



国家电网公司东北分部

NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Large Scale Renewable Energy Integration in the Northeast China Grid

By Du Shibo, Yao Kaifeng

Northeast Branch of State Grid Corporation of China

ESIG Fall Technical Workshop, October 23- 26, 2023, San Diego, CA

Part 1

Grid outline

Part 2

Challenges faced

Part 3

Measures taken

Part 4

Next work



Grid outline



1. General introduction

- Northeast China Grid (the grid) is one of the six regional grids under State Grid Corporation of China (SGCC).
- The grid covers three provinces and the eastern part of Inner Mongolia. Area served is 1.28 million square kilometers and population served is 112 million.



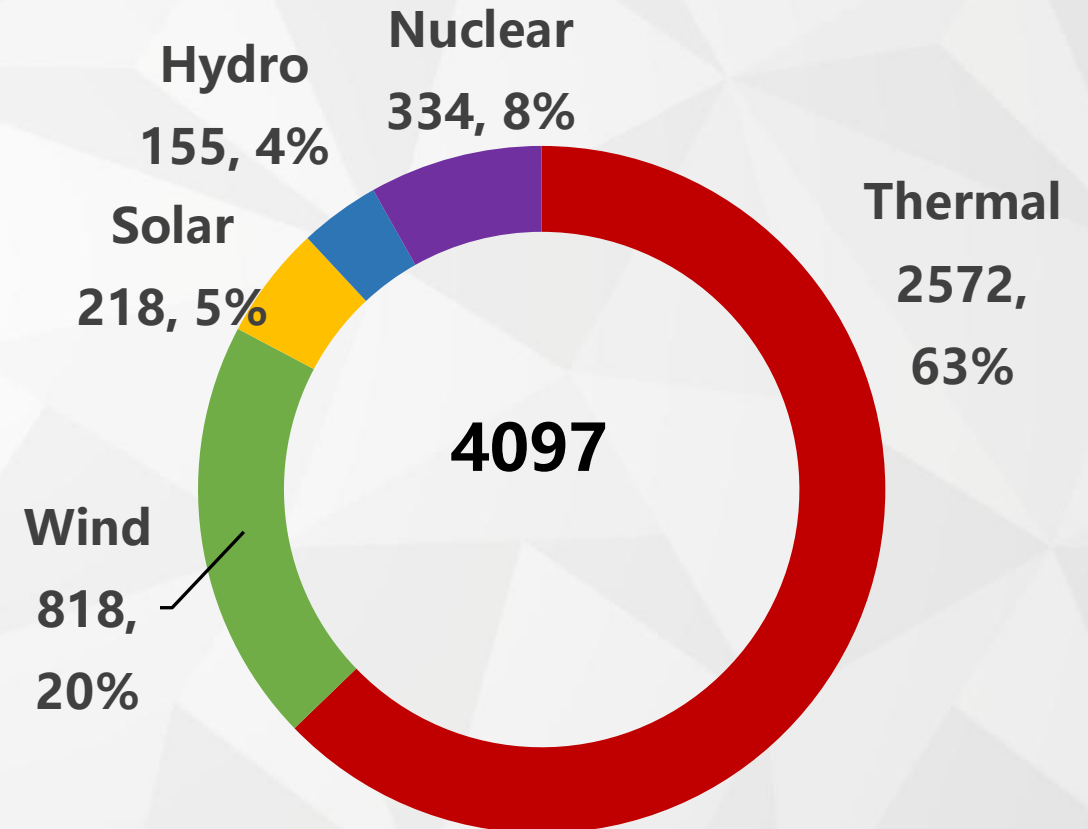


2. Power mix and generation

By the end of Aug. 2023, the grid's total installed capacity is 199GW with the peak load of 74.63GW.

- thermal power: 106GW, 54%;
- wind: 51.77GW, 26%;
- solar: 21.92GW, 11%;
- hydro: 12.19GW, 6%;
- nuclear: 6.68GW, 3%.

Electricity Jan- Aug 2023,
100GWh





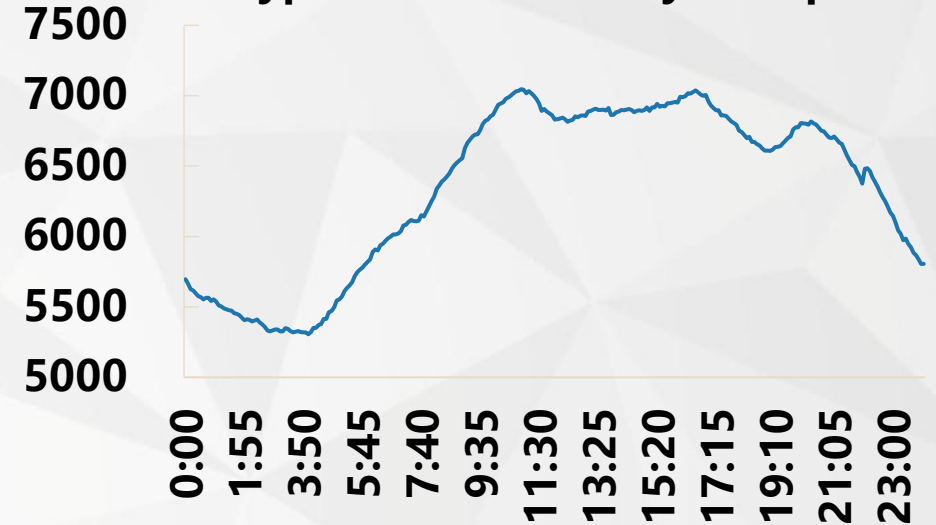
Grid outline



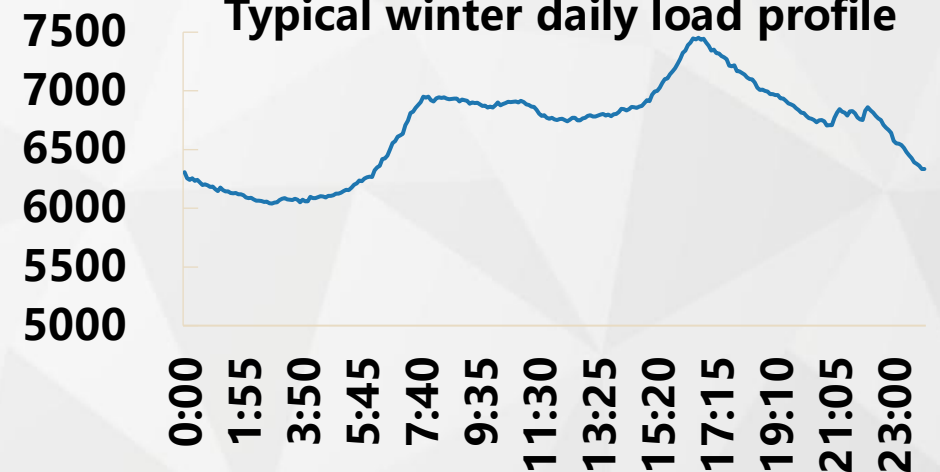
3. Load profile

- The grid's load is featured as 'double peak' in winter and summer. In summer, the peak loads occur around 11am and 5pm and in winter, it appears around 5pm.
- The summer peak load: 72.66GW (2023) ; the winter peak load:74.63GW (2022).

