The Development of New Power System and Power Storage in China

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Part I.

China has launched the construction of a New Power System

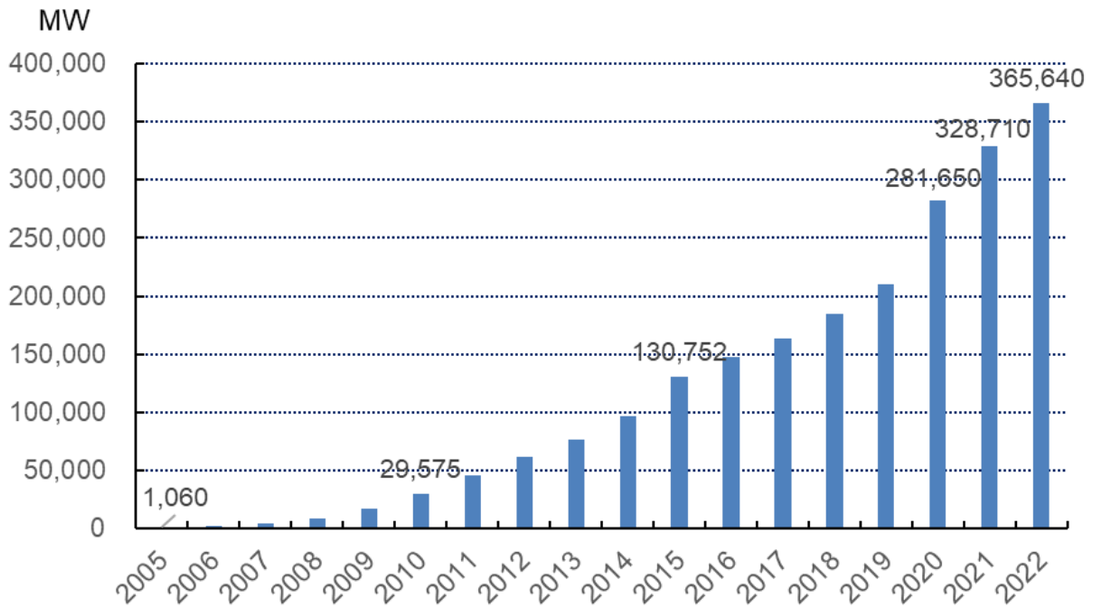
Capacity of Wind Power and Solar PV in China

- Capacity of Wind Power:

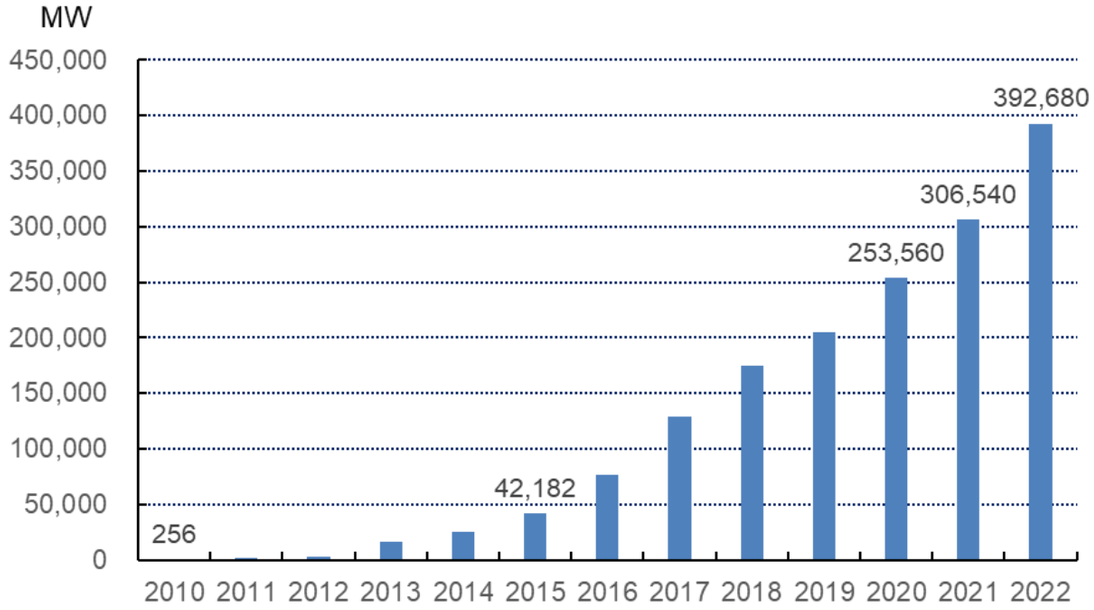
  from about 1 GW in 2005, to 365.64 GW by the end of 2022, increased nearly 365 times

- Capacity of Solar PV:

  started around 2010, reached 392.689 GW by the end of 2022, became the fastest growing power source in China



