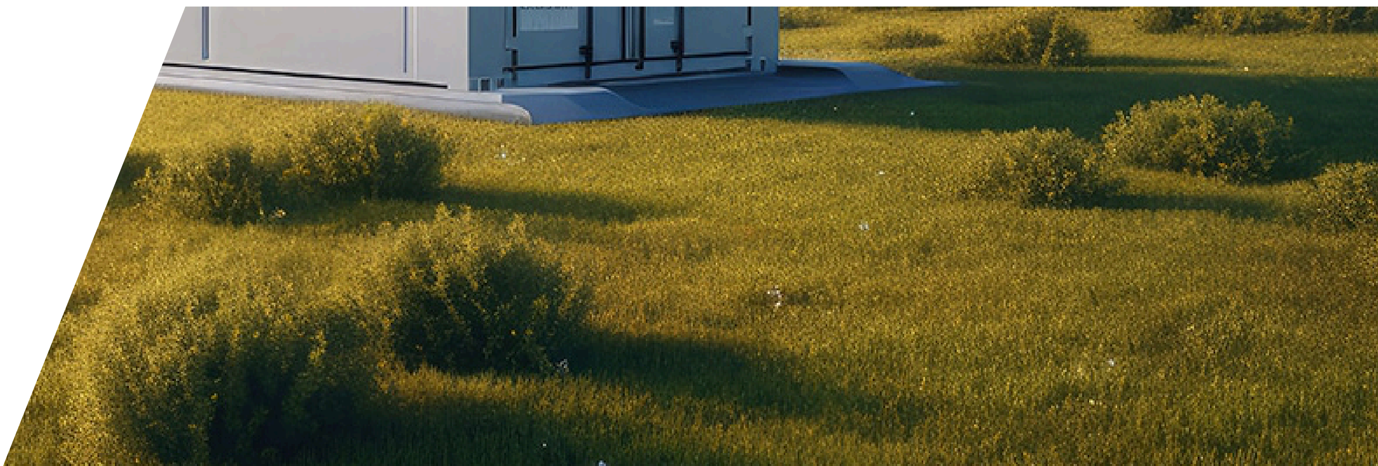
Spotlight

NUMERIS NEWSLETTER - ISSUE 4

BESS Financial Modelling



What is BESS

A **Battery Energy Storage System (BESS**) is a system that stores electrical energy in batteries for later use. The battery energy storage system comprises of the battery stack (cells and modules that store energy), the Battery Management System (BMS) (which monitors, balances, and ensures safety), and the Power Conversion System (PCS) (which converts DC to AC for grid use) among others. BES systems can function either as standalone units, or as co-located assets with solar or wind plants.

Why BESS Financial Modelling Matters

The rapid expansion of renewable energy is driving unprecedented demand for battery storage solutions. As a result, robust financial modelling is critical for BESS project success. The BESS model should factor and analyse different upfront capital and ongoing operational expenses, revenue streams, risk assessment, and key performance indicators (KPIs).
Unlike typical project finance modelling, BESS financial models must capture the unique technical-operational linkages that directly impact revenues and costs. For example, revenue stacking in BESS allows owners to optimise returns by combining multiple revenue streams, such as energy arbitrage, ancillary services, and capacity payments, within a single asset.
Modelling these opportunities requires careful consideration of how battery usage affects degradation rates and overall lifecycle performance. The financial modeller must be able to challenge whether the proposed dispatch strategy aligns with the battery's technical limits, to ensure it can reliably deliver the intended value stacking.

How the system makes money

As BESS projects become increasingly vital to grid stability and renewable integration, developers and investors must evaluate different BESS revenue strategies to help secure financing and optimize returns. Here are the primary revenue sources:

- Capacity markets: allow BESS operators to secure long-term contracts for providing grid services. Grid operators pay a fixed fee based on the system's availability, measured in dollars per kilowatt-hour per month, compensating for capacity rather than actual energy discharged.
- Energy arbitrage: Charging the BESS during periods of low electricity demand (low prices) and discharging it when demand is high (high prices).
- Ancillary services: These services refer to the income generated by BESS for supporting grid stability and reliability.

Most common ancillary services, may include:

- ✅ **Frequency Regulation:** This is the sale of or absorption of small amounts of energy to match frequency requirements e.g., 50Hz).
- ✅ **Spinning Reserve:** BESS can serve as a spinning reserve by providing immediate backup power in case of unexpected generation outages.
- ✅ **Black Start Capability:** In the event of a complete grid shutdown, BESS can supply the necessary power to restart power stations and restore normal operations.

