SPIC HUANGHE HYDROPOWER DEVELOPMENT CO., LTD.
（“HHDC”）

by **Chairman XIE Xiaoping**

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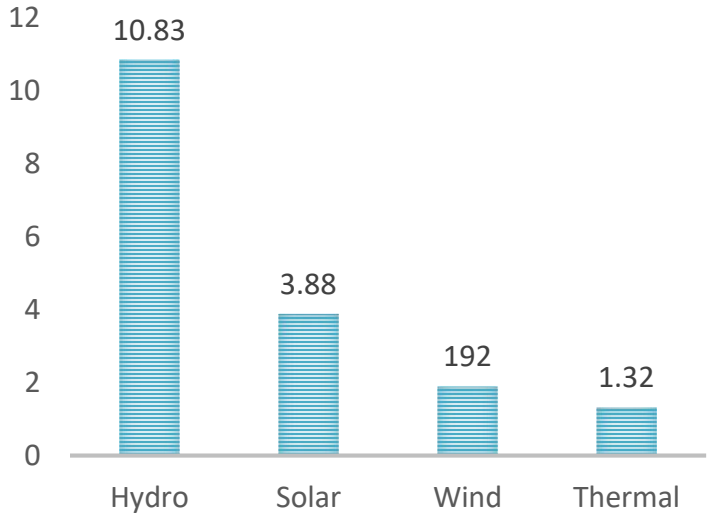
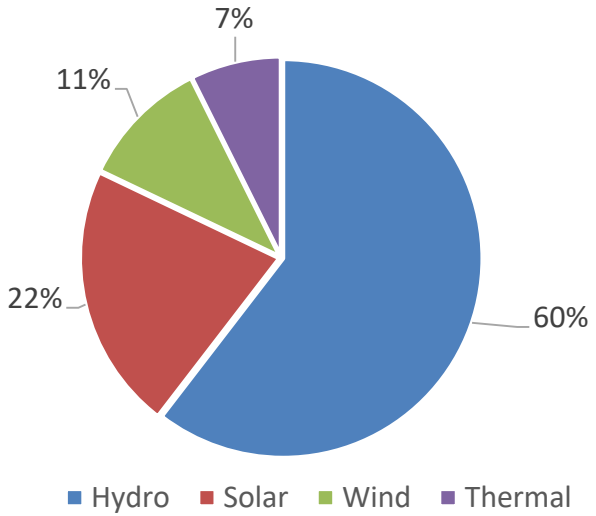
www.hhsd.com.cn

I Company Profile

Installed Capacity





Total installed capacity **17.95**GW

Clean energy proportion **93%**

I Company Profile

Business Scope

Major comprehensive energy company · Total assets of RMB 107.5 bn

Hydro

17 projects

10.83GW

Solar

38 projects

3.88GW

Wind

19 projects

1.92GW

Thermal

1.32GW

II Hydropower Industry

Largest hydropower enterprise in northern China, with hydropower installed capacity over 10 GW

- **Development principles**: *basin, cascade, rolling and integration*
- Created a number of records in China's hydropower construction history
  - some construction indicators meet or exceed domestic and international hydropower construction levels;
  - internationally leading hydropower construction management capability.
- Hydropower stations owned and operated along Yellow River and Datong River: Banduo, Longyangxia, Laxiwa, Lijiaxia, Gongboxia, Suzhi, Jishixia, Yanguoxia, Bapanxia, Qingtongxia, etc.
- **Total hydropower installed capacity** reaches **10.83 GW**.

With years of unremitting efforts, a hydropower base has taken shape at the upper reaches of Yellow River.

II Hydropower Industry

Longyangxia Hydropower Station

- Main functions: flood and ice run prevention, water supply, irrigation, power generation and tourism
- Major power plant of northwestern power grid in China
- Independently designed and constructed by China, represents the highest level of China’ s hydropower project in the 1980s
- Known for its tallest dam, largest reservoir capacity and biggest capacity of single hydro-turbine unit at that time

Installed capacity: 1280MW (320MW ×4)
Annual power generation: 6000GWh
Reservoir capacity: 24.7 bn m^3
COD: 1987
Dam type : concrete gravity arch dam
Max dam height : 178m

II Hydropower Industry

Laxiwa Hydropower Station

- The hydropower station with tallest dam, biggest installation capacity and largest power generation along Yellow River
- Made world record at that time with 750 kV of outlet voltage and 800 kV gas insulation pipeline bus with a height difference of 250 meters
- A pivotal supporting power source for the 750 kV grid of northwestern China.

Installed capacity: 4200MW (700MW × 6)
Annual power generation: 10200GWh for 5 units
Reservoir capacity: 1.079 bn m³
COD: 2009
Dam type : Concrete twin-arch dam
Max dam height : 250m

II Hydropower Industry

Lijiaxia Hydropower Station

Installed capacity: 2000MW (400MW × 5)
Annual power generation: 5900GWh
Reservoir capacity: 1.65 bn m³
COD: 1997
Dam type: 3 centered twin-arch dam
Max dam height: 155m

- The first time China used the double-row units design, which was then the largest hydropower station of double-row units in the world
- new technology utilized for No.4 unit pioneered in China; and the technology of landslide mass, large-tonnage, pre-stressed anchor rope construction was awarded provincial Technical Advancement Prize
- The project was granted with China Construction Engineering Luban Prize （National Prime-quality Project）.

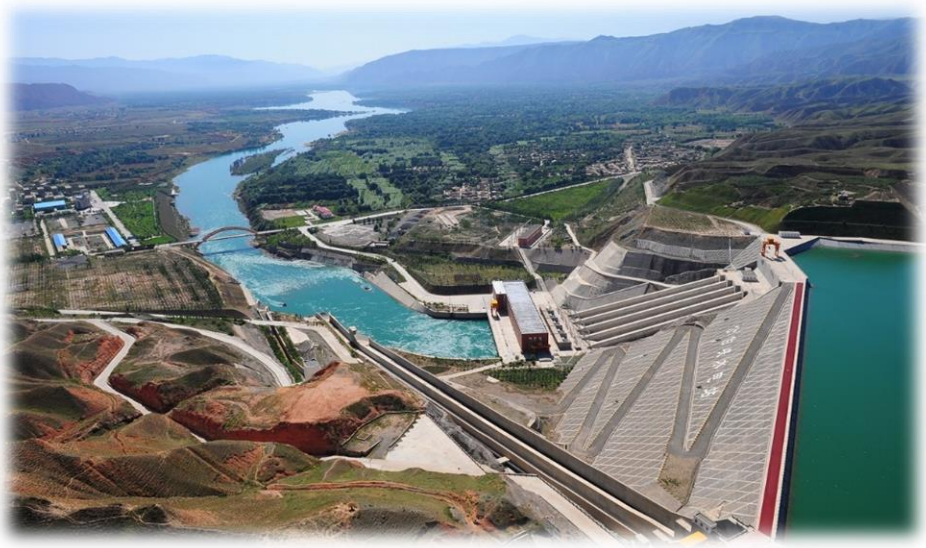
II Hydropower Industry

Gongboxia Hydropower Station

A model project for hydropower station construction in China

Installed Capacity: 1500MW (300MW × 5)
Annual power generation: 5140GWh
Reservoir Capacity: 620 million m³
COD: 2004
Dam type: concrete faced rockfill dam
Max dam height: 132m

- Took 27 months from concreting to COD of first unit, the shortest among similar projects
- Concluded "Eight Practices" during construction, widely recognized and spread in China's hydropower industry
- 32 optimized designs were carried out in the construction
- pioneered in multiple researches and applications of technology at home and abroad
- The first-ever applied concrete extrusion wall technology won the national patent
- Won a lot of honors and awards of provincial and national levels.



III PV Industry

PV Industrial Chain

2500
ton/year

120 mn
slices/year

1100
MW/year

625
MW/year

5.61 mn
ton/year

III PV Industry

Research Background

Energy Security and Environment Protection

- Fossil fuel is drying up
- Human beings are facing energy security issues

Paris Agreement

- Non-fossil fuel accounts for about 15% in 2020
- Non-fossil fuel accounts for about 30% in 2030

Limitations on Conventional Energy

- Thermal: environmental protection, energy consumption
- Hydropower: limited resource, environmental protection, land acquisition

Development of New Energy

- With the advancement of technology, the economic feasibility of new energy is getting higher and higher, and it already has **the ability to compete with fossil energy in some countries and regions.**

National Policy

- The requirements of the 19th National Congress of the Communist Party of China: To establish and improve **an economic system for the development of a green and low-carbon cycle**, to advance the revolution in energy production and consumption, and **to build a clean, low-carbon, safe and efficient energy system**.
- President Xi: To further accelerate the development of the new energy industry and build **PV power** into a pillar industry with **scale, efficiency and market advantages**, making Qinghai to an important new energy industry base in the country.

Problems New Energy Facing

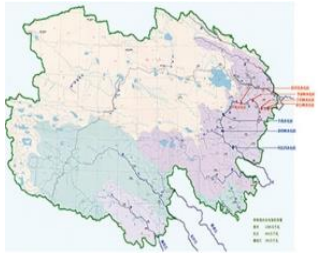
- Imbalance of power output and load
- Fluctuation of power output
- Randomness of power output
- **Above issues needed to be solved for large-scale development through technical aspects**

III PV Industry

Resource Advantages

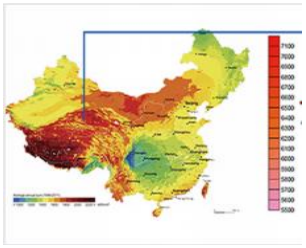
Water Resources

- Qinghai Province, the "Chinese Water Tower", is an important freshwater supply place in China.
- The three major rivers of the **Yangtze River, Yellow River, and Lancang River have an average annual water output of nearly 60 billion cubic meters, maintaining the lifeline of water ecology security in the country and even in Asia.**
- **Qinghai is rich in hydropower resources, with a total reserves of 21.87 million kW, accounting for about 3% in the country.**
- The section from Longyangxia to Qingtongxia section in the upper reaches of the Yellow River, is one of the 13 largest hydropower bases in China.



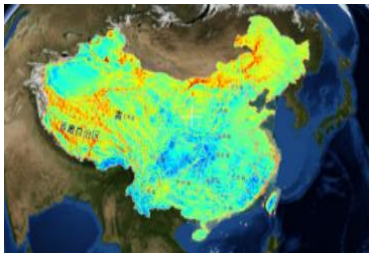
Solar & Land Resources

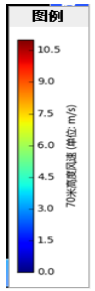
- The annual average total radiation of Qinghai can **reach 5500~7400MJ/㎡**, second only to Tibet, **ranking second in China**
- The area of unused decertified land in Qinghai is about **100,000 square kilometers**, which is a resource advantage for building large-scale grid-connected PV power stations.
- **Under current technology, 3700 GW of PV power plants can be constructed, with an annual power generation of 5900 TWh**



Wind Resources

The wind resource technically developable, with average annual wind power density of 200 W/ m^2 at the height of 70 meters, can reached **75,550 MW**.





III PV Industry

Solar Cell and Module Project

- Production capacity
  high-efficiency solar cell 1100 MW
  high-efficiency solar module 625MW
- HHDC's cell and module **conversion efficiency** is at the world leading level

  Mass-produced PERC bifacial cell overlaid SE + thermal oxidation ＞22.2%
  Mass-produced TOPCon cells ＞ 22.6%.
- Built the first 200 MW N-type IBC cell and module project in China with low cost, large capacity and conversion efficiency greater than 23%.

  The experimental IBC cell has been tested by Japan JET with an efficiency of 23.47%. by the National PV Industry Measurement and Testing Center of Fujian Province with an efficiency of 23.54%

  The technology has reached the world leading level.

III PV Industry

Development History of Solar PV Projects

2011
- Golmud 200 MW power station, the largest single MW power station in the world
- sets the design and construction standard for PV power stations on hundred megawatt level.

2013
- Cooperated with HUAWEI to set up an innovation center
- String inverters were applied on a large scale basis for the first time
- 4G network, power line carrier, and Bluetooth technology were also used

2015
- Golmud 200 MW smart PV power station
- release technology of smart PV power plant to the world.

2014
- Research on large-scale hydro-solar power hybrid technology
- certified as world leading by the National Energy Administration

2016
- The largest Hundred-Megawatt Solar Power Demonstration Base in the world,
- demonstrated, compared and analyzed 148 technical routes

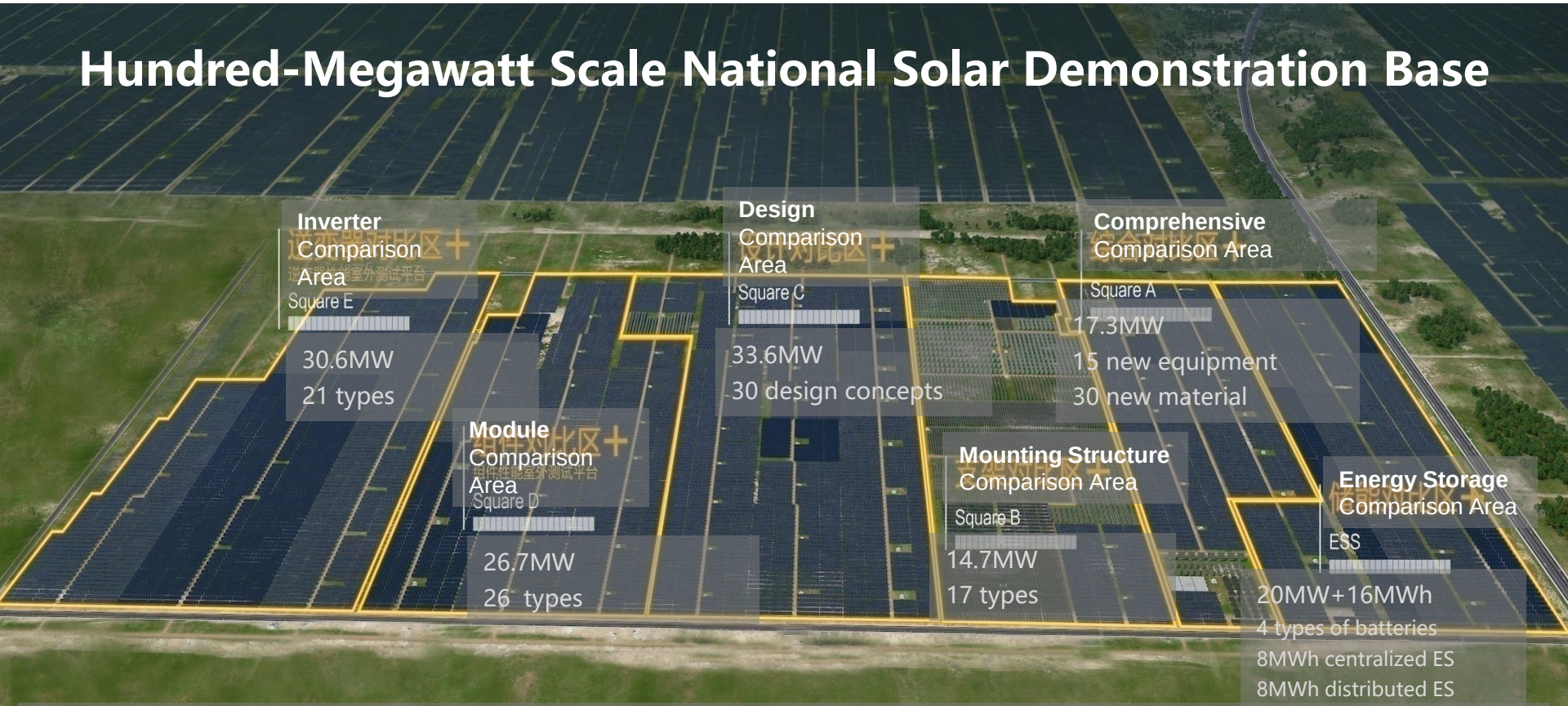
2017
- Golmud 100 MW bifacial module PV power station
- promoted large-scale application of N-type bifacial modules.

