RENON

Based on Smart Matrix A: A White Paper on 300MWh / 150MW Distributed Energy Storage Applications

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Smart Matrix A

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Renon Power

We Care About Sustainability

With our own R&D team and automatic production factory, we are dedicated to delivering innovative, reliable, and affordable energy storage solutions to global customers.

At Renon, we believe that sustainable energy is the future. We are passionate about reducing carbon emissions and preserving our planet for future generations. That's why we invest heavily in research and development, leveraging the latest technologies to design and manufacture energy storage systems that are efficient, scalable, and adaptable.

Our products are designed to meet the needs of a wide range of applications, from residential and commercial buildings to industrial facilities and utility-scale projects. Whether you're looking to reduce your energy bills, increase your energy independence, or support your sustainability goals, Renon has the right solution for you.

Our commitment to quality and customer satisfaction is unwavering. We work closely with our clients to understand their unique needs and provide customized solutions that meet or exceed their expectations. We also provide comprehensive technical support, maintenance, and warranty services to ensure that our customers get the most out of their investment.

Join us on our mission to make renewable energy within reach.

PROVIDE INNOVATIVE, RELIABLE, AND AFFORDABLE ENERGY STORAGE SOLUTIONS TO CUSTOMERS WORLDWIDE.

Contents

Executive Summary

I. Project Needs & Pain Points

The North American power system is facing threefold challenges:

- Peak load pressure continues to rise—high-load nodes such as fast-charging stations, hotels, shopping malls, and industrial parks are stressing the grid;
- The price gap is widening—peak-to-valley price differences commonly exceed 0.3 USD/kWh, creating significant arbitrage opportunities for energy storage;
- Centralized energy storage has long investment cycles and unstable returns—traditional solutions have an ROI of over 6 years, lacking flexibility and reuse value.

Therefore, the market urgently needs a modular, intelligent, and aggregable distributed energy storage system that can be deployed quickly, connected flexibly, and achieve a dual balance of investment returns and operational stability.

II. Solution Overview

Renon Power launched a 10-foot AC liquid-cooled integrated energy storage system, building a four-dimensional integrated ecosystem of "energy storage equipment + local EMS + cloud EMS + aggregator platform."

- Single cabinet configuration: 1.67MWh liquid-cooled battery + 830kW liquid-cooled PCS + cabinet-level EMS + independent fire protection + dynamic environment monitoring.
- Layered architecture: 3 cabinets + communication cabinet + AC distribution cabinet = 1 array; 8 arrays = 1 station; 10 stations = 400MWh project.
- AI scheduling system: station-level EMS → project-level EMS → cloud EMS → aggregator platform,
- realizing peak shaving, valley filling, frequency response, VPP aggregation, and revenue optimization in closed-loop management.
- Data communication: fiber optic backbone + Ethernet/CAN/RS485 hybrid protocol, sampling frequency 5Hz, full-cycle log tracking.
- Safety compliance: fully compliant with UL 9540, UL 9540A, NFPA 855, IEEE 1547, and FEOC standards.

III. Business Logic

This project adopts EaaS (Energy as a Service) and Aggregator revenue-sharing mechanism:

- Investment entities: 80% energy investment company + 20% aggregator platform;
- Revenue structure: peak-valley arbitrage 40% + demand response 20% + standby capacity 20% + frequency regulation and carbon credits 20%;
- Revenue distribution: AI cloud algorithms dynamically allocate based on station contribution.

This model achieves a sustainable financial closed loop of capital investment—system operation—revenue settlement—AI optimization—reinvestment.

IV. Investment Return

Indicator	Value
Total Investment Scale	≈ 160 million USD
Construction Period	12 months
Project IRR	15 – 18%
ROI Cycle	≤ 4.5 years
Average Availability	≥ 99.2%
AI scheduling Revenue Improvement	7 – 10%
Operational Cycle	15 years (design life > 6000 cycles)

Conclusion: The Renon Power 10-foot AC system provides a high-yield, high-safety, and highly flexible distributed energy storage investment solution for North America. Its modular architecture and AI revenue optimization capabilities significantly shorten the ROI cycle, enhancing project replicability and capital attractiveness.

V. Project Sustainability

- Low carbon contribution: Annual reduction of ⩾ 70,000 tons of CO_2 .
- Smart Evolution: Supporting OTA upgrades and AI self-learning scheduling.
- Local Manufacturing: Complying with FEOC and IRA incentive policies.
- Long-term Scalability: Supporting multiple projects in parallel aggregation, forming a regional Virtual Power Plant (VPP).

Comprehensive Conclusion: This project is not only a technical validation platform for energy storage asset investment models but also the core model of Renon Power’s "Distributed + Intelligent + Aggregated" energy ecosystem.

Chapter 1 Global Energy Storage Landscape & Market Competitive Situation

1.1 Global Market Overview

By the fourth quarter of 2025, the cumulative installed capacity of global electrochemical energy storage has exceeded 105 GWh, with a year-on-year growth of 42%, entering the "hundred GWh era," showing a tripartite driving force pattern of "AI + Aggregation + Regional Manufacturing."

Region	Cumulative Installed Capacity by Q4 2025 (GWh)	Year-on-Year Growth	Key Drivers
North America (USA + Canada)	35GWh (+41%)	↑ Rapid	IRA policy + peak electricity price difference + FEOC manufacturing incentives
Europe	28GWh (+37%)	↑ Steady	RENON Power EU targets + VPP project expansion
Asia-Pacific	42GWh (+46%)	↑ Strong	China's "100GW Action Plan for New Energy Storage" + Japan's Community Microgrid Policy
Global Total	105GWh (+42%)	—	Commercial storage fully enters the scaling phase

Trend Characteristics 2025 → 2026:

a. Commercial & Industrial (C&I) storage > Residential storage;
b. Liquid-cooled LFP becomes mainstream (global share > 85%);
c. AI scheduling + Aggregators become the new standard in North America and Europe.

1.2 Policy & Investment Environment

a. North America - The US IRA Act Continues to Drive

- Investment tax credit of 30% + FEOC incentive of 10%;
- Energy Office's independent storage project filing volume increased by 53% year-on-year;
- California's C&I storage average IRR exceeds 15%.

b. Europe - REPower EU & Net Zero Act

- Requires at least 200GWh of storage by 2030;
- Number of VPP operation licenses increased by 38% year-on-year;
- Aggregator Market transaction volume surpassed 3.5 billion euros.

c. Asia-Pacific - China and Japan Dual Center Strategy

- China: "New-type storage 100GW" target;
- Japan: Community energy + distributed VPP subsidies are significant;
- Southeast Asia: The Philippines, Vietnam, and Thailand are rapidly entering the 100MWh project phase.

1.3 Technology Evolution (2024 – 2026)

Technological Direction	Status	Key Breakthroughs
Liquid-cooled LFP System	Mainstream >85% market share	Cycled over 8000 times / Temperature differential < 3℃
High voltage PCS Grid Connection	In circulation	AC1000V Modular Architecture
AIEMS Scheduling	Becoming Trend	Station-level forecast accuracy ±3% / Revenue increase 10 – 15%
Aggregator Platform	Rapid Growth	Support for ISO/RTO Market Automated Trading
Cloud O&M Platform	Standardization	Lifecycle Health Management Module Integration

1.4 Competitive Landscape

Company Brand	Region	Positioning	Key Strength
Fluence	North America/Europe	VPP+AI Scheduling Operator	Leading Algorithms/Strong Financial Support
Tesla Energy	Global	Energy Ecosystem Closed Loop	Virtual Power Plant (VPP) Ecosystem Improvement
Sungrow Power	Asia-Pacific	Liquid Cooling Integration + Self-developed BMS	Cost + Reliability Advantages
Renon Power	North America Core	AI EMS + Aggregator Integration + FEOC Localized Manufacturing	AI Scheduling × Compliant Manufacturing × High Gross Margin Three-dimensional Competitiveness

Renon Power Core Competitive Position:

- First to achieve a four-dimensional integrated architecture of “Energy Storage Devices + Local EMS + Cloud AI + Aggregation Platform”;
- Equipped with an FEOC-compliant production line + AI energy algorithms + integration with the North American Aggregator market;
- Forming a complete business closed loop from hardware to algorithms to revenue.

1.5 Conclusion

Starting in 2026, the core of global energy storage competition will shift from "cost-driven" to "intelligent scheduling and ecological aggregation." Renon Power, with its three major barriers of AI EMS, VPP aggregation, and FEOC-compliant manufacturing, is strategically positioned in the North American Tier 1 market.

Key Judgments:

- Market capacity in 2026 > 150GWh;
- AI aggregation and cloud EMS standardization will enhance industry profits by approximately 20%;
- Companies possessing both AI and Aggregator dual systems will become the preferred choice for the next stage of mergers and acquisitions and capital investment.

Chapter 2 Project Logic & Customer Pain Points & Overall System Architecture

2.1 Project Development Logic

This project follows the overall logic of "Distributed + Intelligent + Aggregation," targeting the North American C&I energy investment market to build a replicable 400MWh distributed energy storage network.

a. Target Positioning:

- Create a regional-level Virtual Power Plant (VPP) demonstration project in North America;
- Establish a modular, intelligent, and AI-driven yield optimization system model for Renon Power;
- Form a closed loop of project investment—construction—operation—reintegration.

b. Overall Logic Diagram:

Customer Demand → System Planning → Site Design → Array Deployment → Cabinet Configuration → EMS Aggregation → AI Yield Optimization → Investment Return Closed Loop

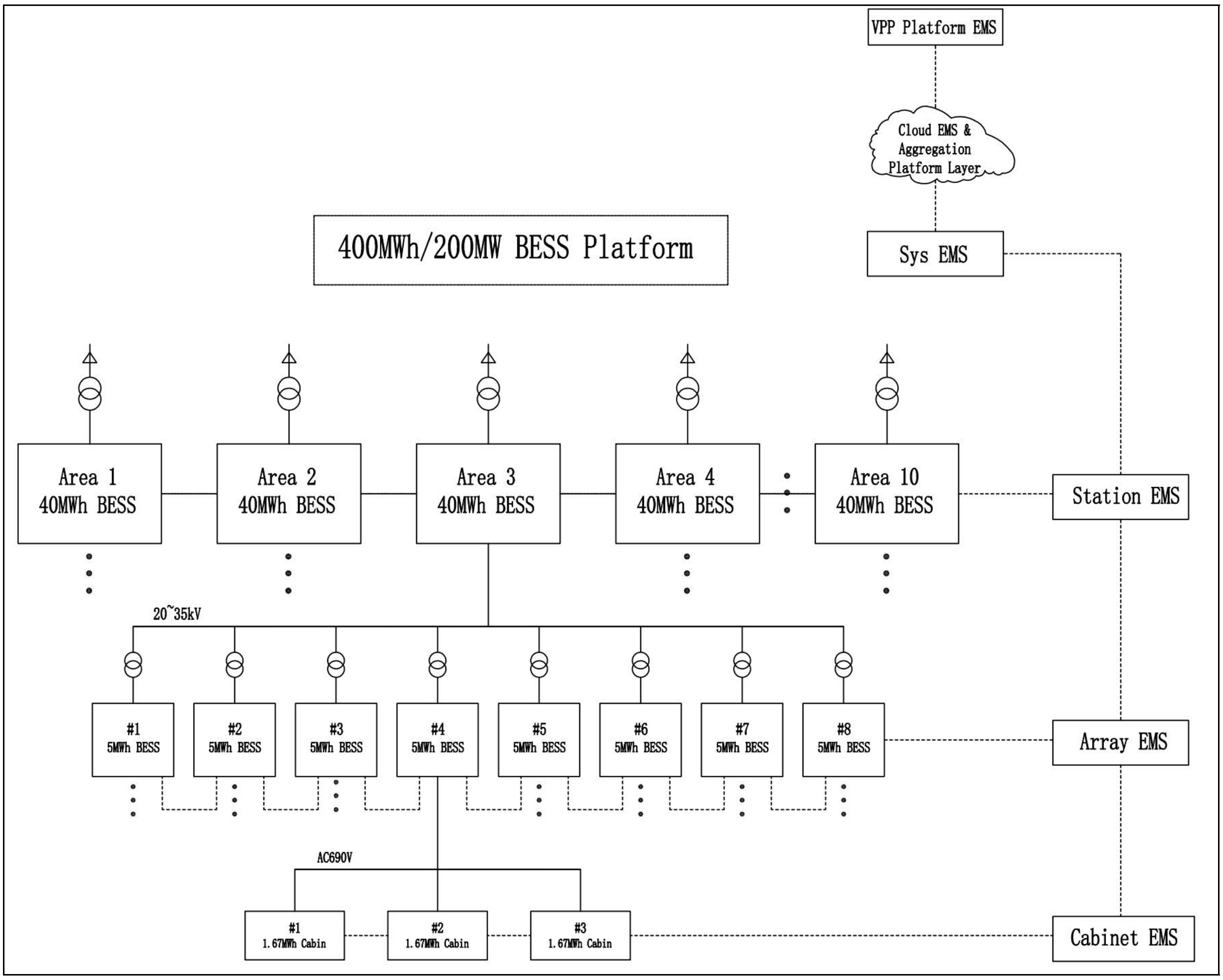
2.2 Customer Core Pain Points

Pain Point Type	Specific Manifestations	Renon Power Solutions
Expansion of electricity price difference	Peak-valley price difference ⩾ 0.3 USD/kWh, high operating costs	High-efficiency liquid cooling system + AI predictive scheduling, automatic peak shaving and valley filling
Lack of flexibility in the power grid	Fast charging stations, hotels, and shopping malls impact the peak load on the grid	Cabinet-level EMS for real-time power regulation, alleviating distribution pressure
Long investment cycle	Centralized power plant ROI > 6 years	Modular construction + EaaS business model, ROI ⩽ 4.5 years
Complex safety compliance	Long certification cycle for multi-site UL9540 and NFPA 855 registration	Cabinet-level UL9540 certification + station-level modular filing
High operational and maintenance costs	Difficulty in multi-station management and high personnel costs	Cloud AI intelligent operation and maintenance + remote OTA maintenance system

Pain Point Conclusion: What customers need is not just energy storage equipment, but a complete systems solution that possesses investment value, predictable returns, and intelligent operability.

2.3 System Overall Architecture

The project adopts a five-layer architecture system: **Cabinet level → Array level → Station level → Project level → Cloud EMS.**



a. Cabinet EMS functional positioning: The lowest layer execution unit and data collection unit, directly managing the smallest battery unit (830kW/1.67MWh).

b. Array EMS functional positioning: Coordinated controller, managing 8 battery cabinets that form a "battery array" (2.5MW/5MWh).

c. Matrix EMS functional positioning: The core optimizer and coordinator within the energy storage power station. Multi-array coordination: Receives data from multiple Array EMS units to manage and coordinate all battery arrays within the entire power station uniformly.

d. Station EMS functional positioning: The "brain" of the entire energy storage power station and its external interface. It provides a complete operational view of the whole station, including all Key Performance Indicators (KPI), alarms, and performance reports, enabling full station monitoring.

e. Cloud platform EMS functional positioning: A group and cross-regional asset management platform. It simultaneously monitors and manages multiple energy storage stations distributed across various geographical locations, achieving aggregate monitoring. Through coordinated control, it "virtualizes" multiple stations into a larger resource in the electricity market environment, participating in the grid ancillary service market to maximize revenue.

