Development and Application of energy storage in Northeast China Power Grid

Northeast Electric Power Dispatch and Control Center of SGCC

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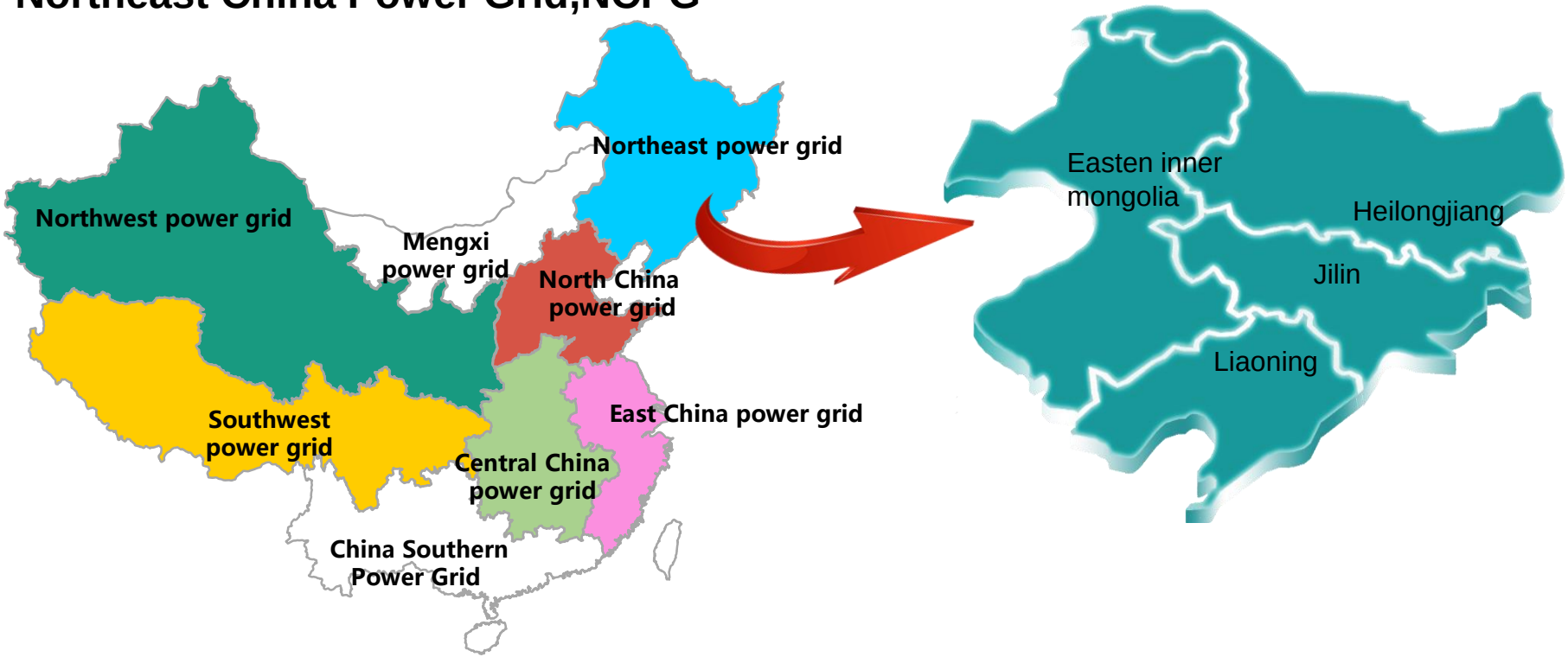
1. General situation of Northeast China Power Grid

