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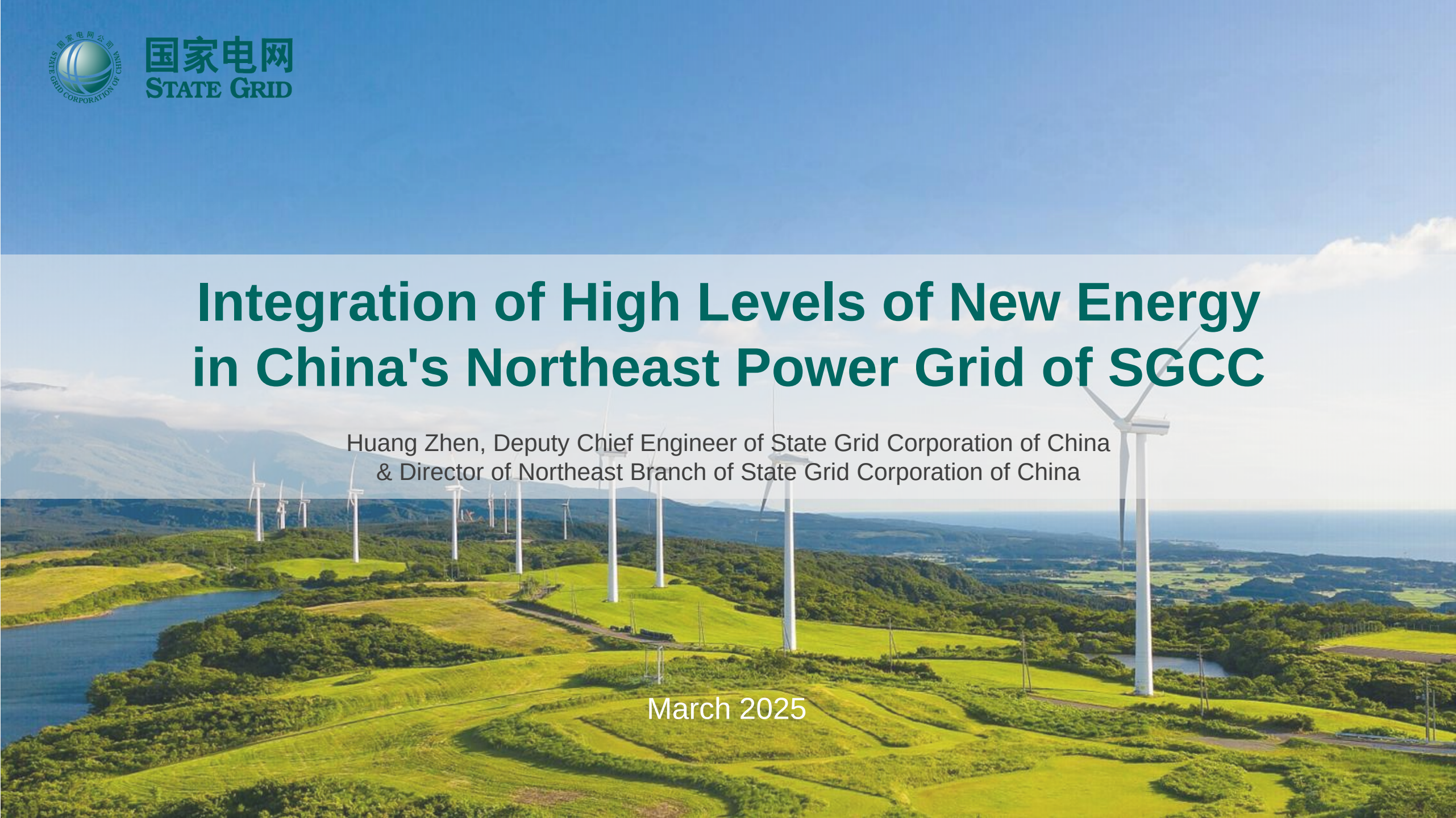
Integration of High Levels of New Energy in China's Northeast Power Grid of SGCC

Huang Zhen, Deputy Chief Engineer of State Grid Corporation of China
& Director of Northeast Branch of State Grid Corporation of China



March 2025

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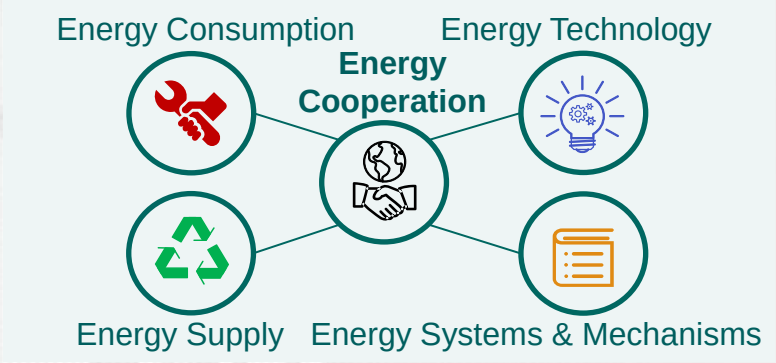
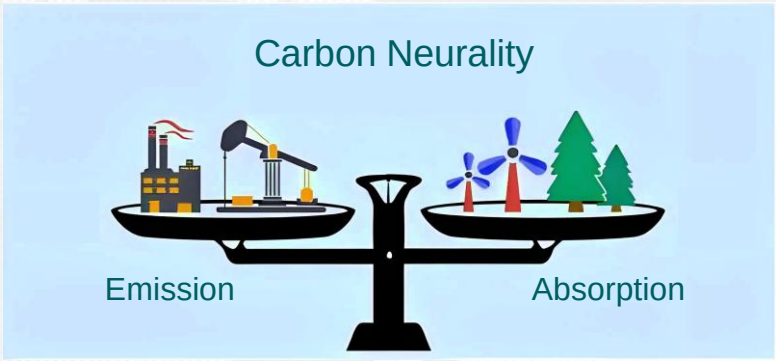
Background





- Featuring Clean & Low Carbon
- Safety & Sufficiency
- Low Cost & High Efficiency
- Coordinated Supply & Demand
- High-level Flexibility & Smartness

Promote the green transformation of energy production and consumption.

1

2014.06

In June 2014, China put forward its new strategy of energy development, which is "four revolutions and one cooperation".

2

2020.09

In September 2020, China proposed its goal of "carbon peaking & carbon neutrality", striving to achieve carbon peaking by 2030 and carbon neutrality by 2060.

3

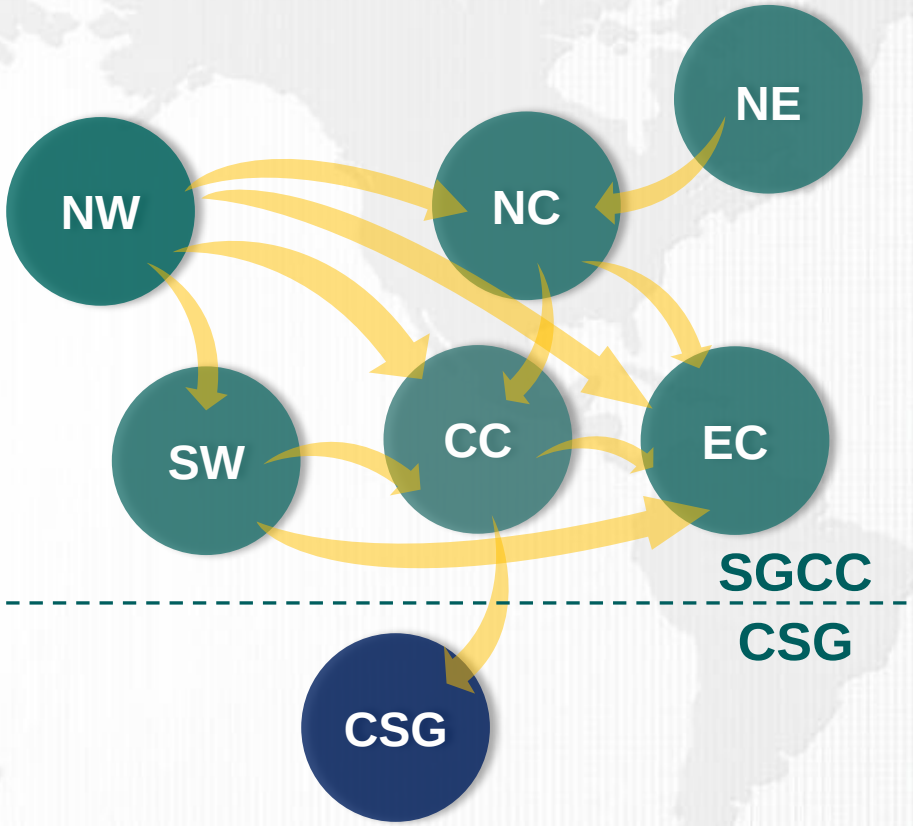
2023.07

In July 2023, China announced to accelerate its construction of new power system.