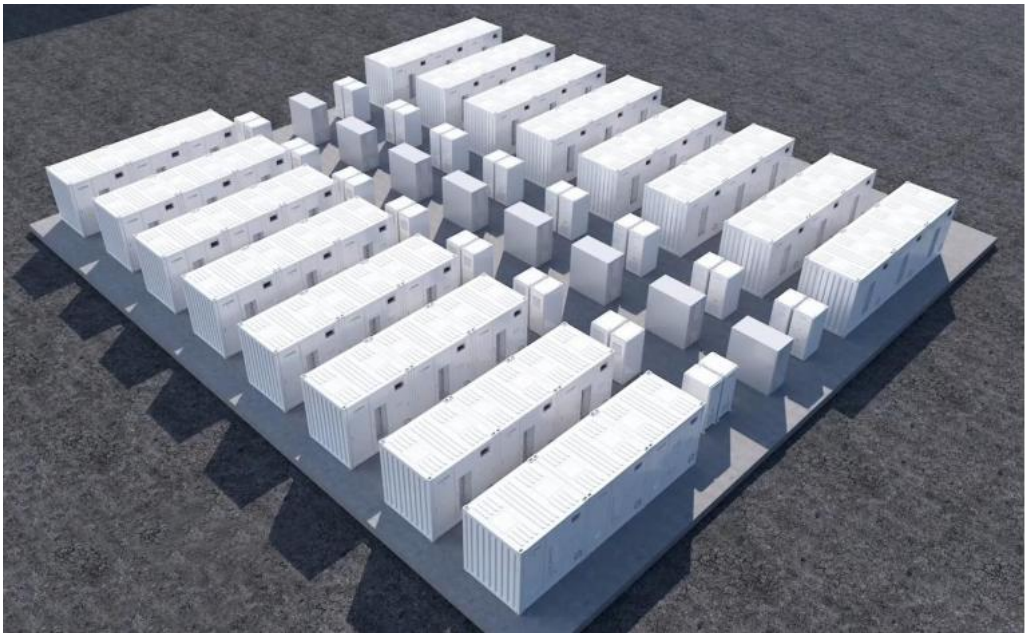
➢ **Cabinet Level**

- Model: 10ft AC liquid-cooled energy storage cabinet
- Configuration: 1.67MWh liquid-cooled battery + 830kW PCS + local EMS + fire safety + dynamic environmental monitoring
- Function: Independent charge and discharge control, data acquisition, status diagnosis, fault isolation
- Communication: RS485/CAN/Ethernet

➢ **Array Level**

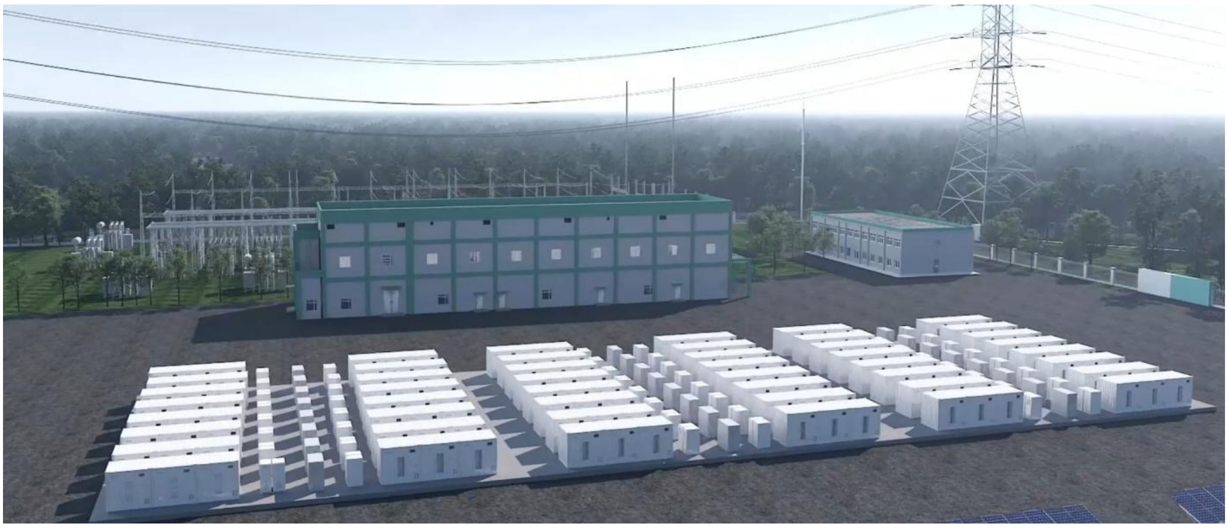
- Composition: 3 sets of 10ft AC cabinets + 1 communication cabinet + AC distribution cabinet
- Array Capacity: ≈ 5MWh/2.5MW
- Function: Array-level EMS coordinates power and safety, executes array scheduling commands

➢ **Station Level**



- Composition: 8 arrays ≈ 40MWh/20MW
- One station level EMS server (regular server)
- Function: Data aggregation, site optimization scheduling, uploading operational logs

➢ **Project Level**



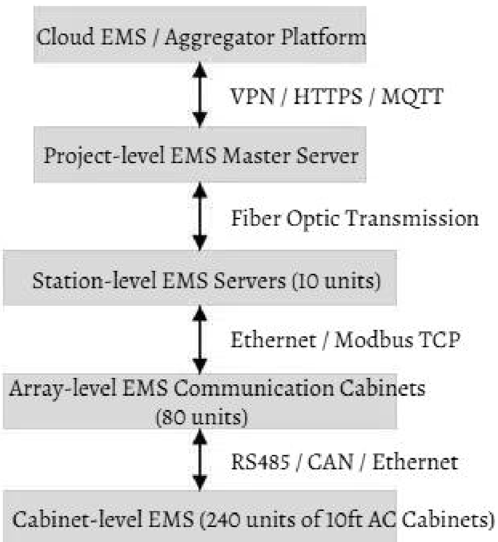
- Composition: 10 sites = 400MWh/200MW
- One high-performance server - project level EMS host
- Function: Network-wide data aggregation, AI revenue forecasting, strategy distribution, energy balancing, unified operation and maintenance

➢ **Cloud EMS & Aggregator**

- Function:

a. Real-time Monitoring and Revenue Forecasting
b. Aggregated Dispatch (VPP)
c. OTA Upgrade and Remote Maintenance
d. Investment Return Data Visualization
e. Multi-project Aggregation and Carbon Credit Settlement

2.4 System Topology



System Characteristics: Each layer has independent control capabilities, forming a structure of "Distributed Autonomy + Aggregated Dispatch," capable of operating offline as well as connecting to the grid.

2.5 Station Planning & Deployment

Hierarchy	Quantity	Function Description
Cabinet-level	240 units of 10ft AC cabinets	Independent energy unit, single cabinet 1.67MWh/830kW
Array-level	80 sets	3 cabinets + communication cabinet + distribution cabinet
Station-level	10 units	Including station-level EMS server + fiber access
Project-level	1 set	High-performance servers gather data from the entire site
Cloud	1 platform	AI scheduling + aggregation of revenue optimization + carbon credit management

Deployment Logic: first run independently on-site → project-level aggregation → cloud aggregation → intelligent scheduling closed loop.

2.6 Technical Advantages & Application Value

Dimension	Description of Advantages	Dimension
Modular Deployment	Cabinet-level independence → Array parallelism → Station-level aggregation, construction period shortened by over 40%	Modular deployment
Intelligent Control	Multilayer EMS intelligent scheduling for dynamic power allocation and self-healing from faults	Intelligent Control
Data Closed Loop	5Hz high-frequency sampling + AI algorithms + cloud learning for continuous optimization of operational strategies	Data Closed Loop
High Safety	Liquid cooling system + independent fire protection + redundancy, UL9540A test passed	High Safety
High Profitability	Peak-valley arbitrage + frequency modulation + DR + multiple revenue paths from carbon credits	High Profitability
Sustainability	Supports FEOC manufacturing, localized compliance, and 15-year O&M lifecycle	Sustainability

2.7 Conclusion

Renon Power's 10-foot AC system establishes a complete energy closed-loop from the cabinet to the cloud through a "five-layer EMS distributed architecture + AI profit optimization engine." This architecture possesses four core values: standardized deployment, intelligent scheduling, aggregative operation, and investment return, providing a unified technical template and commercial logic baseline for the 400MWh project and future multi-site replication.

Chapter 3 Key Technical Specifications & Performance Indicators

3.1 System Overview

Renon Power's 10ft AC liquid-cooled energy storage system centers around high energy density LFP 314Ah cells and adopts an IP65 protected integrated cabinet structure. It combines liquid cooling, AI EMS control, and high-reliability PCS grid connection design to create a standardized platform for 200MWh-level modular parallel applications.

Item	Specification	Remarks
Rated Energy	1.67MWh (per cabinet)	LFP 314Ah
Rated Power	830kW (built-in PCS)	AC Output
System Architecture	Liquid-cooled integrated + independent dynamic ring + fire protection system	Integrated BMS/EMS/PCS module
Protection Grade	IP65/NEMA 4X	Outdoor all-weather
Installation	Ground-mounted prefabricated foundation	Modular parallel expansion
Control Architecture/Control Architecture	Cabinet-level EMS → Station-level EMS → Cloud AI EMS	Three-layer distributed control
Grid Mode/Grid Mode	Grid-connected/Islanding/Black start	Support VPP scheduling
Communication Interface/Communication	Ethernet/RS485/Fiber/4G/MQTT/IEC 61850	Connecting to the Aggregator platform

3.2 Electrical Performance

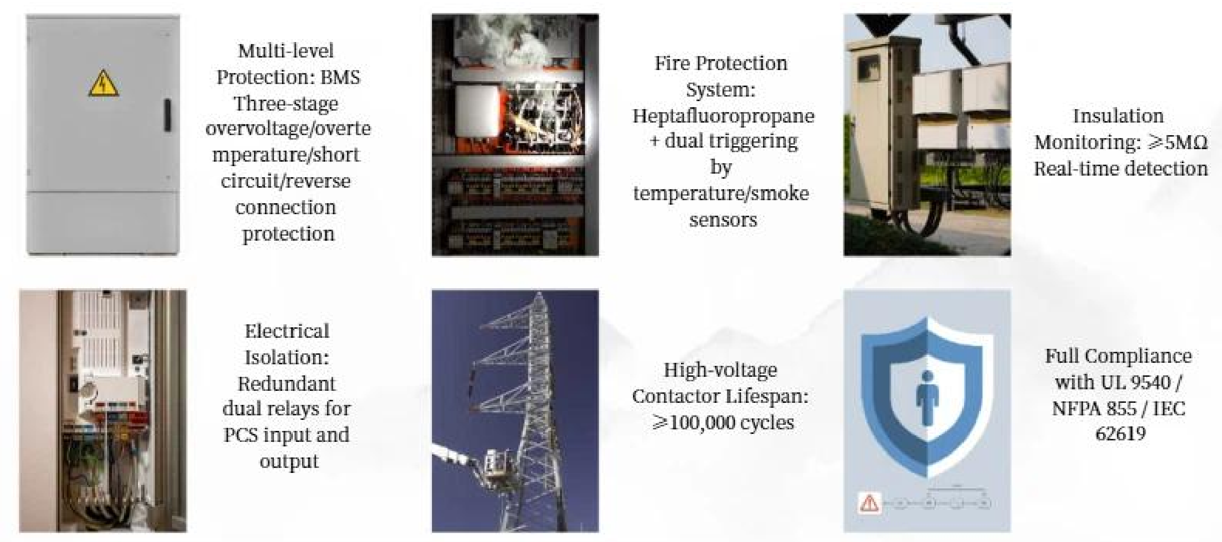
Parameters	V3.1 Optimization Value (Measured)
Cell Model	LFP 314Ah
Rated Voltage	1331.2Vdc
Round-Trip Efficiency	92.8% (+1.3%)
PCS Efficiency	97.8%
Peak Power	125%@10s
EMS Latency	≤80ms
Noise Level	≤75dB(A)

3.3 Thermal Management & Environmental Adaptation

Project	Parameters	Description
Cooling Method	Dual-loop liquid cooling system	Main circuit cold plate + auxiliary circuit cooling unit
Temperature Control Precision	±1℃	Automatic PID adjustment
Uniform Temperature Difference	≤5℃	Improvement of uniform temperature among modules
Ambient Temperature	－30℃ ～55℃	Automatic dehumidification and preheating

Liquid Cooling Pump Lifespan	⩾60000h	Maintenance Cycle 5 Years
Thermal Management Efficiency	93%	Power Consumption Reduction 9%
Safety Protection	Coolant Insulation Monitoring + Flow Alarm	UL 9540A Certification Passed

3.4 Safety & Protection



3.5 Communication & Control

Hierarchy	Interface	Protocol	Function
Cabinet-level EMS	Ethernet	Modbus-TCP	Sampling and Control Loop
Array-level EMS	Ethernet	Modbus-TCP	Array Synchronization and Isolation
Station-level EMS	Ethernet	Modbus-TCP	Cloud Data Upload
Project-level EMS	Fiber Backbone	REST API/TLS 1.3	Interface with Aggregator Cloud
Cloud AI Platform	Web Socket+API	OpenADR 2.0b	VPP Scheduling Command Issuance

- Data Encryption: AES-256+TLS 1.3;
- Packet Loss Rate: < 0.05%;
- Clock Synchronization: NTP⩽1ms error.

3.6 Reliability & Lifecycle

Module	Indicator	Description
Cell Lifespan	⩾8000 cycles @ 25℃	Under DoD 98% conditions
Module MTBF	$\geqslant 1.2\times10^{6}$ h	High Reliability Design
System Availability	> 99.5%	AI Predictive Maintenance
Average Annual Downtime	< 40h	Remote OTA Maintenance
Failure Rate	< 0.3%	AI Anomaly Diagnosis

Lifecycle Carbon Emission Reduction	≈－14tCO_2 /MWh	Reduce the air conditioning cooling system by 22%

3.7 System Efficiency & Economics

- Through AI EMS intelligent scheduling, the combined efficiency of PCS + battery is greater than 92.8%;
- Modular assembly costs are reduced by approximately 11%;
- LCOE decreases by 6% (0.057→0.053 USD/kWh);
- Annual energy loss reduced by 4.5%;
- Maintenance cycle extended to once every 36 months.

3.8 Testing & Certification

Certification Standards	Testing Organizations	Status
UL 9540/9540A	Intertek/CSA Group	☑ Passed
NFPA 855 (2023 Edition)	UL Solutions/NFPA Lab	☑ Passed
IEEE 1547-2018	ETL Certification	☑ Compliant
NEMA 4X/IP65	SGS Protective Laboratory	☑ Passed
FEOC Registration Compliance	US Treasury/DOE	☑ Record completed

3.9 Conclusion

The Renon Power 10ft AC liquid-cooled energy storage system, in conjunction with the 314Ah cell platform, AI EMS algorithm, and IEC 61850 communication system, has achieved a breakthrough in system performance characterized by "high energy efficiency + high reliability + intelligent scheduling."

a. Key Results:

- PCS + battery combined efficiency > 92.8%; power density + 8%;
- Thermal management temperature difference≤5℃; noise < 75dB;
- OPEX annual reduction≈10%; lifespan extended by 20%;
- Meets the triple standards of UL 9540/NFPA 855/FEOC.

b. Positioning Conclusion:

This system has become the technological baseline platform for 200MWh-level projects in North America and is the core carrying unit of Renon Power's "AI + liquid cooling + compliance" strategy.

