国家电网
STATE GRID

国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Renewable Energy Development in China: Market Design and Practice

Guohui Xie
State Grid Energy Research Institute

ESIG's 2019 Fall Technical Worshop
Charlotte,NC October 30th, 2019

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Contents

1 Status of Renewables Energy Development in China

2 Key Issues for Renewable Energy Participation in Electricity Market in China

3 Further Discussions

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

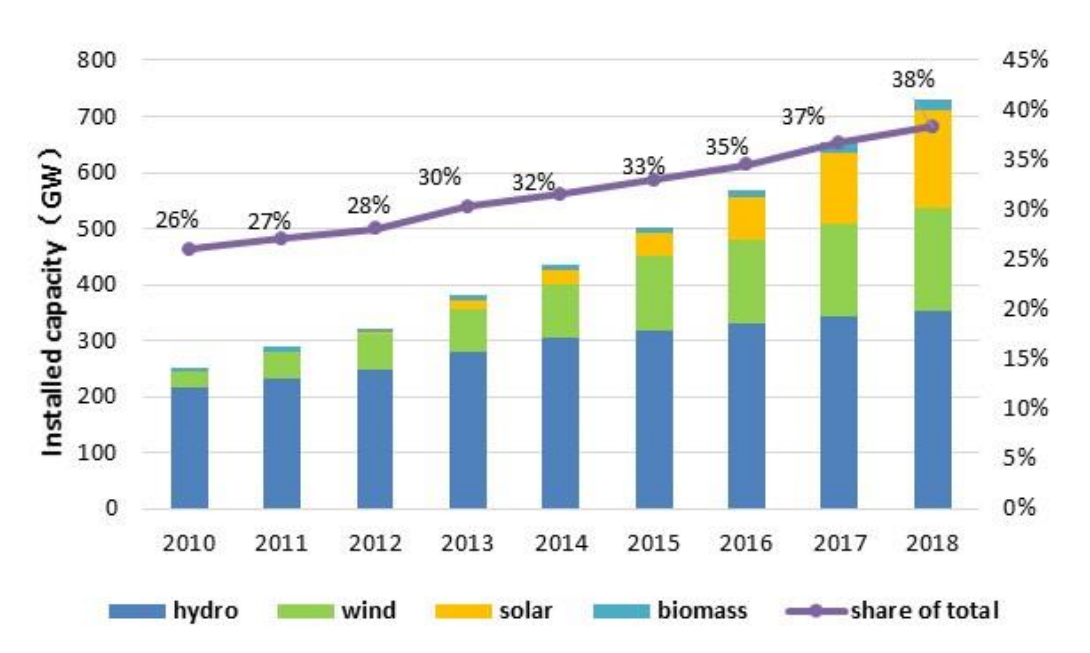
Contents

1 Status of Renewables Energy Development in China

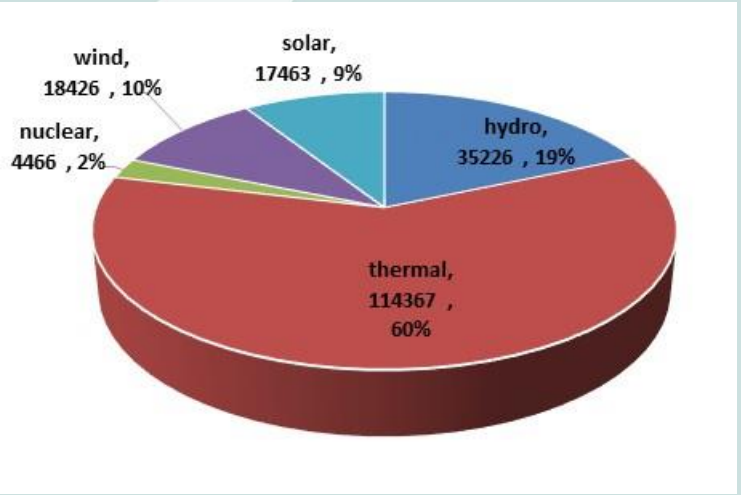
国家电网 STATE GRID
国网能源研究院 STATE GRID ENERGY RESEARCH INSTITUTE

Renewable Energy Development Status in China

By the end of 2018, the cumulative installed capacity of China's renewables reached **729 GW** with an average annual growth rate of **15%** from 2010 to 2018, accounting for **38%** of national total installed power capacity.



Renewables energy capacity in China (2010-2018)