Wind Power Capacity in China

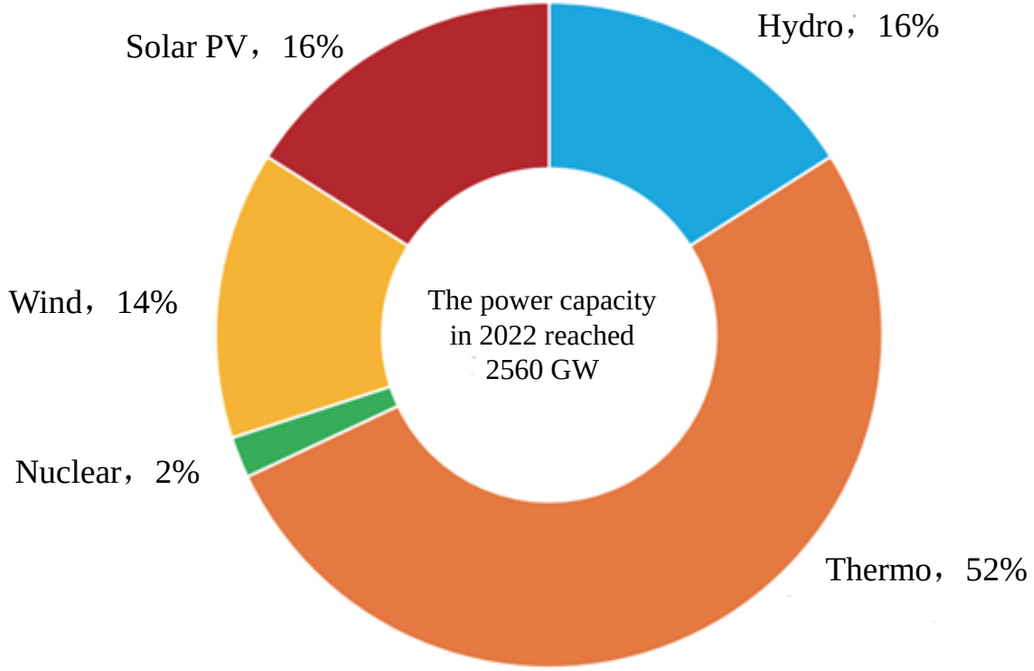


Solar PV Capacity in China

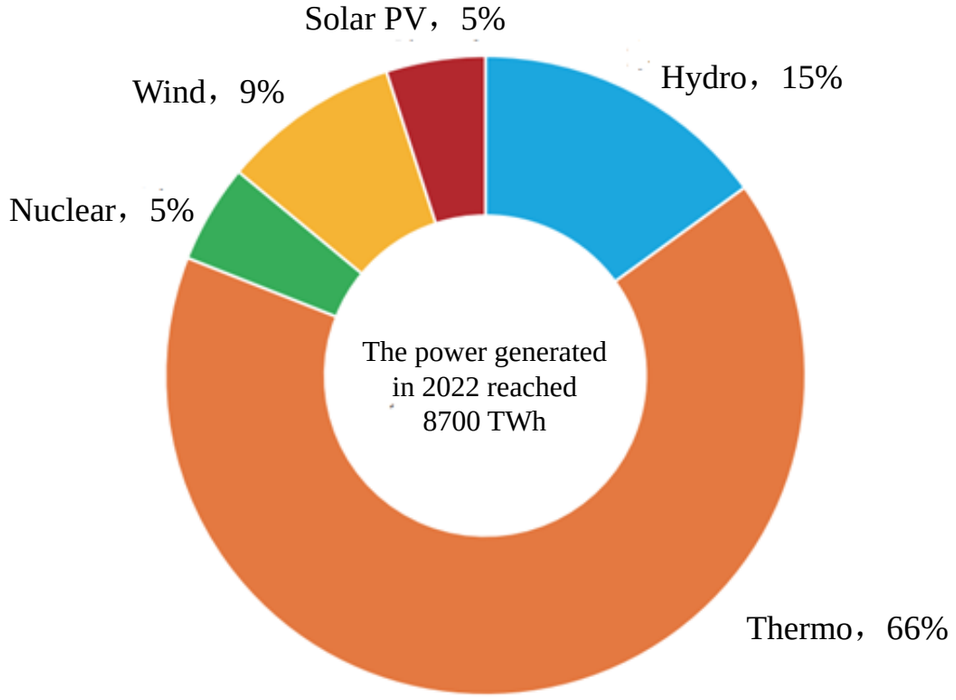
Source： NEA, China

Power Mix & Power Generation Mix of China in 2022

- By the end of 2022, China's power capacity reached 2560 GW, of which renewable energy capacity reached 1210 GW, surpassing the coal-fired power capacity, and accounting for 47.3% of the total power capacity.
- In 2022, China's total power generation reached 8700 TWh, of which renewable energy was more than 2600 TWh , accounting for 31.2% of the total power consumption.



Power Mix of China in 2022

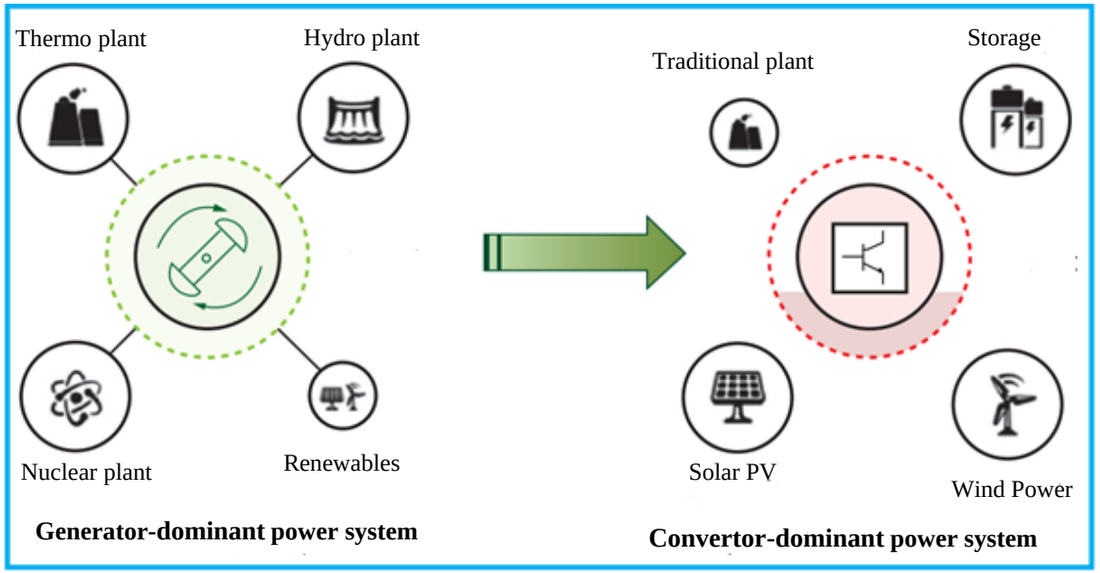


Power Generation Mix of China in 2022

Source： NEA, China

Rapid Growth of New Energy Challenges the Power Systems

- The increasing proportion of new energy consumes the flexible adjustment resources of power system rapidly. Its intermittent, random, and fluctuating characteristics make the balance and safety of power system more critical.
- Compared with traditional power system, the "dual high" power system (high proportion of renewables & high proportion of power electronic equipment) is exposed to greater operational risks. In the event of an accident, it is easier to trigger a chain reaction.
- Because the controllable objects extend from "Power Source" to "Source-Grid-Load-Storage" all links, the control scale expands extremely fast, and the regulation technology and cyber security protection need to be upgraded urgently.