Typical summer daily load profile

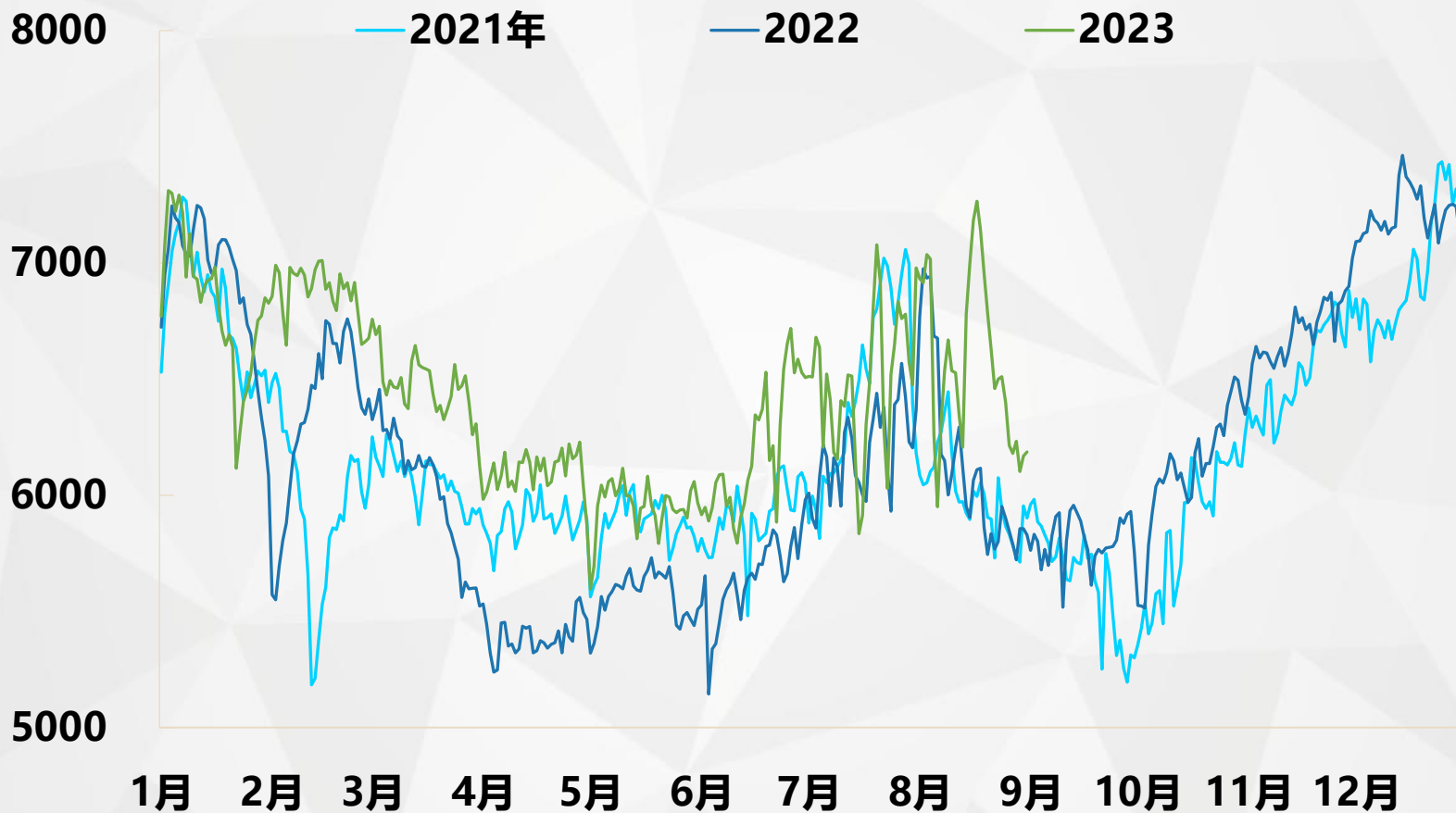


Typical winter daily load profile





Grid's power load profiles



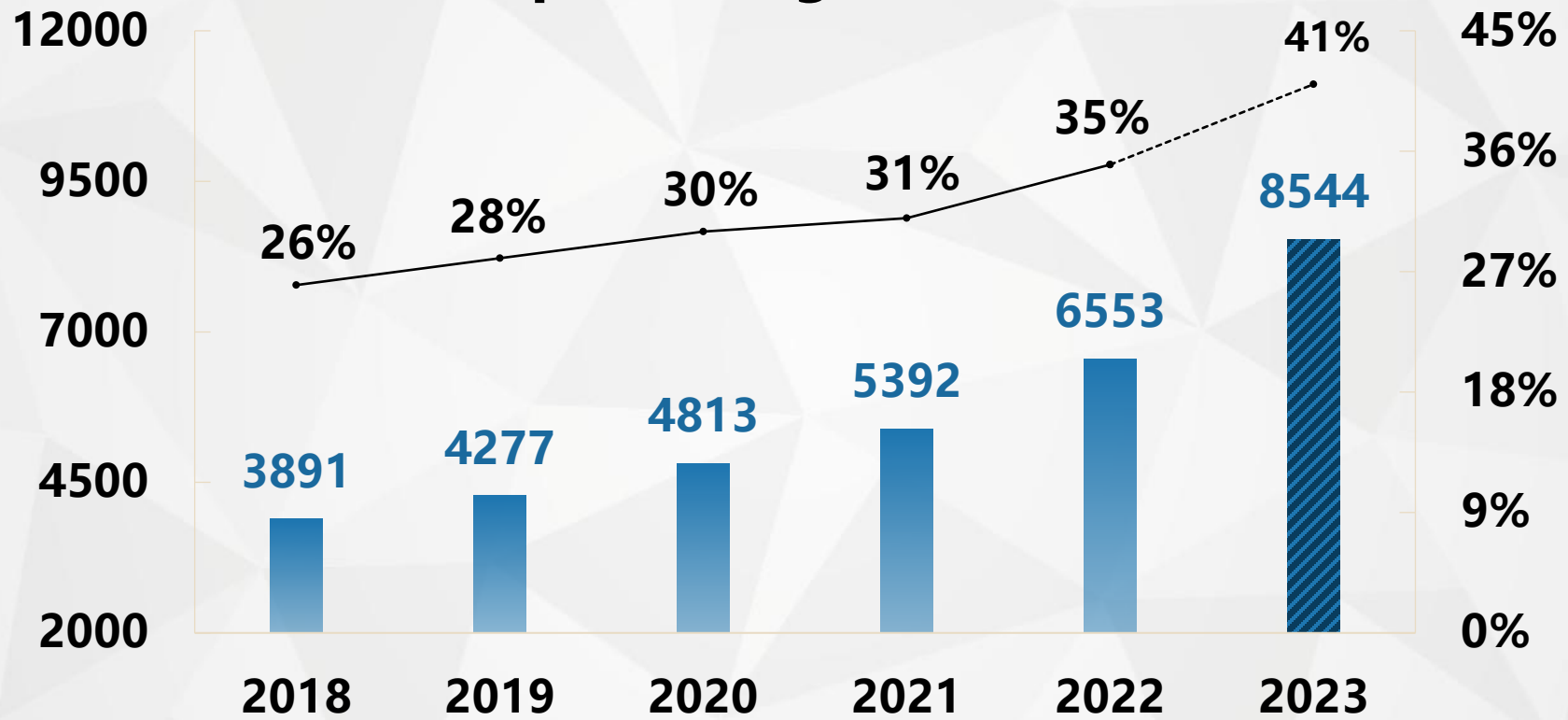


4. New energy development

- In 2022, the grid's new energy (wind+solar) development got accelerated with the installed capacity being 65.53GW, an increase of 11.61GW compared with 2021, more than the sum of the incremental capacities over the past three years. The new energy generation was 129TWh, an increase of 26.4TWh over 2021, which was 6.8TWh more than the total incremental new energy generations over the past three years.
- In 2023, the new energy developments would get further accelerated, with the expected total capacity to be 85.44GW, an increase of 19.91GW, by then, accounting for 41% of the total installed capacity, and the generation to be 158.9TWh, accounting for 25% of the total generation.



