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China's Approaches to Renewable Energy Integration and Power Market Reform Efforts

State Grid Energy Research Institute

December 18th, 2017

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AGENDA

Development of Renewable Energy in China

Challenges of Renewable Energy Integration and Approaches

Power Market Reform

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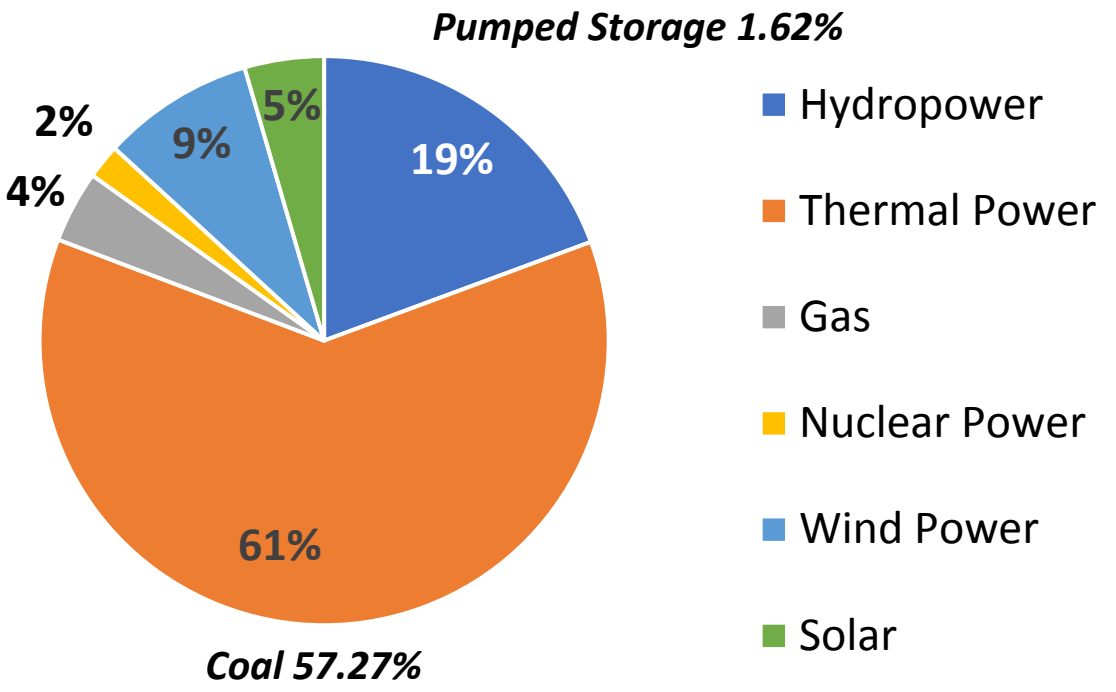
Generation Mix

Coal is the primary source of electricity generation in China. Total installed capacity of renewable energy (including hydropower) in China is more than 550 GW at the end of 2016.

Total	**1645.8GW**
Hydropower	332.1GW
in which: *Pumped Storage*	26.7GW
Thermal Power	1053.9GW
in which: *Coal*	942.6GW
Gas	70.1GW
Nuclear Power	33.7GW
Wind Power	148.7GW
Solar	77.4GW

Breakdown of Total Installed Capacity by Fuel Type



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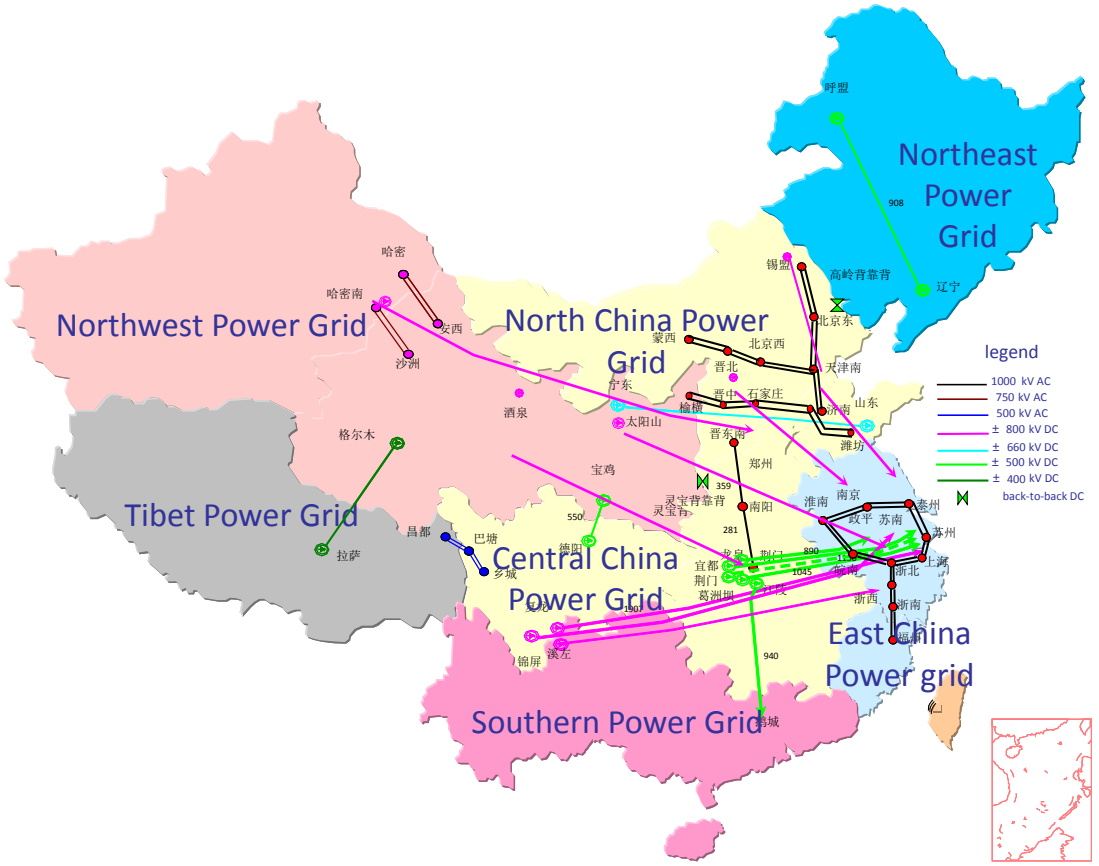
Grid Development

