

### Introduction

Emtel Energy USA's electrostatic energy storage is the world's first long duration energy storage system that uses solid-state, encapsulated supercapacitors as storage media. With its algorithm-driven proprietary balancing, discharge and leakage-control system and encapsulated cell and energy storage structure, this is the only Electrostatic Long Duration Energy Storage (ELDES) technology that affordably delivers all forms of load requirements: medium-to-long duration discharge as well as fast charge/discharge capabilities.

This technology is rooted in electrostatic storage principles, offering significantly superior performance compared to chemical batteries. Emtel's modules leverage supercapacitor-based technology without the hindrances associated with supercap performance. Key advantages include high energy density, no capacity degradation, consistent and predictable capacity throughout its life cycle, and fully utilizable (100%) nameplate capacity. It performs reliably across a wide temperature range, supports charge and discharge rates up to 2C (and higher if needed), and maintains consistent capacity even under multiple daily cycles (up to four). Additionally, it is environmentally sustainable, utilizing recyclable materials that are abundant and free from reliance on hazardous mining, such as lithium-ion extraction.

Emtel's energy storage system is non-igniting and poses zero risk of thermal runaway, as it contains no chemical electrolytes and involves no chemical reactions, making it the safest storage technology available.

With its high energy density, our encapsulated electrostatic energy storage system is modular, scalable, and relocatable, making it suitable for deployment in all scenarios, from kWh to MWh capacities.

### Technology Overview

Capacitor cells have many advantages over chemical cells. They are more efficient, have significantly longer cycle life, can be cycled multiple times per day, are relatively unaffected by temperature variations, do not fade or degrade when cycled, generate much less heat when cycling, can be fully utilized, can be charged and discharged quickly, and are significantly safer.

However, until now, certain limitations regarding manageability, leakage and energy density have restricted their usage to a narrow range of power applications and made them unsuitable as a battery alternative for long duration energy storage. Emtel Energy USA has harnessed the capabilities of supercapacitors and mitigated their downsides to produce a revolutionary energy storage system.

Through proprietary algorithm-based microcontrollers and power electronics, these limitations are addressed and mitigated, enabling supercapacitor-based storage to replace chemical batteries.

## **Operating Voltage and Module Stability**

Individual supercapacitors need to be connected in series and parallel to meet commercial voltage requirements (e.g. 12V or 48V or 1000V etc.). Manufacturing-based variations in capacitance and insulation resistance exist between individual supercapacitor cells due to which the cells have to be continuously balanced to ensure system stability during the charge and discharge cycles.

Furthermore, capacitors can be charged/discharged at a speed of 150C, and therefore tend to get imbalanced at the same speed, which conventional battery management systems (BMS) cannot handle.

GaN based power control circuits controlled by proprietary algorithms embedded in each cell actively balance it with the fastest balancing speeds, lowest energy dissipation and lowest cost. This enables arrays of ELDES cells to be connected in series and parallel to delivery energy storage in any configuration for any application.

## **Self-Discharge**

Capacitors have a high self-discharge rate (when idle), which typically causes energy reduction to 60% within 48 hours. A charge-retention circuit in our system controls self-discharge to just 2% per month by detecting a leakage current and applying a resonant frequency to manage leakage at 5mA, preventing further power loss. In spite of allowing for a 2% per month loss, ENCAP modules have been tested after sitting indoors or outdoors, and after three months, have measured less than 1% energy loss. The frequency and its duty cycle is programmed as per the cell ionic doping.

## **Energy Density (Wh/Kg)**

The standard ELDES module, which has a 10kWh capacity, has been developed with an energy density of 250Wh/kg, which enables the encapsulated system to have a form factor equivalent to most chemical batteries. Containerized ENPACK systems for larger-scale applications are outfitted with 14.5kWh modules and have an energy density of 350Wh/kg, which is superior to the density offered by lithium-ion storage solutions. The energy density of ENCAP modules is continuously improving, so current density and module capacity information should be obtained directly from Emtel Energy USA.

## **Sustainability**

Emtel Energy USA's energy storage systems are 100% recyclable, 80% biodegradable, and use no hazardous materials or chemical reactions. Graphene, the majority component of the ELDES modules, is synthetically produced and does not require any harmful mining. The integration of the ELDES system with renewable energy sources such as solar, wind and hydro, enables renewable energy to serve as a broadly effective and efficient source of sustainable power.

