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国家电网巴西控股公司

Solutions for New Type Power Systems

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Part 01

New-Type Power System

New-Type Power System

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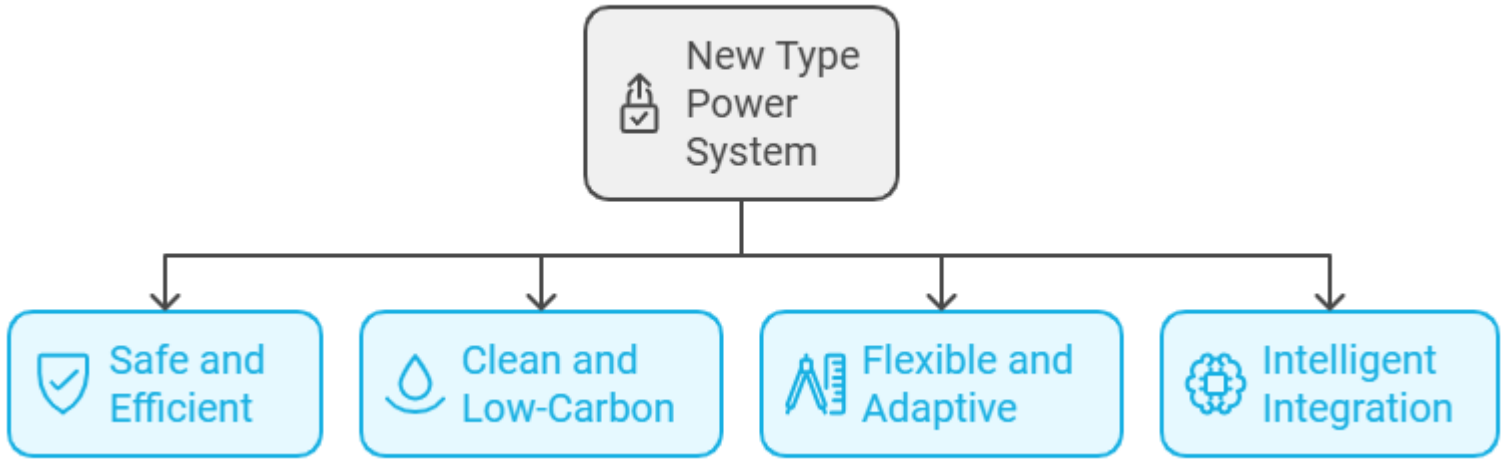
Definition

New-Type Power System refers to a modernized power infrastructure that prioritizes clean energy sources, leverages digital and intelligent technologies, and aims to meet the demands of reliable, economic, efficient, and sustainable electricity. It is designed to align with global energy transitions and decarbonization goals.



Main Features of New-Type Power System

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High proportion of renewable energy power system

Clean, efficient, low-carbon power system

High proportion of power electronic equipment power system

Digital, intelligent, smart energy power system

Multi-energy complementary integrated energy power system

High-resilience, intrinsically safe and reliable power system

Soure-Grid-Load-Storage-Carbon-Digital

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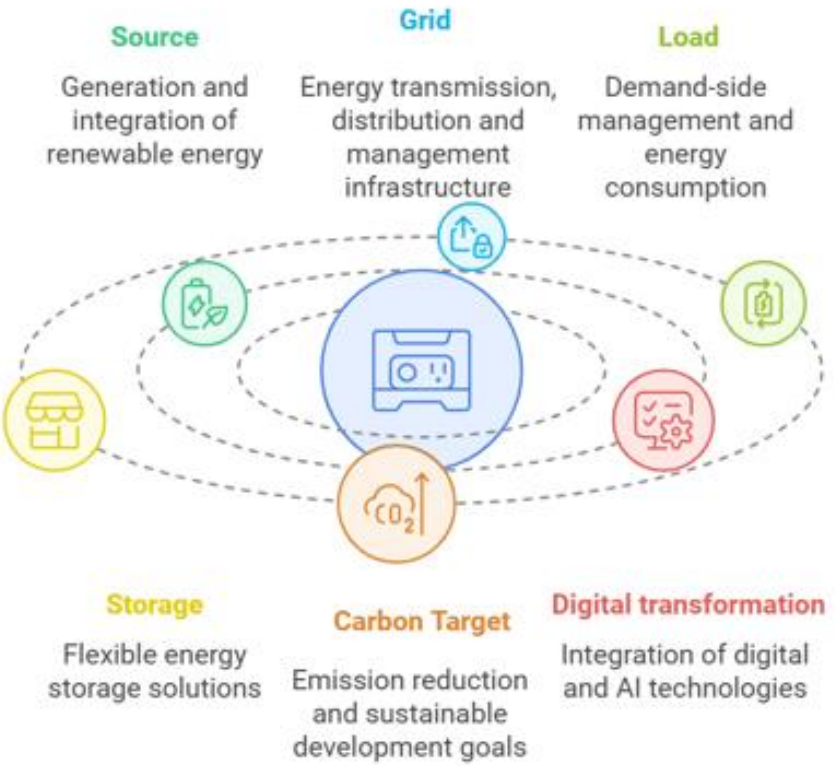
- In the new type power system, the relationship **between "source," "grid," and "load"** is **transitioning from a one-way flow of "source following load" to** a bidirectional flow characterized by **"source-load interaction" and collaborative synergy**.
- For the **"storage"** element, the increasing share of renewable energy is making flexible resources in the power system increasingly scarce, necessitating the deployment of diverse, multi-scale energy storage solutions across all segments of the system—source, grid, and load.
- Regarding **the "carbon"** element, the dual-carbon goals serve as the core driver for building a new power system, influencing the four key elements: source, grid, load, and storage.
- In terms of **the "digital"** element, digital transformation is the key enabler for constructing the new power system, facilitating comprehensive integration with the four elements: source, grid, load, and storage.



Main Technologies to Build New-Type Power System

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Clean Energy Generation

Large-scale deployment of wind and photovoltaic power plants to harness natural resources for clean electricity

Energy Storage

Advanced battery storage systems to address the intermittency and instability of renewable energy generation, ensuring grid stability.