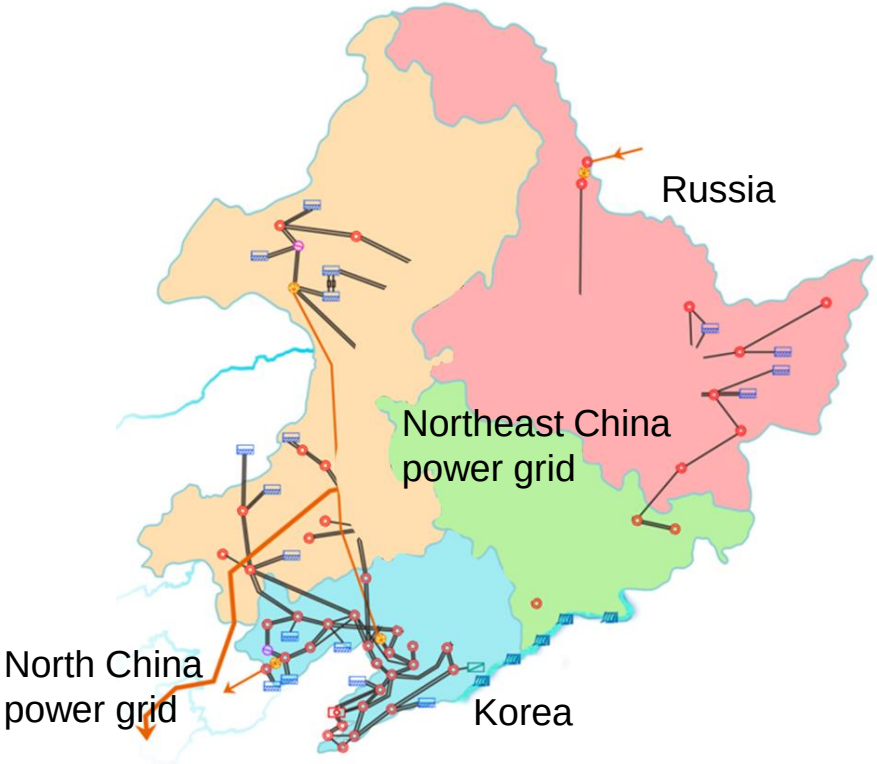
Northeast China Power Grid,NCPG



Northeast China Power Grid(NCPG) is one of the six regional power grids of State Grid Corporation of China(SGCC). It is an AC synchronous power grid, which is located in the northeast of China, **covering three provinces and one region**, with a supply area of 1.28 million square kilometers and **serving population of 122 million**.

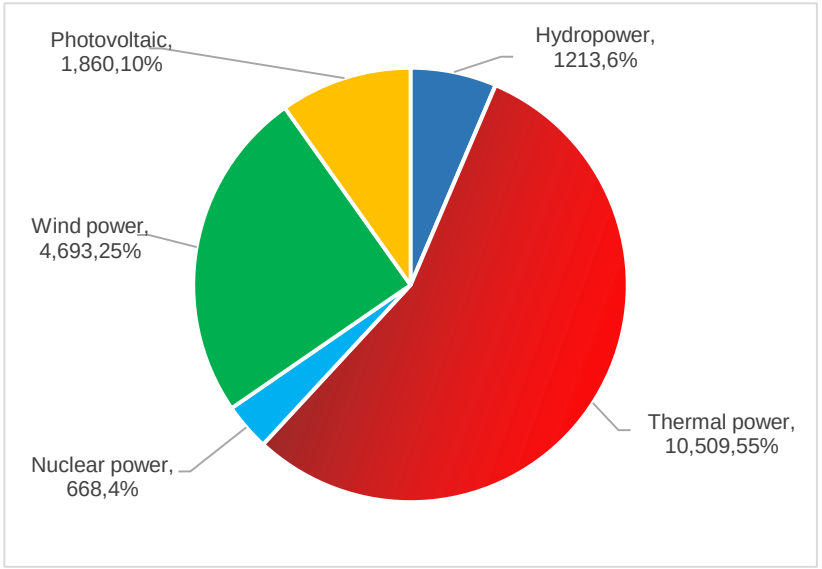
Electricity network configuration and power capacity structure

Electricity network configuration



NCPG is connected with North China power grid and Russia power grid by HVDC lines.

power capacity structure



By the end of 2022, the total installed capacity was 189GW, with thermal power being 55%, and the new energy (wind + solar) being 35%.

