



Battery Energy Storage System Solution

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1 Company profile

Headquarters & R&D Center
(Nanjing, 58,000m²)



IEDs Factory
(Nanjing, 220,000m²)



HVDC & FACTS & Converter
Factory
(Changzhou, 270,000m²)



Intelligent Mechanical Technology
Industrial Park
(Changzhou, 50,000m²)



NR Electric (NR), as a power stability expert, is dedicated to provide smart, reliable and environmental friendly solutions for power generations, power grid and industries. The products and solutions covers protection, automation & control, HVDC & FACTS, renewable & microgrid and engineering consulting & services.

Relying on the know-how capability of power system protection & control technology, NR is one of the foremost companies in the renewable energy industry with the complete product line, the advanced technology and the high market share. NR develops and manufactures key electrical equipment for battery energy storage, such as power conversion system, battery module, battery management systems, energy management systems, and energy storage protection & control devices. NR also has the ability for energy storage system integration. In addition, NR has strong professional system analysis as well as engineering design capabilities. Based on the diversified application needs of energy storage, NR can provide global users with first-class energy storage solutions.

NR always adheres to quality first policy. Quality control runs through every step from R&D and design to product manufacturing. Strict testing systems and testing methods ensure that the entire production process is under good quality control. NR's products have always been known in the industry for their low repair rate. NR has passed ISO9001 quality management system, ISO14001 environmental management system, ISO45001 occupational health and safety management system, ISO20000 information technology service management system, ISO27001 information security management system and ANSI ESD S20.20 and IEC61340 anti-static management system certification. NR's energy storage product series have passed certification of internationally renowned institutions such as UL, TUV and CE. NR's R&D process management has reached the international advanced level, and it has passed the CMMI Level 5 formal assessment.



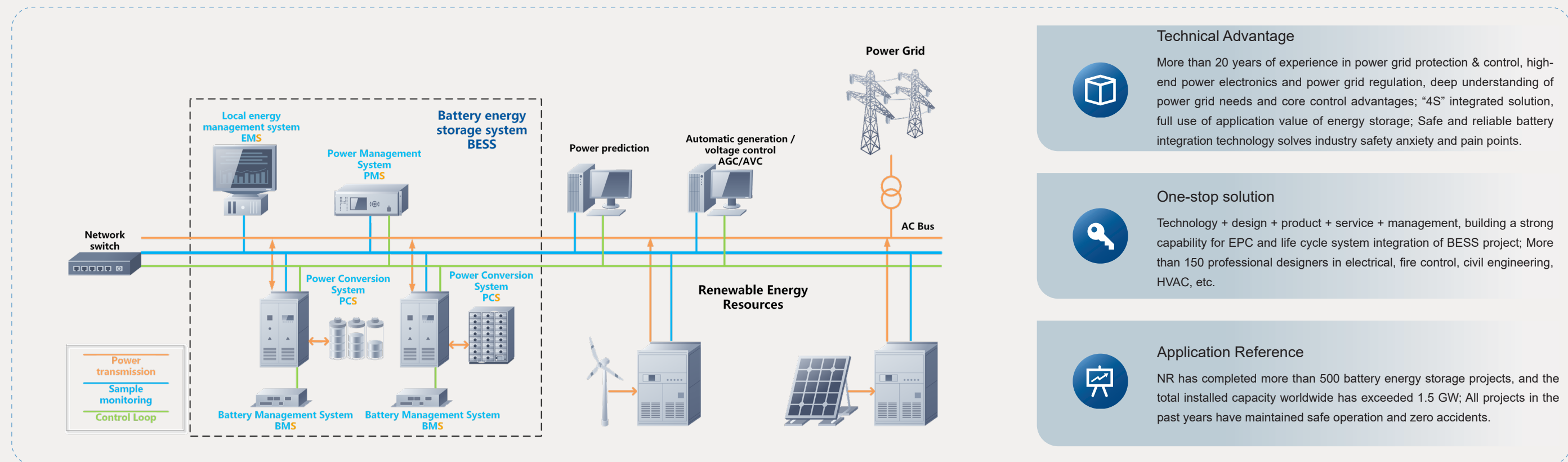
2 Battery Energy Storage System

Battery energy storage system (BESS) is an important part and key supporting technology for building an advance power system. Through power electronics technology, the direct current (D.C) of the battery is converted into alternating current (A.C) and connected to the grid. Through fast and flexible power control, active or controlled participation in grid scheduling and control can realize the mutual flow of energy among the source, grid, load and storage, supporting the safe, stable and economical operation of the power system and improving the renewable energy integration capacity of the power grid.

Relying on the accumulation of power system protection & control and power electronic technology for many years, NR is one of the leading enterprises in the renewable energy industry, with the complete product line, the advanced technology and the high market share. The company has R&D, manufacturing and system integration capabilities of key electrical equipment for energy storage systems such as energy storage converter (PCS-Power Conversion System), battery energy management system (BMS-Battery Management System), energy management system (EMS-Energy Management System), energy storage coordination control device (PMS-Power Management System), energy storage protection & control devices and lithium batteries. Among them, Power Conversion System (PCS)

realizes the bidirectional flow of energy in the battery and the power grid, BMS realizes the effective management and control of the battery, EMS monitors the entire energy storage system, and cooperates with other auxiliary protection devices to realize the steady-state control function to ensure the safe and reliable operation of the system. PMS realizes the dynamic control function and according to different application scenarios, performing corresponding control strategies to reasonably control the coordinated operation of multiple PCSs.

NR also has strong and professional power system analysis capabilities. In order to achieve the goal of "Carbon neutralization", in the face of increasingly diverse energy storage application needs, the company can provide global users with first-class energy storage solutions, to help build a new power system with large-scale renewable energy integration capabilities. The energy storage products provided by NR can be integrated with various types of batteries (lithium battery, sodium sulfur, vanadium flow, lead carbon, etc.). NR has comprehensive field experiences of BESS application for renewable energy integration, large BESS power station, distributed energy storage, thermal power plant frequency regulation, urban flexible distribution network, emergency power supply, micro-grid and other scenarios.



Technical Advantage

More than 20 years of experience in power grid protection & control, high-end power electronics and power grid regulation, deep understanding of power grid needs and core control advantages; "4S" integrated solution, full use of application value of energy storage; Safe and reliable battery integration technology solves industry safety anxiety and pain points.

One-stop solution

Technology + design + product + service + management, building a strong capability for EPC and life cycle system integration of BESS project; More than 150 professional designers in electrical, fire control, civil engineering, HVAC, etc.

Application Reference

NR has completed more than 500 battery energy storage projects, and the total installed capacity worldwide has exceeded 1.5 GW; All projects in the past years have maintained safe operation and zero accidents.

3 Key technology of battery energy storage system (BESS)

Under the background of "Carbon neutralization" and "building an advance power system with renewable energy as the major source", renewable energy will become the main power source, and traditional fossil energy such as coal power will be relegated to auxiliary power sources. The operating characteristics of the power grid will undergo profound changes and stable operation of power system faces new challenges. As an important supporting technology for building an advance power system, energy storage has ushered in a major development opportunity, and can play an important role in the security and stability of the power grid on a short time scale and the balance of power and electricity on a long time scale.



With the gradual improvement of the energy storage mechanism, the energy storage power station can participate in the auxiliary services of the power system as a market entity, and BESS has gradually become a standard need in the development of renewable energy power generation.

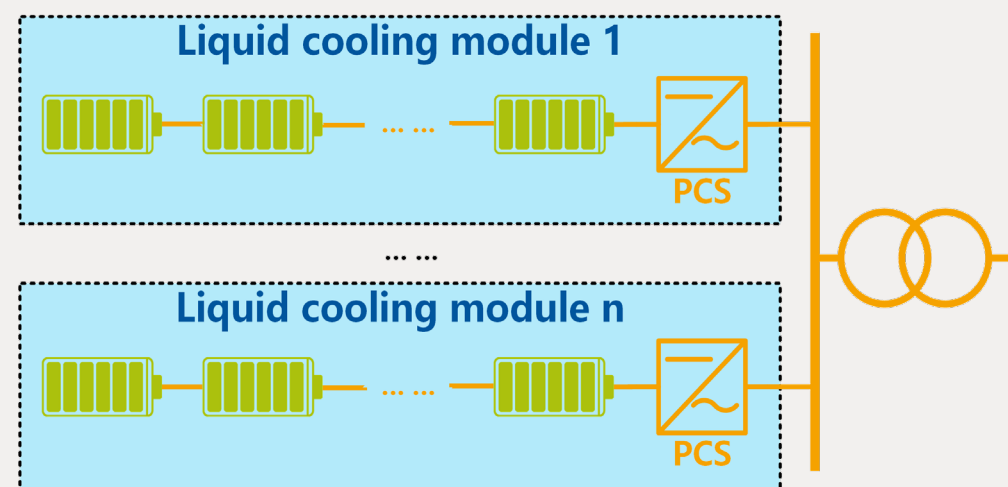
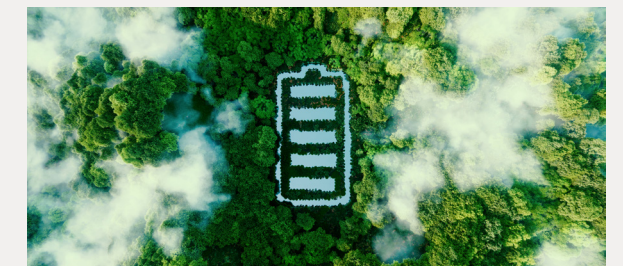
The energy storage industry still faces many challenges, chief among them are security concerns. In recent years, fire and explosion accidents have occurred many times in the application of energy storage projects in China and abroad, and safety issues have become one of the bottlenecks faced by the energy storage industry. Battery aging, capacity mismatch, unreasonable design and unprofessional integration are the main causes of security incidents.

The on-site installation, commissioning, operation and maintenance of energy storage power stations are complicated, requiring professional inspection and maintenance, and the pressure on operating costs has become increasingly prominent.

