



国家电网
STATE GRID

国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Practice on the Coupling Between Power and Heat Sector to Facilitate Renewable Energy Integration in China

State Grid Energy Research Institute

2017.12.5



国家电网
STATE GRID

国网能源研究院

STATE GRID ENERGY RESEARCH INSTITUTE

Outline

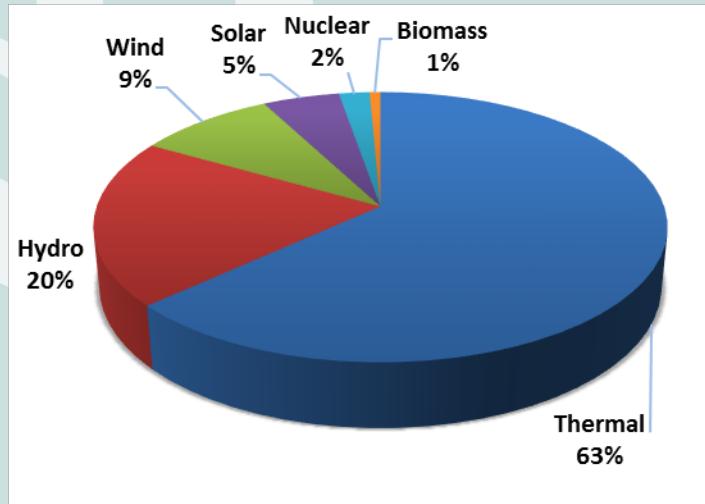
- 1. Current Status of RE Development in China and the Impact of Heat Generation on RE Integration**
- 2. Practice on the Coupling Between Power and Heat Sector to Facilitate RE Integration**
- 3. Thoughts on the Next Step**



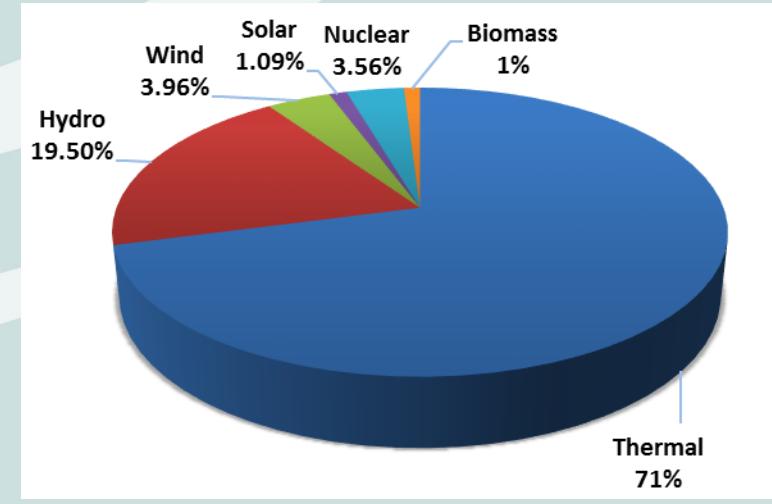


RE Development: Capacity and Energy

- Installed capacity of wind and solar generation: 226.06 GW (by the end of 2016)
- Capacity share: 14%
- Energy from wind and solar: 307.2 TWh (2016)
- Energy share: 5%