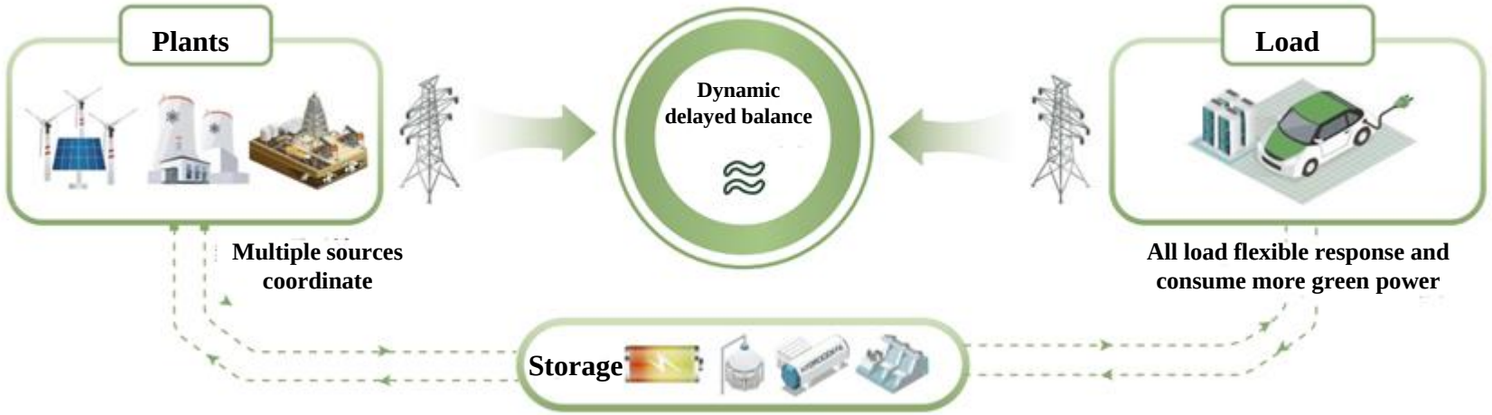
The composition of the power system is changing

Source: *The Blue Book on New Power Systems*"

China Proposes to Build a New Power System

the Difference between Traditional and New Power System

- in perspective of **power generation**, shifting from fossil fuel to new energy which supply reliable power
- in perspective of **power system**, shifting from "Source-Grid-Load" three links to "Source-Grid-Load-Storage" four links
- in perspective of **dispatch operation**, shifting from "sources following loads" to "Source-Grid-Load-Storage" intelligent interaction
- in perspective of **functional orientation**, shifting from serving economic and social development to safeguarding economic and social development and leading industrial upgrading



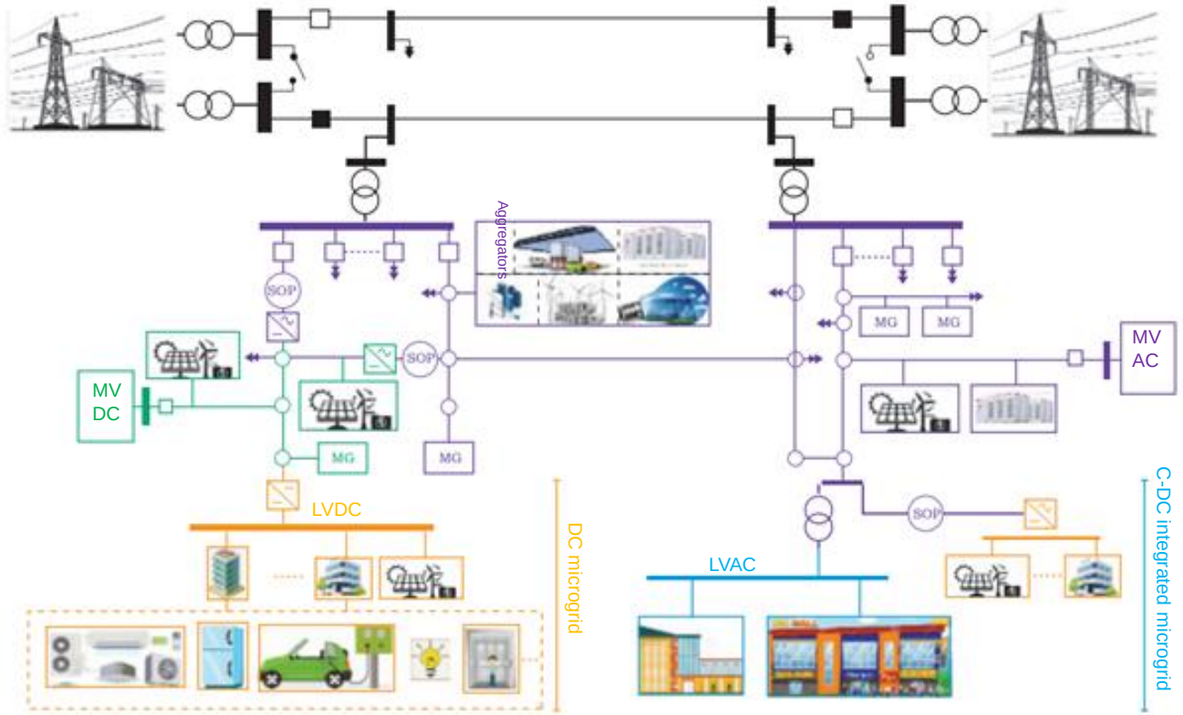
Outlook of New Power System:
safe and efficient,
clean and low-carbon,
flexible and smart integration