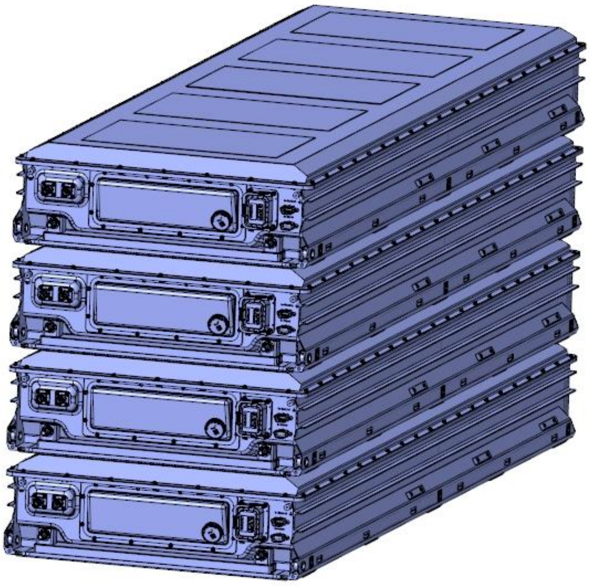
Chapter 4 Core Components & System Configuration Requirements

4.1 System Composition Overview

The 10-foot AC liquid-cooled energy storage system consists of 6 major core subsystems, forming an integrated structure of “electric-control-cooling-protection-communication-intelligence”:

Module Category	Subsystem Composition	Function Description
Power Subsystem	Liquid-cooled LFP Battery Cluster + High-voltage BMS + DC Busbar	Energy Storage and Status Monitoring
Power Conversion Subsystem	830kW Three-level PCS + AC Distribution Cabinet	Bidirectional energy conversion, grid-connected/off-grid control
Control and Communication Subsystem	Cabinet-level EMS + Array-level Communication Cabinet + Station-level/Project-level EMS	Multi-level Scheduling, AI Algorithm Execution, Remote Communication
Thermal Management Subsystem	Liquid Cooling System + Intelligent Temperature Control Unit + Air Cooling Assistance	Temperature Balancing, Energy Efficiency Improvement
Safety Protection Subsystem	Independent Firefighting + Environmental Monitoring + Access Control Sensing	Cabinet-level Safety Closed Loop
Software and Intelligence Subsystem	Cloud EMS Platform + AI Prediction Engine	AI Revenue Optimization and Lifecycle Management

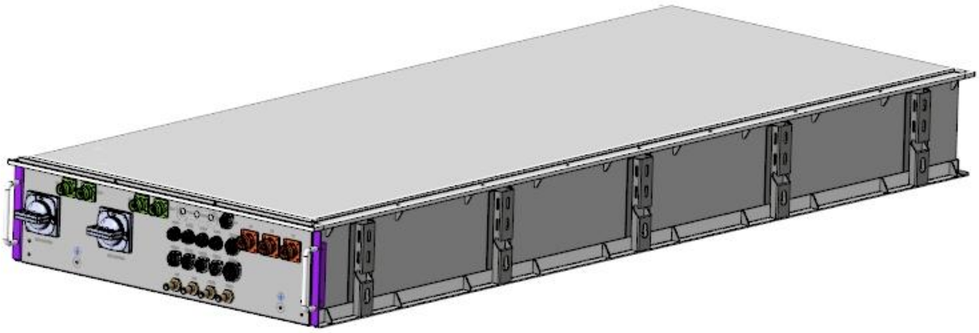
4.2 Battery Cluster & BMS System



Project	Parameters	Description
Cell Type	LFP Lithium Iron Phosphate (314Ah)	High thermal stability, low internal resistance, cycle life > 8000 times
Single Cabinet Capacity	≈ 1.67MWh @ 1331.2V DC	314Ah cell increases energy density by ≈ 7 - 10%
BMS Architecture	BMU+CBMU+MBMU three-level	Module-level → Cluster-level → System-level management
Communication Method	CAN/RS485	Bidirectional communication with EMS
Sampling Accuracy	Voltage ±0.5 V / Temperature ±1 ℃	Real-time sampling ≥ 5 Hz
Protection Function	Overvoltage, undervoltage, overcurrent, short circuit, insulation detection, thermal runaway warning	Module + cabinet double protection
Temperature Control System	Dual-Circuit Liquid Cooling (Cold Plate + Liquid Cooling Unit) + AI Temperature Control Algorithm	Temperature Difference ≤ 5℃ /Cabinet
Certification Standards	UL 1973/IEC 62619	Meets North American + International Standards

Features: The 314Ah battery cell uses a high energy density LFP system, combined with Renon Power's self-developed BMS algorithm, achieving SoH self-learning and dynamic capacity balancing, resulting in approximately 9% energy improvement and about 12% lifespan extension.

4.3 PCS & AC Distribution

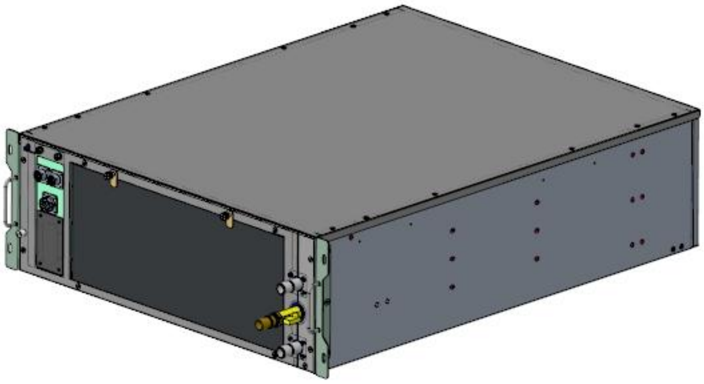


Project	Parameters	Function Description
PCS Rated Power	830 kW Bidirectional	Grid-Connected / Off-Grid / Black Start Three Modes
Topology	Three-level IGBT modular design	THD＜2%
Input Voltage	1000-1500 V DC	Match LFP system
Output Voltage	690 VAC three-phase 60Hz	North American standard
Efficiency	≥ 98.5 %	Peak 98.8 %
Protection Level	IP65 Liquid Cooling	Outdoor Deployment
Communication Interface	Ethernet / Modbus TCP	Real-time Power Scheduling
Safety Protection	Overcurrent, Overvoltage, Backfeed, Arc, Ground Fault	Comprehensive Protection

4.4 EMS & Communication Subsystem

Hierarchy	Control Unit	Function Description
Cabinet-level EMS	Integrated HMI + Data Acquisition Unit + Control Module	Independent Scheduling and Logging
Array-level Communication Cabinet	Communication Management Machine + Switch	Coordination Between Arrays and Data Aggregation
Station-level EMS	Standard Server + Scheduling Logic Engine	Data Aggregation and Strategy Upload
Project-level EMS	High-Performance AI Server + Algorithm Module	Predictive Scheduling / Revenue Optimization
Cloud EMS	Renon Cloud AI System + Aggregator API	Aggregated Scheduling / Remote O&M / Data Analysis

4.5 Liquid-Cooling System



Parameters	Specifications	Description
Cooling Method	Closed-loop Liquid Cooling + Air Cooling Assistance	Constant Temperature 25 ±2℃
Flow Rate	≥ 20L/min / Cabinet	Temperature difference of single unit < 3℃
Refrigerant	Ethylene Glycol Solution (30%)	Antifreeze, Anticorrosion, Eco-friendly
Power Consumption	≤ 1% System Power	Optimal Energy Efficiency Design
Control Logic	Automatic Start/Stop + AI Learning Load Variation	Dynamic Energy Saving
Protection	Leak Detection + Pressure Monitoring + Temperature Difference Alarm	Automatic Shutdown Linked to Fire Fighting
Design Life	≥ 50000h	OTA Self-Calibration Available

4.6 Fire Protection & Environmental Monitoring

Module	Technical Specifications	Function Description
Fire Protection System	Heptafluoropropane + Smoke Detection + Temperature Detection + Heat Trigger + Power Outage Protection	Cabinet-Level Independent Rapid Response <10s
Dynamic Environment Monitoring	Temperature and Humidity / Access Control / Vibration / Smoke Detection / Water Immersion / Infrared	7×24 Hours Online Monitoring
Alarm System	Audio-Visual Alarm + Remote Alarm + EMS Linkage	Multi-Level Event Recording and Analysis
Power Supply Protection	UPS Backup ≥ 30min + SPD Lightning Protection	Ensure Emergency Stable Operation
Communication	RS485/Ethernet	Bidirectional Interconnection with EMS

4.7 System Redundancy & Reliability Requirements

- Control Redundancy: Independent logic at cabinet level/array level/station level, single node failure does not affect the overall system;
- Communication Redundancy: Dual network ports + optical fiber backup link;
- Electrical Redundancy: PCS parallel hot backup;
- Safety Level: SIL Level 2/MTBF ≥ 100,000 hours;

- Full Life Cycle Reliability: ⩾ 15 years of stable operation with > 99.2% availability.

4.8 Conclusion

The 10-foot AC liquid cooling system utilizing 314Ah high specific energy LFP cells, combined with Renon Power's proprietary BMS algorithm, 830 kW PCS, and AI EMS architecture, creates an integrated system platform with high energy density, high efficiency, and high safety. This configuration meets UL 9540/NFPA 855/FEOC standards, providing investment-grade reliability and engineering-grade scalability, thus offering core technical support for 400 MWh distributed projects.

Chapter 5 EMS Architecture & AI Intelligent Scheduling System

5.1 Overall Architecture

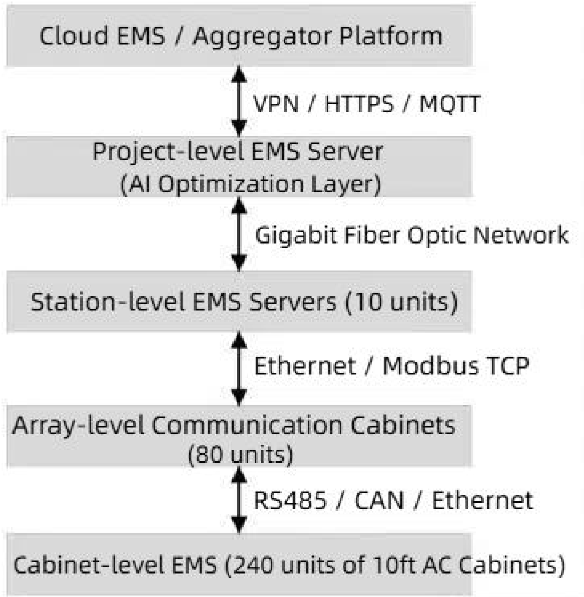
Renon Power EMS system adopts a "five-layer distributed collaborative architecture":

cabinet level → array level → station level → project level → cloud EMS and aggregator platform.

a. The Core Objective is to Achieve:

- Hierarchical autonomy and dynamic collaboration;
- Real-time data collection and multi-level optimization decision-making;
- Support for VPP aggregation and AI profit closed-loop management.

b. Architecture Logic Diagram



5.2 Cabinet Level EMS Control Unit

Module	Function Description
Data Acquisition Module	Real-time sampling of voltage, current, temperature, SOC, etc. > 5Hz
Control Logic Module	Execute BMS instructions, PCS charge and discharge control
Communication Interface	RS485/CAN/Ethernet
Logging	Operating status, local events, alarm records
Local Display HMI	Monitor key parameters and operation logs
Self-diagnosis Function	Battery abnormality → Independent switch to protection mode

Features: The cabinet-level EMS is the system's minimum control unit, with autonomous operation and fault isolation capabilities, ensuring that an abnormal cabinet does not affect the overall array and site.

5.3 Array Level EMS

- Composition: 3 units of 10ft AC cabinets + communication cabinet + AC distribution cabinet;
- Main functions:

a. Data aggregation and power balancing within the array;
b. Control PCS operation and current distribution;
c. Implement array power scheduling, redundancy protection, and alarm uploading;

- Communication protocol: Ethernet/Modbus TCP;
- Scheduling logic: Interference-free operation between arrays, supporting independent maintenance and online expansion.

5.4 Station Level EMS

- Every 8 arrays form 1 station;
- Deploy one ordinary server and install the Renon Station EMS module;
- Function:

a. Unify the scheduling array operation strategy;
b. Monitor voltage, current, and power factor at the grid access points;
c. Data storage and real-time upload to project-level EMS;
d. On-site event alarms and self-healing logic for alarms;

- Intelligent features: Automatically adjust charge and discharge timing based on AI prediction algorithms to enhance profitability and stability.

5.5 Project Level EMS

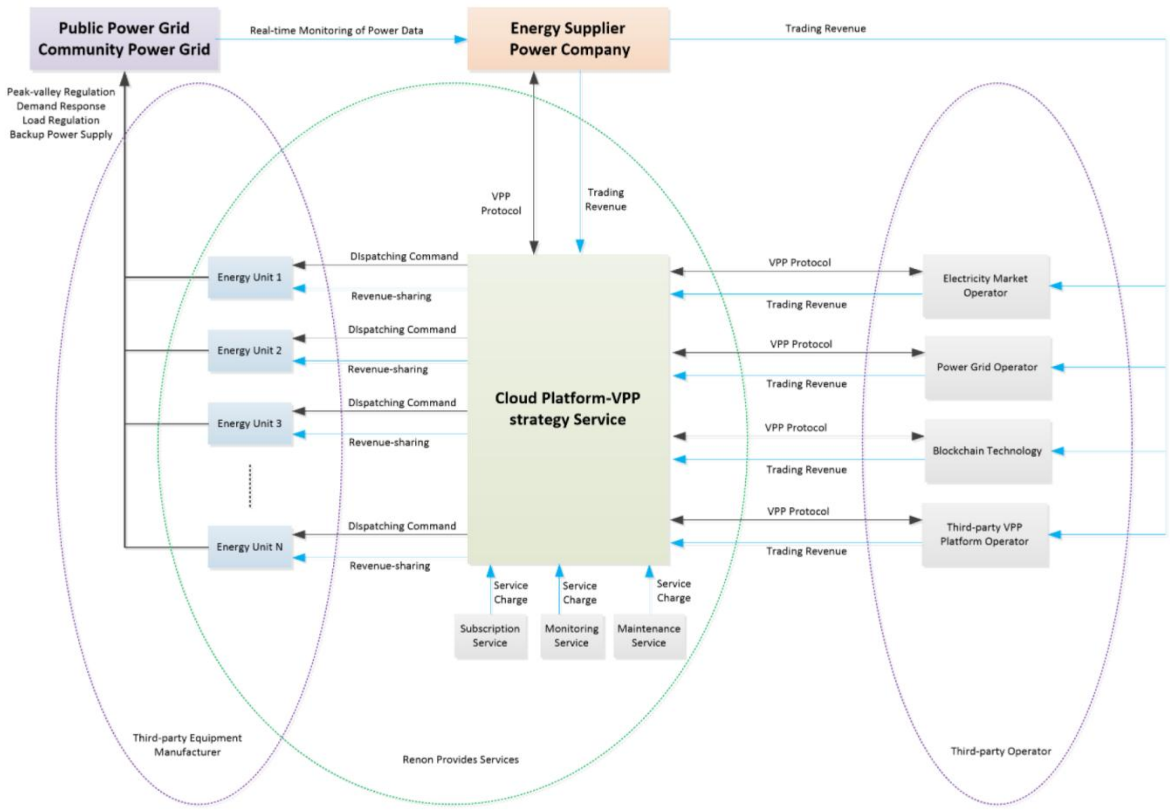
- Deploy one high-performance server to aggregate data from 10 sites;
- Integrate AI profit optimization engine (Renon AI-Opt Core V3.2);
- Core features:

a. Global power scheduling and energy balance;
b. Electricity price forecasting + load forecasting + environmental forecasting;
c. AI profit optimization (maximizing IRR / ROI);
d. Equipment health assessment and lifespan prediction;
e. Strategies dispatched to station-level EMS for execution.