In addition, the control of the energy storage system mostly adopts the grid-following control method, which injects constant power into the grid. The output power depends on the instructions issued by the upper-level control system. There is no inertia and the active support

for frequency regulation and voltage regulation is insufficient. It is difficult to meet the stability requirements of the new power system under the condition of high proportion of renewable energy in the future.

NR energy storage system solves the problem faced by energy storage development. With the advantages of high safety, low cost and strong grid support through liquid cooling modular design, high integration level and grid-forming control technology. NR BESS helps the establishment and optimization of advance power systems, promote the realization of the "Carbon neutrality" goal.



Liquid cooling modular design

- Isolation between clusters

The battery clusters are isolated from each other through the PCS, and are not physically in the same enclosed space. There is no chain reaction of faults in the cluster, and problems such as thermal runaway and electrical fire are effectively isolated, and the system security is essentially improved.

- Single cluster control

No inter-cluster circulation, avoid the accelerated aging of cells caused by circulation, and greatly improve system reliability.

- Distributed arrangement

The separation of batteries and high-voltage boxes eliminates the risk of arcing of switching devices.

- Integrated design

The battery and PCS are integrated into one cabinet, which greatly reduces the DC cable and avoids the risk of short circuit between positive and negative electrodes.

- Liquid cooling technology

The liquid cooling medium is isolated from the environment, without external environment interference, and the system protection level is high.

Balanced heat dissipation, the cells are in the longevity temperature range to avoid inconsistent aging, and the temperature difference between the cells is $<3^{\circ}\text{C}@0.5\text{C}$.

- AC side parallel

The AC side of PCS is connected to the low-voltage power grid in parallel to avoid direct parallel connection of battery clusters, and to limit short-circuit current of the battery below 13kA to ensure reliable fault clearing.

- Cluster management and control

After a single cluster is outage for maintenance or exited after a failure, other clusters keep running normally, and system availability is effectively improved.

- The overall charging and discharging efficiency of the system is increased by about 3.5%

-Single DC/AC conversion, no DC/DC design, conversion efficiency increased by 3%.

-PCS and batteries are liquid-cooled for efficient heat dissipation. Compared with conventional air conditioning, the heat dissipation efficiency is increased by 12%.

-Using 1500kV PCS ANPC three-level topology, the efficiency is improved by 0.2%.

Integrated technology

- **The integrated design of battery, PCS and liquid cooling equipment**

Greatly improves power and energy density, reduces layout space, and reduces installation and commission costs.

- **On-site installation**

Pre-installation of highly integrated batteries, light weight and small volume per cabinet, no need for large cranes, more convenient installation.

- **On-site commissioning**

The integrated debugging is completed in the factory, reducing the workload of on-site debugging and lowering the overall cost of commissioning.

- **Capacity expansion**

The size of the single unit is smaller (the combined capacity output is 200kW~several MW), which can realize flexible deployment, smooth capacity expansion, and lower cost of battery replacement.

- **Maintenance**

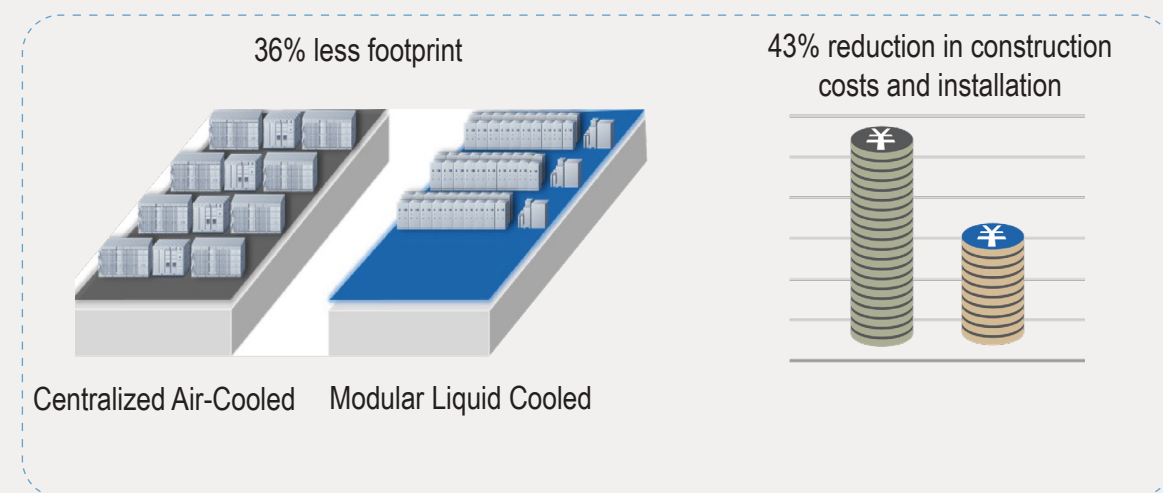
Standardized module design, overall operation and maintenance, reduce security risks.

- **4S integrated solution**

- Full set of energy storage 4S core equipment.
- Dedicated high-speed communication network realizes fast power control of energy storage and fast transient response.
- Support thousands of PCS aggregation and group control/group adjustment.

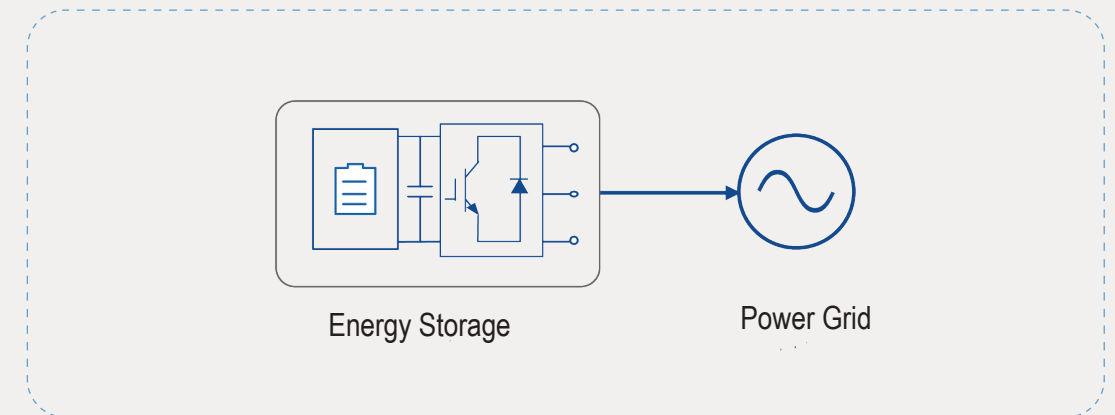
- **Compound control strategy**

- Centralized primary frequency regulation, transient voltage regulation, damping oscillation and other transient control.
- Quickly communicate with the stability control system and participate in the power stability control system.

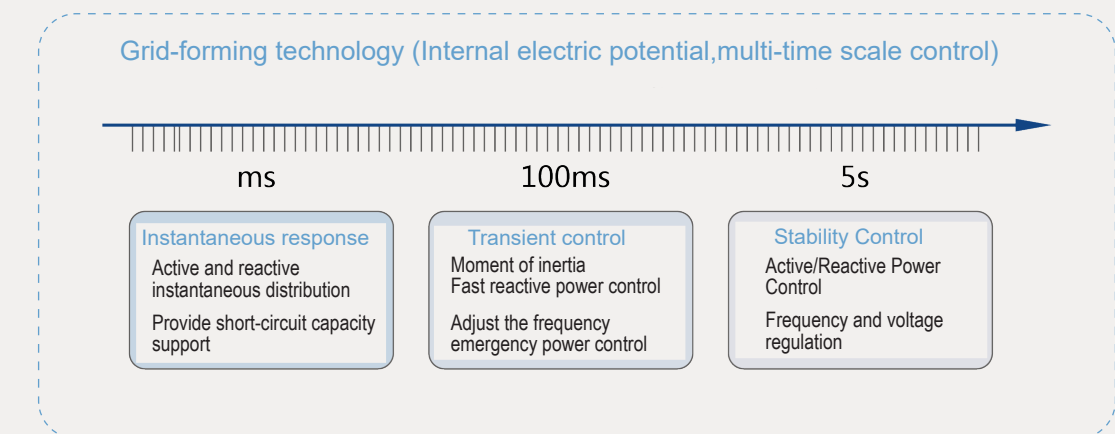


Grid-forming technology

- As a grid-supported power electronic converter, its external characteristics are similar to those of synchronous generation units, and it can provide functions that conventional generators have, such as inertia support, frequency & voltage regulation, and short-circuit capacity increase.













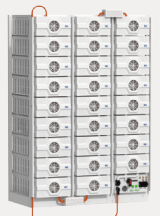








- With full-time scale voltage source characteristics, it can provide fast dynamic reactive power compensation, enhance power grid strength, maximize the application value of energy storage, and broaden user revenue channels.



- With an intelligent high-speed communication architecture, the communication architecture is simple, the data is directly connected and interconnected, the fast communication protocol is supported, and the communication delay is less than 5ms. Multi-dimensional participation in power grid control, able to execute precise or stable control system emergency commands, track planning curves, track wind/solar power prediction curves, smooth power generation fluctuations, participate in peak regulation and frequency regulation, participate in primary frequency regulation of the power grid, and assist thermal power units in black start.

