaft (BSW) forecasts additional ~7 GWh of grid-scale BESS capacity by 2026,
- 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): Bundesverband Solarwirtschaft, Green Dealflow, Solar Power Europe Report, Tamarindo Global Insights, Press Releases and Secondary Research*

# Economic Assessment of BESS (1/2)

## Understanding the Revenue Models for BESS and the Importance Of Optimisers

### BESS Revenue Models

| Revenue Model | Description | Use Cases/Applications |
|---|---|---|
| **Energy Arbitrage** | BESS earns revenue by charging during low-cost off-peak hours and discharging during high-demand, higher-priced periods. | Energy Storage, Peak Load Management |
| **Ancillary Services** | BESS ensures grid stability via frequency regulation, voltage control, and reserves, trading these services with operators or platforms like PICASSO. | Grid Stability, Renewable Integration |
| **Capacity Payments** | BESS ensures power during peak demand, securing large auction contracts, highlighting its vital role in energy security and efficiency. | Peak Load Management, Grid Stability |

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

**Contracted Revenues**
(Contracted revenues for BESS are secured through agreements, ensuring predictable income for financial stability)

- **Frequency Regulation:** A BESS can enter into a contract with a grid operator to provide real-time frequency regulation services, earning a fixed payment for stabilizing grid voltage fluctuations.
- **Demand Response:** The system can participate in demand response programs, where it is paid to reduce load or discharge energy during peak demand times as per contractual obligations.

**Merchant Revenues**
(Merchant revenues for BESS arise from selling electricity or services in wholesale markets managed by ISOs/RTOs(1))

- **Energy Arbitrage:** A BESS charges during low-cost periods, storing electricity, and discharges at high-cost times to earn a profit by exploiting the price gap.
- **Capacity Charges:** A BESS charges when demand is low and releases energy during peak periods, supporting grid stability and maximizing market returns.

German BESS revenues fell below 100 €/kW/yr in Q1'2024 due to mild winter and weak gas prices. By Q3, revenues recovered above 150 €/kW/yr, supported by market volatility and aautomatic Frequency Restoration Reserve (aFRR) fees, boosting investor interest in acquiring & developing BESS projects.

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

BESS optimisers help enhancing operation and profitability of BESS. The primary goal of its services is to enhance the economic performance of the system by using advanced AI and data analytics to determine the best operational strategy in real time.

For merchant strategies, they optimize profit through e.g., arbitrage. For contracted strategies, they ensure optimal performance to meet grid stability and ancillary service requirements under fixed agreements.

In particular smaller BESS operators might outsource the optimisation of revenue strategies and price arbitrage, while bigger operators should have the means to build the necessary capabilities in-house.

**Selective European BESS Optimiser**

enspired, uplight, Entrix, FLUENCE (A Siemens and AES Company), athena powered by stem, enel X

*Source(s): Green Dealflow, and Secondary Research*
*Note(s): (1) ISO refers to Independent System Operator, RTO refers to Regional Transmission Organization*

# Economic Assessment of BESS (2/2)

## Cost Dynamics and Future Outlook of DevEx and CapEx for Grid-scale BESS

### Development Expenditures (DevEx) and Capital Expenditures (CapEx) in Germany

- While CapEx are expected to decrease over time, though not necessarily at a similar speed as seen for solar PV modules, DevEx are assumed to stay more or less constant, given that these are mainly driven by land-costs, license and permission fees and cost of qualified human resources.
- Capex cost for a battery system includes the following components:
  - Electrical Infrastructure
  - Generation Equipment & Infrastructure
  - Grid Connection costs
  - Installation & Indirect costs
  - Owner's costs
  - Site cost

**EUR 40-60k**
DevEx Cost EUR/MW

**EUR 20-30k**
DevEx Cost EUR/MWh

**EUR 600-800k**
CapEx Cost EUR/MW

**EUR 300-400k**
CapEx Cost EUR/MWh

- Above mentioned costs are assumed to be for 2-hr 60MW (120MWh) Energy Storage System, which uses Lithium-ion Battery Technology.
- The relationship between CapEx per kW and CapEx per kWh highlights that a longer duration (time it takes to discharge a battery) reduces CapEx per kWh but increases CapEx per kW.

Based on the grid-scale capacity additions each year (2022-2031) across Germany, we have predicted the below total financing requirements:

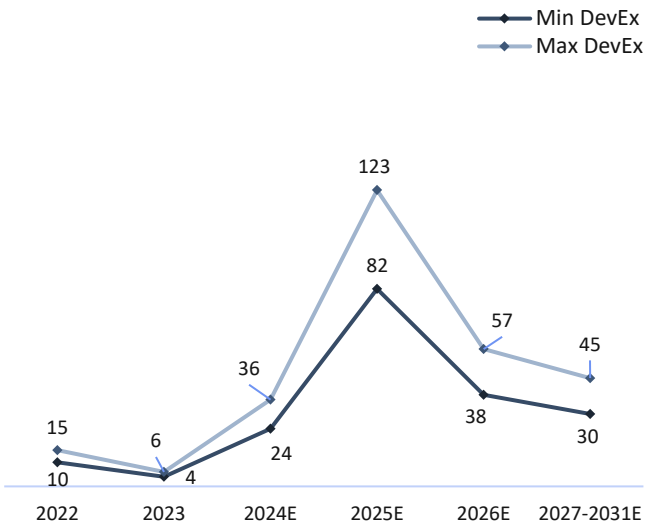
| Year | 2022 | 2023 | 2024 | 2025E | 2026E | 2027-2031E |
|---|---|---|---|---|---|---|
| **Total Financing Required (EUR m)** | **160 - 215** | **64 - 86** | **384 - 516** | **1,312 - 1,763** | **608 - 817** | **480 - 645** |