Algorithm Basis:

- Using LSTM + XGBoost combined model for electricity price forecasting;
- Dynamic optimization of scheduling decisions based on Reinforcement Learning algorithms;
- Achieving self-learning of strategies and self-evolution of profits through AI profit backtesting models.

5.6 Cloud EMS & Aggregator Platform



Functional Modules	Description
AI Aggregated Scheduling Center	Summarizes project-level EMS operational status and unifies revenue scheduling;
Multi-project data aggregation	Supports coordinated control of energy networks across multiple sites/regions;
Revenue prediction and trading interface	Integrates with ISO/VPP market platforms for frequency modulation/demand response trading;
Cloud-based AI learning engine	Automatically identifies operational modes and strategy revenues, forming an optimization feedback loop;
Operation and maintenance management platform	Realize OTA upgrades, remote diagnostics, asset tracking, and carbon credit management.

The commercial significance: Cloud EMS is the core hub for AI intelligent revenue optimization and energy asset aggregation, upgrading energy storage systems from "equipment" to "intelligent assets."

5.7 AI Scheduling Logic

a. Scheduling Workflow:

Data Collection → AI Prediction Engine → Strategy Optimization → Instruction Issuance → Execution Feedback → Revenue Backtest → Self-Learning Update

b. Key Algorithm Modules:

Module	Function Description	Module
Load Forecasting (LF)	Predicting the future 24-hour load curve based on historical power and temperature data	Load Forecasting (LF)
Price Forecasting (PF)	Obtaining the future price change trend through AI models	Price Forecasting (PF)
Energy Distribution (ED)	Dynamic allocation of site/array power and charging/discharging timing	Energy Distribution (ED)
Revenue Optimization (RO)	Objective function Max(IRR, ROI), constraints SoC/safety/lifetime	Revenue Optimization (RO)
Learning Engine (LE)	Continuous training of the model, adjusting parameters based on actual revenue	Learning Engine (LE)

c. **Revenue Enhancement:** AI scheduling increases overall system revenue by 7 – 10%, energy utilization rate by 15%, and peak-valley arbitrage success rate by over 20%.

5.8 Data Flow & Cyber Security

Security Levels	Measures	Description
Physical Security	Cabinet-level access control + infrared monitoring	Prevent illegal access
Communication Security	AES-256 encryption + VPN tunnel	Ensure data transmission integrity
Permission Security	Multi-level identity verification and access logs	Ensure multi-tenant environment isolation
Data Backup	Real-time synchronization + cloud redundancy backup	Prevent data loss
Operational Security	OTA Signature Verification + Remote Firmware Version Management	Prevent Malicious Tampering

5.9 AI Revenue Optimization Model

The AI algorithm optimizes system revenue through the following three dimensions:

a. **Time Dimension** — Predicting Electricity Prices + Optimizing Charging and Discharging Timings ($\Delta P \times \Delta t \rightarrow$ Maximum Revenue);
b. **Space Dimension** — Multi-site Load Aggregation Scheduling, Balancing Regional Power;
c. **Strategy Dimension** — AI Revenue Backtesting + Dynamic Parameter Adjustment → Self-learning Revenue Iteration.

Indicator	Benchmark Value	After AI Optimization	Increase Amplitude
Peak-valley Arbitrage Yield	100%	112%	+12%
Frequency Modulation Response Yield	100%	115%	+15%
Energy Utilization Rate	100%	118%	+18%
Overall ROI	100%	108%	+8%

5.10 Conclusion

Renon Power's five-layer EMS architecture and AI scheduling system constitute the core competitiveness of the project. It achieves a complete technological closed loop of "distributed autonomy + cloud aggregation + AI optimization," enhancing energy asset returns, operational efficiency, and system safety through algorithm-driven solutions.

Results: AI benefits of the 400MWh project increased by 7 – 10%, system availability reached 99.3%, and operational costs decreased by 18%, laying a technological foundation for Renon Power to build a global intelligent energy storage ecosystem.

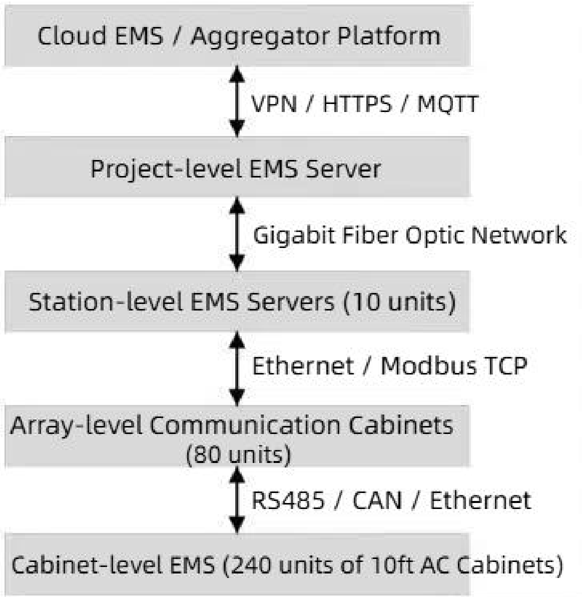
Chapter 6 Communication & Data Acquisition Specifications

6.1 General Objectives

a. Renon Power EMS Communication System Aims to Achieve:

- Multi-level data collection and real-time monitoring (sampling accuracy above 5Hz);
- High-speed and reliable communication between EMS at all levels;
- Comply with UL 9540/NFPA 855/FEOC data tracking requirements;
- Support AI algorithm training, predictive analysis, and lifecycle operation and maintenance.

b. Communication Structure



6.2 Battery System Data Acquisition

Hierarchy	Acquisition Items	Sampling Frequency	Accuracy Requirements	Description
Cell Level	Single Cell Voltage, Single Cell Temperature, SOC, SOH	5Hz	±0.5mV/±0.5℃	BMS directly collects 314Ah cell data
Module Level	Voltage, current, average temperature, balancing status	2Hz	±1%	BMU uploads to CBMU
Cluster Level	Total voltage, current, power, SOC, SOH, cycle count	1Hz	±0.2%	MBMU Aggregated Data
Cabinet Level	Battery Status, EMS Control Commands, Fault Codes, Operating Logs	1Hz	±0.5%	Real-time Monitoring of Cabinet Level EMS
System Level	Charging and Discharging Power, Cumulative Energy, Efficiency, Temperature Distribution	0.2Hz	±0.5%	Project Level Data Center Storage

6.3 PCS & MPPT Data Acquisition

Collection Module	Data Item	Sampling Frequency	Accuracy	Description
PCS Input Side	DC Voltage, Current, Power Factor, Harmonic THD	1Hz	±0.2%	Monitor Energy Conversion Efficiency
PCS Output Side	AC Voltage, Current, Frequency, Active/Reactive Power	1Hz	±0.2%	Synchronize with the Grid Connection Point
MPPT Module	PV voltage, current, input power	2Hz	±1%	Support for PV + wind turbine connection
Diesel Engine Interface	Speed, fuel amount, power output, status	0.5Hz	±1%	For hybrid energy stations
Wind Input	Speed, power, wind speed	0.5Hz	±2%	Monitoring of multi-energy access
Load Output	Load Power, Phase Voltage, Current Unbalance Rate	1Hz	±0.5%	Optimized Distribution by EMS
Grid Connection Interface	Frequency, Phase, Voltage Quality	1Hz	±0.2%	Comply with IEEE 1547 Requirements

6.4 Communication Protocols

Hierarchy	Communication Medium	Protocol Standards	Data Types	Bandwidth Requirements
Cabinet level → Array level	RS485/CAN	Modbus-RTU/CAN open	Raw operating data	≥9.6kbps
Array level → Station level	Ethernet	Modbus TCP/IEC 61850	Summary and status information	≥100Mbps
Station level → Project level	Optical Fiber Ethernet	TCP/IP + MQTT	Real-time data stream and AI commands	≥1Gbps
Project level → Cloud level	VPN/HTTPS	WebSocket/API/TLS encryption	Global monitoring and revenue data	≥10Mbps

a. **Encryption Mechanism:** All cross-layer communications use AES-256 encryption and TLS 1.3 protocol;

b. **Synchronization Mechanism:** NTP network time uniform calibration, maximum time deviation ≤100ms.

6.5 Data Storage & Logging

Category	Storage Period	Storage Location	Upload Frequency	Function Description
Real-time Data	7-Day Cache	Cabinet-level EMS Local	Continuous	For Short-term Debugging and Diagnosis
Array Data	30 days	Array-Level Communication Cabinet	Upload every 15 minutes	Power and energy balance analysis
Station-level Data	180 days	Station-level EMS server	Upload every hour	Site operation statistics
Project-level Data	5 years	Project-level database/cloud synchronization	Daily Summary	Return on Investment Assessment and AI Training

Alerts and Event Logs	Permanent	Cloud O&M Platform	Instant Upload	Lifecycle Records and Compliance Traceability

6.6 Data Integrity & Cybersecurity

- Data Encryption: AES-256 end-to-end encryption + digital signature verification;
- Access Control: RBAC-based permission management, three levels of roles (Viewer/Operator/Admin);
- Network Isolation: Industrial firewall + dual-network interface layered isolation;
- Anti-tampering mechanism: Log hash verification + irreversible signature chain;
- Compliance tracking: Meets NERC CIP/UL 9540/FEOC security audit requirements.

6.7 Synchronization & Timing

- Time source: Dual synchronization of NTP + GPS;
- Maximum deviation: ≤100ms;
- Timing accuracy: ≤20ms (synchronization between devices in the array);
- Applications: AI scheduling prediction model training, event correlation analysis, power phase alignment.

6.8 Compliance & Interface Standards

Standard No.	Name	Scope of Application
IEEE 1547/2030.7	Distributed Resources Interconnection and Communication Interface Standards	PCS/EMS Data Interconnection
IEC 61850/62351	Smart Substation Communication and Information Security	Array to Project-Level EMS
UL 9540A/NFPA 855	Energy Storage System Safety and Log Requirements	Cabinet-Level to Station-Level Operating Records
FEOC Compliance Claus § 45.3	North American Energy Asset Tracking Requirements	Project-Level and Cloud Data Synchronization
NERC CIP 13/22	Critical Energy Infrastructure Security	Network and Data Protection Layer

6.9 Conclusion

Renon Power's communication and data system has constructed a complete data ecosystem of "multi-layer interconnection + high-frequency sampling + AI empowerment + compliance traceability." This system ensures that for a 400MWh project, data is accurate, continuous, secure, and transparent throughout the AI predictions, aggregated operations, remote maintenance, and compliance auditing processes.

Results: System data sampling frequency≥5Hz, time deviation≤100ms, data availability ≥99.8%, meeting the dual requirements of North American FEOC and AI intelligent operation and maintenance.

Chapter 7 Data Collection & Communication Specifications

7.1 Overall Overview

The data communication system of Renon Power's 10 ft AC liquid-cooled energy storage system is designed based on the principles of "multi-layer collection + multi-protocol compatibility + AI labeling," covering a seven-layer structure from cell → module → cabinet level → array → station level → project → cloud.

Core Objectives:

a. Achieve millisecond-level data response and cross-layer data consistency;
b. Ensure the accuracy of cloud-based AI scheduling and Aggregator transaction data;
c. Establish a standardized Tag semantic system to support VPP aggregation and carbon asset tracking.

7.2 AI Data Labeling System (Tag Labeling Rule Set)

Level	Example Tag	Accuracy	Frequency	Type
Cell Level	Cell.V[n], Cell.T[n]	±0.5%	1s	Voltage/Temperature
Module Level	Module.Vavg, Module.Tavg	±0.3%	2s	Module average
Cabinet Level	Cabinet.SOC, Cabinet.Power, Cabinet.Temp	±0.2%	5s	Energy/Power/Temperature
Array Level	Array.Load,Array.AvgTemp	±0.2%	10s	Array Load/Environment
Station Level	Station.ActivePower,Station.HealthIndex	±0.1%	30s	Site Operational Status
Project Level	Project.EnergyFlow,Project.AlarmCount	±0.05%	60s	Project Overview
Cloud	AI.PredictiveLoad,AI.ROI,AI.Lifetime	±0.01%	Variable	AI Prediction/Revenue Model

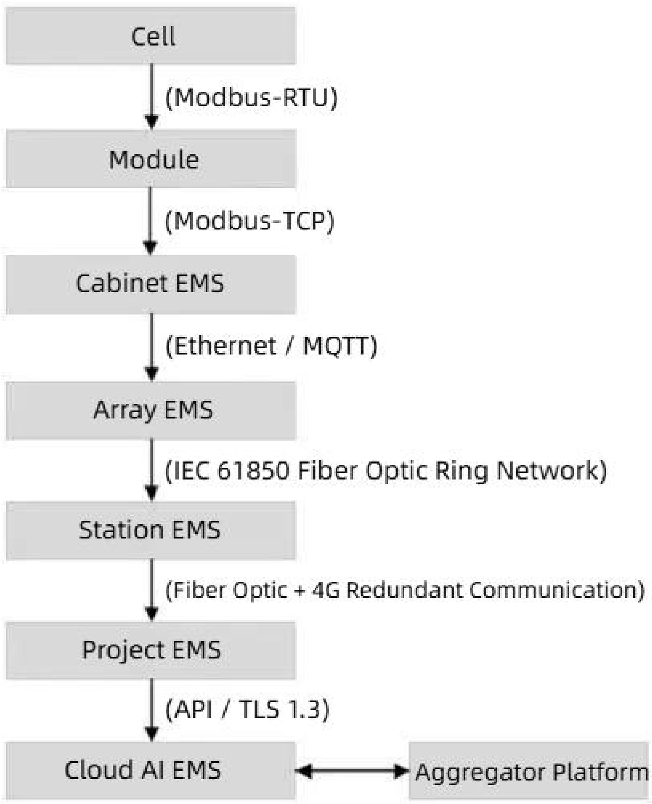
- Naming convention: Level.Object.Parameter structure;
- Field structure: timestamp+source+value+checksum;
- Label length: ≤32 characters;
- Character set: UTF-8, compatible with IEC 61850 standard.

7.3 Data Integrity & Accuracy Requirements

Indicator/Item	Requirement
Packet Loss Rate	<0.05%
CRC Validation	100%
Time Sync Accuracy	≤1ms (NTP protocol)
Data Drift Error	<±0.1% (within 24 hours)

Auto Recovery	Reconnection within ≤60s
Log Integrity	100% feedback to cloud EMS

7.4 Communication Architecture



- Communication Levels: 7 layers;
- Main Protocol: IEC 61850 + MQTT Hybrid Architecture;
- Secure Encryption: AES-256+TLS 1.3 dual layer;
- Data Aggregation: Cloud-based AI engine aggregates power and yield data every 30 seconds.