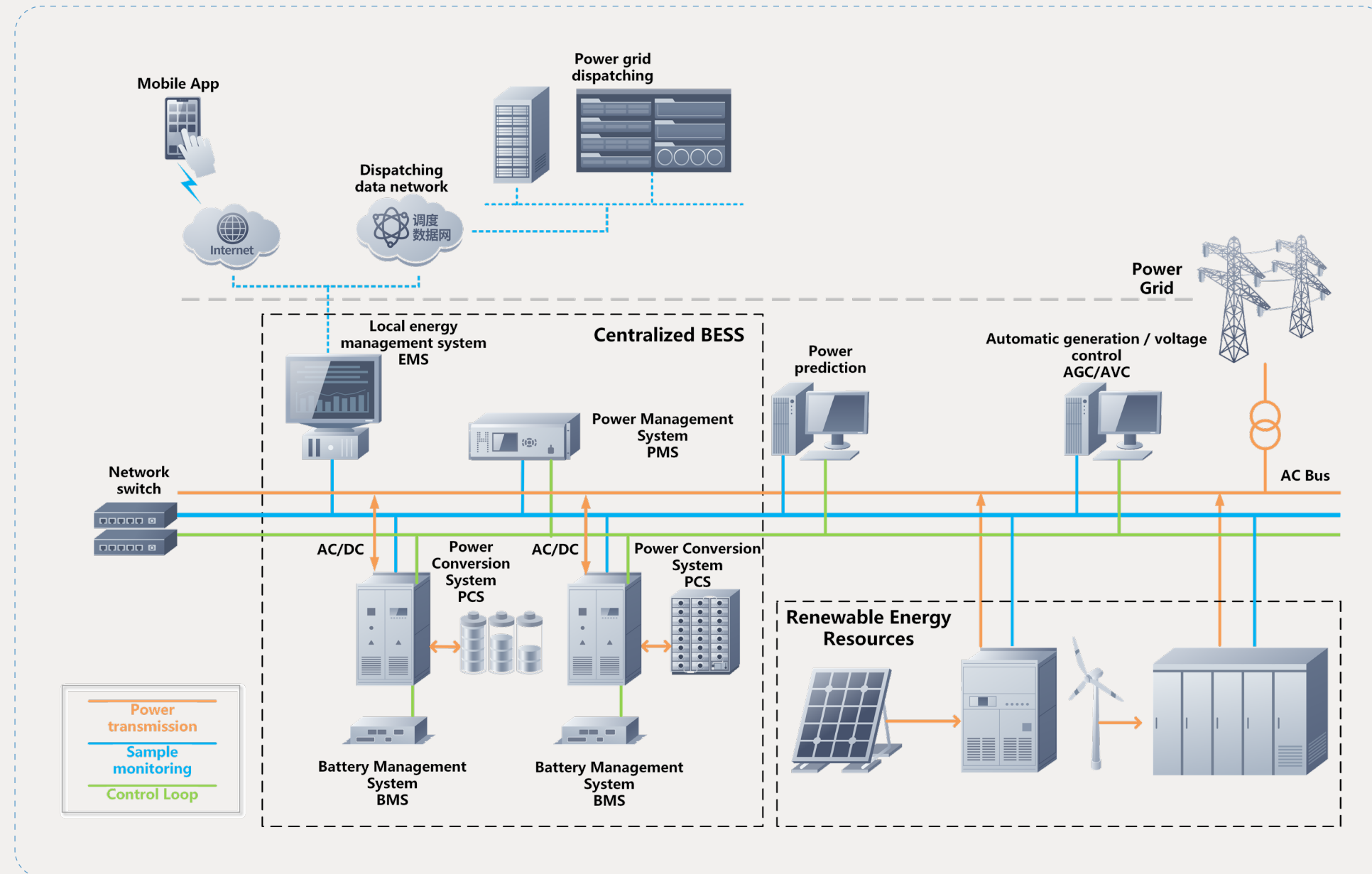
Product list

Note: only typical products are listed

<p>Integration energy storage system</p>	 <p>PCS-8811CB Centralized energy storage system</p>	 <p>PCS-8812PB Liquid cooled energy storage cabinet</p>	 <p>PCS-8813CPB High voltage directly connected energy storage system</p>	 <p>PCS-8813CPB High voltage directly connected energy storage system</p>
<p>Power Conversion System</p>	 <p>PCS-9567TU 1500V series outdoor Power Conversion System</p>	 <p>PCS-9567A Power Conversion System</p>	 <p>PCS-9567AT Power Conversion System (built-in isolation transformer)</p>	 <p>PCS-9567D DC Power Conversion System</p>
<p>Energy storage battery</p>	 <p>NBM-L46.5 Liquid-cooled battery modules</p>	 <p>NBM-F14.3 Air cooled battery module</p>	 <p>NBR-L372 Air cooled cluster</p>	
<p>Battery management system</p>	 <p>PCS-9695A-MD Battery stack management unit</p>	 <p>PCS-9695A-S Battery cluster management unit</p>	 <p>PCS-9695A-UP Battery module management unit</p>	
<p>Energy management system & Power management system</p>	 <p>PCS-9700-ESS Energy management system</p>	 <p>PCS-9567CP Power management system</p>		
<p>Other auxiliary products</p>	 <p>PCS-9567SS Intelligent Static Switch</p>	 <p>PCS-9617MG Microgrid Controller</p>	 <p>PCS-9726L Renewable power integration device</p>	

System Solutions

Centralized energy storage at renewable power plant side



• Application scenarios

- Reduction in wind and solar curtailment, increment in power generation revenue.
- Respond to power dispatch command, participation in power peak regulation and grid frequency regulation.
- Smooth power fluctuation, reduction in grid impact, improvement in power quality for integration of renewable power.

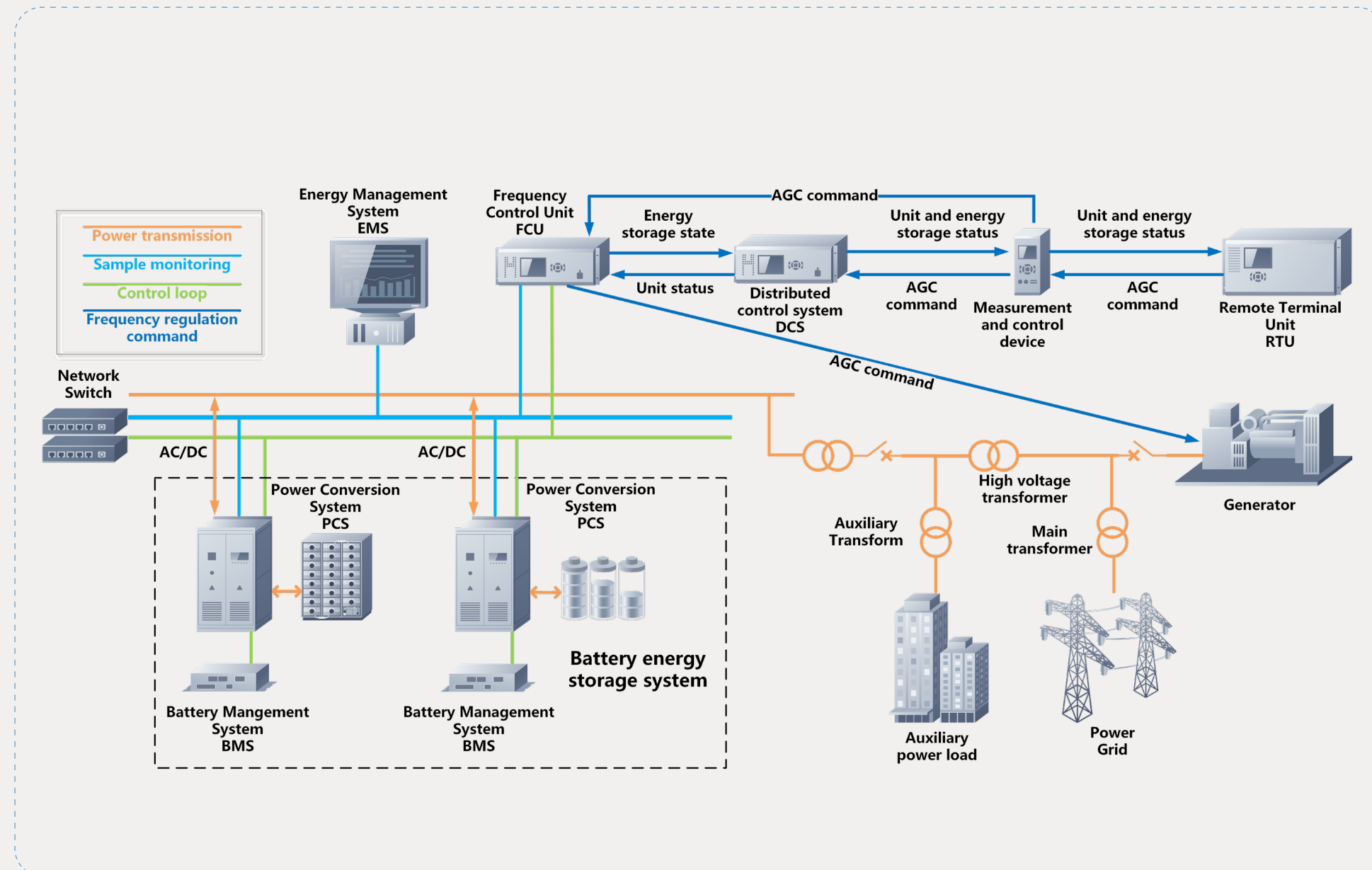


• Scheme features

- Seamless integration of renewable energy and energy storage, in all-in-one operation.
- Operation by accurately tracking of power prediction curve.
- Reactive power compensation and voltage control functions.
- Centralized management, easy installation and maintenance.

System Solutions

Ancillary frequency regulation to thermal power unit at traditional power plant



• Application scenarios

- Participation in power grid frequency regulation along with thermal power units, by solving regulation problems of slow speed, feed-back delay and large error.
- Improvement in the frequency regulation performance of the generation unit and its economic benefits.
- Reduction in generation unit loss, extension in service life, and enhancement in operation safety.