Grid new energy installed capacity and percentage 10MW





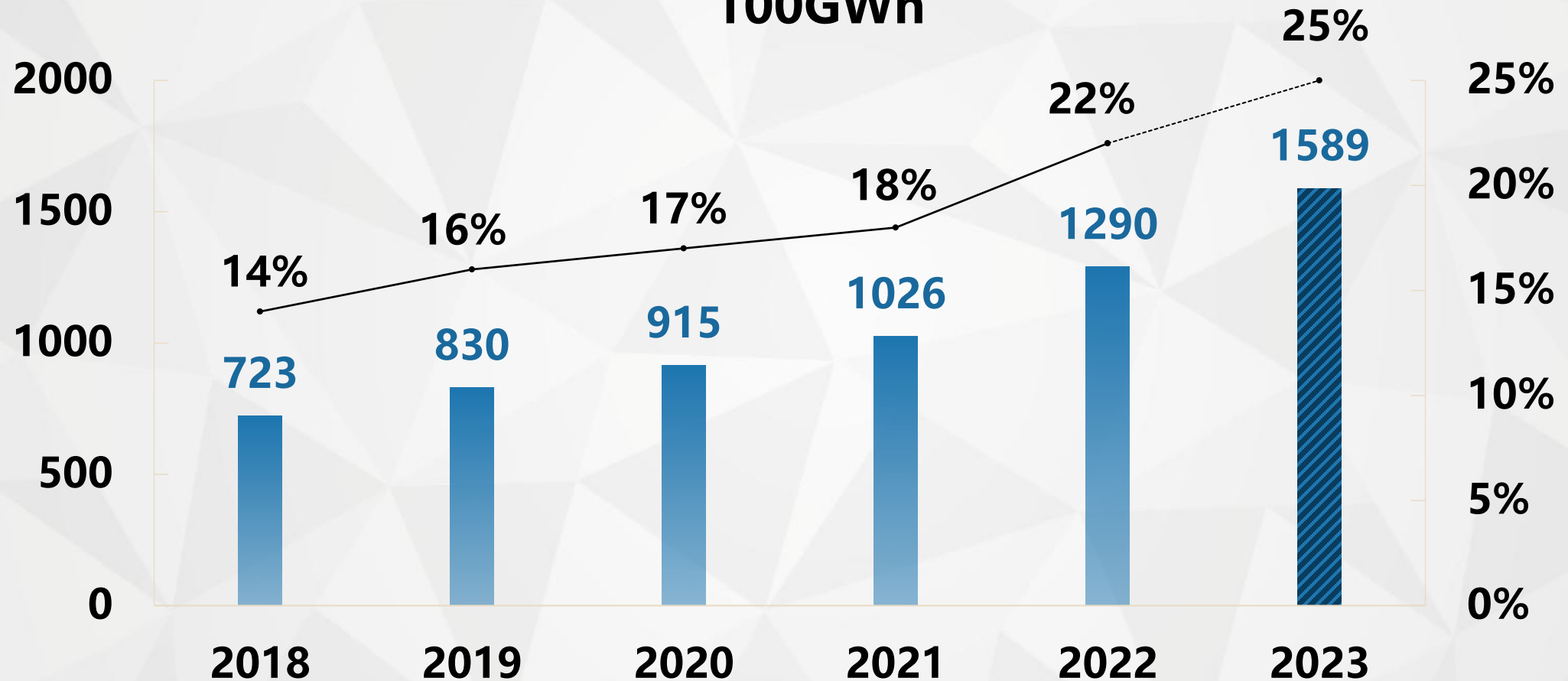
Grid outline



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Grid new energy electricity and percentage