The development new energy in NCPG

- By the end of 2022, the maximum power load in NCPG was 74.63 GW. The installed capacity of new energy was 65.53 GW, and planned to increase to 131 GW in 2025. In 2022, the power generation from new energy was 129 TWh, accounting for 22.5% of the total generation production. In power system operation, the maximum instantaneous share of new energy in electric load has reached 56%.
- With the goal of carbon peaking and carbon neutrality in China, there will be continuous fast development of new energy in NCPG.
- As the penetration of new energy increases, and the share of coal-fired generation decreases and their flexibility being exhausted, energy storage will play an important role in the future power systems.

2. Energy storage in Northeast China Power Grid

- Pumped hydro
- Thermal Storage
- Electrochemical
- flywheel

(1). Pumped hydro

Baishan pumped plant

Dunhua pumped plant

Pushihe pumped plant

Mudanjiang pumped plant

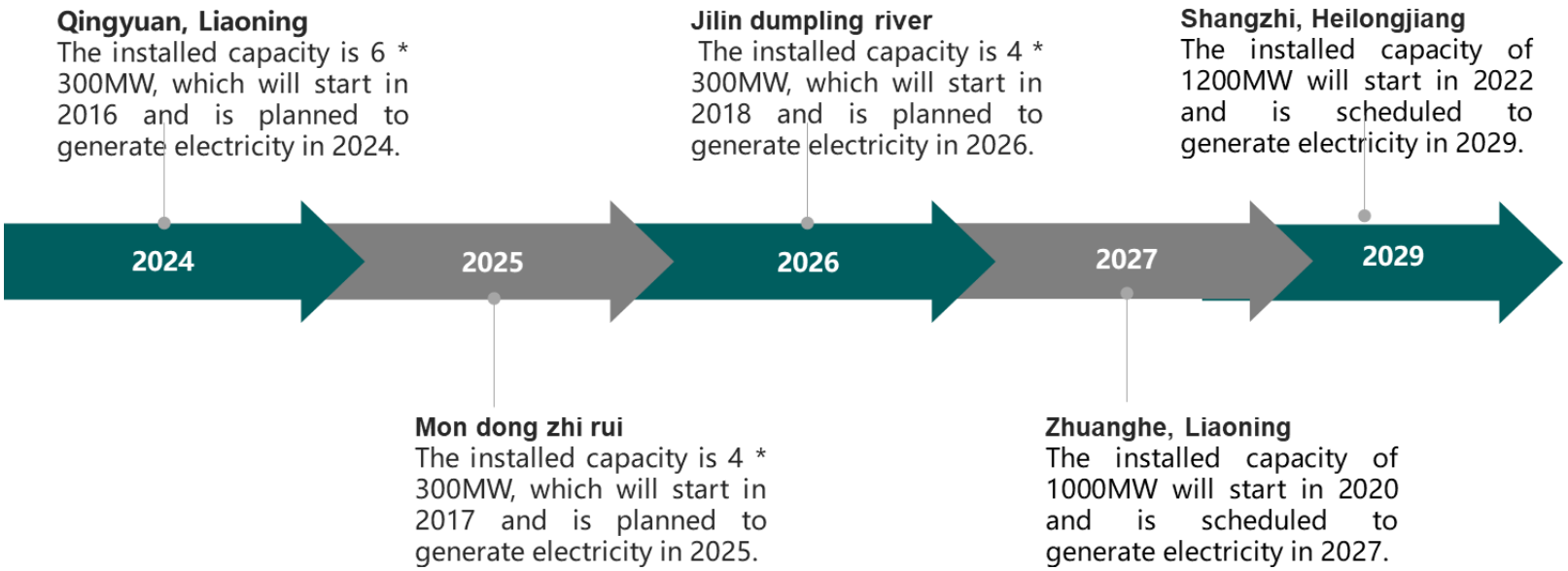
❑ Current capacity and operation

At present, there are four pumped hydro stations in operation in NCPG, with a total capacity of 4.1 GW.