For example, South Africa's ongoing energy shortages and week grid stability have accelerated demand for BESS as both backup solutions and stabilisation systems. To address this, the Department of Mineral Resources and Energy (DMRE) has contracted more than 2,050 MWh of storage under Bid Window 1 and a further 2,464 MWh under Bid Window 2 of the national Battery Energy Storage Systems Independent Power Producer (BESSIPP) programme. Several of these projects are expected to come online between 2026 and 2027, enhancing grid resilience and providing critical backup power during load shedding."

BESS cost structure

The cost structure of a BESS consists of several key components, categorised into capital expenditures (Capex) and operating expenditures (Opex). Understanding these costs is crucial for assessing financial viability and optimising revenue streams.

A. Capital Expenditure (Capex)

Capex refers to the upfront investment required to design, procure, and install a BESS. Major Capex components include:

- **Battery Pack:** The cost of lithium-ion, lead-acid, or other battery technology.
- **Power Conversion System (PCS):** Inverters and bidirectional converters required for DC-AC transformation.
- **Balance of Plant (BoP):** Transformers, switchgear, cables, and safety equipment.
- **Site Preparation & Installation:** Construction, civil works, electrical infrastructure, and permitting costs.
- **Grid Connection Fees:** Charges by utilities for integrating BESS into the grid.

B. Operational Expenditure (Opex)

Opex represents the recurring costs associated with operating and maintaining a BESS. Key Opex factors include:

- **Fixed O&M Costs:** Include insurance, regulatory compliance, land lease payments, legal fees, property taxes, and battery augmentation costs.
- **Maintenance Costs:** General maintenance as well as scheduled and unscheduled maintenance costs.
- **Energy Losses:** Inefficiencies due to round-trip efficiency (RTE) losses (~85-95%).

BESS Technical Parameters

When developing a financial model for a BESS, it is essential to consider key technical parameters. These parameters help forecast system performance, estimate lifetime costs, degradation, revenues and ultimately assess the overall economic viability of the project. These key parameters are as follows

Parameter	Definition
Battery Power Capacity (kW/MW)	Maximum instantaneous power a battery can discharge at any given time.
Storage Duration Hrs)	The number of hours a BESS can sustain its maximum power output before depleting its stored energy.
Storage Capacity (kWh/MWh)	Represents the total amount of energy a BESS can store and discharge in one complete cycle.
Depth of Discharge (DoD, %)	The percentage of the battery's total capacity that is discharged relative to its full capacity.
Round-Trip Efficiency (%)	Describes how much of the energy stored can be discharged. This accounts for conversion inefficiencies, self-discharge, and auxiliary power consumption.
Availability (%)	Represents the proportion of time a BESS is operational and ready to deliver energy.
Annual Degradation (%)	Refers to gradual reduction in battery's capacity and performance over a year due to usage and aging.
Cycles (#)	Total number of full charge-discharge cycles a battery undergoes.

Augmentation strategies and impact

In practice, battery operators often need to add new modules or packs during the project's lifetime to offset capacity losses caused by degradation. The chosen augmentation strategy directly impacts the project's technical performance, financial returns, and bankability.

Battery augmentation strategies can broadly be categorised into three approaches, each with distinct capital, operational, and financing implications.

- **Frequent augmentation** involves adding small amounts of capacity at regular intervals, keeping available capacity constant over time. This reduces upfront Capex compared to overbuilding but increases exposure to future battery price volatility and requires more frequent procurement and installation events.
- **Step augmentation** adds larger capacity blocks at defined milestones, offering moderate upfront costs and fewer augmentation events, with potential cost benefits if battery prices decline.
- **Overbuilding the capacity**. Overbuilding involves installing additional capacity upfront at the commercial operation date (COD) so the system can meet performance requirements throughout the contract life without future augmentation. This approach eliminates augmentation costs and reduces procurement risk but comes with trade-offs such as significantly higher initial Capex, increased insurance and maintenance expenses, and potential value erosion if battery prices fall or technology advances. Despite these risks, lenders often favour overbuilding for its predictability.

Analysing technical data

As financial modellers, we rely on technical inputs from the technical team. Robust financial modelling of Battery Energy Storage Systems starts with accurate interpretation of technical inputs.

Beyond headline figures, financial modellers add real value by analysing parameters such as capacity utilisation, daily cycling, round-trip efficiency, and degradation rates among others, then linking these to commercial outcomes. Verifying downtime assumptions, testing alternative operating profiles, and stress-testing revenues under different scenarios are all critical steps.

Different applications place very different demands on a battery. For instance, frequency response requires short-duration, shallow cycling.

Use case	Duration	DOD Profile
Frequency response	<1 hour	Very shallow DoD
Energy Arbitrage	2–4 hours	Deeper DoD
Load Shifting for Renewables	4+ hours	Medium–High

These technical characteristics directly influence which markets the battery can participate in, how revenues are structured, and what operational strategies are viable.

