500KW & 930kWH Containerized Light Storage Integrated Energy Storage System

Project Name: **500kw/930kWh Containerized Solar Storage Integrated Energy Storage System**

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1. Project Information Overview

1.1 Introduction

This document is written according to the relevant technical standards of electrochemical energy storage power plants. It includes a general description of the product, hardware environment, specific functional requirements and other relevant supporting information, as well as relevant development tasks and specific work carried out by relevant developers based on this.

1.2 Project background

With the rapid development of power construction, the adjustment of economic structure, and the improvement of people's quality of life, the structure of electricity consumption has undergone significant changes, especially the widening gap between peak and trough electricity consumption, the decreasing load rate year by year, the increasingly difficult operation of the power grid, and the unreasonable utilization of resources. The electrochemical energy storage system can achieve peak shaving and valley filling functions of the load by discharging during peak load and charging during low load. Users can use the electrochemical energy storage system to obtain economic benefits by taking advantage of the peak-valley electricity price difference, improve the balance of energy load, delay equipment capacity upgrades, and improve equipment utilization. Energy storage systems have characteristics such as energy storage, fast response, and accurate power tracking. Energy storage technology is regarded as an important part of the power grid operation process. After introducing energy storage into the power system, demand-side management can be effectively implemented, which not only makes more effective use of power equipment and reduces power supply costs, but also promotes the application of Renewable Energy. It can also be used as a means to improve system operation stability, adjust frequency, and compensate for load fluctuations.

1.3 Terminology

- PCS (Power Covert System): An energy conversion system, also known as a converter, is a bidirectional converter system that performs inversion and rectification.
- SOC (State Of Capacity): The remaining capacity of the battery is expressed as a percentage.
- SOH (State Of Health): The health status of the battery pack, expressed as a percentage.
- DOD (Depth of Discharge): The depth of discharge of a battery, expressed as a percentage.
- BMS (Battery Management System) is responsible for managing and controlling the battery part of the energy storage system, including BMU, BCMS, and BAMS.
- BMU (Battery Management Unit): A battery pack management unit responsible for managing multiple battery packs. It has functions such as single-cell voltage acquisition, multi-point temperature acquisition, battery pack equalization control, and total battery pack voltage acquisition.
- BCMS (Battery Cluster Management System) is a battery string management system responsible for managing all BMUs in a battery string. It also has current collection, total voltage collection, leakage detection, and drives the disconnection of the high-voltage power contactor when the battery pack status is abnormal, so that the battery string can exit operation and ensure the safety of battery use.
- BAMS (Battery Array Management System) is a battery system unit management system responsible for managing all BCMS in a battery system unit corresponding to a PCS. It also communicates with the on-site monitoring system, reports the information collected by all battery analog quantities, and reports an alarm when the battery system is abnormal. In addition, it can send alarm information to the PCS when the battery system is abnormal, so that the PCS enters standby mode and protects the safety of battery use.
- Static Tranasfer Switch: Used for switching between two power sources, it automatically switches between two power sources. Under normal working conditions, when the main power supply is within the normal operating voltage range, the load is connected to the main power supply. When the main power supply fails, the load switches to the backup power supply. After the main power supply returns to normal, the load automatically switches to the main power supply.
- DC converter: Bidirectional DC/DC converter (hereinafter referred to as "converter") is mainly used for power conversion between DC low voltage (relative to the high voltage side of the converter) and high voltage (relative to the low voltage side of the converter). It can be used in conjunction with battery DC/DC systems, PV power generation systems, PCS application systems, charging pile systems, etc., and can be widely used in industries or fields such

as industrial and commercial storage, photovoltaic power generation, battery manufacturing and utilization, and microgrids.

- Energy Management System (Energy Management, System): The energy management system is the decision-making center of the energy storage system, and its core functions are safety optimization scheduling strategy and visualization. Energy transformation decision-making, real-time monitoring and control, operation and maintenance management analysis, remote real-time control, etc.
- Fire Fighting System: The fire extinguishing system can monitor the battery system in real time, detect and report fires early, and timely block the occurrence of fires. It consists of triggering devices, fire alarm devices, and fire extinguishing devices.

1.4 Reference standards

GB/T 36276-2018 Lithium-ion batteries for power storage.

2 > UN38.3 United Nations Manual of Tests and Criteria for the Transport of Dangerous Goods - Part 3, paragraph 38.3 - Requirements for lithium batteries;

IEC62619 Safety requirements and test methods for industrial (including fixed) lithium batteries and lithium battery packs.

NB/T42091-2016 Technical Specification for Lithium-ion Batteries for Electrochemical Energy Storage Power Stations.

GB51048-2014 Electrochemical Energy Storage Power Station Design Specification.

GBT34120-2017 Technical Specification for Energy Storage Converter of Electrochemical Energy Storage System.

GB/T36547-2018 Technical Regulations for Electrochemical Energy Storage System Access to Power Grid.

GB/T36548-2018 Electrochemical Energy Storage System Access Grid Test Specification.

GB/T36558-2018 General technical conditions for electrochemical energy storage systems in power systems.

GBT34131-2017 Technical Specification for Lithium-ion Battery Management System for Electrochemical Energy Storage Power Station.

11 > NB-T 31016-2011 battery energy storage power control system technical conditions;

GB 4208-2008 Shell Protection Level (IP Code)

13 > GB/T 17626 Battery compatibility test and measurement technology;

GB 14048.1-2006 Low-voltage switchgear and controlgear Part 1: General provisions;

15 > GB7947-201 Basic and safety rules for human-machine interface marking -

Conductor color or digital identification.

16 > DL/T 614-2007 Multifunctional Energy Meter;

17 > DL/T 621-1997 Grounding of AC electrical installations;

19 > GB/T 12325-2008 Power Quality Power Supply Voltage Deviation;

19 > GB/T 12326-2008 Power Quality Voltage Flicker and Flicker;

20 > GB/T 14549-1993 Power Quality Harmonics in Public Grid;

21 > GB/T 15543-2008 Power quality three-phase voltage imbalance;

22 > GB/T 15945-2008 Power Quality Power System Frequency Deviation;

23 > DL548-94 "Management Regulations for Lightning Protection Operation of Communication Stations in Power Systems"

GB/T13729-2002 General technical conditions for remote end points;

GB/T13730-2002 Regional Power Grid Dispatching Automation System.

26 > T/CEC 176-2018 Large-scale electrochemical energy storage power station battery monitoring data management specification;

Q/GDW10 111-03-004-201 Technical specification for automatic monitoring information transmission of energy storage power stations;

28 > Q/GDW10 111-03-003-2018 Technical specification for computer monitoring system of energy storage power station;

29 > T/CEC 175-2018 Electrochemical Energy Storage System Cabin Design Specification;

30 > T/CEC 373-2020 Prefabricated cabin lithium iron phosphate battery energy storage power station fire protection technical specifications

GB 50016-2014 (2018 Edition) Fire Protection Code for Building Design.

GB 50229-2019 Architectural Lighting Design Standard.

GB 50229-2019 Fire Protection Standard for Design of Thermal Power Plants and Substations.

GB 50034-2013 Architectural Lighting Design Standard.

35 > GB 50116-2013 Fire Automatic Alarm System Design Specification;

GB 50217-2018 Electric Power Engineering Cable Design Standard.

37 > DL/T 502-2005 Technical Specification for Automatic Design of Regional Power Grid Dispatching;

38 > DL/T 553-2017 Technical Regulations for Power System Dispatching Automation Design;

39 > DL/T 5202-2004 Technical Regulations for Design of Electric Energy Metering Systems;

GB 50140-2005 Code for Design of Fire Extinguisher Configuration in Buildings.

2. Overall scheme design of energy storage system

2.1 Energy storage system architecture

The energy storage system consists of battery system (including energy storage battery and battery management system), energy storage converter system (PCS), photovoltaic MPPT system, off-grid switching system, distribution system, lighting system, fire protection system, temperature control system and other main components.

The total installed capacity of this project is 500KW/Wh, and a customized container of 5m * 2.4m * 2.6m is installed.

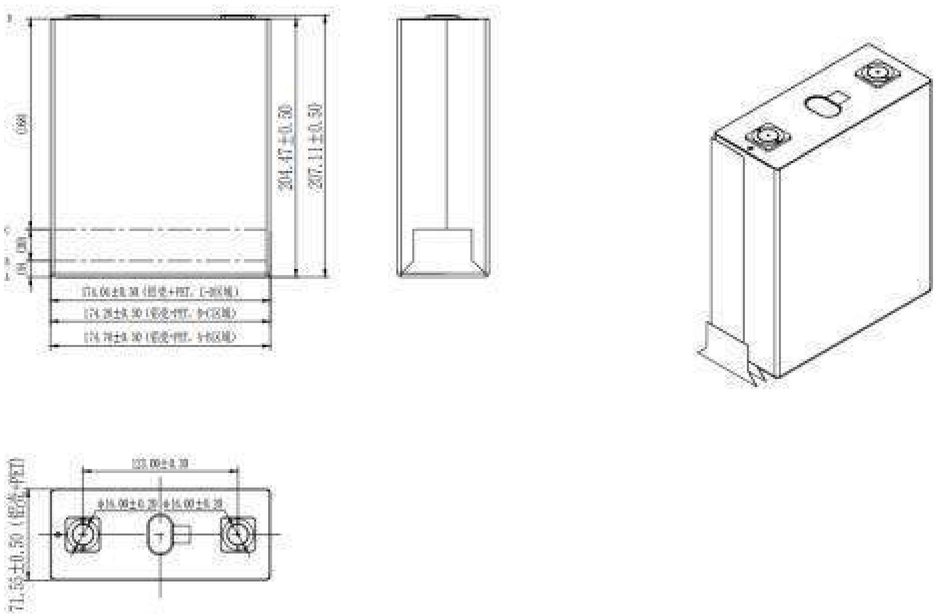
2.2 Energy storage unit

2.2.1 cell selection

This system plans to use lithium iron phosphate batteries with a single unit specification of 3.2V/280Ah. Table 1 below shows the performance data of 280Ah battery cells.

Category	**Parameter**
Cell type	Lithium iron phosphate battery
Rated capacity of monomer	280Ah
Nominal voltage of unit	3.2V
Operating voltage range	2.5~3.65V，25℃±2℃
Standard charge and discharge current	0.5C
Maximum continuous charge and discharge current	1C
Working temperature	Charging: 0 ℃~ 60 ℃; Discharging: -30 ℃~ 60 ℃
Storage temperature	-20℃~45℃
Battery weight	5.43±0.2kg

Dimensions (thickness * width * height)	71.55±0.5mm*174.7±0.5mm*207.11±0.5mm
Battery internal resistance	0.18 ± 0.05mΩ
Cycle life	≥10000 (≥70%)
Standard discharge mode	At room temperature (25 ± 2 ℃), discharge at a constant power of 0.5P to a termination voltage of 2.5V, stop discharging, and let it stand for 30 minutes



2.2.2 Energy Storage Module

(1) 1P16S battery module specifications

Serial number	Project	Parameter	Remarks
1	Cell type	LFP-3.2V-280Ah	
2	Battery PACK string mode	1P16	
3	Nominal capacity [Ah]	280	

4	Nominal energy [kWh]	14.336	
5	Nominal voltage [Vdc]	51.2	
6	Voltage range [Vdc]	40~58.4	
7	Charge-discharge rate	≤0.5P	
8	Cooling mode	Air cooled	
9	Operating temperature range [℃]	0 ～ +55	
10	Storage temperature [℃]	-20 ～ +45	Within 1 month
11	Operating humidity range	5~ 95% RH	No condensation
13	Elevation [m]	4000	> 2000 reduction
14	Weight [kg]	≤105kg	

The structure of the 1P16S battery module is shown in Figure 3 below.