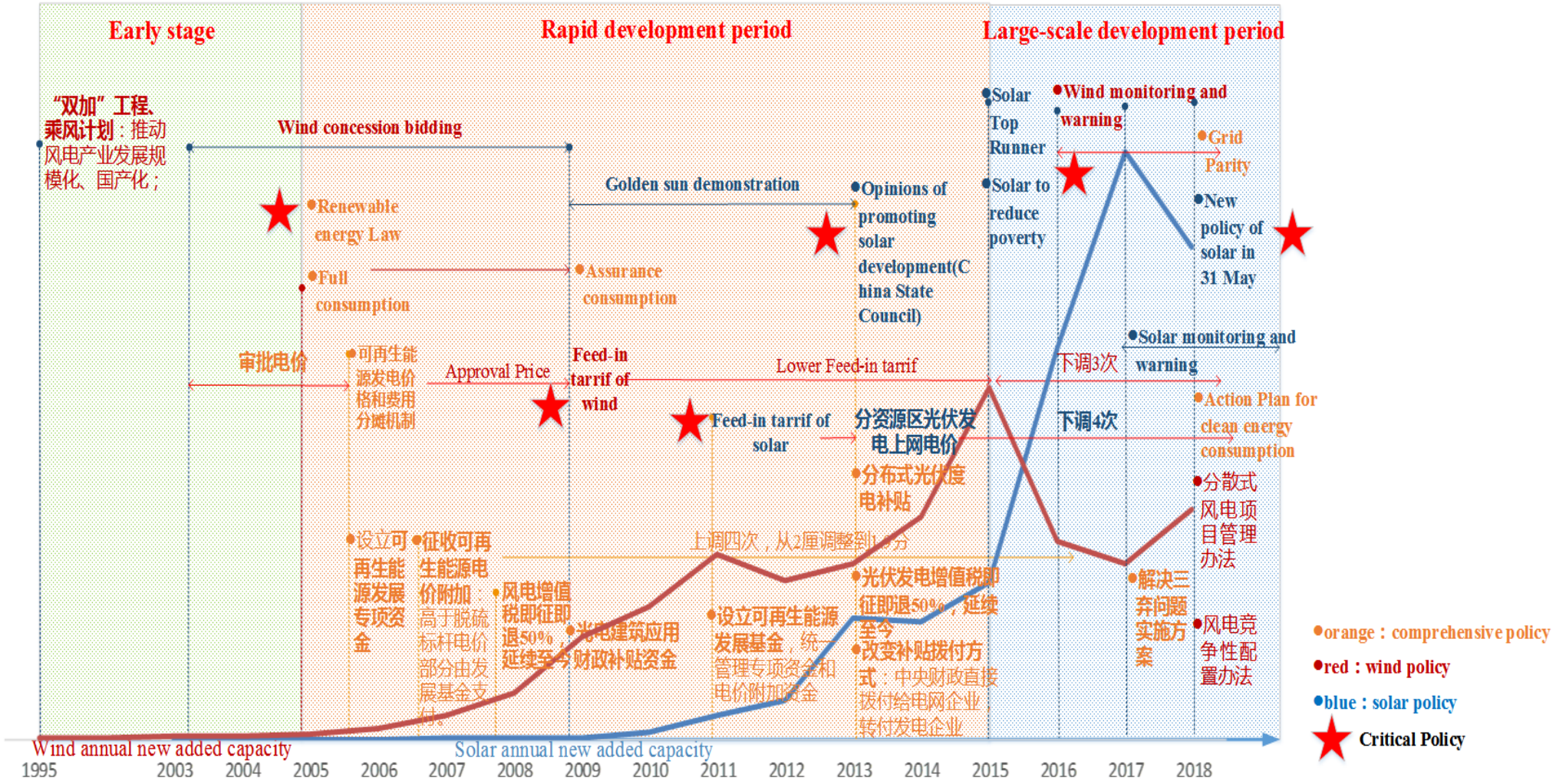


Power mix in China by the end of 2018

国家电网 STATE GRID

国网能源研究院 STATE GRID ENERGY RESEARCH INSTITUTE

Policy-oriented on development of wind and solar power



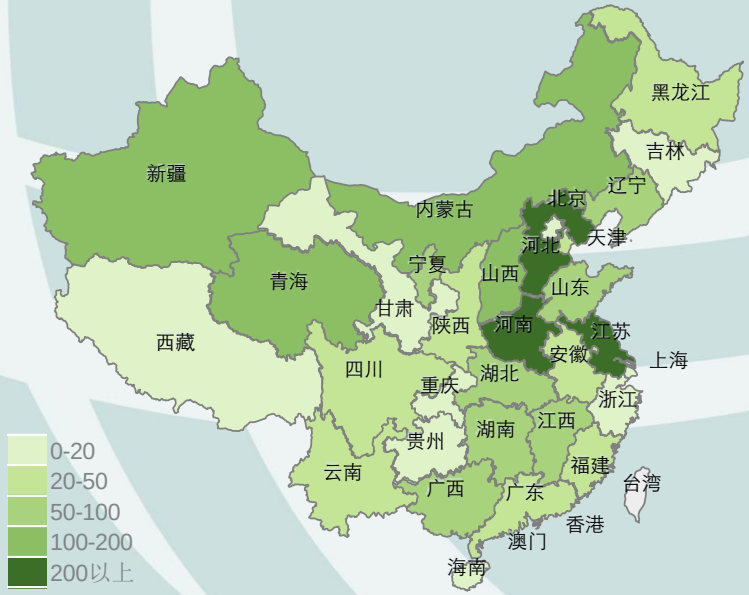
Wind and solar development driven by policy

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

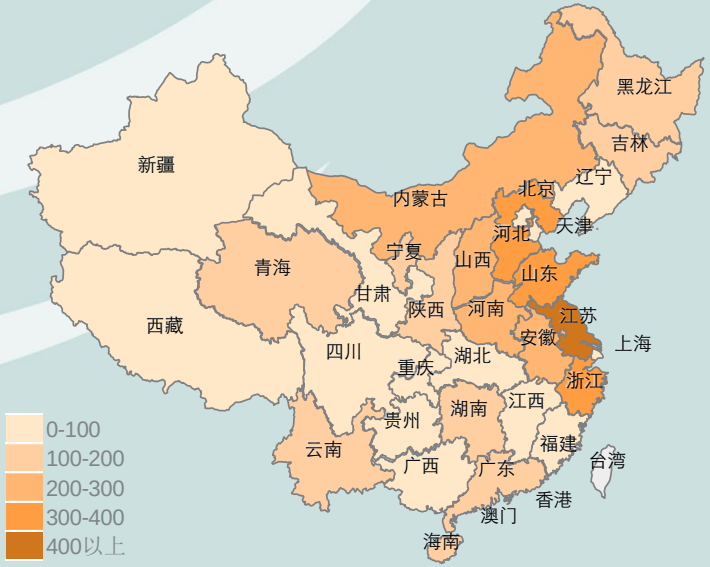
Wind and solar Energy Development Status in China

The wind power reached 184 GW with an average annual growth rate of 12.4%, ranked first in the world for 7 years. **Wind concentrated in Northwest，Northeast and north areas**, Xinjiang、Gansu、Shandong of 7 provinces exceeded 10GW。

The solar power reached 174GW with an average annual growth rate of 34%, ranked first in the world for 3 years. **Solar concentrated in Northwest, North and East,** Jiangsu、Zhejiang、Anhui of 7 provinces exceeded 10GW 。



Wind capacity distribution



Solar capacity distribution

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Renewable Energy Market Participation Status in China

☐ Medium and Long-term Trading Mechanisms

The "Three North" regional power grid companies have established effective medium- and long-term market-oriented trading mechanisms to improve renewable energy consumption, **including generation rights trading and direct energy trading, etc.**

A

Cross-Provincial Generation Rights Trading

Renewable power plants can purchase generation rights from thermal power plants cross-provincially and substitute thermal generation

B

Cross-Provincial Direct Energy Trading

Combine wind, PV and thermal power to transmit via UHV connections, and trade on the cross-provincial platform.

国家电网 STATE GRID
国网能源研究院 STATE GRID ENERGY RESEARCH INSTITUTE

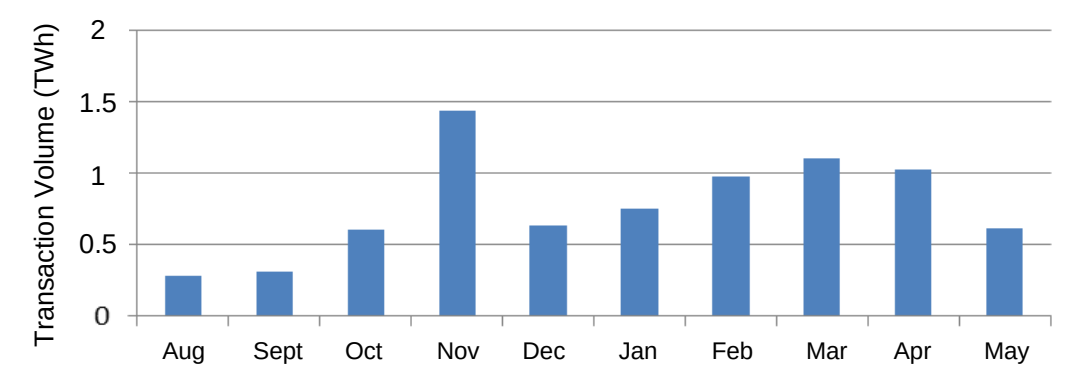
Renewable Energy Market Participation Status in China

☐ Ancillary Service Market

- The Northeast region took the lead in establishing a power peaking ancillary service market and began operations in October 2014.
- At present, Shanxi, Shandong, Anhui, Fujian, Hubei and other provinces have issued operational rules for power ancillary services market.

☐ Excess Renewable Energy Cross-provincial Spot Market

- In August 2017, SGCC launched cross-provincial spot market for excess renewable energy. By the end of April 2019, it has achieved cross-provincial renewable energy consumption of 12.61 TWh.