2018
-N-type bifacial modules, PERC bifacial module + flat single-axis mounting structures used
- launch the IV one-button detection function and bifacial modules with transparent back sheet.

2019
- Started construction of the single largest 3 GW PV power station.
- Construct the large base of "Four Unifications ", with integrated design and integrated manufacturing
- Build supporting energy storage systems

III PV Industry

Hundred-Megawatt Scale National Solar Demonstration Base



The largest hundred-megawatt large-scale outdoor demonstration base in the world.

148 technologies and types compared in the same platform, covering mainstream technologies and productions of PV industry in the world.

Hundred-Megawatt Scale National Solar Power Demonstration Base

Data Acquisition and Analysis Platform

Crystalline silicon reference

IV data

Inverter data

Real-time collection

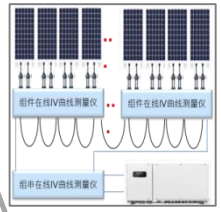
(More than **4,000** measuring devices in **32 categories**)

High-precision power generation

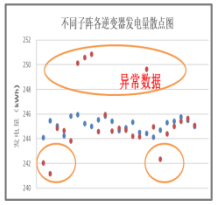
Full weather data

Module temperature

Match loss calculation

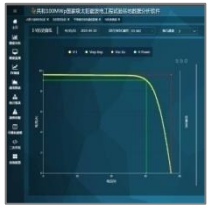


Real-time Analysis



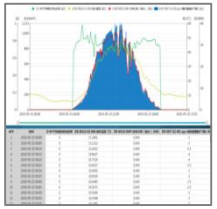
Data screening

Custom develop software

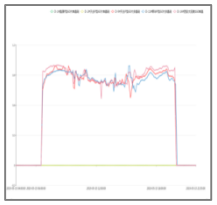


Real-time Comparison

Build 44 analysis models



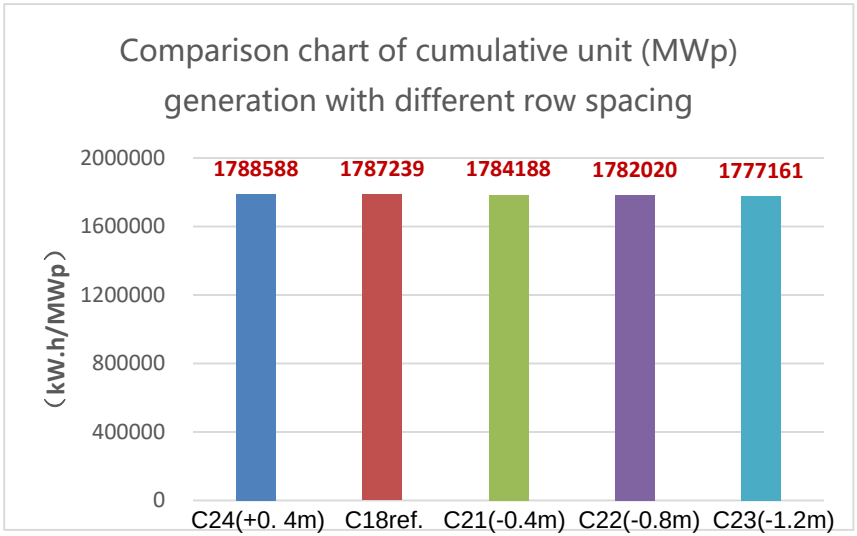
Automatic analysis and comparison report

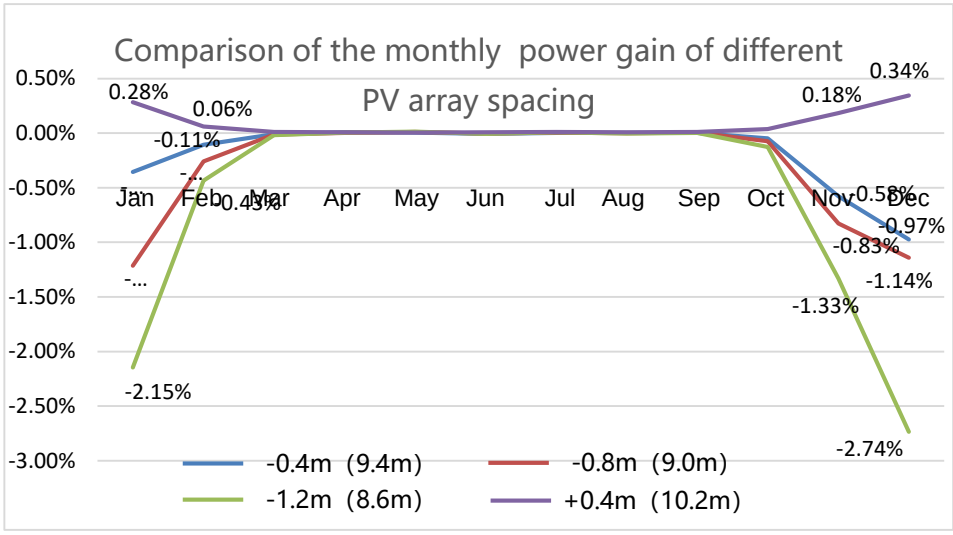


III PV Industry

Hundred-Megawatt Scale National Solar Power Demonstration Base

Design Comparison Areas – Comparison of power generation of different row spacing



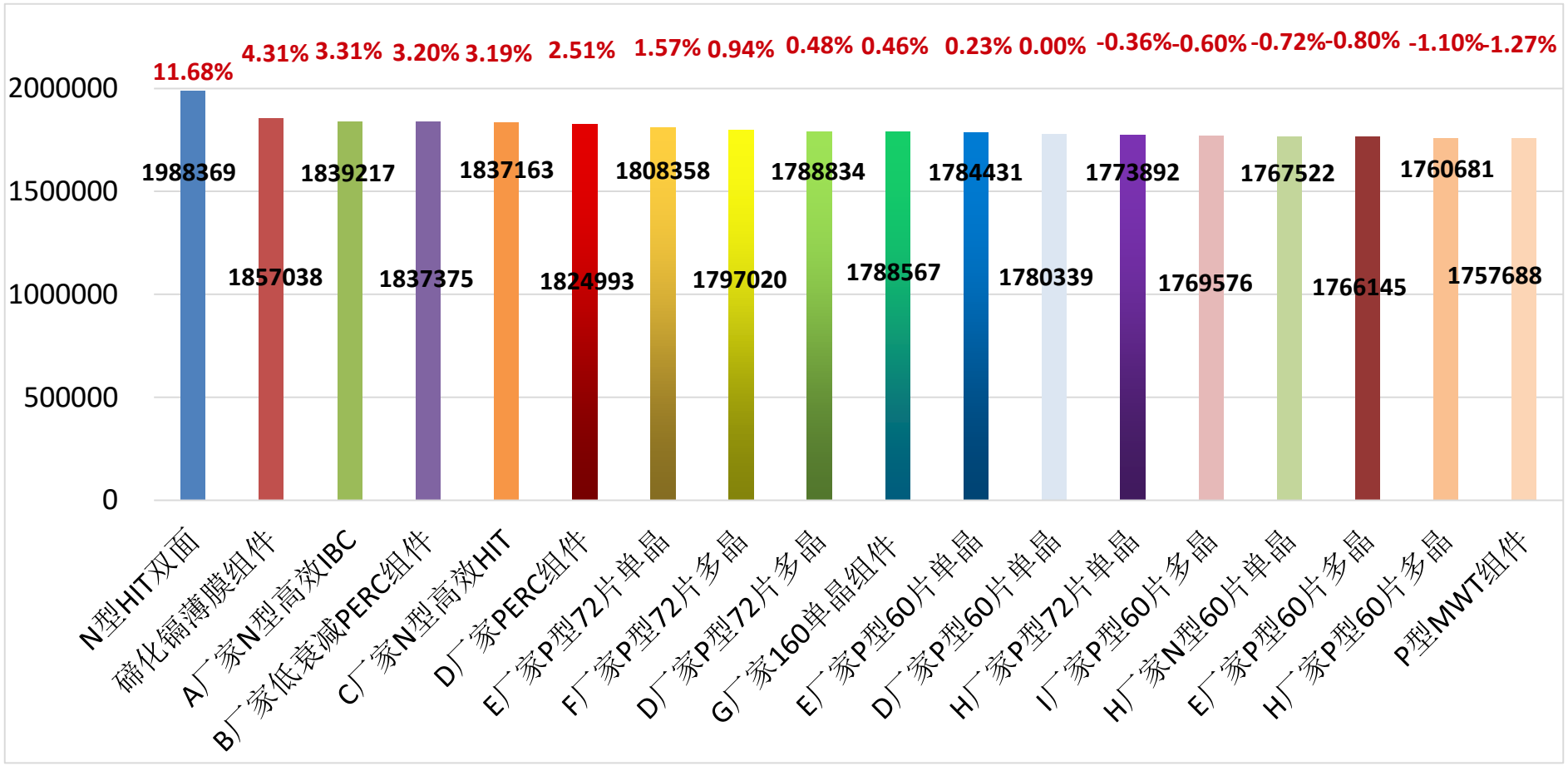


Design Method	-0.4m (9.4m)	-0.8m (9.0m)	-1.2m (8.6m)	+0.4m (10.2m)
Power Gain	-0.17%	-0.29%	-0.56%	0.08%

- Small difference of power generation in summer, but large difference of that in winter.

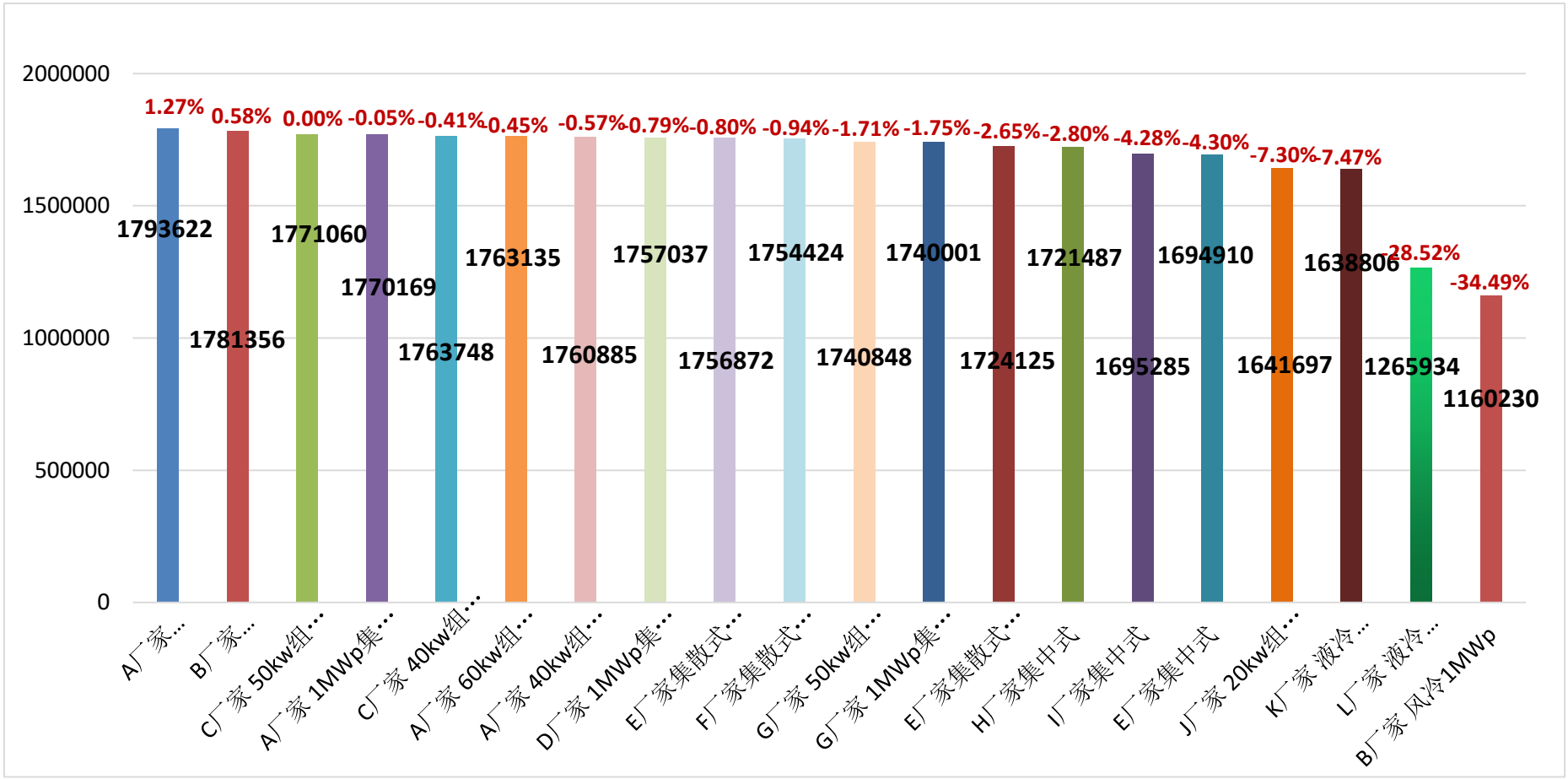
Hundred-Megawatt Scale National Solar Power Demonstration Base

Module Comparison Area: Comparison of cumulative unit (MW) power generation in 2018 （kWh)