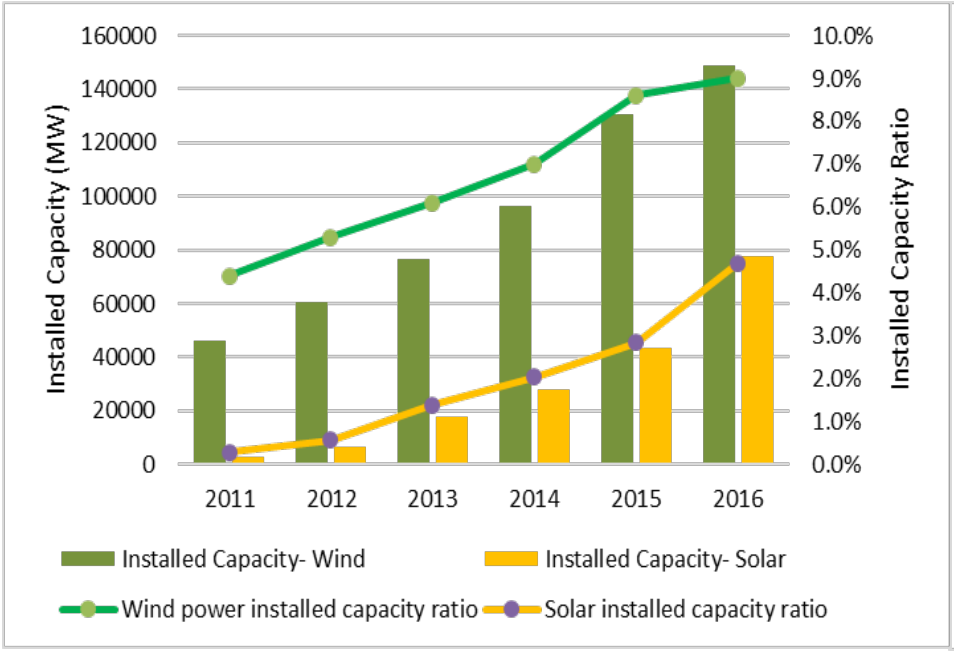
Power grid of China has been interconnected nationwide, mainly including 7 regional power grids.

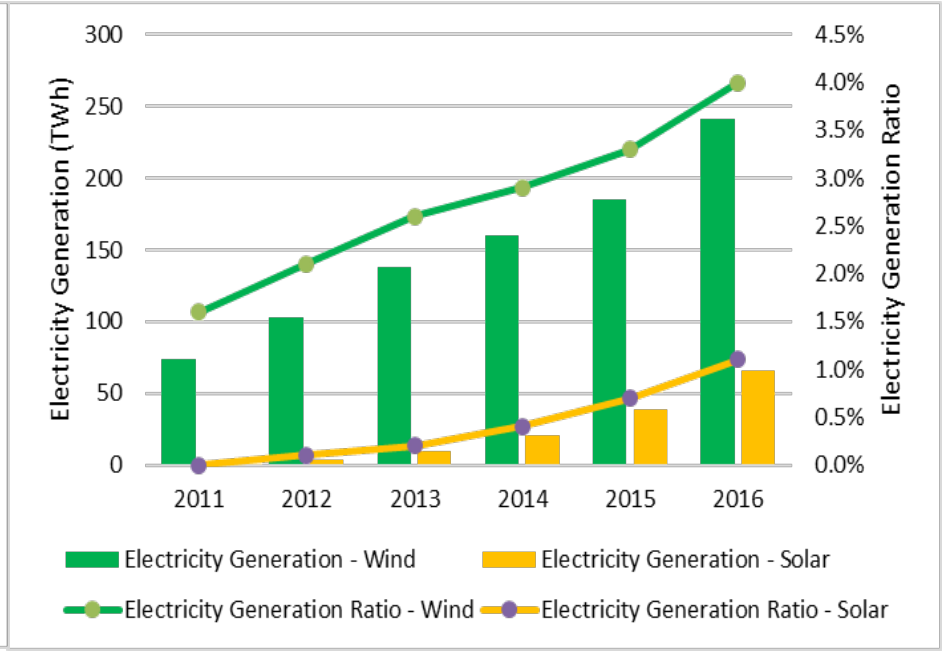
State Grid has built 15 UHV lines, including 8 UHV AC lines and 7 UHV DC lines. Another 5 UHV lines are under construction.



