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Battery Technology HE3DA

Innovation in Lithium-Ion Technology

HE3DA (High Energy 3D Accumulator) batteries developed by Magna Energy Storage a.s. represent a new generation of battery technology, patented as HE3DA®, based on lithium nanomaterials with 3D spatial electrodes. The technology allows the thickness of the electrodes to be adjusted to match the required battery capacity and charging/discharging speed. Other parameters can be influenced by the selection of materials used.

Key Benefits of the New Technology

- **Simple System Design: :** The HE3DA cell design, together with the safety and robustness of the technology, simplifies the overall battery design and makes it similar to lead acid batteries.

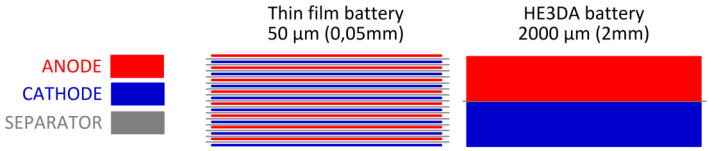


Fig. 1. Thin film electrodes and HE3DA battery with ceramic composite separator.

- **Innovative Cell Design:** The patented ceramic separator and cell design enable the production of battery cells with a high level of safety, comparable to or even exceeding that of lead-acid batteries. (Fig.1).
- **Unique Dry Manufacturing Process:** This process eliminates manufacturing steps that require solvents, adhesives, and binders, which not only increases production efficiency and battery cell performance, but also contributes to environmental protection.
- **Universal Technological Platform:** HE3DA is a versatile battery platform – it is not just a specific type of cell. It allows the use of various technologies, including the possibility of changing the chemical composition.
- **Enhanced Electrode Morphology:** It allows for significantly thicker electrodes (up to 2 mm) and higher battery cell capacities (up to 100 kWh).
- **Storability:** The self-discharge rate of the batteries is below 1% of their capacity per month, which allows for long -term storage even without being connected to a power source. Additionally, HE3DA batteries can be stored in a dry state (without the application of electrolyte).

HE3DA Battery Testing

The behaviour of the HE3DA battery has been tested from various perspectives, in different environments simulating demanding operating conditions, with the following results :

- **Ceramic Composite Separator:** The use of a ceramic composite separator ***increased the performance stability*** and slowed capacity loss compared to standard lead-acid batteries. The graph (Fig.2.) shows that the total battery capacity drops below 85% of the total capacity—at 70% DoD (Depth of Discharge) after 1000 discharge cycles. The decrease below 80% of total capacity occurs after 1800 discharge cycles.

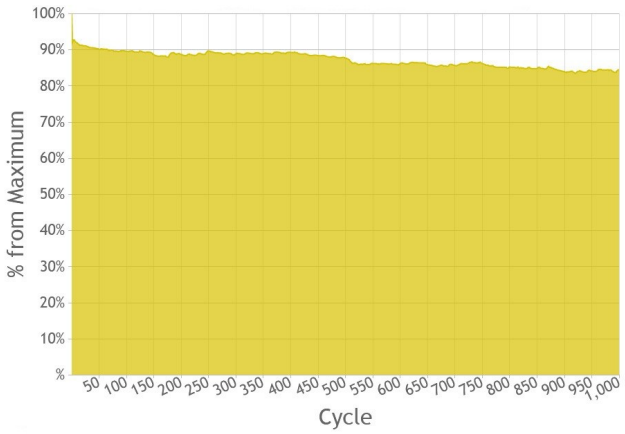


Fig. 2. Normalized of Discharged Wh - 1000 Cycles –1mm electrode.

- **Independent Battery Management System (BMS):** The robust design of the HE3DA battery enables its ***operation without permanent connection to a BMS.*** The BMS is primarily used for remote monitoring of individual battery status, reducing maintenance requirements.
- **Maintenance Charging Mode:** HE3DA battery cells ***can safely operate in maintenance charging mode***, allowing the easy and cost-effective replacement of lead-acid station batteries in existing 48V DC power systems.
- **Wide Temperature Range:** HE3DA battery cells operate over a wide temperature range, enabling cost-effective design and operation of large battery units without the necessity of using air-conditioned rooms. Tests have verified operational functionality over a temperature range ***from -20 °C to +40°C.*** (Fig.3.) .
- **Safety of Technology:** The design and features of the HE3DA battery cells represent a new level of safety. The battery allows ***operation even in the event of structural failure*** due to mechanical damage, fire or long-term short -circuit discharge .

