



Envoltz Supercapacitor Trailer

250 KW Liquid-Cooled Supercapacitor Energy Storage System

Quality Control for Your Power | >1,000,000 Cycles | Sub-Millisecond Response

Mobile Reliable Power

Technical White Paper

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Executive Summary

Envoltz introduces the Supercapacitor Trailer, a ruggedized, trailer-mounted 250 KW liquid-cooled supercapacitor energy storage system engineered for high-power, high-cycle applications in demanding industrial environments. Purpose-built for integration into Envoltz’s modular microgrid ecosystem, this system delivers sub-millisecond response times with a cycle life exceeding 1,000,000 cycles—orders of magnitude beyond any battery technology.

Capacitors store energy by accumulating charge on closely spaced surfaces. Movement of this charge is called current, while the resulting voltage is the difference in potential between these charges. These passive components stabilize voltage, absorbing and releasing current quickly to keep voltage steady. Supercapacitors behave similarly to standard capacitors, but provide substantially more capacitance for their size, enabling high-power energy storage in a compact, mobile form factor.

The Envoltz Supercapacitor Trailer addresses three critical power quality challenges: high-frequency electrical noise reduction, short-duration power buffering, and pulse power delivery. Mounted on a DOT-compliant trailer platform, the system is designed for oil and gas, datacenter, EV charging, and other distributed generation applications where instantaneous power availability and power quality are paramount.

What is a Supercapacitor?

A supercapacitor (also called an ultracapacitor or electric double-layer capacitor) stores energy electrostatically rather than electrochemically. Unlike batteries, supercapacitors charge and discharge in seconds or fractions of a second, with virtually unlimited cycle life. They bridge the gap between conventional capacitors and batteries—offering higher energy density than capacitors and higher power density than batteries.

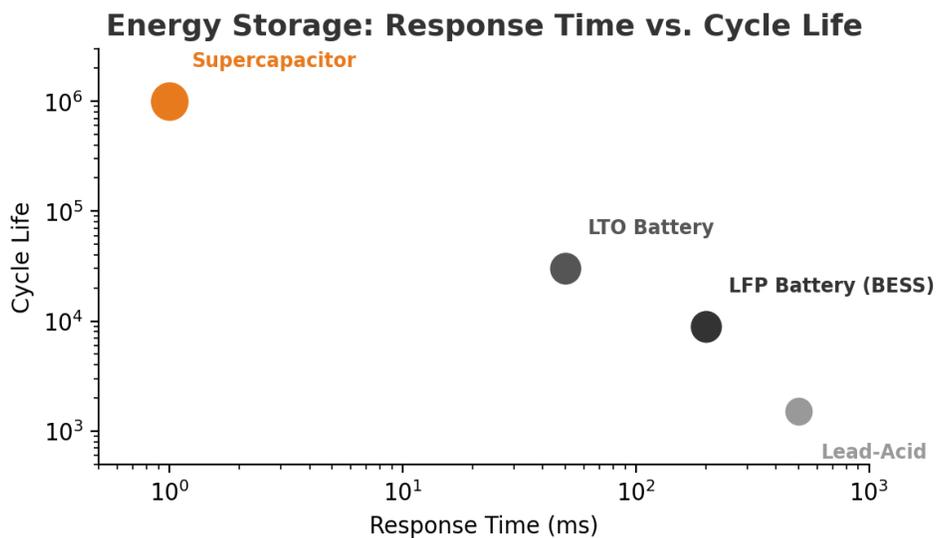


Figure: Energy Storage Technologies: Response Time vs. Cycle Life

System Overview

The Envoltz Supercapacitor Trailer is a core component of Envoltz’s modular microgrid ecosystem. It pairs directly with Envoltz DC gensets, BESS units, and power distribution trailers to provide instantaneous power quality management across the DC bus.