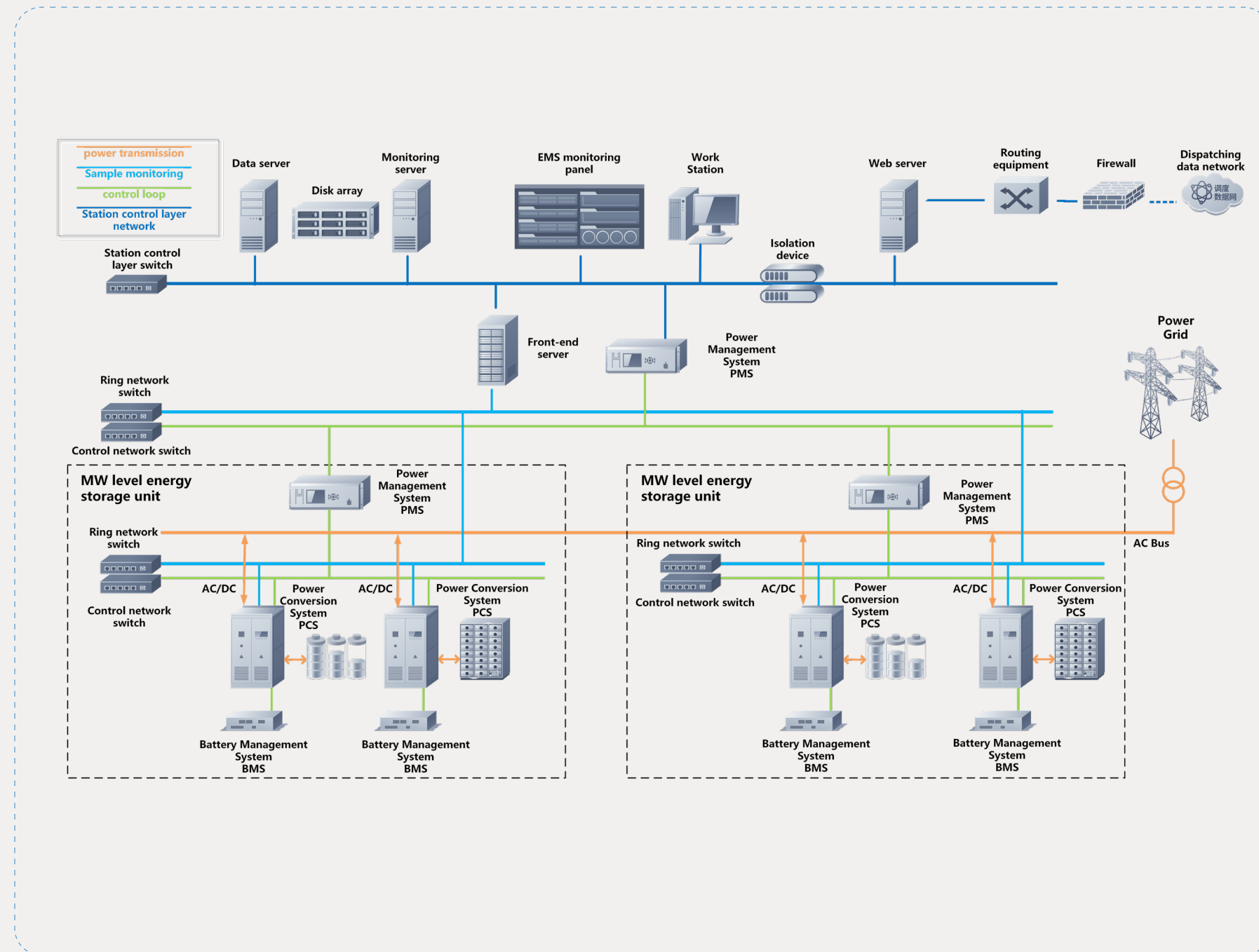


• Scheme features

- Fast response to frequency regulation order.
- Battery life optimization, SOC online equalization, frequency regulation performance analysis and optimization, etc.
- Black start and factory emergency power function.
- Support of various types of signal interfaces, and supports of fast communication such as optical fiber GOOSE network (communication delay is less than 1ms, and the conversion time from issuing commands to PCS completing full power charge/discharge is less than 30ms).

System Solutions

large-scale energy storage power station at utility grid connection



● Application scenarios

- Power peak regulation, frequency regulation, voltage regulation, black start, damping oscillation, etc.

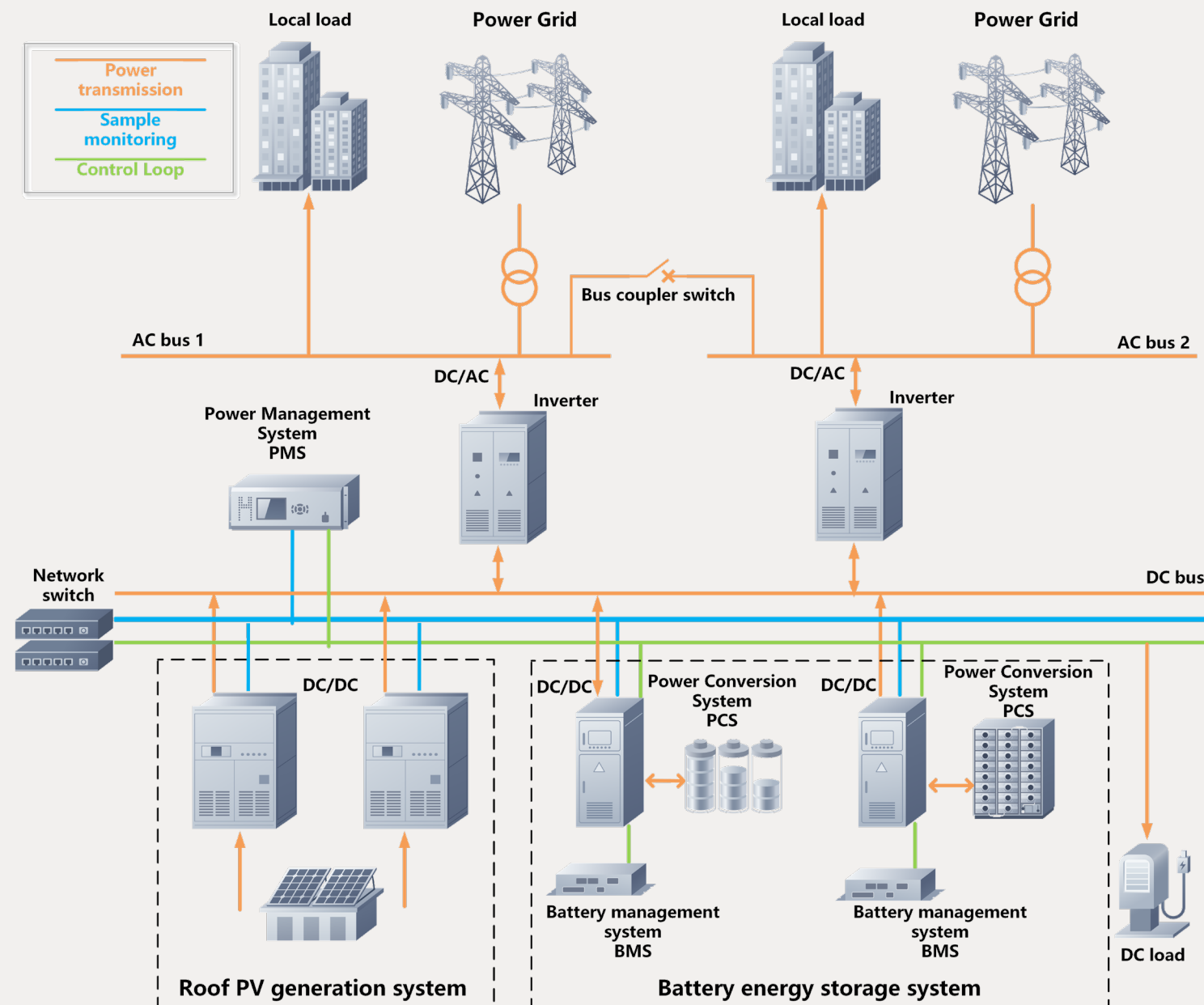


● Scheme features

- Reliably realization of the group control and group regulation of multi-converters in large-capacity energy storage power stations by separately networking of the monitoring network and the coordination control network.
- Coordinated control capability of thousands of converters, by the coordination control system with a hierarchical control structure, high-speed optical fiber communication, and millisecond-level communication delay.
- Strong overload capacity, with network control mode, providing moment of inertia, short-circuit capacity and voltage support.
- Station control layer network supporting the IEC 61850 protocol, realizing the digitization and intelligence of the energy storage power station.
- Energy management system EMS integrating electrical monitoring, energy management, auxiliary monitoring and other functions.

System Solutions

Urban flexible distribution network at Distribution network side



Application scenarios

- Intelligent urban distribution network.
- Solution to uneven power flow of distribution network lines and realizing power mutual assistance.
- Alleviation of the low-load or no-load low-efficiency operation of the main transformer of the distribution network.
- Solution to distribution transformer overload caused by short-term high-power impact loads such as charging piles.