7.5 Modbus Register Index

Address Range	Content	Unit	Accuracy	Update Frequency
40001 – 40050	Cell Voltage/Temperature	V/℃	±0.5%	1s
40051 – 40100	Module SOC/Power	%/kW	±0.3%	2s
40101 – 40200	Cabinet-level Status/Alarm	—	—	5s
40201 – 40300	Array Operating Data	kW/kWh	±0.2%	10s
40301 – 40500	Station-level and Environmental Parameters	—	—	30s

Note: The register range can be expanded to 41000 to accommodate project-level EMS requirements.

7.6 Data Logging & Diagnostics

- Log Structure: JSON format (including tag, value, timestamp, alarm_level);
- Alarm Level: Three tiers of Info/Warning/Critical;
- Diagnostic Mode: AI automatic identification > Manual verification > Cloud feedback;
- Storage Cycle: Local 7-day cache + Cloud 5-year archive;
- Exception Capture: Automatic reselection if sampling anomaly ≥ 3 times;
- AI Self-Healing Mechanism: Fault model self-learning and optimization of trigger threshold.

7.7 Cyber Security & Compliance

Security Policy	Implementation Method
Data Encryption	AES-256 Dynamic Key + TLS 1.3 Tunnel
Authentication Mechanism	Two-Factor Authentication (Device + User ID)
Firewall Rules	Modbus/MQTT Whitelist Filtering
Audit Trail	Full Link Logs + Block Timestamp
Standards Compliance	IEC 62351/ISO 27001/NIST SP800-82

7.8 Aggregator Integration API

- Interface Protocol: REST API/OpenADR 2.0b/WebSocket;
- Interaction Frequency: ≤30s cycle;
- Command Types: Power Scheduling, Price Signals, Revenue Settlement, Carbon Asset Upload;
- Security Assurance: API Token dynamic update; Authorization validity period 24h;
- Compatible Platforms: Fluence AIOS, AutoGrid, Wattstor, Renon Aggregator Cloud.

7.9 Conclusion

Renon Power 10 ft AC Energy Storage System achieves full-link digital closed-loop from the device layer to the Aggregator platform through the V3.1 version AI data collection and communication specifications.

Core Results

- Data collection delay ≤80ms; Packet loss rate <0.05%;
- Labeling system unified naming standardized to 7 layers;
- Support for concurrent IEC 61850 + MQTT dual protocols;
- Meets NFPA 855/UL 9540A communication security requirements;
- Equipped with AI prediction + revenue tracking + carbon credit calculation triple functions.

Chapter 8 AI Intelligent O&M and Lifecycle Management

8.1 Overall Objectives

Renon Power's 10-foot AC system's AI intelligent operation and maintenance system is centered on "prediction + self-diagnosis + learning + optimization", achieving stable operation over the full lifecycle (LCC > 15 years), minimizing OPEX and ensuring traceable asset management.

Core Objectives

- Fault prediction accuracy≥95%;
- Mean Time to Repair (MTTR)≤4h;
- System availability≥99.3%;
- Operation and maintenance costs (OPEX) reduced by≥18%;
- Return on Investment (ROI) improvement≥8%.

8.2 Predictive Maintenance Model

Module	Data Source	Prediction Algorithm	Results Output
Battery Health	Cell Voltage, Internal Resistance, Temperature Curve	LSTM + Kalman Filter	SoH Decay Curve, Life Warning
PCS Status	Current, Voltage, Frequency Waveform	XGBoost Anomaly Detection	Fault Classification + Power Decrease Prediction
Liquid Cooling System	Temperature Difference, Flow Rate, Pressure	CNN Temperature Control Model	Thermal Imbalance Alarm + Energy Saving Strategy
Communication Link	Data Delay, Packet Loss Rate	ARIMA Time Series	Communication Anomaly Trend Prediction
Performance of EMS Algorithm	Scheduling Response, Yield Deviation	Reinforcement Learning RL Model	Policy Adjustment + Yield Optimization

Feature: AI algorithms achieve multi-dimensional predictions from component level to system level to project level through the integration of historical and real-time data.

8.3 Health Assessment & Lifetime Management

Dimension	Indicator	Cycle	Method
Cell SoH	Remaining Capacity > 85% Threshold	Every 3 Months	AI Curve Fitting + Comparative Baseline
PCS Module MTBF	≥100000h	Real-time	Fault Log Self-learning
Liquid Cooling System	Temperature Difference≤3℃ / Flow Rate≥20L/min	Every 1 Month	Remote Flow Analysis
Communication System	Data Availability≥99.8%	Continuous	Ping Test + Bandwidth Monitoring
Machine Lifetime	≥15 years/6000 cycles	Annually	AI Model Prediction + Validation Testing

Results: AI health management reduces manual inspection frequency by 36% compared to traditional O&M, extending the lifespan of key components by 12%.

8.4 O&M Structure and Roles

Cloud AI Monitoring Layer → Project Level AI Strategy Layer → Station Level Execution Layer → Array Maintenance Layer → Cabinet Level Diagnosis Layer

Hierarchy	Main Functions
Cabinet Level	Self-Diagnosis + Log Recording + Incident Reporting
Array Level	Centralized Debugging + PCS Balancing + Fault Isolation
Station Level	Maintenance Plan Generation + Remote Control + Data Aggregation
Project Level	AI Algorithm Strategy Execution + Revenue Monitoring
Cloud	Big Data Analysis + Lifecycle Asset Assessment + Carbon Tracking

8.5 Logging System & Self-Learning Mechanism

Log Types	Content	Storage Period	Usage
Run Log	Voltage, Current, Power, Temperature	5 years	Performance Analysis + Fault Review
Alarm Log	Abnormal Events, Level, Response Time	Permanent	AI Model Training Samples
Operation and Maintenance Log	Repair, Replacement, Costs	15 years	LCC Analysis
Revenue Log	Charge and discharge revenue, scheduling efficiency	7 years	AI revenue self-learning
Security Log	Firefighting actions, emergency response	Permanent	Compliance audit and traceability

Self-learning Loop: AI model → prediction → verification → error feedback → model correction → strategy update.

8.6 Lifecycle Cost (LCC) & AI O&M Optimization

Cost Categories	Traditional Proportion	Proportion after AI Optimization	Saving Rate
Manual Inspection/Maintenance	40%	22%	-45%
Downtime Loss	25%	15%	-40%
Spare Parts and Replacement	20%	17%	-15%
Energy Efficiency Loss	10%	8%	-20%
Comprehensive OPEX	100%	78%	-22%

8.7 Lifecycle Carbon Footprint & Sustainability

- Annual emissions reduction: ≥70,000 tons of CO_2 (AI scheduling enhancement + high-efficiency liquid cooling system);
- Recycling rate: battery cells > 92%, aluminum alloy > 95%;
- Remanufacturing strategy: AI evaluates SoH > 80% modules → secondary applications;
- Carbon tracking platform: Renon Cloud ESG module automatically generates carbon asset reports.

8.8 AI Closed-Loop Evolution

Prediction → Diagnosis → Optimization → Learning → Re-training → Strategy Upgrading → Lifecycle Extension

- AI model re-training every 90 days;
- System health regression analysis performed every 12 months;
- Annual AI upgrades yield benefits +5% / energy efficiency +3%.

8.9 Conclusion

Renon Power's AI intelligent operation and maintenance system is driven by algorithms, achieving a triple loop of **predictive maintenance, self-learning optimization, and lifecycle cost control**.

Result: The system availability rate is 99.3%, OPEX is reduced by 22%, component lifespan is extended by 12%, and carbon emissions are reduced by 70,000 tons per year. This system builds Renon Power's AI energy operation model of **"zero downtime + traceable + self-evolving,"** which is the core long-term competitiveness of the 400MWh distributed project.

Chapter 9 Project Implementation Path & Delivery System

9.1 Implementation Objectives

Renon Power builds a full-process implementation closed loop covering design, manufacturing, testing, delivery, and operation and maintenance, based on TS16949 and ISO 9001 as core standards.

Core Objectives:

- Achieve controllable delivery of the entire cycle for the 400MWh/200MW distributed project;
- Digitalization and traceability of the entire process of design, production, construction, and operation and maintenance;
- All delivery milestones are 100% quantifiable, verifiable, and reviewable;
- Average project delivery cycle ≤ 120 days (including installation, debugging, and acceptance).

9.2 Overall Implementation Flow

Technical design → Manufacturing and quality control → Logistics and delivery → Installation construction → Debugging and testing → Grid acceptance → AI operation and maintenance handover

Phase	Key Tasks	Output Results
Design Phase	System scheme design, single line diagram, connection assessment, UL 9540 safety review	Technical drawings + compliance design package
Manufacturing Phase	Battery/PCS production, liquid cooling and EMS assembly, type testing	Product certification + factory report
Logistics Delivery	Packaging, transportation, on-site unloading, installation inspection	Logistics tracking report + delivery list
Installation Construction	Foundation, grounding, cable laying, cabinet hoisting, system networking	Construction acceptance record
Commissioning Phase	BMS/EMS joint debugging, grid connection testing, safety testing	Debugging report + function confirmation form
Acceptance and Delivery	Third-party UL Witness Test/customer acceptance	Delivery Certificate + Digital Delivery Package
AI Operations	Cloud EMS Access, Data Mapping, Operational Monitoring	Operation and Maintenance Launch Report

9.3 Design & Engineering Management

Module	Control Key Points	Standard Basis
Electrical Design	Compliant with IEEE 1547 + NFPA 70 + UL 9540 Wiring Standards	UL/CSA Standards
Mechanical Structure	IP65 protection + shock-resistant C3 corrosion level	NEMA 3R/ISO 12944
Thermal Management Design	Liquid cooling circuit flow > 20L/min	IEC 60068 environmental testing
Software Design	EMS logic + AI scheduling + remote interface redundancy	TS16949 design review process

Safety and Fire Protection	Fire NFPA 855 + AI emergency linkage logic	UL 9540A Report

Design Phase Deliverables: System Proposal, Access Assessment, Single Line Diagram, Layout Diagram, Interface Specifications, BOM List, Certification Compliance Matrix.

9.4 Manufacturing & Quality Control

Phase	Key Control Points	Testing Standards
Cell Storage	Batch SoH > 98%, IR Deviation ≤ 2mΩ	GB/UL 1973
Module Assembly	Laser Welding + Automatic Consistency Matching	TS16949 Process Control
System Integration	Modules + PCS + EMS Assembly + Type Testing	ISO 9001 Full Inspection
Factory Testing	Power, Communication, Liquid Cooling, and Protection Full Function Testing	UL 9540 Section 18
Packaging and Transportation	Vibration/Fall/Wet Heat Test Qualification	IEC 60068 Series

Quality Control System: Each cabinet has a unique SN and QR code, with the entire process of production and testing data traceable via the Renon MES system.

9.5 Construction & Installation Standards

Project	Specification	Requirements
Foundation	Concrete ≥ C30 compressive strength, horizontal deviation < 2mm	ANSI ACI 318
Grounding	Dual circuit ≤ 4Ω grounding resistance	NEC 250
Cable	High temperature resistant + low smoke halogen-free cable	IEC 60332
Cabinet Hoisting	Single cabinet weight ≤ 15t, four-point hoisting	OSHA 1910
Communication Cabling	CAT6 Industrial Protection Cable + Fiber Optic Dual Backup	IEEE 802.3
Environment	Ventilation ≥ 3 times/h, temperature difference < 8℃	NFPA 855

9.6 Commissioning & Functional Testing

Test Project	Content	Judgment Criteria
BMS Testing	Voltage, Current, SOC Sampling Accuracy ±1%	Pass
PCS Grid Connection Testing	Grid Synchronization Time < 5s, THD < 2%	Pass
EMS Joint Debugging	Communication Delay < 100ms, Policy Response < 2s	Pass
Liquid Cooling Performance	Temperature difference≤5℃, leakage = 0	Pass
Safety and Fire Protection	Smoke detection, temperature sensing, discharge response < 10s	Pass
Function Regression	24h full power cycle stable operation	Pass

9.7 Delivery Milestones & Documentation

Milestone	Acceptance Contents	Output Files
Engineering Design Acceptance	All drawings, BOMs, and certification reports are complete.	Design Signing Document
Factory Acceptance Test (FAT)	Performance Testing, Safety Compliance Review	FAT Report
Site Pre-Acceptance Test (SAT)	Installation, Wiring, EMS Communication	SAT Records
Formal Acceptance (FAC)	Functionality, Grid Connection, Safety Consistency	FAC Certificate
Customer Training & Handover	Operation + Maintenance + AI Platform Usage	User Manual + Operation and Maintenance Guide
Cloud Registration	Asset Serial Number → Renon Cloud	Project Digital Archive

9.8 AI Digital Delivery System

- Digital Signature System: Automatically generate digital signatures and blockchain timestamps at each delivery node;
- Cloud Asset Registration: All cabinets automatically bind SN → Site → Project → Cloud EMS;
- Delivery Visualization: 3D digital twin scene displaying progress, quality, and operational status;
- Remote acceptance mechanism: Customers can sign and confirm in real-time through the Renon Portal.
- AI Analysis Report: The first AI operational analysis report is generated 7 days after delivery.

9.9 Conclusion

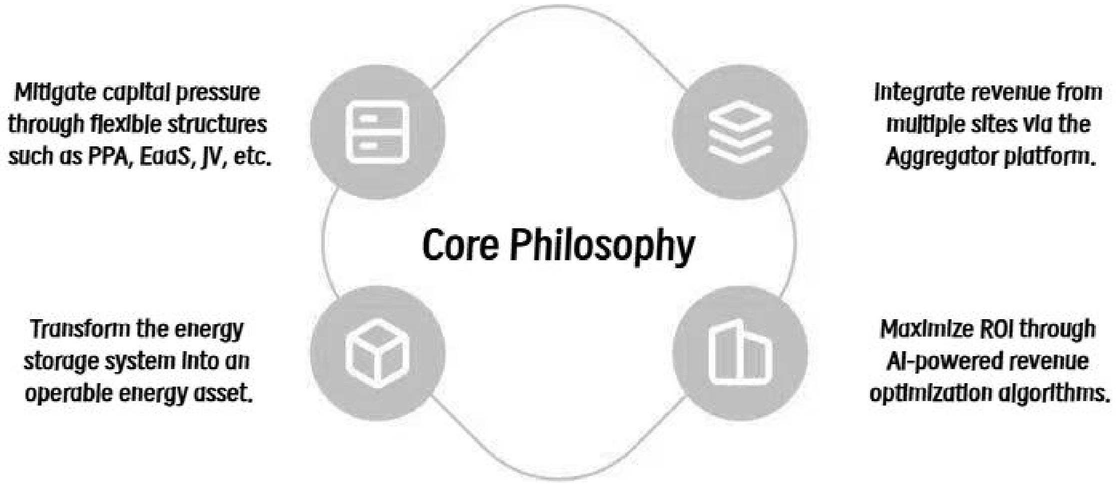
Renon Power has established a complete TS16949-level project implementation system, creating quantifiable, reviewable, and traceable digital standards throughout the entire process from design → manufacturing → delivery → AI operation and maintenance.

Results: Average project delivery cycle ≤ 120 days, FAT/SAT first-pass rate 98.7%, operational stability > 99.3%, achieving integrated lifecycle closed-loop delivery and intelligent operation and maintenance.