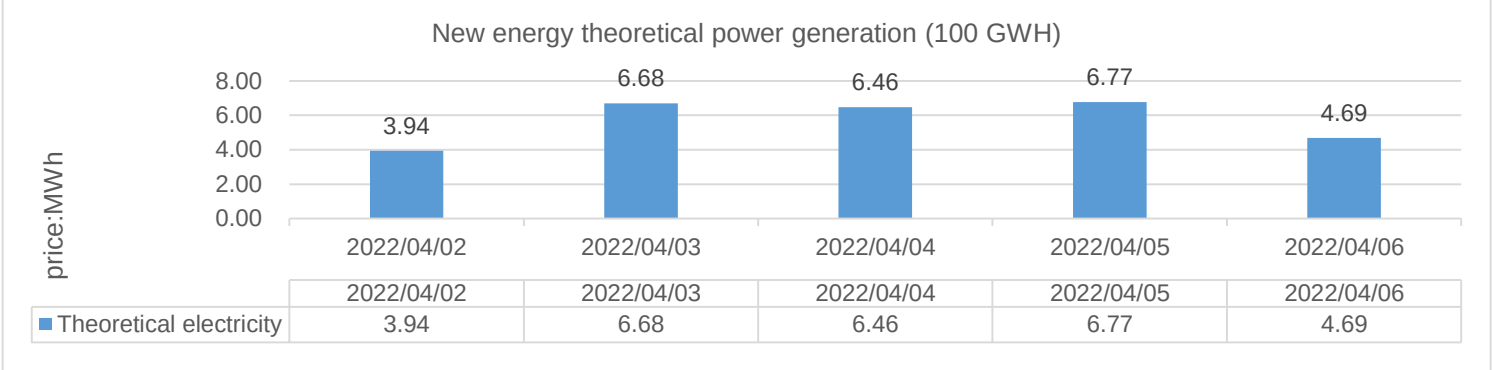
In 2022, the pumped electricity of the pumped hydro stations was 5.1 TWh, mainly used to absorb new energy. Power generation is 3.9 TWh, pumping 4243 times, and generating 4250 times.