Efficient Transmission

Improving the efficiency of long-distance, large-scale power transmission, reducing transmission losses,such as HVDC, FACTS

Smart Grid

Using big data, cloud computing, and IoT to enhance grid prediction, optimization, and scheduling capabilities, allowing real-time data collection, analysis, and decision-making.

Digital and Intelligent Technology

AI, data analytics, and cybersecurity for efficient operations. Intelligent Scheduling and Forecasting,Fault Diagnosis and Self-Healing Capabilities

Electric Transportation and Charging Infrastructure

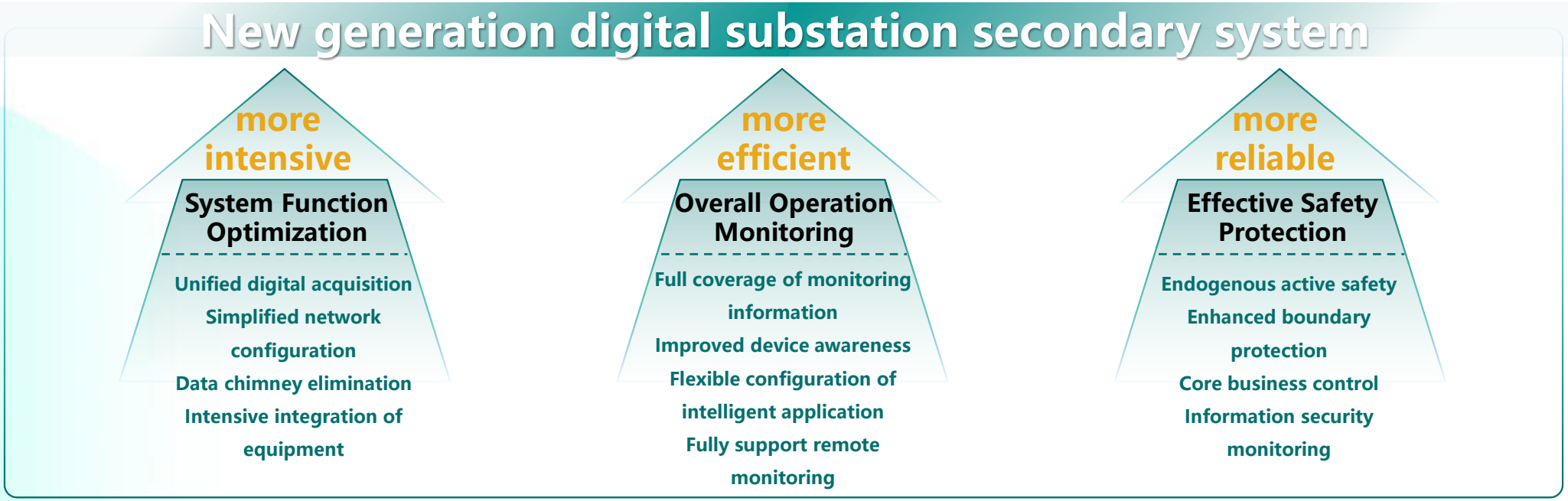
Electric Vehicle (EV) Technologies Promoting electric transportation to reduce carbon emissions .Smart Charging Networks monitor and schedule charging, optimizing charging resource distribution

Part 02

Digital Substation

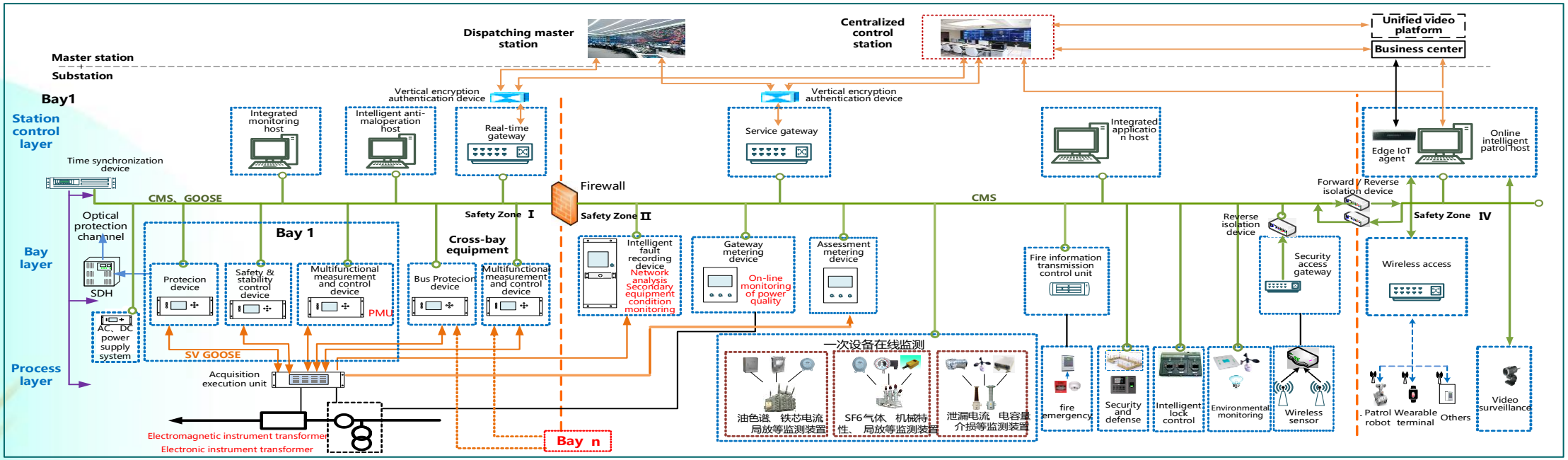
Digital Substation

The main characteristics of digital substation are secondary information digitization, communication platform networking and operation management automation. At present, it has been widely applied in the scope of SGCC, and the technical iterative upgrading has been continuously carried out. In recent years, in order to meet the development needs of the new power system, the secondary system architecture of the digital substation is reconstructed to achieve the purpose of system function optimization, comprehensive operation monitoring and effective safety protection..



