



Envoltz Mobile BESS 250

250 kW / 250 kWh DC Battery Energy Storage System

Ruggedized DC Energy Storage for the Modern Microgrid

Mobile Reliable Power

Technical White Paper

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Executive Summary

Envoltz introduces the Mobile BESS 250, a ruggedized, trailer-mounted 250 kW / 250 kWh DC battery energy storage system engineered for direct integration into 800 VDC microgrids. Built around automotive-grade Lithium Iron Phosphate (LFP) battery packs with an integrated DC/DC converter, this compact system connects directly to an 800 VDC bus without the need for a grid converter or transformer.

The BESS 250 serves three primary functions within a DC microgrid: bus voltage stabilization and power buffering, energy storage for backup or load shifting, and genset load optimization to keep reciprocating engines operating within their peak efficiency band. Mounted on a DOT-compliant two-axle trailer, the system is purpose-built for field service in oil and gas, datacenter, EV charging, and other distributed generation applications.

By eliminating AC conversion stages, the BESS 250 achieves round-trip efficiencies of up to 95%, well above the U.S. utility-scale historical average of approximately 82%. This whitepaper details the system's technical architecture, integration advantages, safety features, and operational benefits.

What is a BESS?

A Battery Energy Storage System (BESS) stores electrical energy in batteries for later use. In a DC microgrid, the BESS connects directly to the DC bus, absorbing surplus energy and releasing it on demand—functioning as both a power buffer and an energy reserve.

System Overview

Envoltz specializes in the design and manufacture of ruggedized mobile electrical equipment, delivering innovative solutions for resilient energy systems. The BESS 250 is a core component of Envoltz’s modular microgrid ecosystem, designed to pair directly with Envoltz DC gensets and supercapacitor trailers.

Unlike Envoltz’s larger containerized BESS platforms (which include grid converters and transformers for AC integration), the BESS 250 is a DC-native system. It features ruggedized automotive-style LFP battery packs connected through a bidirectional DC/DC converter to an 800 VDC bus. This simplified architecture reduces component count, weight, and cost while maximizing efficiency for DC microgrid applications.

Key Specifications

Parameter	Specification
Rated Power	250 kW continuous
Energy Capacity	250 kWh usable
Nominal Bus Voltage	800 VDC
DC/DC Converter	Bidirectional, galvanically isolated
Battery Chemistry	Lithium Iron Phosphate (LFP), automotive-grade
Round-Trip Efficiency	≥95% (DC-DC)
Operating Temperature	-25°C to +55°C
Cycle Life	>9,000 cycles at 70% DoD
Platform	Two-axle trailer, DOT-compliant
Cooling	Liquid-cooled thermal management
Integration	Direct 800 VDC bus connection; compatible with Envoltz gensets, supercapacitors

Envoltz Microgrid Ecosystem

The BESS 250 operates as a building block within Envoltz’s pick-and-choose microgrid architecture. Combine with DC genset trailers (Supply), additional BESS units (Store), and supercapacitor trailers (Stabilize) to create a fully scalable, mobile power system.

Bidirectional DC/DC Converter

At the interface between the LFP battery stack and the 800 VDC bus sits a bidirectional DC/DC converter. This is the central power electronics component of the BESS 250, performing voltage regulation, current limiting, and galvanic isolation.

Voltage Regulation and Bus Support

The LFP battery stack voltage varies with state of charge (SoC), typically spanning approximately 700–900 VDC across the series-connected pack range. The DC/DC converter regulates this variable battery voltage to a stable 800 VDC bus output, maintaining voltage ripple below 1% under varying load conditions. This stable bus voltage is critical for downstream loads including inverters, EV chargers, and other DC-coupled equipment.

Bidirectional Power Flow

The converter operates in two modes. In discharge mode, it boosts or regulates battery voltage up to the 800 VDC bus to supply loads or buffer transient demand. In charge mode, it steps bus voltage down to the appropriate battery charging profile, supporting constant-current/constant-voltage (CC/CV) charging with configurable rates up to 1C. Power flow direction is managed autonomously based on bus voltage droop characteristics or via the system's energy management controller.

