



Intelligent Balancing for Optimal Efficiency Empowering High-Quality Green Development of Global Energy Storage

—White Paper on Smart Scales Intelligent Balancing
Technology for Energy Storage Systems



CLOU
ESS

A Global Leader in ESS Commercialization

PREAMBLE

Currently, the global energy structure is undergoing a profound transformation, with the development and utilization of new energy sources becoming a global consensus. With the construction of distributed photovoltaic energy systems, new power systems, and the extensive deployment of renewable energy, the energy storage sector is experiencing unprecedented opportunities for growth, with a rapidly increasing demand for energy storage products. Energy storage Systems, as a critical link between renewable energy and the power grid, not only enhance energy utilization efficiency and ensure the stable operation of power systems but also bring significant economic benefits to investors.

In addressing the crucial question of achieving sustainable profitability for energy storage Systems through technological innovation and efficient operations, CLOU has leveraged years of project operation experience and adhered to the principles of "user-friendly," "grid-friendly," and "environment-friendly." The company focuses on optimizing power station returns by deeply analyzing the different profit models of passive and active balancing. Based on this analysis, CLOU has innovatively developed the Smart Scales intelligent balancing technology. This technology provides operators of energy storage stations and professionals in the energy sector with a new perspective, opening up new avenues for increasing station returns.



The cost of lithium battery storage has decreased by 80% over the past decade. According to BNEF forecasts, the expected cost in 2025 will continue to decrease by 30% compared to 2020, and by 2030, it will decrease by 50%. With the decline in initial investment CAPEX, more people are focusing on the overall returns of energy storage systems. However, the current energy storage industry still faces many issues, such as inconvenient operation and maintenance, and systems not meeting expected returns, leading to investors not achieving anticipated profits. Ensuring product quality while enabling rapid and convenient deployment, high-quality delivery, and quickly meeting customer needs from a product technology perspective remains a pressing issue for the entire industry.

Vice President of TÜV SÜD Greater China

The adjustment of the global energy structure is accelerating under the target to reduce carbon footprint, with new power systems serving as a crucial part of the energy system transition, driving the green and low-carbon transformation of energy. For 15 years, CLOU has been deeply engaged in the electrochemical energy storage industry, possessing a full-stack, self-developed product line covering the entire energy storage product chain(excluding battery cells) and outstanding capabilities in 3S system integration and EP PACKAGE full-ecosystem complete station solutions. In a market with high product similarity, maximizing value creation for customers by fully leveraging the company's product and technological advantages has always been the goal of CLOU ESS.

General Manager of CLOU Overseas Business Center

Pain Points in Energy Storage Station O&M

In recent years, China's electrochemical energy storage industry has rapidly developed. However, this growth has led to participants of varying quality, resulting in chaotic low-price competition and a trend of "price competition and capacity comparison." Many grid-connected projects fail to achieve expected returns, affecting investment and sustainable project development, which significantly impacts the industry's high quality, safety and healthy growth.

Pain Point 1: Promoting the Commercial Application of Energy Storage

The primary concern for energy storage stations is safety, particularly the risk of battery fires. As battery cell capacity increases, so do technical challenges. Designing and manufacturing large-capacity cells, thermal management, and system integration require higher expertise and stricter quality control to ensure safety and stability.



Pain Points in Energy Storage Station O&M

Pain Point 2: Lack of Operation and Maintenance

Large-scale energy storage stations often face complex application scenarios, high O&M costs due to remote locations, and equipment from different manufacturers causing data silos. This increases O&M complexity. Additionally, the technologies involved are complex, requiring highly trained and skilled O&M personnel.



Pain Point 3: Reduced Returns

New energy storage stations have high investment costs and longer payback periods influenced by market conditions, storage technology types, and equipment scale. Rapid battery degradation and poor consistency cause the "buckets effect," severely limiting stable returns for customers.



Promoting the Commercial Application of Energy Storage

With 30 years of expertise in the power industry and 15 years in energy storage, CLOU leverages its self-developed and self-manufactured products to focus on various business scenarios, placing customers at the center. By addressing customer needs and pain points, CLOU developed the EP Package, offering full lifecycle service for energy storage stations. This approach promotes the commercial application of energy storage and supports the global green and low-carbon transition.