100GWh

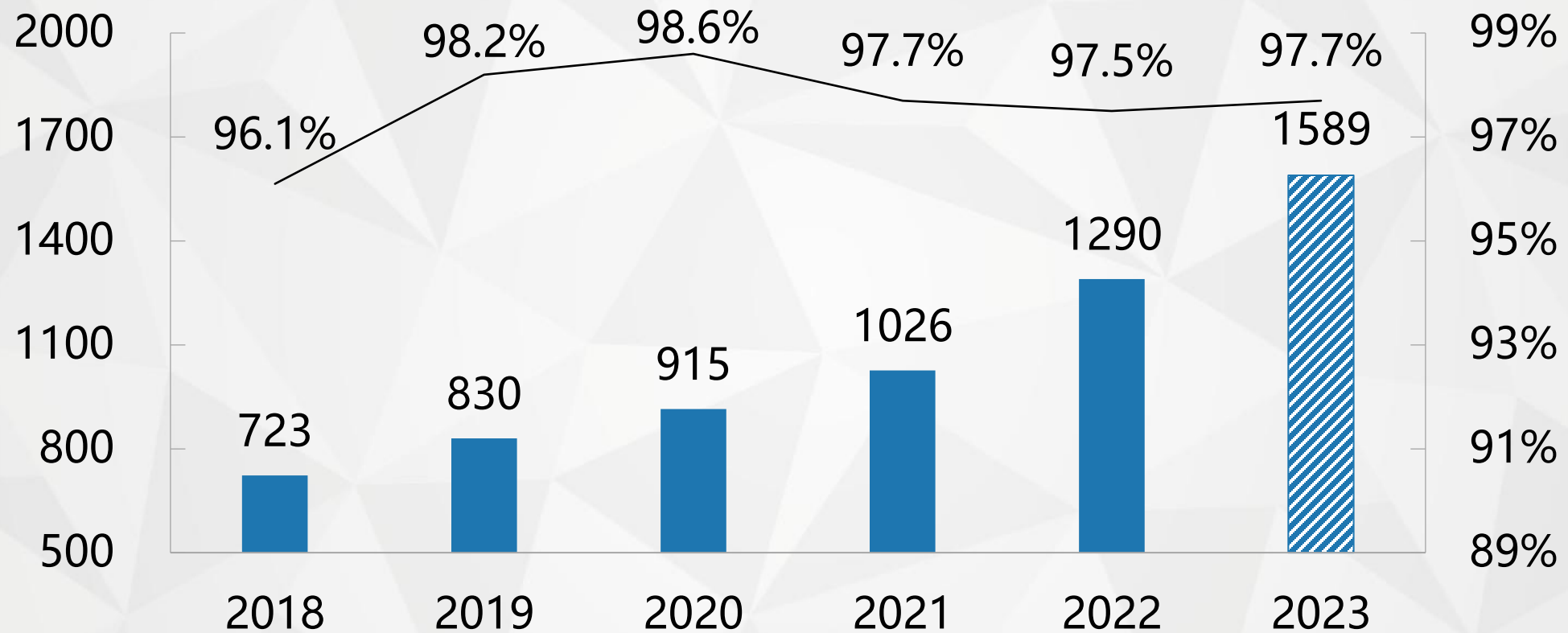




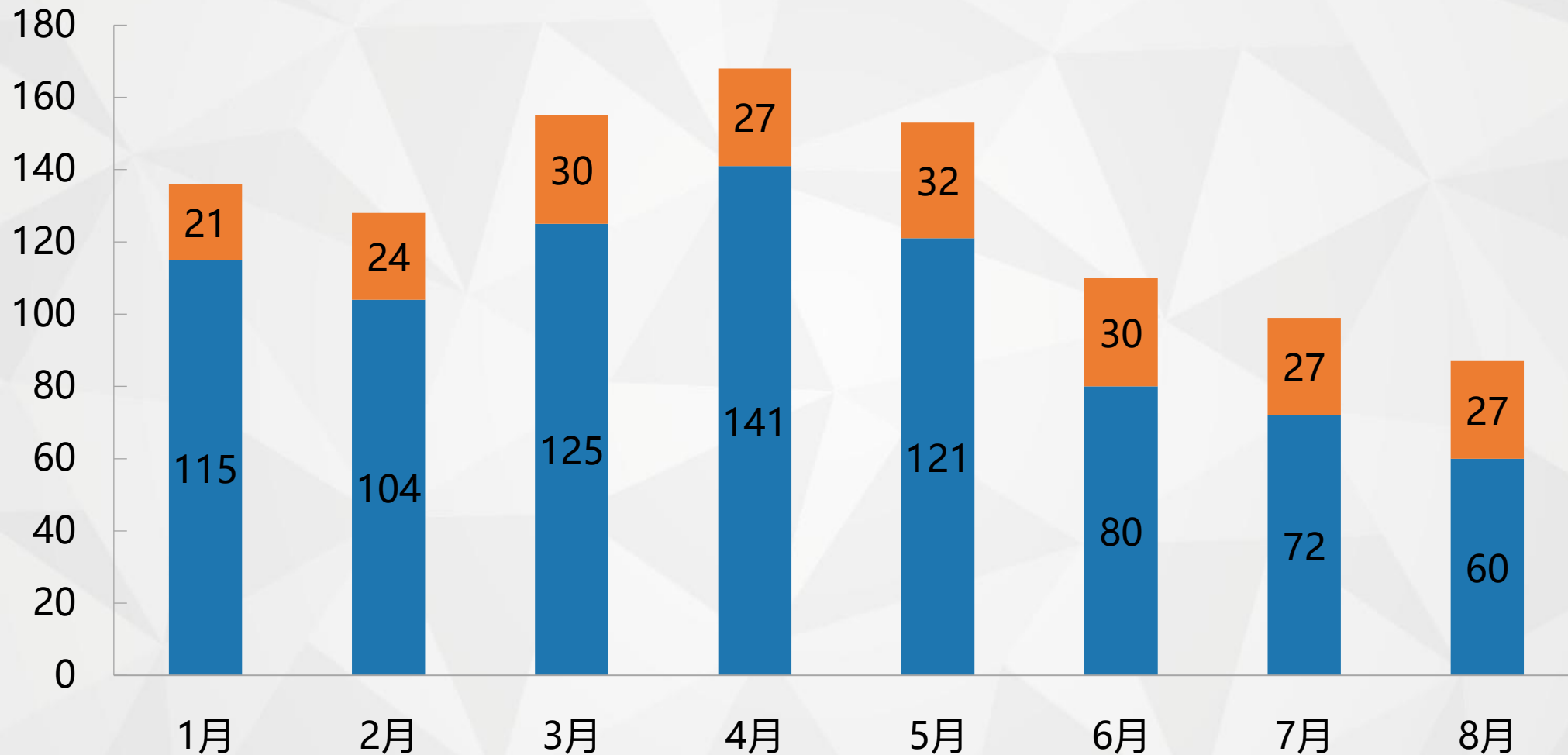
4. New energy development

- By the end of Aug., 2023, the new energy generation was 103.6TWh with an increase of 31% compared with 2022, of which, the wind generation was 81.8TWh and the solar generation was 21.8TWh.
- On April 7th, 2023, the maximum new energy penetration reached a record high of 39.69GW, accounting for 58.5% of the electric load at that point.

New energy electricity and utilization rate



Electricity by wind and solar Jan.-Aug. 2023, 100GWh



Part 1

Grid Outline

Part 2

Challenges faced

Part 3

Measures taken

Part 4

Next work



Challenges faced



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Increased risks of system operation security and stability

With high new energy penetration and high IBRs connected and considering the random and intermittent features, the system stability levels in frequency and voltage tend to be decreasing, thus increasing risks of secure and reliable operation.



Challenges faced



Slow growth of the load and the limited trans-regional power transfer capacity

The slow load growth and the limited trans-regional power transfer capability pose serious situations for the new energy integration. The utilization rates of the new energy tend to be decreasing.



Challenges faced



High coincidence of heating period with high wind generation

Northeast China region heating period starts from November to April, highly coinciding with the high wind generation. Higher CHP units operation mode makes smaller space for new energy integration.



Challenges faced



Insufficient quick and flexible regulating units

The most newly-built power sources are wind, CHPs and nuclear. The hydropower and gas-fired units capable of quick peak-regulating are in smaller percentage, thus not meeting the needs of the new energy integration.

Part 1

Grid outline

Part 2

Challenges faced

Part 3

Measures taken

Part 4

Next work



Improving the power balance strategy



Extending the power balance mechanism from three-day cycle to seven-day cycle, enabling comprehensive evaluation on:

- power production mode,
- load and new energy forecasting credibility,
- transmission equipment maintenance arrangement, and
- demand side management .

The better results have been achieved:

Optimization of the thermal power unit commitments

Reducing the numbers of generating unit start-stop operation

Decreasing new energy integration costs paying for ancillary service usage.



Role of the ancillary service market



In 2014, the first China ancillary service market was established in Northeast China Grid. Based on the ancillary market, the thermal power units have been guided to make in-depth peak-regulating for more wind and solar generation integration.

Thanks to the ancillary market, In the period from Jan. to Aug., 2023, the grid's total additionally integrated new energy generation was 30TWh, accounting for 33.7% of the total new energy generation of this period.