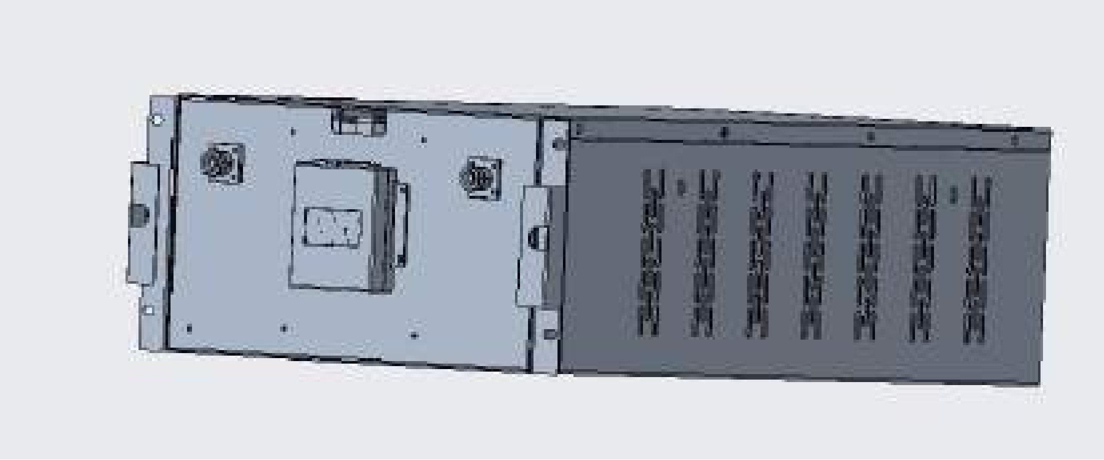


Figure 3 1P16S battery module structure diagram

The 1P16S module BMS is externally installed, which can facilitate the maintenance of the BMU. At the same time, the battery cells inside the module can be quickly balanced to a certain level through the wiring harness.

2.2.3 battery cluster

The battery cabinet is mainly equipped with a battery box, BMS main control management system, supporting wires and cables, high and low voltage electrical protection components, etc. The cabinet adopts a grouped and layered design. The cabinet adopts a maintenance-free technology and Modularization combination assembly structure to ensure that the cabinet structure has good mechanical strength, and the overall structure can maximize the reliability and safety of the entire system.

(1) Battery cluster parameters

Serial number	**Project**	**Technical parameters**	**Remarks**
1	Rated voltage (50% SOC)	819.2V	
2	Rated capacity	280Ah	
3	Systematic grouping	1P256S	
4	Total energy of the system	229.376kWh	
5	System available energy	217.9kWh	Discharge window 95% SOC
6	Operating voltage range	640-934.4V	
7	Maximum pulse discharge current (10S)	420A	25℃，SOC50%
8	Maximum sustained discharge current	280A	55℃>T>=0℃
		140A	0℃>T>-20℃
9	Maximum pulse charging current (10S)	280A	T>=10℃

10	Maximum continuous charging current	140A	T >= 10℃
11	Maximum SOC run window	5%SOC～97%SOC	Available SOC range
12	Cycle life, 0.5C charge and discharge, from SOC 95% to SOC 5%	≥6000cycles	SOH≥80%
14	Working temperature	Same monomer operating temperature	
15	Maximum voltage for constant power or constant current charging	934.4V	
16	Pulse charging maximum voltage (10S)	947.2V	
17	Constant power or constant current discharge minimum voltage	640V	
18	Pulse discharge minimum voltage (10S)	512V	
19	1Month, 25 ℃, 50% SOC self-discharge rate	3%	
20	Insulation resistance value	Greater than 550MΩ	
21	Dimensions	970×2055×794mm	

	(Width x Height x Depth)		
22	Weight	≤1.9T	

(2) The structural dimensions of the battery cluster are shown in Figure 4 below

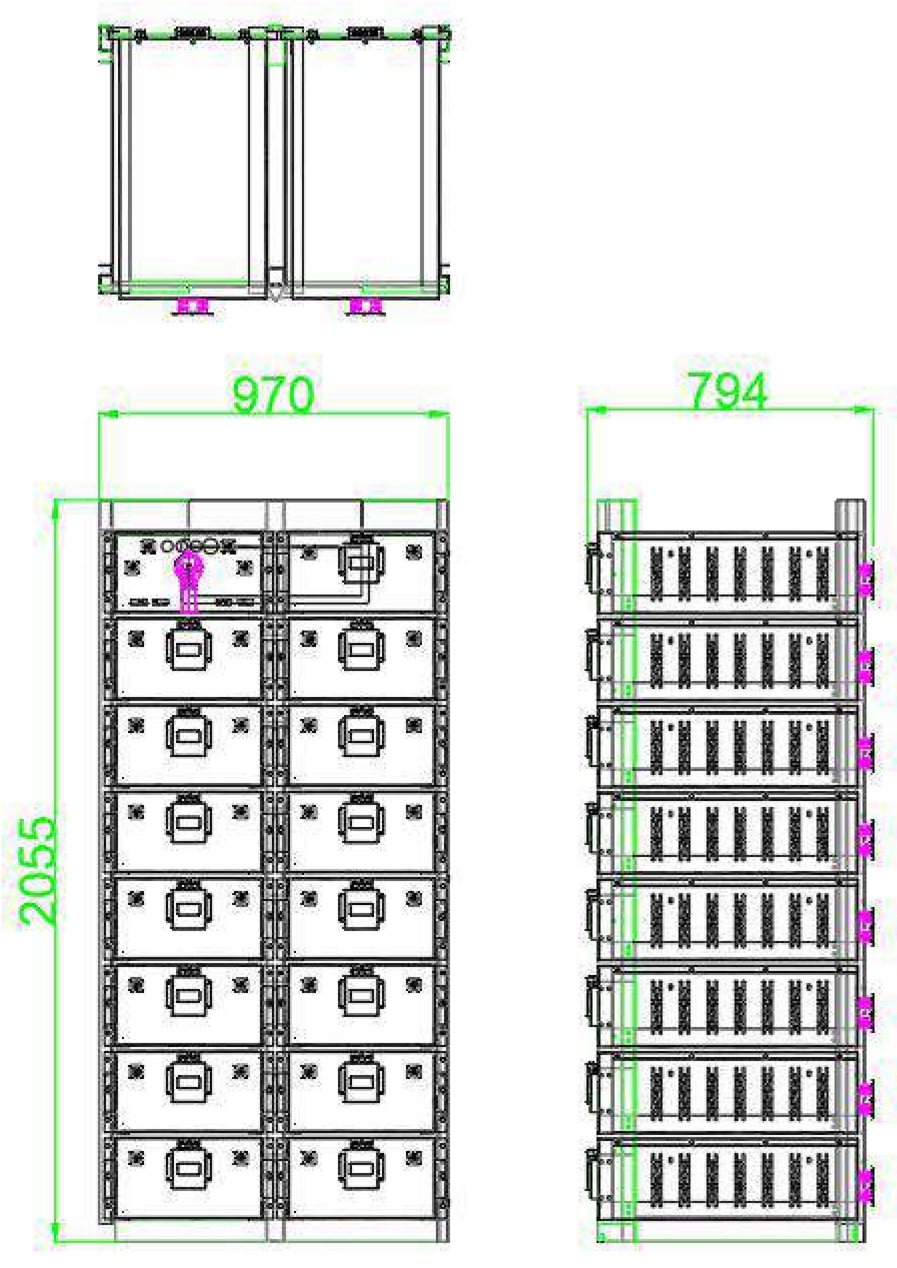


Figure 4, size diagram of battery cluster structure

(3) The electrical principle of the battery cluster is shown in Figure 5 below

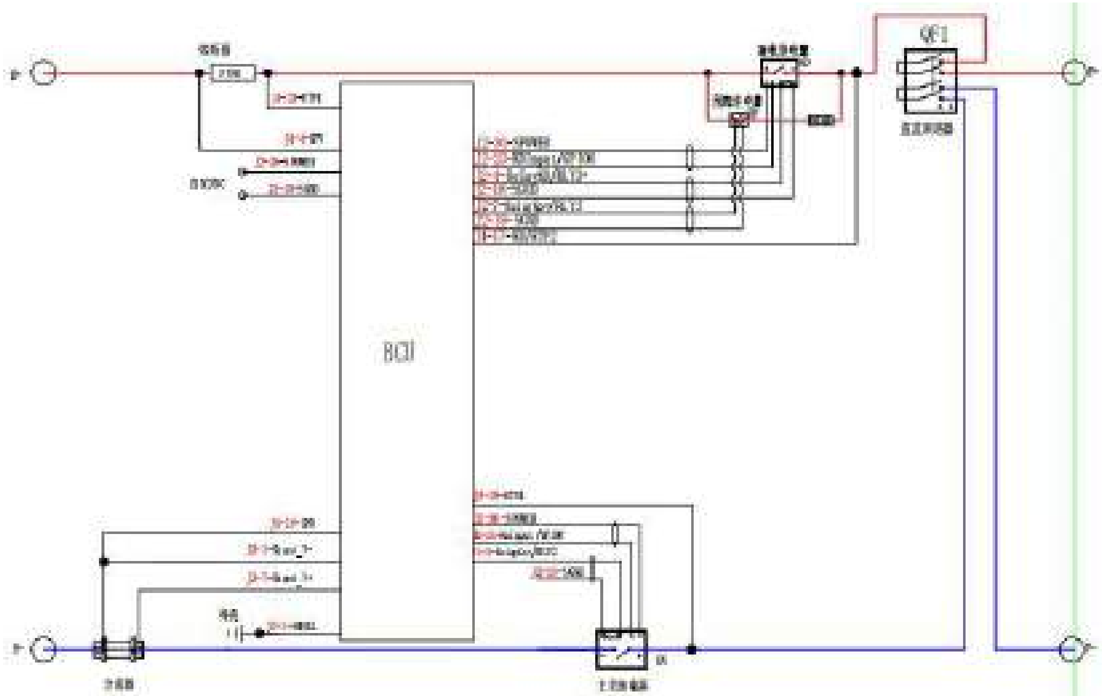


Figure 5, Electrical schematic diagram of battery cluster

2.2.4 container

(1) Container technical requirements

Container internal integrated ventilation system, battery temperature control system, AC system, energy storage system, power distribution system, insulation system, flame retardant system, emergency system, fire alarm and fire linkage system and other automatic control and safety assurance systems.

All the wiring in the container is internal wiring.

The internal equipment of the container has excellent maintainability and replaceability.

The protection level is not lower than IP54 and has unlimited full-load lifting strength within the lifespan (25 years).

B. Uniform spraying color, color RAL9003, paint film thickness ≥ 120um.

C. Waterproofing: The top of the box does not accumulate water, seep water, or leak water. The side of the box does not receive rain, and the bottom of the box does not seep water. A rain test is conducted before leaving the factory to ensure that there is no seepage or leakage in the cabin, bulkhead, and various openings.

D. Insulation: The container wall panels and doors are treated with insulation measures. Under the environmental conditions of a temperature difference of 55 ℃ inside and outside the cabin, the heat transfer coefficient is less than or equal to 1.5W/(m ²· ℃).

E. Corrosion resistance: Container load-bearing skeleton coating treatment. Under actual environmental conditions, the appearance, mechanical strength, corrosion degree, etc. of the container ensure that it meets the requirements of 25 years of actual use.

F. Fire resistance: The container shell structure, insulation materials, interior and exterior decoration materials, etc. are all flame retardant materials.

G. Sand resistance: Containers have good sand resistance.

H. Shockproof: Before the container leaves the factory, it undergoes lifting, load-bearing, and racing tests to ensure that the mechanical strength of the container and its internal equipment meets the requirements under transportation and earthquake conditions, and there are no malfunctions such as deformation, functional abnormalities, and failure to operate after vibration.

I. UV protection: The performance of materials inside and outside the container will not deteriorate due to long-term exposure to ultraviolet radiation.