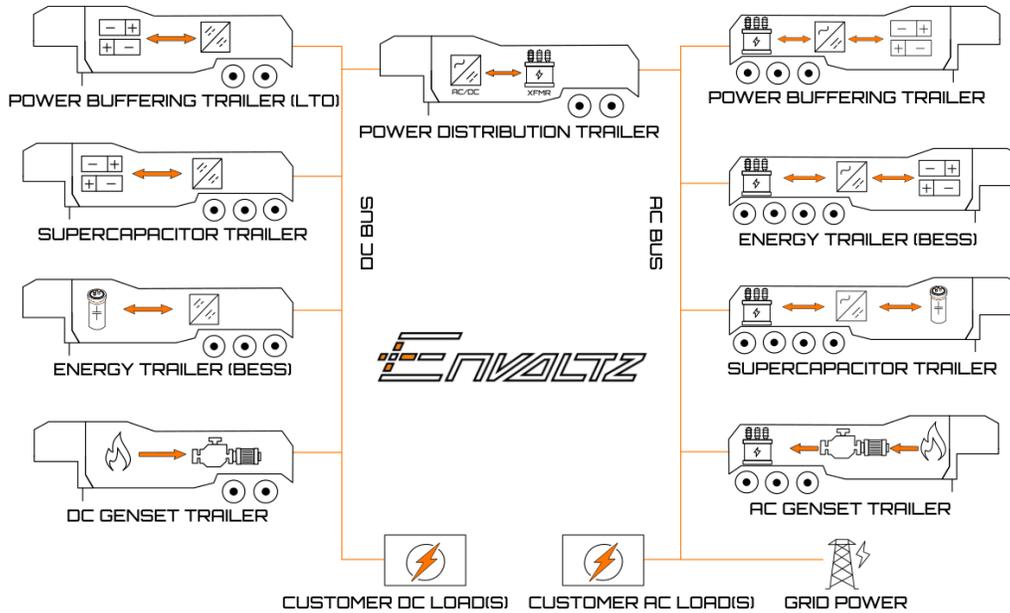


Figure: Envoltz’s Modular Customizable Microgrid Environment

The system houses liquid-cooled supercapacitor banks connected through a bidirectional DC/DC converter to an 800 VDC bus. This architecture enables direct integration with other Envoltz products without additional conversion stages, maximizing efficiency and minimizing response latency.

Key Specifications

Parameter	Specification
Rated Power	Up to 250 KW
Nominal Bus Voltage	800 VDC
DC/DC Converter	Bidirectional, galvanically isolated
Cycle Life	>1,000,000 cycles
Response Time	Sub-millisecond (<1 ms)
Cooling	Self-contained liquid cooling system
Operating Temperature	-25°C to +55°C

Parameter	Specification
Platform	Trailer-mounted, DOT-compliant
Integration	Direct 800 VDC bus connection; compatible with Envoltz gensets, BESS, and power distribution

Envoltz Microgrid Ecosystem

The Supercapacitor Trailer operates as the Stabilize component within Envoltz's pick-and-choose microgrid architecture. Combine with DC genset trailers (Supply), BESS units (Store), and power distribution trailers to create a fully scalable, mobile power system.

Supercapacitor Applications

The Envoltz Supercapacitor Trailer addresses three distinct categories of power quality and energy management challenges. Each application leverages the supercapacitor’s unique combination of sub-millisecond response, high power density, and virtually unlimited cycle life.