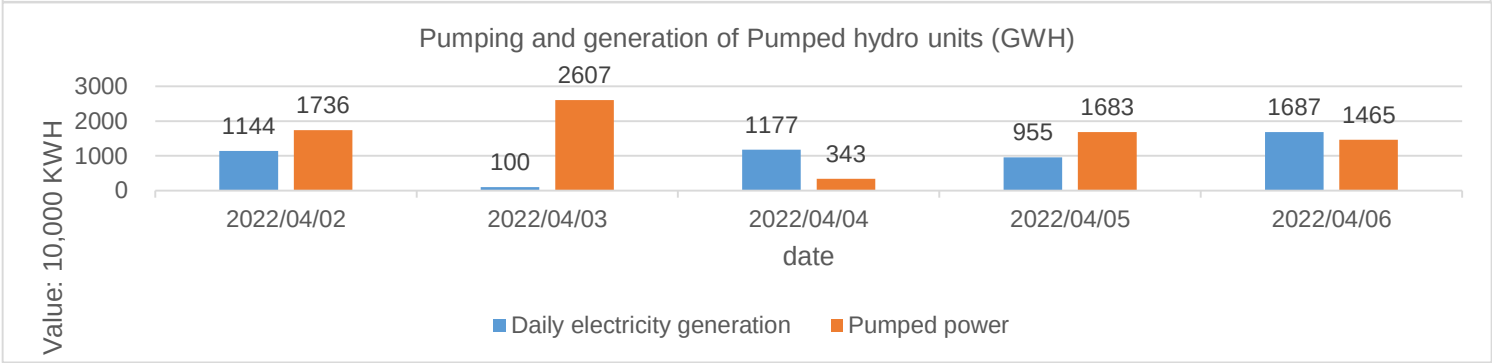
❑ Projects under construction

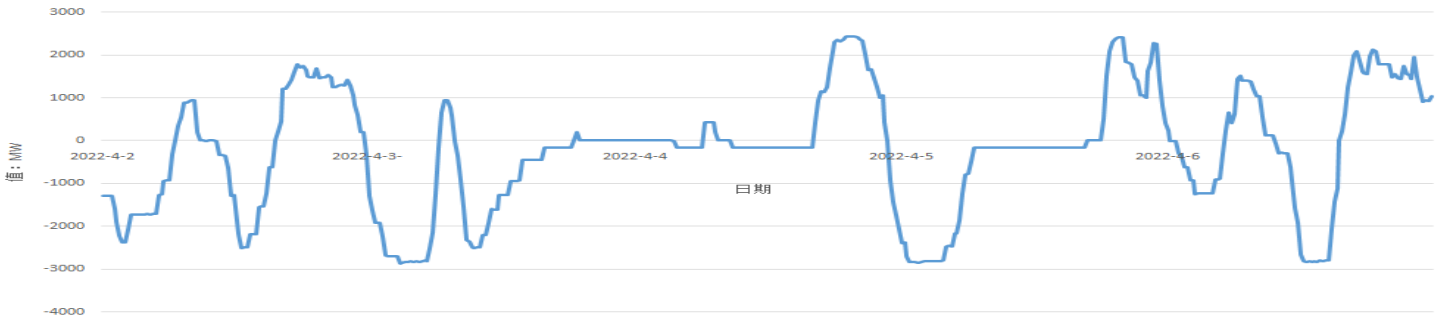
In 2023-2025, the planned new installed capacity is 3 GW, with a total installed capacity of 7.1 GW; by 2030, the installed capacity will reach 10.5 GW. Effectively improve the flexibility of the power supply, and further enhance the level of new energy absorption in NCPG.



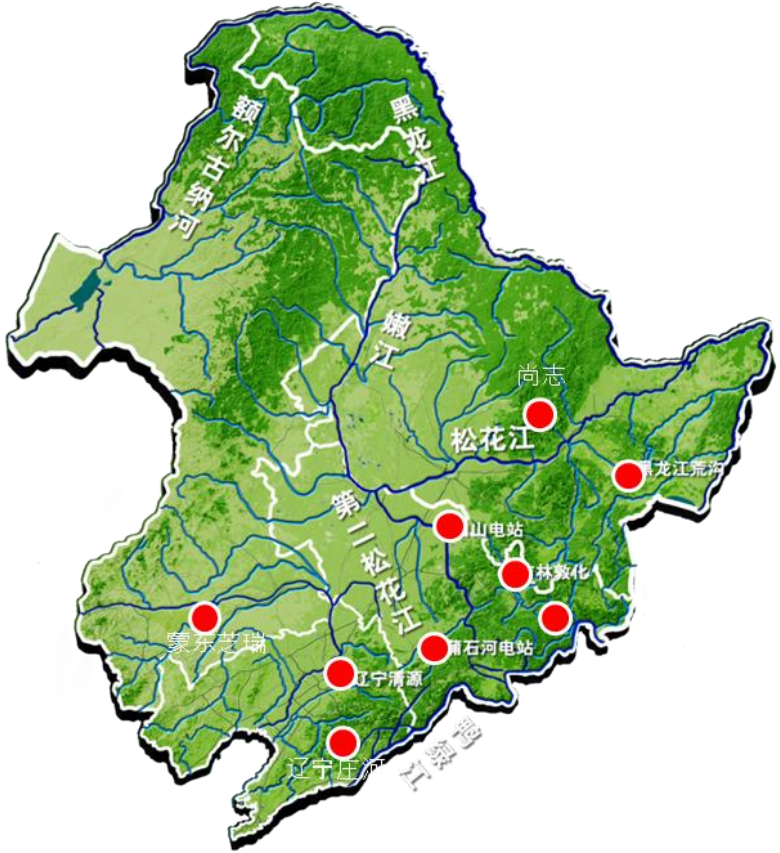
These three figures show typical operation of pumped hydro in the system. The pumped hydro was used to absorb new energy on continuous windy days.