Hundred-Megawatt Scale National Solar Power Demonstration Base

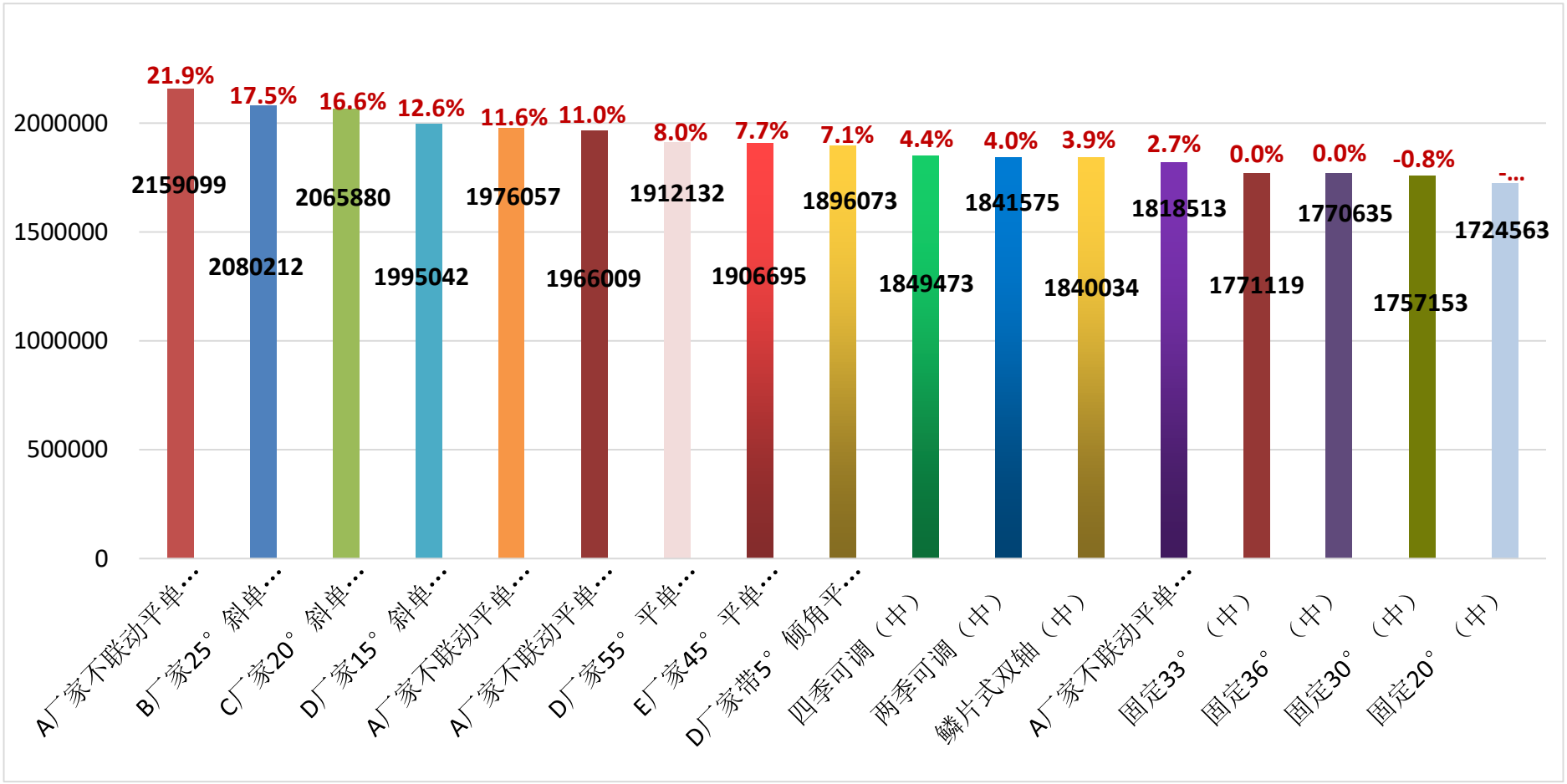
Inverter Comparison Area: Comparison of cumulative unit (MW) power generation in 2018 （kWh)



Hundred-Megawatt Scale National Solar Power Demonstration Base

Mounting Structure Comparison Area:

Comparison of cumulative unit (MW) power generation in 2018 （kWh)



IV Research on Clean Energy Hybrid

Application Research on Hydro + Solar + Wind + ES Multi-Energy Hybrid

Hydro

4160 MW

Yangqu, Banduo and Cihaxia hydropower stations

Solar

4000 MW

Solar PV park in Hainan Prefecture

Wind

2000 MW

Wind generation area in Qieji, Hainan Prefecture

Energy Storage

Tara and Qieji in Hainan Prefecture

Conduct research on the complementary characteristics of clean energy, with applications of hydro, solar, wind and ES hybrid as guidance, based on empirical data.

17

Large, medium & small scale

Kaplan, Francis, tubular

Regulation multi-year/yearly, quarterly/monthly, and daily basis

38

Hydro-solar power Hybrid

Demonstration Base

19

Cover all mainstream models;

Unit size: 50~850MW

3

Cover multiple ES technologies;

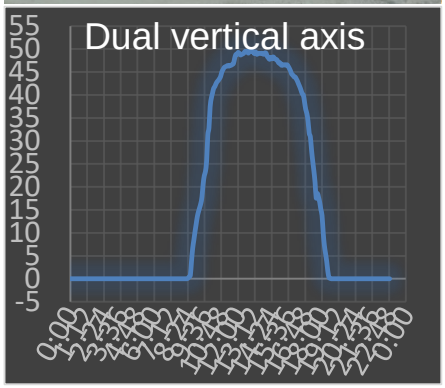
Solar + ES

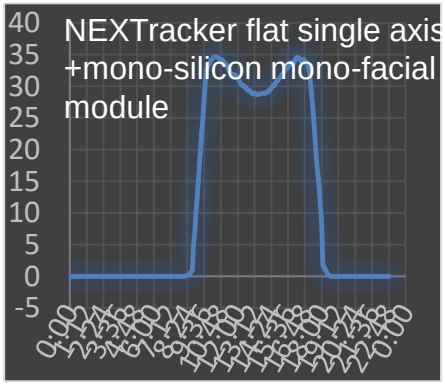
Wind + ES

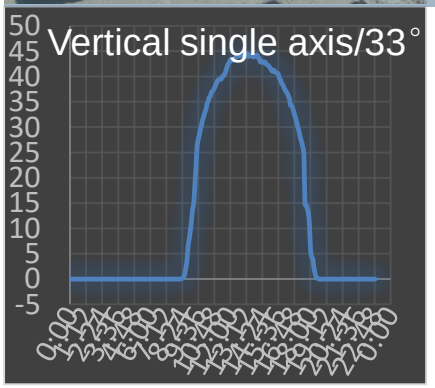
IV Research on Clean Energy Hybrid

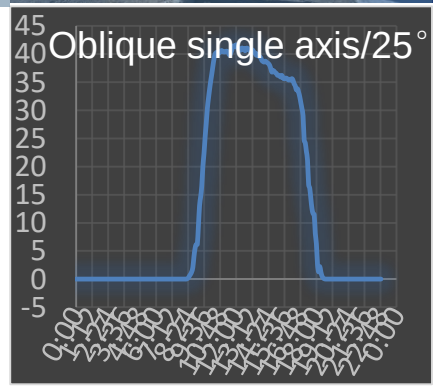
Research on Solar Characteristic

- **Typical power output curve of different types of solar plant**





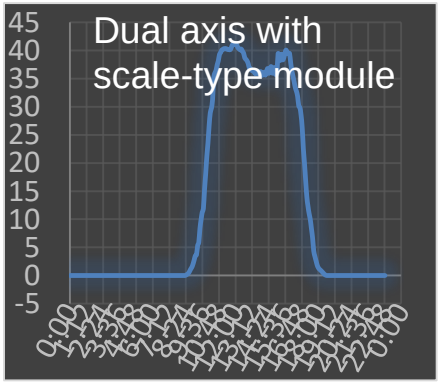


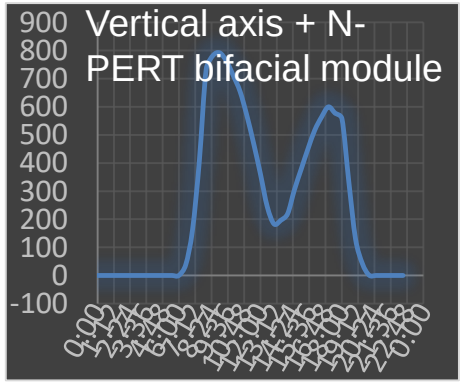


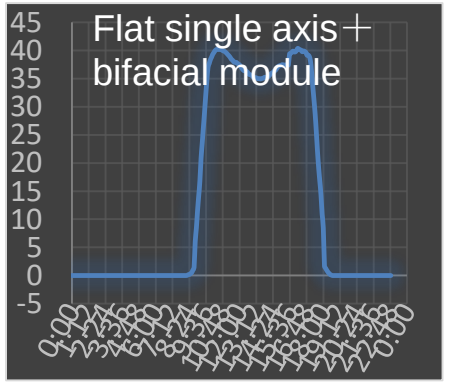
IV Research on Clean Energy Hybrid

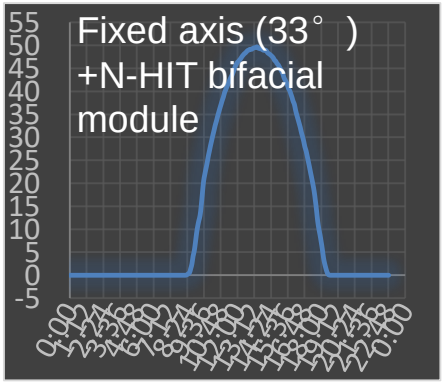
Research on Solar Characteristic

- **Typical power output curve of different types of solar plant**





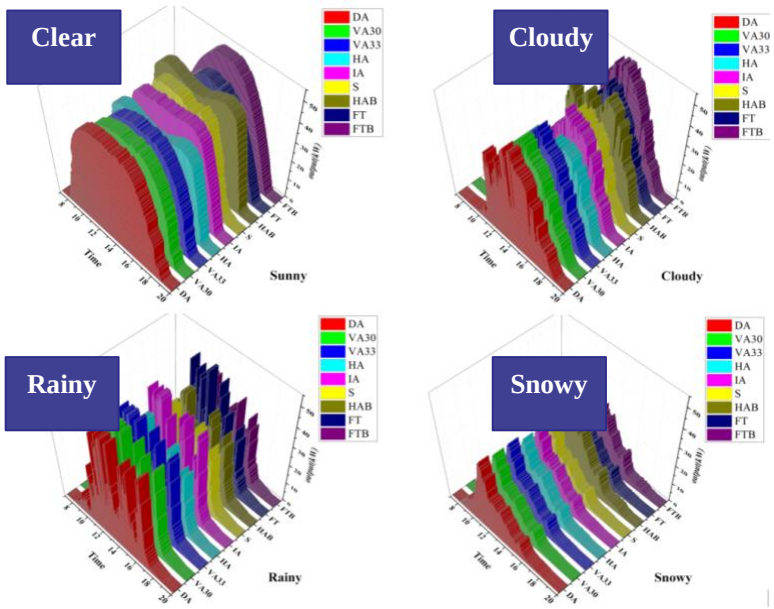




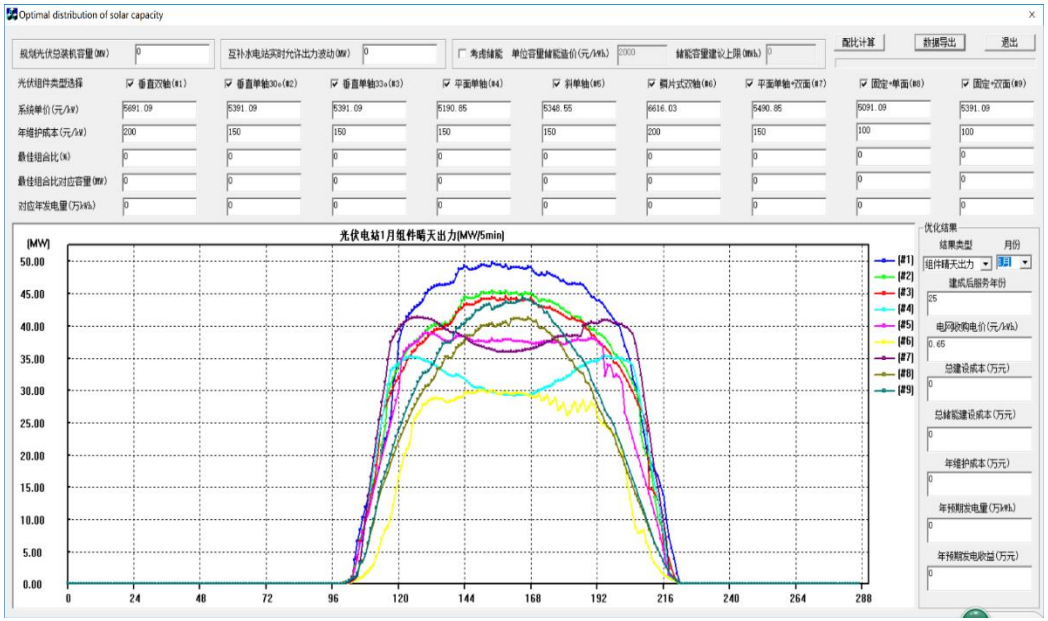
IV Research on Clean Energy Hybrid

Research on Solar Complementation with Different Types of Design Combination

- **Different Solar power output curves in typical weather**



- **Research on complementarity of solar power output with different scale**



- **Reasonably design the capacity using the complementarity characteristic of solar itself, to enhance the economy of solar power plant, reduce output fluctuation range, improve the feasibility of multi-power hybrid.**

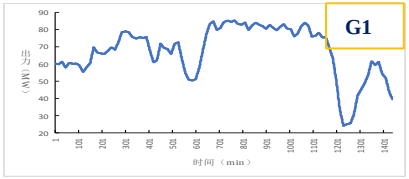
IV Research on Clean Energy Hybrid

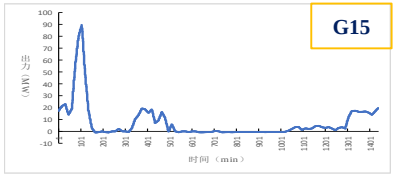
Research on Wind Power Characteristic

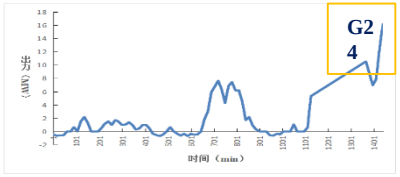
■ Reserch on power output characteristic of wind power plant

The classfication of typical power output curves based on evaluation index of wind power characteristic

SN	Category	SN	Category	SN	Category
G1	high output and generation in spring	G9	high output and low generation in summer	G17	low output and medium generation in autumn
G2	high output and medium generation in spring	G10	low output and high generation in summer	G18	low output and generation in autumn
G3	high output and low generation in spring	G11	low output and medium generation in summer	G19	high output and generation in winter
G4	low output and high generation in spring	G12	low output and generation in summer	G20	high output and medium generation in winter
G5	low output and medium generation in spring	G13	high output and generation in autumn	G21	high output and low generation in winter
G6	low output and generation in spring	G14	high output and medium generation in autumn	G22	low output and high generation in winter
G7	high output and generation in summer	G15	high output and low generation in autumn	G23	low output and medium generation in winter
G8	high output and medium generation in summer	G16	low output and high generation in autumn	G24	low output and generation in winter







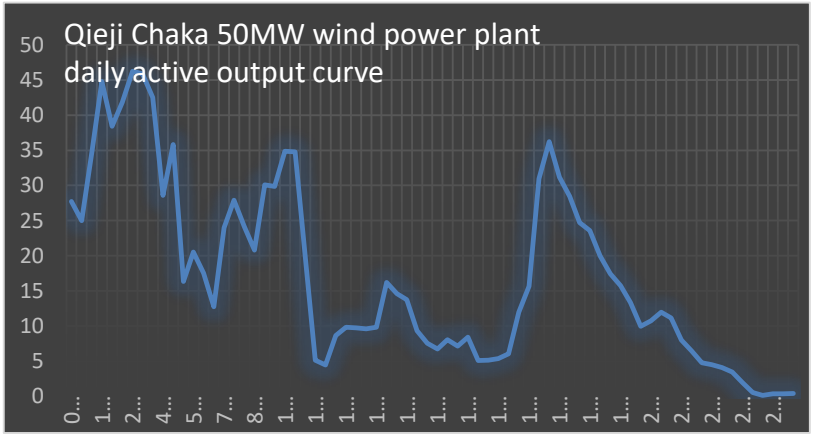
➢ **Obtain 24 types of daily output curves of typical wind power plant through evaluating its daily characteristic considering seasonal characteristic, daily output and generation characteristic.**