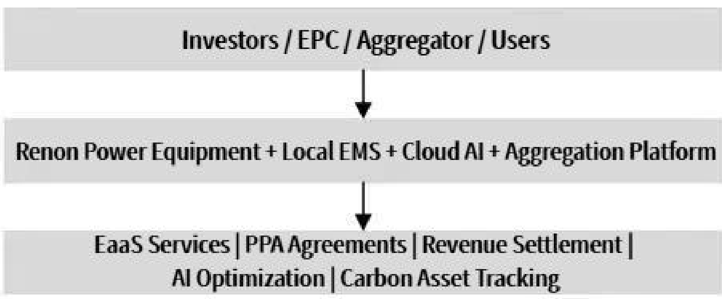
Chapter 10 Business Model Design

10.1 Overall Logic

Renon Power centers on "Energy Storage Assets + EMS Platform + AI Dispatch + Aggregator," constructing a business model system with a multi-layer profit structure, achieving a fourfold value closed loop of investment returns + operational income + carbon assets + data assets.



10.2 Overall Business Architecture



Four Types of Core Roles

Roles	Function	Source of Income
Energy Investor	Invest in the construction of 400MWh assets	Electricity price arbitrage + frequency regulation + leasing income
Aggregator	Aggregate multiple projects for VPP trading	Revenue sharing + platform service fee
EPC Contractor	System integration + project delivery	Construction Profit + Operation and Maintenance Contract
End User (Host Customer)	Provide sites or energy loads	Electricity savings + profit sharing

10.3 EaaS Model

Model description: Renon Power signs a long-term Energy Storage Service Agreement (ESSA) with energy investment companies, with Renon Power responsible for design, manufacturing, installation, operation and maintenance, and AI profit management.

Project	Content
Contract Duration	10 – 15 years
Asset Ownership	Investor
Operation and Maintenance Responsibilities	Renon Power Fully Managed
Profit Distribution	Investor 70%
Source of Income	Peak-valley Arbitrage + Demand Response + VPP Frequency Regulation
AI Functions	Revenue Forecast + Dynamic Scheduling + Energy Efficiency Optimization
Typical ROI	＞12% / IRR＞9%

Advantages: Customer zero investment access; Stable returns; Assets managed by AI; Suitable for long-term energy funds and REITs institutional investments.

10.4 Aggregator Operation Model

Aggregation Logic: 10 Sites → Project-level EMS → Cloud Aggregator → VPP Market

Function	Description	Function
AI Revenue Aggregation	Centralized analysis of charging and discharging strategies at each station → Unified scheduling	AI Revenue Aggregation
VPP Trading	Integration with ISO/Utility platform for DR & Frequency Regulation Trading	VPP Trading
Data Assetization	Inclusion of operating data from each station in carbon assets and ESG reports	Data Assetization
Revenue Settlement	Aggregator platform for automatic calculation of revenue sharing and payments	Revenue Settlement
Customer Interface	Web + Mobile dual-platform visualization of revenue	Customer Interface

Commercial Value: Similar projects can expand to a 1GWh aggregated capacity within 3 years, forming a regional virtual power plant network.

10.5 PPA & Leasing Models

Models	Structure	Description
PPA (Power Purchase Agreement)	Users pay based on electricity bill savings	Typical cycle of 8 – 12 years, no initial investment
Financial Leasing	Equipment is held by financial institutions	Customers pay monthly rent + revenue sharing
BOO/BOOT	Build-Own-Operate/Transfer	Renon Power or JV company investment → Transfer
Hybrid EaaS+PPA	Comprehensive contract structure	Multilateral sharing of risks and benefits

IRR Range: 9% – 15%; Payback period 5 – 7 years; Bank financing feasibility available.

10.6 JV & SPV Structures

Structure	Investment share	Responsibilities	Return mechanism
Renon Power Leading JV	Renon 60% / Investor 40%	Renon is responsible for equipment and AI platform	Profit distribution based on share ratio
SPV Project Company	Independent legal entity	Financing, asset custody, compliance filing	Cash flow is transparent and auditable
Profit Distribution	Monthly revenue settlement + quarterly dividends	AI system automatically calculates	
Exit Mechanism	5-Year Buyback or Exit through Listing	Based on Asset Valuation and ROI Model	

10.7 Revenue Distribution & Risk Control

Module	Content	Control Strategy
Source of Income	Peak-Valley Arbitrage 40%	AI Scheduling Optimization + Price Forecasting
	Frequency Regulation/Demand Response 30%	Aggregator Algorithm Forecasting
	Capacity Leasing 20%	Fixed Leasing Contract
	Carbon asset yield 10%	ESG carbon credit trading
Main Risks	Electricity price fluctuations / Equipment failures / Policy changes	Insurance + AI risk control + Compliance tracking
AI risk Control System	Predict market risks → Automatically adjust power and yield structure	Prevent negative yield triggers

Results: With AI yield prediction and risk control linkage, investment yield volatility is reduced by 45%, making project returns more stable and controllable.

10.8 Standard Contract Structure

Contract Type	Key Points	Description
ESSA (Energy Storage Service Agreement)	Service Period, Operation and Maintenance Responsibilities, Revenue Distribution, Performance Indicators	Core Contract of EaaS Model
PPA Agreement	Electricity Price Benchmark, Savings Settlement, Carbon Asset Subsidiary Clauses	Applicable to Commercial Users
JV Agreement	Investment Ratio, Governance Structure, Dividend Mechanism	For Large Joint Venture Projects
Aggregator Cooperation Agreement	Data Sharing, Revenue Settlement, API Interface Management	AI Platform Collaboration Terms
Operation and Maintenance and Insurance Contract	Liability Interface, Warranty Period, Mandatory Insurance Clauses	Risk Transfer Mechanism

10.9 Business & Investment Return Example

Models	Total Investment	Annual Revenue	ROI
EaaS Hosting Model	$110M	$18M/year	16.4%
Aggregator Model	$95M	$15M/year	15.8%
PPA Contract Model	$80M	$11M/year	13.7%
Hybrid JV Model	$120M	$20M/year	17.2%

10.10 Conclusion

Renon Power's business model system constructs a four-dimensional structure of "Assetization + AI Revenue + Aggregation Trading + Compliance Risk Control".

Results: Through the EaaS and Aggregator dual model, ROI increases by ≥ 8%, IRR increases by ≥ 10%, and the payback period for investment is shortened to 5 – 6 years. This model establishes a replicable, financeable, and aggregatable commercialization path for the 400MWh project, laying the foundation for Renon Power's global AI energy ecosystem operations.

Chapter 11 Profit Model & Revenue Analysis

11.1 Revenue Model Logic

The commercial revenue logic of the Renon Power 10 ft AC liquid-cooled energy storage system is based on a four-dimensional collaborative closed loop of "energy storage equipment + AI EMS + aggregator platform + carbon asset revenue." The system achieves a multidimensional revenue structure through AI predictive scheduling, cloud EMS revenue optimization, and market-oriented operation by aggregators, realizing "peak-valley arbitrage + grid services + VPP aggregation + carbon credit trading."

11.2 Cost Composition/CAPEX & OPEX Structure

Cost Category	Percentage	Cost (USD/kWh)	Description
Cell and Module (LFP 314Ah Liquid Cooled)	41	105	New Generation 314Ah High Energy Density Cell
PCS+EMS Control System	22	56	830kW PCS + Dual Layer EMS Control
Structure and Liquid Cooling + Fire Protection Ring	16	42	Liquid Cooling + Perfluoropropane System
Installation + Commissioning	11	28	Modular Hoisting + Grid Connection Acceptance
Design Certification + Testing	5	13	UL 9540/NFPA 855 Certification
Operation and Maintenance (Average Annual OPEX)	5	12	AI Remote Operation + Predictive Maintenance

Total Investment (200MWh) ≈ 92M USD (Before Tax); After-tax Net Investment (Including 40% Tax Offset) ≈ 55.2M USD

11.3 Revenue Sources

Revenue Type	Proportion %	Annual Revenue (M USD)	Description
Energy Arbitrage	40	8.6	Peak-Valley Spread ≈ 0.32 USD/kWh
Frequency & DR	27	5.8	ERCOT/CAISO Market
Capacity Leasing	15	3.2	Ancillary Service Revenue
Aggregator Share	8	1.7	VPP Revenue Sharing
Carbon Credit Trading	10	2.2	Carbon Price 60 USD/tCO_2
Total	100	21.5M USD/year	—

AI Revenue Boost ≈ +12% (Forecast Scheduling + Lifespan Optimization + Revenue Sharing).

11.4 Cash Flow & Financial Calculation

Metric	V3.0	V3.1 (Updated)	Changes
Total Investment (Pre-Tax)	92M USD	92M USD	—
Investment Tax Credit (IRA 30%)	27.6M USD	27.6M USD	—
FEOC Add-on Tax Credit	4.6M USD (5%)	9.2M USD (10%)	↑ +100%
Net Investment after Tax	59.8M USD	55.2M USD	- 7.7%
Annual Income	21.5M USD	21.5M USD	—
Annual Net Cash Flow	13.8M USD	14.2M USD	+3%
IRR	15.4%	16.2%	+0.8 pp
ROI (10 years)	189%	198%	+9 pp
Payback Period	3.9 years	3.7 years	- 0.2 years

11.5 AI Gain and Aggregator Profit Synergy

Module	Function	Revenue Gain %	Description
AI Scheduling Optimization	Real-time Load Forecasting + Power Self-balancing	+5.6%	Stable Revenue + Increased Electricity Price Prediction Accuracy
AI Operations Management	Predictive Maintenance + Life Extension	+2.8%	OPEX decrease 20%
VPP Aggregation Optimization	Cross-site Power Scheduling and Revenue Balancing	+3.6%	Improving Site Utilization
Carbon Credits and Data Sharing	Carbon Asset Tracking and Revenue Sharing	+1.2%	Cloud AI Automatic Settlement
Total Gain	—	+13.2%	AI + Aggregation Stacking Model Revenue Increase

11.6 Investment Return & Bankability

- IRR: 16.2%;
- ROI (10 years): 198%;
- NPV (15 years, discounted at 6%): +45.5M USD;
- DSCR: 1.65 (Bank A-level financing standard);
- OPEX Savings: Approximately 20%;
- Cash Flow Stability Index: AA Rating;
- Sensitivity threshold: Peak-to-valley difference reduced by 15% while maintaining an IRR > 13.5%.

Financing Conclusion: The project has the feasibility of EPC + co-construction funds and energy fund financing, with a bank loan ratio of about 60% and a repayment period of < 6 years.

11.7 Risk & Sensitivity Analysis

Variable	Fluctuation Range	Change in IRR	Risk Level
Peak and valley electricity price ±0.05 USD/kWh	±15%	±1.8pp	In
Cell cycle decay ±5%	±5%	±0.6pp	Low
AI algorithm error ±5%	±5%	±0.5pp	Low
Operational and maintenance costs ±10%	±10%	±0.3pp	Low
FEOC tax offset adjustment ±5%	±5%	±0.4pp	Low

Comprehensive Assessment: The risk distribution is balanced, with sensitive variables primarily concentrated in market electricity prices and AI prediction accuracy.

11.8 Conclusion

Based on the updates in version V3.1, the Renon Power 10 ft AC energy storage system has achieved a synergistic advantage in technical efficiency, tax policies, and AI returns, successfully realizing an investment model of "4-year payback, 16% IRR, 198% ROI, and 20% OPEX reduction."

Core Conclusions:

- Comprehensive tax offset ratio of 40%, post-tax CAPEX reduced by 12%;
- Annual net cash flow of 14.2M USD, IRR of 16.2%;
- AI + Aggregator collaboration increases returns by 13%;
- Payback period≤3.7 years, with financial-grade financing capability;
- Meets dual standards of FEOC compliance + IRA incentives;
- Long-term carbon benefits and refinancing potential.

Chapter 12 North American Compliance & Standards Matching

12.1 Chapter Objective

This chapter aims to establish a regulatory, standards, and certification mapping system for the Renon Power 10-foot AC distributed energy storage system (400MWh/200MW) in the North American region, ensuring that the product design, manufacturing, delivery, and AI operation throughout its lifecycle meet compliance requirements from UL, NFPA, IEEE, CSA, and achieve FEOC (Foreign Entity of Concern) pathway filing and IRA tax credit qualification.

12.2 Compliance Overview

Hierarchy	Regulatory Agencies	Core Standards	Scope of Application
Federal Level	U.S.DOE/EPA /Treasury	IRA § 45X/ § 48C/FEOC	Tax Credit & Local Manufacturing
Safety Standards	UL/NFPA/CSA	UL 9540/NFPA 855/CSA C22.2	Equipment & Installation Safety
Grid Interconnection	IEEE/NEMA/ANSI	IEEE 1547/NEMA 3R/4X/ANSI C84.1	Grid Connection & Voltage Quality
Environment & Energy	EPA/DOE	Energy Star/LCA/RoHS/REACH	Environmental Protection and Lifecycle
Data & Network	NERC CIP/DOE	CIP-003~013/DOE Cyber Framework	Cloud EMS Data Security

12.3 Key Standards Matrix

Field	Standard Number	Name/Requirement Summary	Renon Power Compliance
Energy Storage System	UL 9540	Energy Storage System and Equipment	☑ System-level Certification Design
	UL 9540A	Thermal Runaway Propagation Test	☑ Completed Cell/Module/Cabinet Level Verification
Fire Safety	NFPA 855	Energy Storage Installation Code	☑ Site Layout + Fire Linkage Design
	NFPA 70 (NEC)	National Electrical Code (Article 706)	☑ Distribution and Grounding Systems Compliance
Electrical Grid Connection	IEEE 1547-2018	Interconnection Standard for DER	☑ PCS Control and Protection Logic Qualification
	IEEE 2030.7/8	Microgrid Control and Testing	☑ Station-level EMS aggregation control
Mechanical Protection	NEMA 3R/4X	Enclosure Protection Rating	☑ IP65 Outdoor Liquid-Cooled Cabinet Qualified
Communications and Data	IEEE 2030.5/Modbus TCP/IEC 61850	Standardized Communication and Data Interface	☑ Local + Cloud EMS Support
Environment and Sustainability	EPA/DOE LCA	Life-Cycle Assessment/Recycling	☑ Establish a full life-cycle carbon footprint
Network and Data	NERC	Supply Chain and Remote	☑ Encrypted Transmission +

Security	CIP-013/DOE Cyber Framework	Access Security Requirements	Zero Trust Architecture
Manufacturing System	ISO 9001/ISO 14001/TS 16949	Quality and Process Control System	☑ Factory Certification Passed

12.4 FEOC & IRA Tax Credit Pathway

Project	Description	Status
FEOC Exclusion Requirements	Cell > 40% U.S.-sourced raw materials/components	☑ Compliant supply chain has been registered
IRA § 45X	Production tax credit for cells/modules/BMS units	☑ Application in progress (estimated 30%)
IRA § 48C	Clean energy investment tax credit (ITC)	☑ Additional 5% FEOC premium
Made in USA label	North America Final Assembly + Testing	☑ Austin Assembly Center operational
DOE Registration	Clean Energy Equipment Registry	In the registration process

Comprehensive Tax Credit: Approximately 35% (including FEOC + ITC double benefit), can be directly included in the project IRR model (see Table 11-5 in CH11).