Contents

State Grid Corporation of China (SGCC)

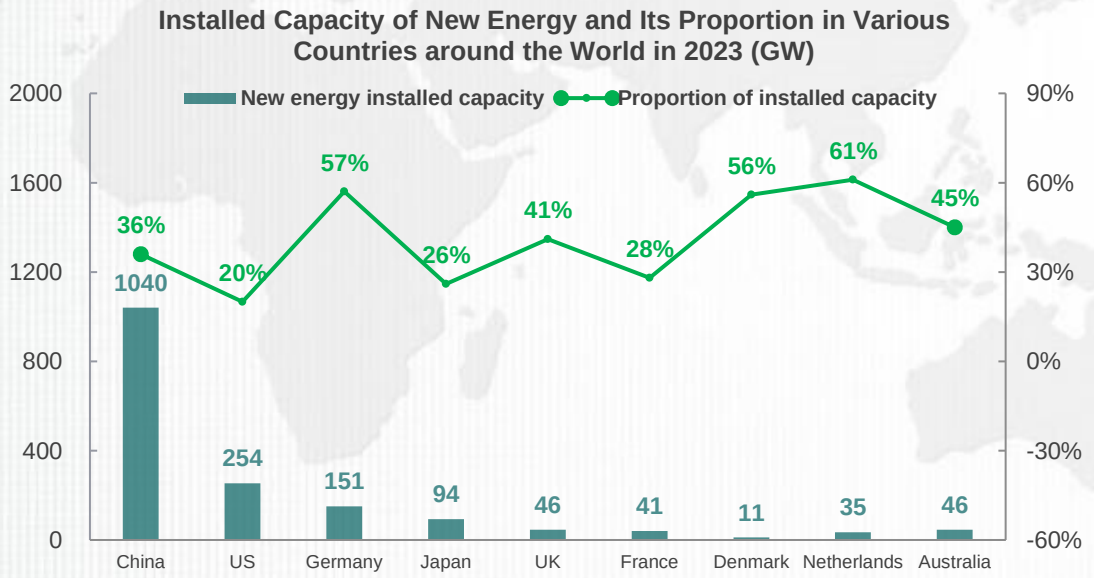
SGCC consists of six major regional grids, including North China Grid, Central China Grid, East China Grid, Northeast Grid, Northwest Grid and Southwest Grid, covering 26 provincial-level administrative areas, with a power-supply area accounting for 88% of the national territory and a service population of 1.1 billion, its maximum power load is 1.18TW.

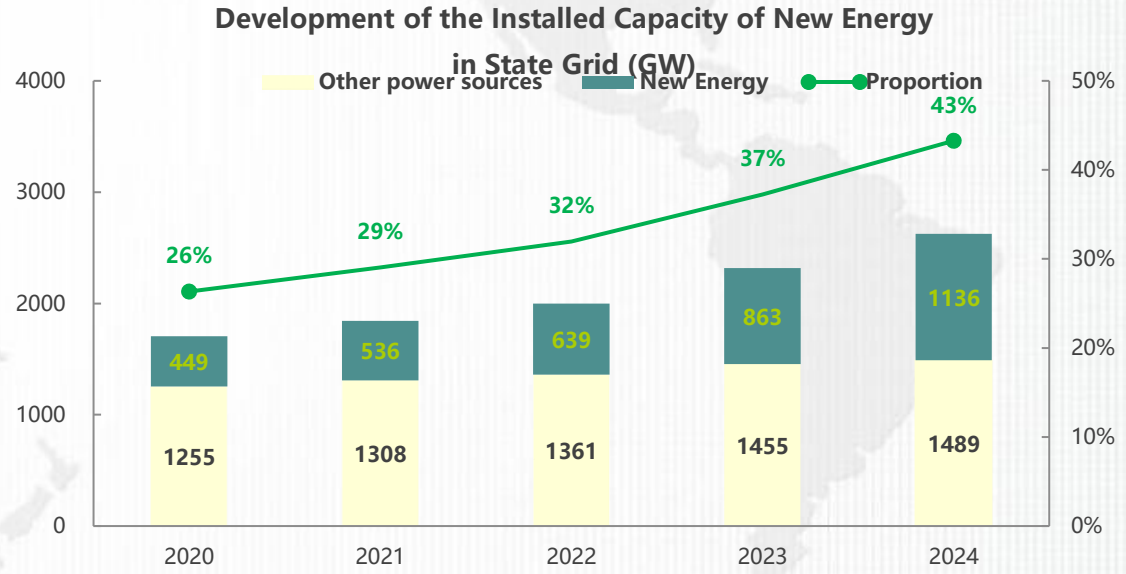


State Grid Corporation of China (SGCC)

China is the country with the fastest-growing and largest-scale installed capacity of new energy (wind & solar) in the world.

By the end of 2024, the total installed capacity of power sources of SGCC had reached 2.63TW, of which the installed capacity of new energy had reached 1.14TW, accounting for 43.3%.





Note: The data is sourced from IRENA

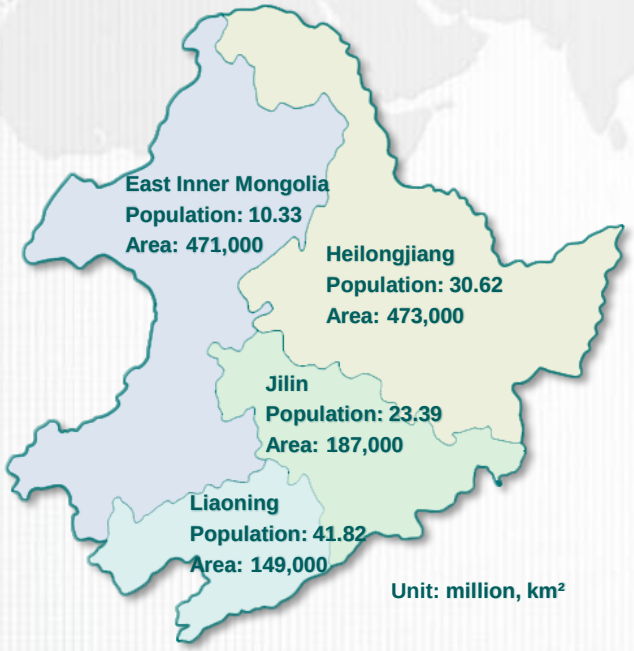
Northeast Grid

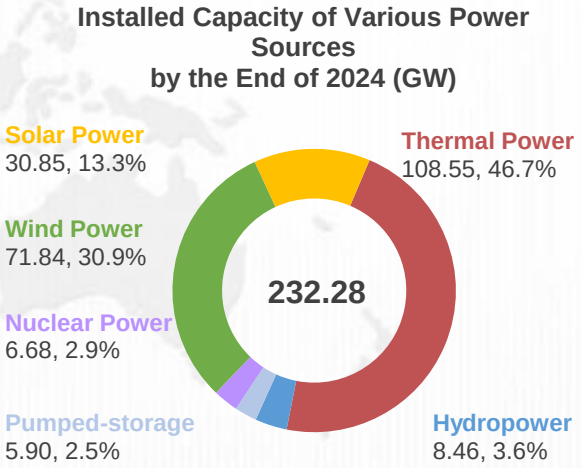
Northeast Grid is one of the six major regional grids of SGCC.

