Envoltz Mobile DC Genset

Natural Gas DC Generator System

250 kW Modular Genset Modules | 800 VDC Output | Up to 2.5 MW per Trailer

Mobile Reliable Power

Technical White Paper

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Executive Summary

This technical whitepaper presents the Envoltz natural gas genset, a state-of-the-art modular power generation system designed for high-power applications in demanding sectors such as oil and gas, datacenters, and electric vehicle (EV) charging depots. Engineered with a focus on efficiency, reliability, and modularity, the genset leverages direct current (DC) output to simplify integration with battery energy storage systems (BESS) and supercapacitors, enhance safety and stability, and reduce energy losses.

By employing multiple smaller reciprocating engines rather than larger units, the system optimizes maintenance, parts availability, and operational flexibility. Integrated battery optimization ensures engines operate at peak efficiency, with dynamic load management and cold-start readiness.

Compared to diesel counterparts, natural gas engines offer superior fuel cost savings, reduced maintenance needs, and enhanced reliability. Mounted on DOT-compliant trailers for individual or fleet deployment (up to 2.5 MW per trailer), the genset provides scalable power delivery tailored to remote and critical infrastructure needs. Drawing on engineering principles, performance data, and market analyses, this paper demonstrates how the Envoltz genset addresses key challenges in distributed energy generation, achieving enhanced fuel savings and system efficiency.

What is a Genset?

Most electrical energy used today enters the grid through a generator. Generators convert mechanical energy to electrical energy. Without some source of mechanical energy, generators cannot operate. One way to create this mechanical energy is to use an engine. Gensets combine a generator and engine in a single unit, converting fuel into electricity.

System Overview

Envoltz specializes in the design and manufacture of ruggedized mobile electrical equipment, delivering innovative solutions for resilient energy systems.

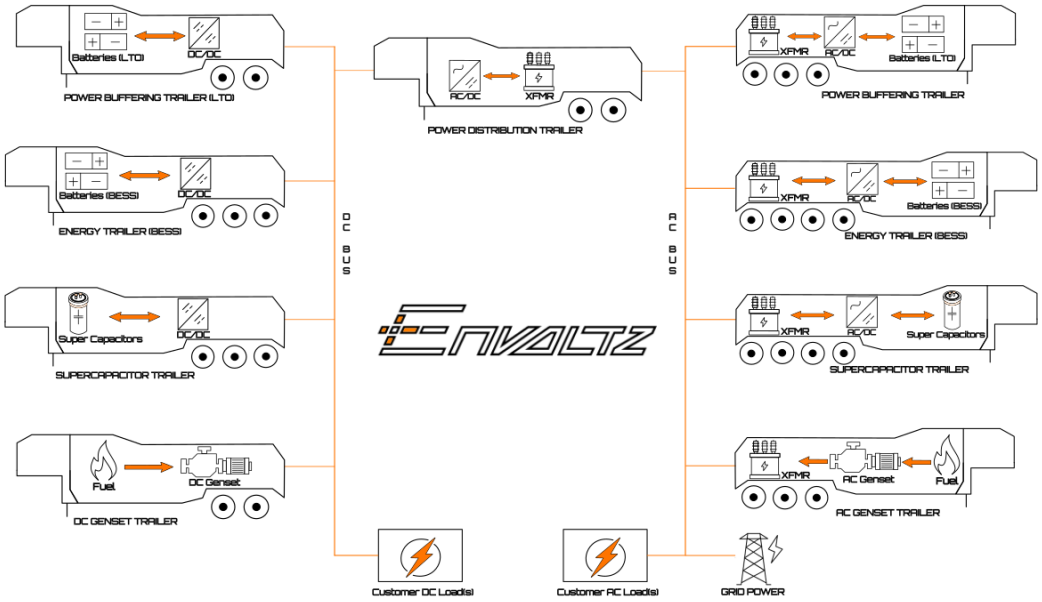

Figure: Envoltz's Modular Customizable Microgrid Environment

Envoltz's power ecosystem features a pick-and-choose style microgrid structure, providing world-class flexibility and portability. Of these portable products, this paper focuses on the DC genset trailer. This genset system represents a pinnacle of this expertise, combining multiple natural gas engines with generators (genset modules) to produce continuous power, scalable to customer needs.