(2) The arrangement inside the container is shown in Figure 6

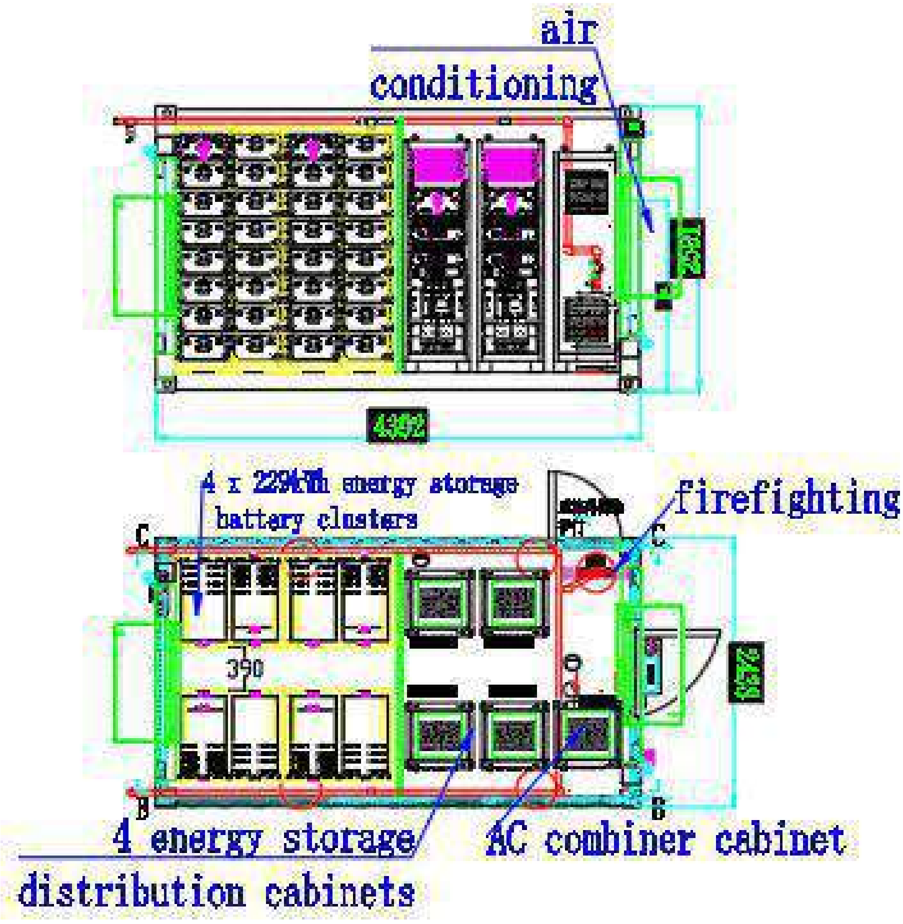


Figure 6, internal structure diagram of the container

(3) The electrical principle inside the container is shown in Figure 7 below

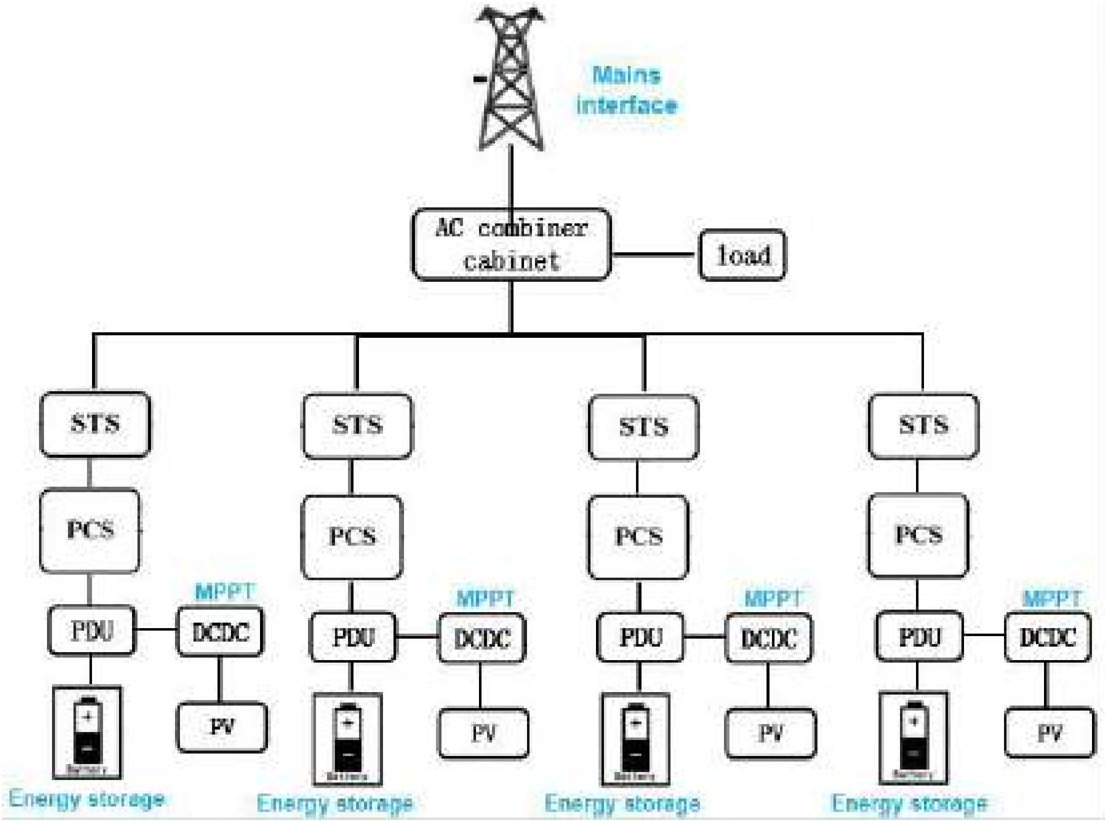


Figure 7, Electrical schematic diagram inside the container

2.3 Battery system single cabin technical parameter table

Serial number	Name	Parameter	Remarks
1.	Rated discharge power	≥500kW	
2.	Rated charging power	≥500kW	
3.	Rated energy storage capacity	≥917.5kWh	
4.	Rated photovoltaic power	480kw	Max 576kw
5.	Energy conversion efficiency	≥90%	0.5C charging and discharging, ambient

			temperature is 25 ± 5 ℃, excluding auxiliary equipment
6.	Number of battery clusters	4 clusters	
7.	Single cluster series-parallel mode	1P256S	
8.	Equipment operating ambient temperature	0℃~45℃	
9.	Cooling mode	Air cooled	
10.	Container specifications	4400*2438*2596mm	

3. Battery Management System (BMS)

3.1 Basic functions of BMS

BMS mainly includes battery status monitoring, operation control, event recording and storage functions, insulation monitoring, dynamic balance management, protection alarm, communication and other functions to ensure the normal, stable and reliable operation of the system.

The main function list of BMS is as follows:

a. The high-precision monitoring and reporting functions of battery analog quantity include real-time voltage detection of battery string, charging and discharging current detection of battery string, terminal voltage detection of single battery, multi-point temperature detection of battery pack, and leakage monitoring of battery string.

b. Battery system operation alarm, alarm local display and reporting function, including battery system overvoltage alarm, battery system undervoltage alarm, battery system overcurrent alarm, battery system high temperature alarm, battery system low temperature alarm, battery system leakage alarm, battery management system communication abnormal alarm, battery management system internal abnormal alarm.

c. Battery system protection function. When the analog quantities such as voltage, current, and temperature in the battery system exceed the safety protection threshold, the battery management system will perform fault isolation, exit the problematic battery pack, report protection information, and display it locally.

d. This battery management system has self-diagnosis function. When there is an interruption or failure in internal communication or external communication of the battery management system, it can report a communication interruption alarm. In addition, it also has the function of fault self-diagnosis, local display, and reporting to the local monitoring system for other abnormalities such as analog acquisition.

e. The battery management system has a non-destructive active equalization function, equalizing the current 2A. Through an efficient equalization strategy, the consistency of the battery pack can be well maintained.

f. The battery management system provides two ways to modify the operating parameters of the battery management system, local and remote, and provides the function of modifying authorization passwords. Local parameter modification is completed on the local touch screen of the battery management system, and remote parameter modification is completed through fiber optic Ethernet communication. The battery management system provides communication protocols and command word formats for parameter modification. Parameter setting items include:

- Single cell charging upper limit voltage
- Single cell discharge lower limit voltage
- Maximum operating temperature of battery
- Battery operating minimum temperature
- Battery string overcurrent threshold
- Battery string short circuit protection threshold
- Battery short-term temperature rise too fast threshold
- Local running status display function

g. This battery management system can store various events and historical data of the battery system locally, recording more than 7000 events and at least 30 days of historical data.

Battery system capacity calibration and SOC calibration. This battery management system can fully charge and discharge the battery pack with the cooperation of PCS, completing the functions of battery system capacity calibration and SOC calibration.

3.2 BMS architecture and basic parameters

The BMS used in this project is designed with a three-level architecture, which includes a battery acquisition equalization unit (BMU), a battery management unit (BCU), and a main processor (BAU).

Serial number	Project	Parameter	Remarks
1	Single cell voltage detection range (V)	0V～5V	
2	Single cell voltage detection accuracy (mV)	±5mV	
3	Total voltage detection range (V)	0V～1000V	
4	Total voltage detection accuracy (%)	1%FSR	
5	Temperature detection range (℃)	-40℃～125℃	
6	Temperature detection accuracy (℃)	±1℃	
7	Current detection range (A)	±1000A	Optional
8	Current detection accuracy (A)	1.0%FSR	
9	SOC accuracy (%)	5%	
10	Active balanced current (A)	2	
11	Protection	Including: overcharge, overdischarge, overtemperature,	

		short circuit protection, and the protection setting value can be set	
12	BMS internal communication party	CAN	
13	Communicating with PCS	Modbus RS485/CAN	
14	Communication method with monitoring background	Modbus Ethernet	
15	Event record storage	≥ 7000 articles	
16	Historical data storage	≥ 30 days	

3.3 System Control Strategy

BMU is responsible for collecting battery voltage, temperature information, and balancing control.

BCU is responsible for managing all BMUs in a single cluster, obtaining the individual voltage and temperature information of all BMUs through the CAN bus. It also has current collection, total voltage collection, leakage detection, and alarm information judgment for the battery cluster. When the battery cluster status is abnormal and PCS fails to effectively protect it, the contactor is disconnected to make the battery cluster exit operation and ensure the safe use of the battery.

The second-level master BAU is responsible for managing the first-level master BCU of each cluster. When a serious failure occurs in the battery cluster, the second-level master can issue instructions to cause the first-level master to disconnect the contactor.

The following describes the main control strategies of the system.

Power-on and pre-charging strategies

First, ensure that the PCS is in the disconnected state. After the BAMS power-on self-test is completed, first check the total voltage of each cluster.

a. If the maximum and minimum pressure difference is less than 10V, each cluster contactor is allowed to close simultaneously, and finally the contactor of the total output loop is closed, and normal charging and discharging signals are sent to the PCS through communication.

b. If the highest and lowest pressure difference is greater than 10V and less than 50V, close the main positive contactor with the highest total pressure, then close the external main circuit main positive contactor, and send power reduction to PCS through communication to 1/3 of the normal discharge power of all batteries. The remaining two clusters wait for parallel operation. When the parallel operation condition is met (close the contactor when the total pressure difference is less than 5V), close the corresponding contactor in that cluster, and send power reduction to PCS through communication to 2/3 of the normal discharge power of all batteries until all battery clusters are operating normally.

c. If the maximum and minimum pressure difference is greater than 50V, a direct fault alarm is triggered, and human intervention is required to troubleshoot and maintain the fault.

2. Insulation acquisition strategy - whether PCS detects insulation

Before the contactor is closed, the primary control BCMS of each cluster collects the insulation resistance separately. After the contactor is closed, the ESBCM insulation collection requirements are issued by PCS for testing.