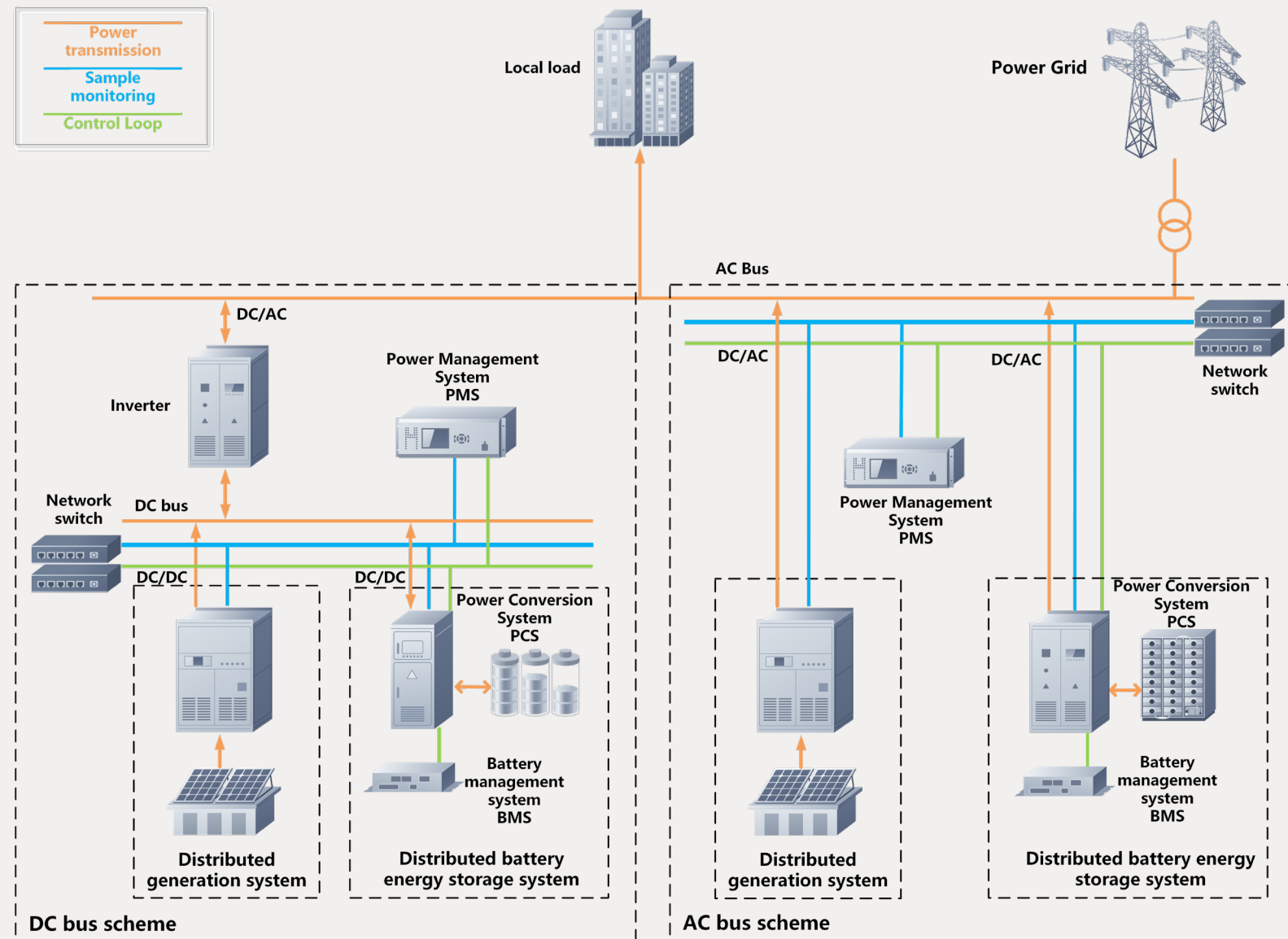


Scheme features

- Power supply support between the busbars, and power allocation in a unified manner to solve the problem of short-term overload.
- Coordination of the energy storage system to participate in emergency power support under fault and overload conditions to increase power supply capacity.
- Common DC bus upon solar panel and storage panel, convenient for the access of DC loads such as charging piles.
- Improving the reliability of distribution network and achieve no power outage.
- DC interconnection between communities to reduce the construction cost of 10kV dual power supply.

System Solutions

Distribution energy storage at distribution network side



Application scenarios

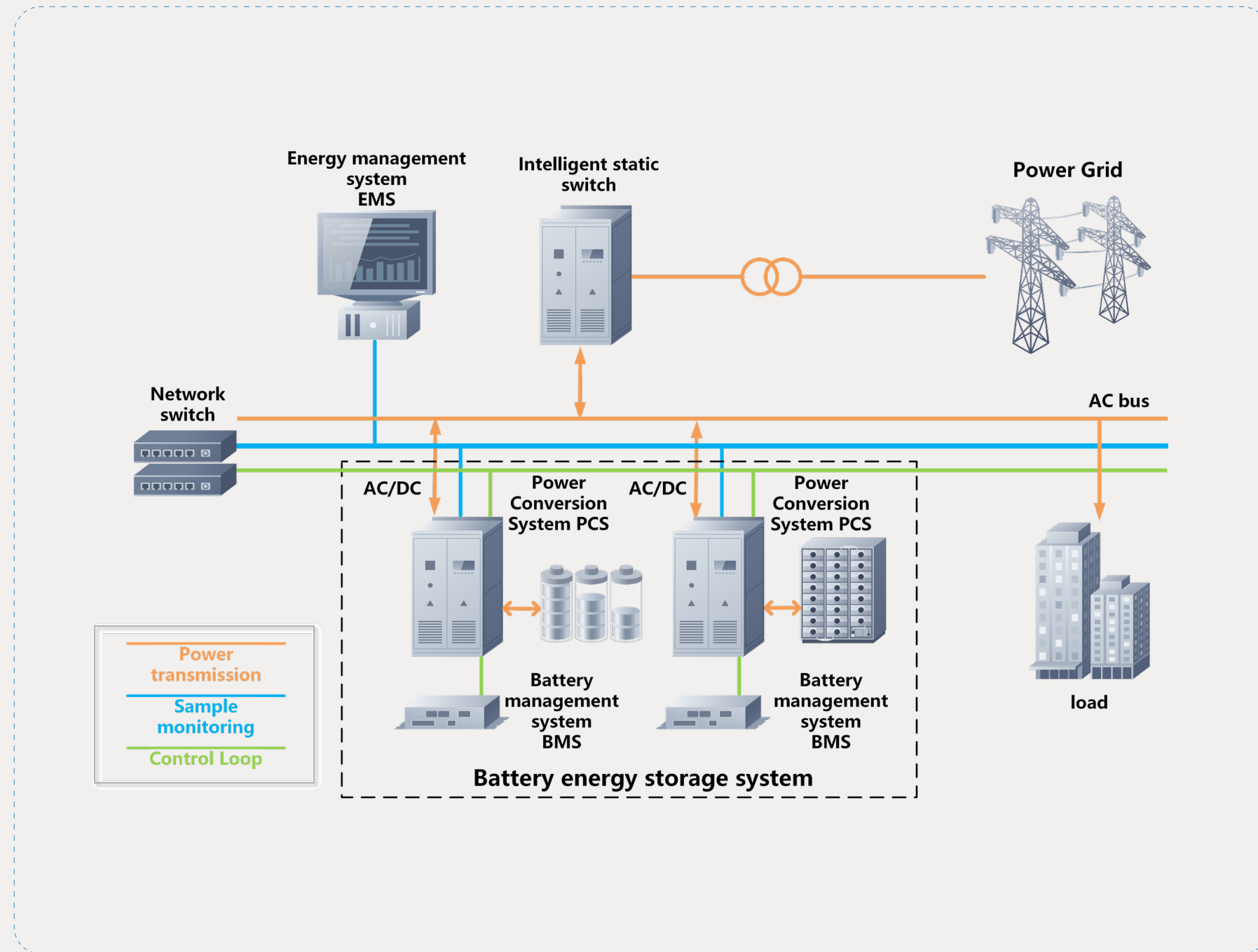
- Power self-generation and self-consumption, and surplus power sales.
- Peak-valley electricity price difference utilization to reduce electricity cost.
- High-capacity peak power demand solution.
- Solution to reduce expansion of power distribution facilities.

Scheme features

- Discharging at the peak and charging at the valley, using the peak-valley electricity price difference to arbitrage.
- Peak shaving and valley filling, peak load smoothing, flexible capacity expansion to reduce power supply requirements for new transformers and other equipment, realizing automated and highly intelligent remote monitoring and reducing operation and maintenance costs.
- DC solution (applicable to occasions with more DC loads).
 - The DC bus being convenient for local access and consumption of photovoltaic, energy storage and DC loads.
 - Reducing power conversion links and power losses, and improving power supply quality.
 - Flexible configuration of energy storage battery within wide battery voltage range.
- AC solution (applicable to occasions without DC load).
 - Simple system structure and control.
 - Energy storage and photovoltaics independently connected to the AC bus.
 - One-level conversion for energy storage and photovoltaic, with high system efficiency.

System Solutions

Emergency power supply at User side



• Application scenarios

- Emergency power supply for important loads to achieve uninterrupted power in the event of external grid failures or planned power outages.