Multiple modules fit on a single mobile platform for expanded capacity. These supply up to 250 kW each, with 800 VDC output. This voltage level optimizes compatibility with most modern DC loads, increasing efficiency by reducing conversion losses. Systems can support other voltage levels to accommodate specific load profiles.

Modular architecture allows seamless paralleling of multiple units to scale from 250 kW to multi-megawatt systems, addressing power demands in off-grid, behind-the-meter (BTM) applications.

Key Specifications

Parameter	Specification
Engine	250 kW natural gas (up to 10 per trailer)

Parameter	Specification
EPA Classification	Not subject to EPA Tier 4 requirements
Output Voltage	800 VDC (optional conversion to standard voltages, AC or DC)
Thermal Efficiency	Up to 35% at optimal load (75–85% capacity)
Module Activation	Stepwise, predictive algorithm-based
Scalability	250 kW to 2.5 MW per trailer; trailers parallel for higher capacity
Platform	Trailer-mounted, DOT-compliant
Integration	Native support for Envoltz BESS, supercapacitors, and additional gensets
Operating Temperature	−40°C to +55°C (with cold-start readiness)

Envoltz Microgrid Ecosystem

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

Advantages of DC Power Output Over AC

Direct current (DC) power generation offers inherent engineering benefits over alternating current (AC) in modern distributed energy systems, particularly for high-voltage, high-power applications like the Envoltz genset. Traditional AC generation requires synchronization of phase and voltage for paralleling, introducing complexity and potential instability. In contrast, DC output simplifies these aspects, enabling efficient, stable, and safe operation.

AC vs DC

Two forms of electrical power are available today: alternating current (AC) and direct current (DC). Direct current (as in a battery) is the simplest form of electrical power, with charge flowing in one direction only. Alternating current (as in a wall outlet) reverses direction several times per second (60 cycles per second in the US). See Envoltz's publication Fundamentals for the Non-Technical Professional for more.

Ease of Paralleling Units

DC systems eliminate the need for phase synchronization, allowing plug-and-play paralleling via simple DC bus connections. For the Envoltz DC genset, multiple units can be connected in parallel with droop control and no active synchronization hardware required. This simplifies system expansion—additional genset trailers can be added or removed from the bus without reconfiguring protection schemes or synchronization equipment.

Safety Enhancements

DC offers a more stable, predictable, and controllable electrical environment, particularly in mobile, enclosed, or high-risk settings. DC systems present lower arc flash energy than equivalent AC systems, reducing hazard severity. Galvanic isolation between power sources prevents fault propagation, and DC protection devices (fuses, disconnects) are simpler and faster-acting than their AC equivalents in this voltage class.

Stability and Load Handling

DC output provides inherent voltage stability, free from AC's reactive power issues. The Envoltz genset minimizes voltage ripple (<1% when coupled with batteries) under varying loads, ideal for sensitive electronics. Stability is enhanced in hybrid systems: DC enables direct connection to BESS, supporting frequency-agnostic operation. For transient loads, DC buses offer more consistent responses than their AC counterparts.

Efficiency Gains

DC-only operations eliminate AC conversion losses. For the Envoltz genset, overall efficiency increases for many loads, including BESS charging. Fully DC systems eliminate the need for

bulky transformers or synchronization equipment. Overall efficiency reaches 96–98% in DC-coupled mode, compared to 90–92% for AC generators with rectifiers. In BESS applications, DC avoids the double conversion penalty, saving 5–10% energy per cycle. Field data from utility-scale projects confirm DC systems reduce operational costs by 15–20% over AC equivalents. This equates to potential efficiency gains of 19–20% for commercial/manufacturing and up to 28% for datacenters [1].