## **Capabilities**

The ELDES system can be deployed in any use case where storage is required, unlike chemical batteries which are application specific. The system's capabilities demonstrate many benefits over chemical batteries, as outlined below:

### **Capacity**

The long duration energy storage system is available from kWh to MWh in any application where a battery is required, and 500Wh 12VDC to 10kWh 48VDC stand-alone modules are currently available and deployed in telecom, residential, EV charging and microgrid applications. Integrated systems (PCS + DC Storage + Enclosure) for grid scale and microgrid applications are and will be deployed in configurations that range from 40kW/160kWh to 200kW/350kWh to

2MW/2MWh - 4.2MWh in a 40' container. Based on formulaic improvements being made to the modules provided in the ENPACK containers, expected capacity in 2025 will reach 10MWh per 40' container, or 5MWh per 20' container.

### **Safety of system design and components**

ENCAP modules and the ENPACK containerized systems have been operating for long periods in extreme conditions such as in the desert of Abu Dhabi and Saudi Arabia, in high temperatures of 122+°F without air-conditioning or forced cooling. Modules have been tested to operate at full efficiency at up to 140°F.

The Abu Dhabi system was cycled four times per day with charge cycles of less than one hour and showed no sign of degradation after 18 months of usage and more than 9MWh of throughput from a 21.3kWh capacity system. Another system is deployed above 13,000 feet in the Alps, exposed to winter temperatures of -22°F and operates optimally without heating, without loss of capacity or efficiency when charged and discharged.

The system has undergone fire safety testing and demonstrated an exceptionally low fire risk. Each ENPACK containerized unit is equipped with its own fire safety system. Unlike lithium-ion battery storage systems, which present a higher fire risk even with the required cooling measures and are difficult to extinguish—often leading to significant losses—ELDES modules and systems have a minimal fire risk and are easily managed in the rare event of a fire emergency.

### **System with flexibility and longevity in multiple use cases**

ELDES is the only storage technology that affordably delivers all forms of discharge requirements - medium to long duration discharge as well as fast charge / fast discharge capabilities. The superior performance, safety and resiliency of ELDES systems allow it to serve numerous use cases, benefiting the full range of backup power to microgrid requirements. Should any issues arise with a module, the module can be hot-swapped without affecting the other strings in the system. This allows critical infrastructure to remain on line without the need to build in additional redundancies.

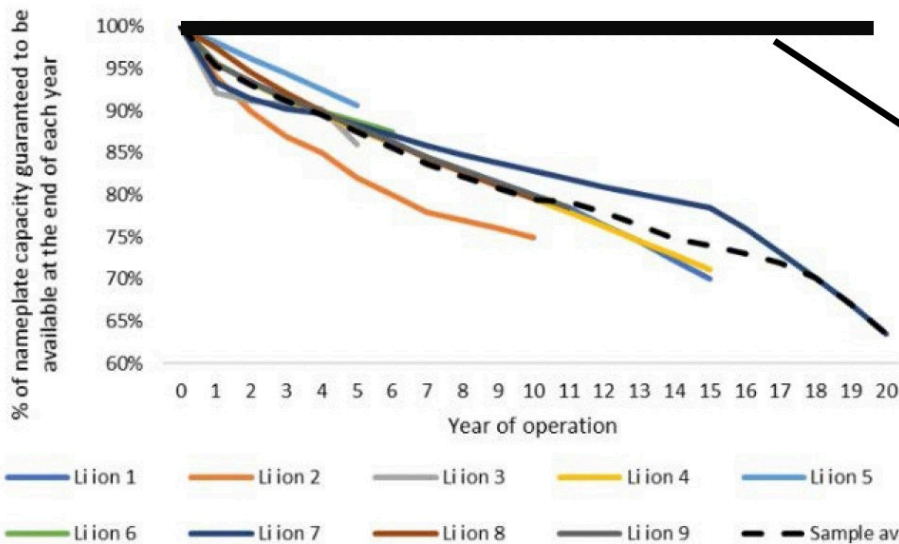
### **Material Supply Chain**

Each module assembly contains between 550-650 different parts, almost all of which are manufactured and readily available (e.g. aluminum, copper and steel sheets, cabling, sensors, circuit breakers, terminals, PCBs, microcontrollers etc.). The encapsulated cells are primarily manufactured from graphene, which is readily available and requires no mining. None of the components in the modules are dependent on Chinese manufacturing.

### **Levelized Cost of Storage (LCOS)**

Encapsulated electrostatic long duration energy storage provides the lowest LCOS in the industry for the following reasons:

- No degradation over life: the capacitor on day one is the same as the capacity at end-of-year warranty. Chemical batteries degrade between 20% to 30% over a 10-year period.