RE Development

China has seen rapid development of wind and solar power in recent years.



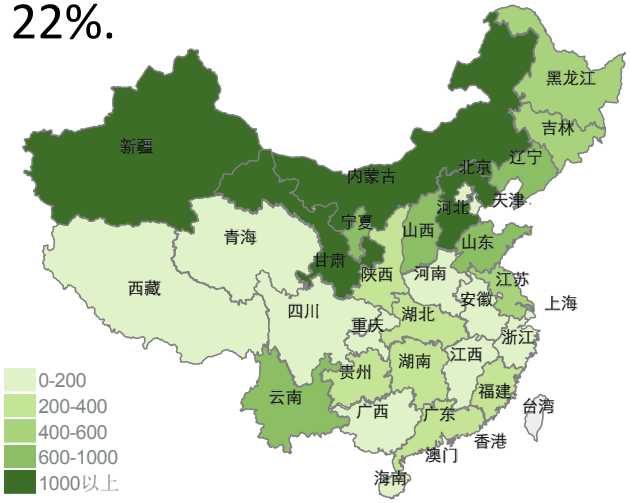


Wind and solar power average annual growth rate (2011-2016) :

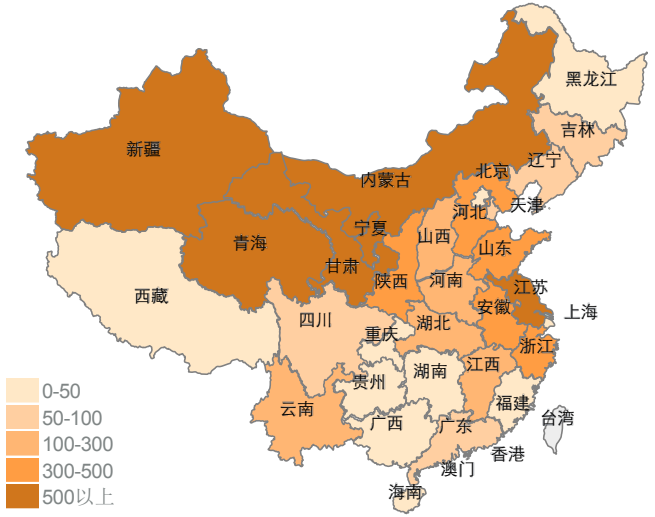
- **Installed Capacity:** Wind - 26%, Solar - 92%
- **Electricity Generation:** Wind - 26%, Solar - 148%

Allocation of renewable energy in China is highly concentrated and away from load centers in the East.

- Wind power in the "Three North" area (Northwest, Northeast and North China) accounts for 77% of total wind power installation.
- Solar power installation in the West accounts for 41% of total capacity.
- In Inner Mongolia, Ningxia, Jilin and Gansu provinces, highest penetration of wind power has exceeded 40%.
- In Qinghai province, highest penetration of solar power has reached 22%.



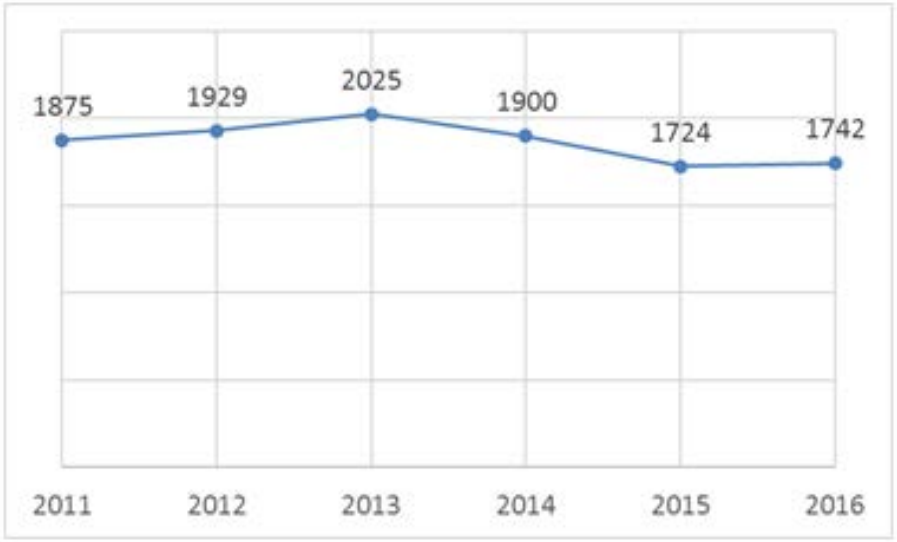
Allocation of Wind Power Installation in China