Digital Substation

- System function optimization: unify data acquisition and transmission, cancel process layer network, integrated equipment, optimize SCD configuration.
- Comprehensive operation monitoring : integrate and streamline station control and auxiliary equipment, form platform + APP software architecture, integrate main and auxiliary monitoring, strengthen station operation support.
- Effective security protection : strengthen system boundary protection, equipment endogenous security, station communication security and network security monitoring.
- Intelligent operation management : improve equipment perception ability, accurately warn operation risk, management data interpenetrate through the whole process.



System Function Optimization

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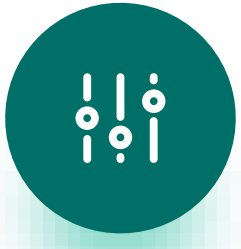
Data collection

Unify the digital collection of the entire station, unify the digital transmission method of the bay layer equipment, cancel the process layer network, simplify the network, significantly reduce the number of switches, and integrate the merging unit and intelligent terminal functions

Device function

Similar functions of secondary equipment in the Bay layer are merged and optimized to improve the integration of homologous technologies, avoid repeated data collection, and reduce the number of equipment and data transmission within the station.。



Network configuration

The process layer network is cancelled, small amount of interlocking GOOSE information are exchanged through the station control layer network. The station control layer network design is standardized and normalized, and the switch configuration is solidified. All are completed before delivery

SCD configuration

The modeling is standardized and normalized, SCD file configuration is simpler, information display is more intuitive, and configuration tools are easier to use. The information configuration and function configuration of protection and control equipment are decoupled (CID and CCD). The version of the SCD file is controllable throughout its life cycle.

Overall Operation Monitoring

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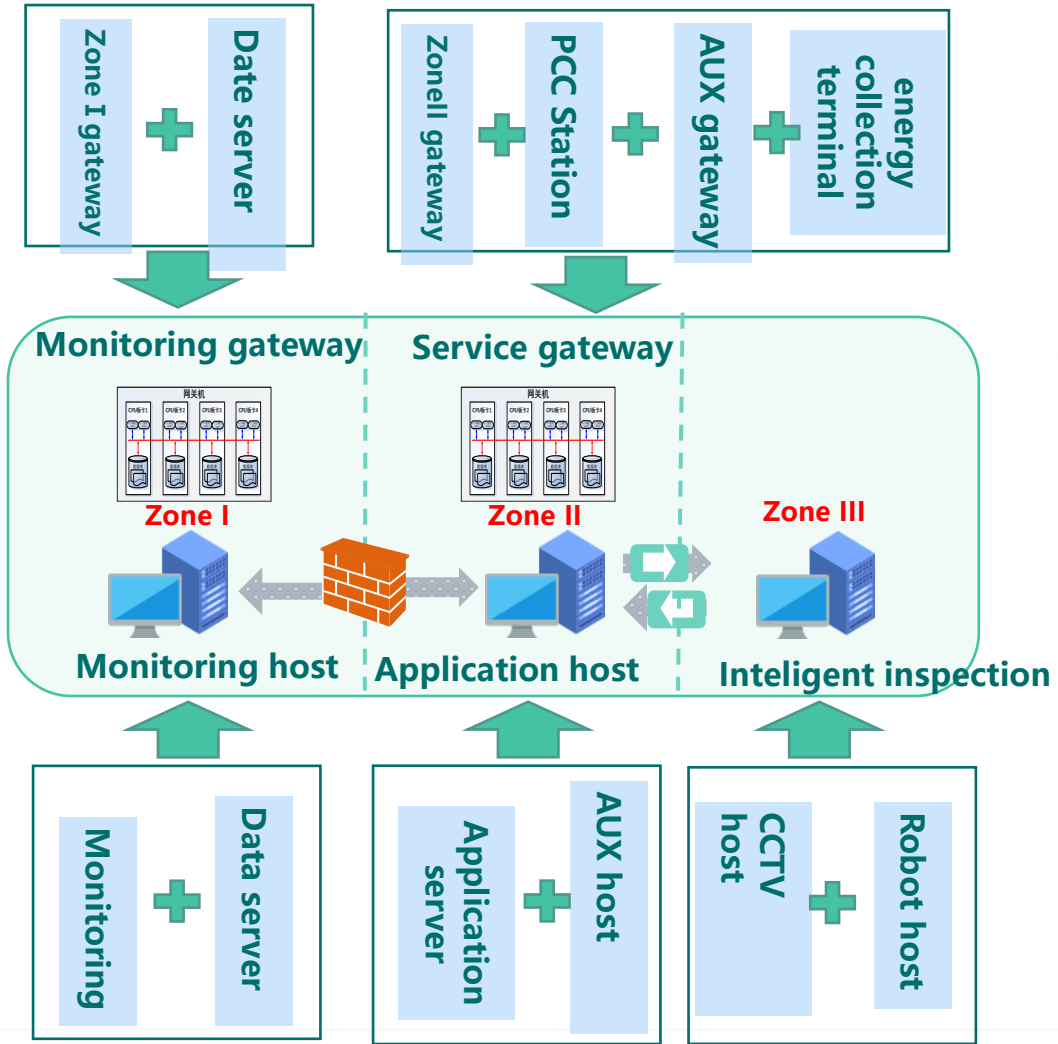
Stations integration

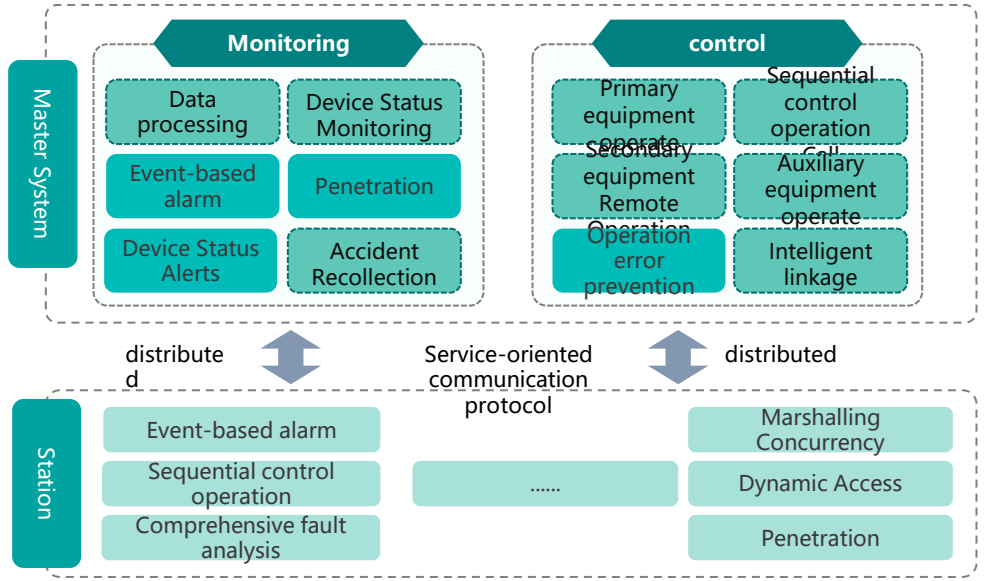
- **Integrated system host**.The station control layer hosts are optimized and integrated, the quantity is greatly reduced.
- **Integrated gateway machines.** The gateway machines are unified into real-time monitoring gateway machines and service gateway machines. The blade-type multi-card design greatly improves performance and supports multi-master and multi-protocol communications.