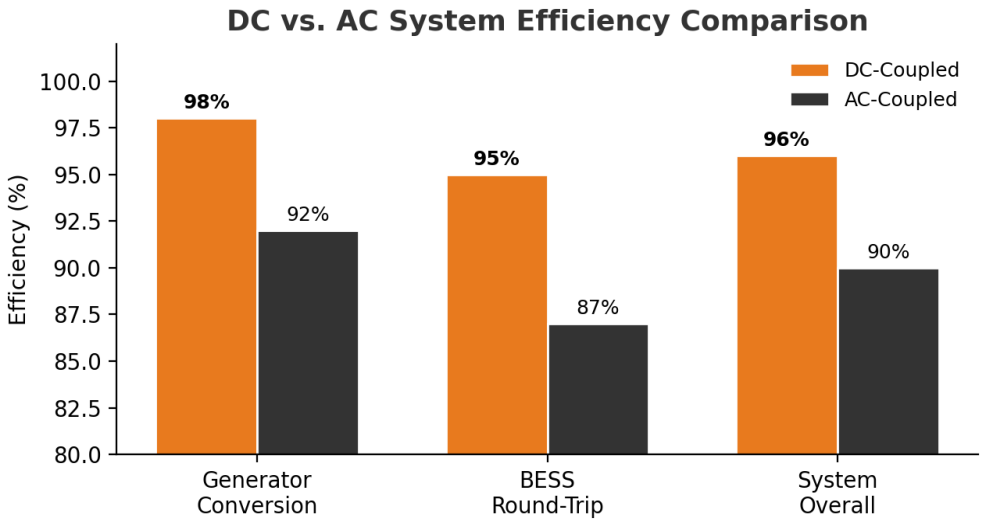

Figure: DC vs. AC System Efficiency Comparison

DC vs. AC Genset Comparison

Parameter	Envoltz DC Genset	AC Genset
System Efficiency	96–98%	90–92%
Conversion Stages	Direct DC output	Generator + Rectifier + Transformer
Paralleling Method	Droop control on DC bus	Phase synchronization required
Arc Flash Risk	Lower	Higher
Synchronization Hardware	Not required	Required
Transformer Required	No	Yes
Reactive Power Management	Not applicable	Required

Benefits of Modular Design

For megawatt-sized power demands, either bulky multi-megawatt gensets can be used, or multiple 250 kW genset modules. Envoltz's genset solution favors multiple movable genset modules over a single larger engine for equivalent power. This approach increases operational range with reduced logistics, reduces training overhead, and improves load-shifting efficiency.

This modular approach leverages economies of scale in manufacturing and maintenance, addressing practical engineering challenges. This increase in reliability translates to reduced cost in time and money while offering increased reliability.

Scalability

Use of uniform DC modules makes combining several units to increase power to the required level straightforward. Each module provides up to 250 kW, with up to 10 fitting on a single trailer (2.5 MW). Trailers can be paralleled in the field to increase capacity further, enabling multi-megawatt systems with no single point of failure.

Commonality and Parts Availability

Standardized engines produced in high numbers ensure global parts availability. Multiple suppliers stock components, reducing lead times and logistical burdens for maintenance. This can reduce maintenance downtime from several weeks or more down to a matter of hours with a common spare parts reserve.

Ease of Maintenance and Reduced Specialization

Standardized components generally require standard tools and mechanics trained on ubiquitous platforms, eliminating the need for certified specialists. For example, larger engines might require maintenance personnel trained to a higher level, such as to ASME Level III. This would decrease availability and drive up costs.

Simplified Replacement

Individual lightweight modules enable replacement with standard forklifts. Larger engines, being much heavier, necessitate heavy-lift equipment. Furthermore, modularity enables fast subunit swapping, maximizing uptime in paralleled systems.

Load Management Strategy

For demands below full capacity, excess engines shut down, reducing fuel consumption and engine wear by 20–30% in some conditions. Load management prevents low-load running, which would cause increased wear in a single larger engine due to incomplete combustion and

oil dilution from running outside the optimal load band [2]. System controls use predictive algorithms based on load profiles, ensuring seamless transitions.