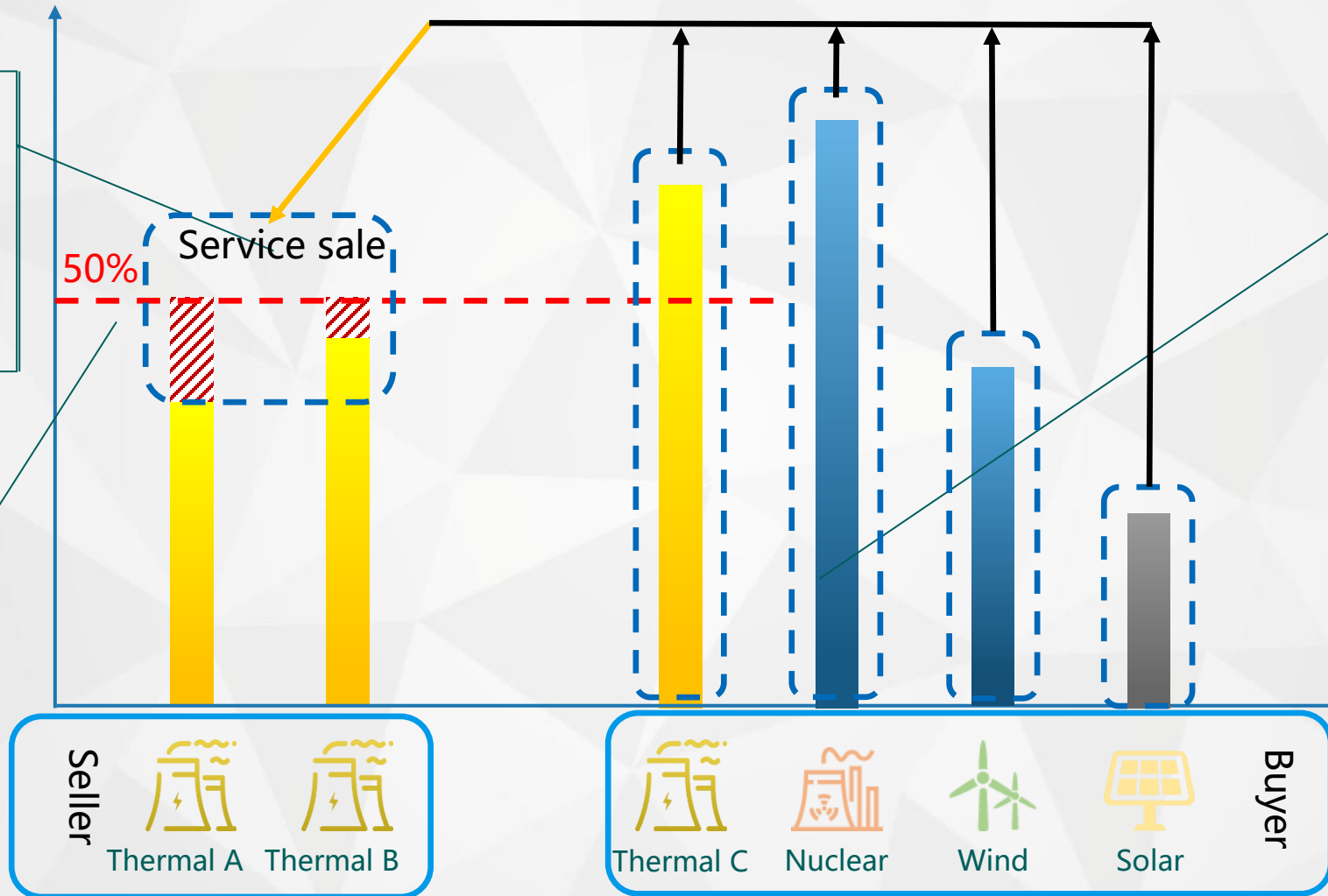


Ancillary service market diagram



Paid peak regulation service offered for sale, cleared at marginal price

50% of load rate set as the threshold between free and paid power regulation



Thermal, wind, solar and nuclear units not providing regulating services should pay the service providers based on their generation shares out of total generation through the market.



Thermal power flexibility retrofiting



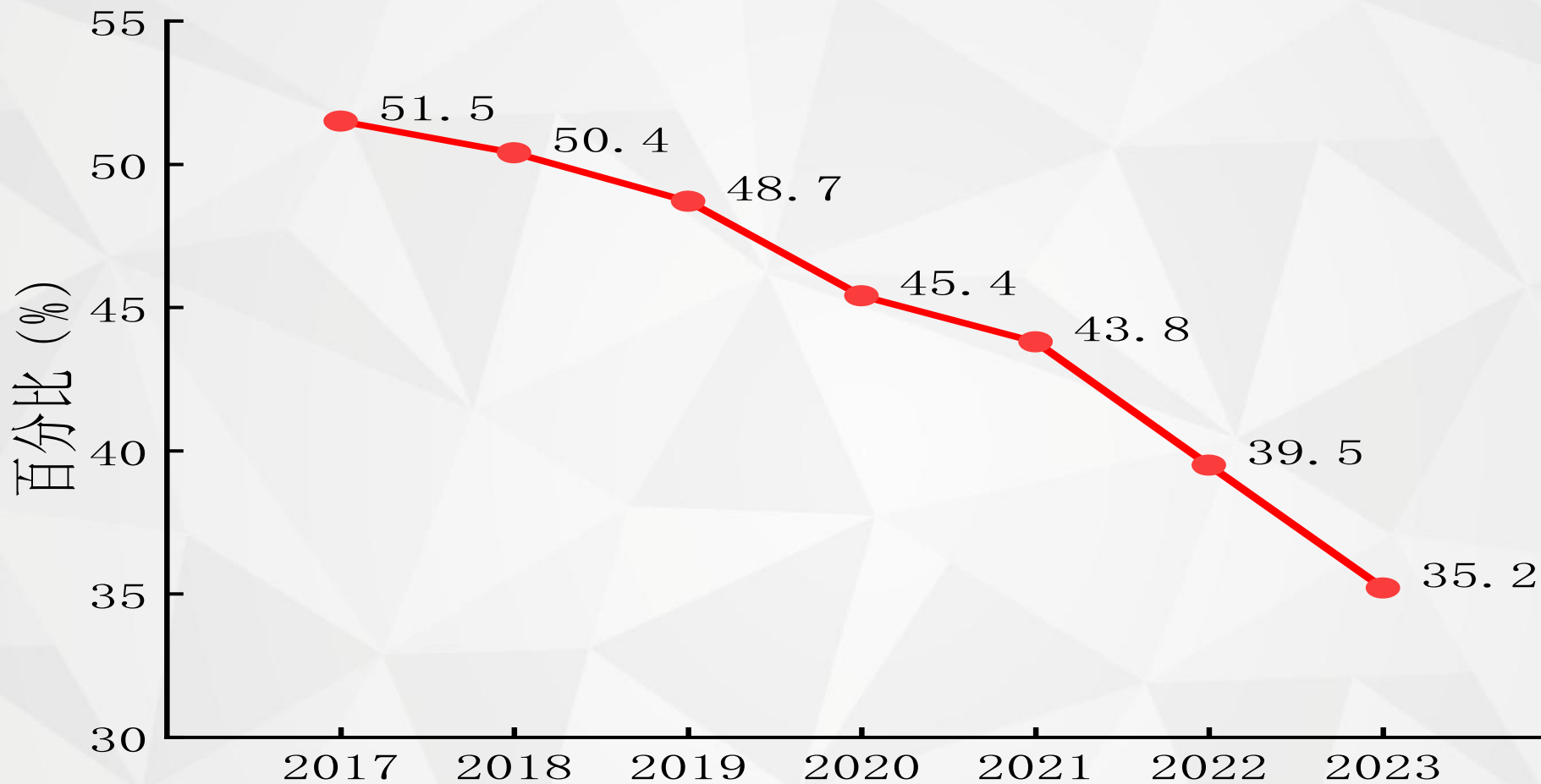
Driven by the ancillary market, **58GW** of the thermal power flexibility retrofiting has been completed, accounting for **65%** of the total thermal power capacity. Some thermal generating units have achieved the minimum stable operation load rate as low as to be **15%**.