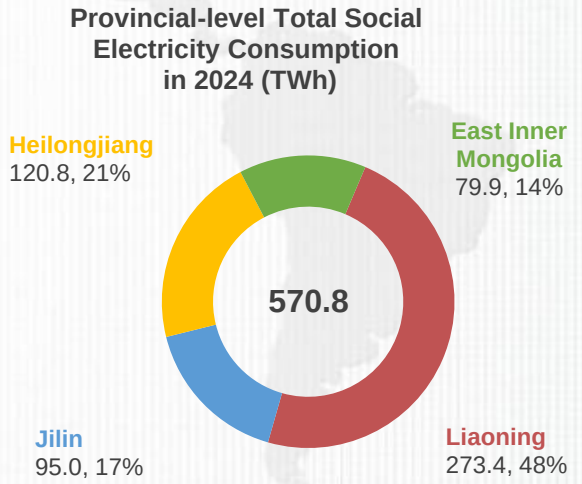
It serves area of 1.28 million square kilometers and population of 106 million.

Its installed capacity totals up to 232GW, with its power generation reaching 642TWh in 2024.

Its max power load reaches 82.32GW, and the electricity consumption reached 570.8TWh in 2024, which is roughly equivalent to that of the Texas power grid in the United States.



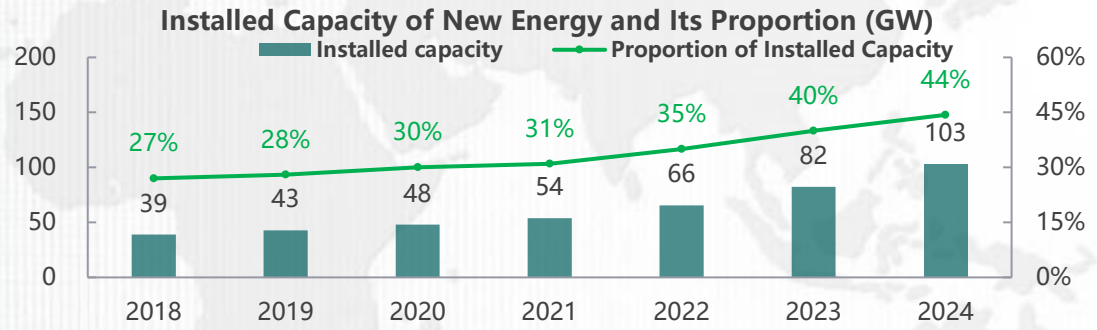


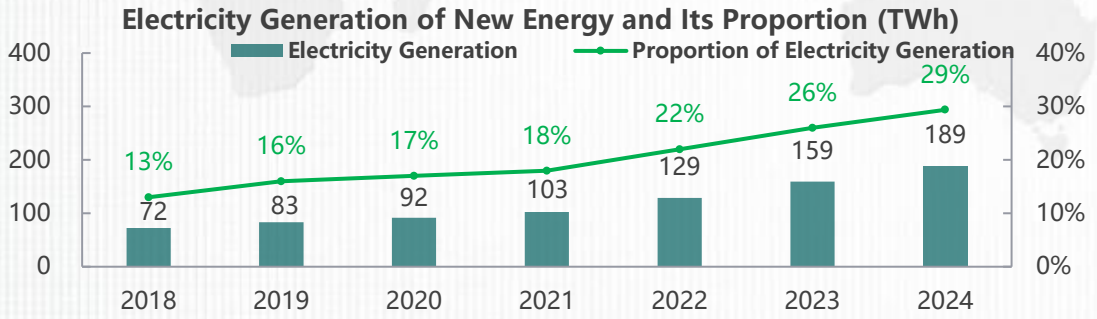


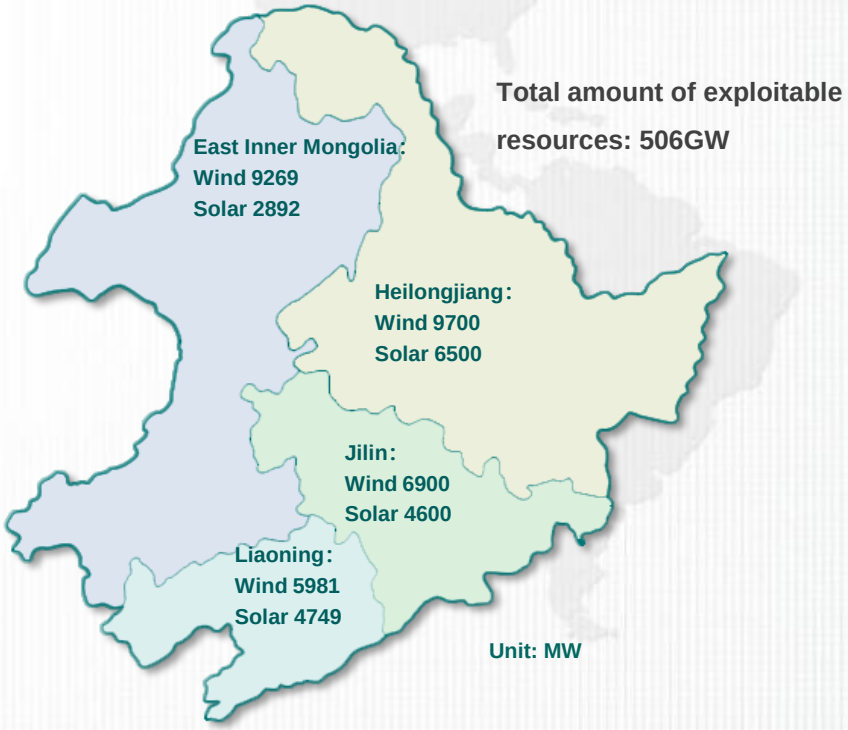
Northeast Grid

From 2021 to 2024, the installed capacity of new energy has doubled, exceeding 100GW, accounting for 44% of the total installed capacity.

The high-speed development of new energy also brings problems to grid operation, which mainly involve two aspects.



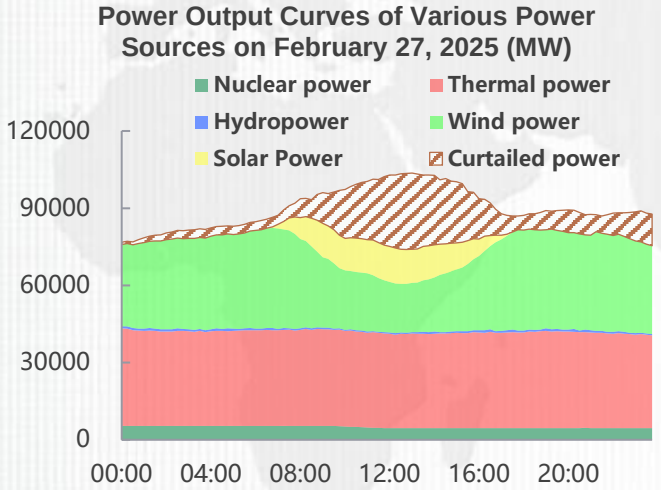




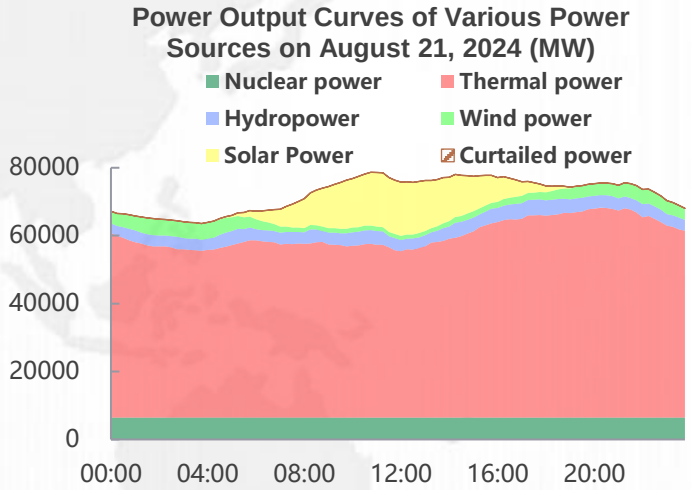
Northeast Grid

Difficulty in Power System Balance.