IV Research on Clean Energy Hybrid

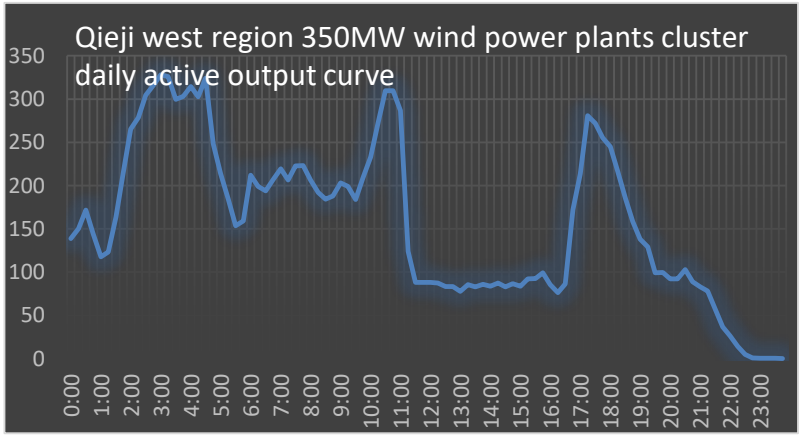
Research on Wind Power Complementarity

- **Research on wind power complementarity under regional synergy & control**

Single wind power plant of 50MW in Qieji



Wind power plants cluster of 350MW in Qieji



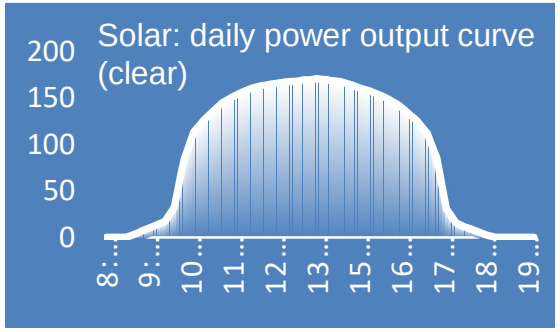
➢ **Considering the wake flow and other effects of the wind power plants cluster in the same region, and through regional synergy and control, improve the complementation performance of the wind turbines, realizing the complementary operation of the wind power plants in the same region.**

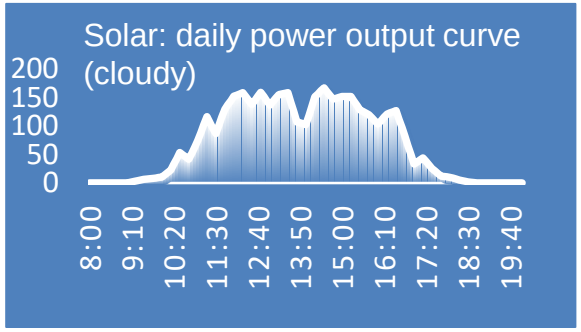
IV Research on Clean Energy Hybrid

Research on Solar-wind Power Hybrid Characteristic

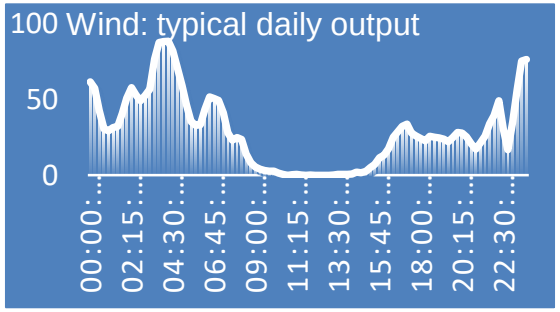
- **The daily power output complementarity of solar and wind**

➢ **The daily output characteristics of solar and wind power in the upstream of the Yellow River are naturally complementary.**

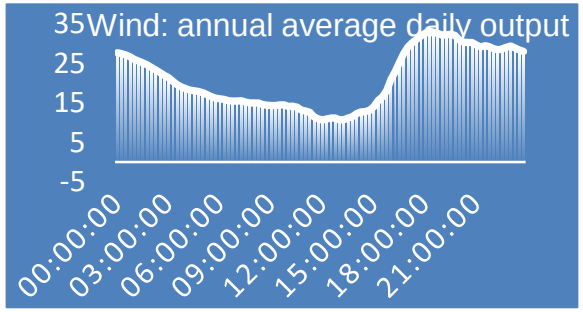




Typical daily power output curve



Annual average daily output curve



IV Research on Clean Energy Hybrid

Research on Solar-wind Power Hybrid Characteristic

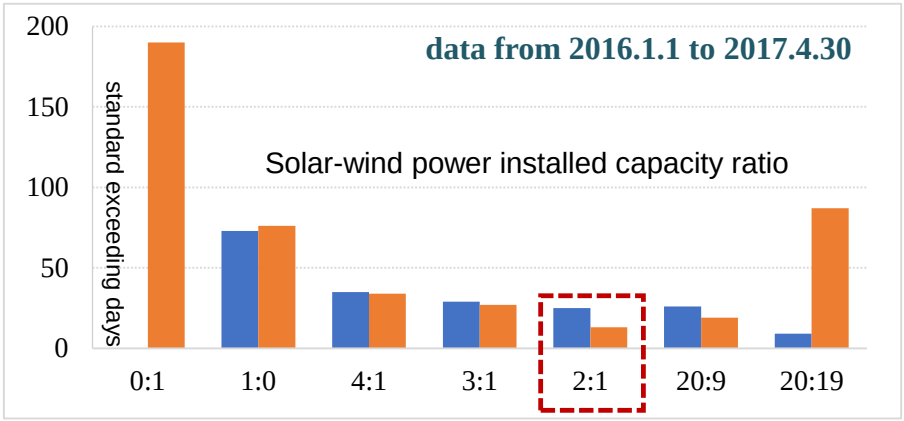
- **The capacity ratio for complementation of solar and wind**

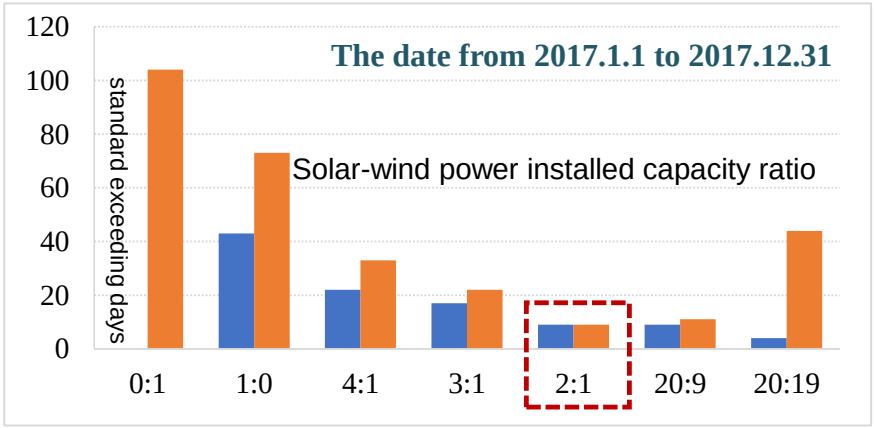
Requirements for grid connection:

Solar: Active power variation in 1min shall not exceed 10% of installed capacity

Wind: The maximum active power variation in 10min and 1min shall generally not exceed 33% and 10% of installed capacity

Statistics of Solar PV and Wind Power Output Fluctuation under Different Capacity Ratio





number of days exceeding the standard with maximum fluctuation rate in 1 min

number of days exceeding the standard with maximum fluctuation rate in 10 min

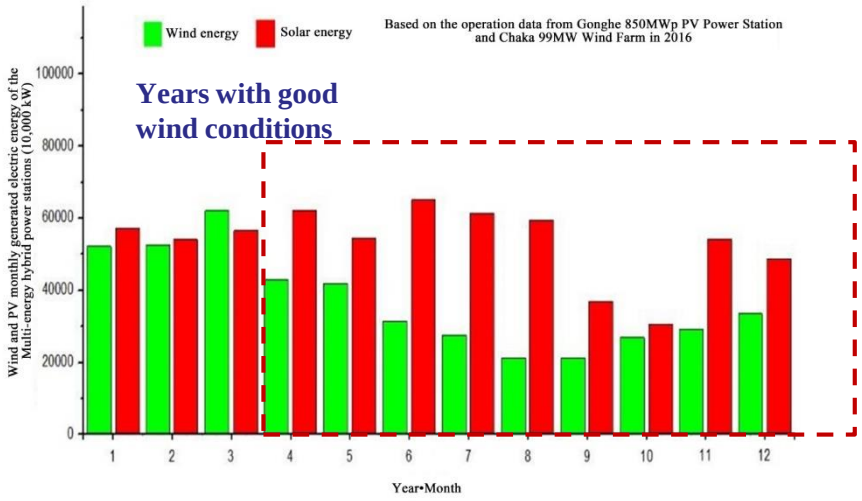
- **Based on the *Technical Rule for PV Power Stations/Wind Farms Connected to Power Grid***
- **To minimize number of days for output fluctuations exceeding the standard**
- **the complementarity of power output could be relatively optimal when the installed capacity ratio of solar and wind power is close to 2:1 in the upper reaches of the Yellow River area.**

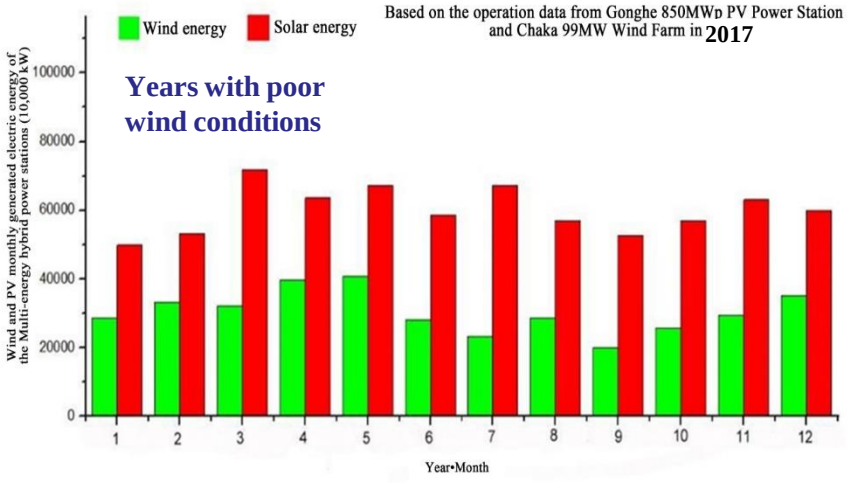
IV Research on Clean Energy Hybrid

Research on Solar-wind Power Hybrid Characteristic

- **Complementarity on annual output of solar and wind power**

Monthly power generation of 4 GW Solar PV Project and 2 GW Wind Power Project



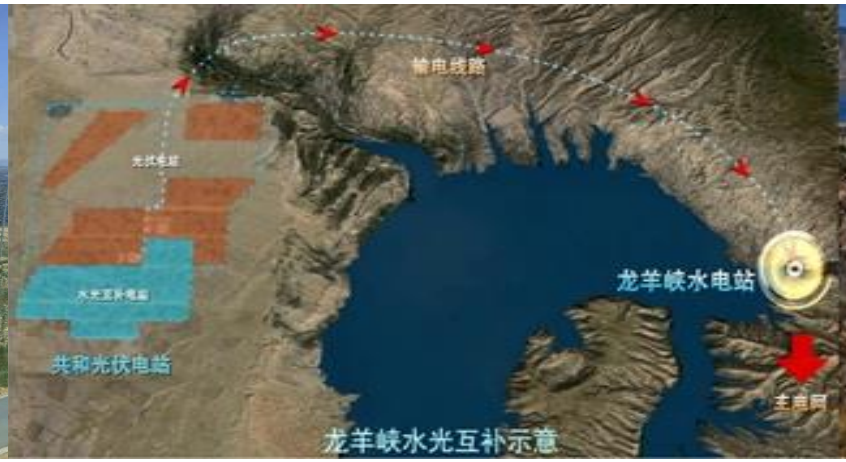


- **According to the monthly power generation, wind power and solar PV in the upper reaches of the Yellow River are complementary in the power generation on a seasonal basis.**

IV Research on Clean Energy Hybrid

Research on Hydro-Solar Power Hybrid Characteristic

850MW Solar Power Station	Hydro-Solar Power Hybrid	Longyangxia Hydropower Station



Location: Gonghe County, Hainan Prefecture, Qinghai Province

Area:24 km^2

50km away from Longyangxia Hydropower Station

Designed annual average power generation is 1434GWh

Annual utilization hours: 1687 hours.

The Hydro-solar Power Hybrid Project is connected to the standby incoming line interval of Longyangxia Hydropower Station via 330kV overhead line (54km) and regulated by hydraulic turbine generator units.

The regulated power is transmitted to the power grid via the transmission line of Longyangxia Hydropower Station.

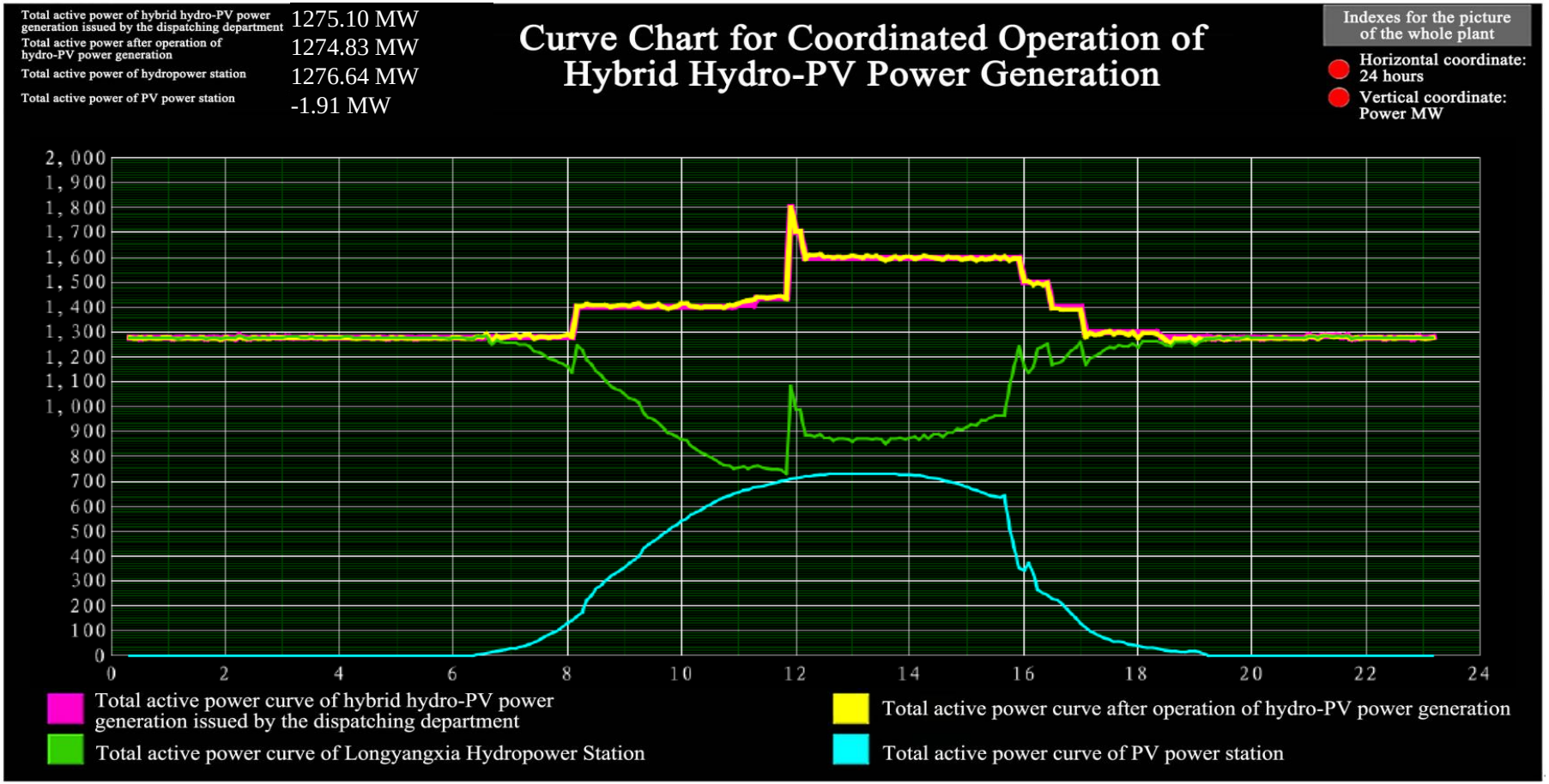
The hydropower station is located on the main stream of Yellow River, and at the boundary of Gonghe and Guinan counties of Qinghai Province.