Transaction Volume of Excess Renewable Energy Cross-provincial Spot Market

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Contents

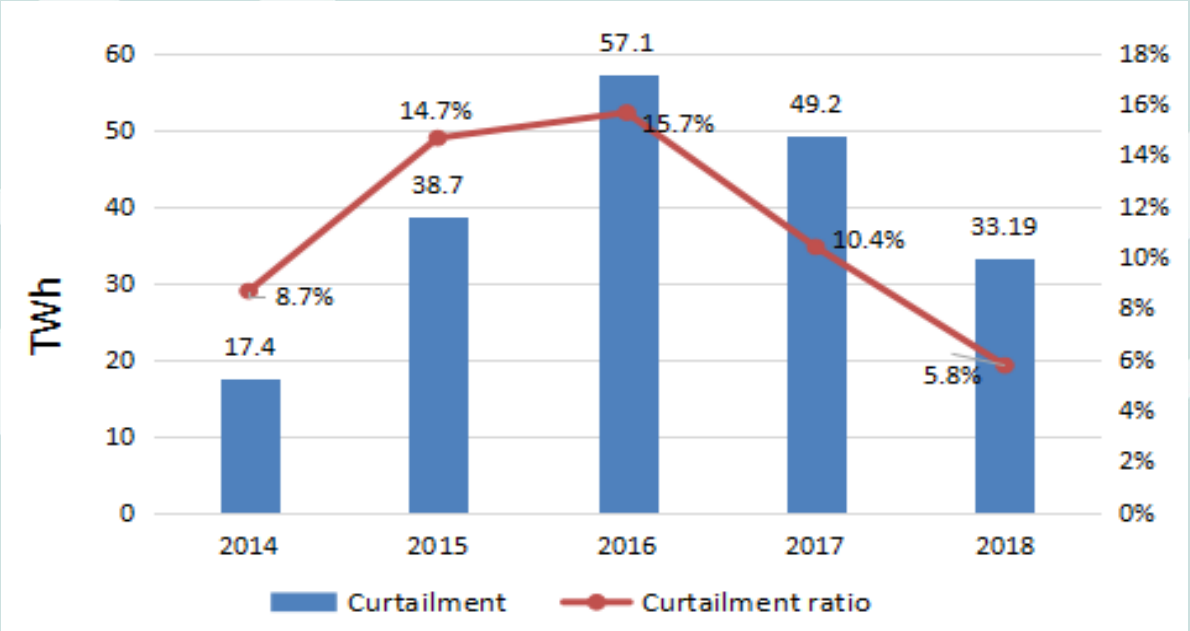
2 Key Issues for Renewable Energy Participation in Electricity Market in China

国家电网 STATE GRID
国网能源研究院 STATE GRID ENERGY RESEARCH INSTITUTE

1. Wind and solar full consumption

Problem Description

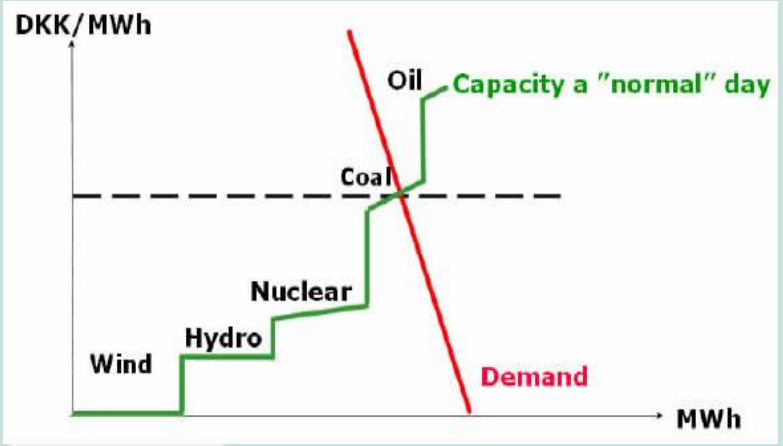
China's policy requires full consumption of renewable energy. Because of the volatility and uncontrollability of renewable energy output, it is difficult to accurately declare in the market. Participation in the spot market may result in renewables curtailment.



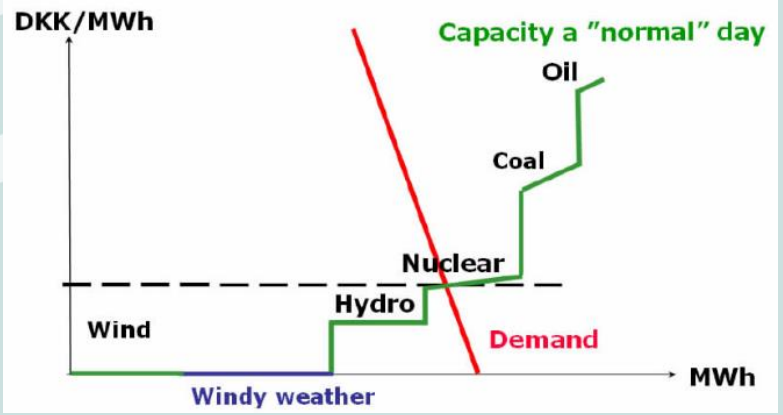
Wind and solar curtailment in China（2014-2018）

How to guarantee the wind and solar priority dispatch in market competition?

- **With subsidies:** Based on government subsidy, wind and solar power could bid extremely lower price because of their low marginal cost;
- **No Subsidies:** This will be very complicated. If wind farm and solar station with heavy sink cost, especial for the new added projects, the bidding price may be a litter or much higher than other plants, and then losing market competitiveness.



Market clearing in the small wind period



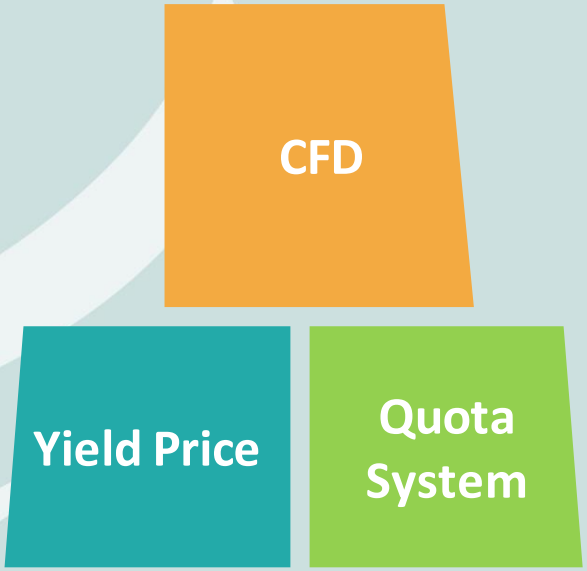
Market clearing in the strong wind period

Suggestions

- **Establish flexible subsidy mechanism for priority dispatch**

In the short term, the cost of renewable energy generation is higher than conventional energy. It needs to be subsidized through a reasonable mechanism to participate in the spot market when the price is competitive.

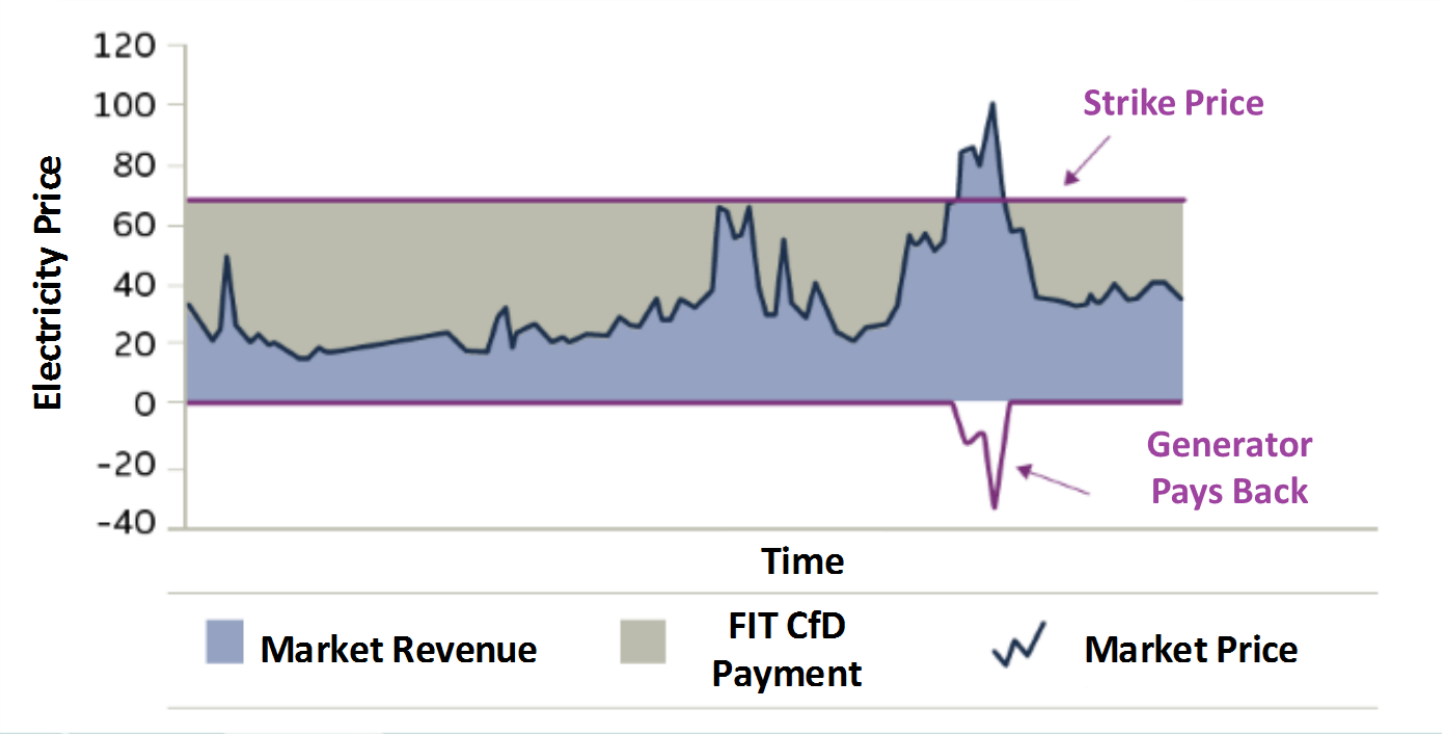
For existing wind and solar projects to bid based on marginal cost