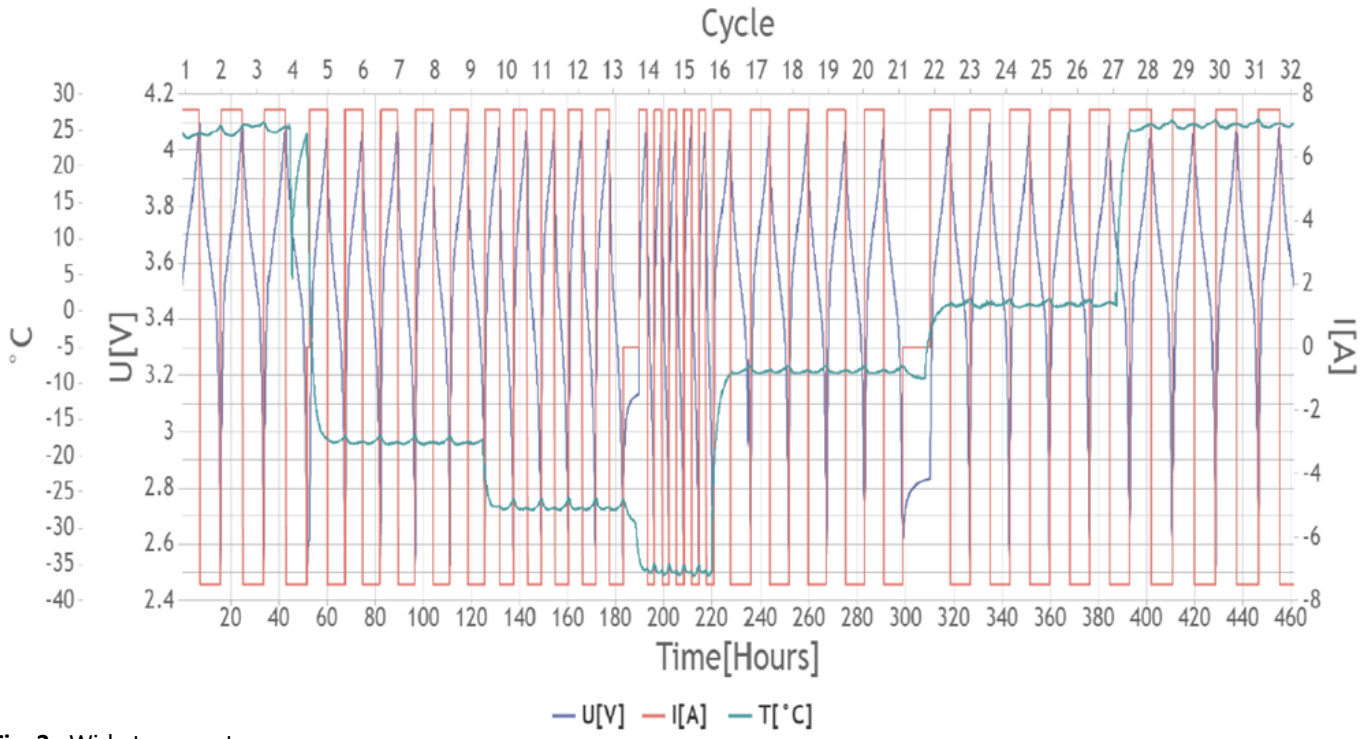


Fig. 3. Wide temperature range

- **Predictable behaviour:** HE3DA batteries have a low internal resistance that changes linearly during cycling. This

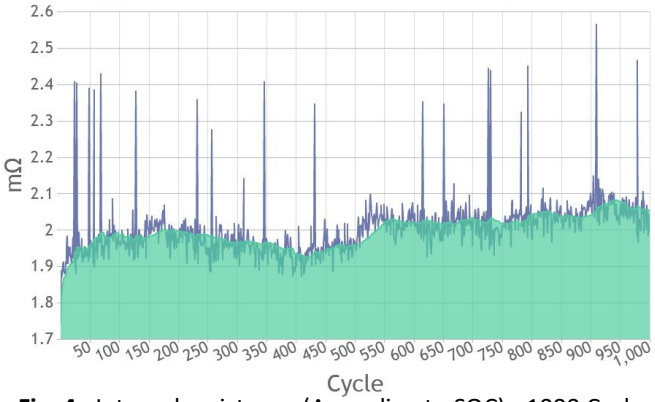


Fig. 4. Internal resistance (According to SOC) - 1000 Cycles - 1mm electrode

makes it possible to declare ***the predictable behaviour*** of HE3DA batteries throughout its lifetime (Fig. 4).

Sustainability and Production of HE3DA Technology.