Source: *The Blue Book on New Power Systems*"

Power Grid Accelerates Transformation to Flexibility, Intelligence and Digitalization

Figure1 Zhangbei Flexible DC Power Grid Demonstration Project and Flexible DC Transmission Equipment (I)

Figure 2 Zhangbei Flexible DC Power Grid Demonstration Project and Flexible DC Transmission Equipment (II)



Distributed smart power grid

Source: *The Blue Book on New Power Systems*”

Requirements for Power Storage in New Power Systems

current to 2030

- multi-application scenarios, multi-technology routes for scale development
- satisfy daily system balancing requirements

2030~2045

- diversified energy storage technologies to ensure security of power supply and meet large-scale new energy consumption needs
- breakthroughs in large-scale, long-term energy storage technology to meet the needs for balance adjustment on timescales of more than one day

2045~2060

- covering the full cycle, diversified energy storage can be combined and operated in synergy, solving the seasonal fluctuation of new energy generation, and realizing the cross-seasonal dynamic balance of the power system
- dramatic increase in flexibility and efficiency of energy system operation

Part II.

The Status, Policy and Prospect of Power Storage in China

Three Types of Power Storage

- 1. Pumped Storage： dominant in power storage
- 2. New Energy Storage (mainly Electrochemical Energy Storage): grow fast with a great prospect
- 3. Green Hydrogen: used in long-duration energy storage

Three Types of Power Storage

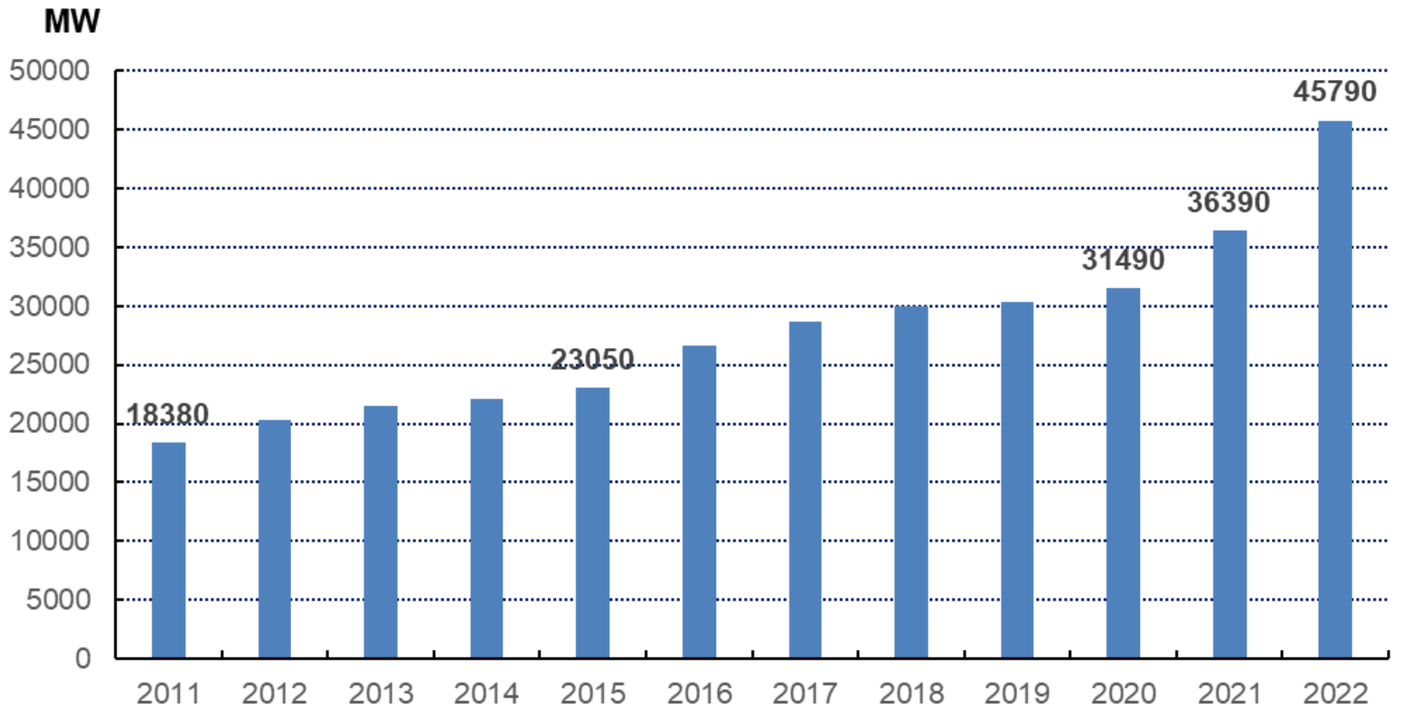
- **1. Pumped Storage：dominant in power storage**

- **2. New Energy Storage (mainly Electrochemical Energy Storage): grow fast with a great prospect**

- **3. Green Hydrogen: used in long-duration energy storage**

Development of Pumped Storage Power Stiaion

- China's pumped storage power stations grow steadily, from 18.38 GW in 2011 to 31.49 GW in 2020, with an average annual growth rate of 6.2%.
- Thanks to new policies, pumped storage capacity has grown rapidly over the past two years, reaching 45.79 GW by the end of 2022.