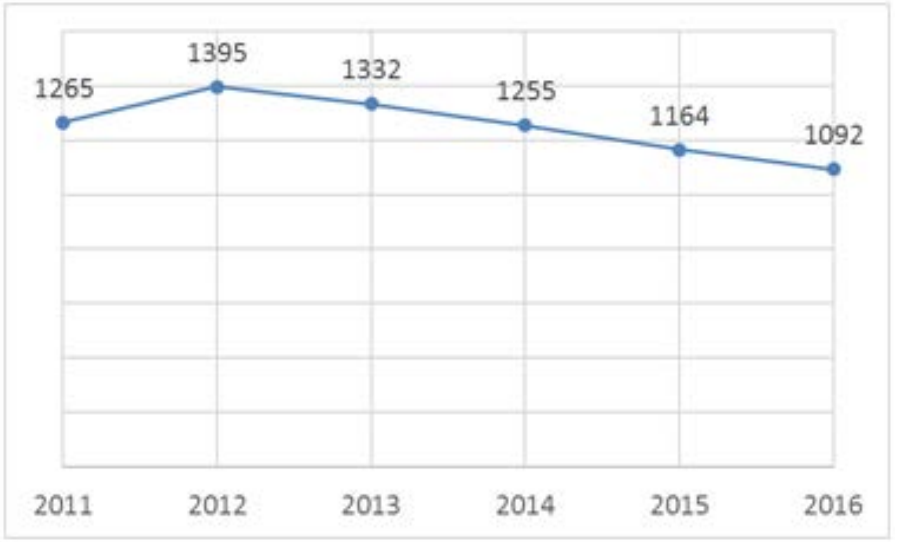
Allocation of Solar Power Installation in China

Utilization Hours of RE

Utilization hours (capacity factor multiplied by 8760) of wind and solar power in China were around 1800h (20%) and 1200h (14%) respectively.



Utilization Hours of Wind Power in 2011-2016



Utilization Hours of Solar Power in 2011-2016

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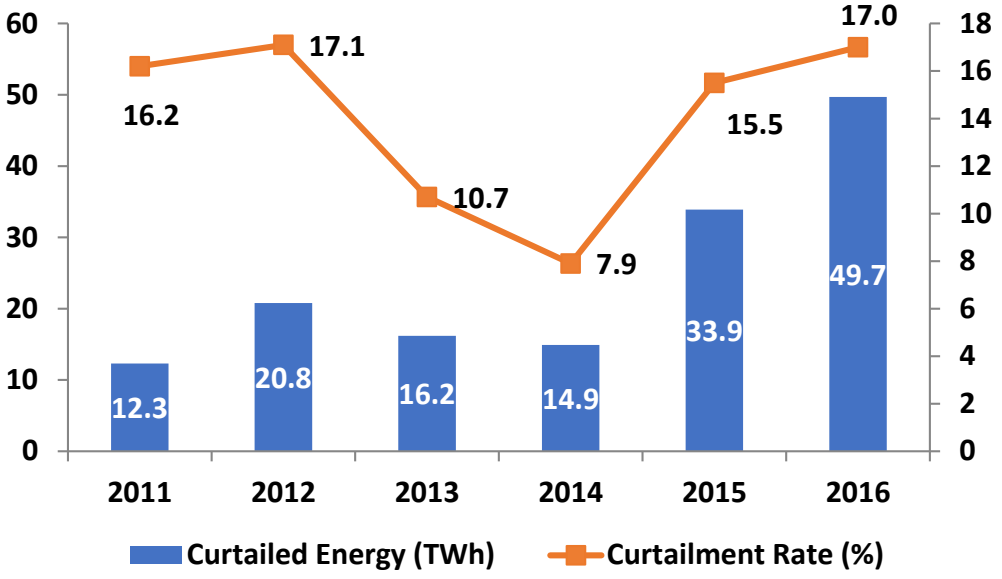
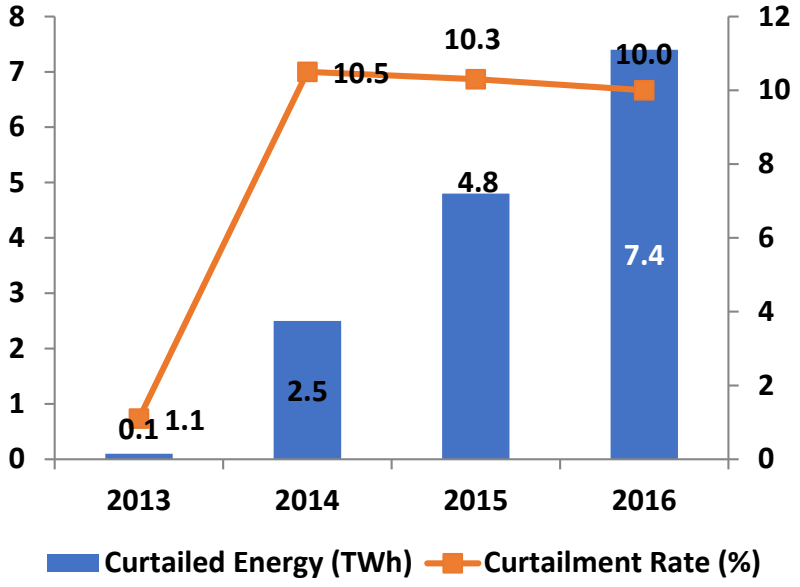
Challenge

In recent years, challenges of wind and solar power curtailment have become increasingly prominent in China. Average curtailment rate of wind and solar power reached 17% and 10% in 2016.