Efficiency

The DC/DC converter achieves conversion efficiencies of 97–98% across the operational power range. Combined with the inherent efficiency of LFP cells and elimination of AC conversion stages, the BESS 250 delivers system-level round-trip efficiency of approximately 95%. By comparison, a BESS with AC conversion (rectifier + inverter) typically achieves round-trip efficiencies in the range of 85–90%, representing a significant energy loss penalty.

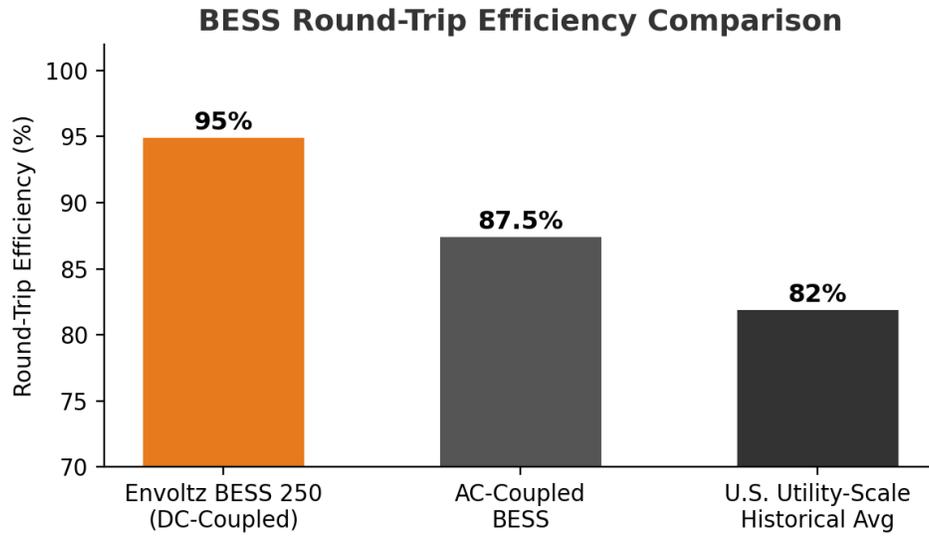


Figure: BESS Round-Trip Efficiency: DC-Coupled vs. AC-Coupled vs. U.S. Historical Average

LFP Battery System

Cell Chemistry and Construction

The BESS 250 utilizes Lithium Iron Phosphate (LFP) cells in an automotive-grade ruggedized pack configuration. LFP chemistry was selected for its superior thermal stability, long cycle life, and inherent safety characteristics. Unlike nickel-based lithium chemistries (NMC/NCA), LFP cathodes do not release oxygen during thermal runaway, substantially reducing fire risk. Individual cells are rated at 285 Ah and are configured in series and parallel to achieve the required pack voltage and capacity.

Cycle Life and Degradation

LFP cells in the BESS 250 are rated for greater than 9,000 charge/discharge cycles at 70% depth of discharge (DoD), with annual capacity degradation of less than 3%. This translates to an expected operational life exceeding 15 years under typical cycling profiles. Pack-level diagnostics and the modular design allow individual pack replacement to extend total system life beyond the initial cell warranty period, reducing the levelized cost of storage (LCOS) by an estimated 15–20% through life-extending module swaps.