3. PCS charge and discharge management

During system operation, real-time monitoring of each individual voltage and battery pack temperature. Based on the battery system status, a charge and discharge allow or disable signal is sent to PCS through communication. When a first-level alarm occurs, BAMS allows PCS to charge and discharge normally; when a second-level alarm occurs, BMS sends a disable charge and discharge command to PCS; when a third-level alarm occurs, BAMS sends a shutdown command to PCS. If PCS fails to shut down effectively within 5 seconds after the signal is issued, BAMS will cut off the contactor to ensure system safety.

4. Fire linkage control strategy (if any)

When the BAMS receives the fire signal, it disconnects the main bus contactor and issues instructions to the lower BCMS to disconnect the total positive and total negative contactors of each cluster.

5) Alarm and fault handling strategies

While ensuring the accuracy of SOC, diversified protection strategies are adopted for charging and discharging protection. Multiple protections such as overvoltage, overcurrent, and overtemperature are used in actual use to avoid battery overcharging. Protection devices such as DC circuit breakers, DC contactors, and fuses are used in the system to form multi-level protection for the system. The circuit can be cut off in time to prevent ignition in case of extreme current or even short circuit.

The BMS battery safety protection plan includes three-level software protection functions, self-diagnosis functions, and fuse configuration in case of software failure, ensuring the safety and stable operation of the system in all aspects. The introduction of each function is as follows:

Three-level software protection function. The three-level software protection strategies in the battery protection plan are:

The first level: When the battery status reaches the first level alarm threshold, the BMS sends alarm information to the PCS and monitoring background, and the monitoring background conducts energy allocation to reduce the PCS charging and discharging power.

Level 2: When the battery status reaches the level 2 alarm threshold, the BMS sends an alarm message to the PCS and monitoring background, and the BMS sends a command to prohibit charging and discharging to the PCS.

Level 3: When the battery status reaches the level 3 alarm threshold, the BMS sends an alarm message to the PCS and monitoring background. The BMS sends a shutdown command to the PCS. If the PCS fails to shut down effectively within 5 seconds after the signal is sent, the BMS will cut off the contactor to ensure system safety.

The specific items of protection alarm parameters are as follows:

Protection alarm parameter					
Serial number	Project	Configuration parameters	Continuous Time	Failure level	Treatment method
1	Total voltage is too high by 1 (V).	256*3.6	5S	Minor alarm	Limit viewership of 1/2
2	Total voltage too high 2 (V)	256*3.65	5S	Moderate alarm	Alarm, PCS stopped charging
3	Total voltage too high 3 (V)	256*3.7	5S	Serious alarm	Alarm, disconnect all relays
4	Total voltage too low 1 (V)	256*3.0	5S	Minor alarm	Limit viewership of 1/2

5	Total voltage too low 2 (V)	256*2.8	5S	Moderate alarm	Alarm, PCS parking power
6	Total voltage too low 3 (V)	256*2.5	5S	Serious alarm	Alarm, disconnect all relays
7	Single voltage is too high by 1 (V).	3.6	5S	Minor alarm	Limit viewership of 1/2
8	Single voltage too high 2 (V)	3.65	5S	Moderate alarm	Alarm, PCS stopped charging
9	Monomer voltage too high 3 (V)	3.7	5S	Serious alarm	Alarm, disconnect all relays
10	Monomer voltage too low 1 (V)	3.0	5S	Minor alarm	Limit viewership of 1/2
11	Low monomer voltage 2 (V)	2.8	5S	Moderate alarm	Alarm, PCS parking power
12	Monomer voltage too low 3 (V)	2.5	5S	Serious alarm	Alarm, disconnect all relays
13	SOC is too low 1 (%)	15	5S	Minor alarm	Alarm
14	SOC is too low 2 (%)	10	5S	Moderate alarm	Alarm
15	SOC is too	5	5S	Serious	Alarm

	low 3 (%)			alarm	
16	SOC is too high by 1 (%).	100	5S	Minor alarm	Alarm
17	SOC is too high 2 (%)	95	5S	Moderate alarm	Alarm
18	SOC too high 3 (%)	90	5S	Serious alarm	Alarm
19	The charging temperatur e is too high by 1 (℃).	45	5S	Minor alarm	Limit viewership of 1/2
20	The charging temperatur e is too high by 2 degrees Celsius.	50	5S	Moderate alarm	Alarm, PCS stops charging
21	The charging temperatur e is too high by 3 degrees Celsius.	55	5S	Serious alarm	Alarm, disconnect all relays
22	The discharge temperatur e is too high by 1 (℃).	50	5S	Minor alarm	Limit viewership of 1/2
23	Discharge temperatur	55	5S	Moderate alarm	Alarm, PCS

	e is too high 2 (℃)				parking power
24	Discharge temperature is too high 3 (℃)	60	5S	Serious alarm	Alarm, disconnect all relays
25	Charging temperature is too low by 1 (℃).	5	5S	Minor alarm	Limit viewership of 1/2
26	Charging temperature is too low 2 (℃)	3	5S	Moderate alarm	Alarm, PCS stops charging
27	Charging temperature is too low 3 (℃)	0	5S	Serious alarm	Alarm, disconnect all relays
28	Discharge temperature too low 1 (℃)	0	5S	Minor alarm	Limit viewership of 1/2
29	Discharge temperature is too low 2 (℃)	-10	5S	Moderate alarm	Alarm, PCS parking power
30	Discharge temperature too low 3 (℃)	-20	5S	Serious alarm	Alarm, disconnect all relays
31	Charging current is too high 1 (A)	180	15S	Minor alarm	Limit viewership of 1/2

32	Charging current is too high 2 (A)	230	5S	Moderate alarm	Alarm, PCS stops charging
33	Charging current is too high 3 (A)	280	5S	Serious alarm	Alarm, disconnect all relays
34	Excessive discharge current 1 (A)	180	15S	Minor alarm	Limit viewership of 1/2
35	Excessive discharge current 2 (A)	230	3S	Moderate alarm	Alarm, PCS parking power
36	Excessive discharge current 3 (A)	280	1S	Serious alarm	Alarm, disconnect all relays
37	Insulation resistance is too low 1 (KΩ)	300	5S	Minor alarm	Limit viewership of 1/2
38	Insulation resistance is too low 2 (KΩ)	200	5S	Moderate alarm	Alarm, PCS stops charging and discharging
39	Insulation resistance is too low 3 (KΩ)	100	5S	Serious alarm	Alarm, disconnect all relays
40	The temperatur e	10	5S	Minor alarm	Limit viewership of 1/2

	difference is too large by 1 (℃).				
41	The temperature difference is too large 2 (℃).	12	5S	Moderate alarm	Alarm, PCS stops charging and discharging
42	Temperature difference is too large 3 (℃)	15	5S	Serious alarm	Alarm, disconnect all relays
43	The single pressure difference is too large by 1 (V).	0.5	5S	Minor alarm	Limit viewership of 1/2
44	Single pressure difference is too large 2 (V).	0.8	5S	Moderate alarm	Alarm, PCS stops charging and discharging
45	Single pressure difference is too large 3 (V).	1.0	5S	Serious alarm	Alarm, disconnect all relays
46	Communication interruption		15S	Serious alarm	Alarm, disconnect all relays

Self-diagnosis function: The battery management system has a self-diagnosis function. When there is an interruption or failure in internal communication or external communication of the battery management system, it can report a communication interruption alarm. In addition, it also has the function of fault self-diagnosis, local display, and reporting to the monitoring system for other abnormalities such as analog acquisition.

Fuse configuration: In extreme cases, when all software controls fail, the fuse configured at the front end of the battery string can quickly blow to prevent system damage or safety accidents caused by electrical short circuits.

4. Thermal management scheme

Energy storage systems have different application scenarios, with large temperature differences between the four seasons and the north and south. The design of the battery's thermal management scheme mainly focuses on the low-temperature start-up process and high-temperature heat dissipation to ensure that the temperature difference between the battery is small, to maximize the safety of the battery compartment and extend the battery life. Therefore, an air conditioning cooling and heating system is added internally.

4.1 Air duct design

The battery rack is placed on both sides of the container. The air conditioner blows air from the middle air duct of the battery rack inside the box. A tapeout is set inside the air duct to ensure that the air duct evenly reaches the back of each battery box. Then, it enters the battery box by opening a hole at the back of the battery box. Then, an exhaust fan is set up in front of the battery box to extract hot air and circulate it back to the air conditioner. As shown in Figure 8 below.

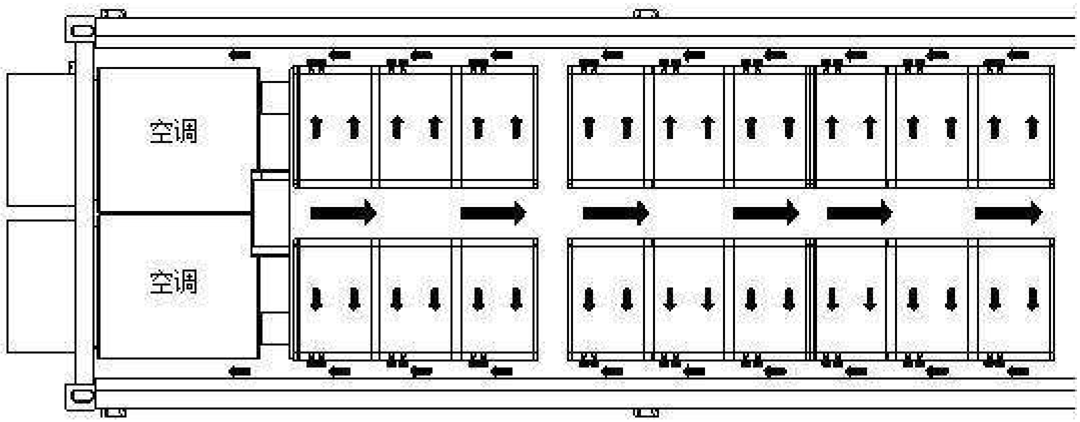


Figure 81, schematic diagram of the air duct

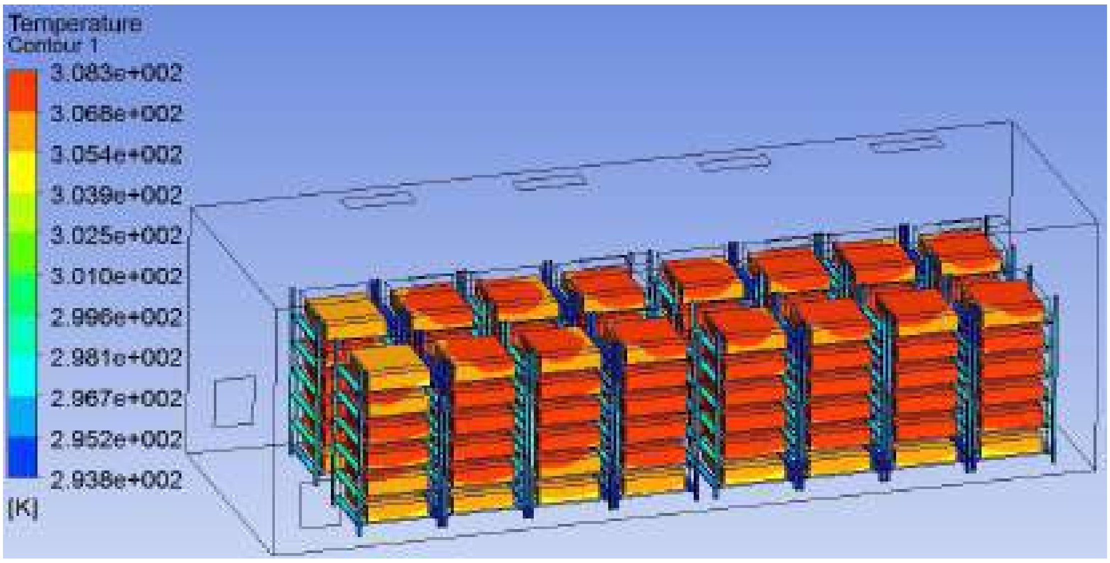


Figure 82, schematic diagram of battery module temperature distribution

4.2 Temperature control strategy

In the case where the external ambient temperature is low, before the system start-up, turn on the air conditioning heating function, adjust the room temperature of the entire container to the appropriate operating temperature of the battery, and the air conditioning standby.