❑ Pricing and Operation mechanism of Pumped hydro power stations



Pricing mechanism: The Pumped hydro power stations in China adopt a two-part electricity pricing mechanism.

Operational mechanism: The Pumped hydro power stations are used for peaking regulation, frequency regulation, phasing operation, black start, emergency standby, etc.

(2).Thermal Storage

- **Current capacity and operation:** Thermal power plants consume surplus new energy for power generation by installing Electricity Boiler with Thermal Storage. By the end of 2022, the capacity of electric boilers was 6.32 GW in NCPG, and 4.2 TWh of new energy were consumed in 2022.

Tongliao Shengfa Thermal Power Plant Installed 116MW electric boiler/5000m^3 . Annually, about 1TWh surplus new energy could be absorbed.

❑ Market mechanism and development potential of thermal storage

- Market mechanism: In 2014, Northeast electric ancillary service market was established.
- Thermal power capacity accounts for a high proportion in NCPG, and their flexibility is low. Through the market mechanism promoting the flexibility modification of these units, the integration of new energy in the system has been greatly improved.
- The modification potential of coal-fired units in NCPG is limited in the future.

(3). Electrochemical energy storage

There are 14 electrochemical energy storage power stations in NCPG, with a total installed capacity of 288MW/892MWh. Generally, they can be divided into two types:

- large scale independent storage, such as Dalian fluid energy storage.
- Wind/solar plus energy storage, such as Tongliao Lithium iron storage.

❑ Dalian liquid Flow Battery Energy Storage Power Station (200MW/800 MWh)

- The construction of the national demonstration project of Dalian flow battery energy was approved in 2016, with a total capacity of 200MW/800 MWh.
- The first phase of the project has already being in operation, with a capacity of 100MW/ 400MWh.

Front of energy storage power station

First floor of the electrolyte storage tank

Second-floor electric reactor container

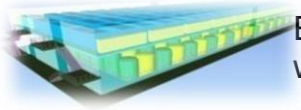
Second floor roof platform

- **technology roadmap of the project**

100 MW / 400MWh
Vanadium liquid flow

3×24MW/96MWh
2×28MW/112MWh

24MW/96MWh 、28WM /112MWh
energy storage unit



Each energy **storage unit** is equipped with one local monitoring system

12×2MW/8MWh
9×3.2MW/12.8MWh

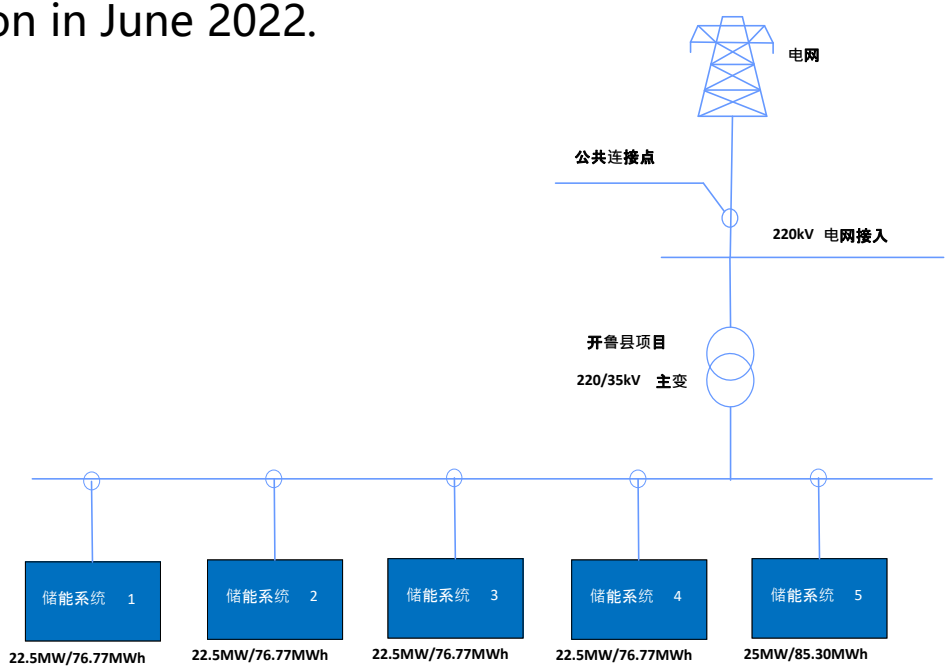
500kW / 2MWh 、800kW / 3.2MWh
Energy storage module