Generation Capacity Structure in China in 2016

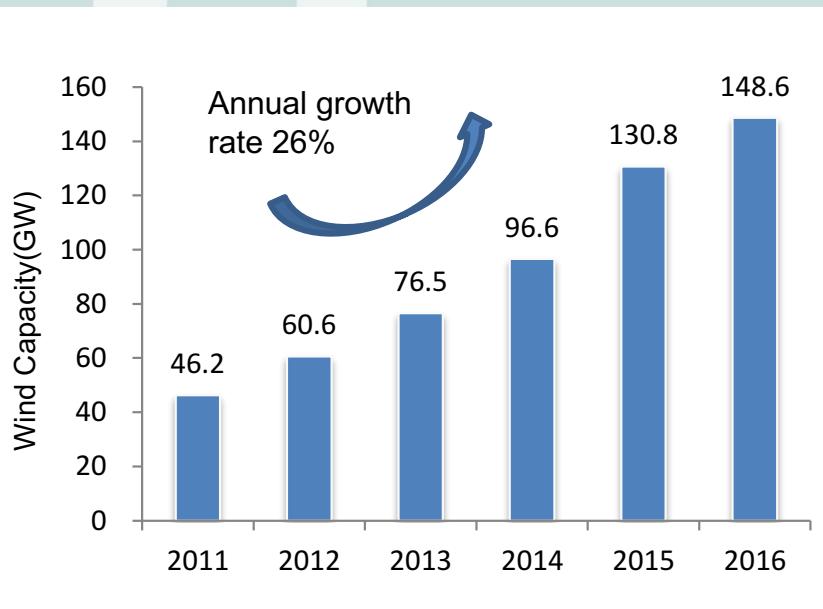


Generated Energy from each type of generation in 2016

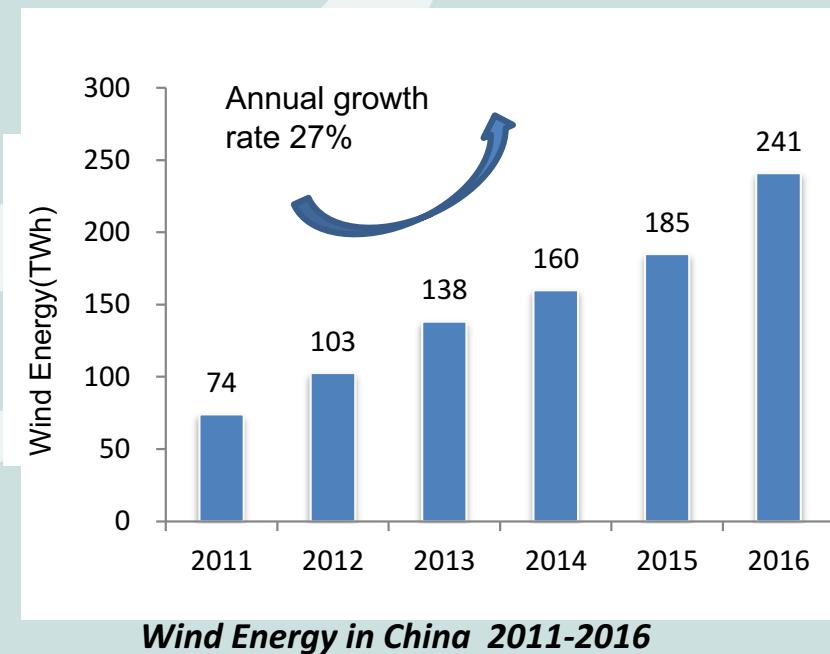


RE Development: Wind

- Installed capacity of wind : 148.6 GW (by the end of 2016)
- Capacity share: 9%
- Energy from wind: 241 TWh (2016)
- Energy share: 4%