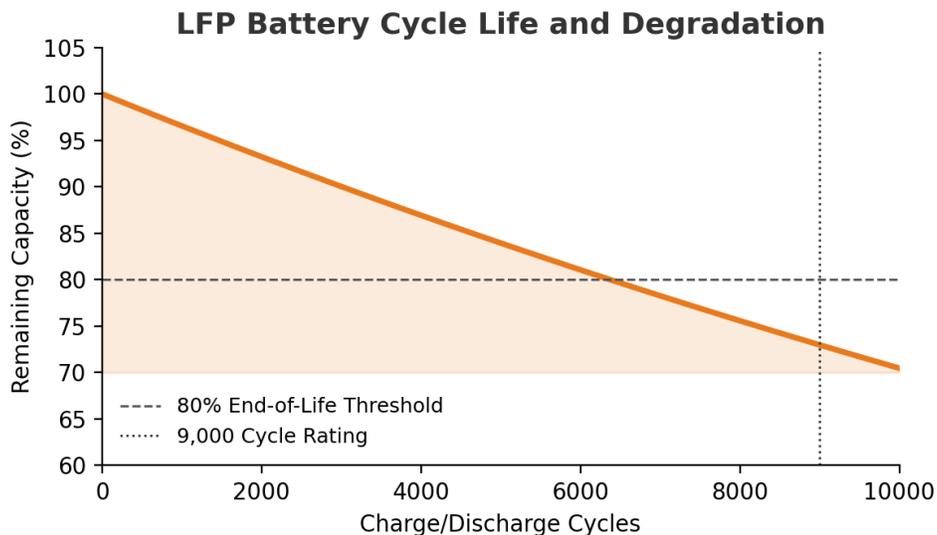


Figure: LFP Battery Cycle Life and Degradation Profile

Battery Management System (BMS)

A three-level Battery Management System monitors and controls the battery at the cell, module, and pack level. At the cell level, the BMS tracks individual cell voltages, temperatures, and balancing currents. At the module level, it manages series/parallel string health and fault

isolation. At the pack level, it governs overall state of charge (SoC), state of health (SoH), and interfaces with the DC/DC converter and external energy management system (EMS).

Communication is provided through optical fiber modules for noise-immune data transfer within the pack, with external connectivity via CAN bus and customizable protocols for integration with Envoltz or third-party EMS platforms. This enables predictive maintenance analytics and remote monitoring.

Modularity and Serviceability

Battery packs are individually replaceable using quick-connect interfaces without full system shutdown. A failed or degraded pack can be swapped in the field with standard hand tools, minimizing downtime. This modular approach supports fleet-level logistics—operators can stock replacement packs and perform maintenance without specialized equipment or factory-trained technicians.

Thermal Management

The BESS 250 employs an active liquid-cooling and heating system to maintain battery cell temperatures within the optimal operating window across the full rated ambient range of -25°C to $+55^{\circ}\text{C}$.

Cooling Architecture

A self-contained liquid coolant loop circulates through cold plates in direct thermal contact with cell modules. An on-board chiller provides active refrigeration, while a heating element ensures cold-weather operability. Liquid cooling provides significantly higher heat transfer coefficients than forced air, enabling consistent thermal distribution and eliminating hot spots that degrade cell life.

This thermal consistency enables continuous charge and discharge at full rated power (1C) without derating, even in extreme ambient conditions. Compared to air-cooled BESS designs, the liquid-cooled architecture of the BESS 250 yields 5–10% higher round-trip efficiency due to reduced thermal losses and more uniform cell temperatures.

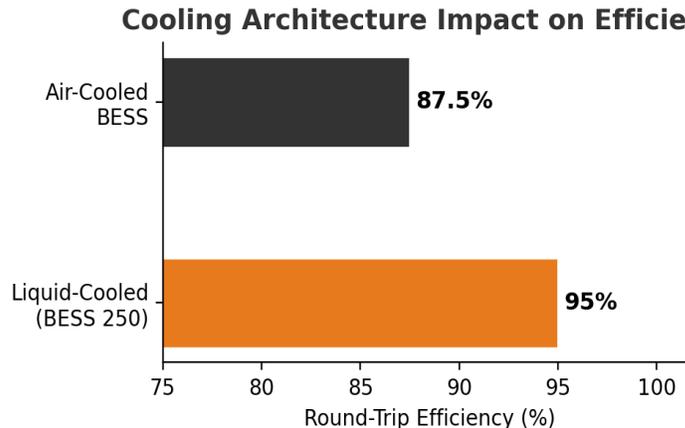


Figure: Cooling Architecture Impact on Round-Trip Efficiency

Why Liquid Cooling?