34 CHP plants have been installed with thermal storage with total capacity of **6.42GW**, realizing decoupling of electricity generation from heating.

By taking all these measures, the increased in-depth regulating capability of **17.29GW** has been achieved. The grid's average thermal power load rate has been decreased up to **35.2%** at minimum.



Thermal power flexibility retrofitting



The yearly grid's average minimum thermal power load rates



Flexible CHP Technical Solutions



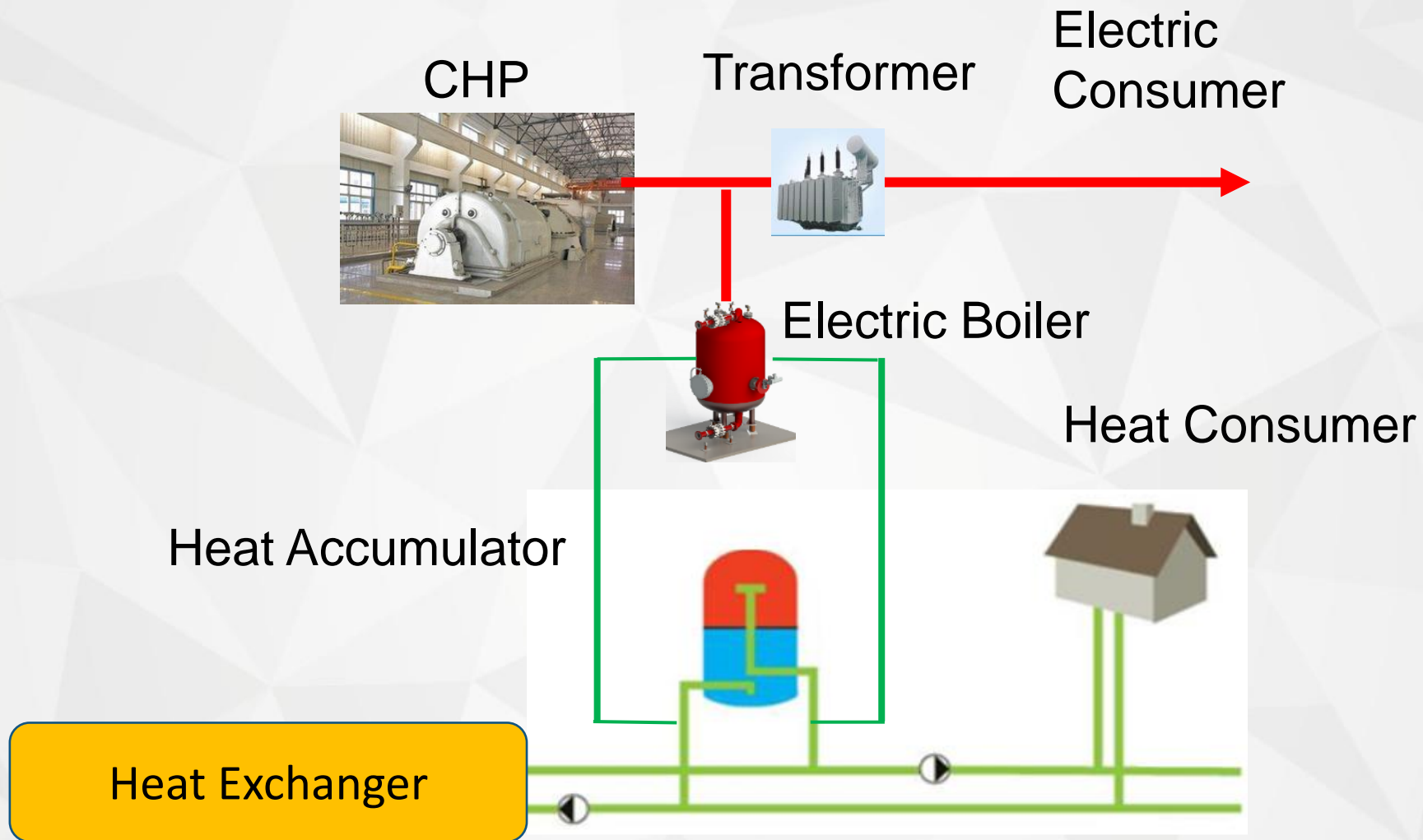
国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

- Optimization of turbine operation mode
- Electric Boiler+Heat Accumulator
- Systematic retrofitting
- Electric Heater+Solid-medium Heat storage
- Turbine LP Cylinder Bypass
- High Back Pressure Retrofit
- Extra Heat Exchanger
- Heat Accumulator





Flexible CHP diagram



CHP Flexibility Retrofitting with Electric Boiler



Thermal storage of CHP plant



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA



The thermal storage of Shengfa CHP plant in Tongliao, Inner Mogolia



Novel energy storage development



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Promoting the novel energy storage development and application. Carrying out study on power dispatching and control mode of novel energy storage.

There are 28 novel energy storage stations in the Northeast China grid with a total capacity of 860MW/2020MWh. They can be divided into two types:

- large scale independent storage, such as Dalian vanadium flow battery energy storage
- wind/solar plus energy storage, such as lithium iron storage



Novel energy storage development



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA



Dalian all vanadium flow battery energy storage 200MW/800MWh,
Phase one now in operation, 100MW/400MWh.



Optimizing pumped hydro operation



There are four pumped hydro stations in operation with a total capacity of 4.1GW.

In 2022, the pumped electricity of the pumped hydro stations was 5.1TWh and the power generation was 3.9TWh, pumping 4243 times and generating 4250 times.