Renewable Energy Subsidy Mechanisms

☐ Participate in the Market with CFD

CFD is the extension of Feed-In Tariff (FiT) mechanism. Renewable energy producers obtain CFD through competition, participate in electricity market on the basis of obtaining the benchmark electricity price guarantee, and obtain its revenue according to the volume gained in market.



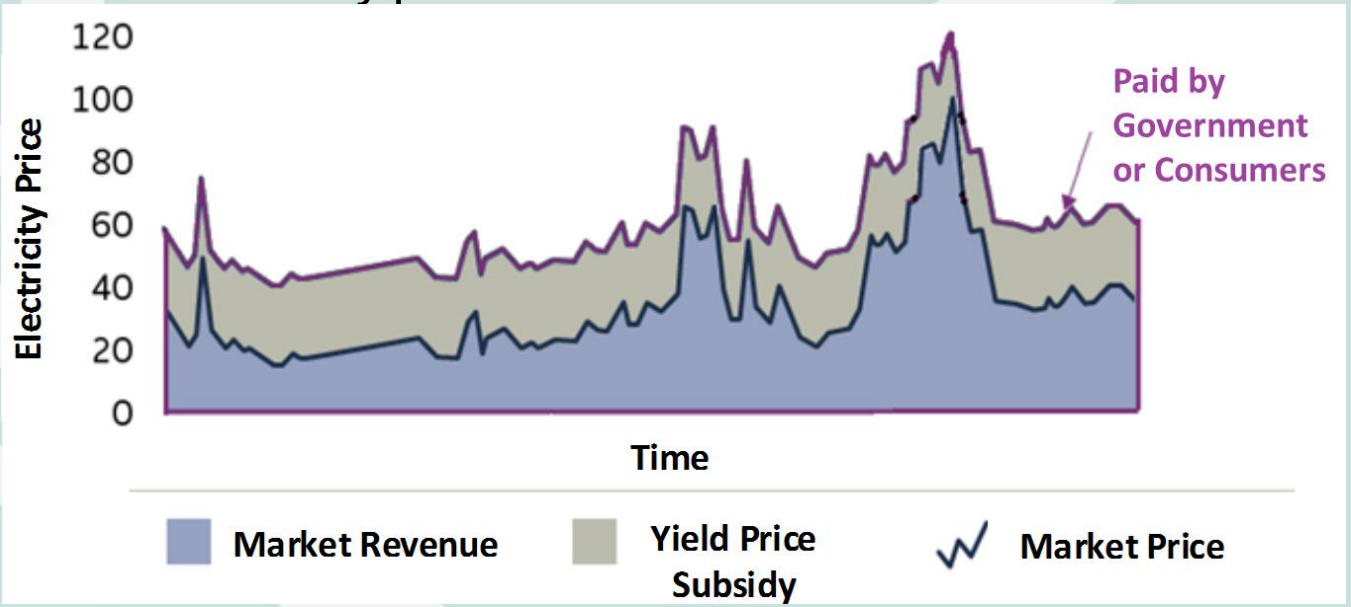
Source: UK Government White Paper

Participate in the Market with Yield Price

In this mechanism, renewable energy producers participate in the electricity market and obtain a proportion of subsidies on the basis of market prices.

Renewable energy producers will participate in market competition in accordance with the same rules.

Due to the high cost of renewable energy generation, the subsidies shall be provided by the government or users, which can be fixed price or adjusted according to the fluctuation of electricity price.



Comparison between CFD and Yield Price

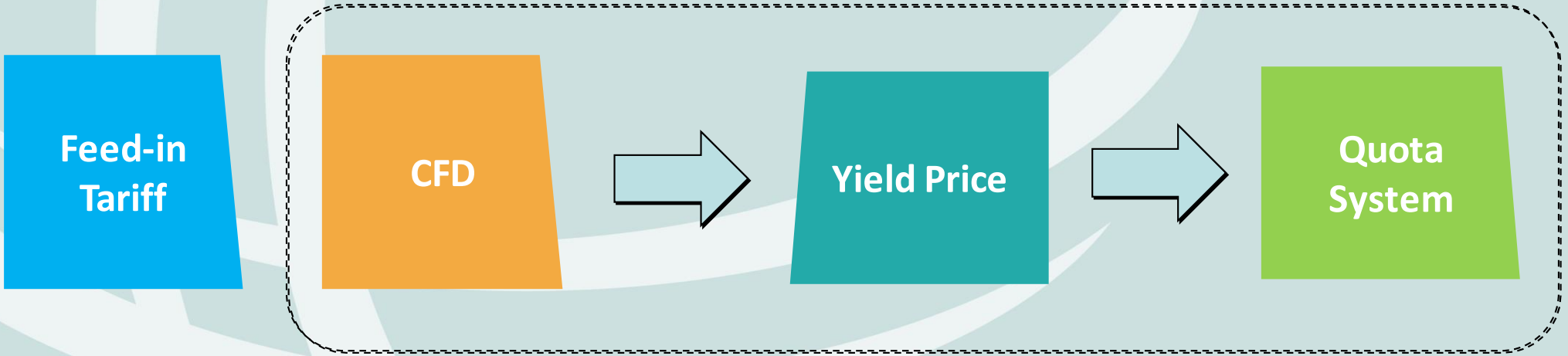
CFD mode can form renewable energy benchmark electricity price through competition, on the basis of controlling total amount of subsidies. Yield price mode increase the flexibility of renewable energy consumption and market level, optimize the allocation of renewable energy power generation by making use of spot market.