Liquids have heat transfer coefficients orders of magnitude higher than air. For high-power, high-cycle applications, liquid cooling prevents localized hot spots that accelerate cell degradation, improving both efficiency and service life.

Operational Modes and DC Microgrid Integration

The BESS 250 connects directly to an 800 VDC bus alongside Envoltz DC gensets, supercapacitor banks, and DC loads. It supports three primary operational modes, configurable through the system's energy management controller.

Mode 1: DC Bus Buffering and Voltage Stabilization

In this mode, the BESS 250 acts as a voltage-stabilizing element on the DC bus. Load transients—such as those caused by EV charger activation, motor starts, or datacenter load steps—create instantaneous power imbalances that can cause voltage sag or swell. The BESS 250's DC/DC converter responds to these transients by injecting or absorbing current to hold the bus voltage within a tight regulation band (<1% ripple when coupled with batteries). This stabilization function reduces stress on genset engines and improves power quality for sensitive downstream equipment.

Mode 2: Backup Power and Energy Reserve

The BESS 250 stores 250 kWh of usable energy, available for backup in the event of genset shutdown, fuel interruption, or planned maintenance. At full rated output (250 kW), this provides approximately one hour of backup power—sufficient to bridge to generator restart or controlled load shedding. For partial loads, runtime extends proportionally. In applications such as oil and gas wellsite operations, this energy reserve prevents costly shutdowns during gas supply interruptions. For datacenters, it provides a UPS-grade power bridge without the losses associated with AC UPS topologies.

Mode 3: Genset Load Optimization

Reciprocating engines achieve peak thermal efficiency within a defined load band, typically 75–85% of rated capacity. Operating below this band causes incomplete combustion, oil dilution, and accelerated wear. Operating above it increases thermal stress and shortens maintenance intervals. The BESS 250 enables the microgrid controller to maintain each online genset module within its optimal efficiency band by absorbing surplus generation (when load is low) or supplementing output (during short-duration peaks).

This load optimization strategy works in coordination with the genset's stepwise module activation: when aggregate load drops, the controller shuts down excess genset modules entirely and uses stored battery energy to cover the difference. When load ramps up, the BESS 250 covers the transient demand while additional genset modules start and reach operating temperature. Field testing of similar hybrid genset-BESS systems by the National Renewable Energy Laboratory demonstrated fuel use reductions of 31% and runtime reductions of 42% compared to standalone genset baselines.

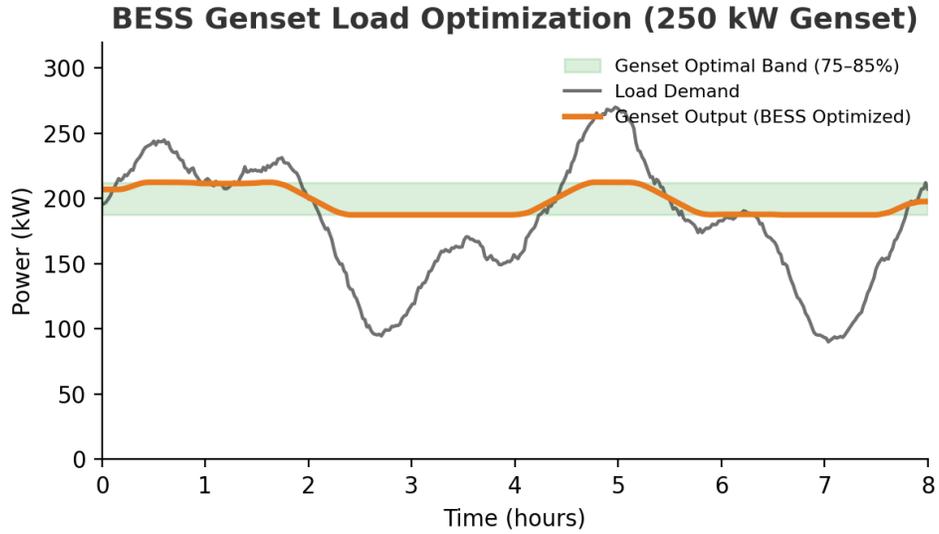


Figure: BESS Genset Load Optimization: Maintaining Engines in Peak Efficiency Band