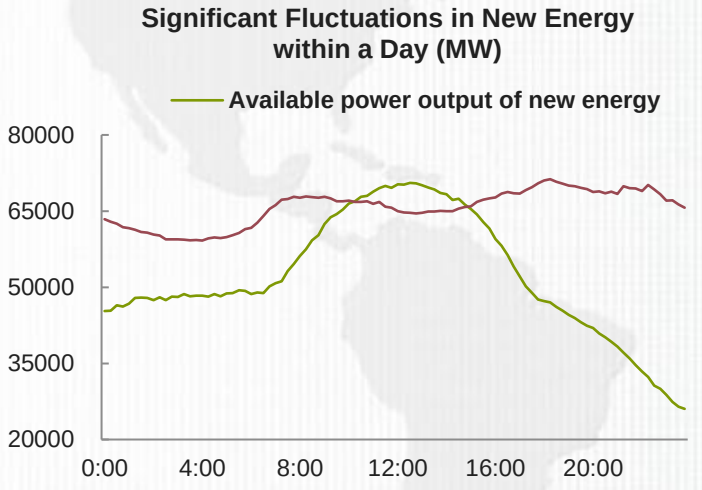
The contradiction between "Insufficient Supply and Excessive Surplus" of new energy is prominent, and the arrangement of conventional power sources is becoming increasingly difficult.



The max available power of new energy reaches 70.56GW, accounts for 70% of the installed capacity, exceed 60% of grid accommodation capacity.



The min power generation from new energy sources is 0.29GW, less than 0.5% of the installed capacity, only accounting for 0.3% of the total power generation.



Max intraday fluctuation reaches 44.51GW, accounting for 62% of the max power load of the day.

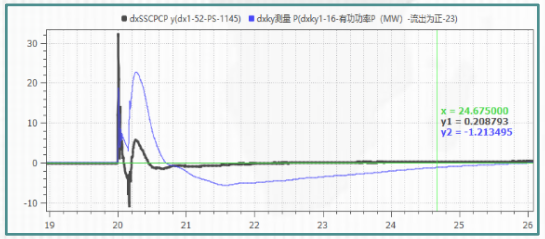
Northeast Grid

The Stability Problem of Power System.

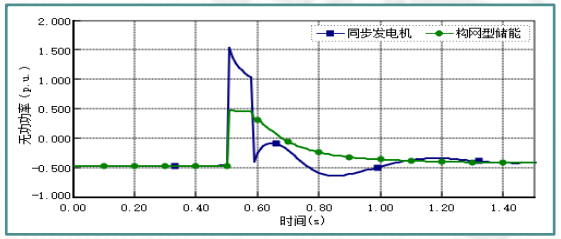
Power generation from new energy sources takes up as high as 58.6% of the total, and the percentage of operational capacity of conventional power sources is dropping continuously.

The natures of new energy sources, such as low inertia, low damping and weak voltage support, appear obviously.

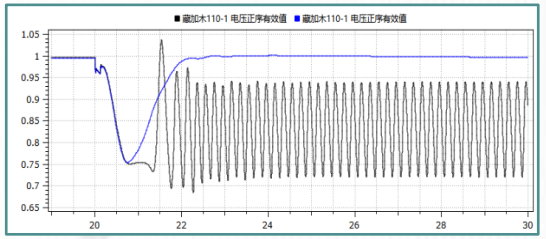
In this case, how to keep frequency and voltage stable becomes increasingly complex, and the stability problem with new-types**, and the risk of chain reactions failure is continuously increasing.**



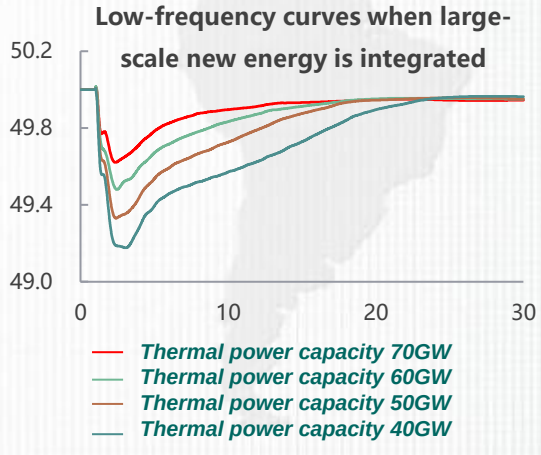
The existing grid-forming equipment has insufficient energy reserves and cannot provide better support in terms of inertia, frequency regulation, etc. for the system during faults.



The existing grid-forming equipment has limited overcurrent capacity. During faults, in order to prevent overcurrent, the reactive voltage support it can provide for the system is limited.



The existing grid-forming equipment has complex control systems and numerous parameters. If the control logic and parameter settings are not reasonable, it may not be able to provide adequate support for the system.



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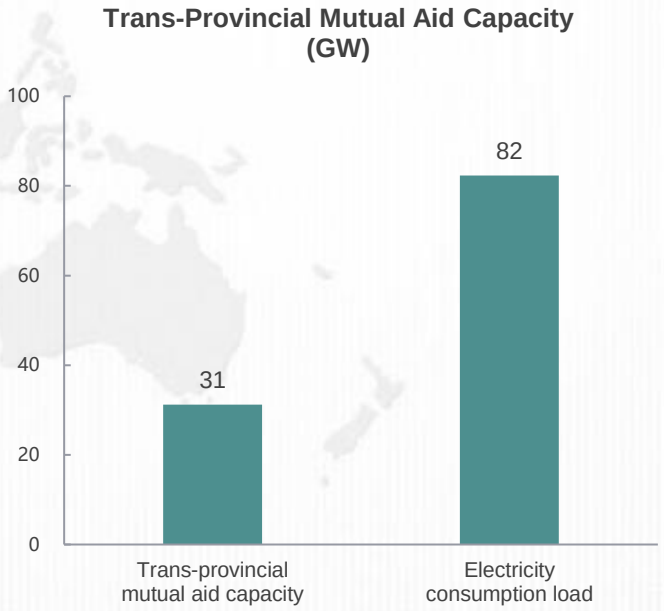
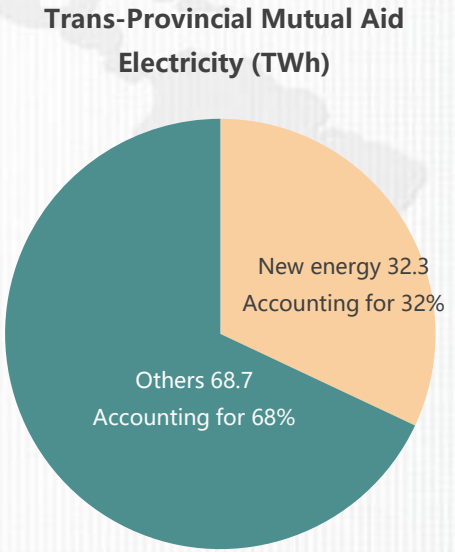
Building a Strong Interconnected Grid

Trans-Provincial Aid. In Northeast Grid, 30 500kV **trans-provincial AC transmission lines and a** ±500kV **DC power transmission project were built, making its trans-provincial mutual aid capacity reach 31.2GW, nearly 40% of its max power load.**

In 2024, the electric quantity under trans-provincial mutual aid reached 101TWh, accounting for 17.7% of the electricity consumption, of which 32% was from new energy.