CFD	**Pros**	- Forms price signal - Overall subsidy limited - Simple and straightforward
	Cons	- Discourages RE to bid in the market - Does not reflect supply & demand
Yield Price	**Pros**	- Encourages market competition - Enhances forecast accuracy
	Cons	- Unlimited overall subsidy can cause financial burdens - Hard to set the price

☐ Chose which mechanism for wind and solar involved in market

No Market

Market Competition



Early Market for smooth transitions

Early or Mid Market for insuring profits of wind and solar

Mature Market encouraging wind and solar competing

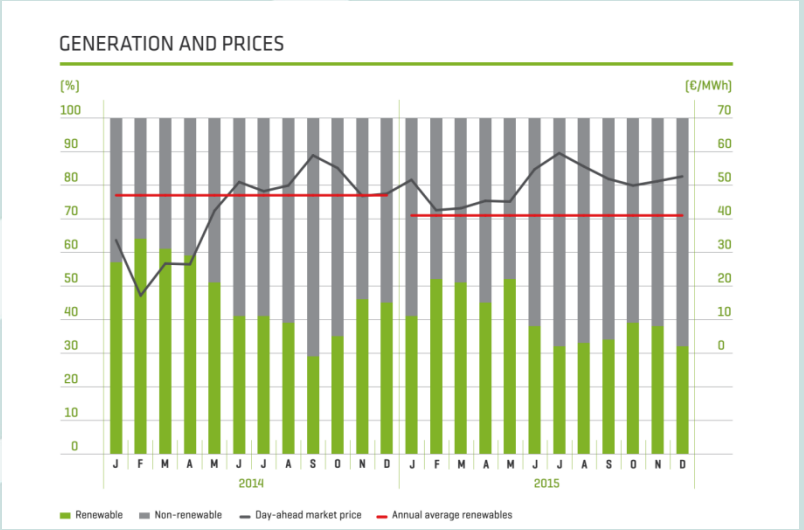
国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

2. Thermal power survival

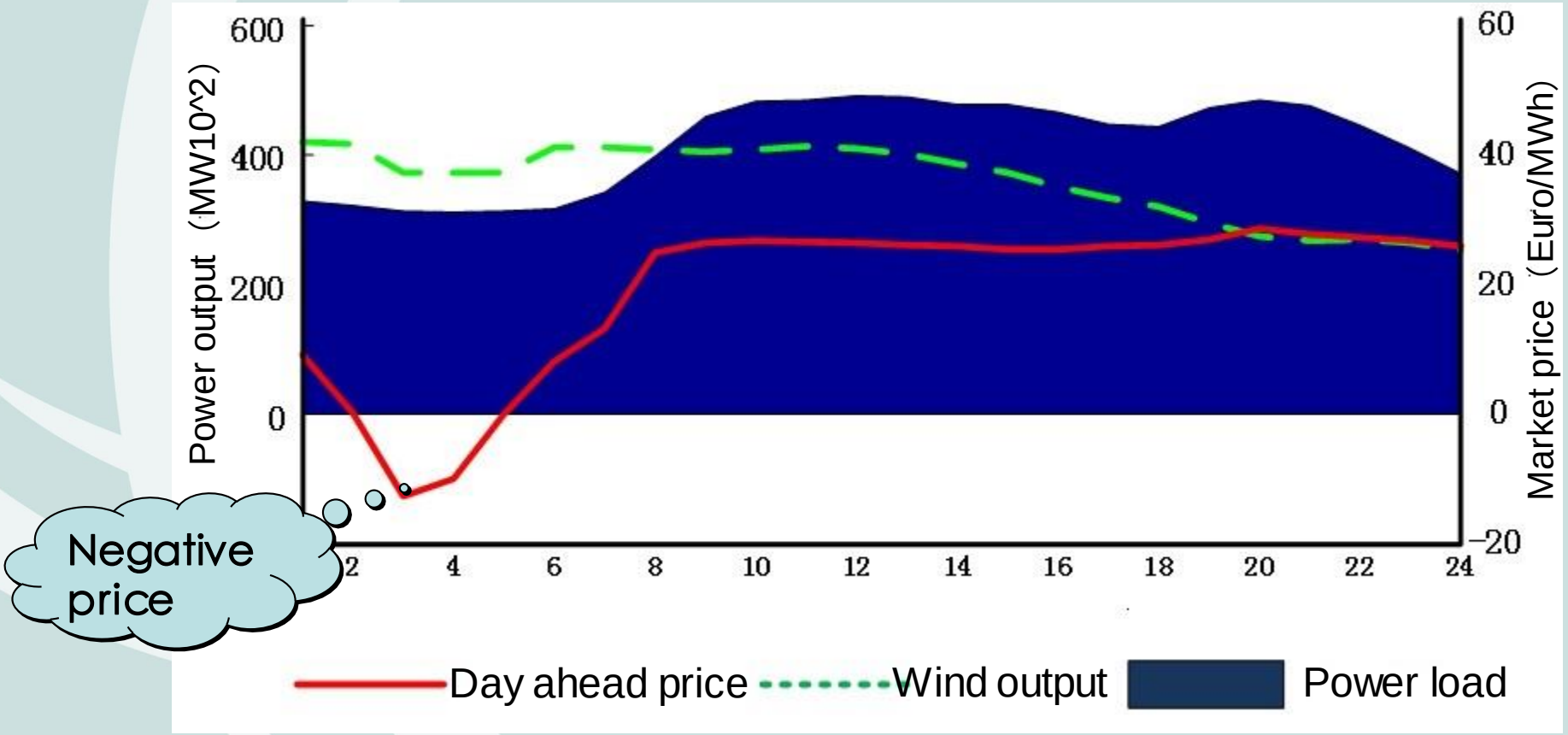
Problem Description

The marginal cost of renewable energy is close to zero, but the fixed cost is high. The special cost structure of renewable energy will affect spot market price.

- **The participation of renewable energy in spot market will reduce wholesale market price.** Due to the low marginal cost of renewable energy, large-scale market participation will lower the price on power generation side.
- **The interests of renewable energy and thermal power are difficult to coordinate.** As the overall price of the market is lowered by renewable energy sources, there may be difficulties in the survival of thermal power enterprises, which may result in insufficient power generation capacity in the long term.