01 Pragmatic Product Strategy

CLOU abandons excessive price competition and capacity rivalry, focusing instead on understanding and meeting customer needs. By adopting a steady, pragmatic approach, making incremental improvements, and precisely refining products, CLOU consistently enhances product performance and user experience. The company remains realistic in market positioning, avoids exaggeration, and refrains from making excessive promises. CLOU ensures smooth delivery of every customer order and provides ongoing operation and maintenance services for power stations, protecting customer interests and ensuring a worry-free cooperation experience.

02 Efficient and Professional O&M

CLOU offers customized, modular product services and provides long-term technical support through its headquarters and localized professional O&M teams, both locally and remotely. By real-time tracking and optimizing system performance, CLOU ensures efficient and stable energy storage system operations. Using data analysis and system adjustments on the CLOU ESS cloud platform, energy utilization efficiency is continually improved. The comprehensive after-sales service throughout the entire lifecycle significantly reduces customers' O&M costs, ensuring a reassuring purchase and satisfying user experience.

03 Dedicated to Enhancing Returns

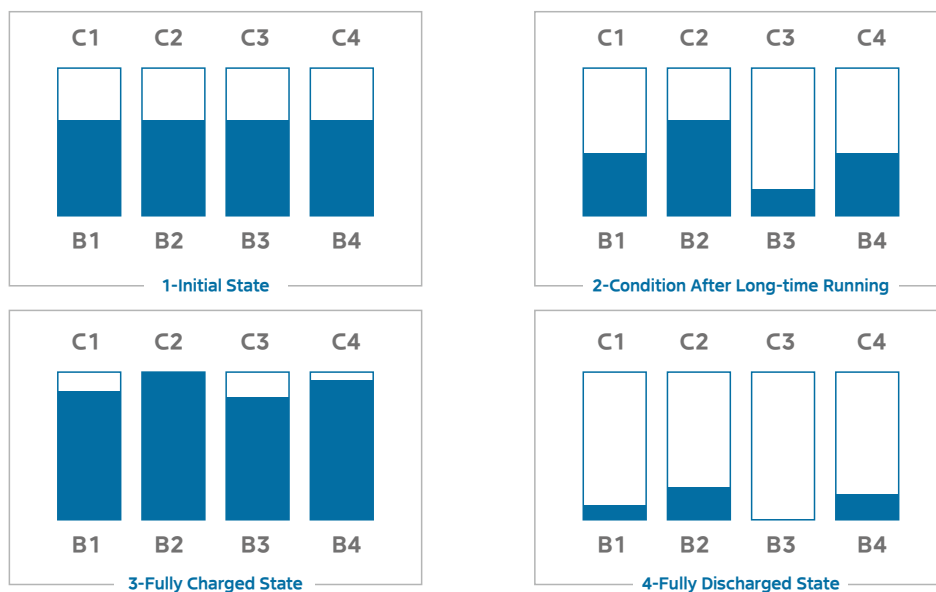
Passive balancing is simple and low-cost but suffers from high energy loss and slow speed. In contrast, active balancing offers high energy efficiency, fast balancing, extended battery life, and improved system performance. Most manufacturers choose passive balancing due to cost and technical constraints, leading to lower initial investment but reduced long-term returns for power stations. CLOU, as a global leader in energy storage, developed the Smart Scales intelligent balancing solution, focusing on customer returns and long-term power station benefits. This innovative solution has received excellent feedback, significantly enhancing customer returns.

CLOU Smart Scales Active Balancing Solution

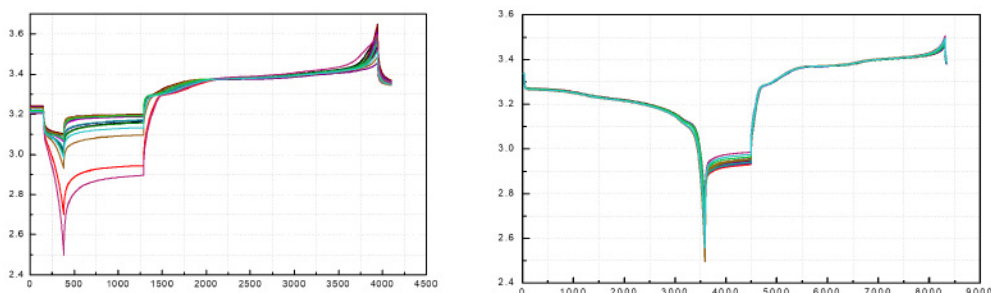
—The industry's first large-scale implementation of Smart Scales intelligent balancing technology, deeply addressing customer return pain points