Wind curtailment from 2011 to 2016 in China



Solar curtailment from 2011 to 2016 in China

Analysis

According to our analysis, curtailment of RE in China is due to several reasons:

System flexibility problem:
lack of flexible power plants in the power system

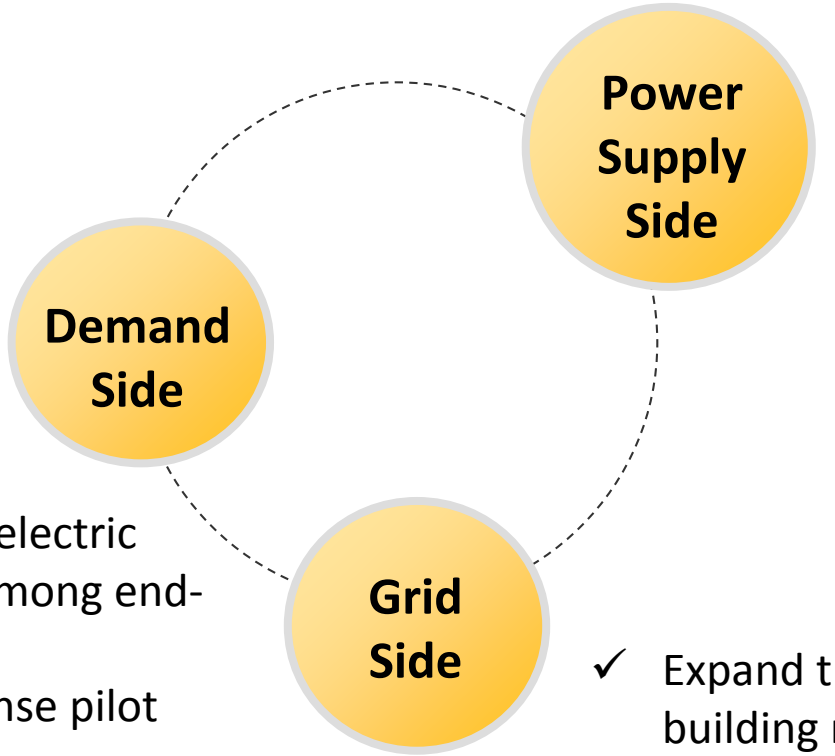
Uncoordinated development of RE and consumption

Transmission limitations:
insufficient transmission capacity and lagging construction of transmission facilities

Policy and mechanism issues:
trade barriers between different provinces and lack of cross-provincial pricing mechanism

Measures (1/2)

To address the curtailment issue, many measures have been taken to promote the integration of RE in China.



Increase flexibility:

- ✓ Lower technical minimum of thermal power plants
- ✓ To decouple heat and power generation of CHP plants
- ✓ More pumped storage power plants are planned

- ✓ To encourage "electric substitution" among end-users
- ✓ Demand response pilot projects

- ✓ Expand transmission capacities by building new transmission lines
- ✓ Smart distribution grid supports development of DER

Measures (2/2)

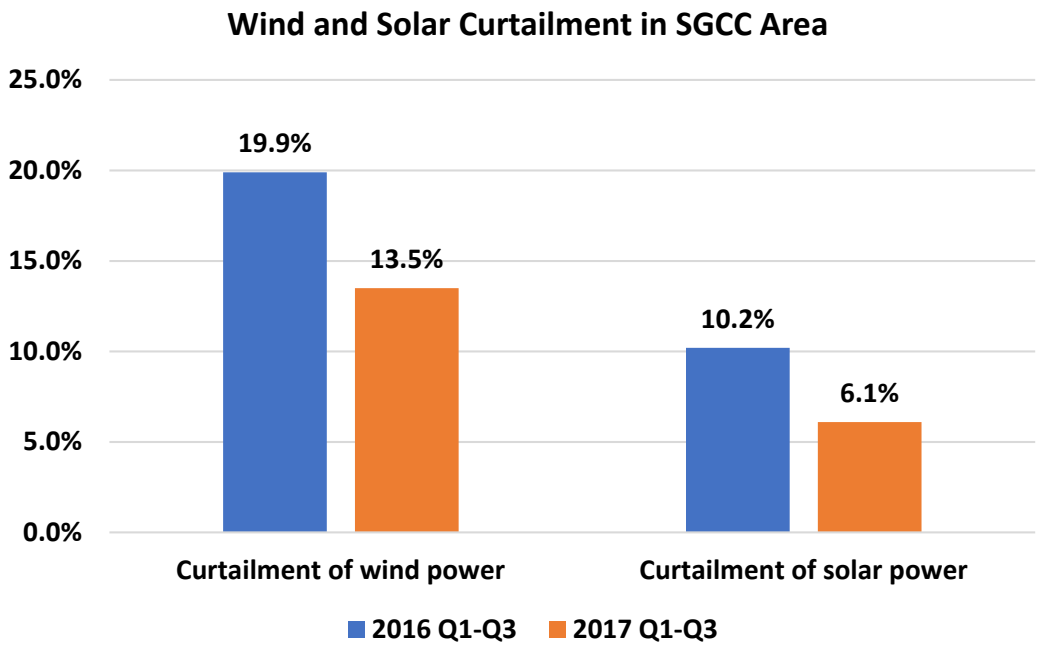
Besides, the curtailment issue was also addressed from policy and market mechanism aspects:

- ✓ Priority dispatch of RE
- ✓ Red alert for wind power investments in regions with large amount of curtailment
- ✓ Cross-provincial “spot market” for excess renewable energy
- ✓ Pilot project of “ancillary services market” in the Northeast and other provinces
- ✓ Voluntary purchase of renewable energy credits (RECs), exploration of RPS in the future

Outcome (1/2)

Curtailment rate is expected to decrease in 2017.

- In the first three quarters of 2017, wind and solar curtailment in SGCC operating area were 13.5% and 6.1%, respectively, reduced from 19.9% and 10.2% last year.



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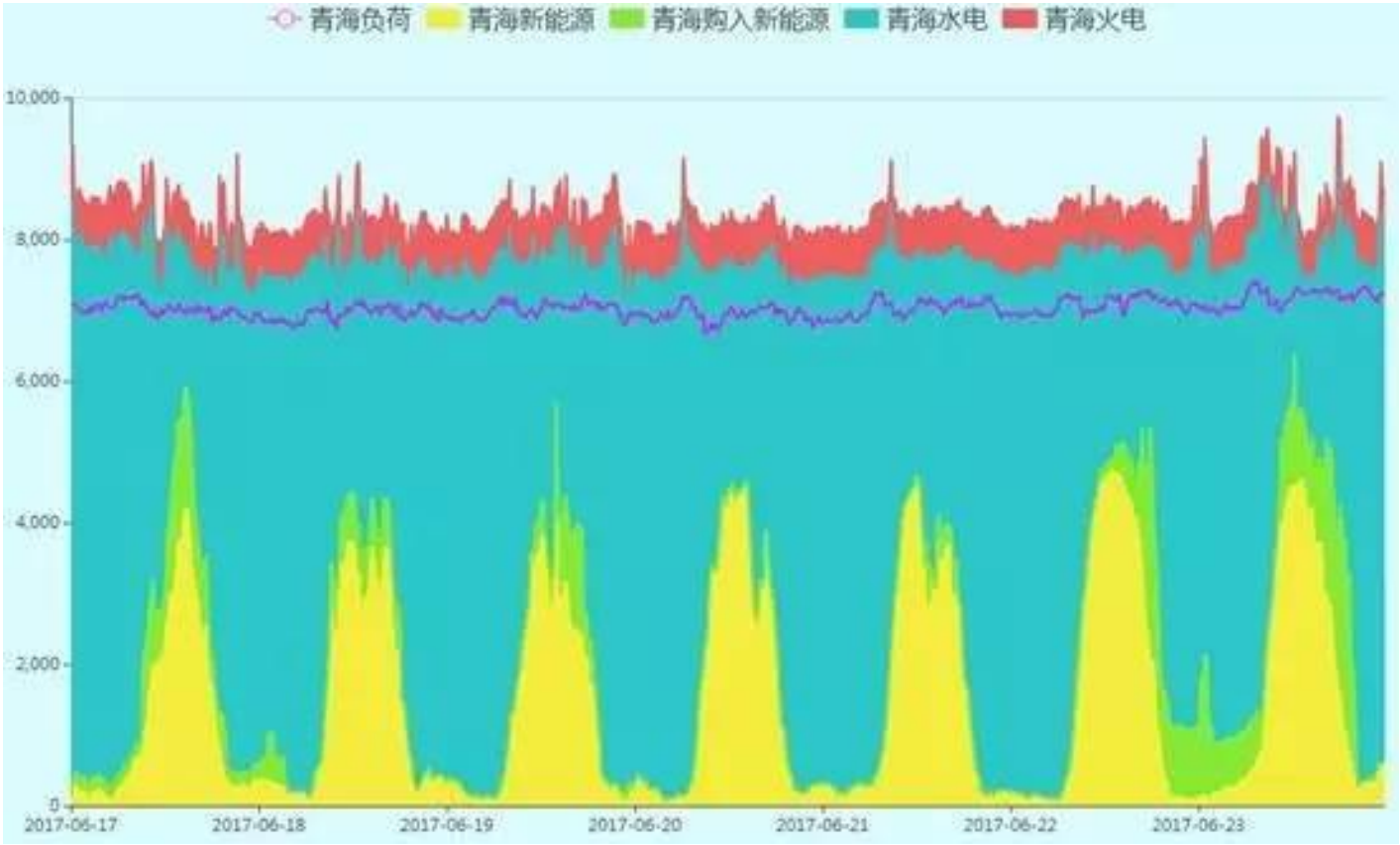
Outcome (2/2)

On June 17th-23rd 2017, 100% of the load was supplied by renewable energy (incl. hydropower) for 168 hours in Qinghai Province.