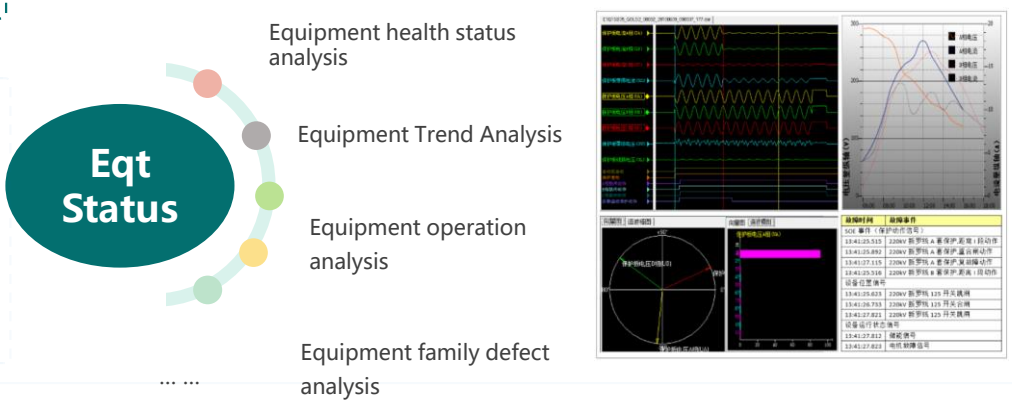


Overall Operation Monitoring

Station full support

- **Model station maintenance and global sharing.** Improve the main and auxiliary equipment models, standardize the interaction between substations and dispatching master stations and centralized control stations, and realize substation source configuration and comprehensive sharing of master stations.
- **Improve the ability of on-site data analysis at the station.** The station can perform on-site analysis and comprehensive judgment of equipment failure anomalies, and upload the results to the main station, which can reduce the pressure on the main station and improve the efficiency of remote monitoring.
- **Strengthen the station's support capabilities for the master station.** The station encapsulates event-based alarms, sequential control operations, remote browsing and other functions as services, supports remote calls to the master station, and realizes the integrated deployment of master and substation application functions.