1、Technical Principles

The consistency issue among battery cells in energy storage systems critically affects performance and safety, reducing capacity, increasing risks, and shortening lifespan. Effective management and consistency control are crucial for long-term stability. Despite refined manufacturing processes, minor differences between cells persist. These differences are exacerbated over time by varying usage patterns (charge rates, temperatures, cycling conditions), leading to performance inconsistencies. In summary, cell inconsistency results from material differences, manufacturing processes, environmental factors, and usage patterns, creating complex performance inconsistency.



By improving battery consistency, we can achieve several goals, including increasing the overall capacity of the battery pack, extending the lifespan of the battery system, and enhancing the safety of battery usage.



Comparison of Imbalance and Balance in Battery Cells During Charge and Discharge

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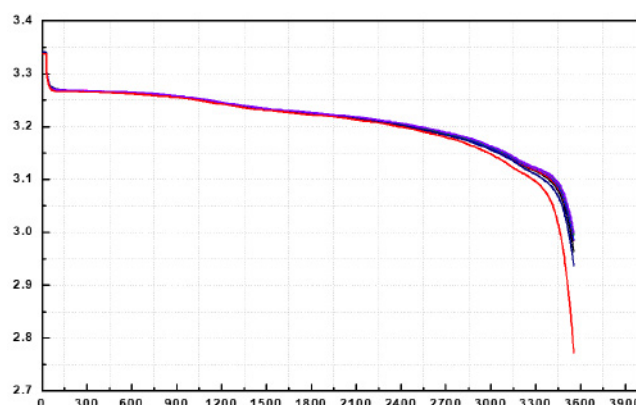
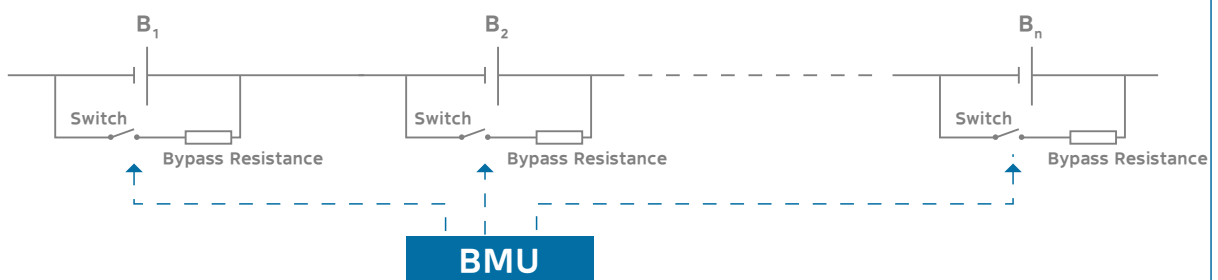
In a battery system, charging or discharging stops automatically when any single cell reaches a set minimum threshold to ensure safety and extend lifespan, while other cells would continue. CLOU's Smart Scales intelligent balancing technology optimizes energy distribution through active balancing. This ensures consistent operating conditions for each cell, reducing performance deviations and enhancing overall system stability and reliability.

Most system integrators use passive balancing due to its simplicity, lower cost and lower complexity, but it has several issues:



**several
issues**

- Resistive discharge releases excess electrical energy as heat, leading to higher cooling energy consumption and low efficiency
- Generates excessive heat, affecting battery lifespan and safety, and increasing system risk
- Balancing current is typically between 100mA and 300mA, leading to long balancing times and poor effectiveness
- With only discharge balancing, if the buckets effect occurs, energy cannot be actively restored