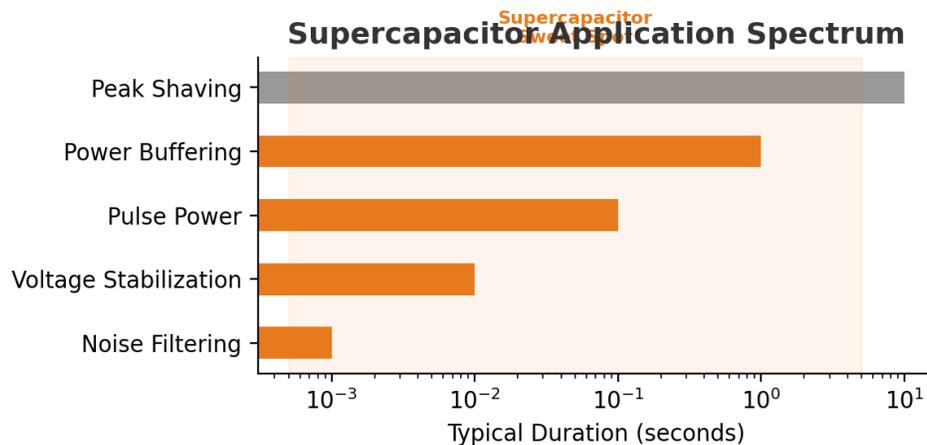


Figure: Supercapacitor Application Spectrum by Duration

Noise Reduction

Quick variations in voltage—electrical noise—can damage or disrupt sensitive equipment including control systems, communication hardware, and precision instrumentation. Sources include switching transients from power electronics, electromagnetic interference from adjacent equipment, and harmonic distortion from nonlinear loads. Supercapacitors smooth out or eliminate this noise by acting as a low-impedance sink, absorbing high-frequency voltage fluctuations and maintaining a clean, stable bus voltage. This is critical in datacenter and oil and gas control system environments where equipment sensitivity demands high power quality.

Power Buffering

When systems start up, shut down, or otherwise change state, short-term power assistance is required. This includes the need for extra power to energize systems (inrush current for motors, capacitor banks, or transformer energization) or having a sink for excess power as loads are taken offline. Supercapacitors excel at this power buffering role, absorbing or delivering high power for durations of milliseconds to seconds.

In a DC microgrid context, the Supercapacitor Trailer bridges the response gap between fast load transients and the genset’s mechanical response time. When a load step occurs, supercapacitors deliver instantaneous power while the BESS or genset modules ramp to meet the new steady-state demand. This prevents voltage sag and protects downstream equipment.

Engineer’s Note — Power Buffering Products

Envoltz offers multiple power buffering products. The Supercapacitor Trailer best addresses high-cycle-count and continuous applications where response time is critical. For mid-duration buffering (1–10 minutes), Envoltz’s LTO-based Power Buffer Trailer is the optimal choice. For long-duration energy storage (hours), the BESS platform is recommended.

Pulse Power

Applications requiring very short, intense pulses of power are classified as pulse power. Examples include drilling surge loads in oil and gas operations, electromagnetic actuator systems, and test equipment requiring high instantaneous current. Supercapacitors maximize available instantaneous power and power available for brief durations, making them ideal for these applications.

Unlike batteries, which are limited by internal resistance and electrochemical kinetics, supercapacitors can deliver their full energy content in fractions of a second without degradation or thermal stress. The Envoltz system supports configurable pulse width and discharge profiles to match specific application requirements.

Engineer’s Note — Pulse Power

Pulse power applications require attention to details considered negligible for most circuits, such as high-frequency reactance and parasitic inductance. Specialized circuitry may be required to modify pulse width or time differential. Impedance fine-tuning optimizes discharge rates for sub-second bursts while maintaining system stability per IEEE 2030.1 [1]. Envoltz engineers provide application-specific support for pulse power integration.