Capacity of Pumped Storage Power Stiaion

Source of data: China Electricity Council

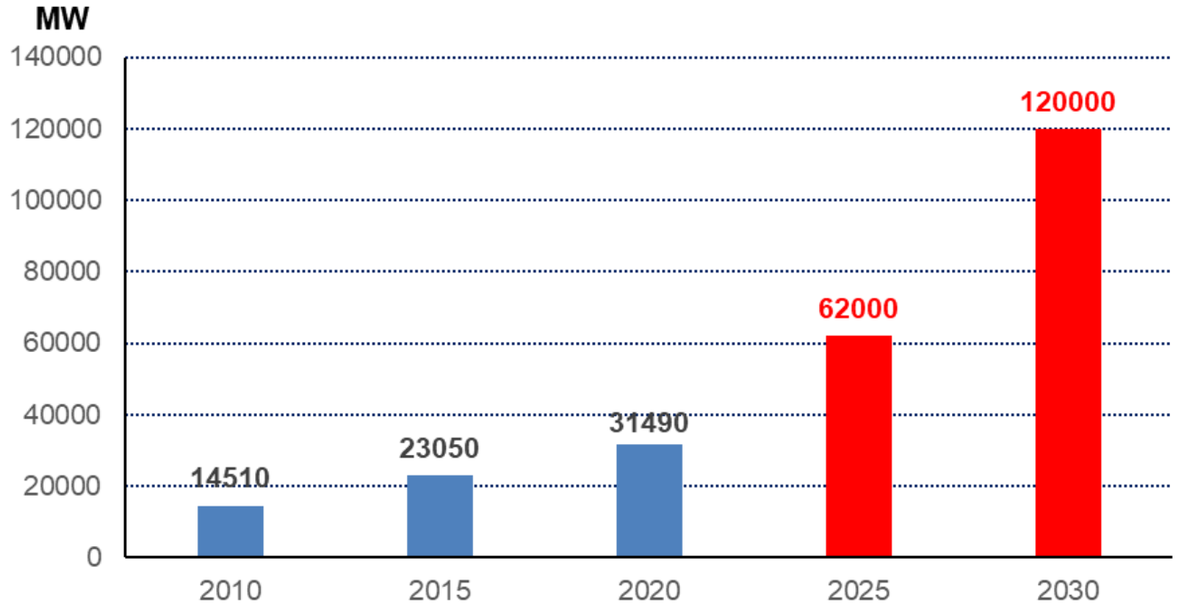
Policy: Improve the Price Formation Mechanism for Pumped Storage

■ *"Opinions on Further Improving the Price Formation Mechanism for Pumped Storage"* (2021, NDRC) propose to optimize the two-part tariff policy for pumped storage

- **Electricity energy tariff** reflect the value of pumped storage power stations in providing peaking services. Pumped storage power stations recover the operating costs of pump and generation through the electricity energy tariff.
- **The capacity tariff** reflects the value of the auxiliary services provided by the pumped storage power station, such as frequency regulation, voltage regulation, system standby and black start, etc. Through capacity tariff, pumped storage power stations recover their costs other than the operating costs of pump and generation, and receive a reasonable return.
- The capacity tariff corresponding to the government-approved pumped storage capacity tariff **is paid by the grid enterprise and is included in the provincial grid transmission and distribution tariff recovery.**
- Accelerate the establishment of the status of pumped storage power stations as independent market entities, and promot the equal participation of power stations in medium- and long-term power trading, spot market trading, auxiliary service markets or auxiliary service compensation mechanisms.

Gradually Accelerates Construction of Pumped Storage Power Stations

- *The "14th Five-Year Plan for a modern energy system"* proposes that by 2025, the installed capacity of pumped storage will reach more than 62 GW, and the installed capacity under construction will reach about 60 GW.
- *"The Blue Book on New Power Systems"* proposes that pumped storage should be scientifically laid out with the actual needs of the power system, and its installed capacity will reach more than 120 GW by 2030.



China's pumped storage power stations development outlook

Source of data:
NEA, China & *"The Blue Book on New Power Systems"*

Three Types of Power Storage

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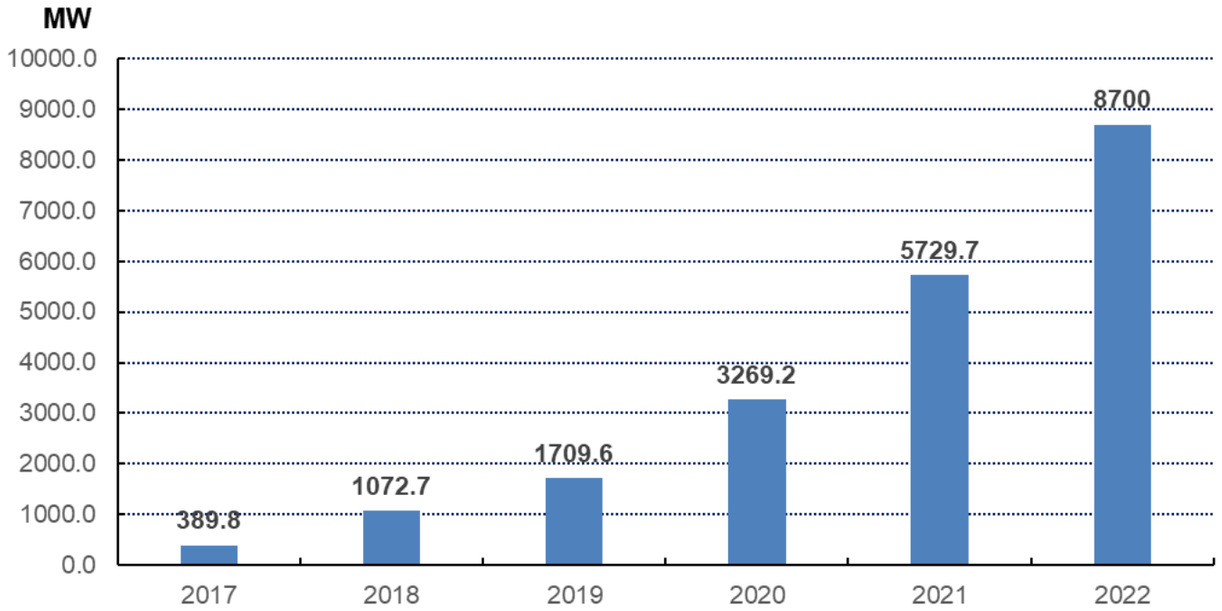
New Energy Storage Grow Rapidly in China

- Since 2017, the installed capacity of new energy storage has grown rapidly, reaching 8700 MW by the end of 2022, 22 times that of 2017.
- The energy scale of energy storage power station is expanding. By the end of 2022, it has reached 18.27 GWh, with an average charging and discharging time of 2.1 hours.
- Influenced by local policies that “new energy power stations must be equipped with energy storage”, storage in power supply-side is the largest, more than 50%.