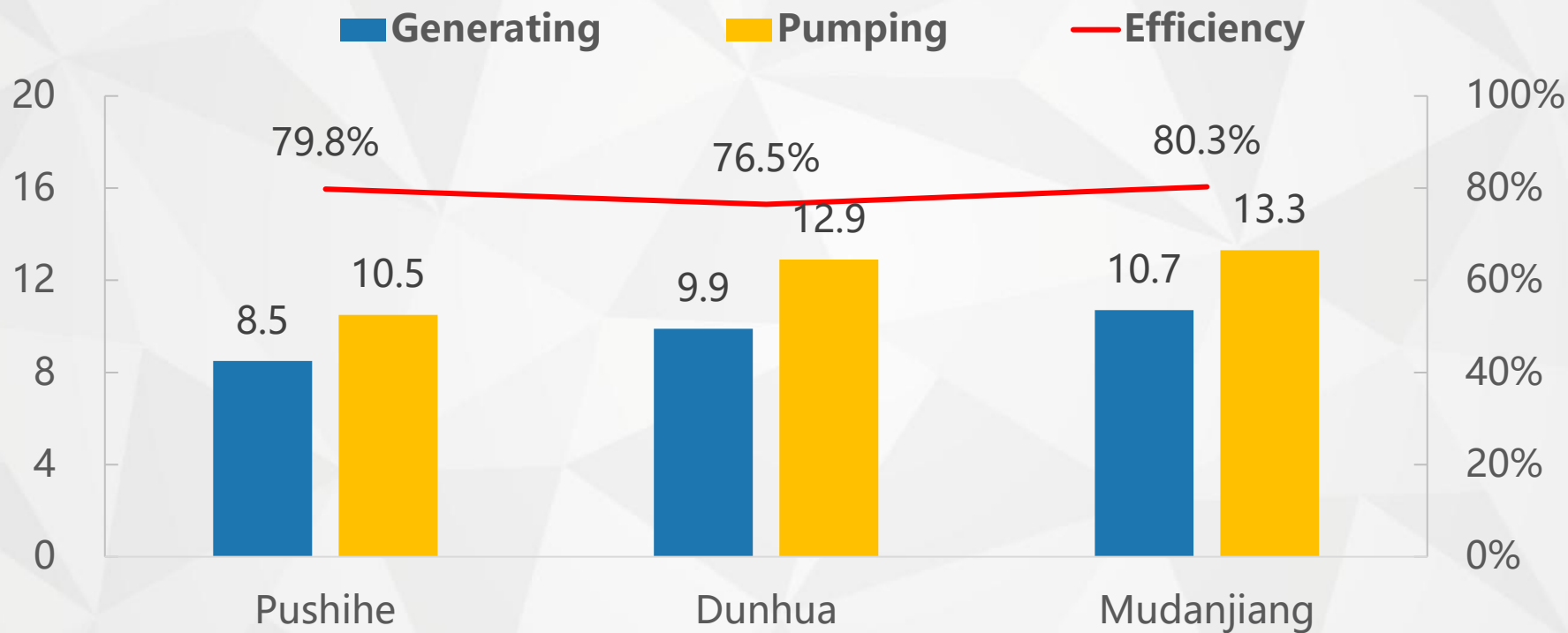
For the purpose of maximizing system regulating capability and the new energy integration, the strategy of dynamically adjusted pumped hydro operation has been taken. During high wind generation, the daily operation of “two pumping and two generating” has been adopted.



Optimizing pumped hydro operation



Pumped hydro generating and pumping electricity and efficiency Jan.-Aug. 2023 (100GWh)



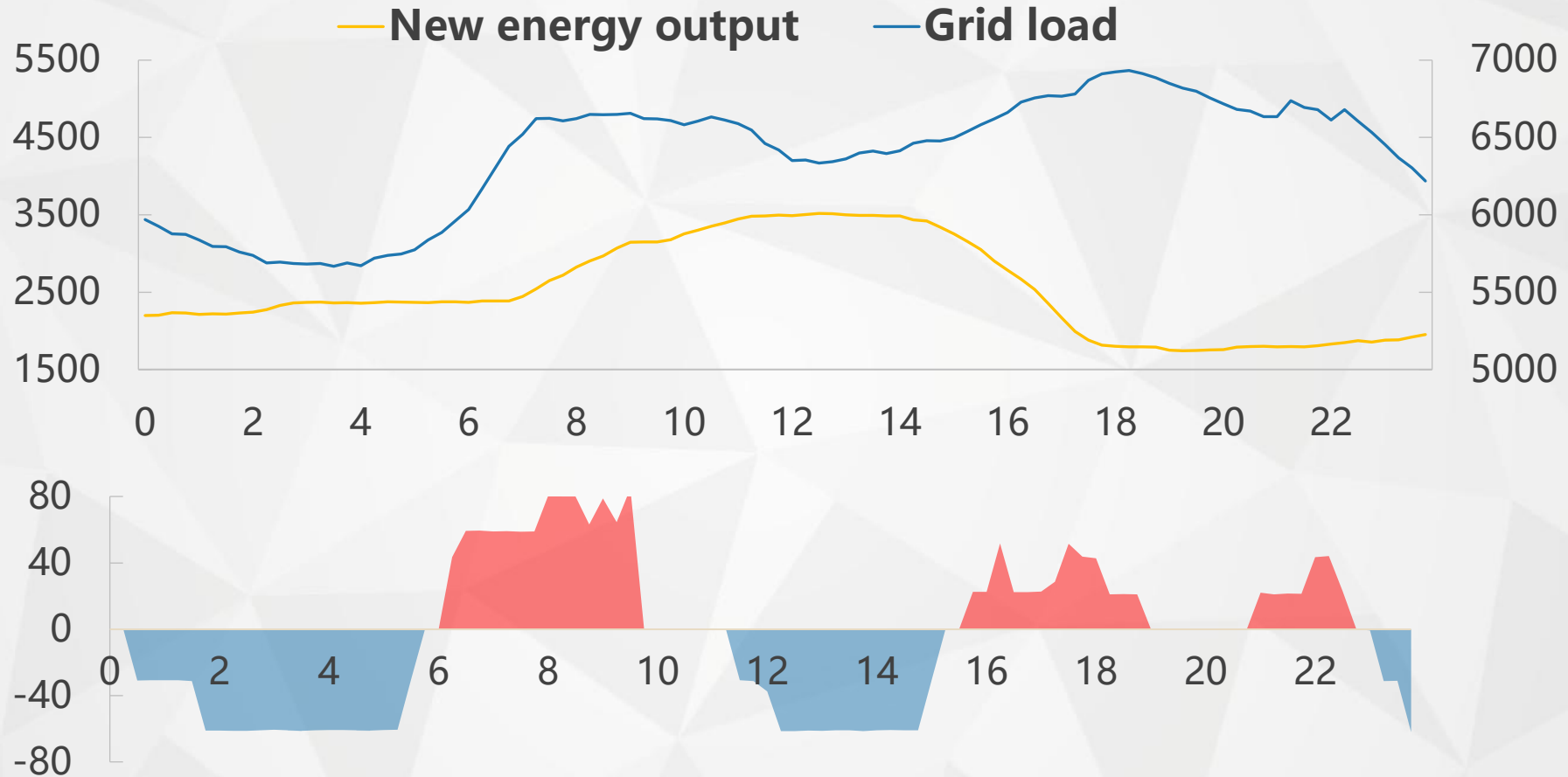


Optimizing hydro pumped operation



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Pumped hydro: multiple pumping and generating diagram (10MW)