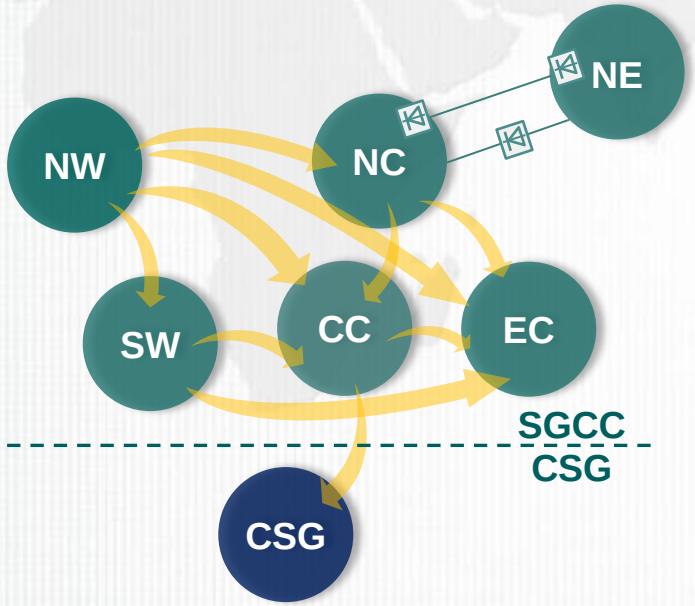


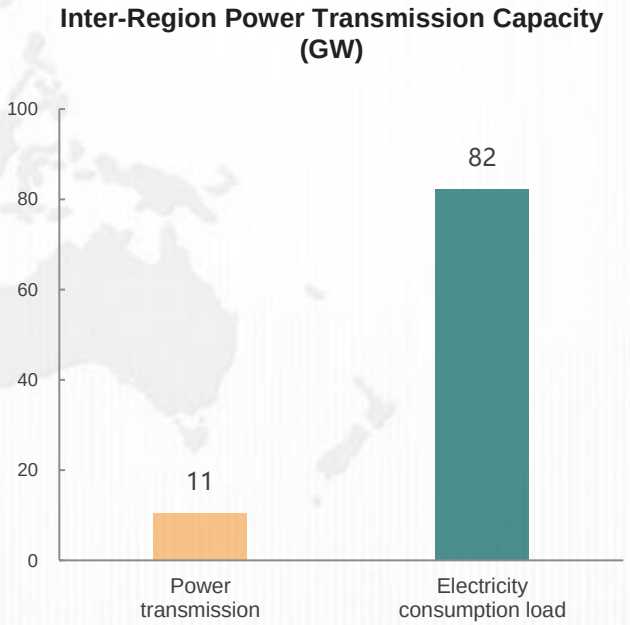
Building a Strong Interconnected Grid

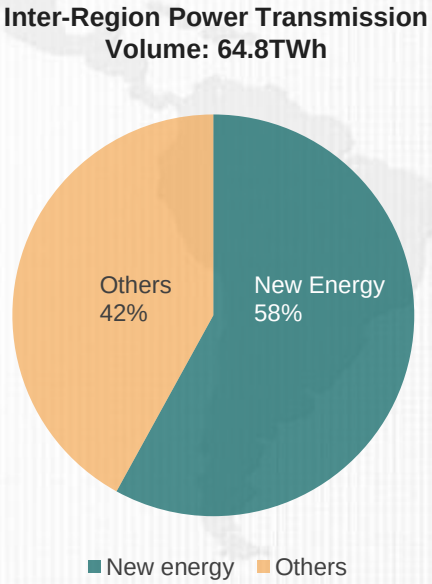
Inter-Regional Delivery. A ±800kV UHV DC transmission line was built, which delivers electricity to North China grid, with a rated capacity of 10GW.

A back-to-back DC power transmission project was built to deliver electricity to North China grid, with a rated capacity of 3GW.

In 2024, its inter-regional power delivery capacity reached 10.5GW, electric quantity to 64.8TWh.



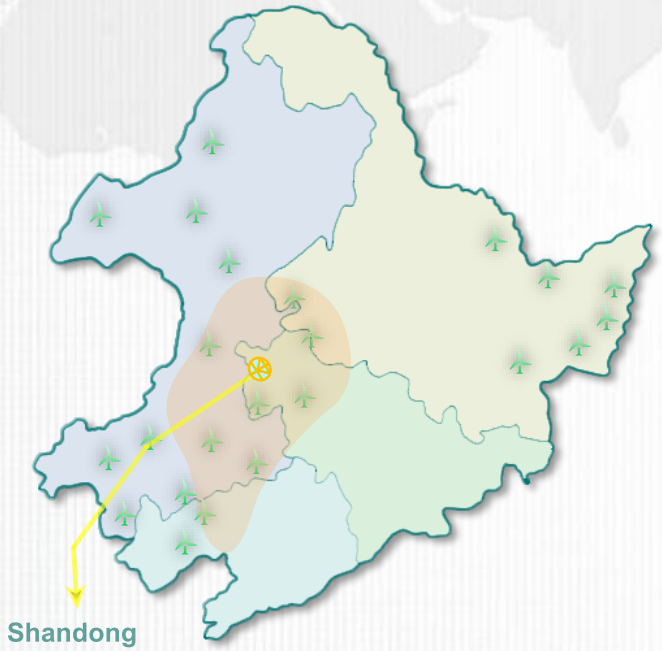


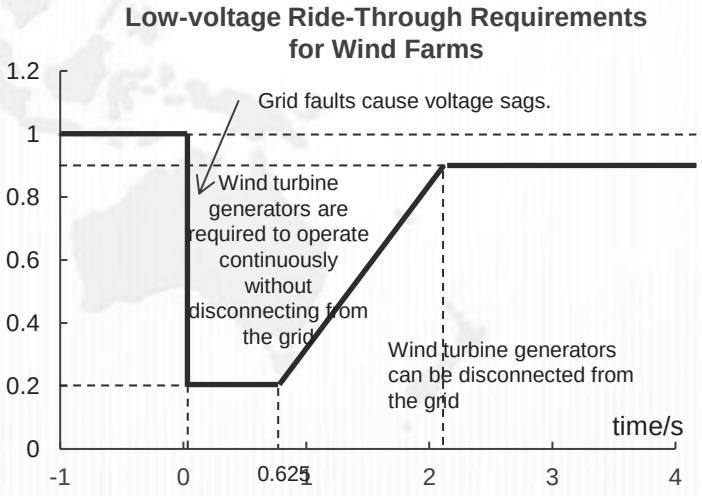


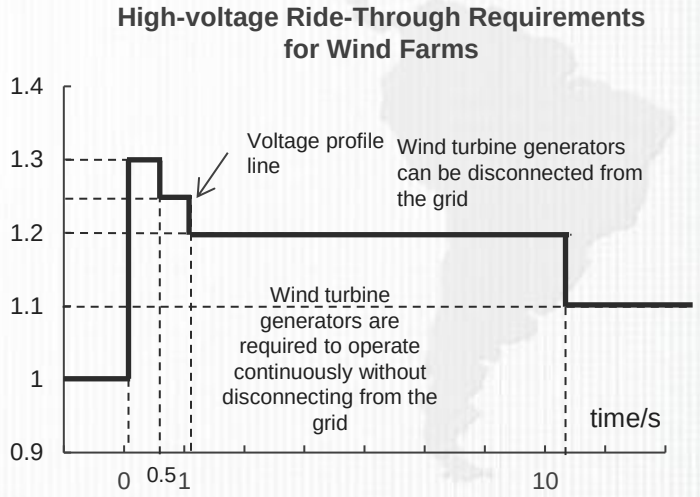
Enhancing Active Support Capacity

Improving grid security performance. To deal with the shortcomings of new energy, we spent 3 years upgrading the whole grid for higher withstanding capacities of new energy.

After upgrading, the frequency tolerance capacity reaches ±1.5Hz(Hertz)**, basically same to the conventional power sources**; the voltage tolerance capacity reaches 0.2p.u.-1.3p.u., ensuring stable operation for over 500 milliseconds under extreme operating conditions.



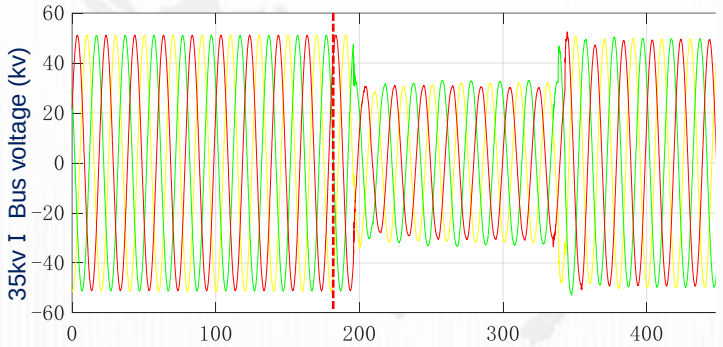


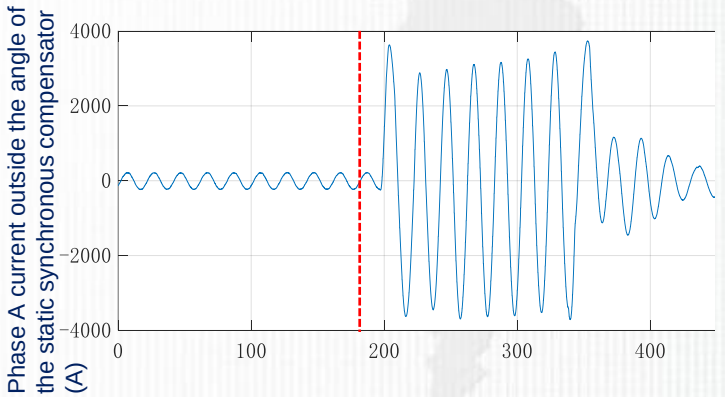


Enhancing Active Support Capacity

Exploring the applications of new technologies. To deal with the low inertia and insufficient voltage support in power systems with high-level penetration of new energy, and concentrating on the key technologies about grid-forming equipment, **we carried out performance tests on a 50MVar** (Megavar) **static synchronous compensator and a new type of energy storage** with a capacity of 50MW.