Capacity of new energy storage in China

Source of data: Zhongguancun Power Storage Union

Formulated Policies to Support New Energy Storage Development

■ *" Guidance on Accelerating the Development of New Energy Storage"* (2021, NDRC) & *"Implementation Program for New Energy Storage in the 14th Five-Year Plan"* (2022, NDRC)

- By 2025, the new type of energy storage will step into the scale development stage from the early stage of commercialization, in which the performance of electrochemical energy storage technology will be further improved, and the system cost will be reduced by more than 30%.
- By 2030, new energy storage will be fully marketable.
- Clarify the status of new energy storage as an independent market entity. Encourage energy storage as an independent market entity to participate in all kinds of power market transactions including auxiliary services, and encourage sharing of energy storage.
- Improve the new energy storage price mechanism, in which the grid-side independent energy storage adopts the capacity tariff mechanism, and the grid alternative energy storage facilities are included in the transmission and distribution tariff.
- Support the incorporation of new energy storage into the green financial system and promote the establishment of an energy storage development fund.
- Strengthen operational safety, and implement the "Regulation for the Management of New Energy Storage Projects (temporary)".

Encourage Diversified Development of Energy Storage Technologies and Demonstration Projects

Promote Diversified Technologies Development

- Hundred megawatt-scale compressed air energy storage key technology
- Hundred megawatt-scale high-security, low-cost, long-life lithium-ion battery energy storage technology
- Hundred megawatt-scale liquid flow battery technology
- Sodium-ion battery, solid lithium-ion battery technology
- High-performance lead-carbon battery technology
- Megawatt-scale supercapacitors
- Liquid metal batteries, metal-air batteries
- Other types of energy storage, including hydrogen (ammonia), heat (cold), etc.

Key Pilot Demonstration Projects

Power Storage Project in Kunshan, Jiangsu

Power Storage Project for auxiliary frequency regulation in Guangdong

Promote the Development of Energy Storage to Support New Power System Construction

➢ Increase efforts to develop new energy storage in supply-side

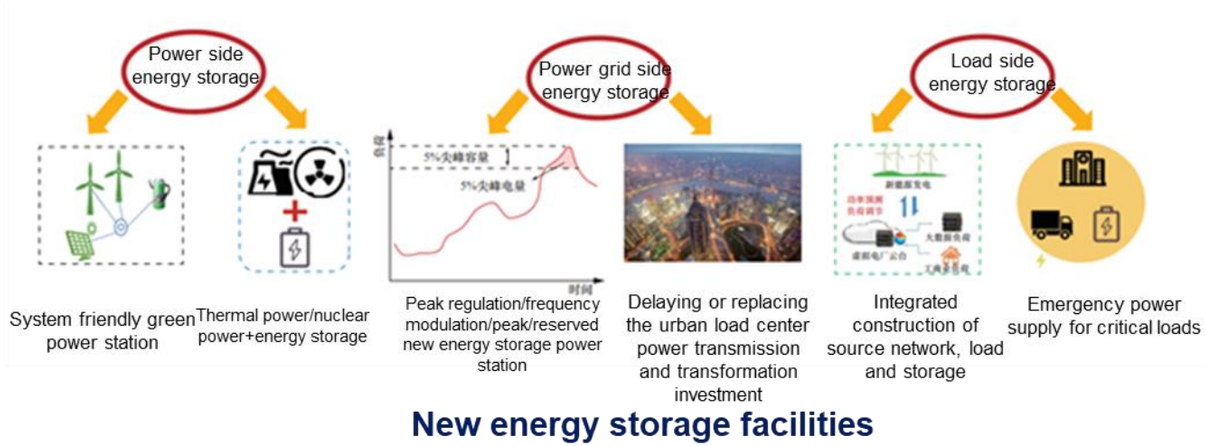
- ✓ Promote large-scale cross-regional transmission and consumption of new energy from large-scale wind power and PV bases in deserts, through "integration of wind, solar, water, coal and storage" model of multi-energy complementarity.
- ✓ Carry out research on the configuration of new energy storage for offshore wind power; promote the rational configuration of new energy storage for coal-fired power; explore the development of new energy storage with nuclear power peak shifting and frequency regulation.

➢ Based on local circumstances to develop new energy storage in grid-side

- ✓ Distribute new energy storage facilities at key nodes of the power grid; construct wind and solar storage power stations in remote areas
- ✓ For important users such as governments, hospitals, data centers, etc., energy storage will be used as an emergency backup power source.

➢ Flexibly and diversified to develop new energy storage in demand-side

- ✓ Support the construction of distributed energy supply systems for big data centers, 5G base stations, industrial parks, highway service areas, and qualified rural users.
- ✓ Provide customized services for users with large-scale demand and high-quality requirements.