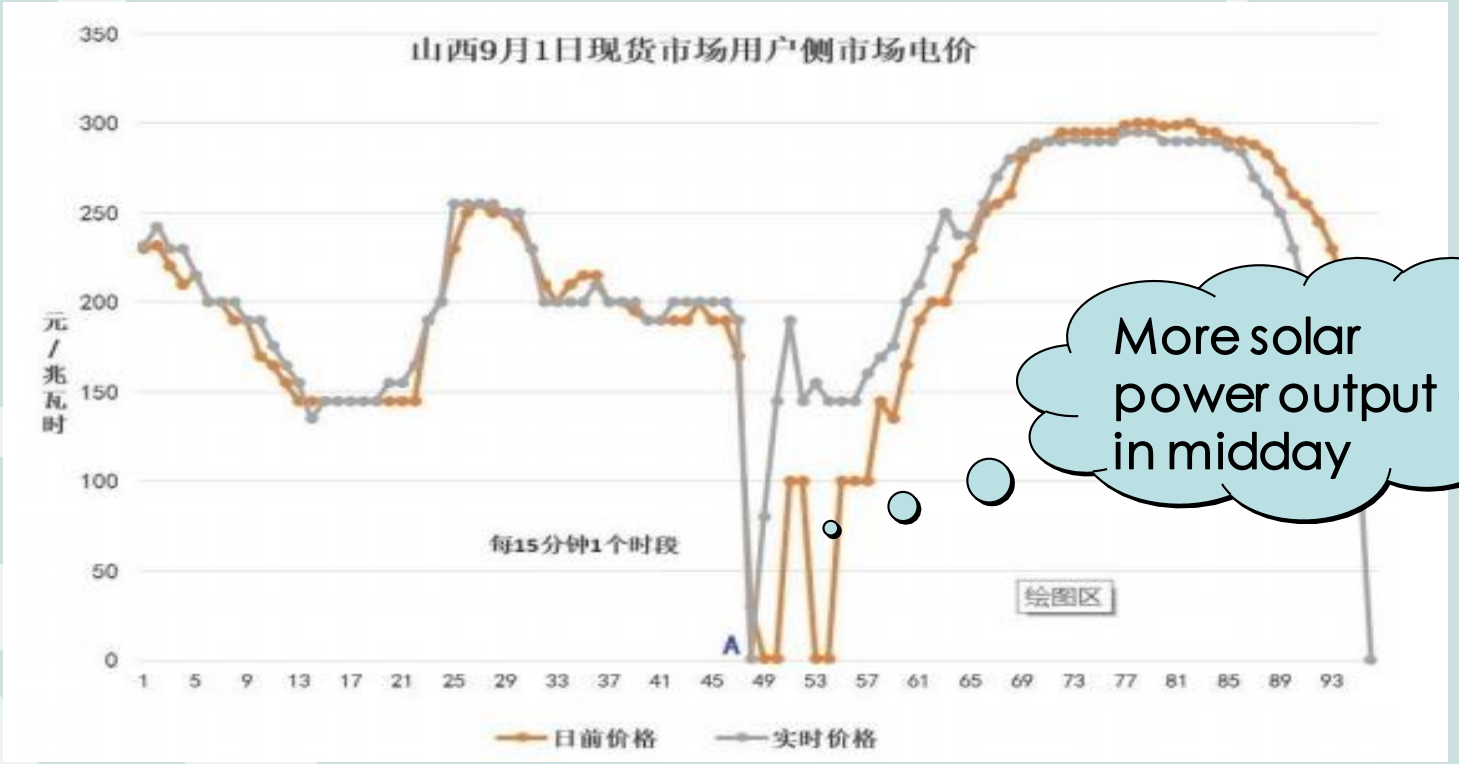


Spot Market Price and Renewable Energy Ratio



Denmark Spot market price on March 17,2014

ShanXi Spot market rules required full load hours of thermal power participated. **Nowadays , the feed-in tariff of thermal power was 320 RMB/MWh,** When day ahead price was extremely lower due to more solar power output in midday, thermal power plants profits would be very small or zero.



ShanXi province Spot market price on September 1,2019

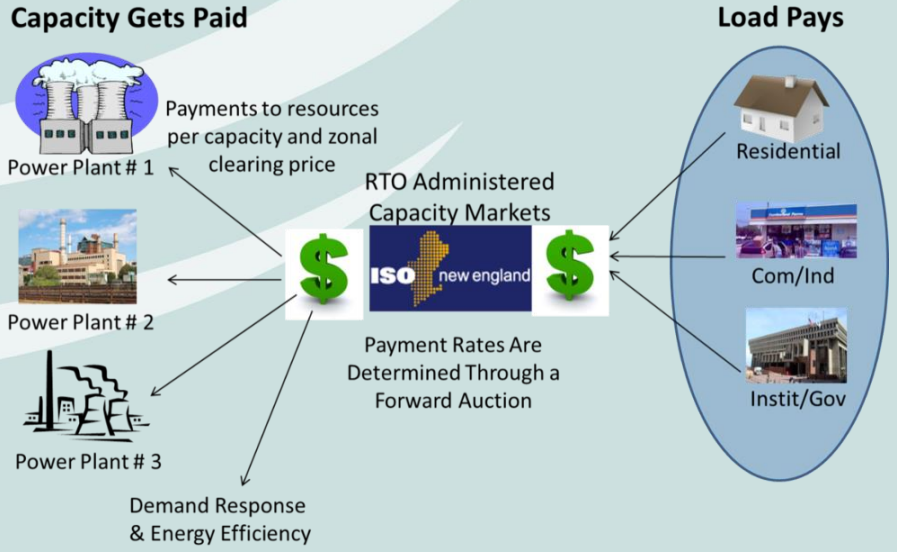
国家电网 STATE GRID
国网能源研究院 STATE GRID ENERGY RESEARCH INSTITUTE

Explore the establishment of Capacity Market for thermal power

Suggestions

- The integration of renewable energy has continuously reduced utilization hours of traditional units. Traditional units face the risk of shutting down, increasing the difficulty of system reserve and peak shaving.
- Many countries have continuously explored capacity market mechanisms to ensure power generation adequacy and system operation safety.

Generation capacity required by the power system in capacity delivery year is traded in the UK capacity market. In November 2014, the UK capacity market organized the first auction and will be delivered in the winter of 2018/19.



UK Capacity Market Diagram

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

3. Prediction Accuracy

Problem Description

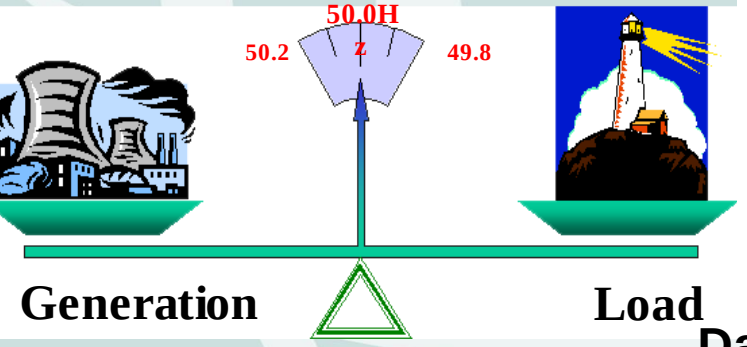
The prediction accuracy of renewable energy directly determines the feasibility of renewable energy companies participating in electricity market. **However the accuracy of renewable energy forecast is still not high, there will be a risk of power inbalance.**

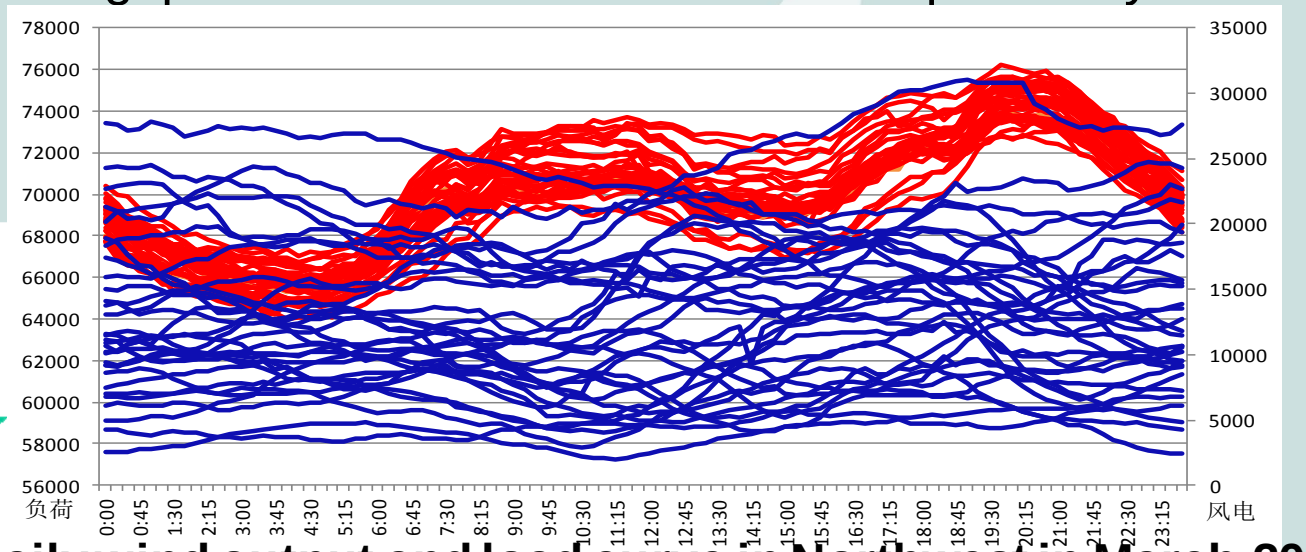
- **In the day-ahead market, renewable energy participates in market bidding based on short-term forecast results.** If the forecast accuracy is low, it will pay a relatively expensive price to compensate in the intraday market.

- **In the intraday market, short-term forecast results are continuously revised based on the results of ultra-short-term forecast and the hourly planned power in day-ahead market is adjusted.** The higher the prediction accuracy, the less the electricity traded in intraday market, and the less the cost.

Problem Description

High penetration wind and solar integrated into the power grid, if the power prediction is not very accurate, the gap between the generation and load will be expanded, which would be bring power unbalances to threaten power system operation security.





Daily wind output and load curve in Northwest in March,2019

The maximum wind output reached 31GW in Northwest, while the minimum power was 2GW. Daily power variation was up to 17.72GW

Suggestions

- **Establish a fair and reasonable deviation penalty principle for renewable energy.** Renewable energy naturally has the characteristics of uncertainty. It is necessary to set reasonable deviation penalty standards for renewable energy and encourage renewable energy to participate in electricity market.