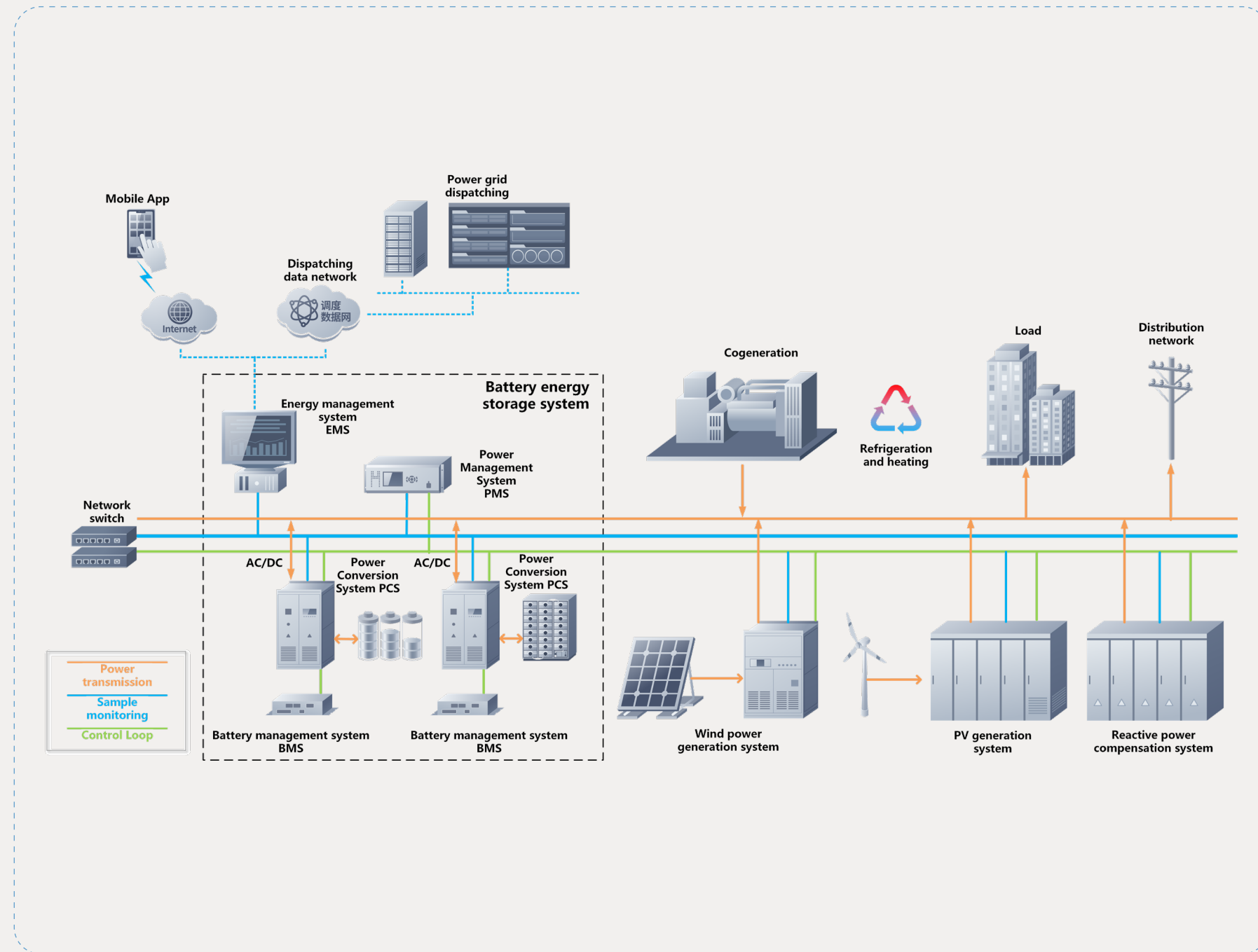


• Scheme features

- Fast breaking characteristics of the thyristor static switch to achieve fast separation from the grid (<10ms).
- Intelligent control system, automatic on/off grid switching, reducing operation and maintenance costs.
- Static switch integrating Micro-grid control function to reduce additional investment.
- Multi-PCS synchronous on/off-grid switching, which is convenient for system expansion and ensures reliable, continuous and flexible power supply.

System Solutions

off-grid power supply at micro-grid side



• Application scenarios

- Multi-energy complementary, spontaneous self-use system in no-power or power-shortfall environment.
- Wind-solar-storage integration in micro-grid.



• Scheme features

- Hierarchical design of the layered distributed protection & control system with advantages of high distributed reliability and centralized easy expansion. Realization of the stable and economical operation of the micro-grid system through the coordination and cooperation of different levels of protection & control.
- Redundancy design of control layer network, independent of each other, safe and reliable.
- High-performance micro-grid coordination control device, millisecond-level response speed, and seamless switching between micro-grid and off-grid operation modes.
- Quickly and flexibly adjustment of power and maintain system frequency and voltage stability as the main power supply in off-grid conditions.
- Increment in the penetration rate of micro-grid new energy and provision of clean energy for the integration of micro-grid wind, solar and storage.
- The setting value adaptation of the protection device under different micro-grid operation modes.

EPC Capability

20

20 years of implementation experience

600

600 R&D engineers

90

Implementation experience in more than 90 countries and regions

120

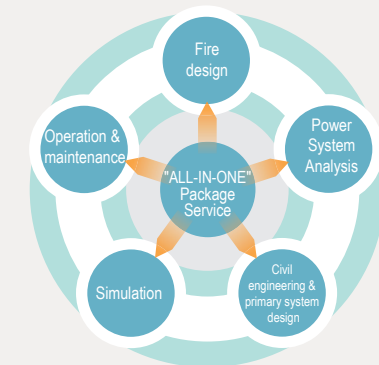
120 design engineers

130

130+ PMI Certified Senior Project Managers

800

800 Field Application Engineers



NR Electric is a world's leading power engineering contractor, dedicated to improving the stability, reliability, efficiency and environmental protection of the global power system. The company has more than 20 years of experience in the design, construction and maintenance of power transmission and distribution systems, renewable energy, micro-grids, industrial power and other fields, and has mature project implementation experience in more than 90 countries and regions around the world. The company has established a professional and experienced project team, including more than 120 design engineers, more than 130 PMI certified senior project managers, more than 800 field application engineers and 600 R&D engineers.

NR Electric advocates the core culture of "practice, Improvement, collaboration and innovation", and provides reliable one-stop turnkey engineering solutions for power grid, power generation, industrial and commercial customers. The EPC capabilities cover consulting, design, supply, installation, commissioning, training and operation.

NR adheres to the enterprise objectives of "creating value and serving the society"

- System analysis and design to provide optimized EPC solutions and minimize life cycle project costs
- Integration of cutting-edge technologies and latest products
- Ensure high availability and maximum energy efficiency
- Complete project process and life cycle management (from initial user requirements, to engineering design implementation and after-sales service)
- Provision of long-lasting solutions to the highest quality standards
- Comprehensive protection for personnel safety
- Life cycle quality control, risk mitigation and program assurance
- End-to-end services for project implementation, minimizing operation and maintenance costs

NR have carried out battery energy storage system related consulting, engineering design and EPC general contracting business in more than 80 countries and regions around the world.



Power System Analysis and Simulation Research

NR has a strong system analysis team, which can provide system analysis and technical consultation for the planned and operated power grid to help realize the economical and reliable operation of the power grid. As an enterprise that truly "knows both products and systems", NR has the capability of energy storage modeling and access system analysis based on mainstream simulation software. According to the application scenarios and different conditions of the power system, the energy storage devices and their control schemes are also different. Through system analysis, the adaptability of the energy storage solution can be improved, so as to achieve the purpose of improving the overall economy of the solution and the security and stability of the grid connection. The company's systems research and technical consulting cover the following areas:

- Load flow and short circuit analysis
- Research on Stability Control Strategy
- System Dynamic Characteristics and Flexible Transmission Research
- Research on Reactive Power Compensation
- Voltage Support and Stability Studies
- Research on HVDC Transmission and Its Stability
- Electromagnetic Transient Research
- Power Quality and Harmonic Analysis
- Series Compensation and Stability Studies
- Network structure planning and optimization

The company has established RTDS laboratory, RT-lab laboratory, dynamic model laboratory, high voltage laboratory, flexible power transmission test platform, and all of them have passed the CNAS certification, and has a team of skilled and experienced test personnel. It can meet the simulation test requirements of energy storage access to power grid in different scenarios. By building a power grid model, multiple energy storage converter control devices, coordination devices and energy management systems applied to the field can be connected to the simulation platform to simulate the on-site off-grid and grid-connected conditions, and perform system-level real-time closed-loop simulation. The software functions and control strategies of the converter and coordinated control system are verified.

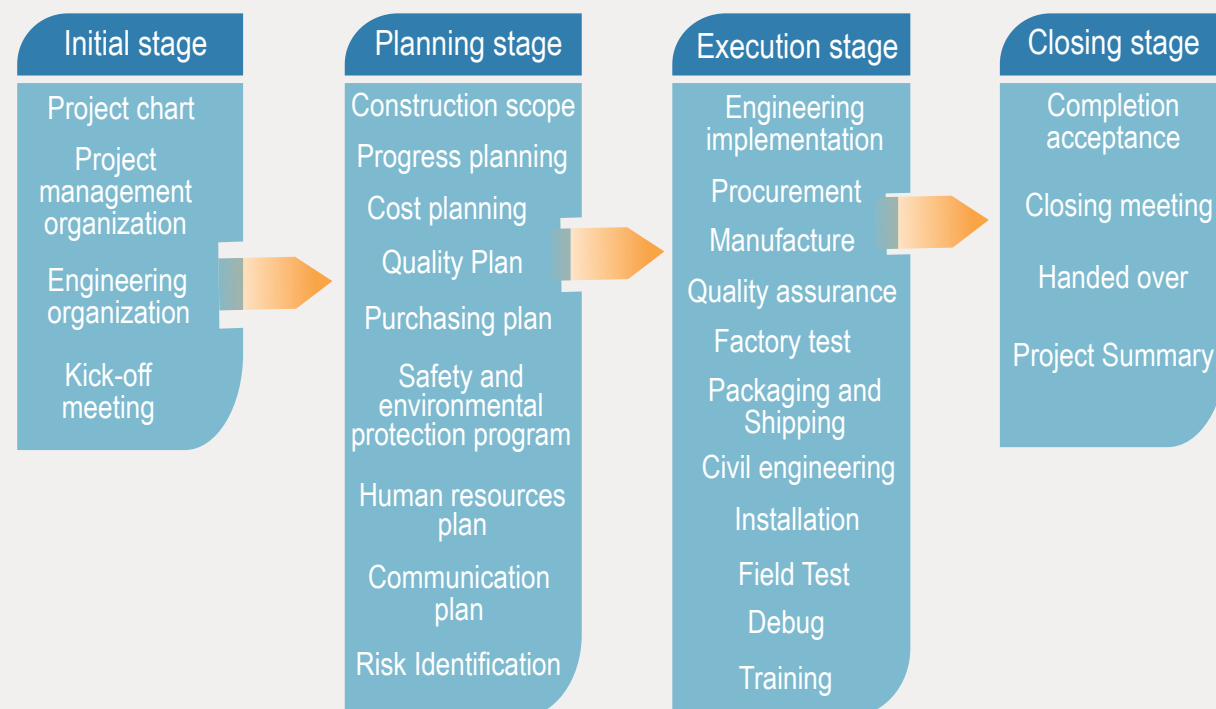
- Project Requirements Definition
- System single line diagram optimization
- Voltage and feeder arrangement
- Main equipment specifications and layout
- Load flow and dynamic stability
- Protection function coordination
- Integrated and distributed resource planning
- Cost minimization

Engineering design

In the course of serving customers over the past decades, NR has always insisted that detailed and precise engineering design is the foundation of good construction and safe operation of the grid, starting from the early stages of a project. Therefore, we continuously strive to improve our engineering design capabilities to maximize the benefits of our clients from the beginning of a project. Based on professional experience gained from thousands of projects with different voltage levels, NR can provide equipment insulation design, grounding grid design, and cable anti-interference design that meet power system standards. At the same time, by giving full play to the technical advantages of multi-professional integration and the team advantages of multi-departmental collaboration, NR can provide you with a station-level energy storage fire protection design scheme, including site and cabin fire protection design, fire detection and early warning linkage design, fire extinguishing and fire protection, explosion-proof design, etc.