Total installed capacity as 1280MW, with 4 units of 320MW hydro generator.

IV Research on Clean Energy Hybrid

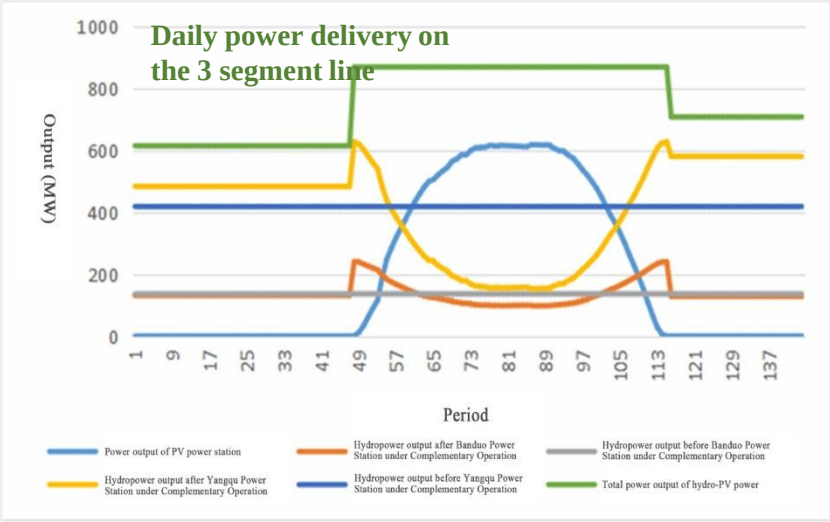
Research on Hydro-Solar Power Hybrid Characteristic

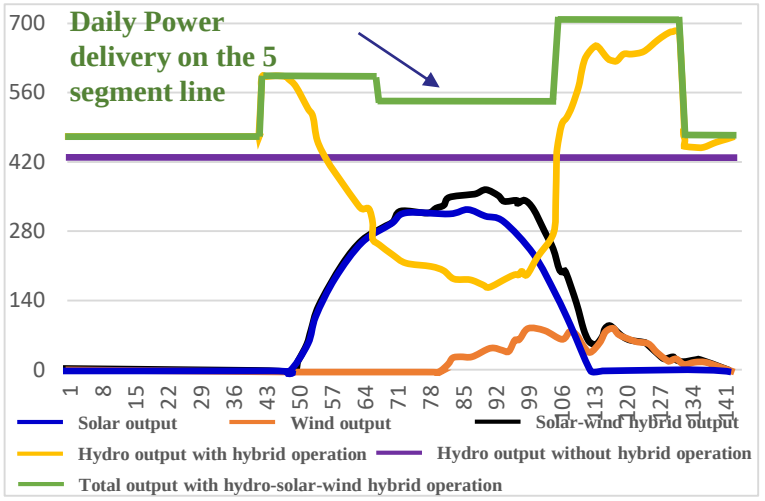
- **Performance of hydro-solar power hybrid operation**



IV Research on Clean Energy Hybrid

Research and Application on Multi-Power Hybrid of Hydro, Wind, Solar





- **According to the characteristics of hydro-solar hybrid power delivery demand in the upper reaches of the Yellow River, two scenarios are set for the power delivery demand of the "3 segment line" (long-distance UHV delivery) and "5 segment line" (local consumption).**

IV Research on Clean Energy Hybrid

Research on Application of Energy Storage System in Power Station

Power Generation System

Fixed + mono-facial/Bifacial
Flat Single-axis + mono-facial/ Bifacial
Oblique single axis + mono-facial /Bifacial
Vertical+ Bifacial

Direct-driven
Doubly-fed
Multi-brid
2.0/2.2/2.5MW

Energy Storage System

DC/AC side

Lithium iron phosphate
Ternary lithium
All vanadium redox flow

Centralized/Distributed

Mode of Operation

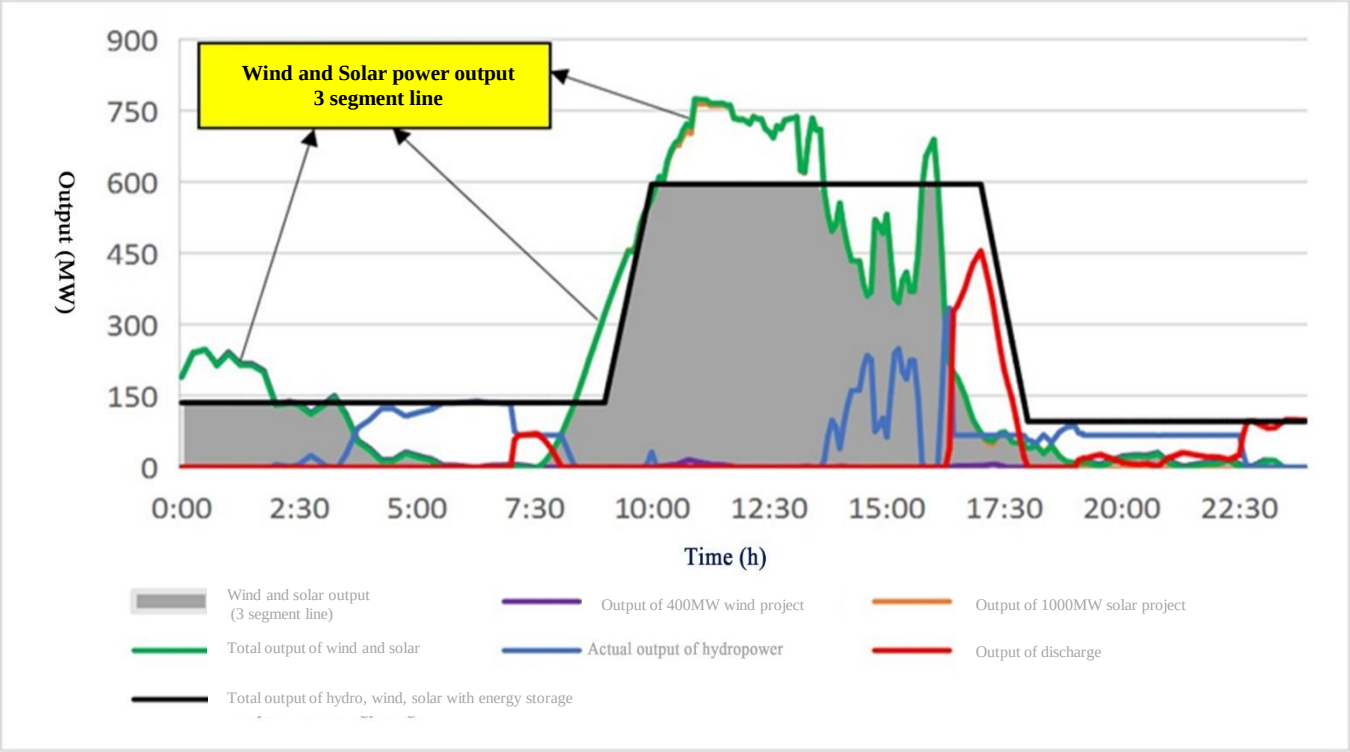
20%/25%/30% power curtailment
Energy transfer
Peak & frequency regulation
Smoothing & tracking output

Energy transfer
Peak & frequency regulation
Smoothing & tracking output

Study on integrated application and optimal configuration:
energy storage system + power generation system + multi-power hybrid system

IV Research on Clean Energy Hybrid

Research on Complementarity of Hydro, Solar, Wind and Energy Storage



- **With the rapid regulation of the energy storage system, peak regulation and output tracking can be realized.**

IV Research on Clean Energy Hybrid

Research on Complementarity of Hydro, Solar, Wind and Energy Storage

Cascade Stages	Hybrid Capacity-PV (MWp)	Hybrid Capacity-Wind (MW)	Total Capacity (PV + Wind) (MW)
Banduo	167	83	250
Yangqu	833	417	1250
Banduo-Yangqu cascade	1000	500	1500
Cihaxia	2600	1300	3900
Cihaxia-Banduo-Yangqu cascade	**3600**	**1800**	**5400**

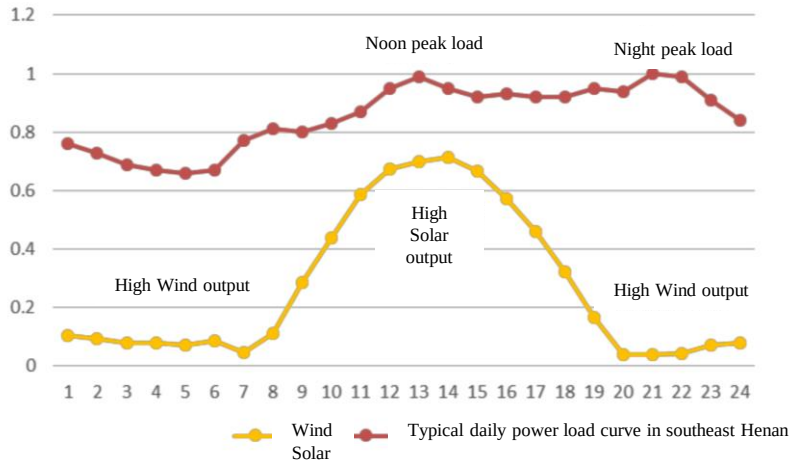
- Based on calculation with capacity ratio of solar and wind power as 2:1, the feasible total wind-solar hybrid installed capacity for the Cihaxia-Banduo-Yangqu cascade hydropower stations is 5,400MW.
- It is feasible to reach 6,000MW by configuration of energy storage system with proper capacity in the power stations.

IV Research on Clean Energy Hybrid

Power Supply for Qinghai Hainan - Henan Zhumadian UHV DC

- China has vast territory, there is 2 hours' time difference of the power load period in Qinghai and the east region, with a good match between the peak power generation at the outgoing delivery side and the noon peak load at the electricity demand side.
- Increase the proportion of non-fossil energy and improve the renewable energy utilization.
- Strengthen the overall planning of power supply and power grid, and scientifically arrange the supporting capabilities of peak regulation, frequency regulation and energy storage, which can effectively solve the problems of wind and solar waste.

Planning of Qinghai UHV Outgoing Channel: the first channel started construction during the 13th Five-Year Plan for Economic and Social Development of China, the second channel is planned during the 14th Five-Year Plan



Matching characteristics of unregulated new energy power supply and receiving end load

V Research on Ecological Environment Impact of Large-scale PV Power Stations

Value the ecological environment protection of the entire life of PV Power Stations

Planning stage: Take desertified land and degraded grasslands as project site.

Design stage: adapting to local conditions, combining prevention and control, scientific configuration, and protecting vegetation. Relevant research has been carried out on bracket foundation, equipment selection, and grounding network structure.

Construction stage: unified planning for the temporary buildings, realizing regional management, reducing artificial disturbance during the process, and focusing on ecological environment protection.

Operation stage: Treat the wastewater, residue, exhaust gases well, value green maintenance on the site, and carry out research on the impact of PV power plant construction on local ecological environment.




V Research on Ecological Environment Impact of Large-scale PV Power Stations

Environmental Monitoring Station in Demonstration base

- **Monitoring Station layout:**
  - 1# Operation, demonstration base
  - 2# Construction planning area
  - 3# Off-site comparing area
- **Analysis indicators:**

  wind speed, wind direction, temperature, air humidity, rainfall, soil composition, vegetation, etc.

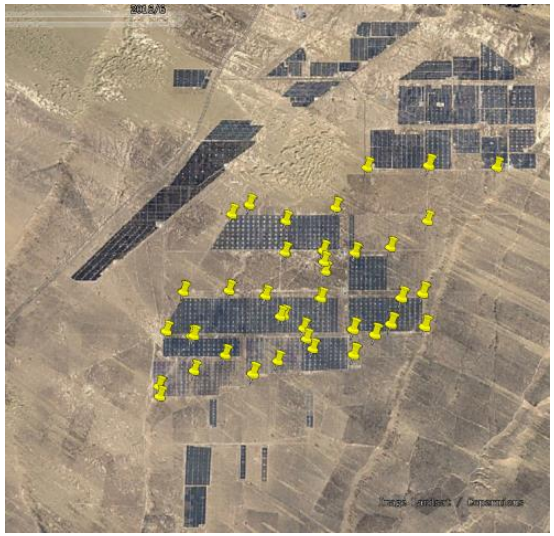
Station 1#

Station 2#

Station 3#

V Research on Ecological Environment Impact of Large-scale PV Power Stations

◆ **Analysis based on test results of soil samples on the project site**



Soil **samples collection**: 68 points; depth 0-5-20M; two rounds of collection in August and December 2018

Soil **index test**: organic matter, total nitrogen, total phosphorus, available phosphorus, available potassium

V Research on Ecological Environment Impact of Large-scale PV Power Stations

- **Study on the interaction between large-scale PV Power development and regional ecological environment**

Construction of large-scale PV stations

PV convert solar energy into electricity, which has **changed the energy distribution of local area**. With the continuous expansion of the scale, **the ecological elements of local and surrounding areas need to be studied**.