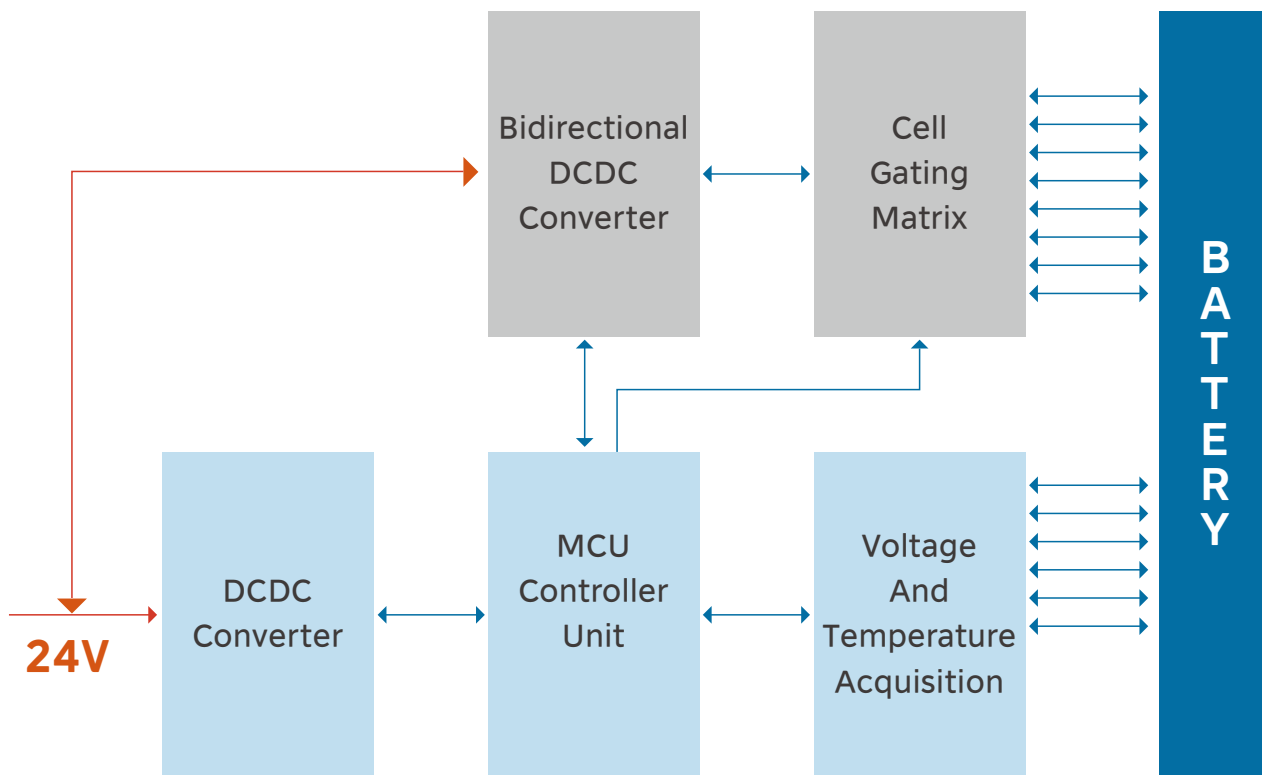


Voltage Change Curve of Passive Balancing Circuit at 0.5C Discharge for Individual Battery Cells

CLOU Smart Scales Active Balancing Solution

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CLOU Smart Scales intelligent balancing achieves efficient energy transfer between battery cells with advanced hardware design and intelligent control. Using the power line as a balancing bus, multiple cells share a single balancer, simplifying the battery management system architecture and reducing initial investment costs.



CLOU Smart Scales Intelligent Balancing Technology

CLOU Smart Scales Active Balancing Solution

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Compared to traditional passive balancing, CLOU Smart Scales intelligent balancing offers significant advantages

01 Bidirectional Energy Control

Allows bidirectional energy transfer between cells for charging balance and energy redistribution during discharge, ensuring effective energy use.

02 High-Efficiency Rapid Balancing

Active balancing technology is much more efficient than passive balancing, achieving faster cell balancing in the same amount of time.

03 High Current Fast Balancing

Balancing current can reach up to $\pm 2A$ or higher, enabling rapid balancing and improving charging/-discharging efficiency.

04 Reduced Energy Loss

Precise energy management minimizes energy loss during energy transfer between battery cells, enhancing overall system efficiency.