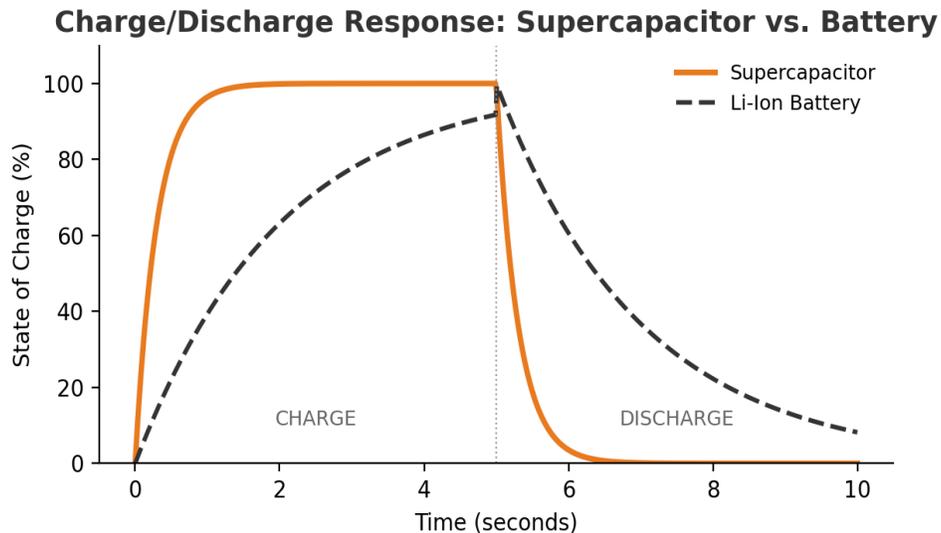


Figure: Charge/Discharge Response: Supercapacitor vs. Li-Ion Battery

Cycle Life and Durability

The Envoltz Supercapacitor Trailer is rated for greater than 1,000,000 charge/discharge cycles with minimal degradation. This represents a fundamental advantage over electrochemical battery technologies, which are limited by irreversible chemical reactions during cycling.

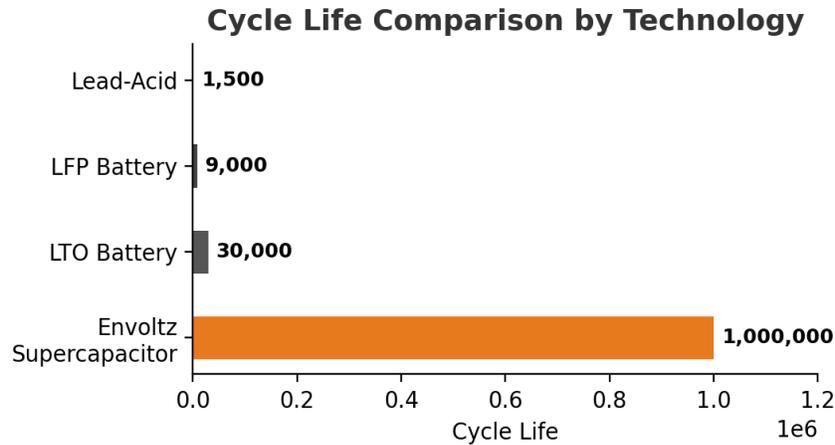


Figure: Cycle Life Comparison by Energy Storage Technology

Supercapacitors store energy electrostatically rather than through chemical reactions. Because there is no chemical transformation during charge and discharge, the degradation mechanisms that limit battery cycle life—electrode dissolution, SEI layer growth, lithium plating, and electrolyte decomposition—do not apply. This makes supercapacitors ideal for applications requiring continuous, high-frequency cycling such as power quality management, regenerative braking energy capture, and load following in variable-demand environments.

Supercapacitor vs. Battery Technology

Parameter	Supercapacitor	LTO Battery	LFP Battery
Cycle Life	>1,000,000	>30,000	>9,000
Response Time	<1 ms	~50 ms	~200 ms
Power Density	Very High	High	Moderate
Energy Density	Low	Moderate	High
Optimal Duration	ms to seconds	1–10 minutes	Hours
Degradation Mode	Electrolyte evaporation	Electrochemical	Electrochemical
Maintenance	Minimal	Moderate	Moderate

Thermal Management

The Supercapacitor Trailer employs a self-contained liquid cooling system to maintain cell temperatures within the optimal operating window across the full rated ambient range of -25°C to $+55^{\circ}\text{C}$.

During high-power charge/discharge cycling, supercapacitor cells generate heat through equivalent series resistance (ESR) losses. Liquid cooling provides significantly higher heat transfer coefficients than forced air, enabling consistent thermal distribution and eliminating hot spots that accelerate electrolyte evaporation—the primary degradation mode for supercapacitors. The cooling system maintains cell temperatures within the manufacturer's rated range under continuous maximum-power cycling, ensuring the rated cycle life is achieved in field conditions.