- **Strategic Independence:** Unlike competing lithium-ion batteries, where all layers of the battery supply chain are heavily dependent on Asia, particularly China, the development and production of HE3DA batteries aligns with the EU's efforts to achieve greater competitiveness and strategic autonomy. The batteries are developed by the Czech company Magna Storage Energy a.s. and manufactured in the Czech Republic, with a strong emphasis on European supply chains.
- **Recyclability:** The design facilitates easy separation of material for recycling, promotes economical use of Class A materials and contributes to a truly sustainable battery economy.
- **Sustainability:** The simple and economical HE3DA battery cell recycling process sets new standards of sustainability for lithium-ion batteries .

Examples of Batteries:

- **HE3DA BES cell** (Fig. 5).: In production since 2025. The



Fig. 5. HE3DA BES second generation commercial cell.

battery features electrodes with a thickness of 0,5–1 mm and a capacity of 0,8 kWh. It weighs 5 kg and achieves an energy density of 170 Wh/kg.

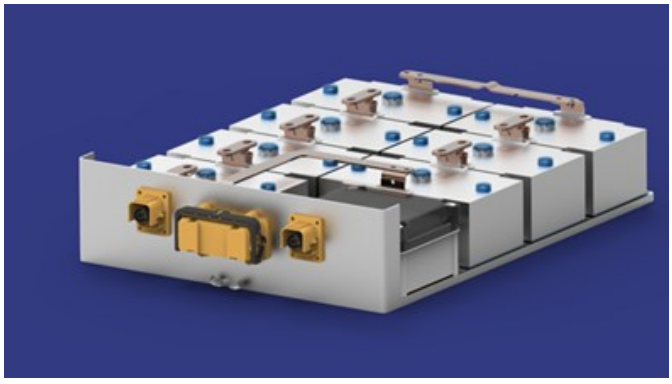


Fig. 6. The example of 7 kWh battery module

- **HE3DA 7kWh Battery Module:** Battery modules can be assembled from individual cells in a simple way (Fig. 6). The modular solution enables very efficient, easy, and most importantly, fast replacement of modules.

COMPARING BATTERIES

When selecting battery technology for critical infrastructure backup power systems (Uninterruptible Power Supply), it is essential to evaluate the suitability of each option across a range of criteria to ensure long-term reliability, performance and cost-effectiveness. The comparison between traditional lead-acid station batteries, conventional lithium-ion batteries and HE3DA batteries from the various points of view is given in the following paragraphs:

Reliability and Simplicity

- **Lead-acid batteries:** These are a well-established technology that has been used in power systems for decades. Their reliability in terms of availability and performance is well-proven. Systems using lead-acid batteries feature a relatively simple design and standardized charging and discharging processes. This simplicity and long-term use make them advantageous for maintenance and repair. However, in recent years, reliability has been declining, mainly due to the use of recycled lead in production. Not all manufacturers refine the lead to "pure lead" levels, which results ***in lower reliability and shorter battery lifespan*** than required.
- **Lithium-Ion batteries:** These offer higher efficiency and more reliable performance over a wide range of charge cycles. Batteries are generally more internally stable and less prone to leakage and corrosion compared to lead acid but require more sophisticated Battery Management Systems (BMS) to monitor performance, charge/discharge cycles and temperature control. If not well managed, the systems can cause higher failure rates.



Fig. 7. Safety of Technology - high mechanical endurance, prevents risk of fire.

- **HE3DA batteries:** Thanks to their robust and safe design, they do not require a complex battery management system (BMS) to ensure reliable operation. Their reliability is therefore comparable to lead-acid cells. Just like lead-acid batteries, their simple design and potentially widespread use make them advantageous for maintenance and repair. The battery's construction allows it to operate even in the case of partial damage.

Costs and Economic Efficiency

- **Lead-acid batteries:** They have significantly lower upfront costs compared to lithium-ion batteries. However, it's always necessary to consider not only the purchase price but also the total cost of ownership, including maintenance. Moreover, EU directives aiming to reduce the use of lead must be taken into account, raising the question of when lead-acid batteries will need to be phased out.
- **Lithium-ion batteries:** Although they have higher initial costs, their longer lifespan and lower maintenance requirements can lead to a lower total cost of ownership (TCO) compared to lead-acid batteries.
- **HE3DA batteries:** The purchase price reflects the stage of development, the level of innovation, and the process of market introduction. At this point, the acquisition cost is higher, but the unique design allows the solution to be optimized according to specific needs – both in terms of initial investment and overall costs for service and maintenance. In this regard, it is comparable to conventional lithium-ion batteries. However, unlike them, it offers a significant economic advantage for users who need to replace lead-acid batteries in existing systems. This technology enables such replacement without the need for major modifications, whereas standard lithium batteries cannot achieve this without additional expenses.