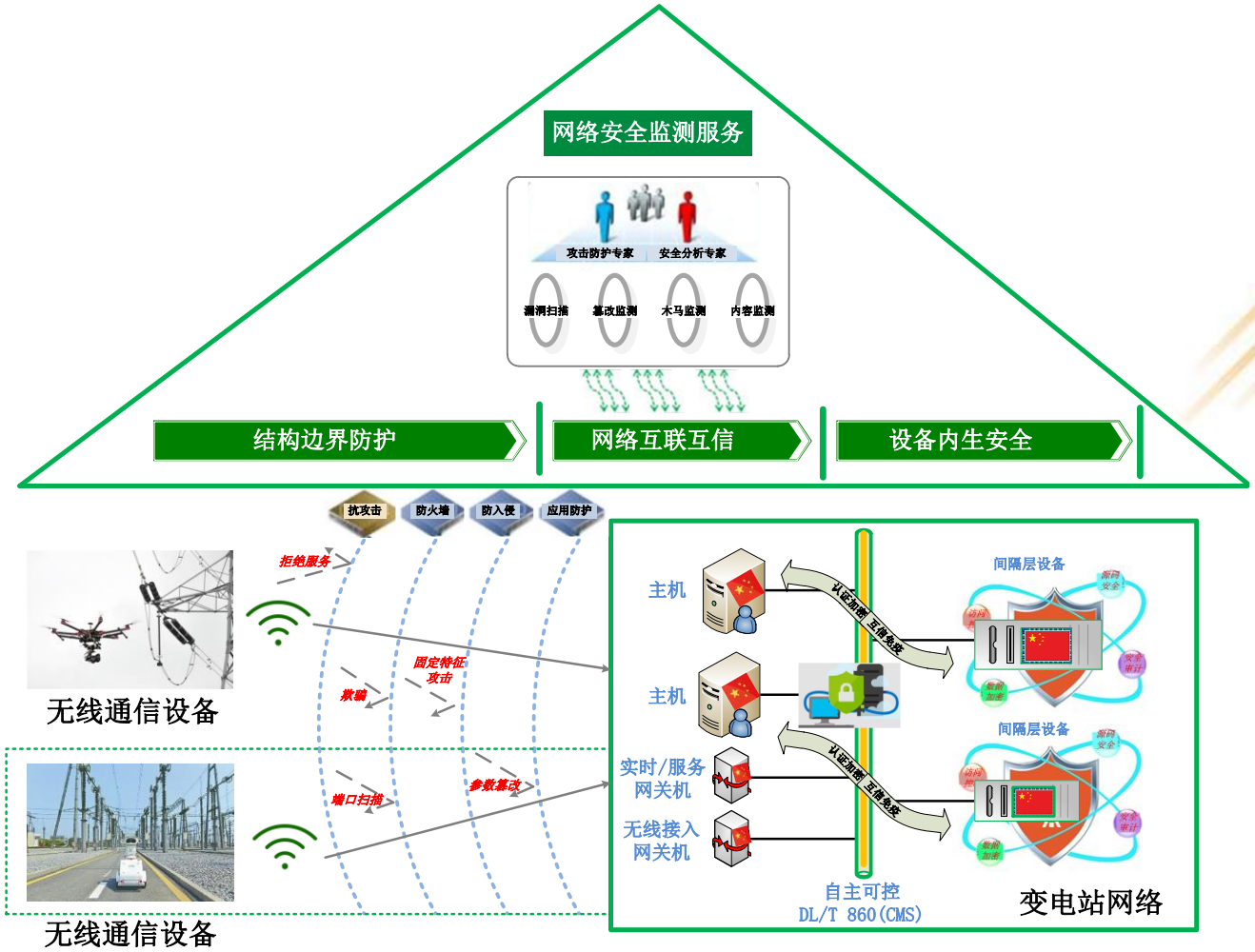




Effective security protection

Build a comprehensive **three-dimensional protection system of " equipment security and controllability + communication encryption and authentication + solid boundary protection + full-site network monitoring" .**

Focus on strengthening the protection of in-station communications, add new measures such as wireless access protection, trusted immunity, and operation and maintenance management, expand the scope of monitoring and collection, effectively protect the substation network from attacks, and ensure the security of the substation system in all aspects.

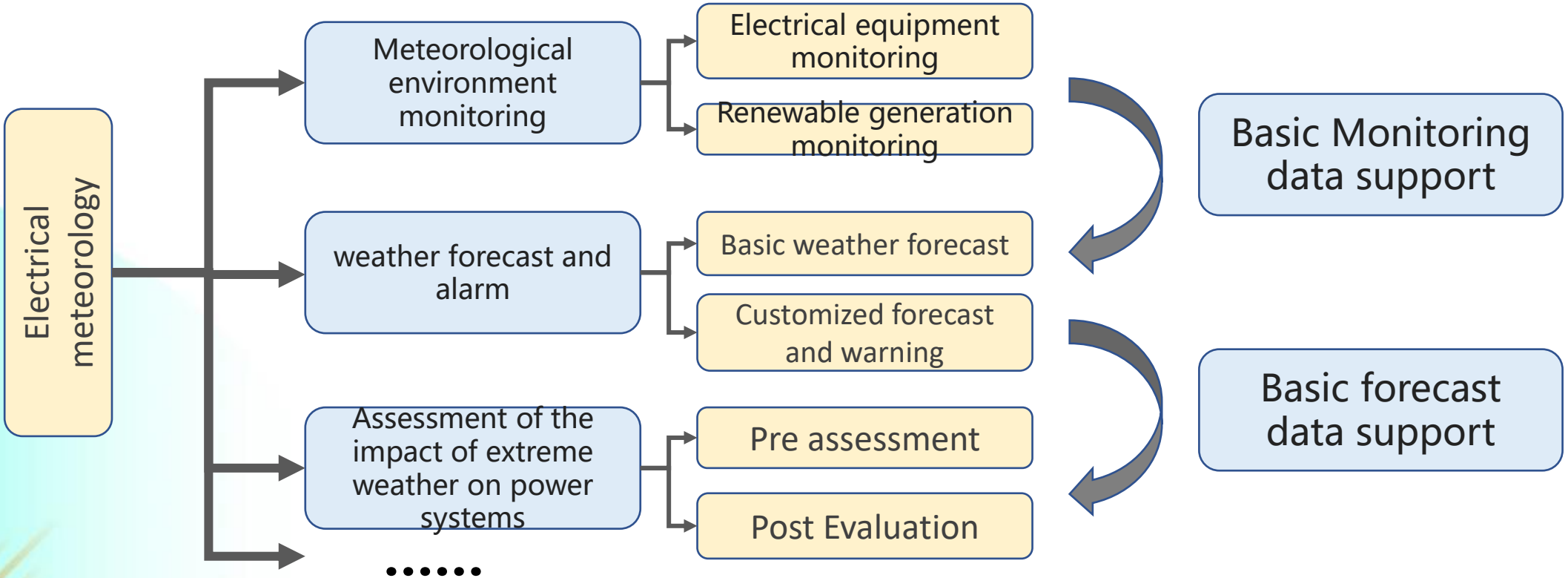


Part 03

Electrical Meteorology

Electrical Meteorology

Electrical meteorology technology refers to the methods and means by which power systems respond to meteorological influences, including meteorological environment monitoring of power equipment, power meteorological forecasting and early warning, and assessment of the impact of extreme weather on power system.



Electrical Meteorological Technology System

Discrepancy between Electrical Meteorology and the public meteorology service

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1

Public Data Limitations

The monitoring data and forecast information obtained from public meteorological service agencies are far from the actual needs of power production and operation.

2

Observational Gaps

The monitoring sites are far away from power transmission and transformation equipment and new energy stations, and the data is not representative.

3

Forecast Deficiencies

The forecast information provided by public meteorological services is mostly text products or pictures. The charges for individual grid data are high, and the full-factor field of the horizontal and vertical grid is not provided. The data application is unable to provide customized services with fixed time, fixed point and fixed quantity to meet the needs of the power grid.

Discrepancy between Electrical Meteorology and the public meteorology service

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Key elements required for power meteorology:

- Wind speed at wind turbine hub height/cut-out wind speed
- Transmission Line ice thickness/wind turbine blade ice thickness
- Photovoltaic panel sand/snow/ice thickness
- Transmission line path wind direction, extreme wind
- Equipment operation and maintenance index, new energy power generation index
- Load index, power supply risk index, etc.

Key Technology of Electrical Meteorology

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Basic Numerical Weather Forecasting Technology

- Numerical weather forecasting technology is the basis of customized forecasting and warning for power. Numerical weather forecasting technology uses large computing clusters to input the initial forecast field into the numerical weather forecast model, solve the basic equations of atmospheric motion, add various physical process parameterization schemes, use ensemble forecasting and other methods, and use observational data for assimilation and correction, and finally obtain forecast data that evolves over time.
- Meteorological observation data is the basic input for numerical weather forecasting, and meteorological observations for power equipment are particularly important.
- The forecast initial field comes from the global meteorological observation network including ground, ocean, sounding, aircraft, radar, satellite, etc. After a certain analysis, processing and calculation, the global grid initial field data is finally obtained. The grid resolution is generally around 100 kilometers, which can be used to drive the calculation of more refined numerical weather forecasts.