An artificial short-circuit test was performed to verify the voltage and inertia support capacity of the grid-forming equipment, which can be reached 3 times capacity of a grid-following device.





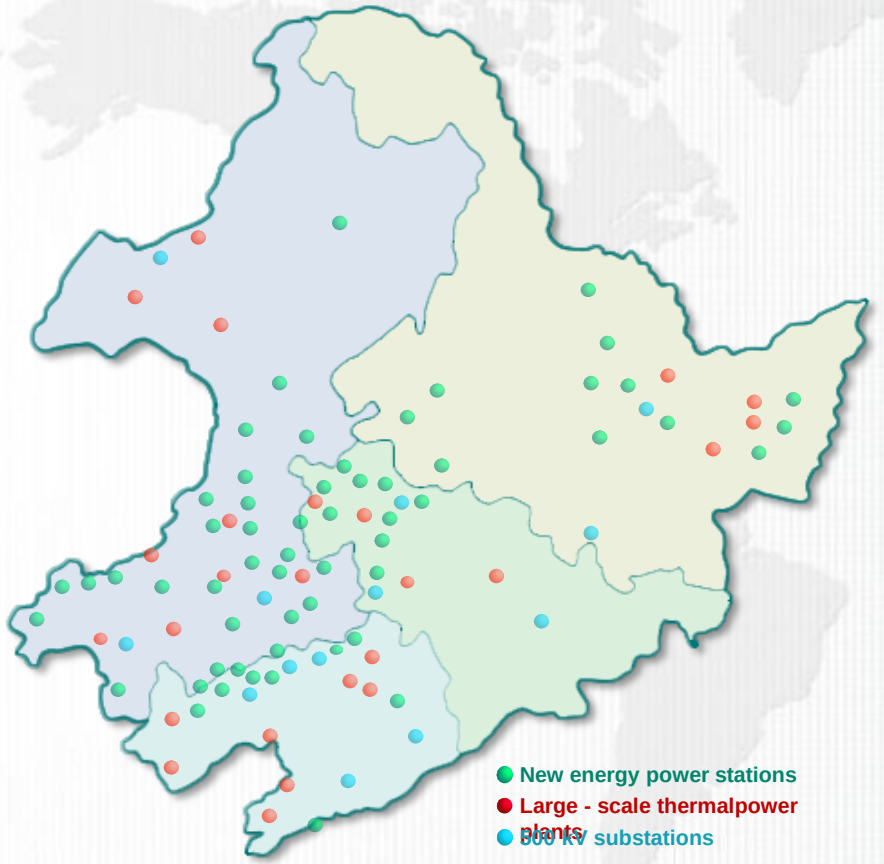
The Test of the World's First Static Synchronous Compensator

Enhancing Active Support Capacity

Resisting high-frequency risk:

We built a high-frequency emergency control system to control the power capacity at a level over 70GW. Meanwhile, **the system rapidly cut off the surplus** power of new energy, hydro-power and thermal power **within 200ms**(millisecond)**, ensuring the fluctuations of frequency within the normal range.**

In case a cross-regional delivery UHV DC transmission line is blocked, the max surplus power of the system will surpass 10% of the power load, and the frequency will climb up to 51.5Hz or higher within 10s.



Distribution Map of Protection Sites in the Northeast Grid

Enhancing Active Support Capacity

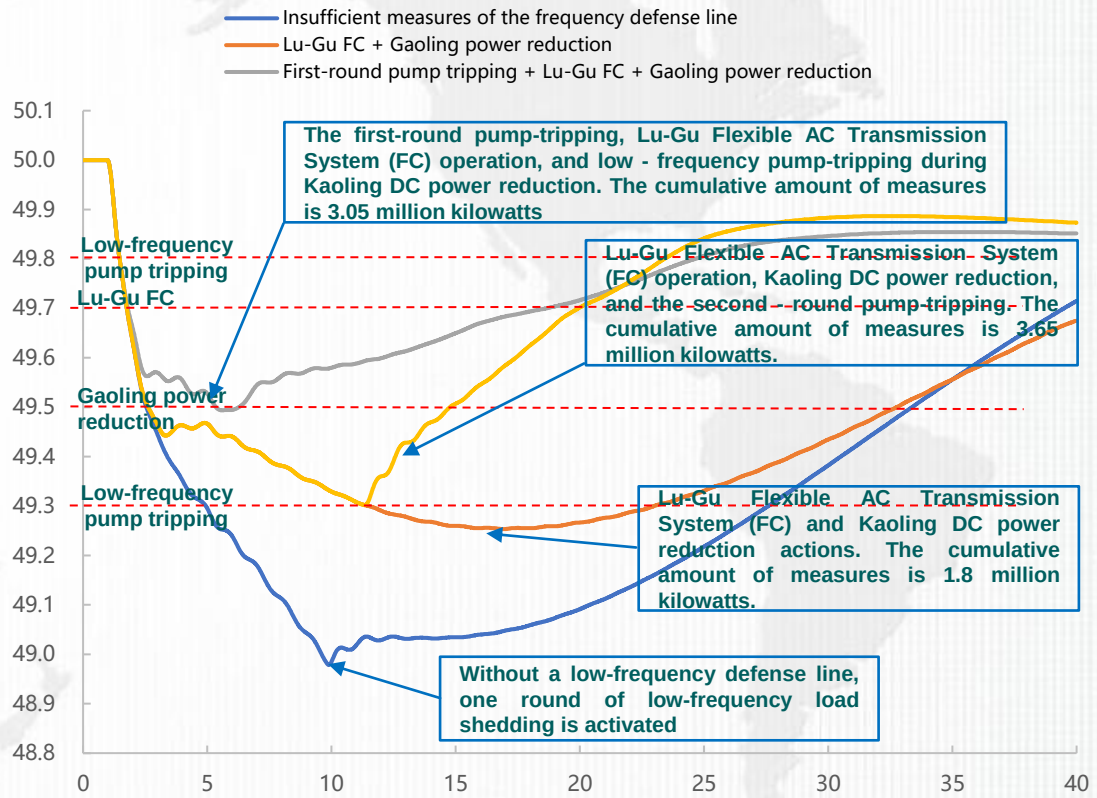
Resisting low-frequency risk:

We built a low-frequency emergency control system, with controllable resources exceeding 14GW .

Through quick DC regulation and cutting off pumped storage units and interruptible loads, etc., the low-frequency load shedding device is ensured not to be triggered.

In case a large power source trip or a large scale of new energy entering into low-voltage ride through(LVRT) zone, max power shortage of system will overtake 30% of the power load.

Adaptability of the Low-Frequency Defense Line under High-Output Scenarios of New Energy in Spring and Autumn-Response to the Tripping of 6 Units at Hongyanhe