CLOU Smart Scales Active Balancing Solution

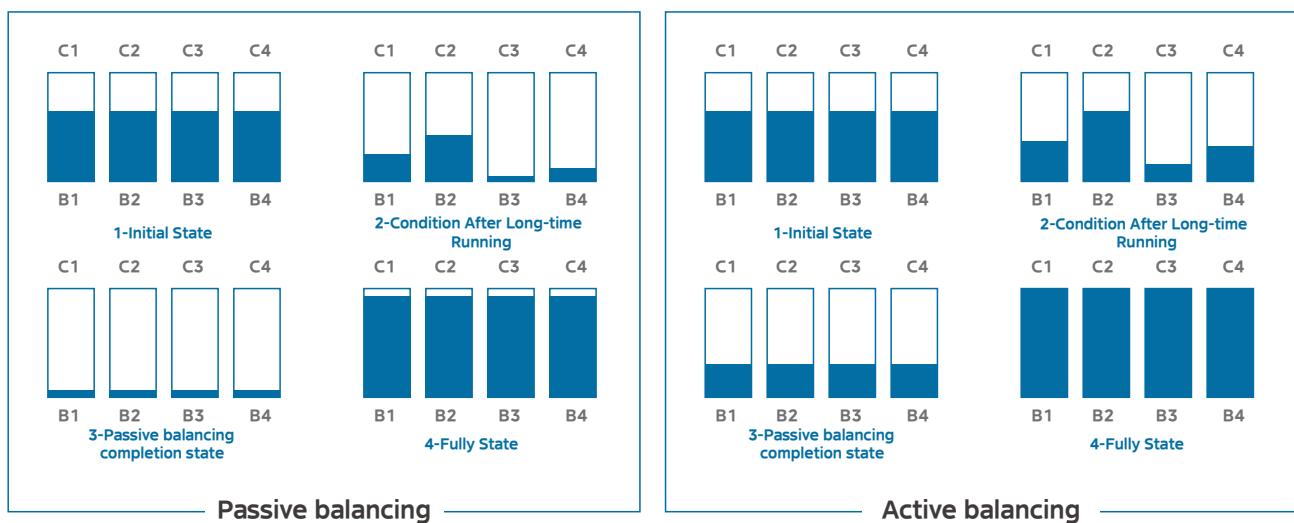
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05 Optimized Battery Performance

Maintains cell performance consistency, extends battery lifespan, and enhances system reliability.

06 Easy Scalability and Maintenance

Shared balancer design simplifies scaling and maintenance, reducing system complexity and O&M costs.



Passive balancing can only balance cells at the end of discharge, preventing full charging. Active balancing balances cells during both charging and discharging, allowing full charge, increasing usable energy, and adding commercial value. CLOU Smart Scales intelligent balancing is an innovative battery management feature that enhances performance and extends the lifespan of battery energy storage systems through intelligent and efficient energy management.

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2、Data Analysis

Data monitoring over three years at multiple sites in Texas shows that sites using CLOU Smart Scales intelligent balancing technology showed a battery State of Health (SOH) that is more than 2% higher than those using passive balancing.

| | Active Balancing Sites 2021 Data | Active Balancing Sites 2024 Data |
|--------------------|----------------------------------|----------------------------------|
| Charging Energy | 38165 | 36752 |
| Discharging Energy | 37169 | 35793 |
| SOH | 100.0 | 96.3 |

| | Passive Balancing Sites 2021 Data | Passive Balancing Sites 2024 Data |
|--------------------|-----------------------------------|-----------------------------------|
| Charging Energy | 38108 | 35930 |
| Discharging Energy | 36290 | 34185 |
| SOH | 100.0 | 94.2 |



3、Profit Calculation

01 Increasing Project Returns

CLOU Smart Scales intelligent balancing technology enhances the operational efficiency and economic benefits of energy storage stations. It reduces electricity purchase costs, increases sales revenue, and improves arbitrage profit margins, supporting long-term profitability and sustainable development. For every 100 MWh of charge and discharge, Smart Scales can reduce purchase costs by 3% and increase sales revenue by 2%. In spot price arbitrage, it improves available energy and operational effectiveness, achieving over a 5% profit margin increase compared to passive balancing, resulting in higher returns.