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Evolution of China's Power Sector Reform

The development and reform of power sector in China can be divided into the following stages:

1997-2001: Separation of Enterprise from Administration

- Abolishing the Ministry of Electrical Power
- Establishing the State Power Corporation of China (SPCC).

2002: Separation of Generation from Transmission

- Restructuring the SPCC into 2 power grid companies, 5 generation groups, 4 complementing industry groups
- Establishing the regulatory body (SERC)

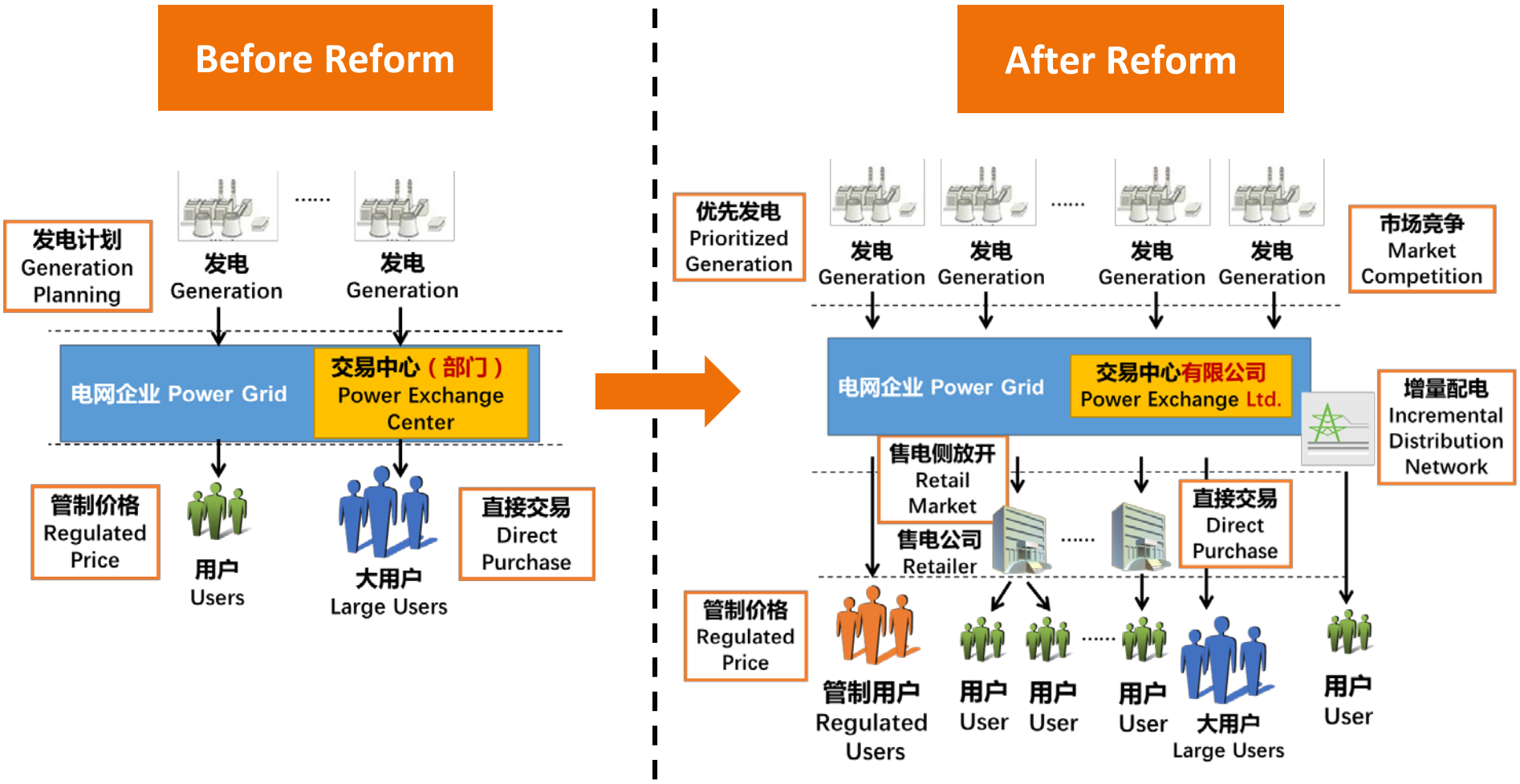
2003-2014: Further Reform Explorations

- Carrying out pilots for price bidding, regional market and direct trading

2015-Present: New Round of Reform

- No.9 Document
- Reform of T&D tariff, establishing a power market, opening retail market, etc.