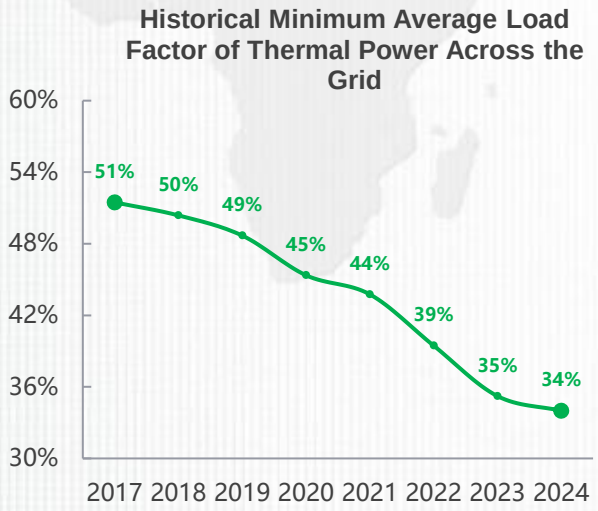


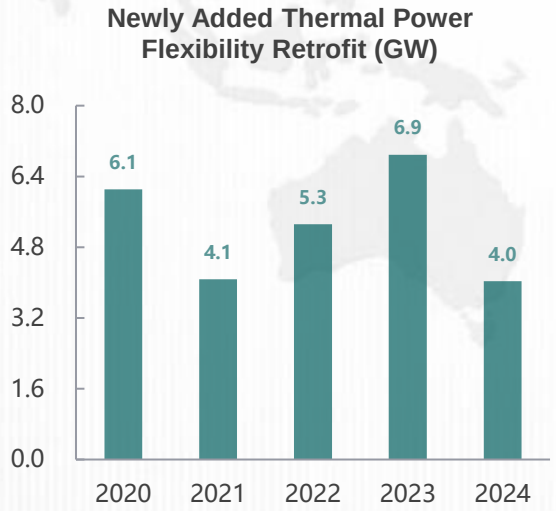
The Layout of Flexible Resources

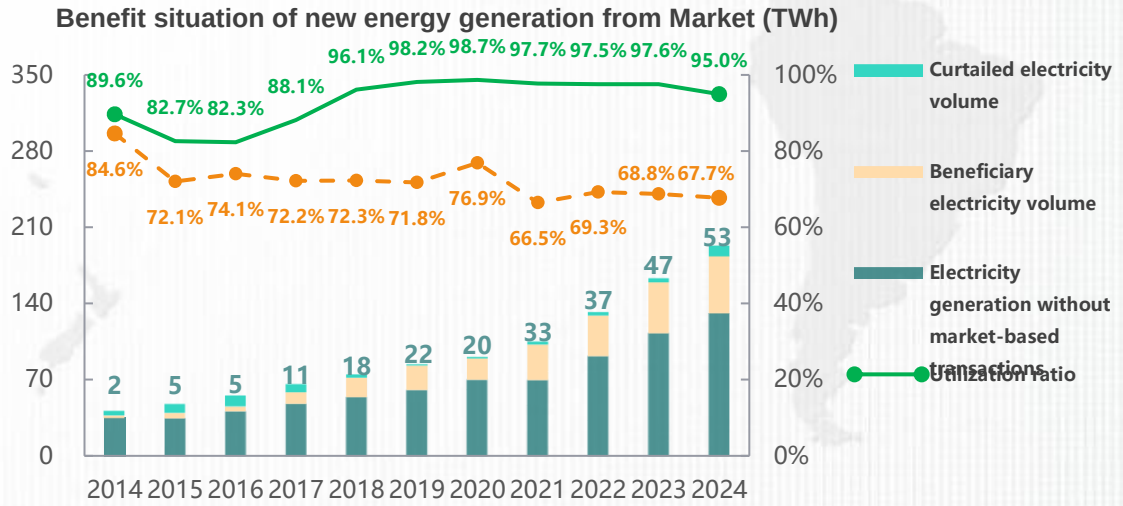
Enhancing the Regulating Capacity of Coal Power. By upgrading the combined heat and power generation of coal power units through market incentive mechanism, we have improved the thermal efficiency and their peaking capacity of coal power units remarkably, while ensuring residential heating.

By the end of 2024, we had completed the upgrading for 60GW coal power units.

During periods of significant power output of new energy, the average load rate of coal power dropped down to 34%, while some units even dropped down to 14%.





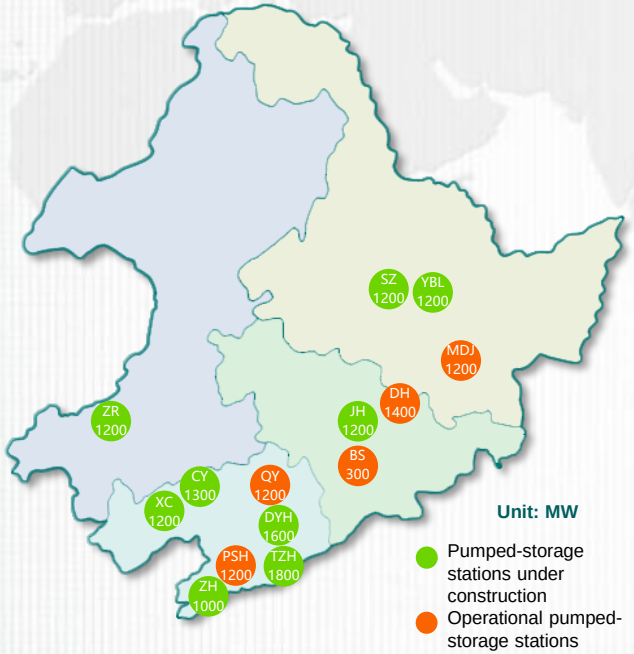


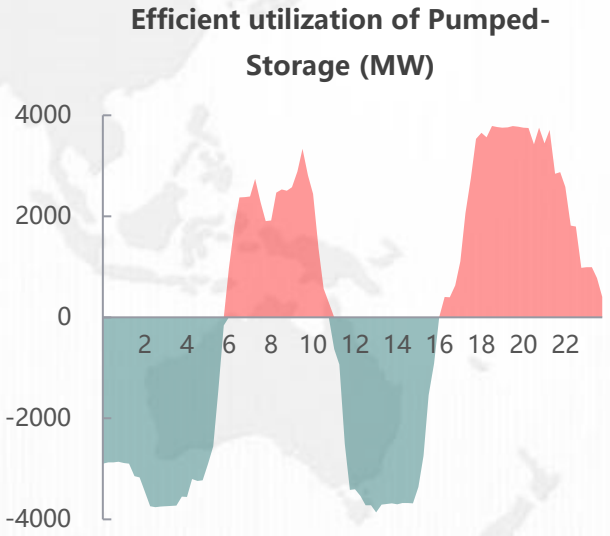
Over the past 10 years, a total of 252.6 TWh of additional new energy was integrated, accounting for 26% of the total from new energy sources.

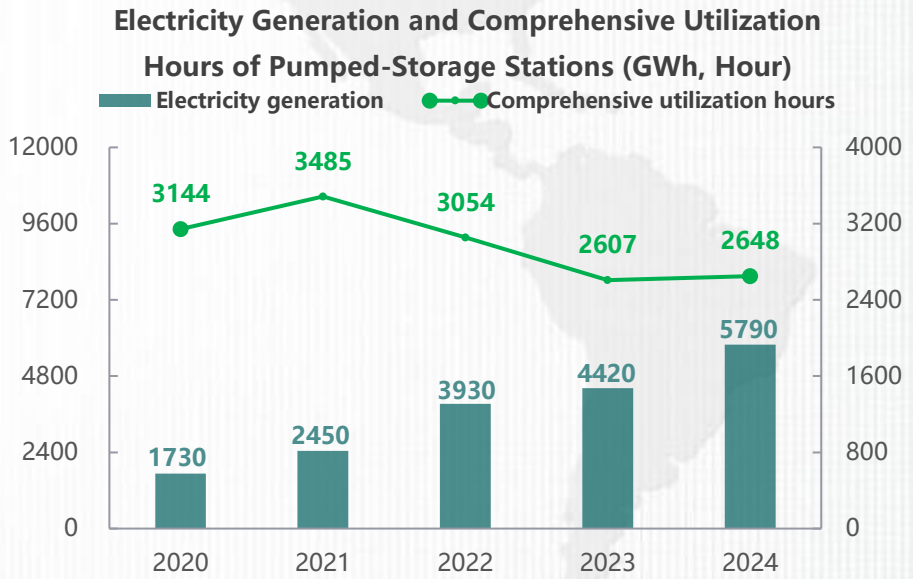
The Layout of Flexible Resources

Accelerating the Construction of Pumped Storage.There are 5 pumped storage stations in operation, with a total installed capacity of 5.9GW, a growth of 44% year on year.

There are 9 pumped storage stations under construction, with a total installed capacity of 11.7GW, and it is estimated all these stations will be commissioned by 2030.