Encapsulated Capacitor Energy Storage  
Zero Degradation  
Impact: ~30% higher throughput over life

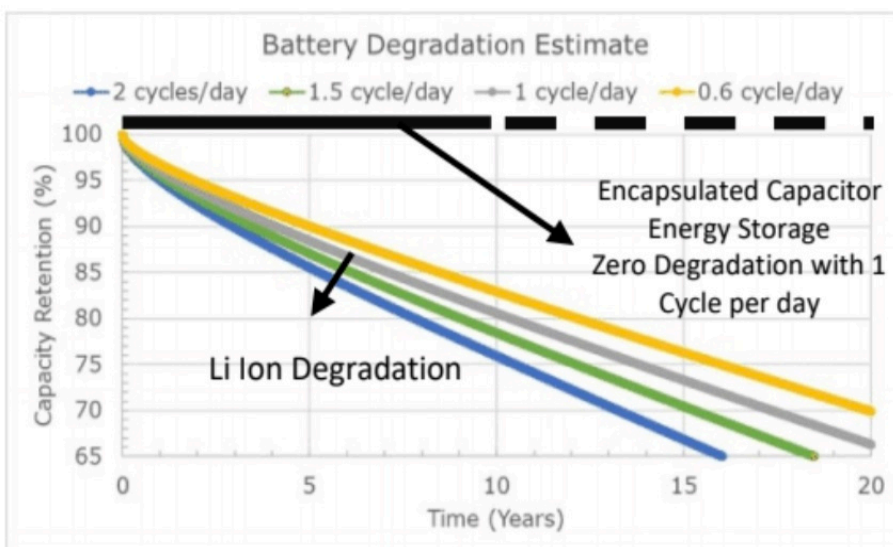
Source: DNV

- 100% usable capacity under all operating conditions. Chemical batteries typically operate at around 80% DOD at best.

These first two criteria alone enable encapsulated ELDES energy storage systems to be designed to deliver ~40% more throughput than chemical batteries.

ELDES also delivers myriad other performance benefits that support lower LCOS:

- High C-rates up to 2C (and more if required) without affecting capacity and cycle life. Chemical batteries limit their charge and discharge rates to not more than 0.5C and reduce capacity and cycle life significantly if C-rates are higher.
- Multiple cycling of up to four times per day without affecting capacity. Chemical batteries degrade significantly in performance if cycled more than once per day (see chart below). Therefore, there are capacity throughput limitations in chemical batteries whereas there are no such limitations on encapsulated ELDES Systems.



Encapsulated Capacitor Energy Storage  
<5% Degradation with 4 Cycles per day

Source: DNV

- Encapsulated electrostatic energy storage systems are much safer than chemical batteries because there is no heat generated during cycling, there is no risk of thermal runaway and no igniting substances or reactions caused by electrochemical reactions, therefore, there is no need for costly safety infrastructure.
- Longest warranty: Emtel Energy USA's encapsulated ELDES solutions are built to last for over 500,000 cycles and offer warranties of up to 20 years with no degradation or efficiency loss.
- Modules can operate optimally in a wide operating temperature range, which means minimal auxiliary load requirements for thermal management. Chemical batteries require costly temperature management.

## Grid Storage Applications

- **Load Leveling:** During periods of high demand, the system can supply power that has been stored during low-demand periods, thereby reducing the overall consumption from the grid.
- **Peak Shaving:** ELDES systems can cycle multiple times per day, making it the most affordable solution for peak shaving. If connected to the grid, the system can pull power during periods of low demand, taking advantage of the lower cost of power, and, through the system's intelligent energy management system, utilize the power during peak hours, offering significant cost savings in addition to load leveling.
- **Capacity Firming:** Emtel Energy USA's energy storage systems enable variable, intermittent power output from a renewable power generation plant to be maintained at a committed level for a period of time, smoothing output and controlling ramp rates to eliminate rapid voltage and power swings on the grid.
- **Frequency Regulation:** The system presents the fastest response time available in the industry. In addition, the high C-rate capability, ability to cycle multiple times per day with minimal degradation, and the high round trip efficiency make it the most economical product for frequency-regulation applications.
- **Congestion Relief:** The ELDES system can be deployed at congested locations either temporarily or permanently. With the capacity to charge quickly and deliver multiple cycles per day, as well as the option to transport the system if necessary, the system is ideal for locations that are experiencing congestion.
- **EV Charging Stations:** With multiple-cycle capability, super-fast charging and lack of degradation, the encapsulated electrostatic energy storage system enables the rollout of DC fast charging (Level 4) without deploying additional grid capacity at demand centers.

## Conclusion:

Emtel Energy USA's solid-state energy storage technology represents a groundbreaking advancement in long-duration energy storage. By overcoming traditional limitations of supercapacitors and offering superior energy density, safety, and environmental sustainability, Emtel provides a robust and versatile solution for diverse applications. From residential and commercial use to grid-scale deployment, ELDES enables consistent performance, unmatched cycle life, and the lowest levelized cost of storage in the industry. Its scalable design and compatibility with renewable energy sources make it a practical choice for meeting the growing demand for reliable and sustainable energy storage.