01 **Climatic element**
Micro-climate regulation

02 **Soil element**
Water and soil function regulation

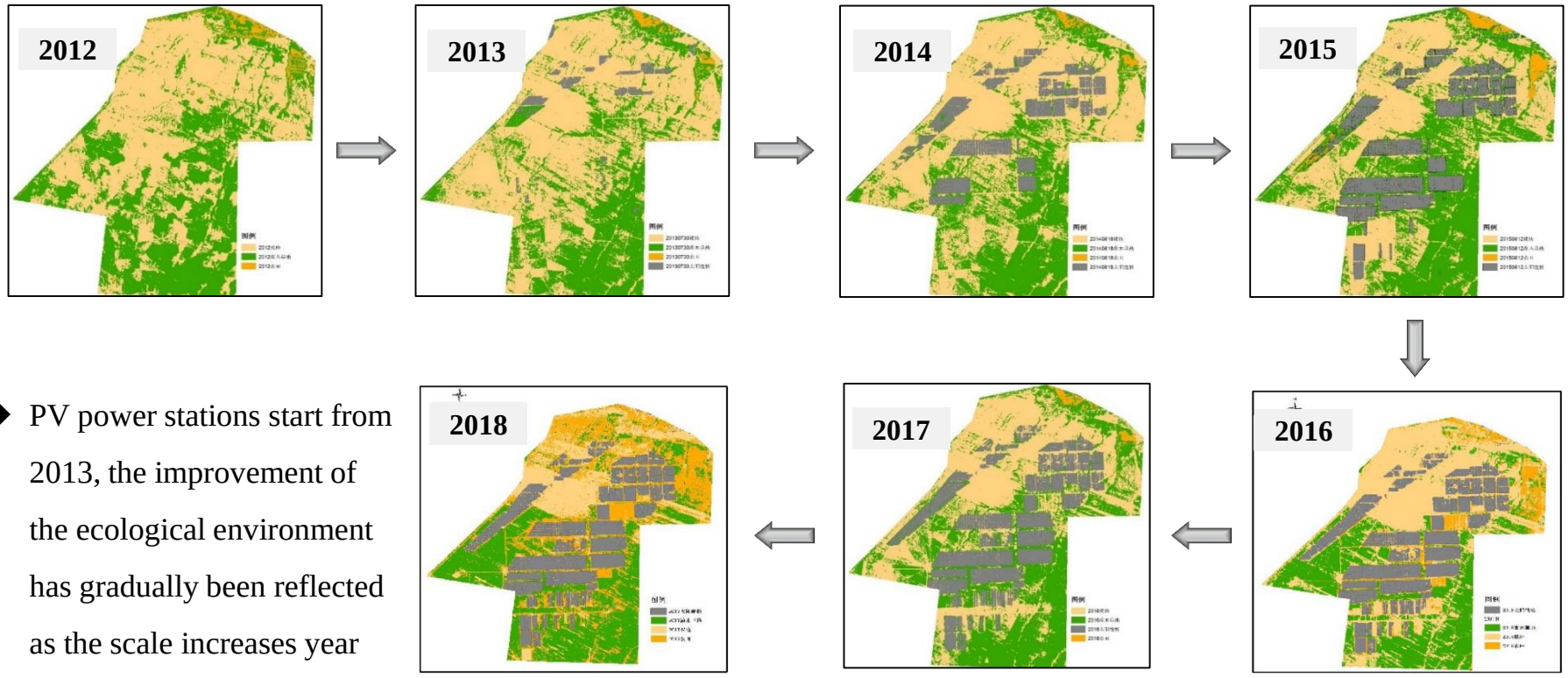
03 **Vegetation elements**
Vegetation restoration and reconstruction

Qualitative judgment	**Regional ecological environment improvement**
Quantitative Study	**Influence factors, interaction and mechanism**

Considering the new requirements of ecological development during construction of large-scale PV power plants, **quantitatively study the eco-environment effects, explore and achieve a win-win situation** of ecological environment restoration and solar power development, which is the social responsibility and key issue for PV companies.

V Research on Ecological Environment Impact of Large-scale PV Power Stations

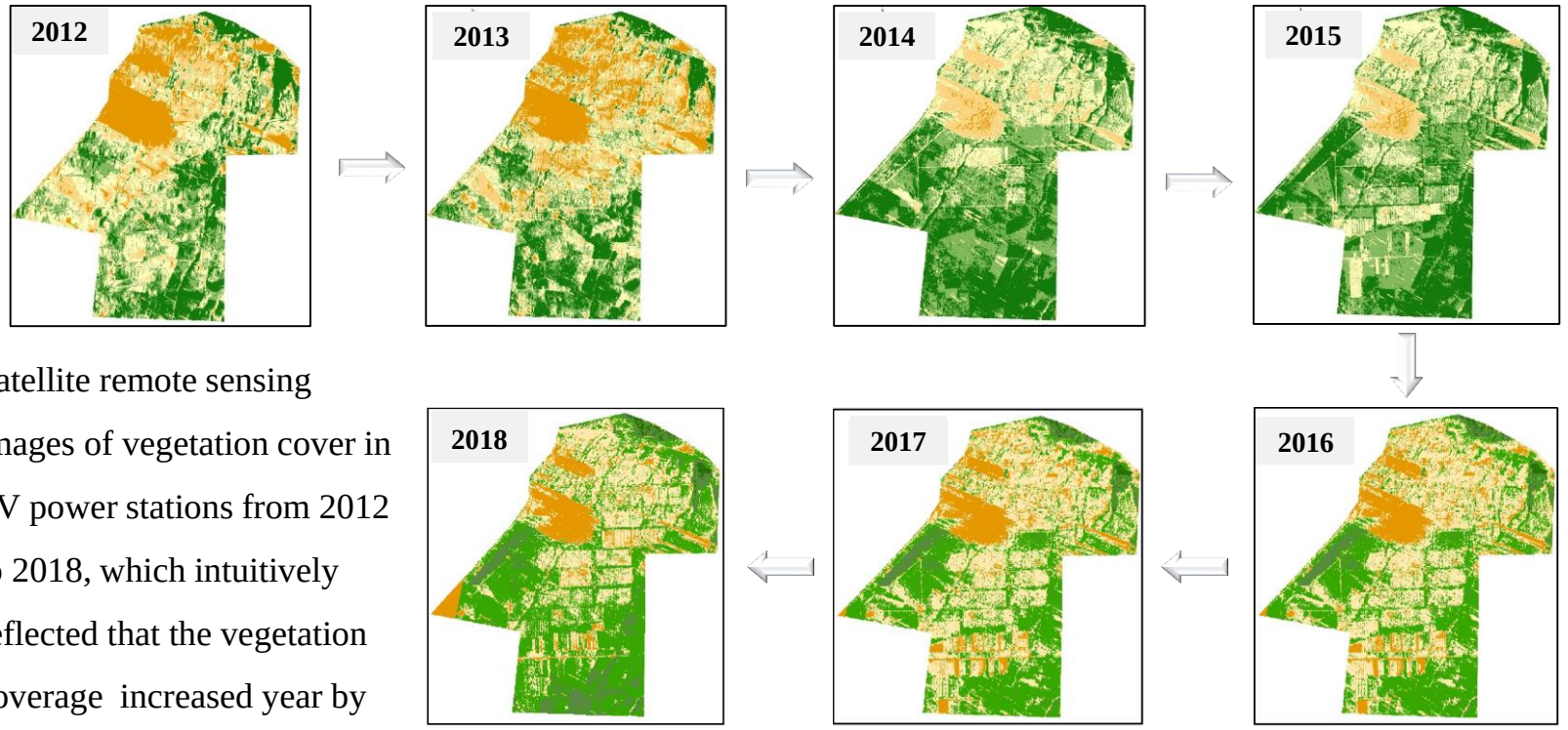
Research on Ecological Environment Trend Based on Satellite Remote Sensing Data——Vertical Comparison



- PV power stations start from 2013, the improvement of the ecological environment has gradually been reflected as the scale increases year by year.

V Research on Ecological Environment Impact of Large-scale PV Power Stations

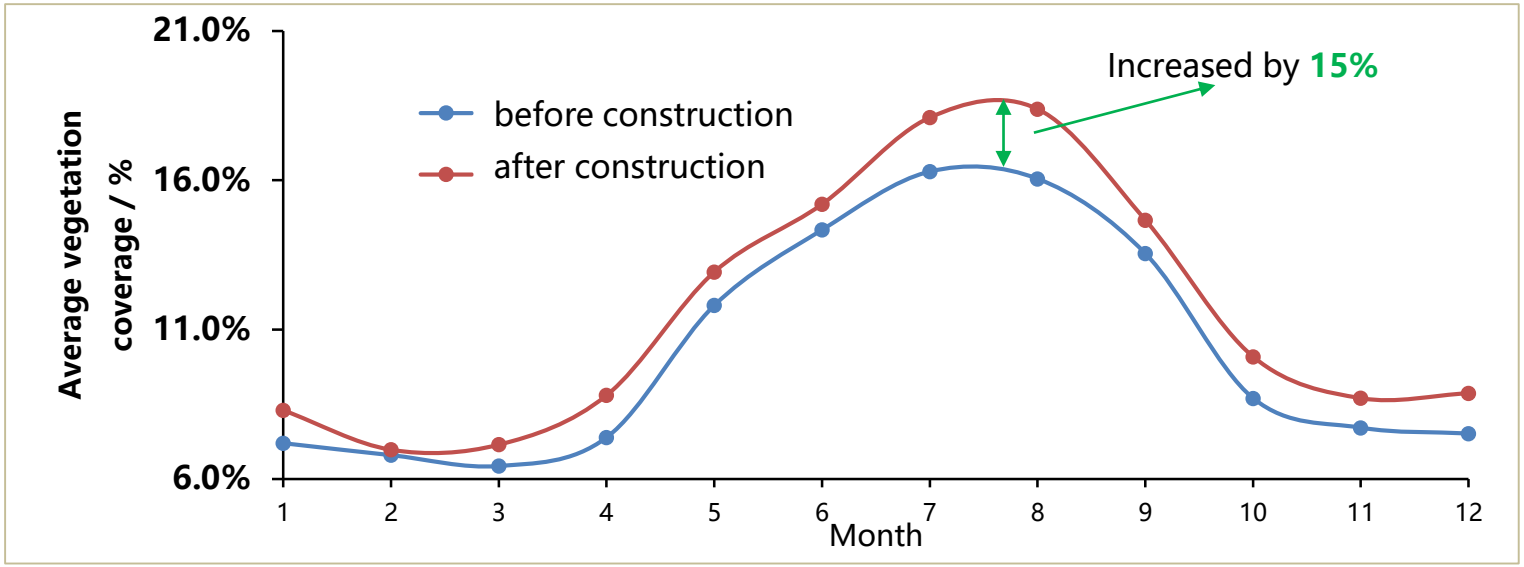
Trends on vegetation cover in the solar park



- Satellite remote sensing images of vegetation cover in PV power stations from 2012 to 2018, which intuitively reflected that the vegetation coverage increased year by year.

V Research on Ecological Environment Impact of Large-scale PV Power Stations

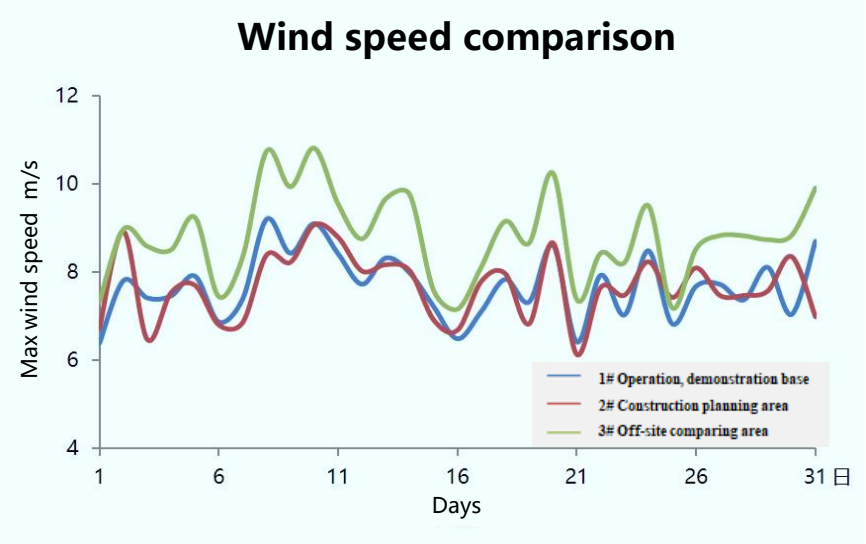
Average vegetation coverage on the project site

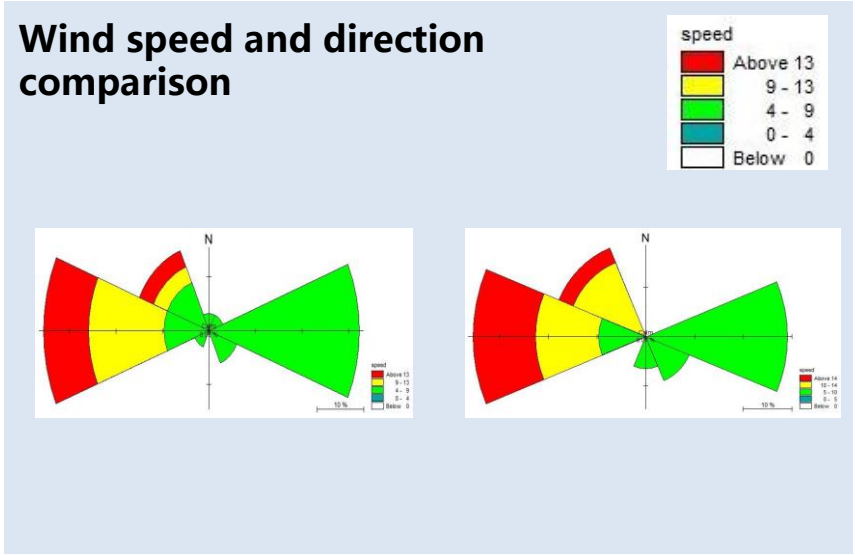


- The vegetation coverage of the park increased significantly after construction of the stations, mainly in July and August, which increase by 15% (ratio). With the operation of the power station, **the vegetation improved obviously**.