Understanding linkages

When incorporating technical data from engineering teams into a BESS financial model, it is not sufficient to merely transfer figures into a spreadsheet.

A robust model requires a clear grasp of the **interdependencies between technical and financial variables**, since a shift in one parameter often triggers adjustments across several others.

- **Depth of Discharge (DoD)**: Higher DoD accelerates degradation, increasing augmentation costs and shortening the financing horizon.
- **Cycling Frequency**: Even at moderate DoD, high cycling hastens wear, bringing augmentation CAPEX forward and altering long-term O&M profiles.
- **Debt Repayment Structures**: Lenders may demand faster amortisation in scenarios with intensive cycling, shifting repayment obligations to earlier years.

For financial modellers, mapping these linkages ensures that assumptions remain technically sound and commercially defensible. This creates outputs that withstand both engineering scrutiny and lender due diligence, avoiding models that misrepresent risk or overstate returns.

How to run Sensitivity Analysis in BESS Modelling

BESS financial models present unique challenges compared to wind or solar projects, where simple Excel goal seek functions or VBA macros can determine the tariff needed to achieve target returns. The interconnected nature of BESS variables requires modellers to query "If X changes, what else changes?" Maintaining an input dependency map will help show which financial model inputs are technically linked and avoids inconsistent assumptions.

This makes sensitivity analysis for BESS projects more complex compared to typical renewable energy models. Stress testing different operating strategies, requires not only the understanding of the intricate linkages, but also the ability to translate these dynamics into the model. A best practice approach would be using scenario-based assumptions, with each case tied to specific technical and operating profiles, thereby minimising errors and better capturing the interdependencies that drive project viability.

Other considerations in BESS Financial Modelling

- ✅ Discount Rates & Cost of Capital: These determine the financial feasibility of BESS projects by assessing risk-adjusted returns. BESS projects have varying risk profiles, and higher discount rates may be used due to uncertainties around revenue stability, policy shifts, and technology risks.
  Projects with long-term revenue agreements (e.g., through Power Purchase Agreements - PPAs or capacity contracts) may justify lower discount rates.
- ✅ Tax Considerations and Incentives: Tax incentives and policies significantly impact cash flow projections and overall project feasibility. These should be incorporated in the model and scenarios included.
- ✅ Financing Structure and Debt Terms: The financing structure directly affects capital costs, debt repayment schedules, and cash flow stability. Projects with stable contracted revenues (e.g., through PPAs) can secure better financing terms and lower interest rates. Merchant-based BESS projects (selling energy in wholesale markets) may face stricter financing conditions due to revenue volatility and market exposure.

Financing arrangements often include protective measures such as cash sweep mechanisms, target closing balances (structured on a $/kW or $/MW basis), shorter contract tenors, and higher debt service coverage ratios (DSCR) to mitigate lender risk exposure.

Conclusion

Battery energy storage has evolved from emerging technology to essential grid infrastructure. While investors are becoming more comfortable with merchant revenue risks, the rapidly changing BESS landscape makes revenue diversification critical. As BESS projects become increasingly complex, a robust financial model is not just an analytical tool but the foundation on which investment decisions rest. The credibility of that model depends on the expertise of the team building it, people who can translate technical parameters into financial realities, test interdependencies, and anticipate the sensitivities that matter to lenders and investors. Without that depth, assumptions collapse under scrutiny; with it, projects gain the clarity and resilience needed to attract capital and withstand changing market conditions.

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Brought to you by:

Ruben Mooneesawmy
CEO / DIRECTOR
VALUATION & FINANCIAL MODELLING
+230 59 33 1805
ruben@numeris.mu

- Fellow Chartered and Certified Accountant 15+ years in finance
- Previously at EY (Manager - corporate finance)
- 500+ hours of modelling across project finance, corporate finance and renewable energy modelling
- 25+ valuations carried out in the Indian Ocean, Eastern and Western Africa across real estate. banking and financial institution.

Gabriel Nyashanu
ASSISTANT MANAGER FINANCIAL MODELLING
(ENERGY, INFRASTRUCTURE, ENVIRONMENT)
+27 66 399 4219
gabriel@numeris.mu

- MCom., Finance – Great Zimbabwe University
- Certified FMVA analyst
- Advanced Financial Modeler (FMI Institute)
- 6+ years in financial modelling, valuation and project finance advisory in the infrastructure space (covering mostly wind farms, solar farms in South Africa)

Kame Golo
ANALYST
FINANCIAL MODELLING
+254 728 589 172
kame@numeris.mu

- Certified FMVA analyst
- MSc. Development Finance (pending dissertation) – Strathmore University
- 3+ years in financial modelling and valuation

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