New energy storage facilities

Three Types of Power Storage

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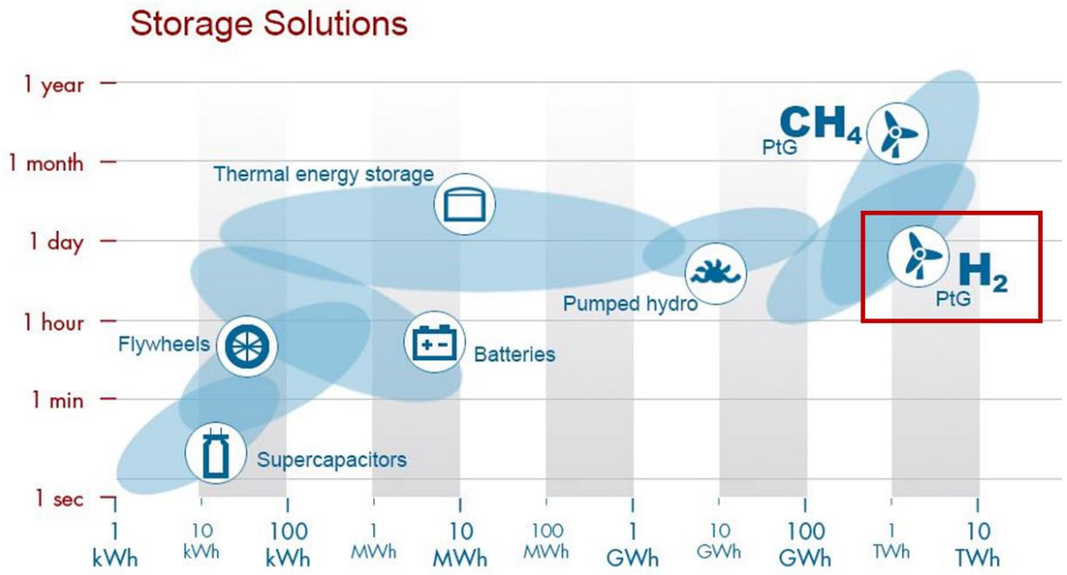
Green Hydrogen: A Game Changer in Power System

- ***"Medium and Long-term Plan for Hydrogen Energy Development (2021-2035)"*** **(2022, NDRC) proposes that hydrogen will be an important component of the national energy system in the future**

- Hydrogen is an important carrier for the efficient use of renewable energy. It also has large-scale, long-term energy storage capacity, which can promote the optimal allocation of different energy sources across regions and seasons.

- By 2025, green hydrogen production will reach 100,000-200,000 tons/year, achieving CO2 emission reduction of 1-2 million tons/year.

- By 2035, the share of green hydrogen in end-use energy consumption will increase significantly.

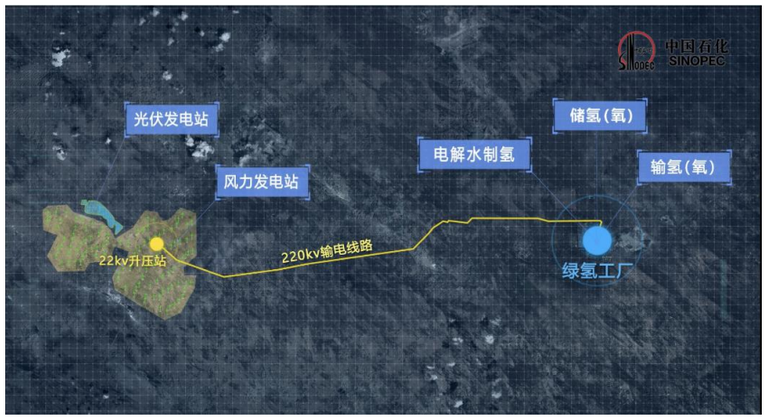


Hydrogen has large-scale, long-term energy storage capacity

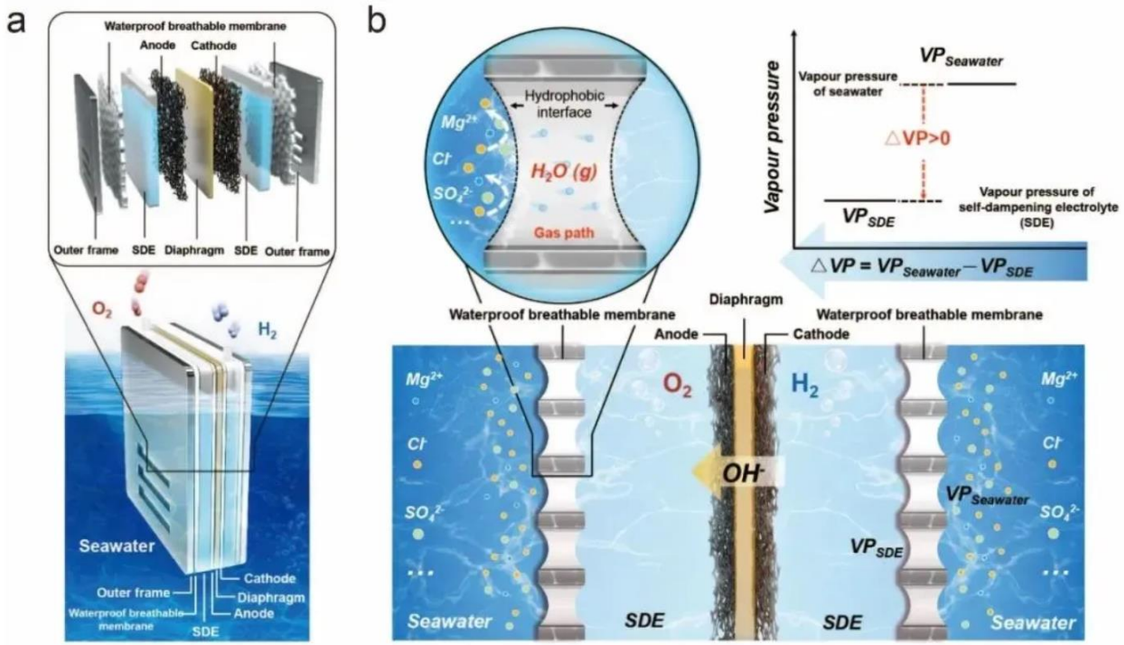
Promoting Green Hydrogen Production Demonstration Projects

- Local governments have announced a series of policies to encourage the development of the local green hydrogen industry
- A lot of typical demonstration projects have emerged, and new technologies are being explored.