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

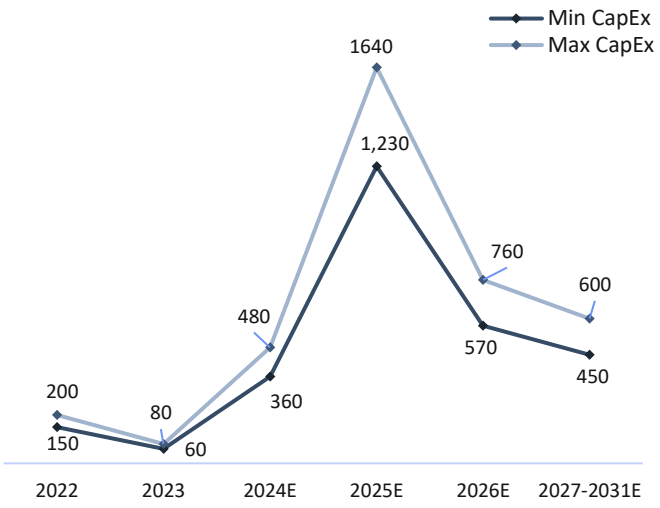
# BESS Financing in Germany (1/3)

## Rapid Expansion of of BESS Capacities Triggering Substantial Front-loaded Financing Demand

### Total DevEx Financing YTD and Forecast (EUR m)[1]

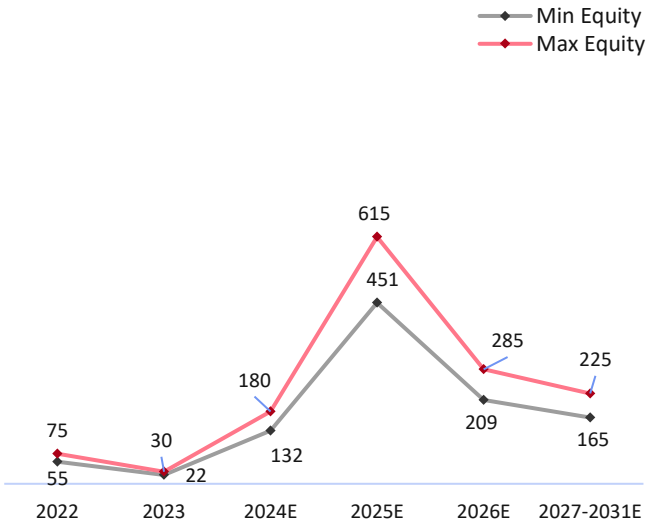


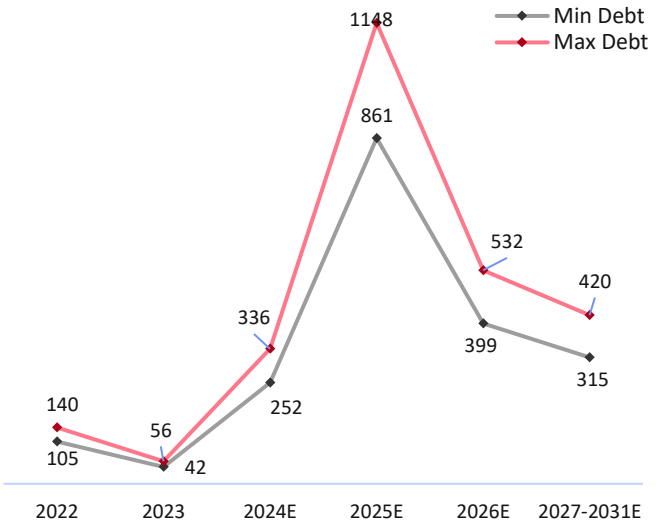

### Total CapEx Financing YTD and Forecast (EUR m)[1]




- Given the growth predicted by BSW for grid-scale BESS capacity over the next years (see page 5), developers of BESS are expected to display significant financing needs both for financing of their development activities as well as the construction of approved locations.
- In subsequent years this financing pressure should ease, though we do expect that projects and financing needs will spill over into the following years, providing for smoother but still significant financing volumes p.a.
- Based on the assumption that DevEx will predominantly be financed by equity, and applying an LtC of 70% for CapEx as often seen for solar PV, we have predicted the below capital requirements both in equity and debt.