Installed Capacity of wind in China 2011-2016

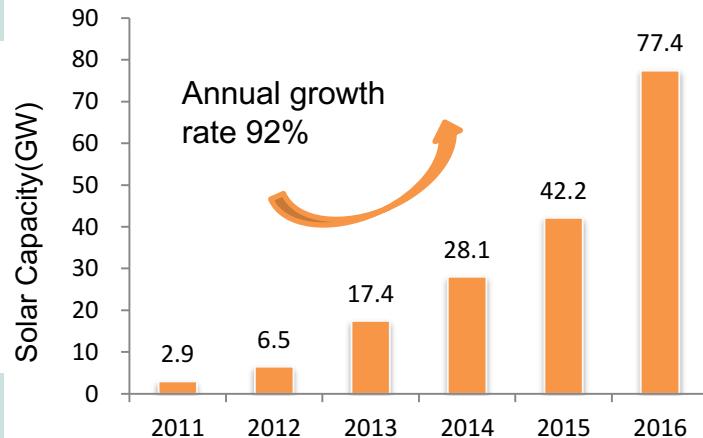


Wind Energy in China 2011-2016

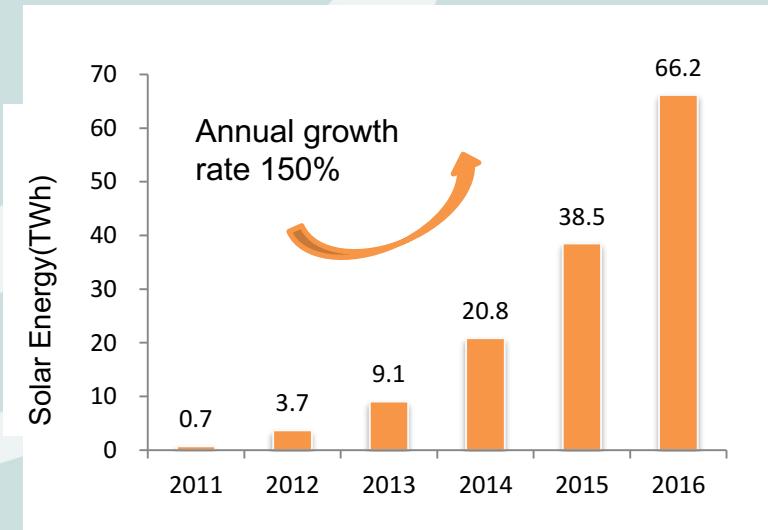


RE Development: Solar

- Installed capacity of solar : 77.4 GW (by the end of 2016)
- Capacity share: 5%
- Energy from wind: 66.2 TWh (2016)
- Energy share: 1%



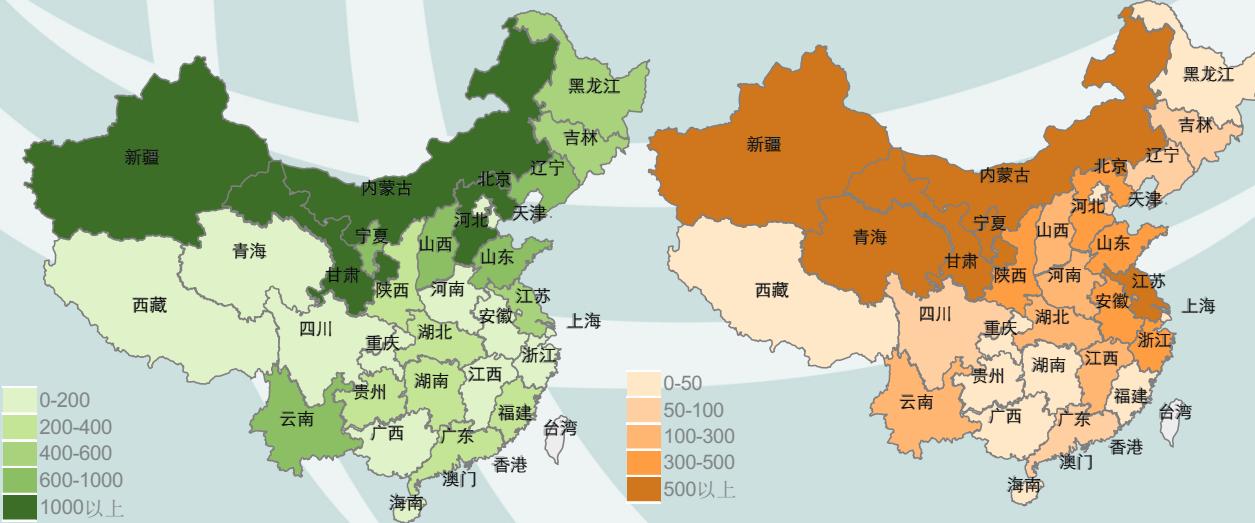
Installed Capacity of solar generation in China 2011-2016



Solar Energy in China 2011-2016

RE Development: Characteristic

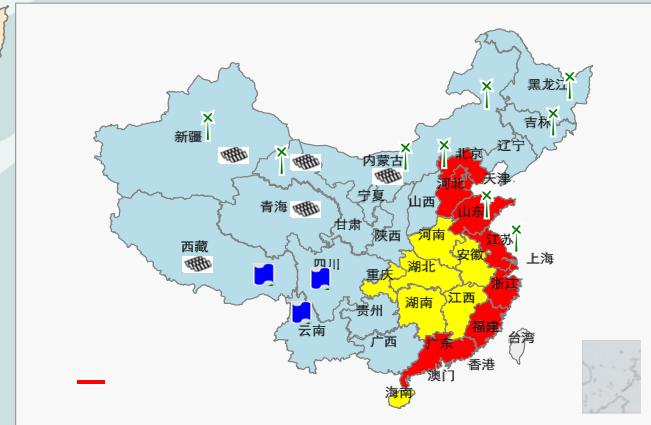
- Concentrated in the “Three North” regions: North China, Northeast China, and Northwest China, ~80% of the total capacity.
 - Far from the load centers: Mainly in the central and eastern regions, ~65% of the total electricity consumption in China.