- **Renewable energy producers and system dispatch center both need to conduct renewable energy forecasts.** On the one hand, system dispatch center predicts clean energy generation within the network, and can reasonably arrange dispatching and maintenance plans to achieve optimal dispatch and ensure the safety and stability of power system. On the other hand, renewable energy producers also need to forecast their power generation and make reasonable offers in electricity market.

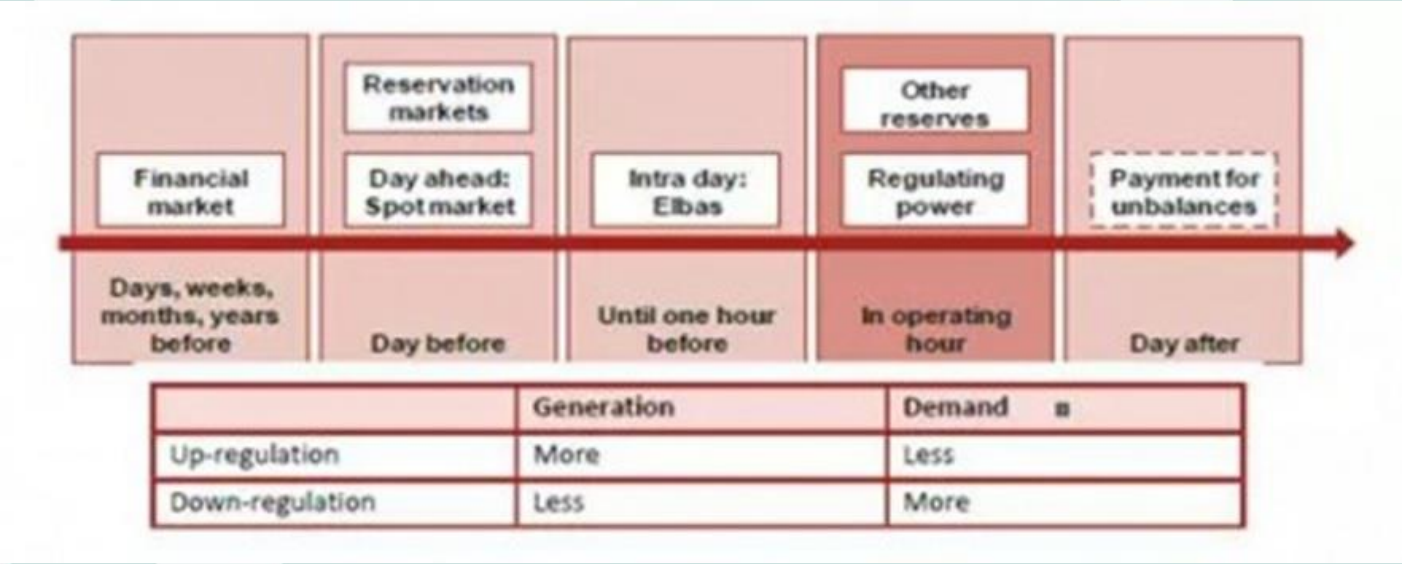
In order to deal with the strong randomness of renewable energy and improve the prediction of wind power, **the assessment of wind power output deviation should be strengthened to reduce the balancing burden of real-time market.**

- Spanish Electricity Law requires that Spanish wind power enterprises are obliged to notify the power grid dispatching agency of the wind power forecast ahead of time. If the forecast is not correct, the wind farm will have to pay a fine. Considering the difficulty of forecasting wind power generation, Spain permits a 20% deviation in forecasting wind power, and fines are payable when the deviation exceeds this ratio.

- Texas Electricity Market requires that when wind abandonment occurs in real-time operation, if wind power does not reduce its output according to dispatching instructions, it will be assessed for deviation. ERCOT's allowable wind power output deviation is 10%.

➢ Establish diversified Market

In order to increase the prediction accuracy of wind and solar, we had better need the short-time power forecasting, such as 1 hour or 15 minutes. Day ahead, intraday, and hours balance markets are required to allocate all flexible resources to balance the power deviations.



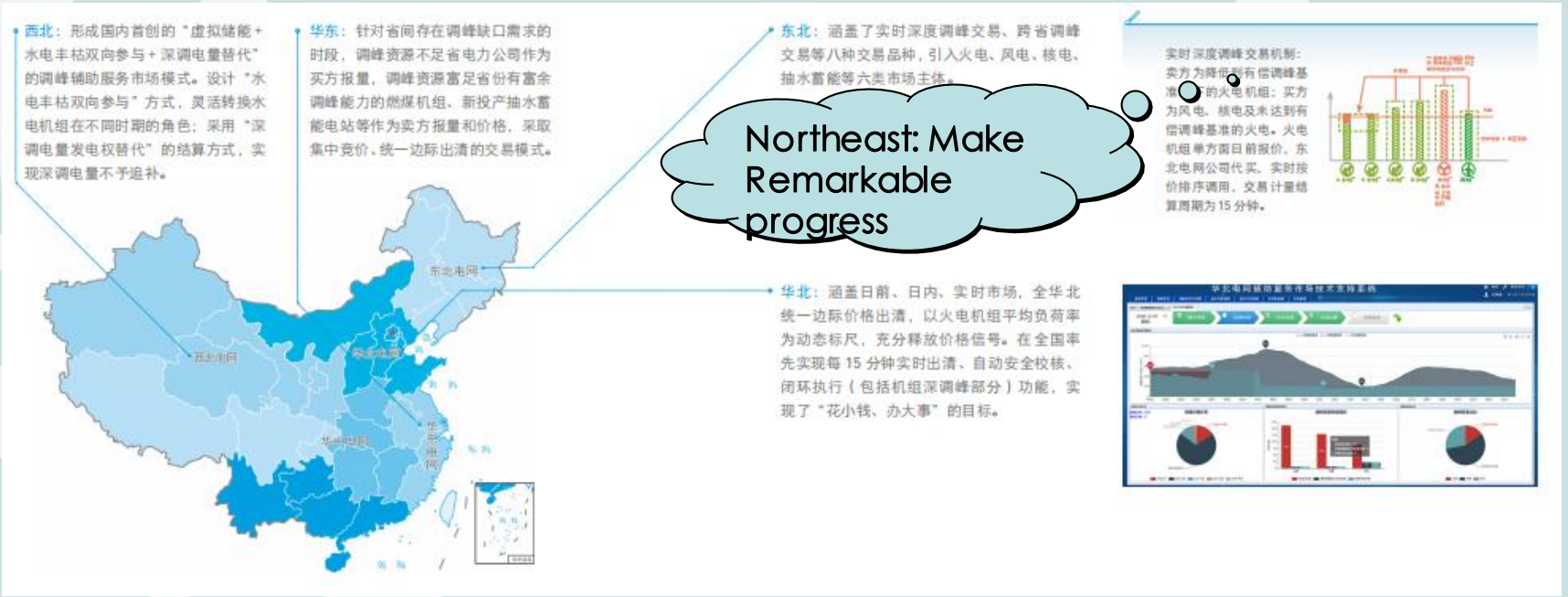
	Generation	Demand
Up-regulation	More	Less
Down-regulation	Less	More

Denmark power market: including day ahead, intraday, regulating power market

We should pay more attention on Ancillary market with high wind and solar power system

➢ Enhance ancillary service market

Correctly reflect the ancillary service cost and market value, rationally allocate auxiliary service cost to demand side, guide users to reduce power system balance pressure.