Each set of energy **storage module** can be connected to the power grid through independent PCS, and can realize separate charge and discharge control

- standardization
- modularity
- high redundancy

❑ Lithium iron phosphate energy storage (the main type of electrochemical energy storage in China, taking a share of 93%)

Tongliao “Wind-Solar-Storage” Integrated Project 115MW/345MWh Energy Storage Power Station was put into operation in June 2022.



Access system diagram

The planned capacity of the Tongliao "wind-solar-storage" integrated project is 2GW new energy + 320MW/960MWh of energy storage. The full capacity is expected to be in operation by 2025.

Comparison of electrochemical energy storage performance

Battery type	plumbic acid	Sodium sulfur	lithium ion	Vanadium liquid flow	Lithium iron phosphate
Power upper limit	Ten megawatts	Ten megawatts	MW level	Hundred megawatt	Hundred megawatt
energy density (Wh / kg)	35 ~ 50	100 ~ 150	150 ~ 200	12 ~ 18	150 ~ 200
Cycle life (times)	500 ~ 1500	2500 ~ 4500	1000 ~ 5000	> 16000	1000~5000
Service life (years)	5-10	5-10	5-10	>20	⩾10
Charge and discharge efficiency of (%)	50-75%	65-80%	90-95%	65-80%	90-95%
capacity attenuation	Not recoverable after attenuation	Not recoverable after attenuation	Not recoverable after attenuation	Can be recycled online	Not recoverable after attenuation
Cost (RMB / kWh)	(Current) 1,500 (Future) 1,000	(Current) 3,000 (Future) 2,000	(Current) 3,000 (Future) 1,500	(Current，4h) 3,000 (Future，4h) 2,000	**(Current) 900** **(Future) 700**
safety	good	medium	poor	good	medium
At present, the main application fields	System backup power supply	System frequency modulation and peak modulation	Electric vehicles, mobile energy storage	Large-scale storage	generation side, grid side, user side
superiority	Mature technology, the lowest price	High energy density and less footprint	High energy density and high efficiency	**High charge and discharge times, long service life**	Long cycle life, large capacity, high integration, and extensive application scenarios
inferior strength or position	Low energy density, can not be deep discharge, scrapped battery processing is difficult	Strict operating conditions and life span are affected by deep charge and discharge	Poor safety, high production cost	Low energy density	Poor low-temperature performance and poor consistency

Electrochemical energy storage is now in the stage of demonstration.

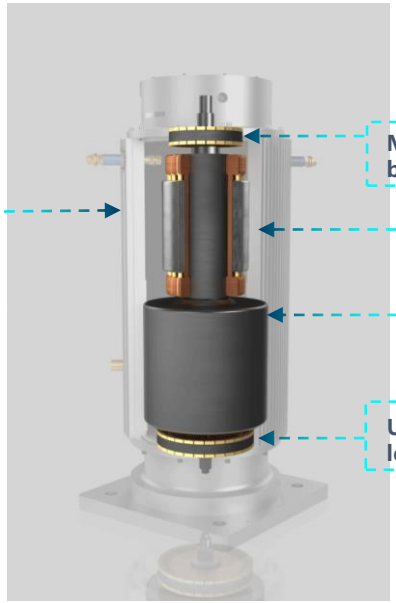
Electrochemical energy storage is mainly used for peaking regulation, frequency regulation, accident backup, black start, etc.

- Lithium iron phosphate battery: Currently, it is the mainstream in the development of electrochemical energy storage, with advantages in economics and disadvantages in safety.
- Vanadium liquid flow battery: It has advantages of high safety, long life cycle, and environment friendly.