in Kuche, Xinjiang



in Ordos, Inner Mongolia

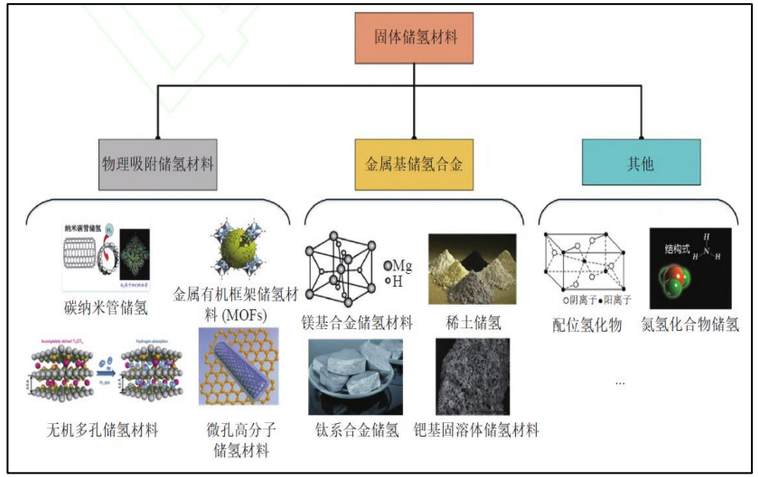


Direct electrolysis of seawater for hydrogen production without desalination (XIE Heping, 2022)

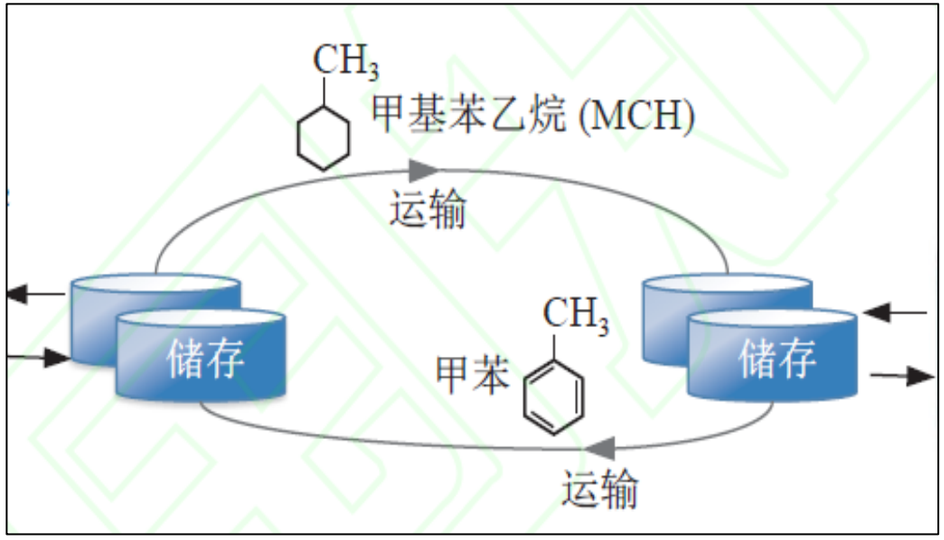
Actively Developing various Hydrogen Storage Technologies

Compressed Hydrogen

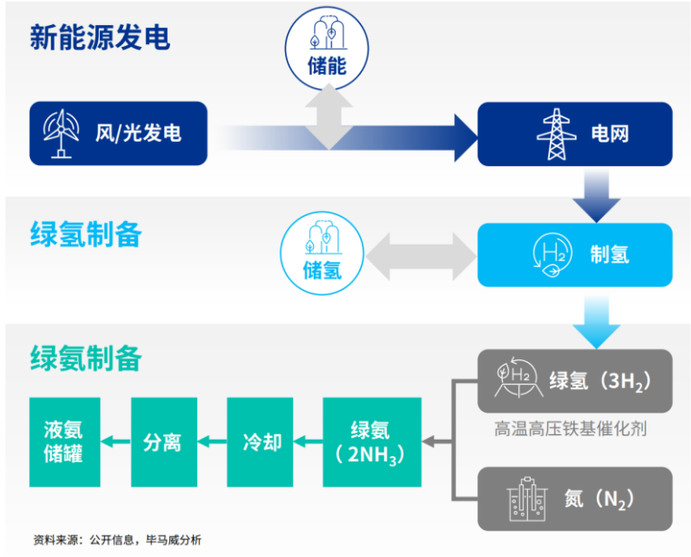
Liquid Hydrogen Storage



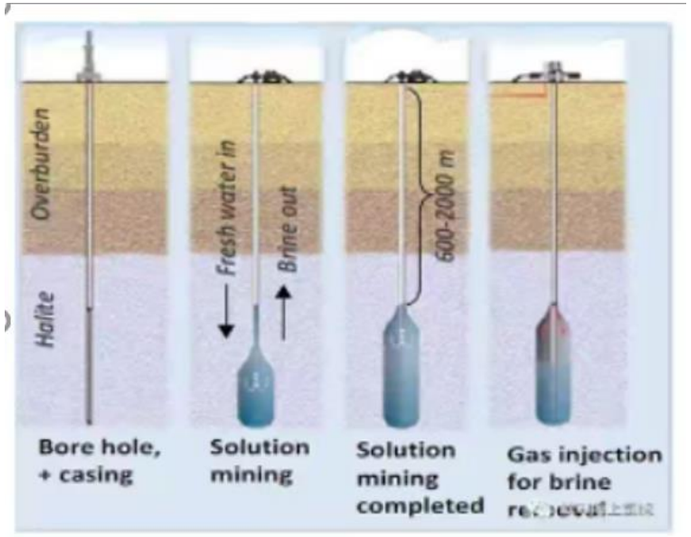
Solid Hydrogen Storage



Organic Liquid Hydrogen Storage: (MCH)



Ammonia for Hydrogen Storage



Underground Hydrogen Storage

Thanks for your attention !