Peak Shaving with BESS

The BESS 250 absorbs load peaks (e.g., 100% overload for 10 seconds), allowing 20–60 seconds for additional genset engines to start. Post-peak, batteries recharge at optimal rates (0.5–2C for LFP), minimizing losses (<5%). Round-trip efficiency: 92–95%.

Advantages of DC-Native Architecture

The BESS 250 is designed exclusively for DC bus integration, eliminating the grid converter and transformer required by AC-coupled BESS platforms. This DC-native architecture provides several engineering and economic advantages.

Elimination of AC Conversion Losses

In an AC-coupled BESS, energy passes through a rectifier (AC→DC) during charging and an inverter (DC→AC) during discharge, with each conversion stage incurring 2–5% losses. Additional losses occur in the step-up/step-down transformer. The BESS 250 avoids these conversion stages entirely, with only the DC/DC converter in the power path. Overall system efficiency reaches 96–98% in DC-coupled mode versus 90–92% for AC-coupled configurations. In BESS cycling applications, this avoids the double conversion penalty, saving 5–10% energy per cycle.

Simplified Paralleling

DC systems eliminate the need for phase synchronization, frequency matching, and reactive power management that complicate AC paralleling. Multiple BESS 250 units connect to a shared 800 VDC bus using droop control, with no active synchronization hardware required. This simplifies system expansion—additional BESS trailers can be added or removed from the bus without reconfiguring protection schemes or synchronization equipment.

Reduced Component Count, Weight, and Cost

By eliminating the grid converter (inverter/rectifier) and transformer, the BESS 250 reduces system weight, physical footprint, and capital cost compared to an equivalent AC-coupled system. This weight reduction is what enables the compact two-axle trailer format. Capital expenditure reduction from bypassing inverters and transformers is estimated at 15–20%, with additional OPEX savings from fewer components requiring maintenance and lower thermal management loads.

Enhanced Safety

DC systems present lower arc flash energy than equivalent AC systems, reducing hazard severity in enclosed or mobile installations. Galvanic isolation provided by the DC/DC converter prevents fault propagation between the battery bank and the bus, and DC protection devices (fuses, disconnects) are simpler and faster-acting than their AC equivalents in this voltage class.

DC vs. AC BESS Comparison

Parameter	BESS 250 (DC-Coupled)	AC-Coupled BESS
Round-Trip Efficiency	≥95%	85–90%
Conversion Stages	1 (DC/DC)	3+ (DC/DC + Inverter + Transformer)
Paralleling Method	Droop control on DC bus	Phase synchronization required
Arc Flash Risk	Lower	Higher
Grid Converter Required	No	Yes
Transformer Required	No	Yes
Relative CAPEX	Lower (15–20% savings)	Baseline

Safety Features

The BESS 250 is engineered for operation in demanding and potentially hazardous industrial environments. Safety features span the cell, module, pack, and system levels.

Thermal Runaway Resistance

LFP chemistry provides inherent resistance to thermal runaway. The olivine crystal structure of the LFP cathode does not release oxygen during decomposition, eliminating the oxidizer that drives cascading thermal events in NMC and NCA chemistries. The system is designed to UL 9540A test standards for thermal runaway propagation resistance.

Fire Suppression

Integrated temperature sensors monitor each module continuously. In the event of an over-temperature condition, aerosol-based fire suppression agents deploy automatically to contain the event within the affected module, preventing propagation.

Enclosure Protection

Battery modules are rated to IP66 for dust and water ingress protection, housed within a ruggedized enclosure with C5 corrosion resistance for harsh industrial settings. Overcurrent fuses and DC disconnect switches provide fault isolation at the string and pack level.