Key Technology of Electrical Meteorology

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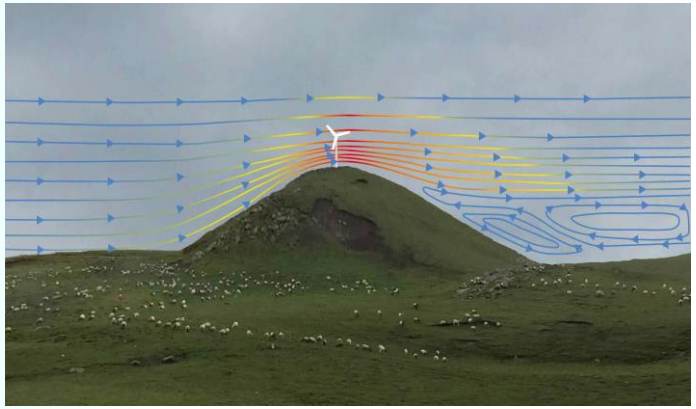
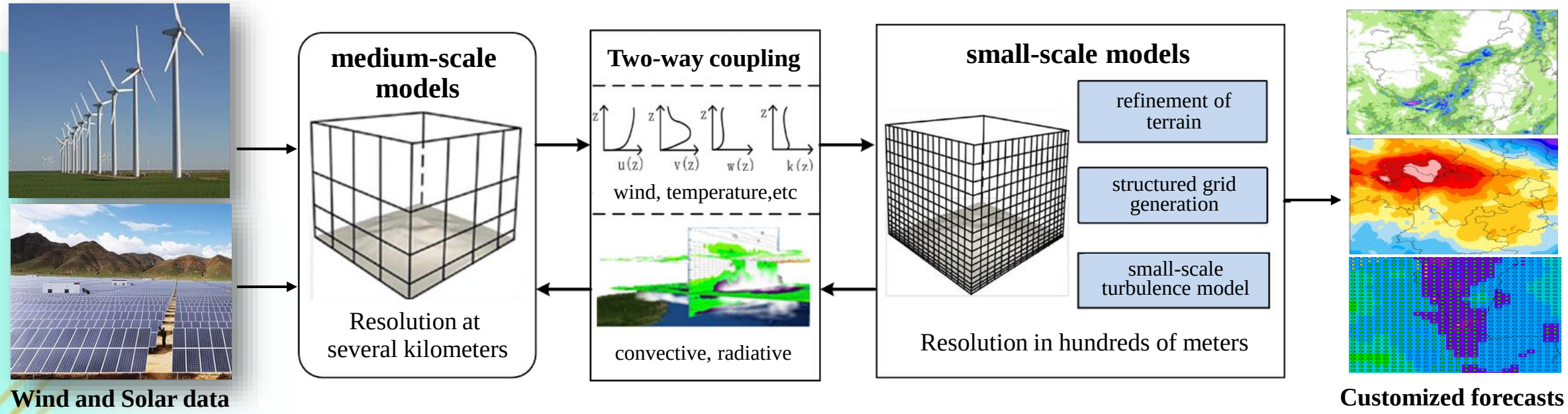
Customized power weather forecast and warning technology

- Key factors in wind energy forecasting: local topography, surface roughness, dominant climate types in each region, local micro-meteorological conditions, etc.
- Key factors for solar energy forecasting: clouds, near-surface water vapor, dust, haze, terrain height, etc.
- Key factors in lightning forecasting: collision and friction of supercooled water droplets, ice crystals and other particles in the air, different types of charges on particles, electric field in space between thunderclouds and the ground, etc.
- Key factors in heavy rain forecasting: water vapor conditions, rising air flow conditions, weather systems that form heavy rain such as typhoons, local severe convection, fronts, shear lines, etc.



Numerical weather prediction for power production

- Aiming at the demands of power grid production and operation, the numerical forecast system has customized and developed, which integrates realtime four dimensional data assimilation, rapid updating cycle, and ensemble forecast.
- The two-way nested 3D grid encryption technology are used, the meteorological observation data of renewable energy stations and transmission lines are assimilated into the numerical prediction model, which improves the prediction accuracy of key meteorological elements..

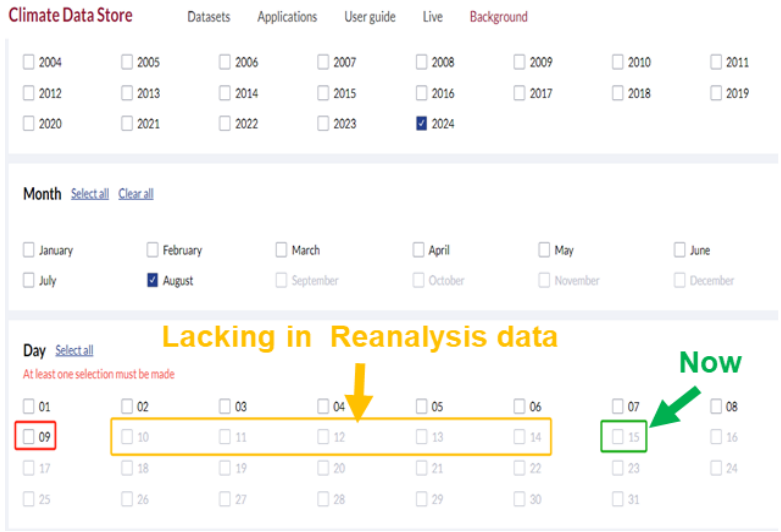


AI Foundation Models for Weather and Climate

- Various AI-based models have been set up for doing weather and climate forecast.
- Recent approaches using transformers, physics-informed machine learning, and graph neural networks have demonstrated state-of-the-art performance on relatively narrow spatiotemporal scales and specific tasks.
- With a lack of real-time initial field data, the AI models cannot give forecasting results with enough resolutions and necessary variables for the power system.
- Therefore, power system shall build up a specialized AI-based weather model to produce NWP not only for renewable power forecasting but for a sound foundation of the New-Type Power Systems as well.