Under the condition of high temperature in the external environment, the temperature of the entire system is reduced by natural heat dissipation and air conditioning cooling. After the system starts-up, the temperature of the entire system rises between 10 ℃ -20 ℃, that is, the internal temperature of the container is higher than the external environmental temperature. The internal temperature of the container can be adjusted by introducing a natural cold source. If natural heat dissipation is used, when the internal temperature of the container continues to rise above 30 ℃, the air conditioning forced cooling mode should be started.

In other cases, such as high temperatures of around 30 ℃ in outdoor environments or frequent charging and discharging of the system, causing a sudden rise in temperature inside the container, the temperature cannot be quickly reduced through natural heat dissipation. This causes heat accumulation inside the system, so it is necessary to turn on the air conditioning for rapid cooling.

The control strategy of the thermal management system is shown in Figure 9 below.

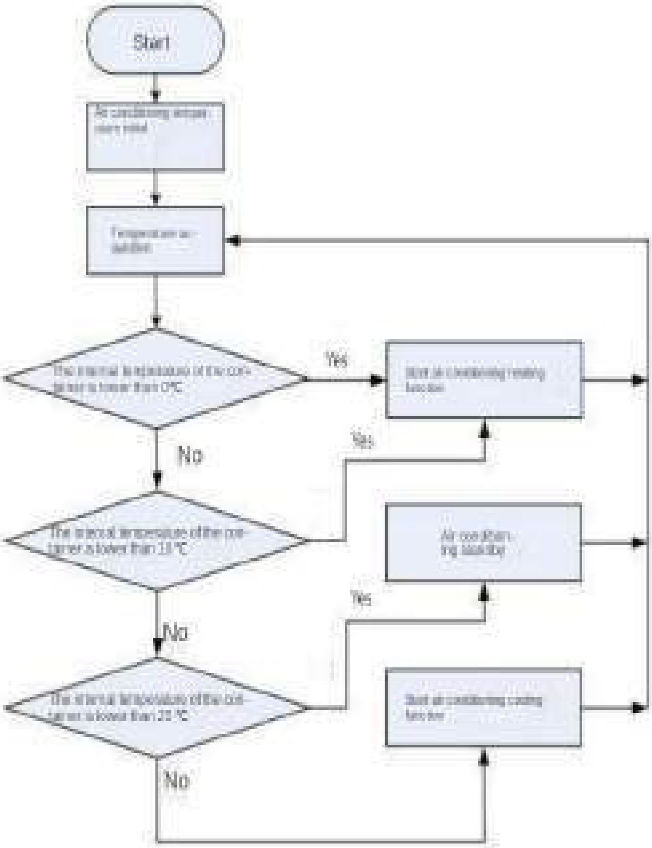


Figure 9, thermal management system control strategy

5. Fire department

5.1 Fire protection design principles

The fire protection design of this project follows the Fire Protection Law of the People's Republic of China and relevant national policies, implements the fire protection work policy of "prevention first, prevention combined with elimination", and aims to achieve the purpose of self-defense and self-rescue, prevent and reduce fire hazards, and ensure personal and property safety. For different buildings and facilities, various effective and meeting fire protection measures are adopted, and advanced, reasonable, and economically reliable fire protection technologies are adopted. Relevant fire protection standards, regulations, and norms must be strictly implemented in the layout, process design, and material selection.

5.2 Construction specifications

The equipment of this project mainly consists of battery cabins and PCS systems. The fire hazard classification and fire resistance rating of the buildings in this project are strictly implemented in accordance with GB51048-2014 "Code for Design of Electrochemical Energy Storage Power Stations" and GB50016-2014 "Code for Fire

Protection Design of Buildings".

GB51048-2014 "Electrochemical Energy Storage Power Station Design Code" Article 11.1.3 stipulates that the fire hazard of outdoor lithium-ion battery equipment is classified as Class E (Class E is a non-combustible substance), which is consistent with Article 6.3 of Q/GDW 11265-2014 "Technical Regulations for the Design of Battery Energy Storage Power Stations".

11.1.3 The fire hazard classification and minimum fire resistance rating of each building, structure and equipment in the station shall comply with the provisions of Table 11.1.3.

Table 11.1.3 Fire Hazard Classification and Fire Resistance Rating of Buildings, Structures and Equipment

Name of building, structure and equipment		Fire hazard classification	Fire resistance rating
Battery room	Lead-acid batteries, lithium-ion batteries, flow batteries	E	Level II
	Sodium-sulfur battery	A	Level 1
Outside the house Battery Equipment	Lead-acid batteries, lithium-ion batteries, flow batteries	E	Level II
	Sodium-sulfur battery	A	Level 1
Power Distribution Building (room)	Oil quantity of single equipment above 60kg	C	Level II
	Oil quantity of single equipment 60kg and below	T	Level II
	Oil-free electrical equipment	E	Level II
Outboard Fit Electric device	Oil quantity of single equipment above 60kg	C	Level II
	Oil quantity of single equipment 60kg and below	Ding	Level II
	Oil-free electrical equipment	E	Level II
Oil-immersed transformer room		C	Level 1
Gas or dry-type transformer room		Ding	Level II
Main control Communication Building		E	Level II

The fire hazard category and the minimum fire resistance rating of each building and structure of the 6.3 battery energy storage power station shall not be lower than those specified in Table 1. The design of the whole and components of each building and structure shall not only meet the use function, but also comply with the relevant provisions on fire prevention.

Table 1 Fire hazard classification and fire resistance rating of buildings and structures

Serial Number	Name of building and structure		Fire hazard category	[illegible]
1	Main control Communication Building		戊	Level II
2	Relay room		戊	Level II
3	Internal and external power distribution devices	Oil filling quantity of each equipment More than 60kg	丙	Level II
		Oil filling quantity of each equipment 60kg and below	Ding	Level II
		Oil-free electrical equipment	戊	Level II
4	[illegible]		戊	Level II
5	Indoor and external sodium sulfur batteries		甲	Level 1

Note 1: [illegible]

Note 2: [illegible] C.

When parts of different uses are arranged in a building or joint building, the fire hazard of the building is divided [illegible]

5.3 Battery fire protection

The fire protection measures for batteries in the battery compartment mainly use the perfluorohexanone automatic fire extinguishing system. The fire distribution lines are all concealed in non-combustible structures or protected by metal pipes, and the cables are all flame-retardant cables. Fire protection measures such as sealing, blocking, and isolation are taken for cables. Fireproof plugging materials are used to tightly seal the cable entrances and exits of the distribution device and the cable trenches.

The perfluorohexanone automatic fire extinguishing system is a modern intelligent automatic fire extinguishing device that integrates gas extinguishing, automatic control, and fire detection. It is a clear, colorless, and odorless liquid that is supercharged with nitrogen and stored in a high-pressure gas cylinder as part of the fire extinguishing system. It has excellent environmental performance.

1. Excellent environmental performance: The environmental indicators of perfluorohexanone fire extinguishing agent products comply with the strictest international environmental regulations.

2. High fire extinguishing efficiency: The product has a minimum fire extinguishing concentration of 3.5% for Class A fires and 4.5% for Class B fires.

3. Safe to use: Its fire extinguishing concentration is much lower than the concentration of invisible harmful effects (NOAEL), with a large safety margin.

Good electrical insulation performance: The dielectric strength of perfluorohexanone fire extinguishing agent can reach (3mm) 74.6kV, and it has passed the electrical insulation performance test of 110KV.

5. Perfluorohexanone fire extinguishing agent has a unique cooling effect after spraying;

6. No residue after use: The perfluorohexanone fire extinguishing agent evaporates rapidly after use and will not cause damage to precision instruments or antique calligraphy and paintings.

7. Convenient and safe storage and transportation at atmospheric pressure: Perfluorohexanone fire extinguishing agent is a liquid at room temperature and is transported as ordinary goods, making it easy to fill, transport and store.

Comparison table of physical and chemical properties of heptafluoropropane and perfluorohexanone fire extinguishers:

Project	Unit	Heptafluoropropane	Perfluorohexa-none
Dielectric strength, latm(N2 = 1.0)		2	2.3
Vapor pressure (at 25 #)	Pa	0.404	5.85
Water-soluble (at 25 #)	%	0.06	< 0.001
Heat of vaporization (at boiling point)	kJ/kg	132.6	88.0
Liquid viscosity (at 25 #)	Centipoise	0.184	0.524
Specific volume (1atm at 25 #)	m^3/kg	0.1374	0.0719
Density (gas at 1atm at 25 #)	g/mL	0.03	0.0136
Density (saturated liquid at 25 #)	g/mL	1.407	1.6
Freezing Point	℃	−131.1	−108
Boiling point (1atm)	#	−16.4	49.2
Relative molecular weight		170.03	316.04
Chemical formula		CF_3CHFCF_3	CF_3CF_2C (O) CF [illegible]

The fire protection system consists of a fire alarm controller/gas fire extinguishing control panel, smoke detectors, temperature detectors, sound and light alarms, alarm bells, bleed indicator lights, manual emergency start/stop buttons, business box fire extinguishing devices (including fire extinguishing agent storage bottles, electromagnetic drive devices, pressure signalers), business box accessories (nozzles, high-pressure hoses), and power supply box fire extinguishing devices (including fire extinguishing agent storage bottles, electromagnetic drive devices, pressure signalers).

This project is based on the effective use of container layout space, so a special design is adopted.

According to the layout of the equipment inside the container, the fire extinguishing method adopts a fully submerged fire extinguishing system. Within the specified time, spray the designed amount of perfluorohexanone into the container and evenly fill the entire container's fire extinguishing system.

Due to the limited height inside the container, the design of directly fixing the perfluorohexanone gas tank inside the container is adopted.

(3) The starting method uses a solenoid valve device to start. This device must be removed during transportation, placed in a fixed position in the container, and fully debugged. Only when it is put into normal use can the solenoid valve be installed.

5.4 Electrical fire protection

The PCS cabin is equipped with smoke and temperature detectors, and a handheld fire extinguisher is placed at the entrance to the cabin.

Accident lighting: Safe passages are set up inside the container, and evacuation signs with light display are set up at the entrance and exit of the container.

5.5 Fire alarm and control system

According to the relevant requirements of GB500116-2013 "Design Specification for Fire Automatic Alarm System", the design of fire automatic alarm and linkage control system is carried out.

The fire automatic alarm system equipment set up in the container includes a fire alarm controller, detector, control module, signal module, manual alarm button, etc. It monitors the fire alarm signals in each area of the system and can implement automatic linkage control for each energy storage unit according to fire protection requirements. The fire alarm controller is equipped with operating status indicators and manual operation buttons for the controlled equipment.

Smoke and temperature detectors are selected for the detector, and manual alarm buttons and sound and light alarms are set. When the detector or manual alarm button is activated, the fire alarm controller emits sound and light alarm signals and displays the address of the alarm point, and prints relevant information such as the alarm time and address of the alarm point. The normal working power supply of the fire alarm controller is AC 220V.

6. Electrical system

6.1 Station power supply

This energy storage station plans to use mains power for electricity and lighting AC220V.