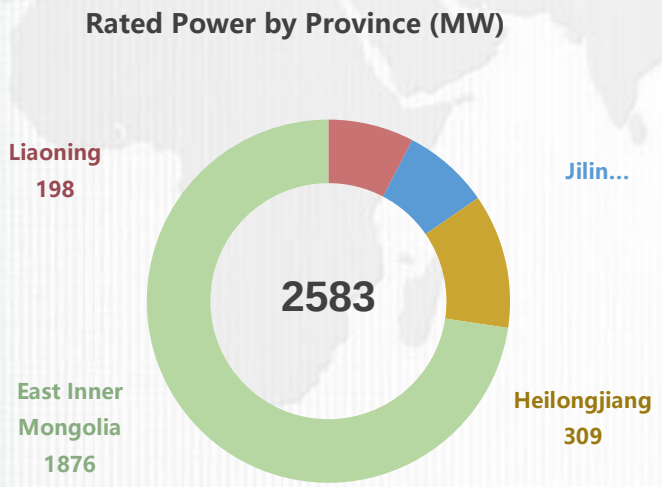


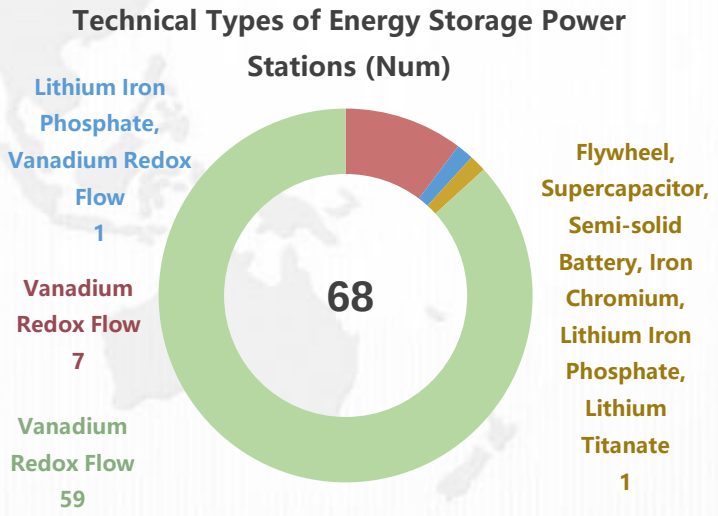
In 2024, pumped storage operated in a "Two rounds of pumping and generating" way for 237 days, with 7.3TWh of electric quantity being pumped, and comprehensive utilization hours reaching 2648.

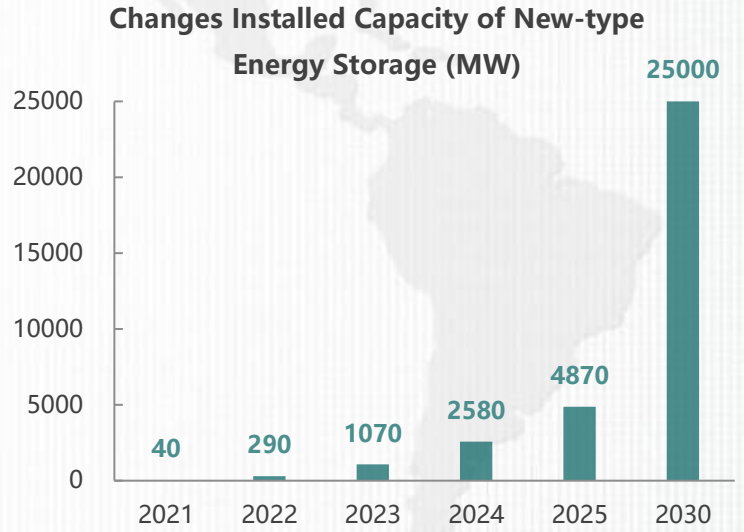
The Layout of Flexible Resources

Promoting New-type Energy Storage Applications.There are 68 new-type energy storage stations in operation, with an installed capacity totaling 2.58GW/5.62GWh, and the max installed capacity of a single station reaching 476MW/476MWh.

It is estimated that, **by the end of 2030, the total installed capacity will reach 25GW/**52GWh**.**



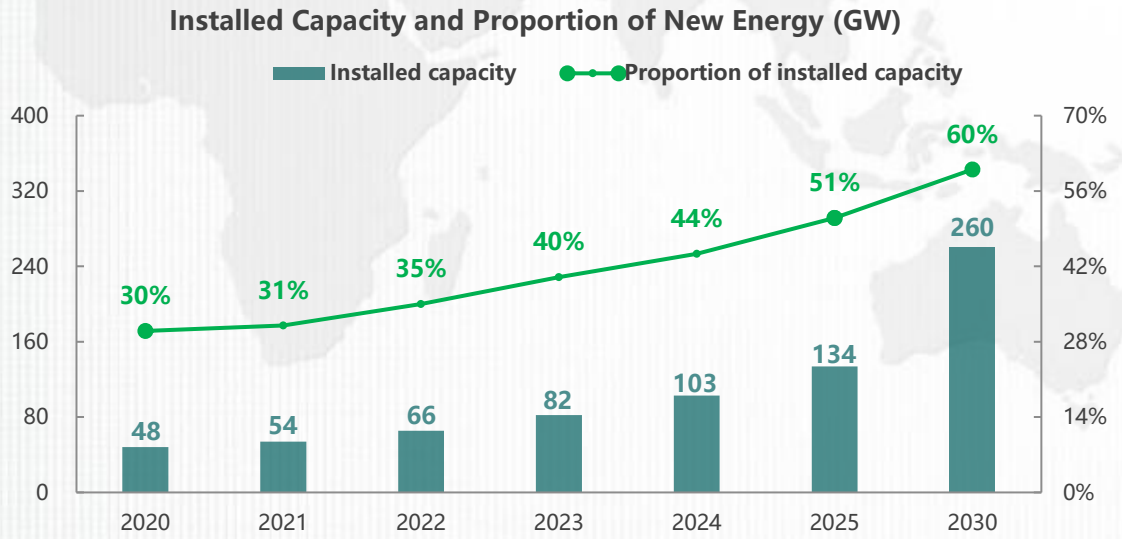


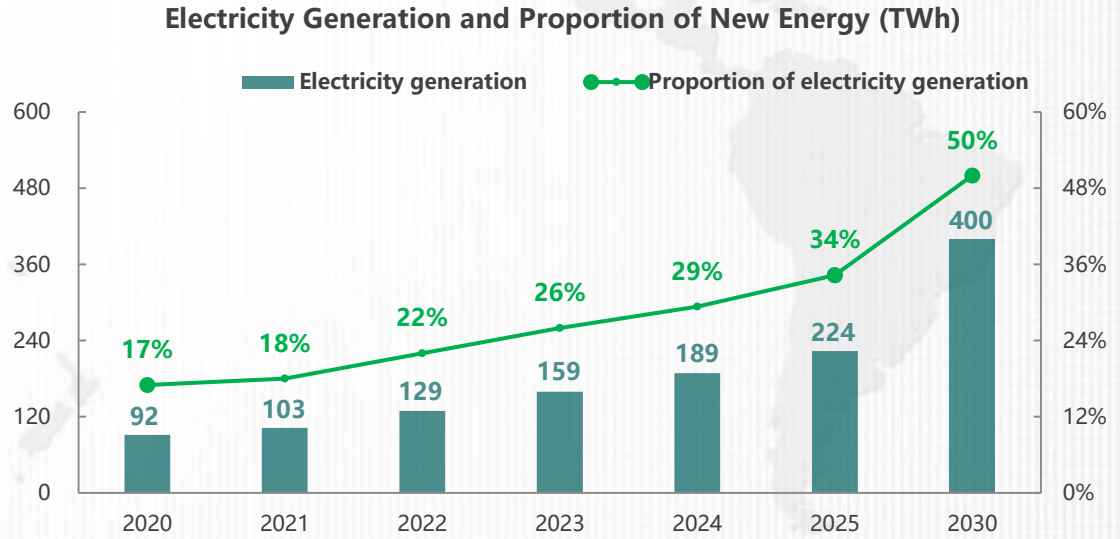


Expectation

Compared to 2021, the annual power generation of new energy doubled in 2024, rising from 91.5 to 188.6TWh, with a percentage of from 17% to 29% , higher than that of European Union (28.5%) - International leading position; utilization rate kept over 95%.

By 2030, the installed capacity of new energy will reach 260GW, accounting for 60% of the total installed capacity, with an annual power generation of around 400TWh, accounting for 50% of the total power generation.





It is estimated that, by the end of 2025, the installed capacity of new energy will reach 134GW, accounting for 51% of the total installed capacity, with an annual power generation of around 223.6TWh, accounting for 34% of the total power generation.

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THANKS