Distribution of Wind Resource in China



Distribution of Solar Resource in China



Distribution of Electric Load in China



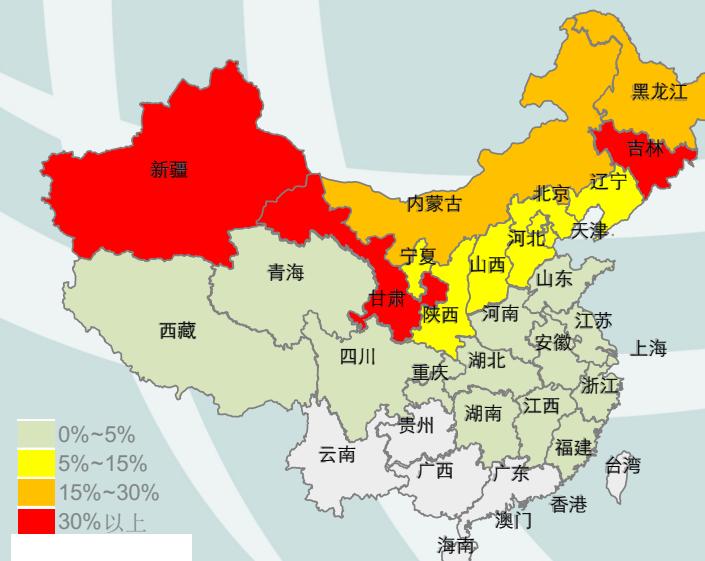
RE Curtailment

Amount of wind curtailment in China: 49.7 TWh (curtailment rate 17%).

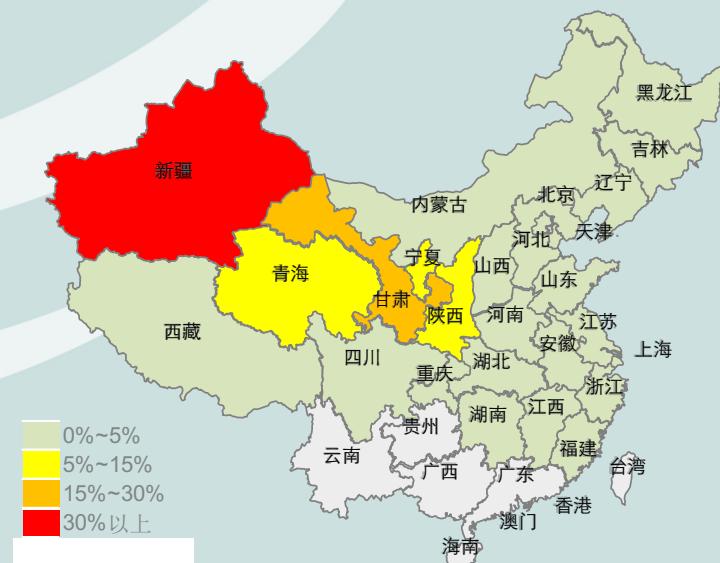
Distribution: Gansu, Xinjiang, Jilin and Inner Mongolia are over 20%.

Amount of solar curtailment: 7.04 TWh (curtailment rate 10%).

Distribution: Northwest China, i.e. Gansu, Xinjiang, Qinghai, and Ningxia.