6.2 Energy storage cabin electrical principle

The power supply for the station is AC220V, and all power switches are installed in the energy storage compartment. The circuit breakers in the distribution box are all made of high-quality domestic brands, and their power supply principle is as follows:

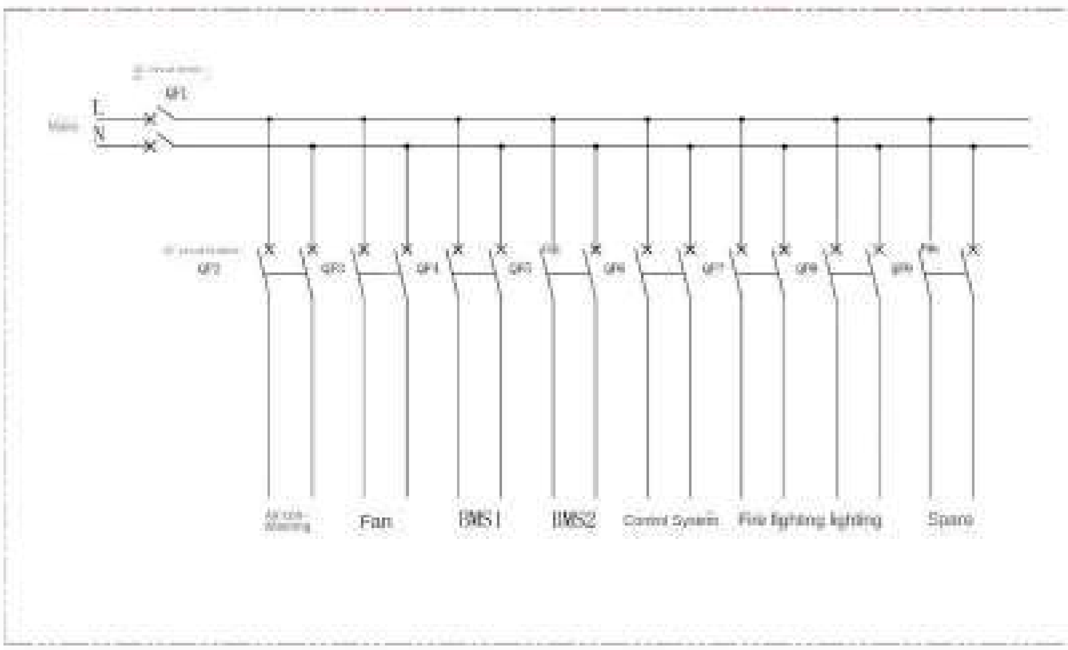


Figure 11, power supply schematic for station

6.3 Lighting

According to the "Technical Regulations for Lighting Design of Thermal Power Plants and Substations" DLGJ56-95, station area floodlights are set up in the energy storage power station area, and the power supply is connected to the energy storage station lighting distribution box.

The lighting system of the energy storage unit consists of two parts: normal lighting and emergency lighting. The normal lighting in the container is powered by mains electricity, and the emergency lighting part has a self-contained battery for evacuation instructions.

LED lighting is uniformly used in the container as normal lighting and accident lighting. Safety channel indicator lights and evacuation lighting lights are installed at both sides of the maintenance door. The illumination in each area meets the requirements of the "Technical Regulations for Lighting Design of Thermal Power Plants and Substations".

Fire automatic alarm and linkage control system design is carried out according to the relevant requirements of "Design Specification for Fire Automatic Alarm System" (GB500116-2013).

The lamps inside the energy storage unit container are all explosion-proof.

6.4 Lightning protection grounding

1) Lightning protection

PCS input and DC side are equipped with surge protectors to protect against indirect lightning and direct lightning effects or other instantaneous overvoltage surges.

Energy storage in-app uses container units without outdoor electrical equipment. Referring to Article 5.3.7 of GB50057-2010 "Code for Lightning Protection Design of Buildings", it shall be implemented in accordance with the design requirements of Class II lightning protection buildings.

Protective grounding mainly refers to the safe grounding of the cabin casing. It forms a good conductive connection between the metal parts in the system that are usually not charged and the ground to protect equipment and personal safety. An external connection point is set up for the energy storage cabinet, and a grounding strip is set inside the cabin. As part of the lightning protection measures, the lightning protection grounding is used to introduce the electric surge through the lightning protection device into the earth. The lightning protection of electrical equipment is mainly connected to the protected equipment at one end of the lightning protection device and the grounding device at the other end. When a direct lightning strike occurs, the lightning protection device will direct the electric surge generated to itself, and the electric surge current will enter the earth through its lead wire and grounding device, thus avoiding damage to electrical equipment or endangering personal safety. The AC and DC lightning arresters in this scheme are installed in the energy storage cabin, and their fault status is monitored through the energy management system.

2) Grounding

According to the requirements of "Grounding of AC Electrical Devices" (DL/T621-1997), reliable grounding is required for all electrical equipment shells and other metal components that may be accidentally charged. The specific requirements are as follows:

All battery pack brackets are directly connected to the ground grid to prevent static electricity accumulation and protect the conductive parts of the equipment. All equipment shells are connected to the main grounding grid through grounding wires.

The same grounding grid is used for protection grounding, working grounding, and overvoltage protection grounding. The grounding grid adopts a manual composite grounding grid method.

The main grounding grid of the energy storage station is mainly composed of horizontal grounding bodies, supplemented by an appropriate number of vertical grounding bodies to form a composite grounding grid. It is recommended to use galvanized flat steel for the main grounding grid.

7. Video surveillance system

Image monitoring and environmental protection system equipment includes video servers, multi-screen splitters, recording equipment, cameras, encoders, access control magnets, water level sensors, temperature sensors, etc. Among them, the background equipment such as video servers has been configured in the on-site monitoring room and exchanged for host monitoring interfaces. This construction only needs to configure compatible cameras and connect them to the nearest exchange host.

All cameras in this issue use network cameras. The video signal of the camera is transmitted to the network switch through the network cable, and the network switch transmits the signal to the video server in the monitoring room for video storage and storage devices.

The environmental protection system acquisition equipment includes door magnetic sensors, temperature and humidity sensors, water immersion sensors, etc. Among them, the door magnetic sensor is connected to the network IO module, and the analog quantity is converted to digital quantity. All data is uploaded to the energy management system through the serial port server.

8. Energy storage distribution cabinet

8.1 Definition of Energy Storage Distribution Cabinet

The energy storage distribution cabinet is a power electronic interface device that connects the power grid and energy storage battery pack. It can achieve AC/DC bidirectional conversion of voltage and current through control. It consists of a main power part, a signal detection part, a control part, a driving part, a monitoring and display part, and an auxiliary power supply.

It consists of one 125kw PCS module and two 60kw photovoltaic DCDC modules connected in parallel, forming a 360kw MPPT module and one 250kw STS module connected in parallel. It is composed of a 1000V high-voltage box system and a distribution system. The whole cabinet integrates photovoltaic MPPT, energy storage converter, off-grid switching, and isolation transformer in one cabinet, which is uniformly dispatched by EMS for energy scheduling. It supports off-grid application and can output full power with load in pure off-grid mode. It can also support adding modules. In off-grid scenarios, the requirements for load are as follows:

- Load switching instantaneous peak current (base current + impulse current) does not exceed 1.2 times the PCS rated current
- Direct advertising motor load does not exceed 60% of the PCS rated power.
- When there are other types of loads, the load capacity ratio of direct advertising motors needs to be reduced. The load of other variable frequency or soft start motors should not exceed 2/3 of the rated power of PCS.

- It is not supported to input the load-side transformer after PCS startup. It is recommended to input the load-side transformer synchronously with PCS startup.

Main features

• Leading technology, fully meeting the access and control requirements of the power grid or load
• Energy efficient, more integrated, better customer experience ◦ It has grid-connected and off-grid parallel functions and good scalability ◦ With low voltage and zero voltage ride-through function, it can handle complex power grid situations calmly ◦ It has the functions of autonomous frequency modulation and voltage regulation and controlled frequency modulation and voltage regulation ◦ The off-grid belt has strong three-phase unbalance ability ◦ The maximum conversion efficiency can reach 98.2%. ◦ Front maintenance, reliable wall installation, saving equipment space ◦ Efficient PWM modulation algorithm reduces switching losses ◦ Dual-power redundant power supply scheme improves system reliability ◦ Perfect protection and fault alarm system, more secure and reliable

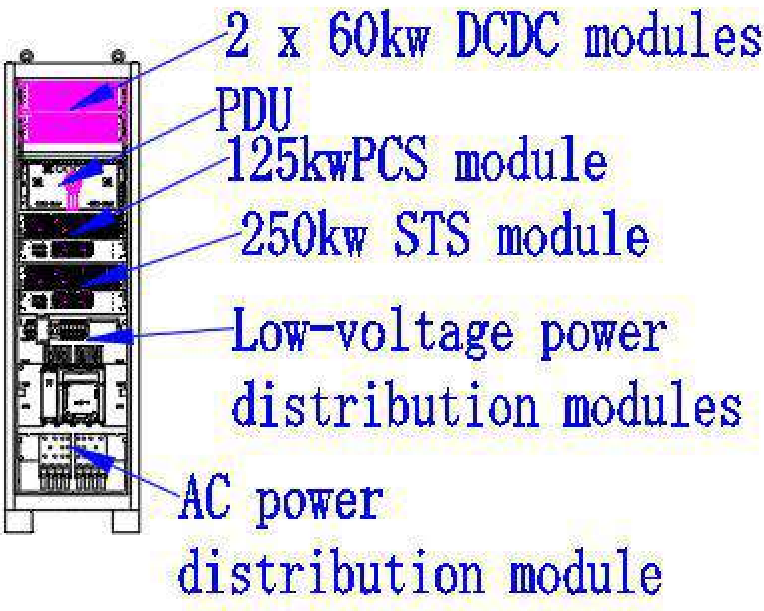
8.2 Parameters of Energy Storage Converter Cabinet

	Project	**Parameter**	**Remarks**
Photovoltaic input parameters	Maximum input voltage	1000V	
	MPPT voltage range	150V~1000V	
	Maximum input current per MPPT	45A	
	Number of MPPT	4	
	Number of input strings per MPPT	1	
	Total photovoltaic	120kw	

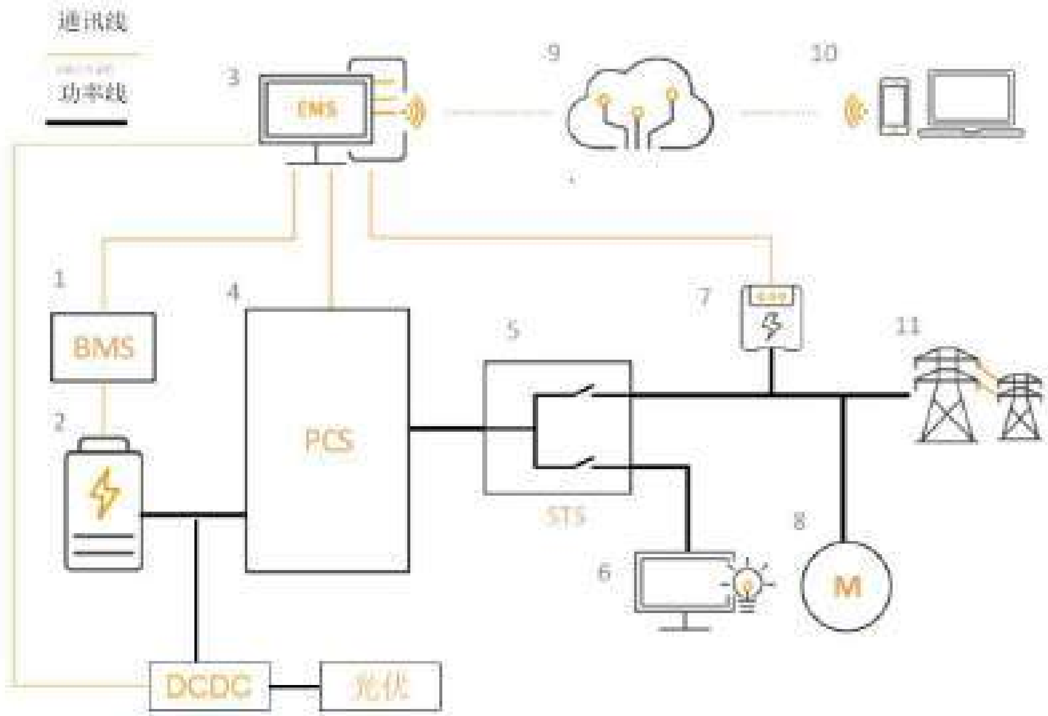
	capacity		
Battery input parameters	Battery type	Lithium-ion	
	Battery voltage range	580V~1000V	Off-grid: 680V~ 1000V
	Maximum charge and discharge current of battery	216A	
Grid-connected output parameter	Rated grid-connected output apparent power	125kVA	
	Rated grid voltage	400V	
	Grid voltage range	300V~440V	
	Rated grid frequency	50Hz/60Hz	
	Output rated current	182A	
	Power factor	> 0.99 (-0.8~ 0.8 adjustable)	
	Total current harmonic THD	< 3% @rated power	
Off-grid output parameter	Rated apparent power	125kVA	
	Rated output voltage	400V	
	Rated output frequency	50Hz/60Hz	
	Output rated current	182A	