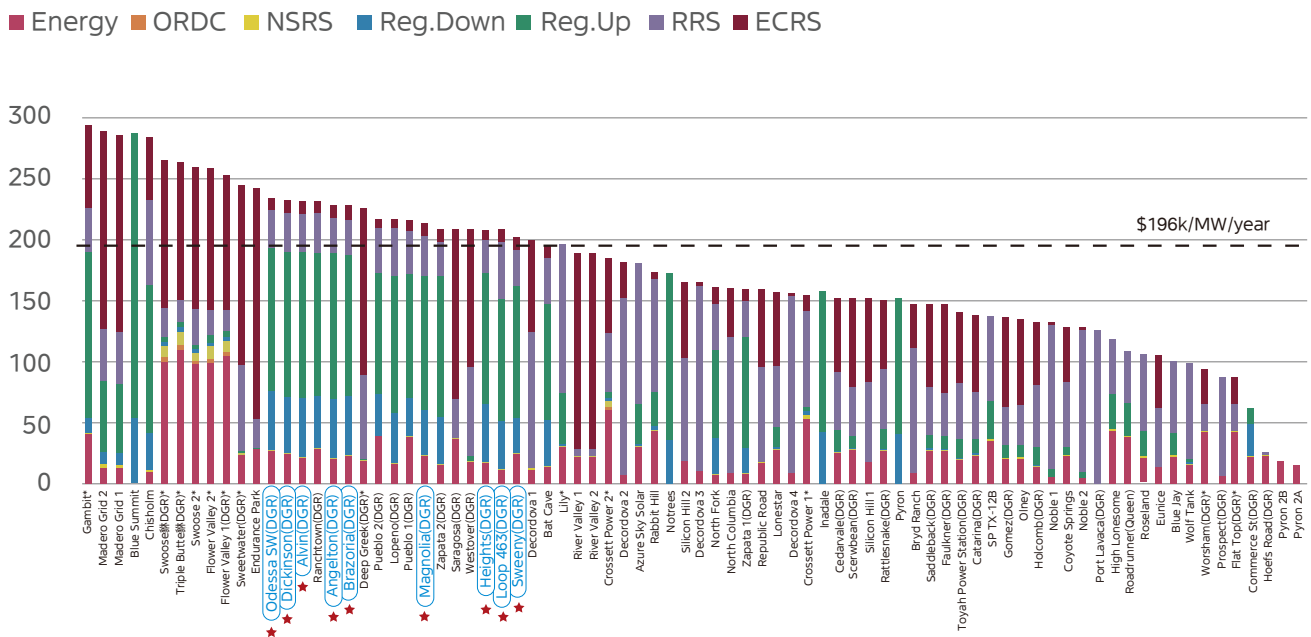
02 Reducing O&M Costs

Operational costs are crucial for long-term energy storage station operation. For a 100 MWh station, traditional manual balancing and maintenance, conducted every three months, incurs a labor cost of \$24,000 per session (excluding the cost of the balancer equipment itself). If balancing is done four times a year, the labor cost alone accumulates to \$96,000 annually. Over 20 years, labor costs alone reach a staggering \$1.92 million.

CLOU Smart Scales Intelligent Balancing Project Case

Texas, USA Project

In April 2024, Modo Energy's earnings rankings for energy storage sites in Texas' ERCOT market showed CLOU's TX10 project excelling. All 9 sites ranked within the top 30, showcasing CLOU ESS's superior product capabilities and efficient system integration. This highlights CLOU's core strength as a global leader in commercial energy storage, delivering tangible returns for customers.



Source: Modo Energy

Notes: Systems that are >1.5h in duration are marked with an *

MODOENERGY

CLOU Global Typical Projects

Atacama Desert Project, Chile

—The largest solar and storage integrated project on the new energy generation side in South America. Successfully operated in extreme conditions of drought, sandstorms, and intense heat.



Indiana Project, USA

—The world's first commercial 20-foot energy storage container. Pioneered the 20-foot container cabinet model and 20-foot full-load transport method.



CLOU Global Typical Projects

California Project, USA

—Successfully passed the UL9540 field test in California. Overcame the strictest environmental and security compliance requirements in the United States.



Costa Rica Project

—The world's first application of island mode and Costa Rica's first energy storage pilot project.



CLOU Global Typical Projects

Haifeng Project, China

—One of the first eight technological innovation (energy storage) pilot demonstration projects by the National Energy Administration. Achieved an equivalent cycle count of over 9000 cycles.





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