Project management

Based on rich experience in engineering projects, NR believes that the key factor to achieve project success is professional project management. From project beginning to completion, NR provides full life cycle project management and assigns qualified project managers to ensure that projects can be implemented efficiently and cost-effectively. The project manager will be responsible for executing the project within the scheduled time and within the calculated budget, managing changes in client needs, focusing on client satisfaction and risk control.



Product Manufacturing and Quality Control

Reliable and safe power system operation relies on advanced system solutions and high-quality products. As a professional system solution provider, NR produces high-quality products and integrates qualified third-party equipment to ensure projects are completed on time. NR protection and control equipment industrial park and intelligent power equipment industrial park have world-class production facilities: covering an area of more than 500,000 square meters, with an annual production capacity of 1.6 million smart devices, 37,000 panel cabinets and 1,300 pieces of power electronics equipment.

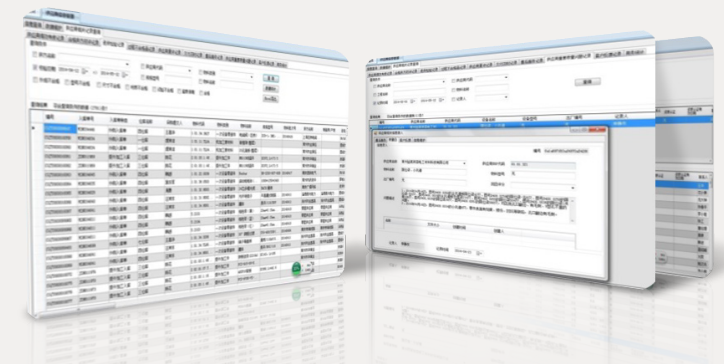
NR believes that the quality of products and services is critical to the long-term safety and reliability of power transmission. We implement strict quality control processes through procurement, manufacturing, configuration, delivery and service. From circuit board soldering, module inspection to final device assembly, every step is performed by our expert technicians, verified by our test engineers, and monitored by our quality control engineers to ensure mechanical quality and electrical performance.





Third Party Purchase and Quality Control

As a general contractor and system integrator, NR procures qualified third-party equipment, materials and services to achieve the best overall value of customer investment. Our procurement system builds a database of suppliers and carefully selects and investigates suppliers by white-listing. Our procurement professionals understand the importance of choosing the right supplier and will strictly adhere to the safety and quality of the project.



The company always adheres to the policy of quality first. Quality control runs through every link from R&D and design to product realization. Strict testing systems and perfect testing methods ensure that the entire production process is under control. The company's products have always been known in the industry for their low repair rate. The company has passed the ISO9001 quality management system, ISO14001 environmental management system, ISO45001 occupational health and safety management system, ISO20000 information technology service management system, ISO27001 information security management system and ANSI ESD S20.20 and IEC61340 anti-static management system. The company's energy storage product series have passed the certification of internationally renowned institutions such as UL, TUV, and CE. The company's R&D process management has reached the international advanced level, and it has taken the lead in passing the CMMI Level 5 formal assessment.

The company is equipped with several high standard facilities for manufacturing and testing to meet reliability and safety standards. The company has developed a rigorous testing process to ensure device quality, starting with module inspection and continuing through electrical and mechanical testing. The manufacturing plant is equipped with a full set of in-house advanced test laboratories to facilitate the analysis of equipment or system performance, including type test laboratories certified by ILAC and CNAS, high voltage AC/DC analog/digital test laboratories, high voltage test laboratories and IEC 61850 Class B testing laboratory. The RTDS Simulation Lab verifies system functionality and performance under simulated final system conditions to ensure delivered systems meeting field quality standards.



On-site construction and installation

Regardless of the location or conditions, NR always appoints experienced project managers and engineers to the site to manage and implement construction and installation work. Based on your specific requirements, we carefully select subcontractors to complete projects on time. Our construction and installation management services include:

- New or retrofit projects
- Civil work
- Field work
- Erection and installation
- On-site assessment for safe and cost-effective on-time delivery
- Work with qualified contractors

Field test and commissioning

NR's engineering team always works closely with end users to reduce the time and cost of on-site testing and commissioning. This service enables well-trained field service engineers to provide operators with practical troubleshooting. Our on-site testing and commissioning services cover the below:

- Battery cluster, battery stack insulation and voltage detection
- Overvoltage, undervoltage, differential pressure, high temperature, low temperature, temperature difference and other protection tests
- Fire fighting and HVAC test, intertrip logic test
- Charging and discharging test of small power gradually increasing to full power
- Full charge discharge cycle and SOC calibration test



After-sales service

After the project is completed, NR can provide flexible and comprehensive maintenance services to ensure the long-term safe and economical operation of your system. Our full range of maintenance services include equipment and plant testing and commissioning, troubleshooting, repair and replacement, spare parts supply and engineering training.

Through our high-tech preventive maintenance, equipment availability and operational safety are highly guaranteed, and the customer's own maintenance consumption is greatly relieved. Fast and efficient replacement services minimize production downtime and ensure your critical assets reach their full potential.

System retrofits and upgrades create the challenge of being forced to work within the confines of existing infrastructure. NR has the experience and skills to optimally optimize current assets and ensure compatibility of new equipment without compromising operational performance. We can help retrofit complex projects including substations, static var compensators, HVDC transmission and battery energy storage systems. Our services allow for equipment replacement with next-generation equipment and technology.

NR's spare parts service is all over the world, we

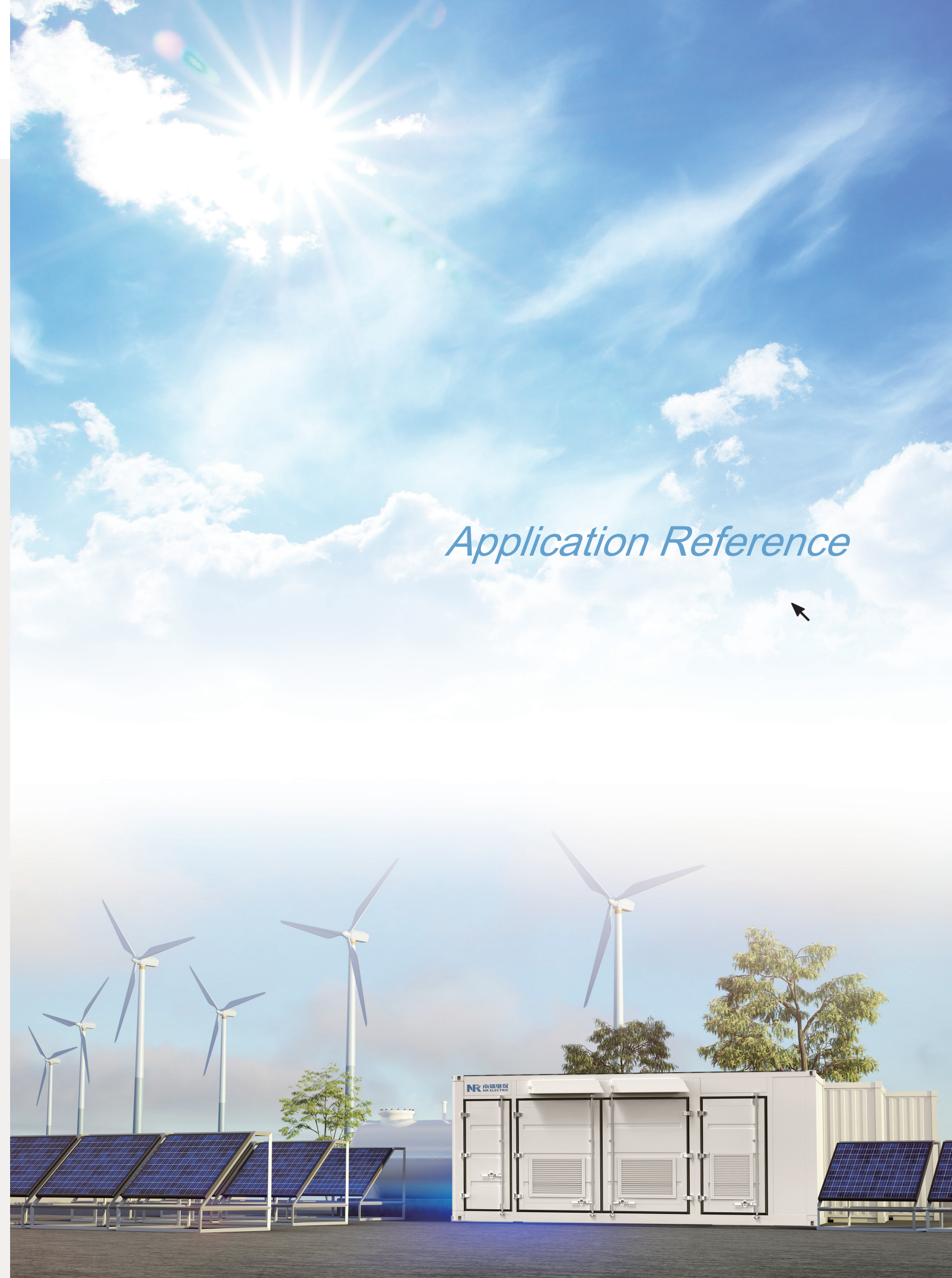
store spare parts close to customers and ensure that replacement parts arrive at their destination as soon as possible. All of our spare parts kits and replacement services are of original factory quality.

NR provides first-hand knowledge training directly from the manufacturer. The training combines coaching, factory training and on-the-job training, including the basics of power systems, as well as an introduction to protection & control, automation, HVDC, flexible transmission, micro-grids, and renewable energy solutions.