Model Name	Developer	Input Data	Prediction Horizon	Calculation Cost	Cost for per Prediction	Region/ Resolution
FourCastNet	NVIDIA	ERA5	7 days	16 hours 64 NVIDIA A100 GPU	2s	Global /30km
Climax	Microsoft	CMIP6、ERA5	6 to 720 hours	80 NVIDIA V100 GPU	\	Global /620km &115km
GraphCast	Google	ERA5	10 days	4 weeks 32 Cloud TPU v4(32GB)	60s	Global /30km

Three Typical AI Foundation Weather Models



The One-Week Delay of ERA-5 Data

Electrical Meteorology Application Status

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高性能计算系统

- Blade servers: 600
- Computing cores: 16,080
- Storage capacity:2.65PB
- Computing speed: 400 trillion times per second

张北气象卫星接收装置

- 9 polar-orbiting meteorological satellites including NOAA, Metop, MODIS, NPP, Fengyun-3, etc.
- Fengyun-2 geostationary meteorological satellite
- Sunflower-8 geostationary meteorological satellite

Electrical Meteorology Application Status

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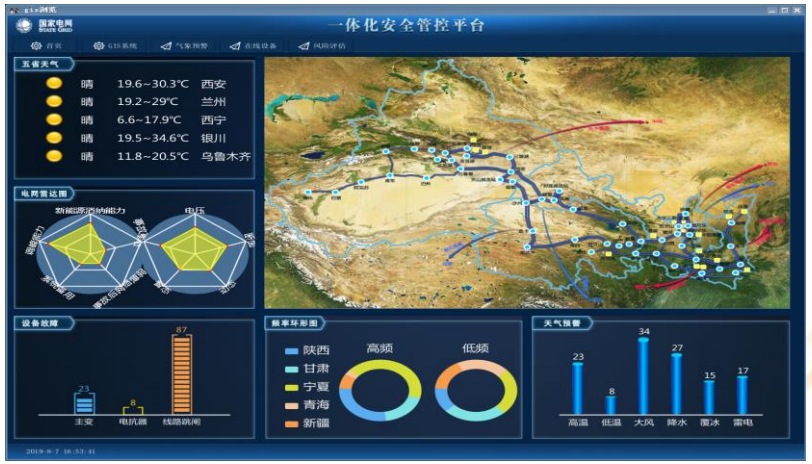
- Based on advanced basic numerical forecasting technology, complete observation data and powerful computing platform, we have built a number of operational forecasting systems. Key indicators such as spatial resolution (3km×3km), temporal resolution (15 minutes), and forecast time (7 days) are in the leading position in the industry, providing a reliable and accurate data source for new energy resource assessment and power forecasting, power meteorological disaster warning, etc., and also providing accurate meteorological services for the company's production and operation.
- Focusing on the key meteorological elements of new energy and power transmission and transformation equipment, we have mastered the disaster formation mechanism and calculation methods, built a customized forecast and warning model, developed an electric power meteorological disaster warning system, and provided key customized meteorological elements for power demand.



Part 04

Others

Energy storage technology

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- **Current situation:** Energy storage technology has entered a rapid development stage and can be applied on the source side, grid side and load side of the power system. In the past five years, the average annual growth rate of chemical energy storage in China has been about 90% , with a total installed capacity of 710,000 kilowatts, of which the installed capacity on the source side accounts for the largest proportion, reaching 49%.

- **Key breakthrough directions:** In the near and medium term, lithium-ion, lead-acid and liquid flow batteries will be the main focus; in the long term, breakthroughs in new generation energy storage technologies such as liquid batteries and superconducting energy storage will be achieved, which will have the characteristics of high safety, long life and low cost to meet the application needs of different scenarios.

Energy storage technology

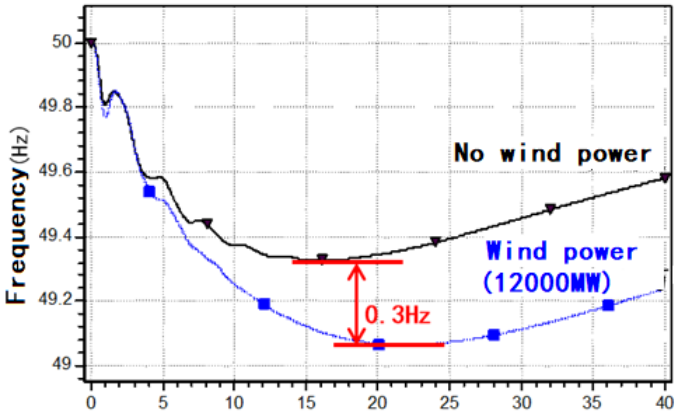
Energy storage type	Key breakthrough directions
Pumped Storage	Research and development of variable speed pumped storage units, manufacturing of high head and large capacity units, construction and operation and maintenance of intelligent pumped storage power stations
Compressed air	New gas storage technology and equipment at supercritical pressure
Electrochemical Energy Storage	Achieve intrinsic longevity, intrinsic safety and efficient large-capacity integration
Phase change thermal storage	Large-scale preparation of low-cost, long-life, high-density heat storage materials, and high-efficiency, low-temperature composite cold storage materials

Energy Storage Technology	Duration	Unit capacity cost		
		2025	2030	2060
Compressed air	Hourly	8000 yuan /kW	7000 yuan /kW	**6500 yuan /kW**
Flywheel energy storage	Minute level	3000-4000 yuan /kW	2000-2500 yuan /kW	1500-2000 yuan /kW
Lithium battery	Hourly	900-1100 yuan /kWh	**500-700 yuan /kWh**	300-400 yuan /kWh
All-vanadium flow battery	Hourly	2500-3000 yuan /kWh	1500-2000 yuan /kWh	1000-1500 yuan /kWh
Sodium-ion batteries	Hourly	1800-2500 yuan /kWh	800-1000 yuan /kWh	**250-300 yuan /kWh**