Currently in China, large-scale electrochemical energy storage is still in the stage of demonstration. **There is a lack of effective market mechanisms. Key technology innovations are still needed, i.e. life cycle, battery recycling , and safety.**

(4). Flywheel energy storage

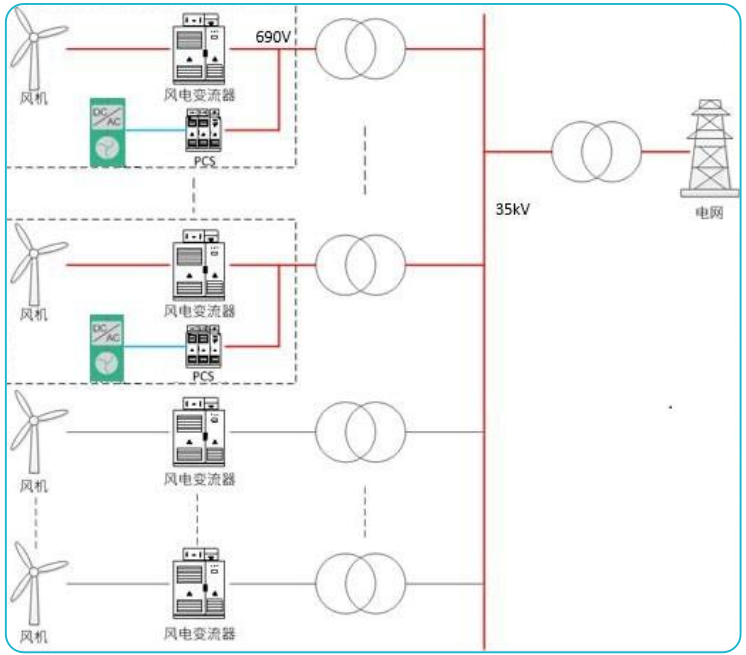
Flywheel energy storage is mainly used for frequency regulation and virtual inertia response.



System technical parameters	
Function name	parameter
Rated AC power	1.0-1.6MW
Rated available energy	32MJ
System-level response time	10ms
Full-power response time	<100ms
Grid-side rated power accuracy	<±1%
Rated power charge-discharge cycle	> Two million times
Access form	Non-isolated type, external booster pressure and isolation transformer
levels of protection	IP54
cooling-down method	Forced air cooling + control system auxiliary air conditioning
ambient temperature	-45~60℃
Integrated size	6058*2438*3000mm

Typical application 1: flywheel combined with wind turbine to provide primary frequency regulation and virtual inertia

Fuxin Chatai wind field, the flywheel-wind turbine system realized the single wind generator participation in the primary frequency regulation and virtual inertia response of power grid.



Typical application 2: flywheel combined with electrochemical energy storage to improve frequency regulation of the wind field

Liaoning Fuxin Haili Wind field hybrid energy storage frequency regulating project:

Adopting 0.5MW flywheel+4.5MW lithium battery hybrid energy storage route, it is the first "flywheel+lithium battery" hybrid energy storage primary frequency regulation and inertia response commercial project in China. **The lifecycle of battery could be extended.**

Conclusions

- **The fast development and high penetration of wind and solar in the system pose great challenges to power system operation**, i.e. VRE integration, power supply security, power system stability. Energy storage will play an important role in the future power systems.
- **Pumped hydro storage has already made great contribution in NCPG**. New pumped hydro stations are being planned and under construction. At the same time, pumped hydro storage development is **constrained by site selection, long construction period, and possible high cost in the future**, which gives comparable advantages to new types of energy storage, such as electrochemical energy storage, flywheel.
- **Projects of electrochemical energy storage, flywheel are now constructed, with some being pilots and some being mandated**. With their technological innovation and continuously reducing cost, these new type of energy storage will play bigger roles in system operation. **Policies and measures to support the economics of these projects are yet to be implemented** in China.

Thank You!