Distribution of Wind Curtailment in China



Distribution of Solar Curtailment in China



Barriers to RE Integration in China

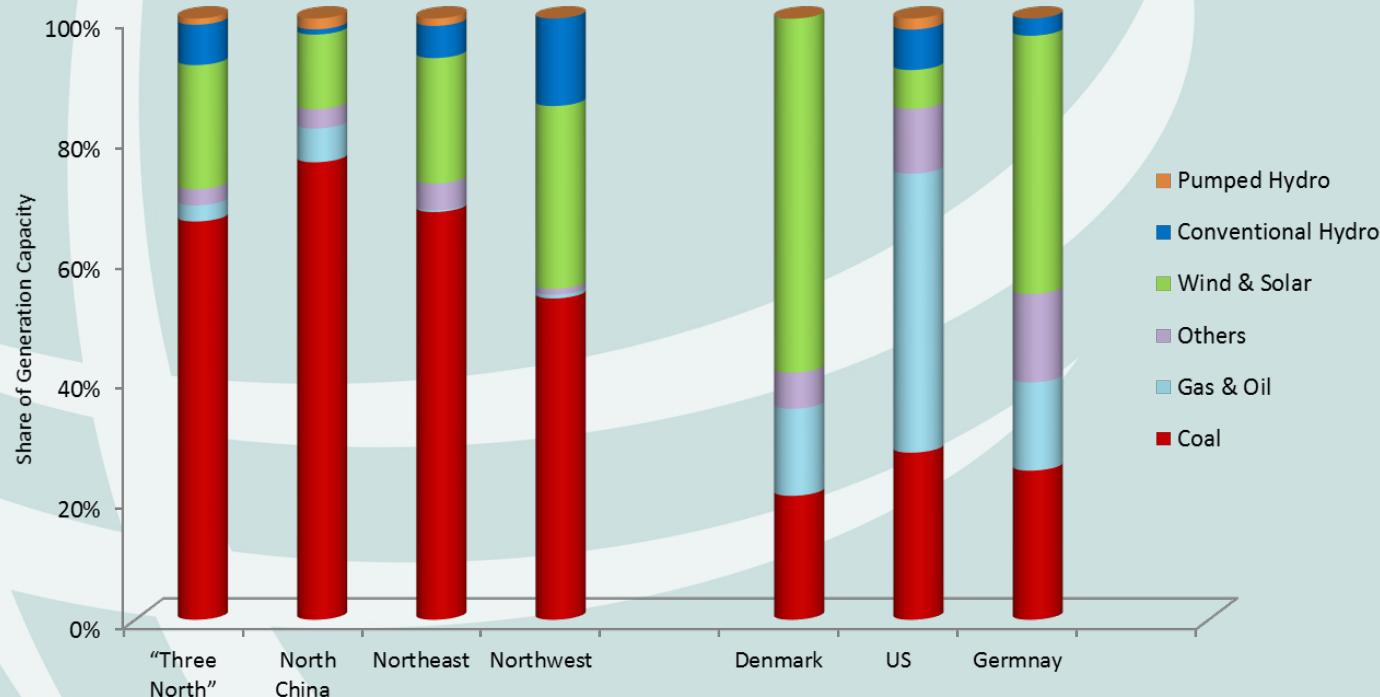
- High penetration of wind and solar in some provincial power grids
- Fast development of all types of generation, and slowing down of electric demand growth
- Limited trans-regional and trans-provincial interconnection
- **Lack of flexibility from conventional generation**
 - CHP
 - Self generation
 - Nuclear
- Institutional barriers
 - Lack of ancillary service market
 - Inflexible price mechanism
 - Lack of demand side participation in renewable energy integration
 - ...



Generation Structure in China

In general, there is a high share of coal-fired generation in China.

The share of coal-fired generation in the Three Norths Areas is ~70%.

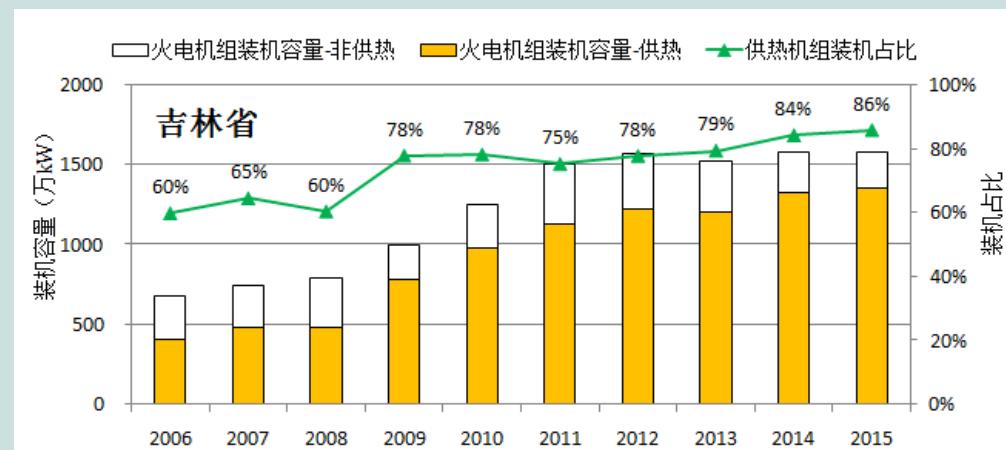




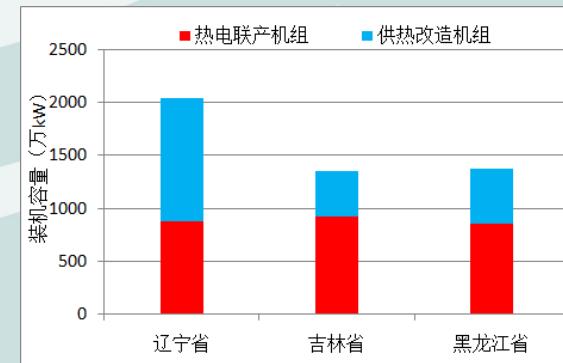
CHP Issue in China

Of all the coal-fired generation, there is a high proportion of CHP generators.