NR's training center prepares samples of a full range of products and conducts professional training for customers. We offer regularly scheduled courses that include theoretical lessons and hands-on interaction using relays and meters, test tools, automation software, communication equipment and commissioning computers. Trained instructors have years of practical experience working on high-quality technical topics.

In order to allow customers to get the maximum benefit from our training, NR provides the option of conducting on-site training courses at the user's premises. These on-site training courses can be tailored to specific engineering projects and requirements. All necessary testers and literature will be provided on site for operational practice.

Application Reference



Wind farm energy storage project using NR's integration solution

"Turnkey" delivery as the EPC general contractor, and supply of complete sets of key equipment for energy storage system

Huaneng Mengcheng Wind Farm

📍 Anhui, China

📊 total capacity (two step-up stations) 40MW/40MWh lithium battery energy storage system

🕒 August 2020

Challenge

The output of the wind farm is intermittent and fluctuating, and the unbalance of power generation and consumption is large, which makes it difficult to adjust the peak load of the power grid, and the problem of wind curtailment occurs.

to participate in grid ancillary services to pursue maximum power generation benefits.

It is difficult to realize the multi-functional composite control of wind and storage, and the multi-time scale control structure is not clear, and it is difficult to coordinate and cooperate.



Solution

As the general contractor of EPC, NR is responsible for problem investigation, system analysis, scheme design and integration, equipment supply, engineering design, civil engineering, and construction, etc.

The station control layer adopts the IEC 61850 standard communication protocol, and uses the coordinated control system of the unified software and hardware platform to realize the fast power control function.

Design and converter group wind-storage combined operation control strategy under different working conditions to meet the grid dispatching requirements and optimize the utilization of wind power.

Innovate and optimize the PCS box design, add a precise energy efficiency monitoring system, and further reduce costs and increase efficiency.

Achievement

For the first time in China, the steady state, transient state, emergency and other multi-dimensional composite control functions of energy storage in new energy applications have been realized.

Improve the utilization rate of wind power resources under the premise of safe operation of the system.

The response time of primary frequency regulation and voltage regulation is less than 30ms.

Reduced air conditioning loss by 55%, increased overall energy storage efficiency by about 1.5%, and increased energy density per unit area by 25%.

<30ms

response time of primary frequency regulation and voltage regulation

55%

reduced air conditioning loss

1.5%

increased overall energy storage efficiency

25%

increased energy density per unit area

NR Energy Storage Helps Gas Turbine Frequency Regulation and Black Start

Energy storage solution integrating power system, static frequency converter and excitation control technology

Zhuhai Hengqin Power Plant

📍 Guangdong, China

📊 22MW/20.5MWh lithium battery energy storage system

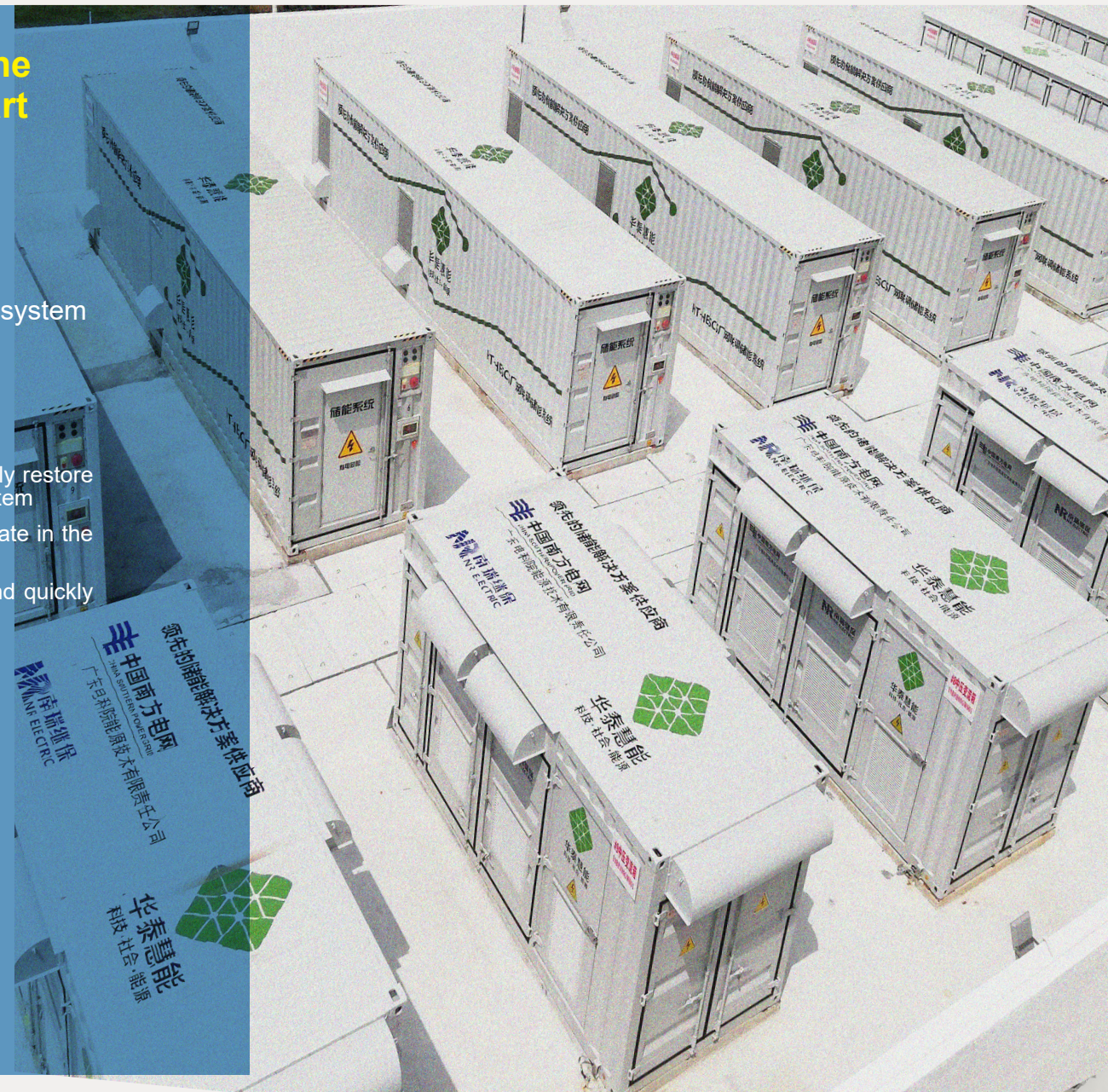
📅 December 2020

Challenge

The black start function of the gas turbine is required to quickly restore the power supply to deal with major disasters in the power system

When the unit is running in a steady state, it needs to participate in the electricity spot market transaction of the Southern Power Grid

The speed regulation of the unit is slow, and it cannot respond quickly to the dispatching frequency regulation command



Solution

- Combined with the research of power system operation, LCI static frequency converter, excitation control and other technologies and equipment, carry out the scheme design of energy storage converter and coordinated controller
- Using VSG virtual synchronous generator technology to solve the synchronization problem of grid energy storage system
- Integrated PMU fault recording function to track and analyze gas turbine and operating conditions

Achievement

- One-time realization of the world's first energy storage-assisted 9F-class gas turbine black start, improving the ability to support the power grid
- The frequency regulation and voltage regulation have fast response, flexible control, high conversion efficiency, and improved operating stability of the unit
- The system design is compact and easy to install on site; Integrated wave recording improves operation and maintenance efficiency



Vanadium-redox-flow-battery Energy Storage

📍 Dalian, Liaoning

📊 100MW/400MWh

Peak shaving, frequency regulation, black start



Huadian Tengzhou Power Plant Peak Shaving Energy Storage Project

📍 Tengzhou, Shandong

📊 101MW/202MWh

PCS+PMS+EMS integrated supply

Peak shaving, frequency regulation, voltage regulation



Huaneng Xiaojian Wind Farm Lithium Battery Energy Storage Project (EPC)

📊 30MW/30MWh

Reduce wind curtailment, track forecast curve, smoothen fluctuations, grid auxiliary services



Huaneng Xutuan Wind Farm Lithium Battery Energy Storage Project (EPC)

📊 10MW/10MWh

Reduce wind curtailment, track forecast curve, smoothen fluctuation, grid auxiliary services



10MW/5MWh Zhangye Power Plant Energy Storage Frequency Regulation Project Zhangye, Gansu

Power Plant Auxiliary Frequency Regulation



300kW/340kWh Low-voltage flexible distribution network lithium battery energy storage + DC distribution network converter project Xuzhou, Jiangsu

Flexible DC distribution network control, auxiliary frequency regulation and voltage regulation



12MW/48MWh Jinling Station Lead-acid Battery Energy Storage Project Huzhou, Zhejiang

Frequency regulation, voltage regulation, peak shaving and valley filling, auxiliary services



12MW/48MWh Baililian Lithium Battery Energy Storage Project Jiaozuo, Henan

Peak shaving and valley filling \ auxiliary services



2MW/4MWh User side lithium battery energy storage project, Conghua, Guangdong

Auxiliary services, peak shaving and valley filling



1MW/0.5MWh India Power Grid first energy storage system, India

Peak shaving and valley filling, auxiliary frequency regulation



2MW/2.17MWh EWJR lithium battery energy storage project, Switzerland

Power grid peak shaving, frequency regulation and voltage regulation



3MW/2MWh PEA Micro-grid Energy Storage Project , Thailand

Micro-grid coordination control, auxiliary frequency regulation and voltage regulation



100kW/100kWh Thailand's first Micro-grid energy storage project, Thailand

Micro-grid coordination control, auxiliary frequency regulation and voltage regulation

1MW/2MWh Ibaraki user-side Vanadium Redox Flow Battery energy storage project, Japan

Peak shaving and valley filling, off-grid main power supply



1.2MW/7.2MWh NGK Shikoku Island ITO sodium-sulfur battery energy storage project, Japan

Peak shaving and valley filling, auxiliary frequency and voltage regulation

600kW/3.6MWh TOTO factory user-side sodium-sulfur battery energy storage project, Japan

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