V Research on Ecological Environment Impact of Large-scale PV Power Stations

- **Change of wind speed and direction**

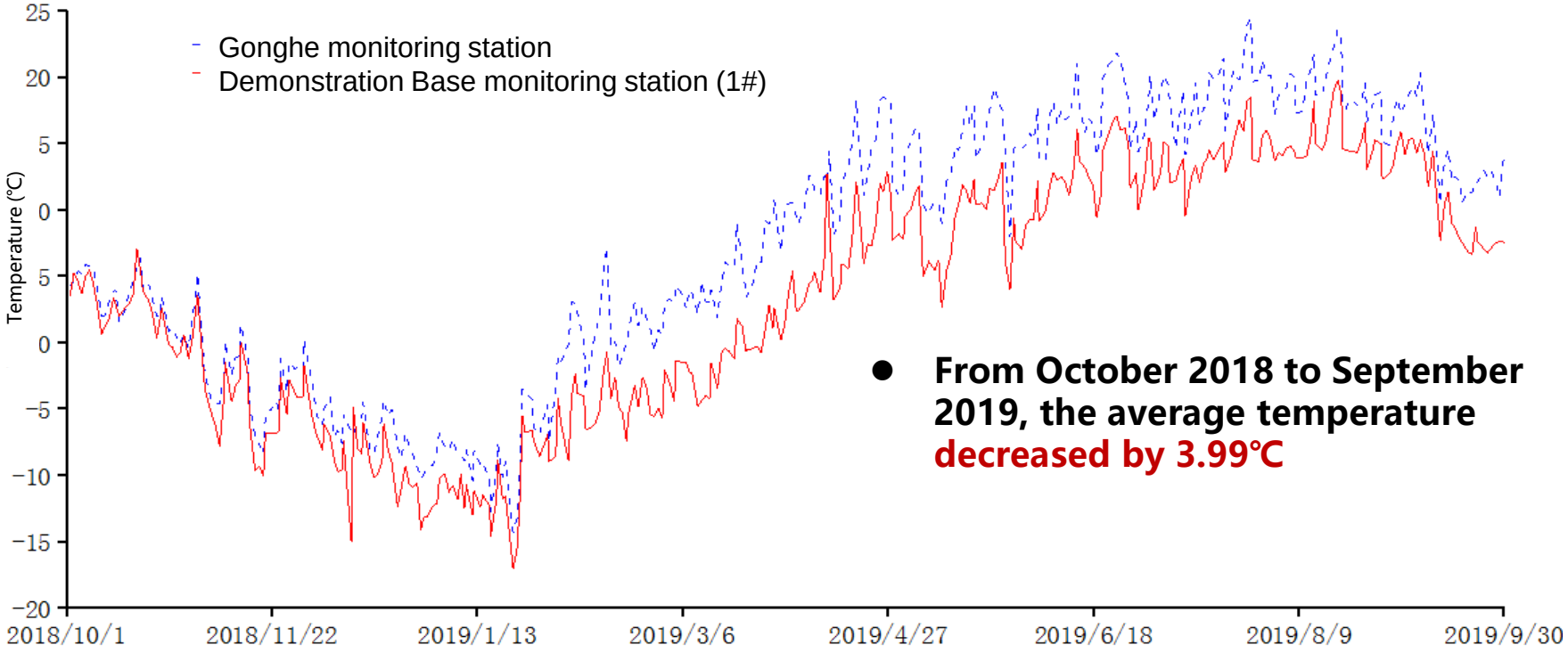




- **According to the statistics, the maximum monthly wind speed on the site was 13.4% lower than off-site area.**

V Research on Ecological Environment Impact of Large-scale PV Power Stations

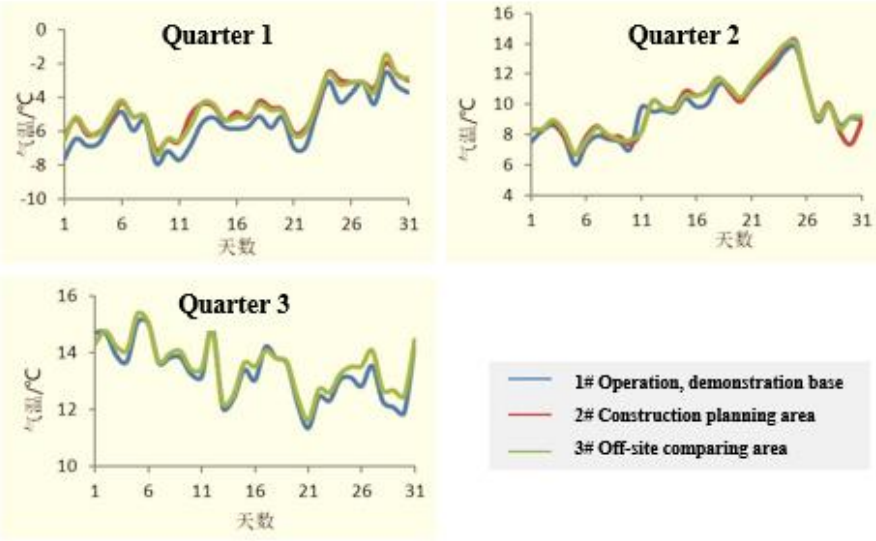
- **Temperature variation in Gonghe area and demonstration base**



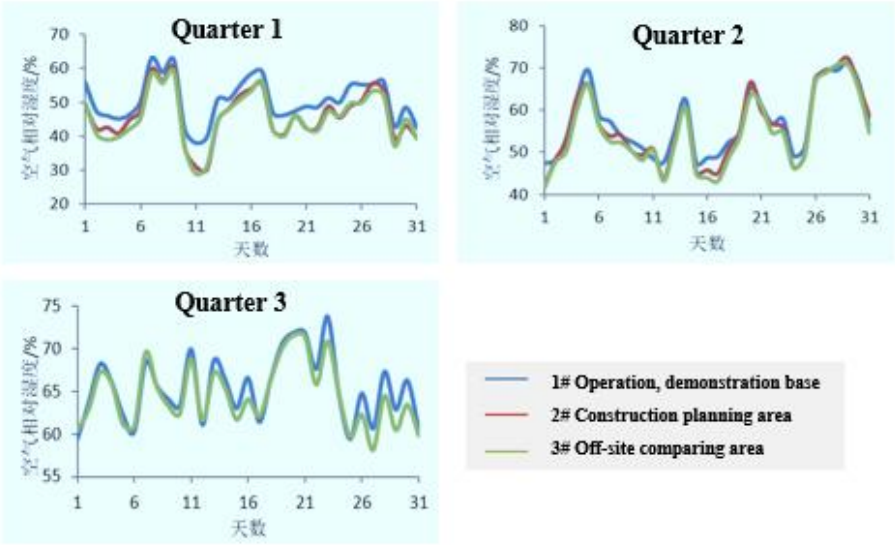
- **From October 2018 to September 2019, the average temperature decreased by 3.99℃**

V Research on Ecological Environment Impact of Large-scale PV Power Stations

Temperature comparison



Humidity comparison

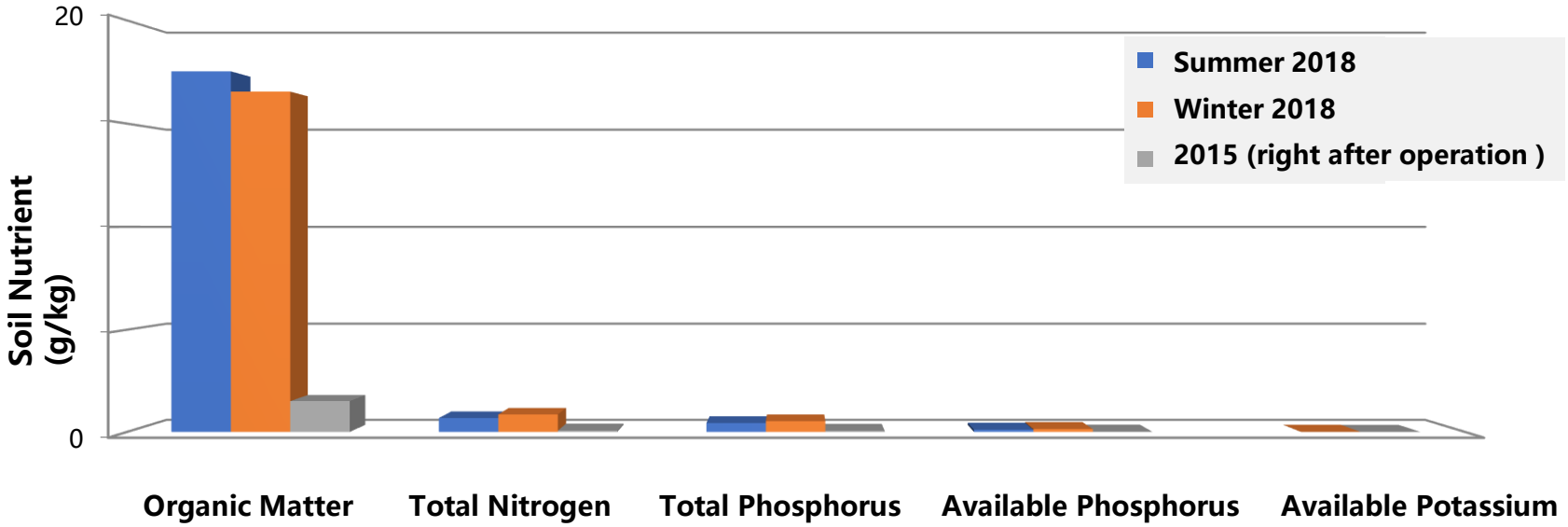


- Quarter 1, 2, 3 of 2019, the land surface temperature of the solar park is respectively 0.74℃, 0.26℃ and 0.23℃ **lower than off-site comparing area**.
- **Large-scale PV stations can reduce land surface temperature.**

- Quarter 1, 2, 3 of 2019, the air humidity in the solar park is respectively **increased** by 4.96%, 2.26% and 0.90% **than off-site comparing area**.
- Large-scale PV construction can **increase humidity.**

V Research on Ecological Environment Impact of Large-scale PV Power Stations

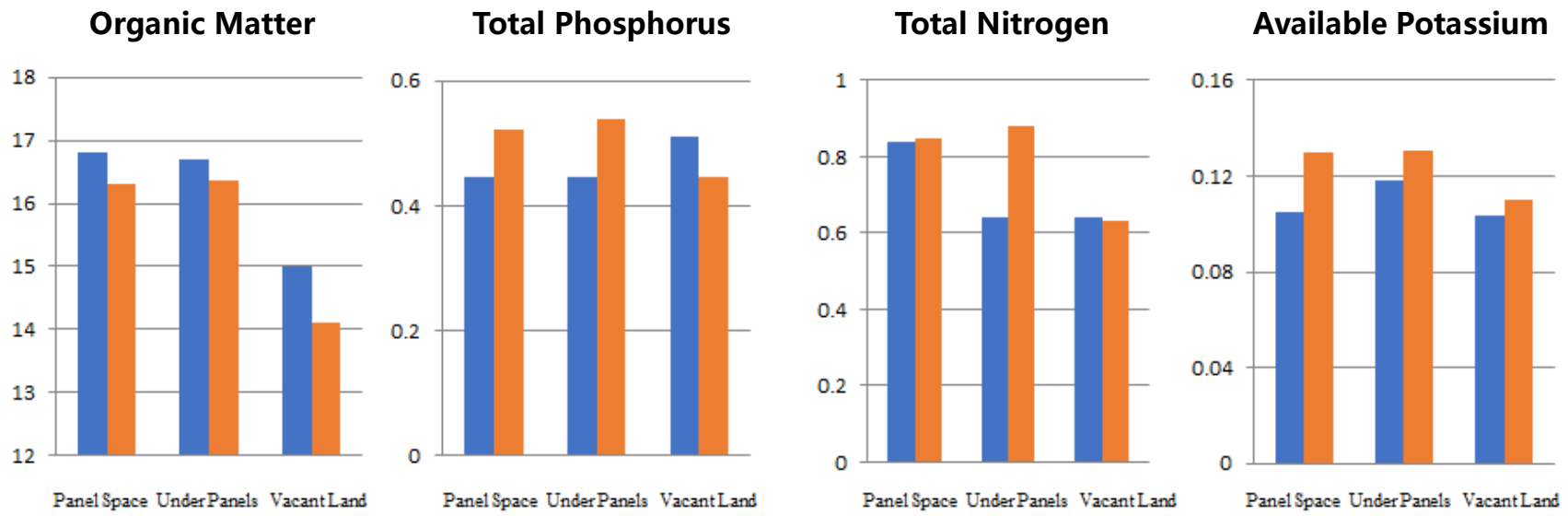
- **Overall trend of soil nutrients**



- Since 2015, soil nutrients have been increased, especially organic matter. In summer of 2018, the organic matter is 11.6 times higher than the initial operation stage of the PV power station, and the total nitrogen increased by 11.3 times, **soil fertility obviously improved**.
- Regular cleaning of PV panels increases soil moisture around the panels, which creates virtuous cycle of the soil nutrients。

V Research on Ecological Environment Impact of Large-scale PV Power Stations

- **Soil nutrient trend comparison of vacant land and land under panels**

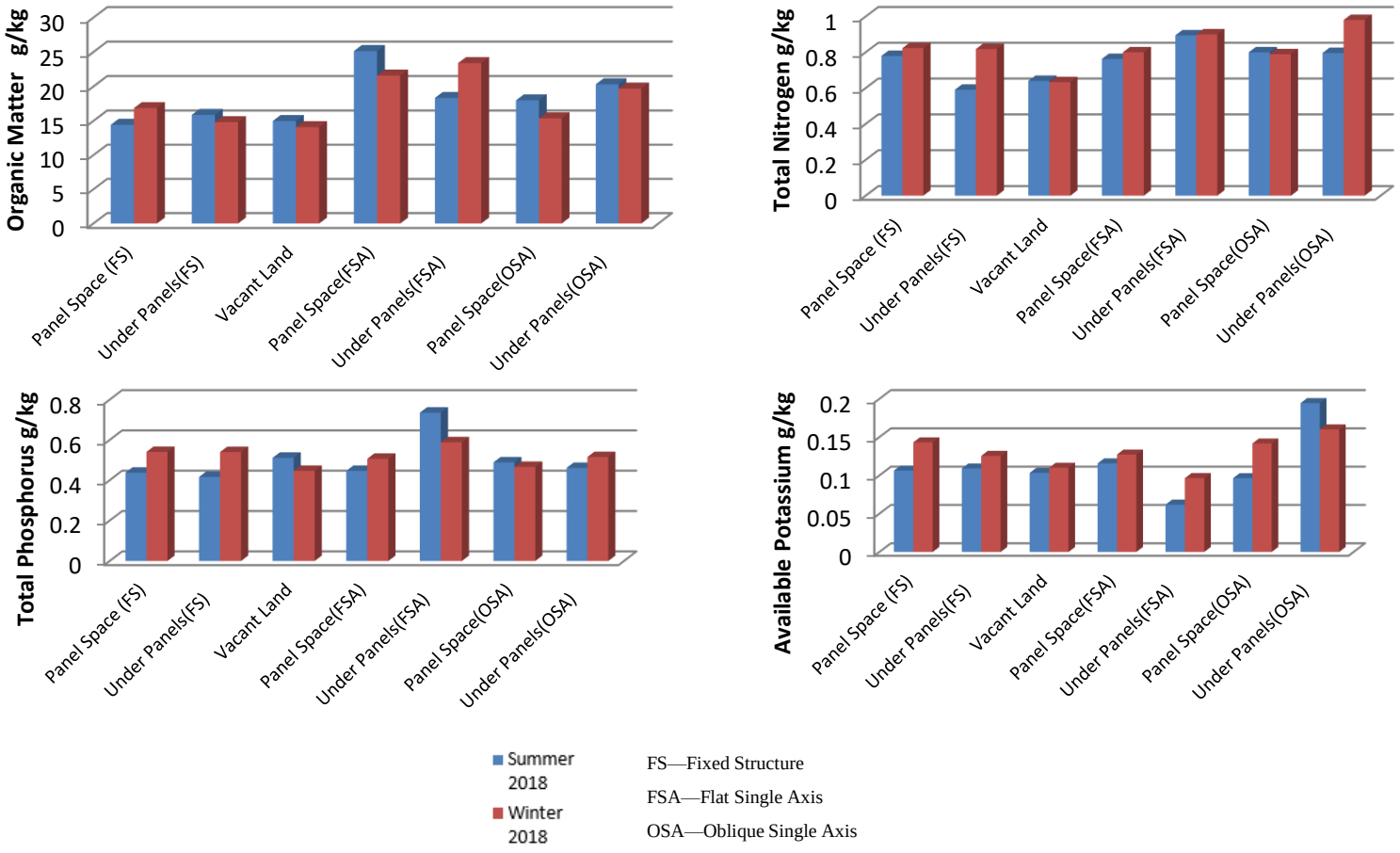


- **Test result of organic matter, total nitrogen, total phosphorus and available potassium content of land between PV panels, under panels and vacant land shows the soil nutrient trend,**

  under panels > space between panels > vacant land

V Research on Ecological Environment Impact of Large-scale PV Power Stations

- **Soil nutrient trend comparison of different tracking systems:** there were differences on nutrient trend for different brackets



FS—Fixed Structure

FSA—Flat Single Axis

OSA—Oblique Single Axis

V Research on Ecological Environment Impact of Large-scale PV Power Stations

Ecological Environment

Vegetation restoration

Vegetation restoration suppresses dust

Humidity increase

Vegetation restoration, sand fixation

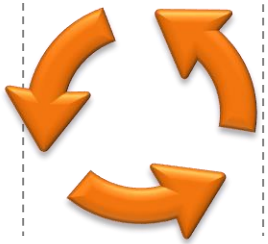
Temperature reduction

The land surface temperature of the PV plant area is reduced by about 1℃, reducing the water evaporation rate, which is conducive to the slow water absorption of vegetation

Wind speed reduction

Conducive to soil moisture, vegetation restoration, sand fixation

Virtuous cycle



Achieve a win-win situation

PV power station

Dust suppression

Improve surface cleanliness of PV modules, which increase power generation; Reduce hot spot and extend life of PV modules

PV module cleaning

PV module cleaning can improve soil moisture and promote vegetation restoration

PV module cooling

PV power generation increased benefits to the temperature reduction

Mounting structure stability

Ground turbulence develops as vegetation restoration, wind speeds reduced, improve tracking system reliability and save the investment of mounting structure .