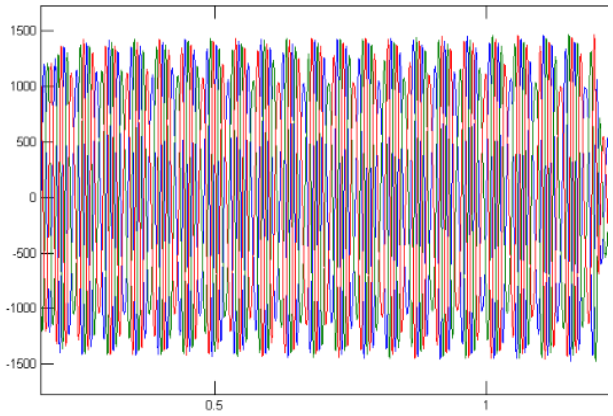
Large scale Renewable Energy Connection & Control

Under the development mode of constructing large renewable energy bases and sending it out through ultra-high voltage DC (UHVDC), the renewable energy base exhibits the characteristics of "high-penetration renewable energy and high-penetration power electronicsthe following 3 risks emerged:

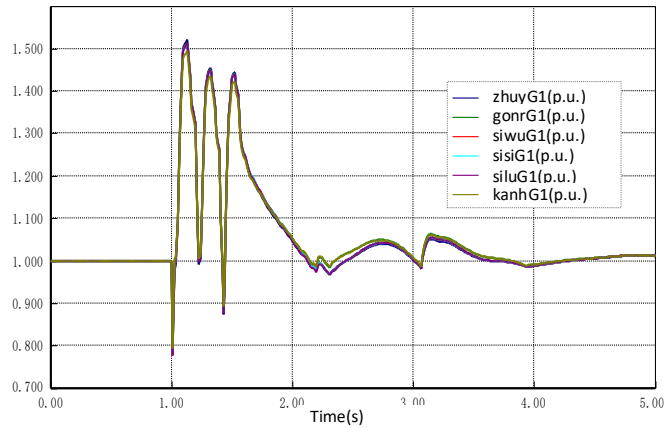
- The inertia decreases and the frequency characteristics change;
- The broadband risks caused by interaction between different power electronics;
- The transient over voltage risk caused by AC/DC.



Weakened frequency regulation capability



Increased broadband oscillation risk

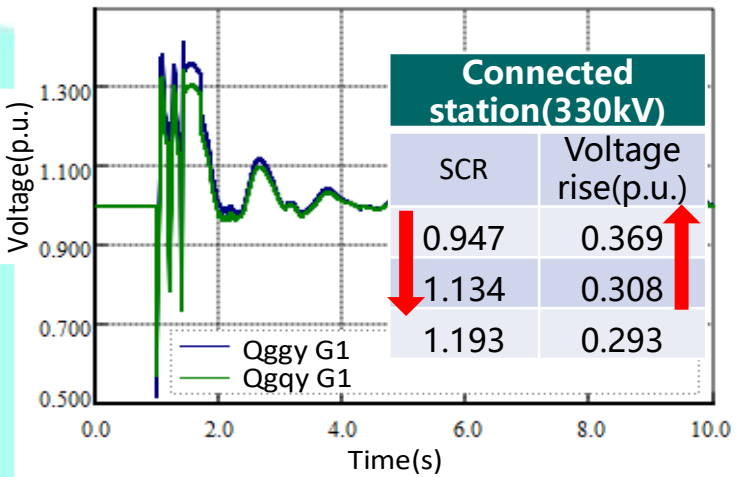


Increased transient over voltage risk

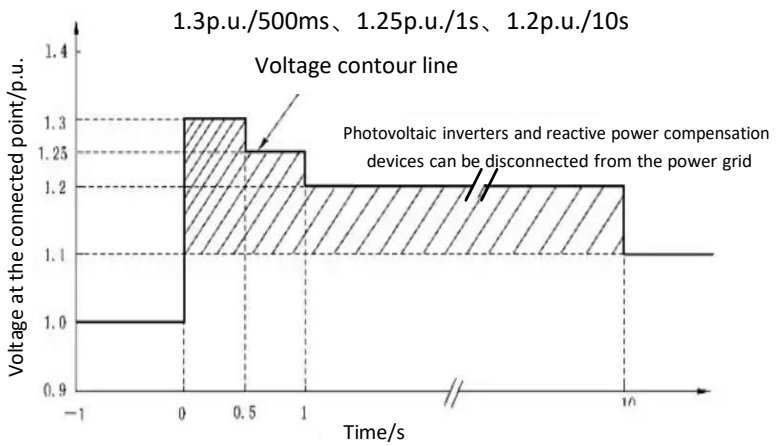
Large scale Renewable Energy Connection & Control

The transient overvoltage problem of the transmission grid is currently the main focus. To ensure voltage stability, SGCC has proposed multiple transient overvoltage suppression techniques, including:

- Mastered the high & low penetration performance requirements of new energy units, and established national standards in accordance with these requirements.
- Proposed optimization strategy for HVDC control parameters to suppress transient overvoltage.
- Proposed centralized and distributed condenser configuration methods.



The lower the short-circuit ratio, the higher the overvoltage level



HVRT performance in GB/T 19964-2024

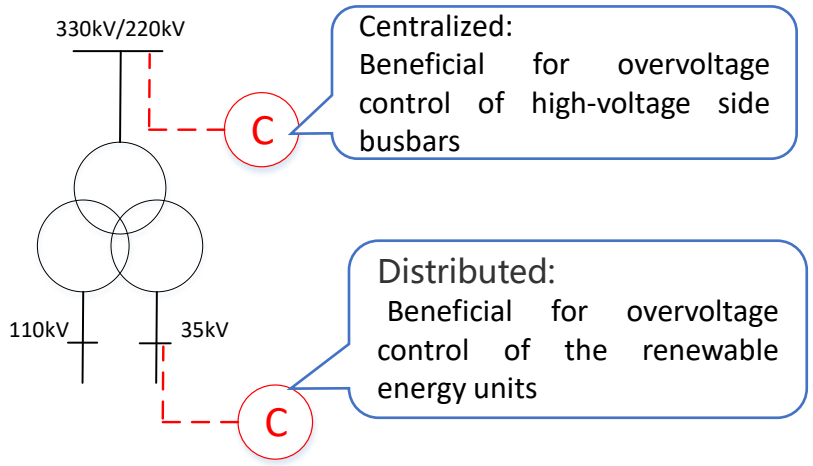


Diagram of condenser configuration

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