In cold-weather operations, the thermal management system provides active heating to maintain cell temperatures above the minimum operating threshold, ensuring reliable performance in arctic and sub-arctic environments.

AC System Compatibility

Envoltz supercapacitors become polarized when initially energized. Therefore, they cannot connect directly to AC systems. Integration with AC buses is achieved through bidirectional AC/DC converters, which Envoltz provides as part of the Power Distribution Trailer or as standalone conversion equipment.

For applications requiring capacitance directly on an AC system—such as power factor correction—Envoltz offers separate, purpose-built solutions using AC-rated capacitor technologies. These packages are designed for compliance with IEEE 519 harmonic limits [2].

Engineer's Note — AC Compatibility

These supercapacitors polarize upon initial bias, preventing direct AC use. Indirect integration via converters is feasible. For AC-specific trailer needs, Envoltz offers custom packages compliant with IEEE 519 for harmonic limits [2]. Contact Envoltz engineering for application-specific AC integration support.

System Deliverables

The Envoltz Supercapacitor Trailer is delivered as a fully integrated, factory-tested system. Each unit includes the following:

Deliverable	Description
Trailer Platform	DOT-compliant trailer (requires Class 8 tractor; truck not included)
Supercapacitor Banks	Liquid-cooled supercapacitor modules, pre-integrated
DC/DC Converter	Bidirectional, galvanically isolated for 800 VDC bus interface
Wiring and Interconnection	Complete power, logic, and communication wiring
Software	Deployment of Envoltz's proprietary control and monitoring software
Safety and Maintenance	Signage, manuals, and consumables support
Testing and QA	Quality assurance and function checks with documentation
Supplier Warranties	3-year warranty on supercapacitor container and converter
Envoltz Warranty	Standard 1-year parts warranty from delivery date on other components

Key Market Applications

Oil and Gas

Drilling operations generate intense, short-duration power demands (surge loads) that stress generation equipment and cause voltage instability. The Supercapacitor Trailer absorbs and delivers these pulse loads, protecting genset engines from transient overloads and maintaining stable bus voltage across the wellsite microgrid. In flaring gas recovery applications, the system buffers variable generation output, smoothing power delivery to connected loads.

Datacenters

Hyperscale and edge datacenters require ultra-clean power with minimal voltage variation. The Supercapacitor Trailer filters high-frequency noise and buffers load transients caused by server power supply cycling, cooling system starts, and UPS testing. Sub-millisecond response ensures sensitive computing equipment is protected from power quality events that conventional UPS systems cannot address.

EV Charging Depots

EV fast-charging stations generate high-peak, intermittent DC loads. The Supercapacitor Trailer buffers charger activation surges, preventing voltage sag on the DC bus and reducing peak demand on upstream generation or grid connections. This enables higher charger utilization rates without oversizing the generation or grid connection.

Defense and Emergency Response

Forward operating bases and emergency response deployments require reliable power with zero tolerance for voltage instability. The Supercapacitor Trailer provides instantaneous power quality management for critical communications, medical, and command systems in austere environments.

Conclusion

The Envoltz Supercapacitor Trailer delivers unmatched power quality management for DC microgrid applications. With sub-millisecond response times, greater than 1,000,000 cycle life, and 2.5 MW power capacity on a mobile trailer platform, the system provides critical noise reduction, power buffering, and pulse power capabilities that battery-based systems cannot match.

As a core component of Envoltz's modular microgrid ecosystem, the Supercapacitor Trailer integrates directly with Envoltz DC gensets, BESS units, and power distribution trailers via the 800 VDC bus. This pick-and-choose architecture allows operators to configure precisely the power quality and energy storage capabilities their application demands.

Contact Envoltz for customized configurations and deployment planning.

References

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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.