V Research on Ecological Environment Impact of Large-scale PV Power Stations

1. Vertical comparison: With the construction of large-scale PV power stations, the cumulative effect of PV power stations on regional ecological environment is gradually obvious, and the vegetation coverage gradually increases.

2. Parallel comparison: Large-scale PV power stations have changed the local climate, especially reduced wind speed and increasing air humidity. At the same time, the soil nutrient changed significantly, and soil fertility obviously improved.

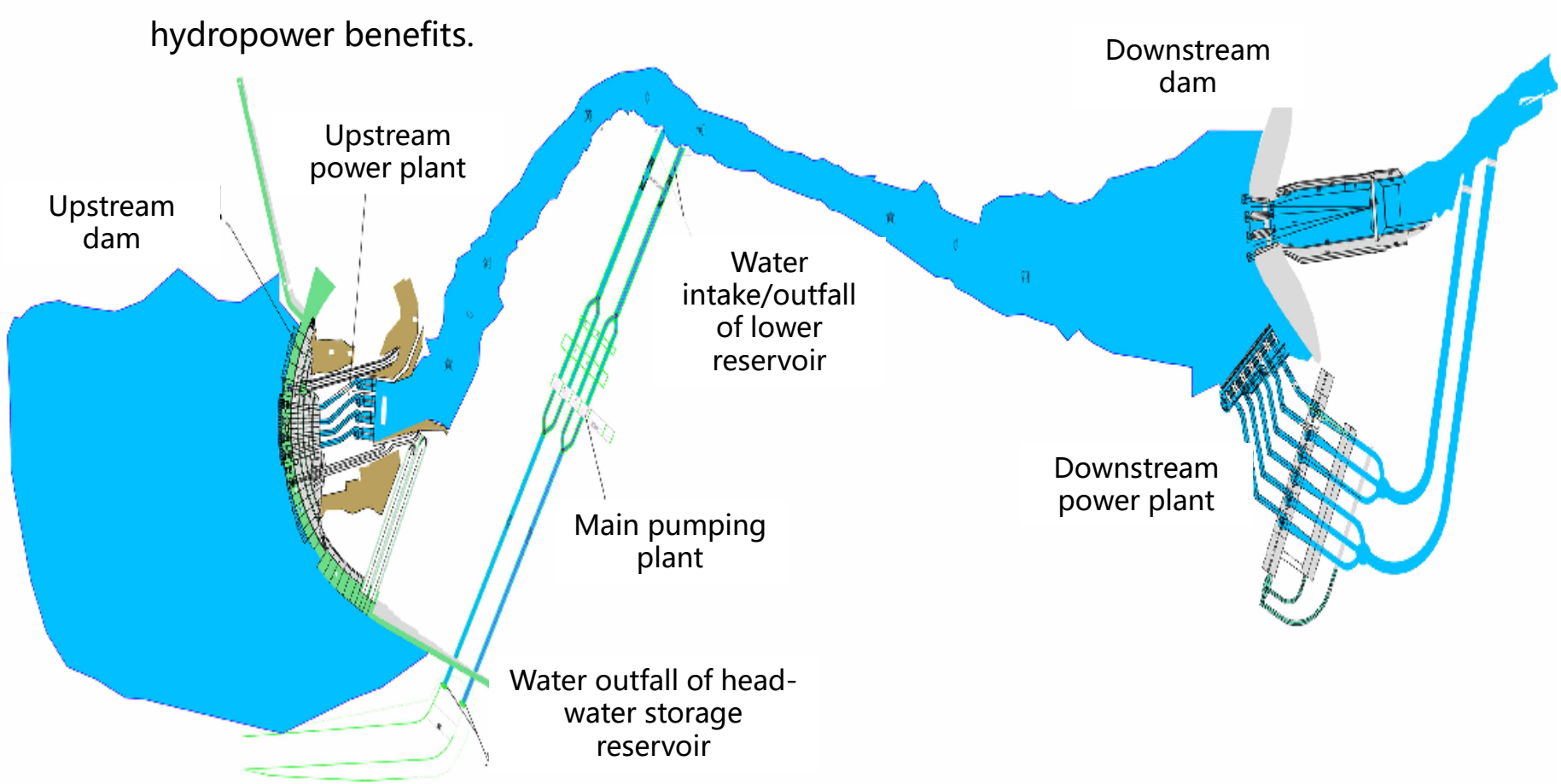
Coordinated Development of PV Power Generation and Ecological Environment Construction

Large-scale PV power stations promote regional ecological environment restoration, and ecological restoration improves the safety and stability of PV power generation and equipment, which has initially formed a win-win development situation.In the future, combined with a variety of research methods, the impact mechanism of large-scale PV power stations on the ecological environment will be continuously focused, providing technical support for the decision making of ecological environment protection and management in large-scale solar parks.

VI Energy Storage Factory

Schematic diagram for the operating principle of ES factory

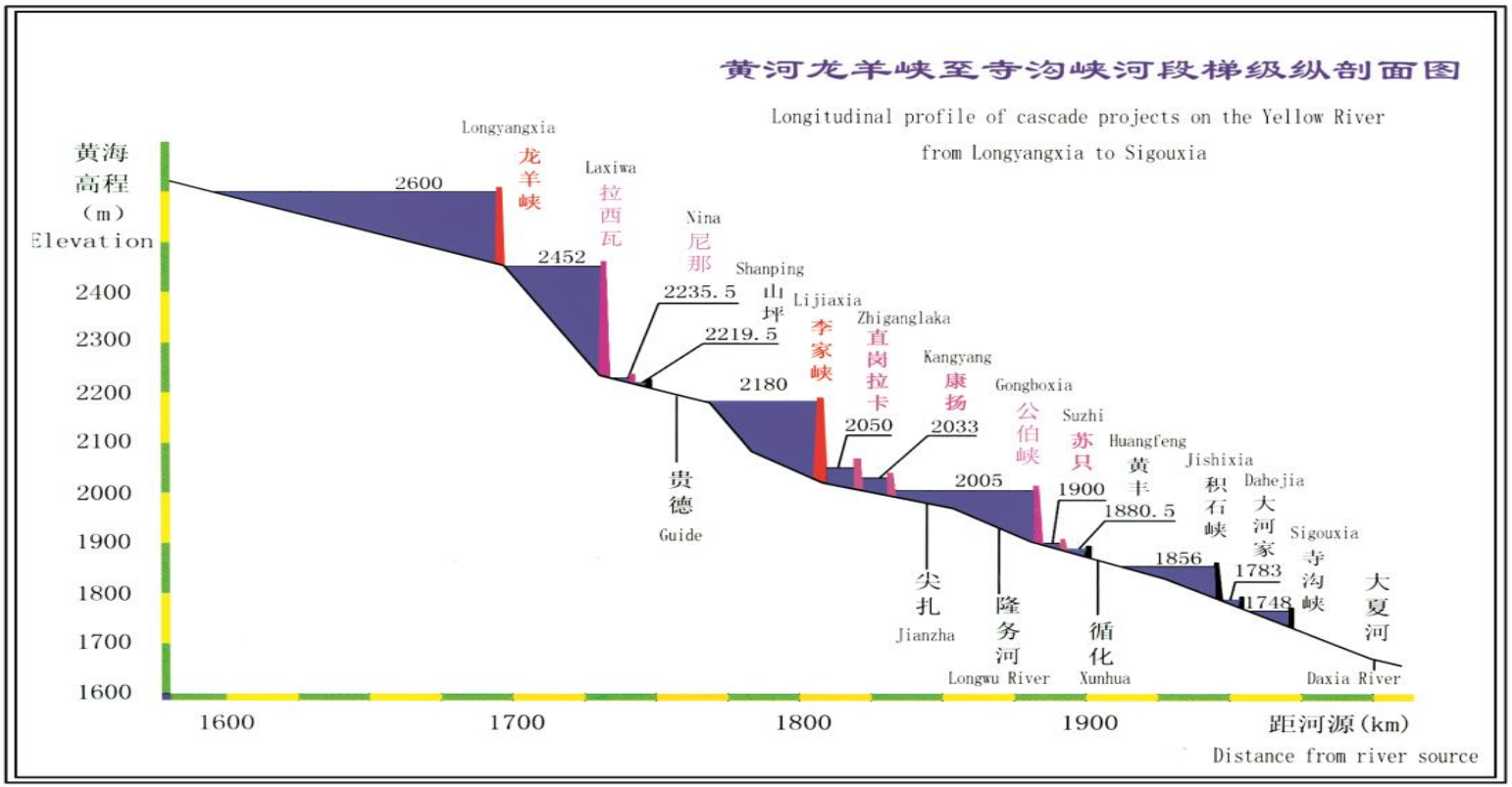
- Improve the energy structure, consume the wasted electricity (due to curtailment) of new energy, and enhance safety and stability of power transmission.
- Improve the use of cascade hydropower resources in the basin and increase hydropower benefits.



VI Energy Storage Factory

Hydropower Projects Layout on the Upper Reaches of Yellow River

The upper stream of the Yellow River is equipped with energy storage for new energy joint operation. With high flow, high lift, and energy storage pumping stations, the water is lifted from the lower cascade reservoir to the upper cascade reservoir, realizing energy transfer.

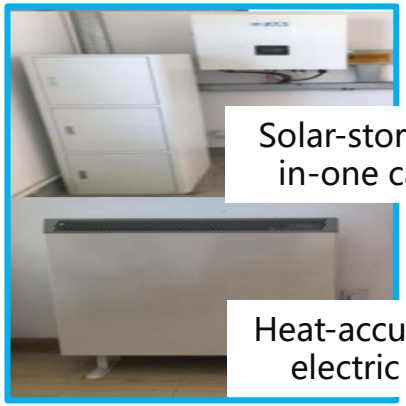


VII Clean Heating Supply Projects

"High-quality life" --Demonstration project of clean heating supply for poverty alleviation in Yangqi Village, Zeku County

Located in Yangqi Village, Zeku County, Huangnan Prefecture, the 365-square-meter clean energy party activity room is equipped with PV power generation, energy storage, and heat-accumulation electric heating systems, to meet the daily power consumption, heating, and other life demands of local herdsman.

- 160.9 square meters of heating area;
- **the indoor temperature reached 16 degrees compared with the outdoor temperature of -18 degrees below zero**;
- 8 months of heating period, and **the heating cost is dropped by about 50%** to 3.4 RMB/m^2/month;
- The on-grid energy is about 6000 kWh during the non-heating period of 4 months, and accordingly about 850 kWh during the heating period, which **provides an extra income with about 1560 RMB per year** if calculated by grid parity tariff;
- Cost effective than traditional heating.

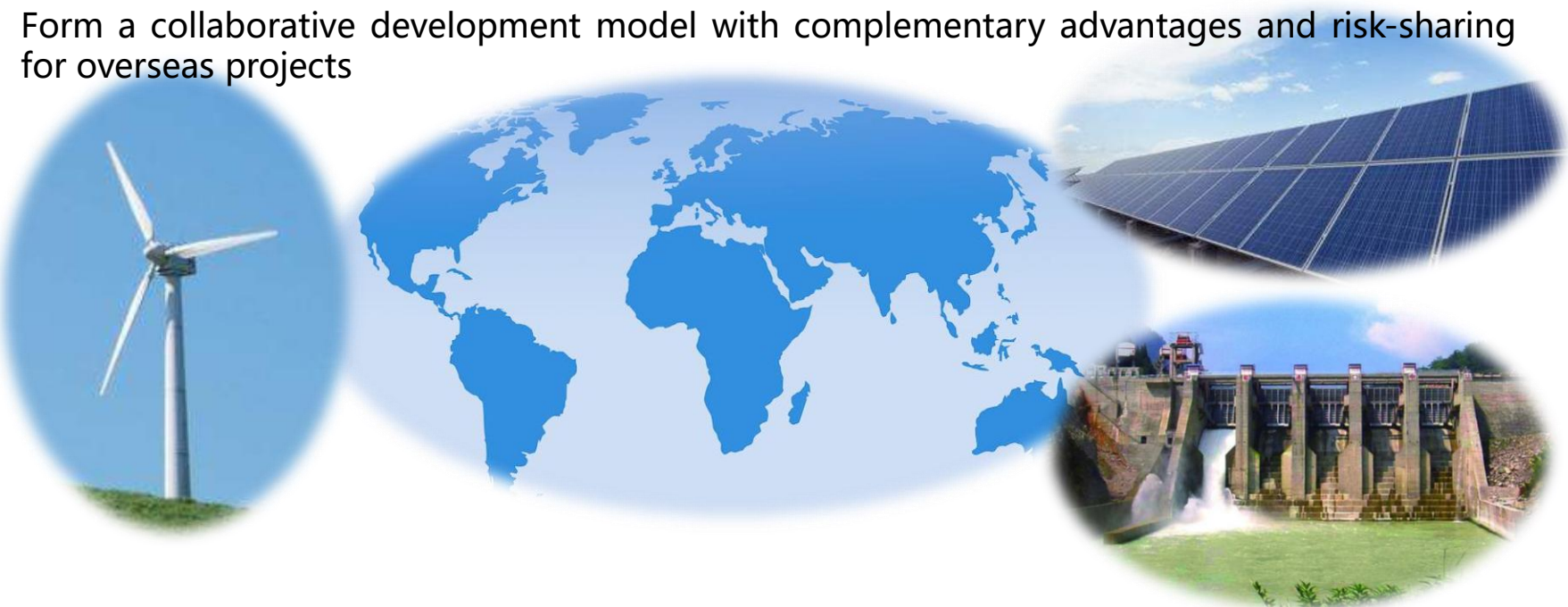


Solar-storage all-in-one cabinet

Heat-accumulation electric heater

VIII International Development

- Guided by the "2035 World-Leading Strategy" of State Power Investment Corporation Limited
- Extensively **expand industrial advantages**, and **promotes clean energy development**:
  - high-quality and systematic development in PV power plants, PV manufacturing, PV systematic research & integration, multi-energy hybrid and other fields
  - coordinate power plant development, engineering & technical services
  - sale of solar modules
  - international exchanges & cooperation
- Preliminary work on clean energy development in *Europe, Central Asia, Africa, South America and other regions*
- Form a collaborative development model with complementary advantages and risk-sharing for overseas projects



THANK YOU!

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