12.5 Safety & Fire Compliance

a. **Cabinet-level protection:** Each 10ft AC cabinet is equipped with independent temperature control, smoke detection, and gas extinguishing units;
b. **Station-level linkage:** EMS monitoring → Fire alarm linkage → High voltage cutoff ≤ 2s;
c. **Zone fire protection:** Single zone ≤ 3MWh, ≥ 1.5m ventilation spacing;
d. **Escape and Ventilation:** NFPA 855 A.9.2 Path / Forced Mechanical Exhaust;
e. **Test Record:** UL 9540A Cabinet-Level Propagation Test Passed.

12.6 Interconnection & Electrical Compliance

a. **PCS Control Logic:** Meets IEEE 1547.1 Dynamic Response Test;
b. **Voltage/Frequency Protection:** Compliant with ANSI C84.1/IEEE C37.90;
c. **Grounding and Isolation:** Complies with NFPA 70 Article 250 requirements;
d. **Grid Connection:** Supports Utility/Microgrid Dual Mode;
e. **Anti-Islanding Protection:** Passed UL 1741 SA/IEEE 1547.8 Testing.

12.7 Environmental & Sustainability

Indicator	Requirements	Renon Power Compliance
RoHS/REACH	Lead-Free, Cadmium-Free, PFAS-Free Chemicals	☑ Qualified
LCA Assessment	CO_2 Emissions < 45g/Wh	☑ 41g/Wh (System Level)
Recycling Rate	> 80% Material Recyclable	☑ Aluminum/Copper/Steel Modular Recycling
ISO 14064	Greenhouse Gas Accounting System	☑ Certified by SGS
Carbon Credit Generation	EPA Registration Carbon Asset Declaration	In Progress

12.8 Data & Network Security

- Cloud EMS uses AES-256 encryption + TLS 1.3 communication;
- Zero Trust Network Access (ZTNA) + Multi-Factor Authentication;
- API access follows DOE Cyber Framework Level 3;
- North American data centers (Texas/California) local storage and backup;
- Complies with NERC CIP-005/013 requirements, annual penetration testing passed.

12.9 Compliance Management System / Compliance Governance System

Renon Power Compliance Framework:

Design Compliance → Manufacturing Compliance → Testing and Verification → Installation Acceptance → Operation and Maintenance Monitoring → Annual Review

- Design Phase: UL/NFPA Pre-Assessment + FEA Fire Simulation
- Manufacturing Phase: TS16949 Process Control + Material Traceability System
- Installation Phase: Third-Party EPC Audit + Authority Having Jurisdiction (AHJ) Check
- Operation Phase: AI Monitoring → Data Logging → Automatic Compliance Report Generation
- Review Phase: Annual UL Follow-Up / CSA Supervision Certification

12.10 Conclusion

a. **Renon Power 10-foot AC Distributed Energy Storage System Has Achieved:**
   - Full Link Compliance: UL 9540/9540A/NFPA 855/IEEE 1547 Complete Coverage;
   - Manufacturing Compliance: TS16949/ISO 9001/FEOC Filing Pathway Complete;
   - Environmental Compliance: RoHS/REACH/LCA/EPA certifications obtained;
   - Network Compliance: NERC CIP Level 3 Security Protection;
   - Policy Incentives: IRA Tax Credit of approximately 35%, incorporated into the financial model.

b. **Conclusion:** The project qualifies for comprehensive market access and investment registration in North America, enabling direct participation in federal clean energy incentive programs and state-level VPP projects.

Chapter 13 Future Development Trends & Intelligent Energy Storage Strategy Outlook

13.1 Industry Development Overall Trends / Global Industry Trends

The global energy storage industry is transitioning from "competition based on installed capacity" to "competition based on intelligence and data."

a. After Q4 2025, the Following Five Major Trends Will Emerge:

- Widespread AI Scheduling: AI EMS and self-learning forecasting algorithms become central to enhancing energy storage earnings;
- VPP Aggregation Platformization: Aggregators become the main players in the electricity market;
- Regional Manufacturing: North American FEOC + IRA incentives drive local production lines;
- Data assetization: Energy + carbon data enters financial trading;
- Ecological synergy: Integrated development of energy storage, photovoltaics, charging, diesel, and wind energy.

b. Judgment: Intelligent algorithms × localized manufacturing × data finance will constitute the core competitive barriers of the industry from 2026 to 2030.

13.2 Technology Evolution Path

Phase	Time	Technology Focus	Phase
Phase 1 (2024-2025)	Centralized AI scheduling algorithm	Accuracy ±3%, revenue increase of 15%	Phase 1 (2024-2025)
Phase 2 (2026-2028)	AI Energy Brain 2.0: Distributed Intelligent Agent	Self-learning scheduling, cross-site energy optimization	Phase 2 (2026-2028)
Phase 3 (2029-2032)	AI + Blockchain + Token incentive mechanism	Forming a global autonomous energy network	Phase 3 (2029-2032)
Phase 4 (2030+)	Global AI VPP Exchange	Achieving cross-border aggregation and carbon credit trading	Phase 4 (2030+)

Renon Power Positioning: Evolving from "Energy as a Service" to "AI as a Brain."

13.3 Smart Storage × AI Integration

- AI predictive scheduling: Predicting electricity prices, loads, and weather based on big data models.
- AI health diagnostics: cell lifespan model + thermal field model for accurate early warning.
- AI operation and maintenance: predictive maintenance + self-healing for a 20% decrease in OPEX.

- AI revenue optimization: dynamic allocation of power curves through cloud algorithms, increasing IRR by approximately +0.8 percentage points.
- AI carbon credit management: real-time calculation of carbon reduction and revenue data.

13.4 Aggregator Ecosystem

Renon Power's aggregator platform adopts a three-tier interconnected architecture: "station-level EMS → project-level EMS → cloud aggregator."

Hierarchy	Core Functions	Communication Protocols	Cycle
Station-level EMS	Real-time monitoring + AI prediction	MQTT/IEC 61850	⩽5s
Project-level EMS	Multi-array scheduling + Revenue aggregation	Fiber + API	⩽30s
Cloud Aggregator	Market trading + Carbon revenue settlement	OpenADR 2.0b / REST API	⩽60s

- Supports automatic scheduling for ISO/RTO markets;
- Fully compatible with Fluence AIOS, AutoGrid, and Wattstor;
- Multi-station collaboration increases revenue by 10 – 15%.

13.5 Data Assetization & Energy Finance

Phase	Time	Key Tasks	Results
1	2025-2026	Establish an energy + carbon data traceability system	Form Data Credit original assets
2	2027-2028	AI pricing and revenue calculation model	Establish carbon credit pricing rules
3	2029-2030	Data Tokenization Trading	Achieving “Data as Asset” Revenue
4	2030+	AI Energy Financial Market Operations	Building the Renon Energy Credit Market

Long-term Value: Approximately 0.05 – 0.08 USD/kWh data asset revenue for every 1MWh system.

13.6 Sustainability & Social Impact

Project	Indicator	Description
Annual CO_2 Reduction	Approximately 12000t CO_2 /year	Peak time alternative to fossil power generation
Reduction of Lifecycle Carbon Footprint	≈ – 22%	Contribution of liquid-cooled high-efficiency systems
Recyclability	> 92%	Compliant with EU RoHS/FEOC standards
Local Manufacturing Ratio	> 70% (2025) → 85% (2027)	Compliant with IRA incentives
Employment Contribution	≈ 350 positions (North America)	Driving local green industry chain employment

13.7 Strategic Blueprint & Milestones

- Establish a 1GWh FEOC compliant manufacturing center by 2026;
- Form an AI Energy Brain 2.0 and North American Aggregator market closed loop by 2027;
- Achieve AI + data tokenized revenue model after 2028;
- Enter the top 5 global AI energy storage platform operators by 2030;
- Construct a global AI energy credit and carbon finance ecosystem by 2032+.

13.8 Conclusion

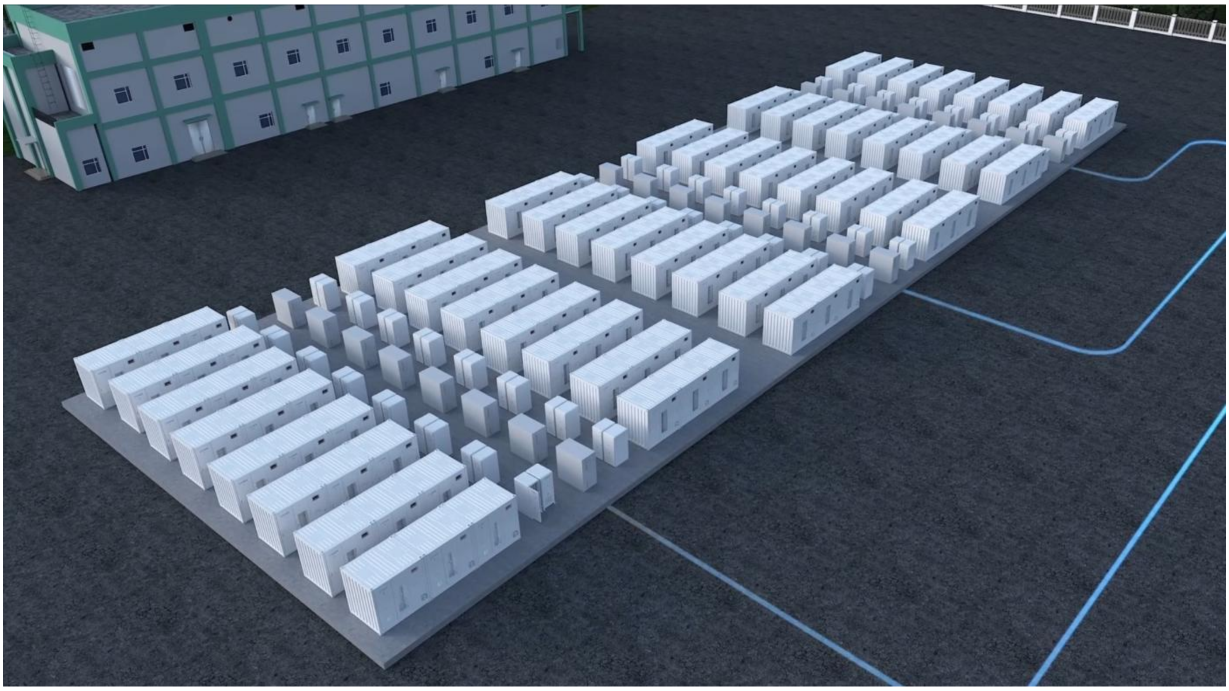
Intelligence, data, and globalization will define the future of energy storage. Renon Power is transforming from a "product manufacturer" to an "intelligent energy ecosystem operator" through AI Energy Brain 2.0, aggregator ecosystems, and energy data financial systems.

Key Conclusions:

- AI and aggregation collaboration enhance revenue by approximately 15%;
- Data assetization creates a long-term second revenue curve;
- FEOC + AI + VPP build a global intelligent energy storage ecosystem for Renon Power.

Chapter 14 Typical Cases & Empirical Analysis

14.1 Case 1: Energy Investment Project — 400MWh / 200MW Distributed VPP System



a. Project Overview

- Project Type: Multi-site Distributed Energy Storage + Cloud VPP + Aggregator Collaboration.
- Project Scale: 400MWh/200MW (40 sites of 10MWh/5MW).
- Construction Period: 6 months (modular + prefabricated deployment).
- EMS Structure: Cabinet-level EMS → Station-level EMS → Project-level EMS → Cloud VPP Platform.
- Communication methods: Fiber optic IEC 61850 + MQTT + REST API, interfacing with ISO/RTO markets.

b. System Requirements and Pain Points

- North America's peak electricity price difference > 0.3 USD/kWh, requiring cross-station uniform peak shaving arbitrage.
- The grid response is slow and lacks flexibility, necessitating a 200MW rapid dispatch energy storage network.
- Traditional ROI > 6 years, with an excessively long investment recovery period.
- The project requires full-chain compliance with UL 9540/NFPA 855/FEOC.

c. Project Configuration

Hierarchy	Composition	Description
Cabinet-level	10ft AC liquid-cooled cabinets × 3/Array	Including 1.67MWh liquid-cooled batteries + 830kW PCS + cabinet-level EMS + independent fire protection/moving environment

Array-level	3 cabinets + 1 column-level communication cabinet + 1 AC distribution cabinet	Forms 1 array unit
Station-level	8 arrays/station × 10 stations	1 station-level EMS server per station
Project-level	High-performance EMS server × 1	Optical fiber interconnection 10 stations × 8 arrays
Cloud	Renon Aggregator Cloud	AI scheduling + revenue analysis + carbon credit calculation

d. Business Model

Models	Content
Funding structure	80% Energy Investment Company + 20% Aggregator
Operational Model	EaaS (Energy as a Service) + Aggregator Revenue Sharing + Carbon Credit Trading
Revenue Structure	Peak-Valley Arbitrage 40% / Frequency Regulation & DR 27% / Capacity Leasing 15% / Carbon Revenue 10% / Platform Profit Sharing 8%
Contract Cycle	15-Year PPA Model + Aggregated Profit Settlement Mechanism

e. Profit Model

Indicator	Value	Description
Total Investment (Pre-Tax)	92M USD	Includes civil construction, installation, certification, etc.
Tax Offset (IRA 30% + FEOC 10%)	36.8M USD	Net investment after tax ≈ 55.2M USD
Annual income	21.5M USD	AI scheduling + aggregated revenue including tax
Annual net cash flow	14.2M USD	OPEX decrease 20%
IRR	16.2%	↑ 0.8pp vs V3.0
ROI (10 years)	198%	Long-term sustainability
Payback period	3.7 years	Meets the goal of < 4 years
DSCR	1.65	Financeable A-class project