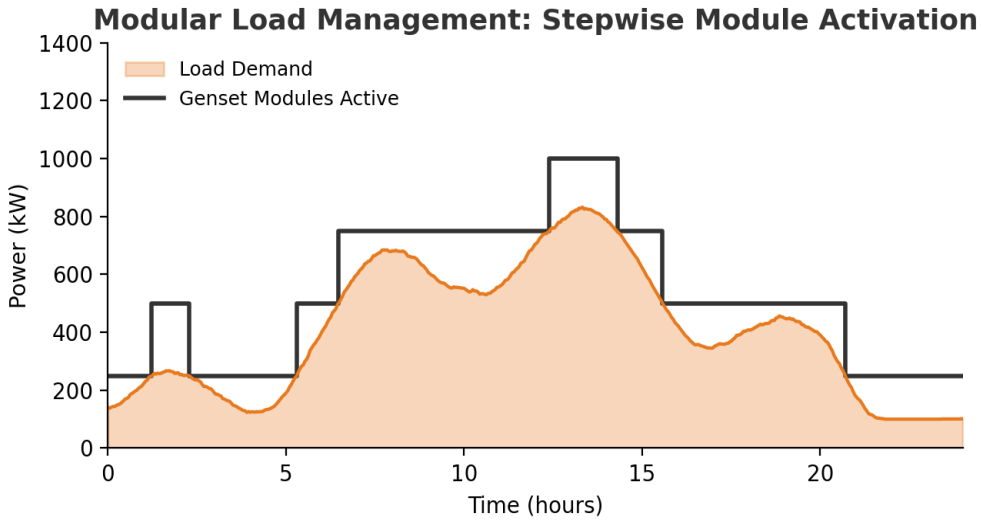

Figure: Modular Load Management: Stepwise Module Activation Over a 24-Hour Load Profile

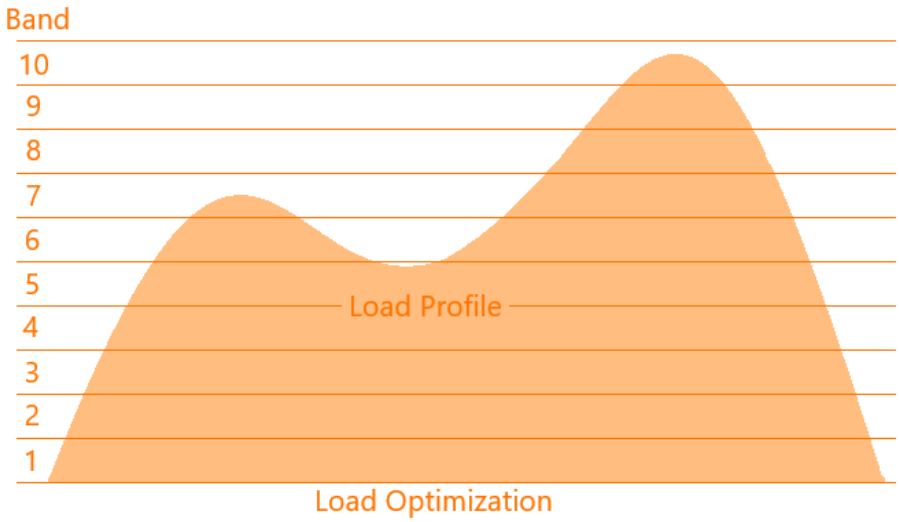

Figure: Genset Module Load Band Optimization

BESS Peak Shaving and Load Truncation

Envoltz provides an inclusive microgrid environment tailored to specific power requirements. Combination with Envoltz's BESS unit enables load band truncation, allowing continuous optimization of genset subunits. BESS units also provide additional capacity to handle short-duration surges, reducing genset wear.

BESS absorbs peaks (e.g., 100% overload for 10 seconds), allowing time (20–60 seconds) to start additional engines. Post-peak, batteries recharge at optimal rates (0.5–2C for LFP/LTO), minimizing losses (<5%). Round-trip efficiency: 92–95%. For a similar hybrid system built by the

Department of Energy, fuel use and run time were reduced 31% and 42% from baseline, respectively [3].

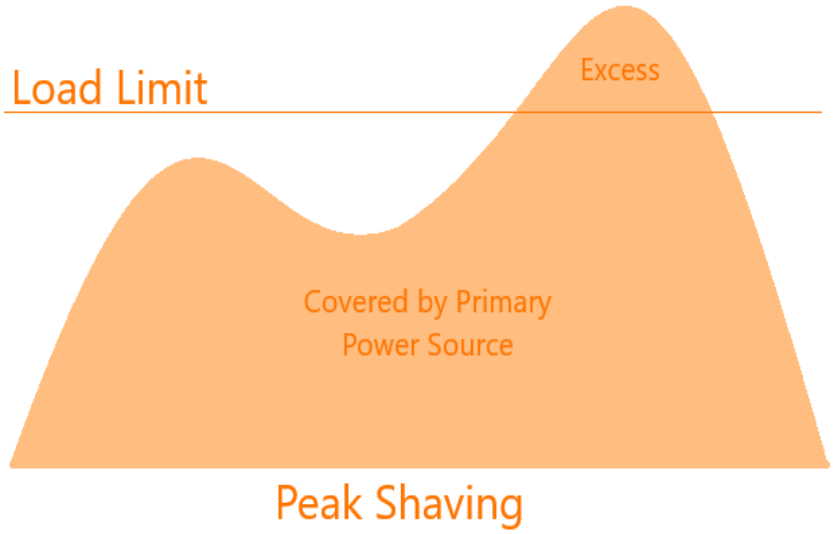

Figure: Optional BESS Integration for Peak Shaving and Load Management

Peak Shaving with BESS

Addition of Envoltz's mobile battery energy storage system (BESS) enables peak shaving without load shedding and enhances fractional module power efficiency. The BESS absorbs transient overloads, allowing genset modules to start incrementally while maintaining continuous power delivery.