	Total current harmonic THD	< 2% @rated power	
	And off-grid switching time	≤10ms	
Basic parameters	Operating temperature range	-25℃~60℃	45 ℃~ 60 ℃ reduction, reduction coefficient 5%/℃
	Storage temperature range	-25%~70%	No condensation
	Relative humidity	0~ 100%	No condensation
	Maximum working altitude	4000m	Over 3000m reduction, reduction factor 1%/100m
	Cooling mode	Intelligent air cooling	
	Display	LED+APP+LCD	
	Communication method	RS485/CAN/Ethernet	
	Topological structure	Isolation transformer	
	Protection level	IP54	
	Weight	300kg	
	Size (W * D * H)	600*600*2200mm	

Appearance diagram



Internal layout diagram



Wiring diagram

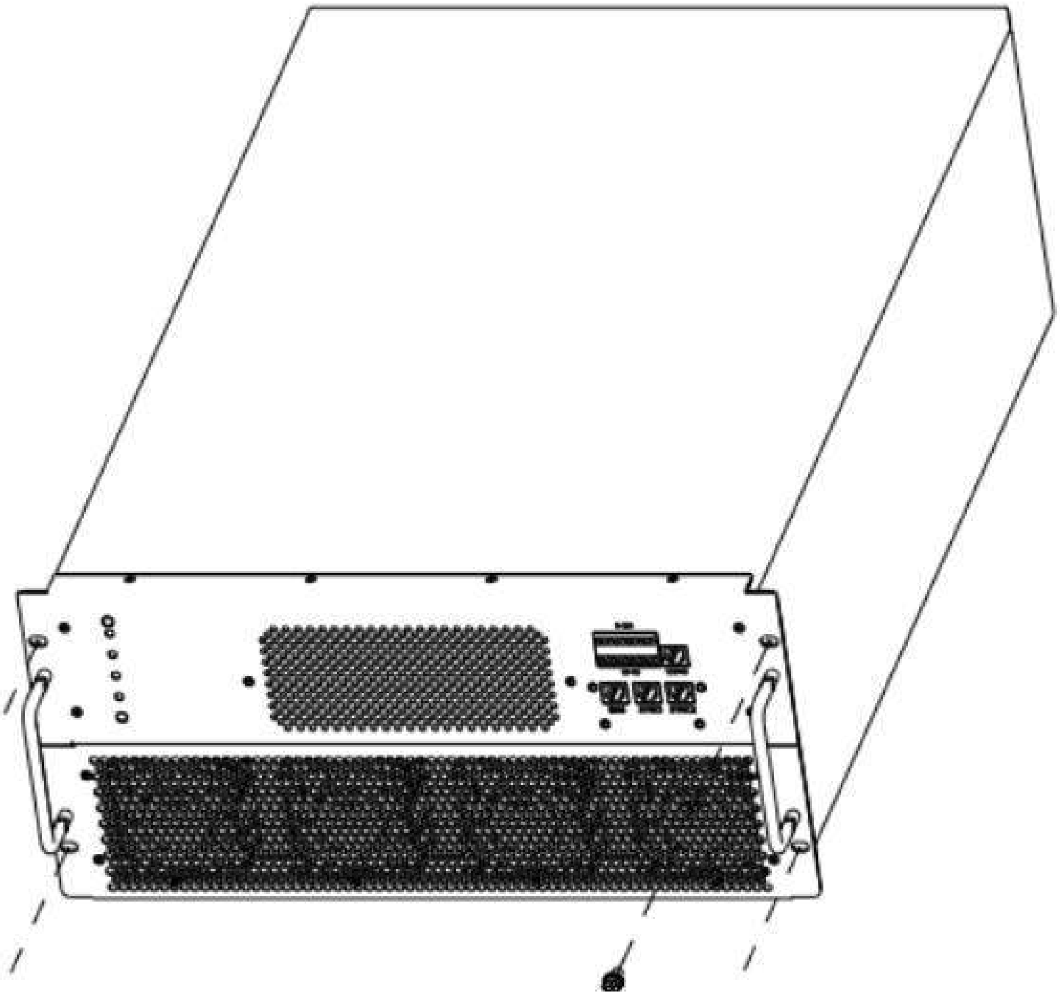
8.3 PCS technical parameters

	Project	Specification parameters	Remarks
DC side	Scope of DC Voltage Work	580~1000V	Off-grid minimum access 680V
	Maximum current on DC side	216A	
AC side grid connection	Rated charge and discharge power	125kw	
	Maximum charge and discharge power	150kw	Lasts for 1 minute
	Rated charge and discharge current	182A	
	Allowable grid voltage range	300~440V	

	Rated grid frequency	50Hz/60Hz	
	Current total harmonic distortion rate	< 3% (at rated power)	
	Power factor	>0.99	
	Power factor range	-1~1	
AC off-measurement network	Rated output voltage	400V	
	Voltage deviation	±2%	
	Voltage total harmonic distortion	< 3% (linear load)	
	On-load power	40%	Resistive load with load 100%
Efficiency	Maximum efficiency	98.9%	
Protection	DC reverse protection	Possess	
	AC short circuit protection	Possess	
	AC output overcurrent protection	Possess	
	Surge protection	Secondary	
	Insulation resistance monitoring	Possess	

	Temperature protection	Possess	
	Direct current switch	Possess	
Basic parameters	Size (W * D * H)	444*720*220mm	
	Weight	＜58kg	
	Topology	External isolation transformer	
	Working environment temperature	-40~+60℃	
	Protection level	IP20	
	Working environment Mechanical condition	Sinusoidal steady-state vibration: 2Hz ≤ f < 9Hz, displacement 1.5mm. 9Hz ≤ f < 200Hz, acceleration 5m/s2. GB/T 4798.3-2007 3M2	
	Cooling mode	Intelligent air cooling	
	Maximum working altitude	4000m	Over 3000m, derated operation
	Standby power consumption	＜12W	
Human-machine interaction	Display	LED	
	Communication	Ethernet、	

	method	RS485、CAN	

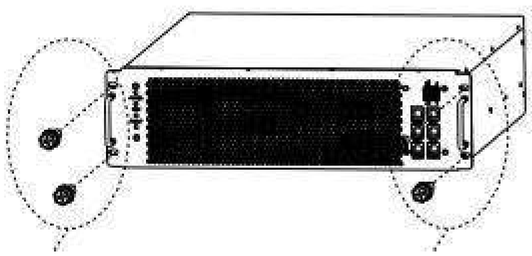


8.4 Photovoltaic DCDC Technical Parameters

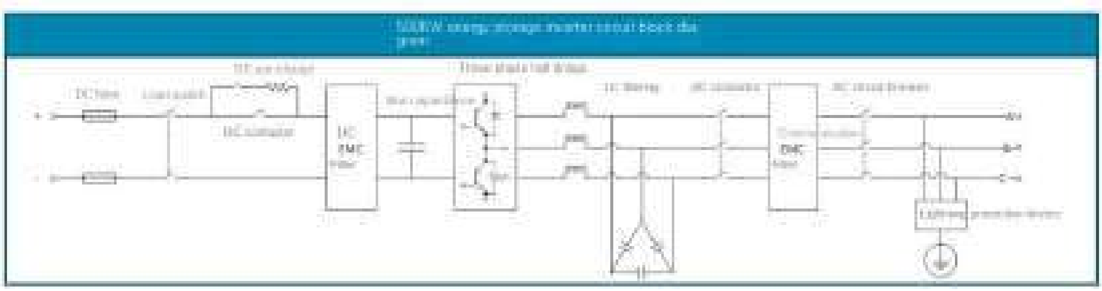
	Project	Specification parameters
PV side	Rated power	60kW (PV input 4 * 15kW)
	Rated current	180A (PV input 4 * 45A)
	Rated voltage	350V
	Maximum voltage	1000V
	Voltage range	150~1000V

	Full power voltage range	340~1000V
	Low side voltage requirements in buck mode	150V ≤ low voltage terminal voltage ≤ high voltage terminal voltage, maximum 1000V
	Low side starting voltage	150V
	Voltage stability	1%
	Current stability	1%
DC high voltage side	Rated power	60kw
	Rated current	90A
	Rated voltage	700V
	Maximum voltage	1000V
	Voltage range	350~1000V
	Full power voltage range	680~850V
	Low voltage side voltage requirement for buck mode 1000V ≥ high voltage terminal voltage * 0.95 > low voltage terminal voltage, minimum 350V	
	High voltage side starting voltage: 350V	
	Voltage stability: 1%	
	Current stability: 1%	
Basic parameters	Size (W * D * H)	444*550*130mm
	Weight	＜25kg
	Topology	Non-isolated
	Working environment	-30~ + 60 ℃ (> 45 ℃

	temperature	derated operation)
	Protection level	IP20
	Relative humidity	< 95% No Gel
	Cooling mode	Intelligent air cooling
	Maximum working altitude	4000m
	Maximum efficiency	99%
Human-machine interaction	Display	LED
	Communication method	Ethernet、RS485、CAN
Meet the standards	Safety regulations	IEC62477-1，IEC62109-1
	EMC	IEC 61000-6-2，IEC 61000-6-3



8.5 Electrical principle block diagram



9. EMS energy management

This project is a 500kw/917kWh energy storage system. The energy storage energy management system can accept power grid dispatch instructions or control instructions from the AGC/AVC system of the power plant. It supports various modes such as local peak-valley mode, power rationing mode, and debugging mode.

Application scenarios support:

- Industrial park pure energy storage system (mainly peak-valley mode, power rationing mode)
- Industrial park energy storage demand-side response (mainly peak-valley mode, AGC scheduling, demand-side response)
- Solar power station supporting energy storage system (main mode is AGC dispatch, system peak shaving, joint operation)

9.1 Design principles

Energy storage stations are designed in a "unmanned, manned" mode.

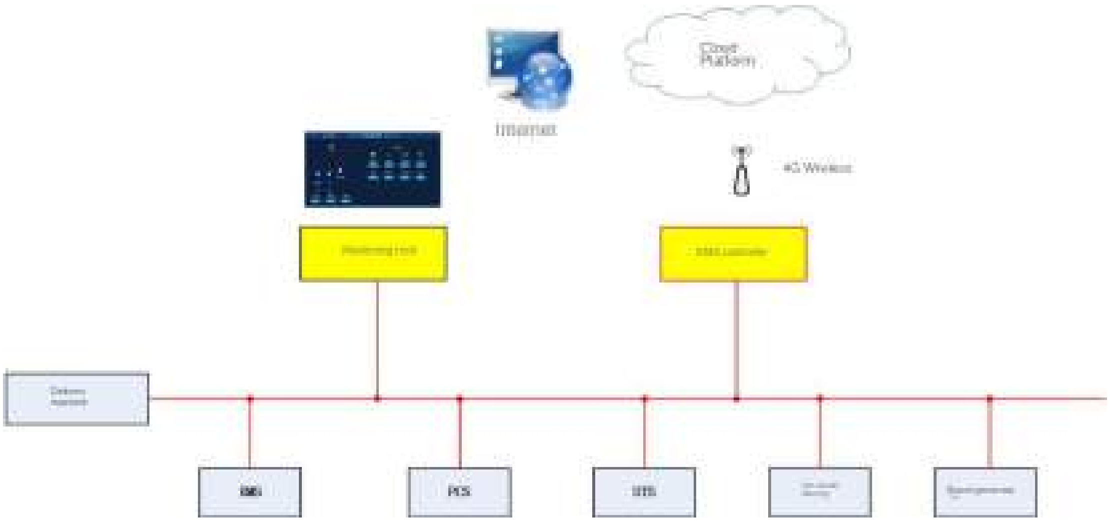
The secondary control of the energy storage station adopts a computer monitoring system.