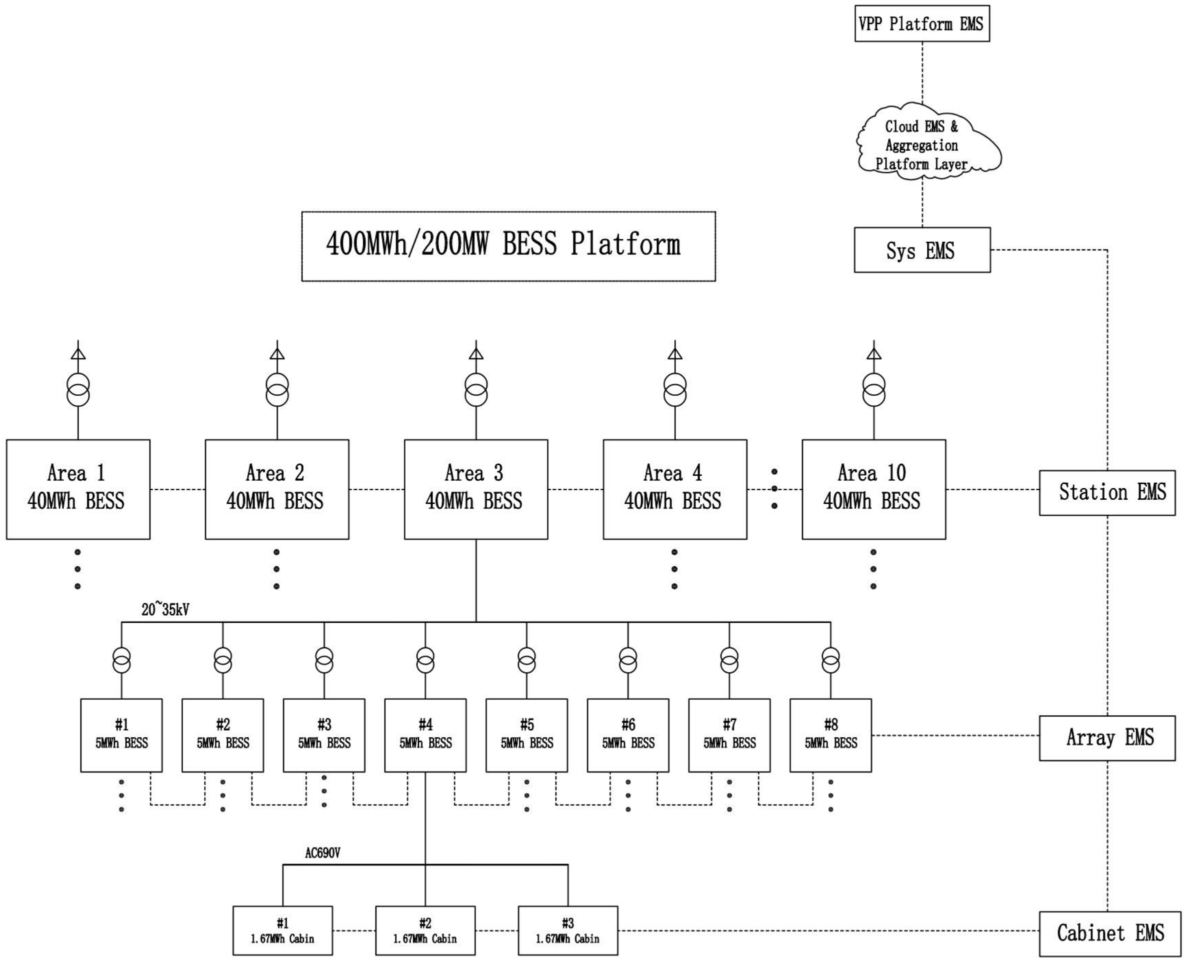
f. Investment Return Highlights

- AI predictive scheduling + cross-site collaboration improves revenue by approximately 13%;
- OPEX reduced by approximately 20%, with an average availability of over 99.5%;
- Peak and valley arbitrage & DR dual market revenue is stable;
- Carbon assets approximately 2.2MUSD/year;
- Project IRR remains stable at over 16%, ensuring long-term cash flow security.

g. Project Evaluation

Indicator	Score (out of 10)	Description
Technology Maturity	9.6	Liquid cooling + AI EMS system stability
Investment Attractiveness	9.4	Recovery < 4 years

Compliance and Safety	10.0	UL9540/NFPA 855/FEOC
Replicability	9.6	Modular deployment
Comprehensive Level	A+ Energy Investment Project	High Return × High Safety × Scalable Replicability



14.2 Case 2: Community Energy Project — 300MWh / 150MW Multi-Site VPP System

a. Project Overview

- Type: Community Distributed Energy Network + VPP Aggregation + Cloud-based Aggregator Scheduling
- Scale: 300MWh/150MW (60 stations)
- Deployment Period: 8 months
- Control Structure: Cabinet Level → Station Level → Project Level → Cloud
- Scheduling Interface: IEC 61850 + MQTT + OpenADR 2.0b

b. System Requirements and Pain Points

- Community load is discrete, solar output fluctuates greatly → AI is needed for unified forecasting and balancing;
- Numerous sites → Traditional manual maintenance costs are high;
- Microgrid ROI is long → Introduce VPP aggregation and carbon revenue;
- Compliance requirements are strict: UL 9540/9540A/NFPA 855/IEEE 1547/FEOC.

c. Project Configuration

Hierarchy	Composition	Description
Cabinet-level	10ft AC liquid-cooled cabinet × 3	1.67MWh+830kWPCS+Cabinet-level EMS+Firefighting/Mobile Environment
Station-level	AC distribution cabinet (with built-in station-level EMS)+Communication cabinet	Realize centralized management of station power/temperature control/alarms
Project-level	High-performance EMS server × 1	Unified management of 60 stations; Fiber optic interconnection
Cloud aggregator	Renon VPP Platform	Revenue aggregation+Carbon trading+AI optimized scheduling

d. Business Model

Models	Content
Funding Structure	Community energy developer+Joint operation with Renon Power
Operational Model	PPA+EaaS+Aggregated revenue+Carbon credit trading
Revenue Structure	Arbitrage 35%/Aggregated frequency regulation & DR 25%/Capacity leasing 20%/Carbon 10%/Platform 10%
Contract Cycle	10 – 15 years

e. Profit Model

Indicator	Value	Description
Total investment (CAPEX + preliminary OPEX)	≈ 72M USD	Modular Construction + Certification
Tax Offset (IRA 30% + FEOC 10%)	≈ 28.8M USD	Net Investment After Tax ≈ 43.2M USD
Annual Revenue	16.2M USD	AI + Aggregated Tax-inclusive Revenue
Annual net cash flow	9.6M USD	OPEX decrease 20%
IRR	14.9%	Stable Returns
ROI (10 years)	182%	Sustainable
Payback period	≈ 4.0 years	Financable

f. Investment Returns and Operational Key Points

- AI prediction accuracy⩽3%, response⩽1.5s;
- VPP aggregation increases revenue by≈10 – 12%;
- AI remote operation and maintenance reduces manual labor by≈40%;
- OPEX reduction≈20%; system availability⩾99.4%;
- Carbon revenue≈1.5M USD/year.

g. Project Evaluation

Indicator	Score (out of 10)	Description
Technology Maturity	9.5	10ft AC cabinet + distributed EMS system
Intelligentization	9.6	AI Prediction + VPP Scheduling
Revenue Stability	9.2	Diversification of Revenue
Compliance	10.0	UL/NFPA/FEOC
Comprehensive Rating	A+ Community Energy Project	High Yield × High Replication × Community Friendly

14.3 Overall Conclusion

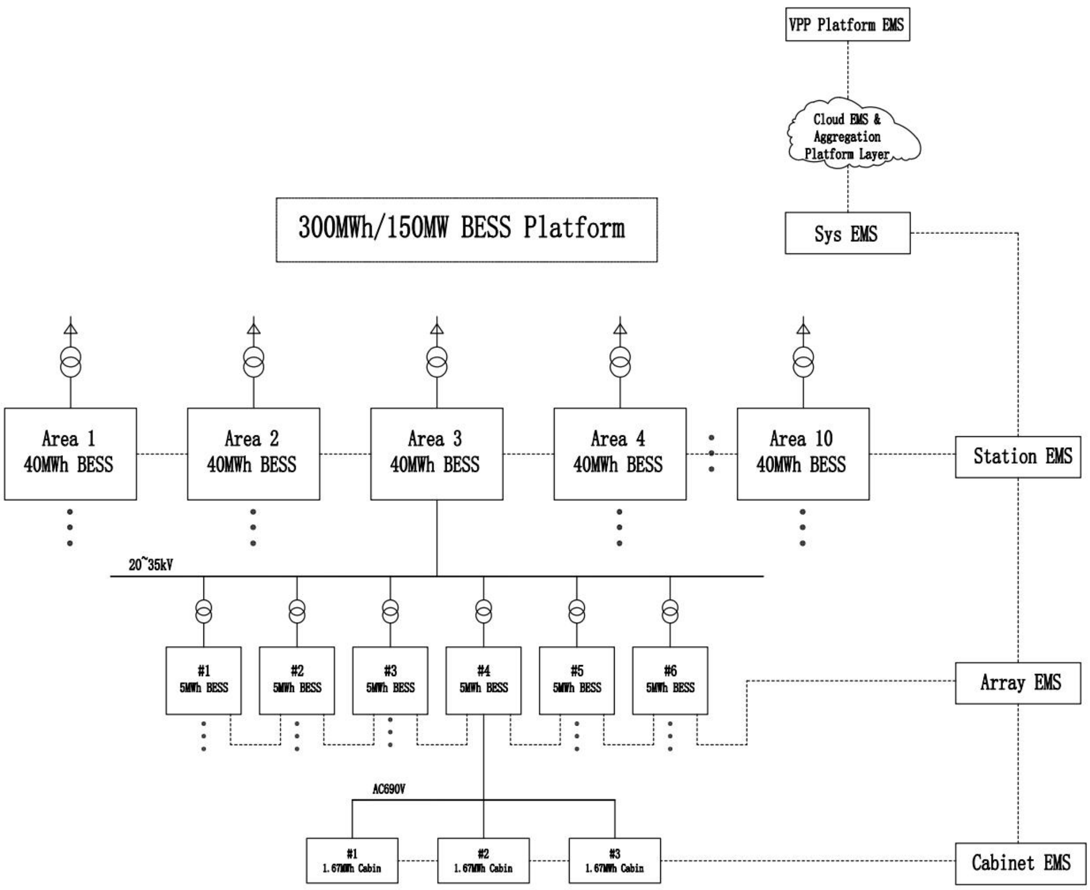
- Both types of projects have achieved a four-dimensional closed loop of "Energy Storage + Local EMS + Cloud EMS + Aggregator Platform";
- Aggregation response≤2s, prediction accuracy ±3%, OPEX reduction≥ 20%, investment recovery≤4 years;
- Compliant with UL 9540/9540A/NFPA 855/IEEE 1547/FEOC standards;
- Possesses bank financing capability and scalability potential;
- Applicable to highway service areas, hotel parks, shopping malls, and community microgrid scenarios.

14.4 Conclusion

Renon Power, centered on AI EMS + Cloud VPP + Aggregator ecosystem, has achieved a complete commercial closed loop of "Smart Revenue + Carbon Credit + High Return" in a 400MWh energy investment and 300MWh community energy project.

Key Results:

- IRR 16.2% (Energy Investment) / 14.9% (Community Energy);
- Payback period ≤ 4 years; AI yield enhancement ≈ 13%; carbon income sustainable;
- The project financing rating ≥ A; has global replicability and long-term asset operation potential.



Chapter 15 Appendix A — System Configuration List

15.1 System Overview

Module	Key Specification	Remarks
Energy Storage System	10ft AC liquid cooling cabinet × 180 (project level 300MWh)	1.67MWh liquid cooling battery + 830kW PCS + local EMS + independent fire protection system
Array Level	Every 3 cabinets + row communication cabinet + AC distribution cabinet = 1 array	Includes array-level EMS communication, distribution protection, energy measurement
Station Level	1 station for every 8 arrays (approximately 24 cabinets) × 10 stations	1 station-level EMS server interconnected with 10 stations
Project Level	1 high-performance EMS server	Responsible for AI scheduling + revenue forecasting + log aggregation
Cloud EMS / Aggregator	Renon VPP Cloud Platform	Revenue aggregation + carbon asset tracking + AI optimized scheduling

15.2 Electrical Configuration

Item	Specification	Remarks
Rated Energy	1.67MWh (per cabinet)	LFP 314Ah liquid cooling module
Rated Power	830kW (built-in PCS)	AC 690V output
System Voltage	1331.2V DC→AC MV Grid	—
Power Factor	0.99 adjustable	Bidirectional Inverter
Efficiency	PCS + Battery Combined Efficiency ≥92.8%	Round-Trip
Insulation Monitoring	≥5MΩ	Automatic Alarm/Cut-off
Grid Connection Response Time	≤2s	Support VPP scheduling
Redundant Control	Dual Contactor + Relay Redundancy	—

15.3 Liquid Cooling & Thermal Management

Project	Parameters	Description
Cooling Method	Dual Circuit Liquid Cooling	Main circuit cold plate + auxiliary circuit cooling unit
Temperature Uniformity Accuracy	±1℃	Temperature difference between modules ≤5℃
Coolant	Environmentally-friendly insulation type	UL94-V0 level flame retardant
Pump Lifespan	≥60000h	Maintenance cycle≥5 years
Noise	≤75dB(A)	Environmentally friendly

15.4 Communication & Protocols

Hierarchy	Interface	Protocol	Function
Cabinet-level EMS	Ethernet/RS485	Modbus-TCP	Sampling and Control Loop
Array-level EMS	Ethernet/RS485	Modbus-TCP	Array Synchronization and Isolation
Station-level EMS	Ethernet/RS485	Modbus-TCP	Data aggregation and diagnostics
Project-level EMS	Fiber Backbone	REST API/TLS 1.3	Summary of AI scheduling and revenue upload
Cloud Aggregator	WebSocket + OpenADR 2.0b	Real-time revenue and carbon trading interface	

Data Security: AES-256 dynamic encryption + TLS 1.3; packet loss rate < 0.05%; NTP clock error⩽1ms.

15.5 AI Data Tag Structure

Hierarchy	Example Tag	Accuracy	Sampling Cycle	Description
Cell	Cell.V[n], Cell.T[n]	±0.5%	1s	Voltage, Temperature
Module	Module.Vavg	±0.3%	2s	Module Average Data
Cabinet	Cabinet.SOC, Cabinet.Power	±0.2%	5s	Status and Power
Array	Array.Load, Array.Temp	±0.2%	10s	Power/Environment
Station	Station.ActivePower	±0.1%	30s	Site Power Flow
Project	Project.TotalEnergy	±0.05%	60s	Total Energy Statistics

15.6 Safety & Fire System

Project	Configuration	Description
Fire Protection System	FM-200 Fire Extinguishing + Temperature/Smoke Dual Detection Trigger	Automatic Detection + Audible and Visual Alarm
Electrical Protection	Overvoltage/Overcurrent/Short Circuit/Reverse Polarity Protection	BMS three-level protection
Grounding Design	Independent Equipotential System	Complies with NFPA 855
Safety Level	UL 9540/9540A Certification	Passed Intertek Testing
Environmental Protection	IP65/NEMA 4X	Outdoor All-Weather Use

15.7 Compliance & Certification

Standard	Agency	Status
UL 9540/9540A	Intertek/CSA Group	☑ Passed
NFPA 855(2023)	UL Solutions/NFPA Lab	☑ Passed
IEEE 1547-2018	ETL Certification	☑ Compliant
NEMA 4X/IP65	SGS Protective Laboratory	☑ Passed
ISO 9001/14001	Renon Manufacturing System	☑ In Progress
FEOC Filing	US Treasury/DOE	☑ Record completed

15.8 O&M and Inspection Items

Dimension	Inspection Content	Cycle	Remarks
Hardware Inspection	Cell voltage and temperature sampling accuracy	Monthly	Automatic calibration
Liquid Cooling System	Flow, pressure, and temperature detection	Quarterly	Automatic adjustment of abnormal alarm thresholds
PCS/EMS	Communication delay and redundancy check	Weekly	AI detection + log summary
Safety System	Smoke and Temperature Detection and Fire Trigger Test	Every six months	Simulated Trigger Test
Firmware Upgrade	BMS/EMS OTA Update	As needed	Supports Remote Upgrade
AI Health Assessment	SOH/SOC Trend Analysis	Real-time	Cloud Forecast Report

15.9 Configuration Summary

Renon Power's 10ft AC liquid cooling system has formed a four-dimensional integrated architecture of “Energy Storage Device + Local EMS + Project-level EMS + Cloud Aggregator Platform” in version V3.1.

Core Features

- Cell 314Ah liquid cooling module lifespan ≥ 8000 cycles;
- PCS + battery combined efficiency ≥ 92.8%; grid response ≤ 2s;
- Data acquisition delay ≤ 80ms;
- Meets UL9540/NFPA 855/FEOC full chain compliance;
- Supports AI predictive scheduling + VPP aggregation revenue optimization;
- Possesses industrial-grade stability and bankable certification foundation.

Technical Support

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