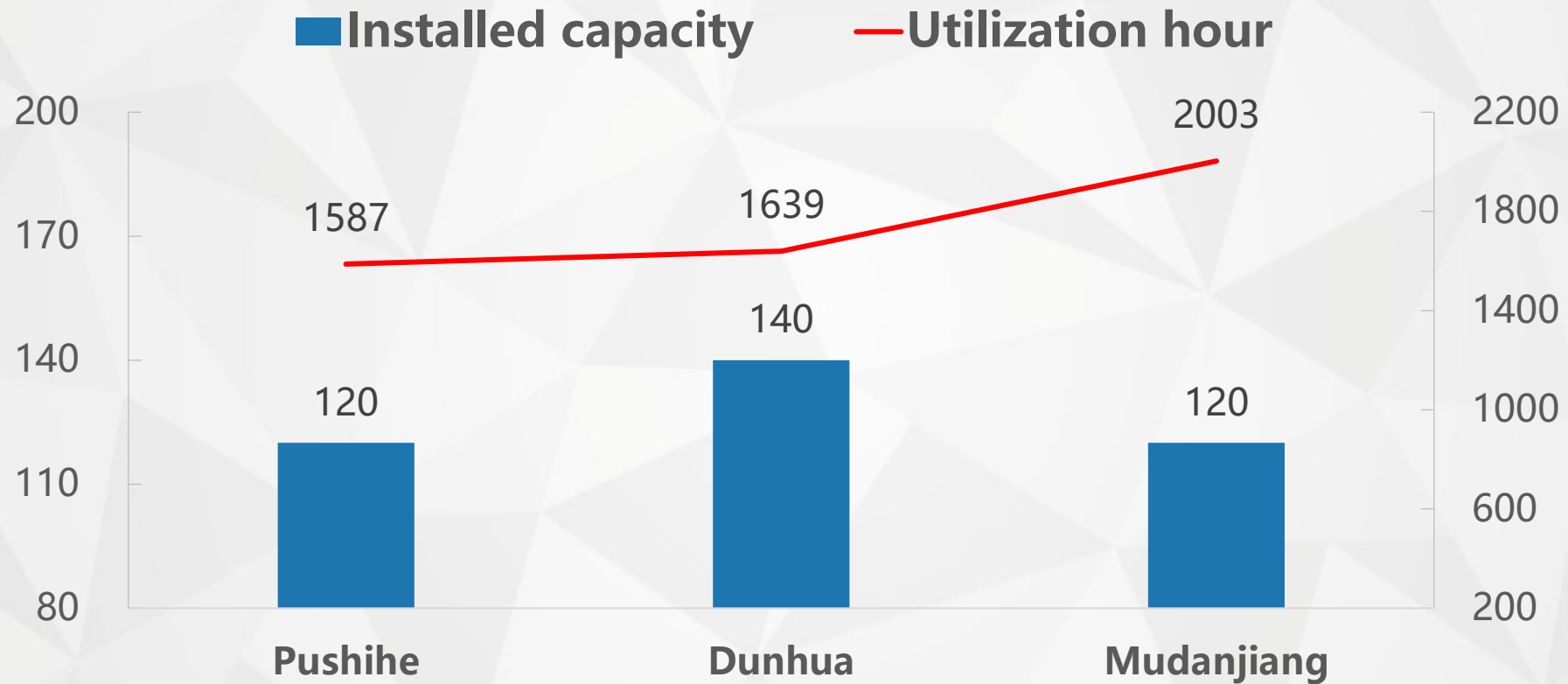


Optimizing hydro pumped operation



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

Pumped hydro installed capacity and utilization hours Jan.-Aug. 2023 (10MW、hour)





Record high new energy penetration



On Feb. 27, 2023, the grid's new energy penetration reached 38.07GW with daily electricity generation being 790GWh. Wind power penetration was 32.02GW with daily electricity generation being 710GWh.

All were at record highs. Actions taken include:

- As large as 4GW of the thermal storage facility was put into operation.
- Pumped hydro operation: three times pumping and generating each;
- Nuclear units operation load rate down to: 76%;
- Dalian flow storage operating at maximum capacity: 100MW/400MWh
- Trans-regional power transfer trade output as high as 3.03GW with traded electricity of 52.85GWh
- 4GW of thermal units shutdown orderly arranged in advance

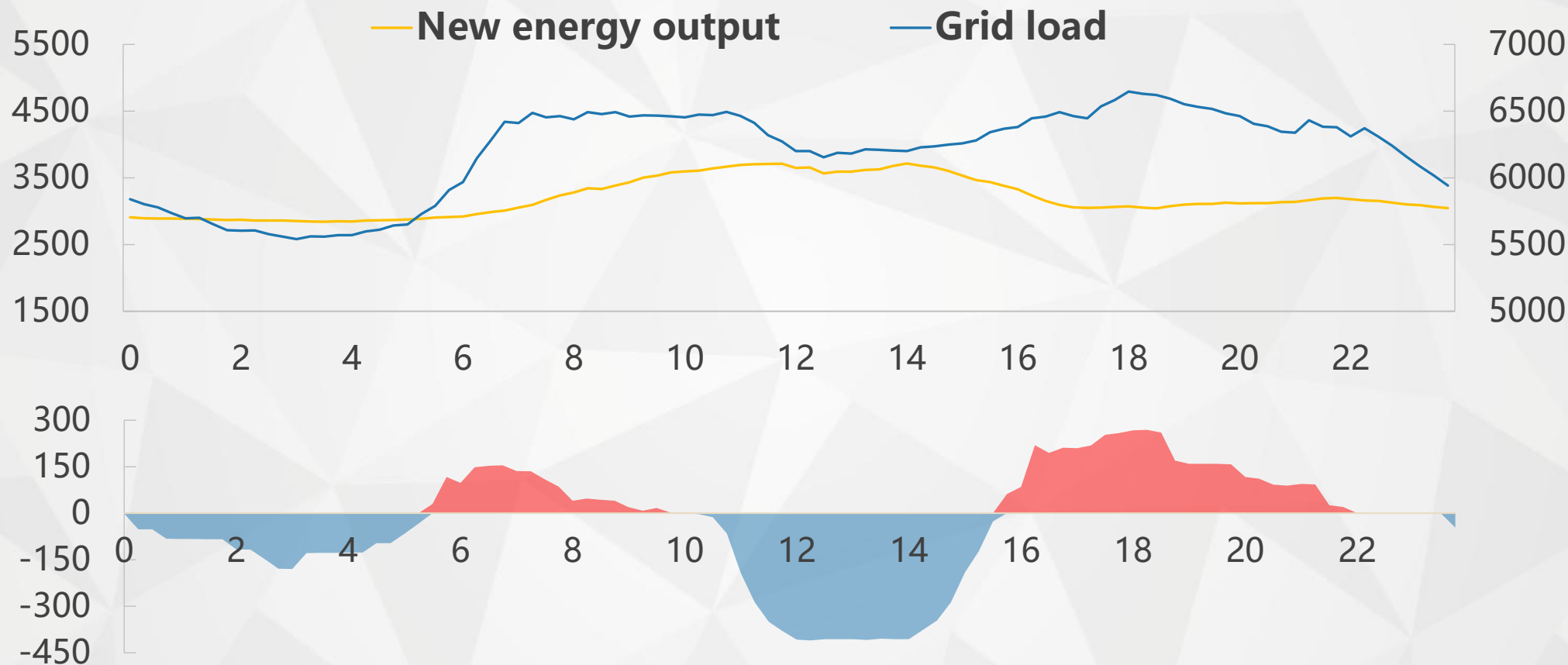


Record high new energy penetration



国家电网公司东北分部
NORTHEAST BRANCH OF STATE GRID
CORPORATION OF CHINA

The grid's new energy penetration, load and pumped hydro operation on Feb. 27, 2023 (10MW)



Part 1

Grid outline

Part 2

Challenges faced

Part 3

Measures taken

Part 4

Next work



Next work



By the end of 2023, the new energy installed capacity is going to be 85GW being 41% of the total capacity and by the end of 2025, the new energy installed capacity is expected to be 120-130GW, 47%-50% of the total installed capacity.

- Improving ancillary service market and promoting thermal power flexibility retrofiting.
- Promoting the novel energy storage development and application.
- Speeding up pumped hydro construction. By 2025, the pumped hydro capacity is to be 7.1GW and by 2030, the total capacity will reach 10.05GW.



Thank you!