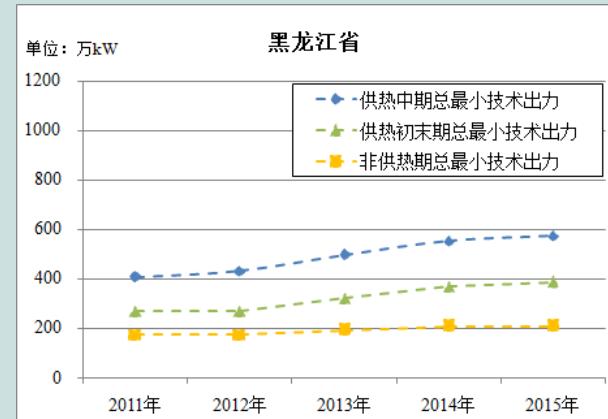
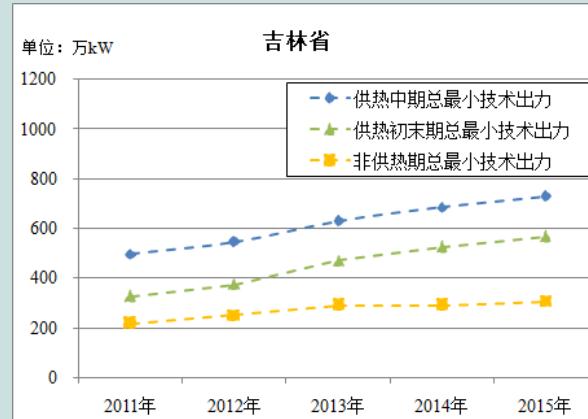
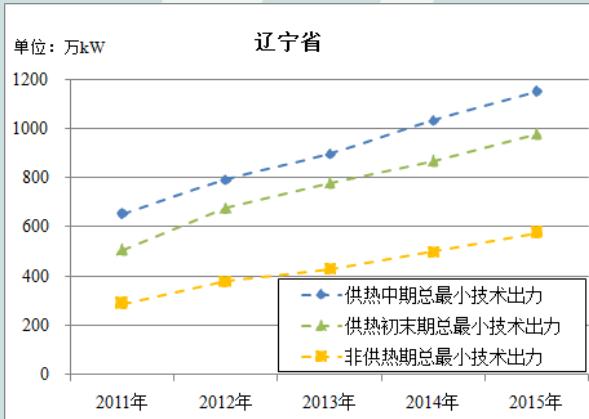
- Motivation: More generation opportunity
 - More energy quota
 - Higher minimum output
- Retrofit CHP from non-CHP units.



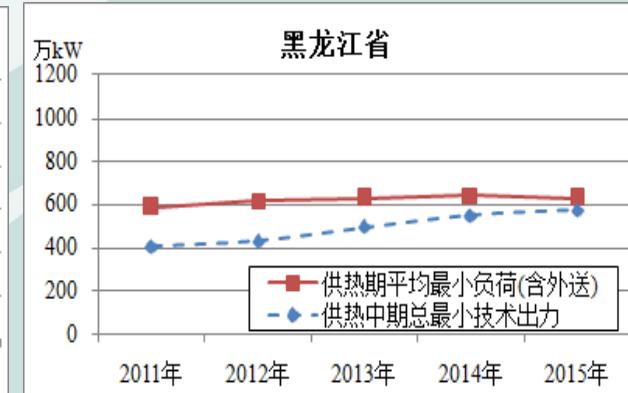
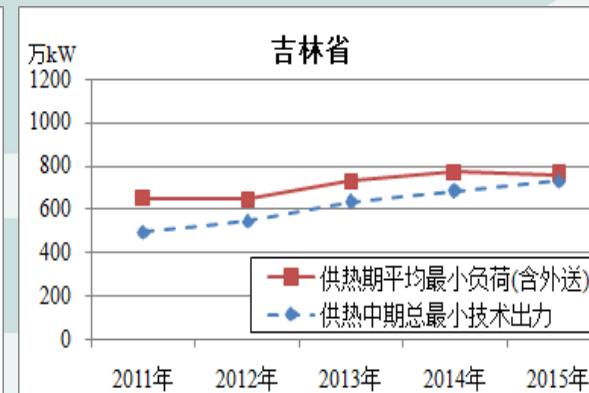
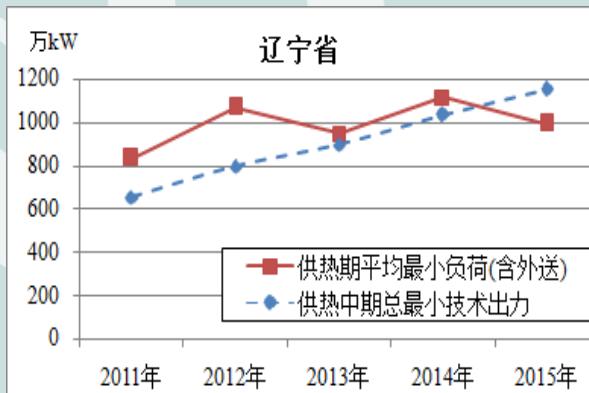
The capacity and share of CHP generators in Jilin Province 2006~2015