Size and Weight Characteristics

- **Lead-acid batteries:** They are large and heavy, requiring more space and potentially increasing the total weight of the power supply system. This poses a problem in space-constrained environments, especially in large data centres or facilities with limited room size or floor load capacity.
- **Lithium-ion batteries:** These are more compact and lighter compared to lead-acid batteries, which is a significant advantage in space-constrained environments. Their higher energy density enables the use of smaller and more energy -efficient systems, thereby reducing the overall weight of the power system.
- **HE3DA batteries:** Like lithium-ion batteries, HE3DA batteries are more compact and lighter than lead-acid batteries. Their higher energy density allows for the use of smaller, more energy-efficient systems, reducing the overall weight of the power system. At the same time, the design of HE3DA batteries enables the production of batteries in the size of lead-acid ones, but with significantly higher capacity.

Lifetime Period of Batteries

- **Lead-acid batteries:** Depending on usage and environmental factors, their lifespan ranges from five to ten years. Over time, battery performance deteriorates, requiring replacement. This leads to costs not only for new batteries but also for transportation, environmental disposal, and the physical replacement itself. Furthermore, replacement may be operationally inconvenient, especially for critical

infrastructure that must remain continuously operational. Currently, the lifespan of station lead-acid batteries is negatively affected by the use of lower-quality lead, which accelerates degradation.

- **Lithium-Ion batteries:** They typically last 8 to 15 years or more, depending on type and use. Their ability to withstand a greater number of charge cycles (typically 2,000 to 5,000 cycles compared to 300-500 for lead acid) translates into a longer operating life, making them a better choice for systems with long-term life cycle requirements.
- **HE3DA batteries:** They achieve exceptional longevity through optimized electrode morphology, robust cell construction preventing delamination and swelling, and a durable mineral separator. These advancements ensure low internal resistance, gradual linear capacity degradation, and eliminate sudden performance drops. Unlike conventional lithium-ion batteries, which require replacement at 70–80% capacity due to rapid degradation, HE3DA batteries utilize their full capacity without instability. Their ability to operate efficiently between 70% and 20% remaining capacity nearly doubles their cycle life.

Environmental Conditions

- **Lead-Acid batteries:** These are susceptible to extreme temperatures during operation, especially in colder climates. Their capacity decreases dramatically at lower temperatures, and they are more susceptible to sulphation (an irreversible process that occurs when batteries are exposed to high temperatures).
- **Lithium-Ion batteries:** These also have a limited operating temperature range but are generally more stable and can operate efficiently over a wider temperature range. Some lithium-ion batteries are specifically designed to operate in extreme conditions, although extreme heat can still degrade their performance.
- **HE3DA batteries:** HE3DA battery cells are designed to operate reliably across a wide temperature range (between - 20°C and 40°C), ensuring stable performance under varying environmental conditions. This capability enables the cost-effective design and operation of large-scale energy storage systems by reducing the need for extensive thermal management. As a result, overall system efficiency improves, operational costs decrease, and reliability is enhanced, making these battery cells an ideal solution for demanding energy storage applications.

Environmental Sustainability

- **Lead-acid batteries:** They are environmentally unsustainable due to the presence of toxic materials (mainly lead and sulfuric acid). However, they are recyclable, and the recycling rate of lead-acid batteries is relatively high.
- **Lithium-ion batteries:** They do not contain toxic materials. However, lithium mining and end-of-life battery disposal are not environmentally friendly. With the development of production technologies, innovations in recycling and more sustainable material sourcing are being introduced, making lithium-ion batteries a more sustainable long-term option.
- **HE3DA batteries:** HE3DA battery technology enhances sustainability by optimizing production, operation, and recycling. Its manufacturing process eliminates most energy-intensive steps, avoids harmful solvents, and achieves near -zero defects, reducing material waste. At the end of life, easy material separation and the absence of cross-contamination enable cost-effective recycling and reuse of high-quality materials. HE3DA thus combines sustainability with economic efficiency, creating a circular battery that meets the stringent environmental standards set by the EU.

Compatibility with Existing Power Systems

- **Lead-acid batteries:** They are the standard in most existing power systems. However, the above comparisons show that in the long run, they will be replaced by new-generation batteries.
- **Lithium-ion batteries:** Although lithium-ion batteries offer significant advantages, they are not directly compatible with older power systems designed for station lead-acid batteries. UPS systems that were not originally designed to support lithium-ion batteries require additional equipment or replacement of the charging module and battery management system (BMS). These additional costs and efforts must be taken into account when making decisions.
- **HE3DA batteries:** Unlike conventional lithium-ion batteries, HE3DA batteries can directly replace original station lead-acid batteries in existing systems without major modifications. The first commercial type of HE3DA battery cell, BTS, was specifically developed for these applications, ensuring seamless integration and improved performance in operational systems.



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