### Equity & Debt Mix for the Financing Required (EUR m)[1]




*Source(s): NREL, and Secondary Research*
*Note(s): (1) Costs are based on Grid-Scale BESS capacity additions each year, and Proprietary Research-based costs per MWh for CapEx, and DevEx*

# BESS Financing in Germany (2/3)

## Overview of Various Types of Potential Investors Driving Growth in Germany's BESS Market

### Overview

- Grid-scale BESS battery investments offer strong returns, with internal rates of return (IRRs) typically ranging from 8% to 12%, driven by ancillary services and energy trading.
- Due to the relative infancy of BESS compared to solar PV and wind, the saturation of some institutional investors with these mature asset classes, and the yet volatile revenue profile of BESS, equity investors are not as numerous as for traditional renewable energy projects, both on the corporate equity and project equity side.
- For debt, German banks are expanding into BESS financing with both floor-protected and merchant-based debt facilities. This is helped by BESS developers getting benefits from rising demand and evolving offtake contracts, offering strong 5-to-10-year terms.
- Below is an overview over the main investor groups, their investment motivations and risk appetite.

### Private Equity Funds

- Provides capital for high-risk opportunities, such as early-stage developments, aiming for substantial returns by accepting development risks and leveraging expertise to maximize growth potential.
- Firms support investments with technical expertise and management resources, acquiring assets early in development to create value and capitalize on growth opportunities, delivering significant returns despite inherent risks. **Examples include:**

AQUILA CAPITAL, BlackRock, PARTNERS GROUP, Brookfield, MACQUARIE

### Infrastructure Funds (Equity & Debt)

- Equity investors share motivations akin to private equity funds, seeking substantial returns by taking on higher risks, such as early-stage developments or growth opportunities
- Debt investors often accept higher risks than traditional banks or asset managers, such as construction or merchant revenue risks, in exchange for elevated interest and enhanced return potential. **Examples include:**

EIFFEL INVESTMENT GROUP, ENCAVIS, Luxcara, GLOBAL INFRASTRUCTURE PARTNERS, Schroders

### Banks/Asset Managers

- These type of financial investors typically participate in a senior position within the capital structure, focusing on projects at advanced stages of development, such as construction or operational phases.
- These investors offer longer-term financing solutions with substantial debt volumes, enabling projects to meet their capital needs during later development stages. **Examples include:**

Allianz Global Investors, Hamburg Commercial Bank, NORD/LB, SwissLife Asset Managers, UniCredit

### Corporation

- Strategic equity investors seek to acquire a pipeline of projects to expand and diversify their portfolios and to supplement their product offerings through the value chain.
- They also aim to acquire in-depth development and operational expertise within the asset class, further enhancing their ability to manage, optimize, and scale renewable energy solutions. **Examples include:**

e·on, EDF, EnBW, TotalEnergies, VATTENFALL

*Source(s): Pitchbook, Timera Energy and Secondary Research*

# BESS Financing in Germany (3/3)

## An Overview of the selected BESS Transactions in 2024

| Deal Date | Target | Investor/Acquirer | Deal Description | Deal Type | Deal Size (EUR m) |
|---|---|---|---|---|---|
| Nov-24 | Terra One | S4 Energy | S4 Energy reached a definitive agreement to acquire 310 Mega Watt Portfolio of BESS Project in Germany of Terra One for an undisclosed amount on November 12, 2024. | Corporate Asset Purchase | na |
| Sep-24 | Battery Venture (VPI / Quantitas Energy) | VPI, Quantitas Energy | Quantitas and VPI have entered into an agreement to form a joint venture as of September 12, 2024. The joint venture with an aim to develop 500MW/1GWh of battery energy storage systems in Germany. | Joint Venture | na |
| Jun-24 | Joint Venture (Green Energy Storage Initiative / The Mobility House) | Green Energy Storage Initiative, The Mobility House | The company was formed as a joint venture between Green Energy Storage Initiative and The Mobility House on June 25, 2024. | Joint Venture | na |
| Jun-24 | ToRa (62 MWp Solar and 60 MW / 240 MWh Battery Storage Project in Saxony, Germany) | MET Holdings | The 62 MWp solar and 60 MW / 240 MWh battery in Saxony of ToRa was acquired by MET Holdings for an undisclosed amount on June 20, 2024. | Corporate Asset Purchase | na |
| Feb-24 | Kyon Energy | TotalEnergies | The company was acquired by TotalEnergies for an undisclosed amount on February 20, 2024. | Merger/Acquisition | 90 |

*Source(s): Pitchbook, and Secondary Research*

# About the Authors

**Dr. Stefan Bund** • Senior Advisor

Dr. Stefan has 24 years of experience in international structured finance, specializing in asset-based finance and energy transition. With a proven track record in managing transactions up to 500 million, he brings expertise in equity, DevEx, Mezz Debt, Whole Loan, and Construction Finance for Energy Transition assets

**Mohit Sharma** • Senior Associate

Mohit has 3 years of experience in capital markets and corporate financing. He specializes in developing management presentations, pitch decks, and Information Memorandums, along with conducting in-depth industry research, market studies, and building data books and financial models focused on energy transition strategies.



info@r2advisors.com

**www.r2advisors.com**

Alter Wall 32
22457 Hamburg, Germany

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