The comprehensive automation system adopts an open hierarchical distribution system structure.

The computer monitoring system must meet the requirements of the Chinese national standard "Criteria for the Classification of Computer Information System Security Levels", the "Regulations on the Security Protection of Secondary Power Systems" and the "Notice on Printing and Distributing the" Overall Plan for the Security Protection of Secondary Power Systems "issued by the Electricity Regulatory Commission. The information security protection level of the power plant shall be determined in accordance with the" Guiding Opinions on Printing and Distributing the Classification of Information System Level Protection in the Power Industry "issued by the State Electricity Regulatory Commission.

10. System introduction

10.1 System Architecture



Communication topology diagram of the system

The EMS monitoring system adopts a single network configuration. The EMS controller communicates with the PCS, BMS, STS, and dynamic system of the energy storage unit, and transmits data to the Cloud Computing Platform via wireless network for unified data monitoring.

10.2 EMS device monitoring module function

3.1 Data Acquisition:

1) According to the BMS information of the connected manufacturer, the total voltage, current, average temperature, SOC, SOH, charging and discharging current and power limit, single cell voltage, single cell temperature, fault and alarm information, historical charging and discharging amount, historical charging and discharging energy, capacity, rechargeable amount, dischargeable amount, charging and discharging times and other commonly used information of each group of batteries in the battery management system are collected and displayed.

Based on the PCS information of the connected manufacturer, collect relevant parameters of PCS, including voltage/current/power on the DC side, commonly used information such as three-phase active power, reactive power, three-phase voltage, three-phase current, power factor, frequency, operating status, alarm and fault information, as well as daily input power, daily output power, cumulative input power, cumulative output power, etc.

3) According to the STS information of the connected manufacturer, collect the relevant parameters of STS, including switching status, operating parameters (voltage, current, power, etc.).

Collect smart meters, air conditioning systems, and fire protection systems for statistics and display.

3.2 Data Storage:

Cloud Computing Platform has the ability to store collected data in a hierarchical manner, with important information stored in seconds and overall information stored in minutes. Cloud Computing Platform stores data, and both parties communicate and negotiate the resources and fees occupied by Cloud as a Service.

3.3 Alarm display function:

Collect alarm information from the entire system and display it. When the analog quantity collected by the system exceeds the limit or the digital quantity changes, notify the operator of the situation.

3.4 Energy Management:

The EMS system allocates energy in the microgrid according to the optimal principle and coordinates the power flow between various power generation units in the microgrid. The following functions are mainly implemented in this system.

1. Based on the principle of economic dispatch, control the power of the energy storage system, combine time-of-use electricity prices to reduce peak and valley energy storage, and formulate demand management and dispatch strategies to ensure the optimal economy of the system.

2. Spontaneously use it to avoid the situation of energy storage discharge being sent back to the power grid.

3.5 Peak shaving and valley filling mode

1. System start-up logic

The user operates EMS and selects to enter the peak shaving and valley filling mode. At this time, the EMS output signal controls the ATS switch of the test cabinet to switch to the power grid side. EMS feeds back the touchpoint signal through the ATS switch, determines that the system has entered the peak shaving and valley filling mode, and displays the status.

During peak shaving and valley filling mode, the system discharges or charges at a constant power according to the time period set by EMS.

2. Functional requirements

EMS can set charging period, charging power, discharge period, and discharge power.

The system operates at a constant power according to the set discharge period and discharge power.

EMS outputs passive dry contact signals, controls the ATS switch of the test cabinet, and the status feedback signal of the ATS switch is passive dry contact.

10.3 Control strategy

(1) System protection

Set up hysteresis charge and discharge protection to prevent battery overcharging and overdischarging. Respond to the SOC setting requirements of the battery to ensure the accuracy and reliability of battery information.

(2) Peak shaving and valley filling

Charge during the valley period, discharge during the peak period. Determine whether it is "off-grid mode" or "grid-connected mode" by testing the switch status of the incoming cabinet. Peak shaving and valley filling can only be used in "grid-connected mode".

(3) Temperature control

Based on the ambient temperature of the battery container and the temperature uploaded by the cell temperature sensor, automatic control of the ambient temperature and cell temperature inside the container is achieved.

10.4 Cloud Computing Platform Functions

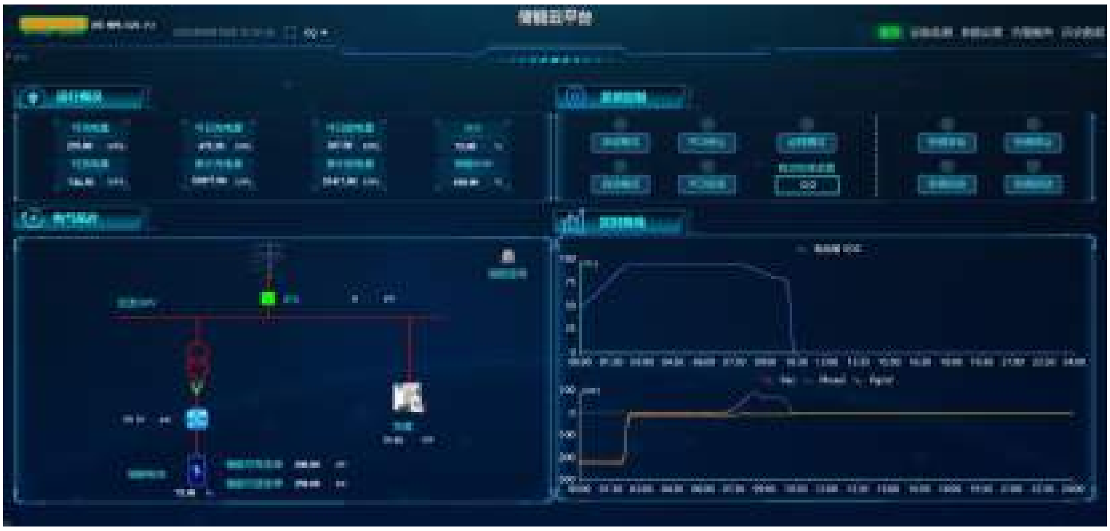
The communication controller realizes the collection of data from equipment such as PCS, BMS, STS, and air conditioning, and uploads it to the cloud via 4G wireless, which can realize cloud storage and remote monitoring of energy storage systems.

The functional interface of Cloud Computing Platform mainly includes: operation monitoring, device monitoring, alarm service, historical data, user management, etc.

(1) Operation monitoring

The operation monitoring page is mainly divided into several modules: project operation status, real-time project operation control, electrical topology, and real-time project operation curve.

Overall operation status realizes the statistical analysis of the total operation data of the project, including the daily charging and discharging amount, cumulative charging and discharging amount, daily charging and discharging number, cumulative charging and discharging number, daily income, cumulative income, etc.



Schematic diagram of operation monitoring page

(2) Equipment monitoring

The equipment monitoring page can perform real-time online monitoring of the operating parameters of energy storage system equipment such as transformers, PCS, STS, etc.

Device Monitoring Page Schematic

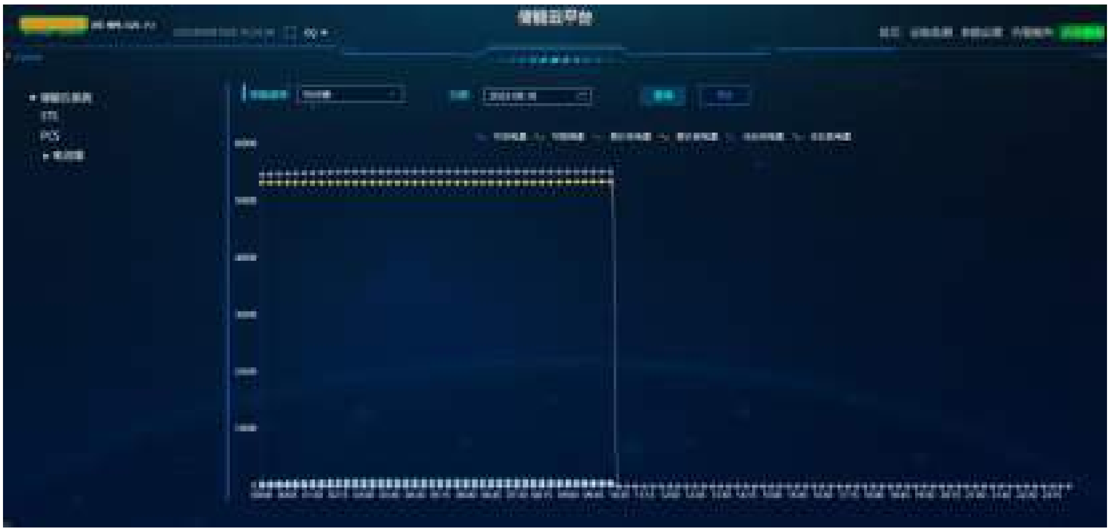
(3) Alarm service

The alarm service page can provide real-time alarms and classification statistics for equipment devices.

Alarm service page diagram

(4) Historical data

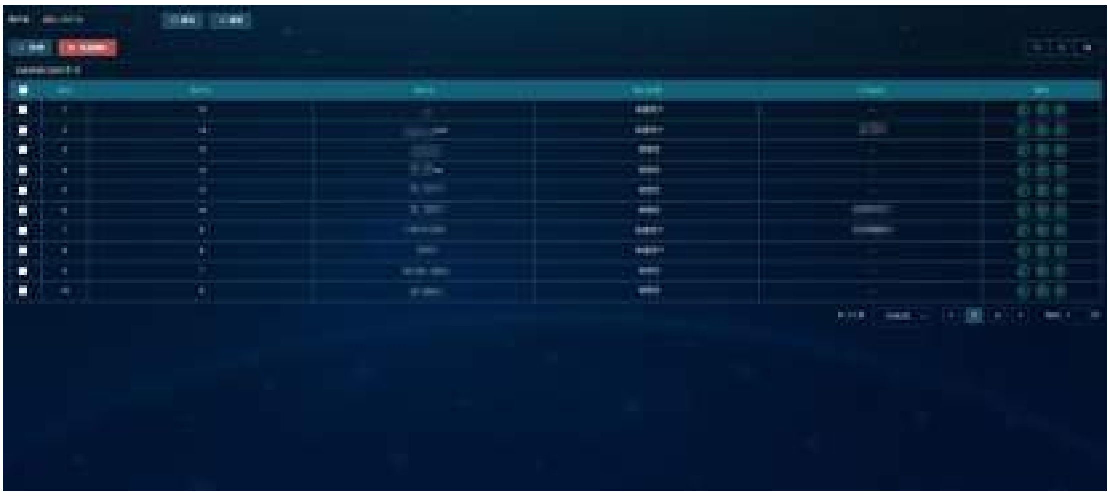
Historical data can be queried and exported for key data such as PCS, battery stack, and battery cluster. Important data is saved for one year, while other data is saved for six months.



Schematic diagram of historical data page

(5) User management

The user management module can realize the management of users and the allocation of user permissions.



User management page diagram