Power market in China before and after the reform:



Major Tasks

Electricity Market

- **Create a coherent market with both long-term trading and spot market**
- Encourage market players to participate in direct trading
- Establish prioritized generation (e.g. RE) and consumption mechanisms
- Improve cross-provincial trading mechanisms

Power Exchange

- **Establish a relatively independent power exchange center**
- Form a fair and orderly market platform
- Create market management councils

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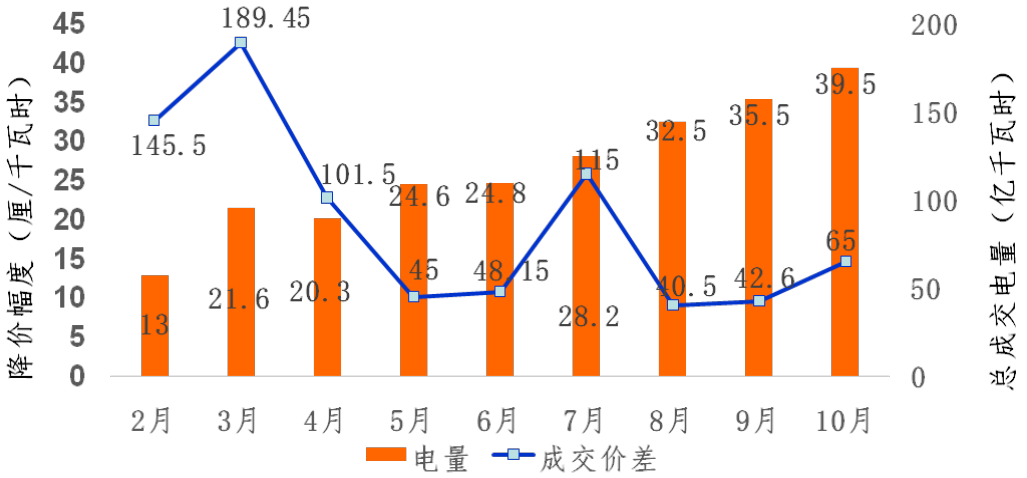
Long-term Trading

Long-term trading includes physical bilateral contracts and centralized bidding. It takes place between generation companies and consumers or retailers, usually on a yearly or monthly basis. Products traded are the total amount of energy within that period.



Monthly centralized bidding results of Guangdong province in 2017

Effects of long-term trading in Guangdong province:

- ✓ more market players, more effective competition
- ✓ increase of traded volume
- ✓ lower prices

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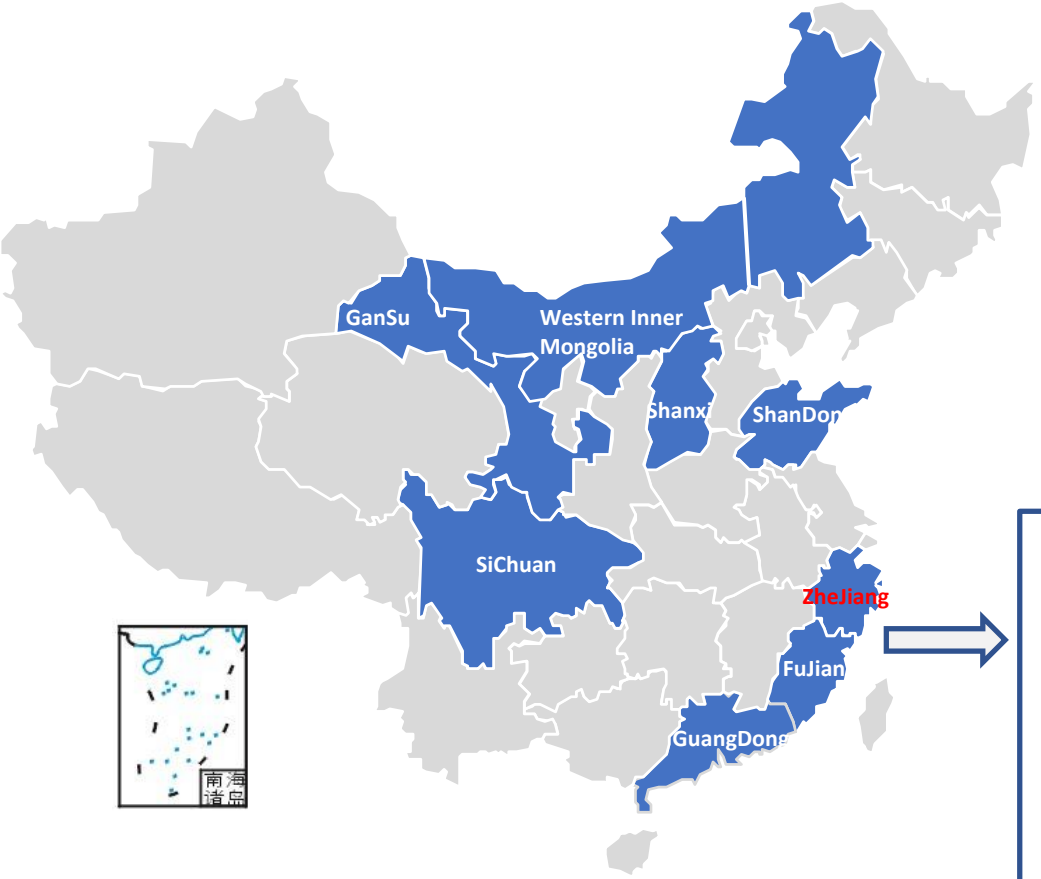
Spot Market



In Aug. 2017, NDRC and NEA of China issued the policy to start spot market pilots in China, choosing 8 districts as the first pilot, including the South (starting in Guangdong province), Western Inner Mongolia, Zhejiang, Shanxi, Shandong, Fujian, Sichuan and Gansu.

Spot market of Zhejiang will be designed by China Electric Power Research Institute and PJM.

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Thank you!