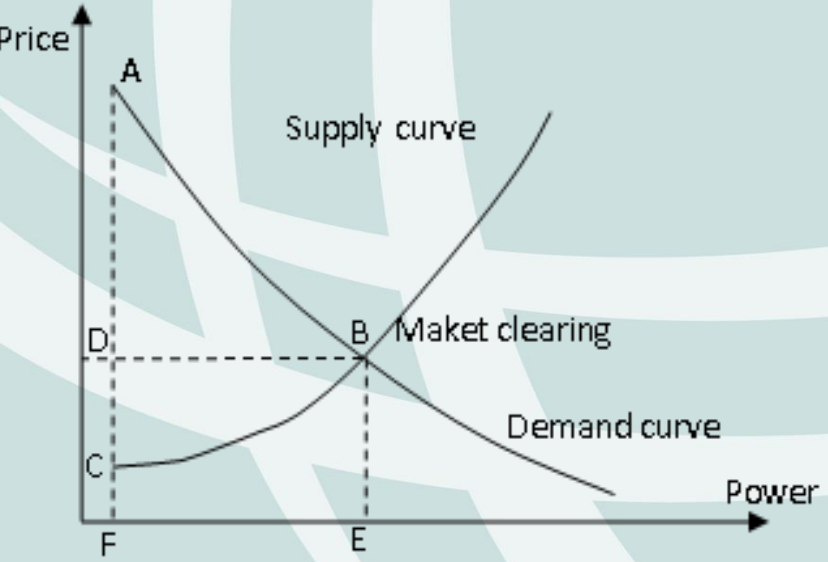


Current Regulation Ancillary Market in regions in China

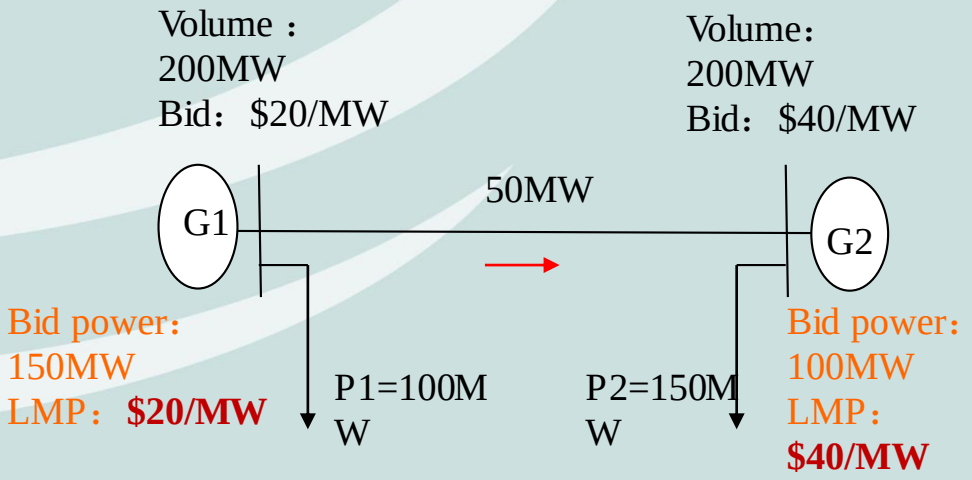
Future Ancillary Market: Strong, flexible, trading varieties for stable power system

4. Nodal price or Zonal price

In the spot market, choosing which pricing is critical for market stakeholders. There is two major pricing implemented in recent power market, **on is the zonal price such as Nordpool power market**, Texas power market and so on, **the other is the Nodal price(LMP), such as PJM**, NewYorkISO market and so on. Considering the grid congestions, LMP mechanism can give nodal price in different area to guide the reasonable supply and demand. Zonal price will form the same price in a total area.

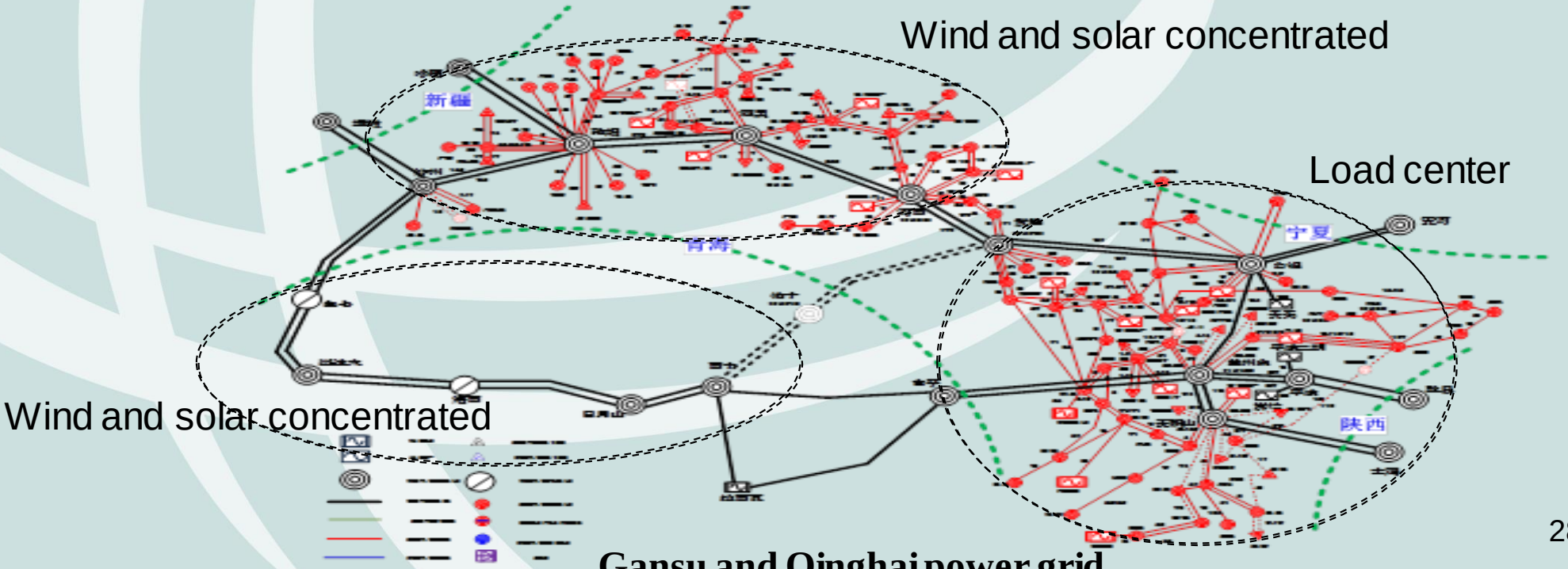


Zonal price



Bidding result with line constraint and different nodal price（LMP）

In northwest, northeast and north area, such as Gansu, Qinghai, Xinjiang, Jilin, Hebei, wind and solar concentrated in remote area or the end of power grid, **inner-province congestion will cause the higher nodal price in the load center and congestion fees udder LMP mechanism.** How to avoid higher price and which pricing mechanism was proper when integrating more wind and solar power?



Gansu and Qinghai power grid

Suggestions

- **Early Market:** In order to encourage more wind and solar making more profits, the Zonal price will be proper ignoring the location of wind and solar station. If the LMP mechanism is implemented, the remote nodal price will be lower than the expected even much lower than the new energy Feed-in Tariff.

- **Developed Market:** In order to optimal the power plants location to avoid the heavy congestions, the LMP mechanism will be brought to reflect the power grid structure and guide wind and solar station investment.

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Contents

3 Further Discussions

- **Exploring Flexbile Resources?** Lacking of more Flexible Resource has become the big challenge in current power system. How should we do? Thermal power combined heat pump? Add some energy storage? Enhance Demand Side Response? And which is more economic?

- **Power system security with high VRE penetrations:** In the future, more and more wind and solar are added to power system in China, over 500GW wind and solar respectively by 2030, how to deal with the huge deviation? To rebuild the power system? Adding tremendous energy storages?

- **Policy and market coordination:** In the past 10 years, wind and solar were driven by central and local government polices, and now shifting to the power market, we should abandon or make the more proper policy?

国家电网
STATE GRID
国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Thank you for your attention!

For questions and feedback:
xieguohui@sgeri.sgcc.com.cn
+86 13520600818
010-66603738