Trailer Platform and Mobility

The Envoltz DC genset is built on DOT-compliant trailer platforms engineered for over-the-road transport by standard Class 8 tractor. Trailer-mounted deployment offers logistical and operational superiority for a range of markets.

Modular Design for Mobility

Envoltz's modular design enables precise balancing of power output with weight constraints, making it ideal for deployment in remote and austere environments. Each portable unit can be scaled to meet specific energy demands while remaining within transportable weight limits, allowing access to locations where infrastructure is minimal or terrain is challenging. This adaptability ensures reliable power delivery without overburdening logistical operations, supporting critical systems in a wide variety of environments.

Fuel Choice: Natural Gas vs. Diesel

Most distributed generation uses natural gas or diesel fuel. Important differences between these fuel types are: reliability, cost, and emissions. Natural gas engines generally outperform diesel in these categories, making them ideal for power generation.

Reliability

Nationwide data shows natural gas generators outperform diesel in terms of reliability. Natural gas generally does not share the same challenges of diesel. Spark ignition, as used with natural gas, does not exhibit the same problems with particulate buildup, reducing maintenance intervals.

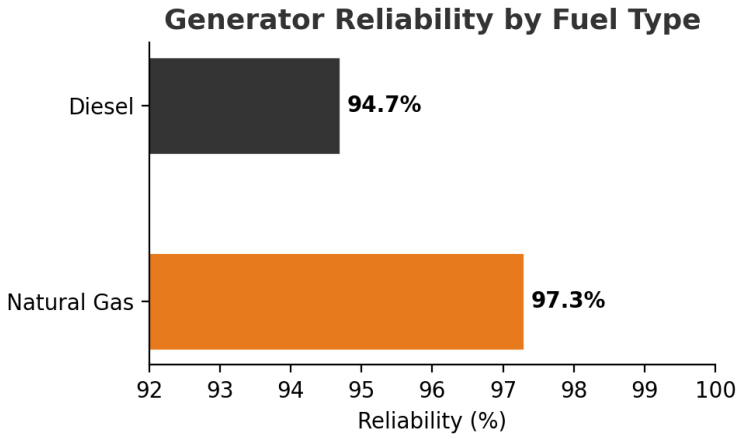

Figure: Generator Reliability by Fuel Type (U.S. Average) [4]

Cost

Energy cost efficiency, price per unit of energy generated, is typically lower for natural gas compared to diesel. Without considering fuel costs, diesel systems cost marginally less than natural gas generation. However, including logistics and the cost of fuel consumption, natural gas easily outperforms diesel as operating hours increase.

Pipeline or bulk delivery infrastructure further enhances the practicality and cost-effectiveness of natural gas-based generation. One notable efficiency advantage in the oil and gas industry is the recovery of flaring gas, turning a waste product into free productive value.