The capacity of CHP and retrofitted CHP generators in Northeast China in 2015



Minimum output of all the CHP generators in Northeast China during 2011~2015



Comparison of average minimum output of generators and average minimum load during mid term heating season in Northeast China during 2011~2015



国家电网
STATE GRID

国网能源研究院

STATE GRID ENERGY RESEARCH INSTITUTE

Outline

- 1. Current Status of RE Development in China and the Impact of Heat Generation on RE Integration**
- 2. Practice on the Coupling Between Power and Heat Sector to Facilitate RE Integration**
- 3. Thoughts on the Next Step**





Mainly, three types of solution.

- Wind heating
- Co-operation of CHP generators and electric boilers, heat storage
- Electricity substitution





Wind Heating

Basic idea: Use the curtailed wind energy for heating.

- 10+ pilot wind-heating projects in China so far, mainly in wind-intensive areas, such as Jilin, Inner Mongolia.
- Two business models
 - Wind power plant owners invest in electric boilers, which buy potentially curtailed wind from the power grid and sell the generated heat to heat companies

Wind power plant

Power grid

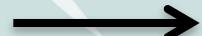
Heat company



Residency

Electric boiler

Power flow



Cash flow





Wind Heating

- Direct trading between wind and electric users, who uses electric boilers for heat generation
 - ✓ Wind power in Northeast China – Beijing electricity users
 - ✓ Reduced FIT for wind power