Standards Compliance

The system is designed for compliance with UL 9540 (Energy Storage Systems), UL 9540A (Thermal Runaway Fire Propagation), IEC 62477-1 (Power Electronic Converter Systems Safety), and applicable OSHA and NFPA regulations for industrial battery installations.

Trailer Platform and Mobility

The BESS 250 is built on a DOT-compliant two-axle trailer platform, engineered for over-the-road transport by standard Class 5 truck. The two-axle configuration keeps the system within standard highway weight limits while providing a lower profile and tighter turning radius than the larger three-axle platforms used for containerized BESS systems.

All components—battery packs, DC/DC converter, thermal management system, BMS, and safety equipment—are pre-integrated on the trailer and factory-tested as a complete system. Field connections are limited to DC bus cables and communication links, minimizing on-site integration effort.

For applications requiring more than 250 kW / 250 kWh, multiple BESS 250 trailers parallel directly on the 800 VDC bus. This modular scaling approach allows operators to match energy storage capacity precisely to site requirements, adding or redeploying trailers as needs evolve.

Key Market Applications

Oil and Gas

Remote wellsite and fracking operations require reliable power in locations without grid access. The BESS 250 pairs with Envoltz DC gensets to optimize fuel consumption, reduce engine wear, and provide backup power during gas supply interruptions. The trailer format supports relocation between pads as drilling programs progress. In flaring gas recovery applications, the BESS 250 stores excess energy from variable gas supply, smoothing output to connected loads.

Datacenters

Hyperscale and edge datacenters increasingly adopt DC power distribution to reduce conversion losses. The BESS 250 integrates directly with DC power distribution units (PDUs), providing UPS-grade backup without the double conversion losses of traditional AC UPS systems. For facilities with DC bus architectures, overall efficiency gains of up to 28% have been reported compared to equivalent AC-distributed systems. Multiple BESS 250 units can be paralleled to match the power and energy requirements of the facility.

EV Charging Depots

EV charging loads are inherently high-peak, intermittent, and DC-native. The BESS 250 buffers charging demand, shaving peaks that would otherwise require oversized genset capacity or grid connections. In off-grid or constrained-grid locations, the BESS enables fast-charging capability that would not be possible from generation alone. The system's DC architecture eliminates the AC→DC conversion stage at the charger input, improving net charging efficiency.

Conclusion

The Envoltz Mobile BESS 250 delivers a focused, efficient solution for DC microgrid energy storage. By pairing ruggedized automotive-grade LFP batteries with a high-efficiency bidirectional DC/DC converter on a compact two-axle trailer, the system eliminates the complexity and losses of AC conversion while providing critical bus stabilization, backup energy, and genset optimization functions.

With round-trip efficiencies of 95%, cycle life exceeding 9,000 cycles, and full operability from -25°C to $+55^{\circ}\text{C}$, the BESS 250 is engineered for the demands of oil and gas, datacenter, EV charging, and other distributed power applications. Its modular, scalable architecture allows operators to deploy exactly the capacity they need, when and where they need it.

Contact Envoltz for customized configurations and deployment planning.

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Company

Envoltz has been producing mobile battery power solutions since 2015 for a variety of industrial and utility customers. Envoltz's core strength comes from its ability to provide development and deployment of custom electrical and mechanical solutions. Many Envoltz products, such as cable pullers and wireline units, are turnkey products. For special projects, Envoltz collaborates with other manufacturers to integrate Envoltz products into the customer's existing design.

Envoltz also integrates batteries and other components into independent or semi-independent power networks at the request of customers. This specialized approach promotes flexibility and modularity, with systems converting, storing, and supplying energy on demand. Envoltz staff can address the customer's most complicated power problems.

100% U.S. Workforce

The U.S. Department of Energy identifies growth of the power electronics industry within the U.S. and allied nations as a critical strategic goal. Envoltz supports this goal with a 100% domestic workforce.