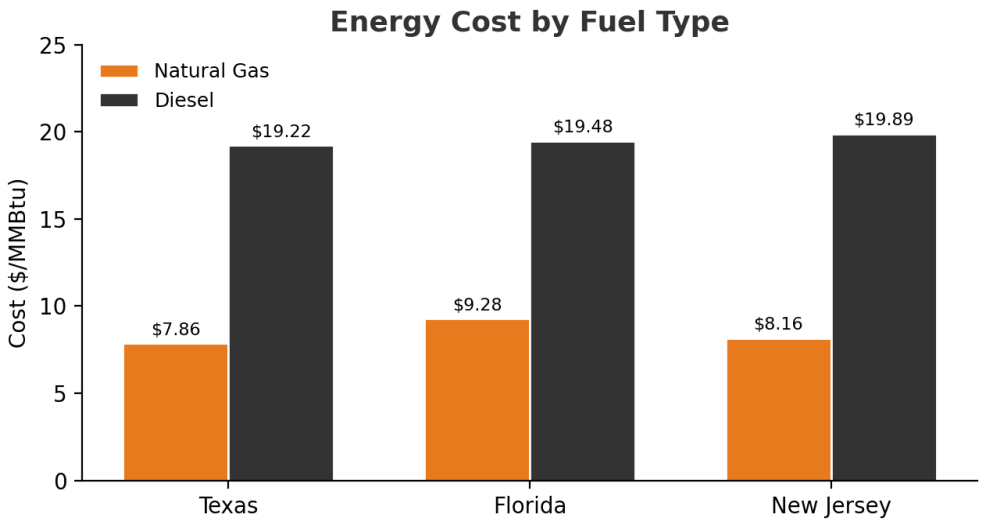

Figure: Energy Cost by Fuel Type by Region [4] (Note: does not include additional cost of ultra-low sulfur diesel required by EPA)

While initial capital investment for a natural gas system can be marginally higher, cost savings in maintenance, logistics, and fuel reduce total cost of ownership by as much as 27%.

Emissions

A natural gas genset regulated under 40 CFR Part 1048 offers clear advantages in emissions compliance over a diesel genset under 40 CFR Part 1039. Use of diesel fuel for mobile power requires specially processed fuel—Ultra Low Sulfur Diesel (ULSD)—EPA Tier 4 compliance, diesel particulate filtering, and selective catalytic reduction [5]. Natural gas, which burns cleaner, is not subject to those measures [6].

Characteristic	Natural Gas	Diesel
EPA Regulation	40 CFR Part 1048	40 CFR Part 1039
Tier 4 Compliance	Not required	Required
Particulate Filtering	Not required	Required (DPF)
Selective Catalytic Reduction	Not required	Required (SCR)
Fuel Processing	Standard pipeline gas	Ultra Low Sulfur Diesel (ULSD)
CO_2 Emissions (relative)	Lower	Higher

Cold-Start Readiness

Prewarming generating units plays a critical role in maintaining mechanical reliability and ensuring successful cold-weather readiness [7]. During cold weather operations, idle engines are kept warm using energy from active units or BESS (e.g., 5–10 kW for heaters), enabling starts in −40°C ambient. This maintains correct oil viscosity and reduces wear, reducing certain types of cold-weather startup wear by 56.8–85.4% [8].

Why Cold-Start Readiness Matters

Cold starts without prewarming cause accelerated wear due to high oil viscosity, metal-to-metal contact, and thermal shock. Envoltz's integrated prewarming system uses waste heat from active modules or stored BESS energy to keep idle engines at optimal starting temperature, extending engine life and ensuring reliable starts in extreme conditions.

Key Market Applications

Oil and Gas

Remote wellsite and fracking operations require reliable power in locations without grid access. The Envoltz DC genset provides optimized fuel consumption, reduced engine wear, and modular scalability across multiple well pads. Natural gas fuel sourcing directly from the wellhead or pipeline eliminates diesel logistics entirely. In flaring gas recovery applications, the genset converts a waste product into productive power, creating economic value from otherwise vented or flared gas.

Datacenters

Hyperscale and edge datacenters increasingly adopt DC power distribution to reduce conversion losses. The Envoltz DC genset integrates directly with DC power distribution units (PDUs), providing backup and primary power without the double conversion losses of traditional AC genset systems. For facilities with DC bus architectures, overall efficiency gains of up to 28% have been reported compared to equivalent AC-distributed systems [1]. Multiple genset trailers 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 Envoltz DC genset, paired with BESS, buffers charging demand, shaving peaks that would otherwise require oversized genset capacity or grid connections. In off-grid or constrained-grid locations, the genset 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 DC Genset delivers a focused, efficient solution for distributed DC power generation. By combining standardized, modular natural gas engine-generator modules with 800 VDC direct output on DOT-compliant trailer platforms, the system eliminates the complexity and losses of AC conversion while providing critical scalability, efficiency, and reliability.

With thermal efficiencies up to 35% at optimal load, modular scaling from 250 kW to multi-megawatt configurations, natural gas fuel advantages, and native integration with Envoltz BESS and supercapacitor systems, the DC genset is engineered for the demands of oil and gas, datacenter, EV charging, and other distributed power applications. Its modular architecture allows operators to configure exactly the capacity they need for evolving site requirements.

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.