Wind power plant



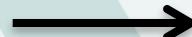
Power grid



Residency



Power flow



Cash flow

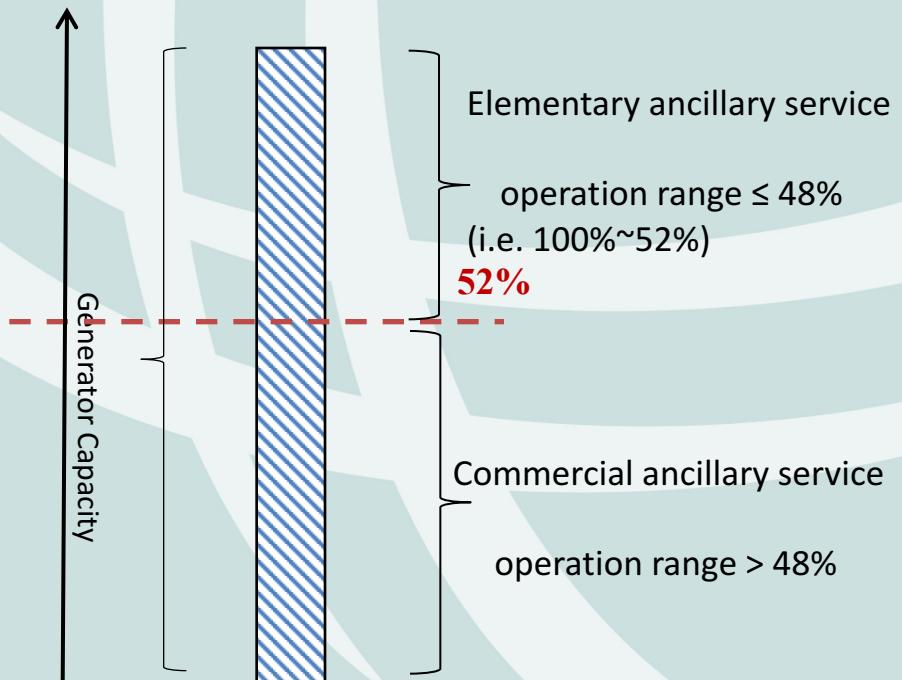




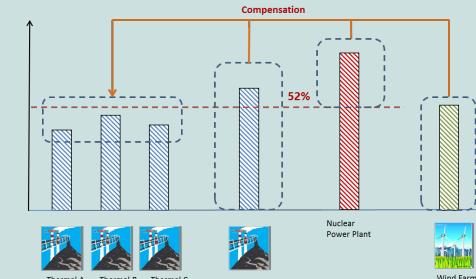
Co-operation of CHP generators and electric boilers

Basic idea: Co-operation of CHP generators and electric boilers, heat storage, ...
to increase the flexibility of CHP generators, so as to facilitate RE integration

- Pilot projects in Northeast China.
- Incentive: **downward regulation ancillary service market in Northeast China**
- Profit share between CHP generators and electric boiler investors



Period	Type	Loading rate	Bid Floor (RMB/kWh)	Bid Cap (RMB/kWh)
Non-heating	Non-CHP	$40\% < R \leq 50\%$	0	0.4
	CHP	$40\% < R \leq 48\%$		
	All	$R < 40\%$	0.4	1
Heating	Non-CHP	$40\% < R \leq 48\%$	0	0.4
	CHP	$40\% < R \leq 50\%$		
	All	$R < 40\%$	0.4	1





国家电网
STATE GRID

国网能源研究院

STATE GRID ENERGY RESEARCH INSTITUTE

Example: Dandong Jinshan CHP power plant in Liaoning Province, Northeast China



- 2*300MW CHP generators, 19 million m² heating area
- Pilot of flexibility promotion projects for CHP
- Incentivized by the downward regulation ancillary service market, a solid electric heat storage system was constructed in 2016, owned by a heat storage company.
 - Capacity: 260MW
 - Annual electricity consumption is 300GWh, which is 3% of the curtailed wind energy in Liaoning province.
- Auxiliary power is used for heat generation. The amount of electricity fed into the power grid is reduced, which is seen as a downward regulation service from the system operators' side.
- Pay back period: 3~5 years



Electricity Substitution

Basic idea: Substitution of the direct consumption of fossil energy such as coal, oil and natural gas with electricity in energy consumption, and increase the proportion of power energy in the terminal energy consumption, which help RE integration.

- Widely implemented in China since 2016.
- Incentive: Air pollution prevention. Indirectly for RE Integration.





- SGCC has accumulatively implemented over 90 thousand electricity substitution projects in which fossil fuel consumption equaling to about 280 billion kilowatt-hour of power was substituted.
- Increase the **utilization of electric boilers** for heat generation is a key part of electricity substitution.
 - Subsidies in equipment investment
 - Preferable retail electricity price during valley load hours to for heat generation



国家电网
STATE GRID

国网能源研究院

STATE GRID ENERGY RESEARCH INSTITUTE

Outline

- 1. Current Status of RE Development in China and the Impact of Heat Generation on RE Integration**
- 2. Practice on the Coupling Between Power and Heat Sector to Facilitate RE Integration**
- 3. Thoughts on the Next Step**





- ✓ Coupling of the power and heat sector is important in facilitating renewable energy integration in areas with heavy wind generation and heat demand. Current practice has proven its effectiveness.
- ✓ There are many ways of power and heat coupling to help RE integration. Promising options in the future.
 - Direct trading between wind and electricity users with heat generation requirement
 - Cooperation of CHP generators with electric heat storage
 - Electricity substitution



✓ Price mechanism is important.

- For direct trading between wind and electricity users with heat generation requirement, cheap electricity is needed for the economics of electricity heating.
 - Cheap feed in price for wind
 - Reduced transmission fee
 - Dispatch of cheap wind
- For cooperation of CHP generators with electric heat storage, attractive profit from ancillary service market is needed.
- For electricity substitution, cheap electricity price is needed.



- ✓ In the future, with the construction and mature of spot electricity market in China, price signals in the spot market should be used to reflect the oversupply of renewable energy, which could further incentivize the consumption of electricity from heat generators.



国家电网
STATE GRID

国网能源研究院
STATE GRID ENERGY RESEARCH INSTITUTE

Thank you !



If you have further questions, please contact
wangcaixia@sgeri.sgcc.com.cn

