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Topic:
Perspectives from dynamic markets with ambitious VRE (variable renewable energy)targets: how to leapfrog from previous experiences

Are additional interconnection, transmission, and flexible generation needs linked to renewables included in medium/long term power expansion strategies?

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China's Renewable Energy Development Strategies and Diversified Operation Mechanisms

China Renewable Energy Engineering Institute - Hu Xiaofeng

Copenhagen, Oct. 21, 2014

Introduction

1 Brief Introduction to CREEI

2 Present Condition of China's Renewable Energy Development

3 China's Renewable Energy Development Strategies

4 Establishment of A Diversified Supply System

5 Conclusions

1 Brief Introduction to CREEI

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1. CREEI

INTRODUCTION:

1.China Renewable Energy Engineering Institute(CREEI) is the technical regulator authorized to be responsible for of hydropower, wind power, solar power generation industries development in China.

2.As entrusted by the State Council`s relevant department, CREEI is entrusted with the tasks to manage renewable energy sources quota station, hydropower Project quality supervision station and National Renewable Energy information center

3.CREEI also for long provided energy industrial planning, technical review, policy study, information service, standard formulation, quality supervision and other services for renewable energy development in China.

Xiluodu hydropower Station in Yunnan

Windpower base in Hami, Xijiang

Solar power base in longyang Xia,Qinhai

2 Present Condition of China's Renewable Energy Development

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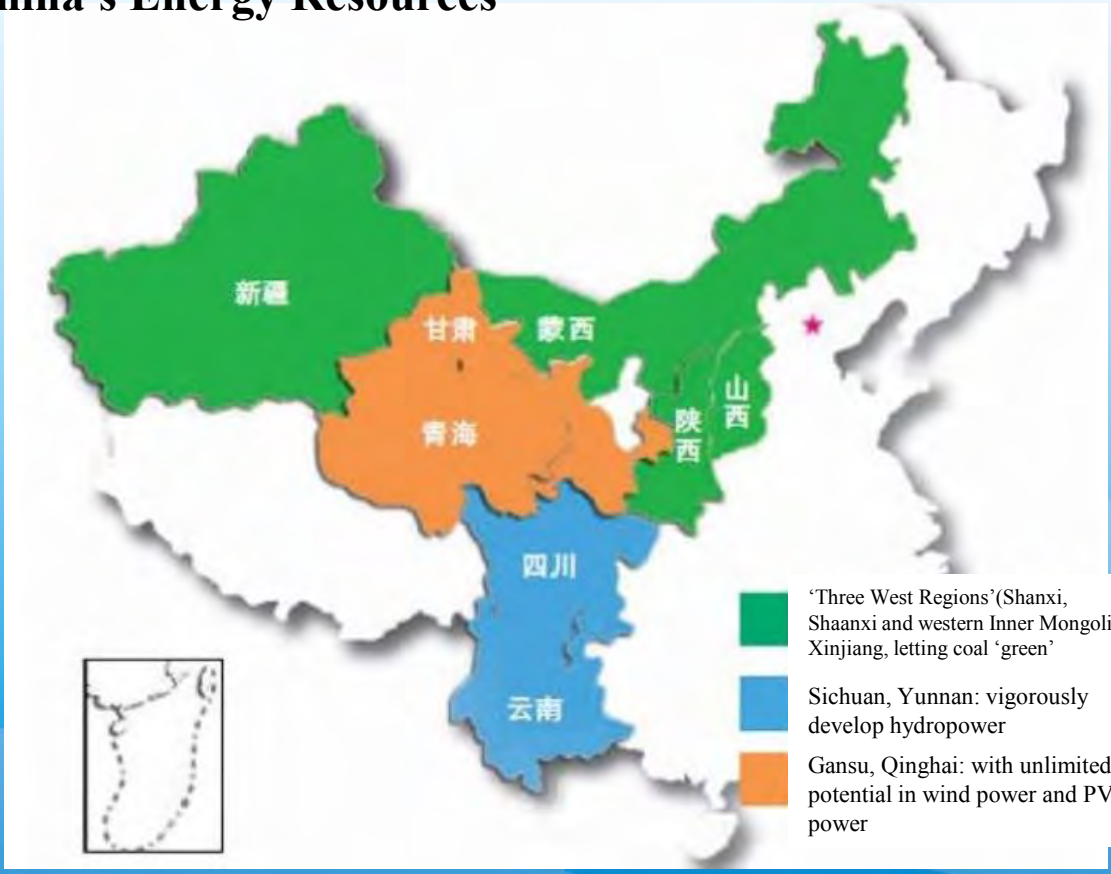
2. Present Condition of China's Renewable Energy Development

1. Distribution Characteristics of China's Energy Resources

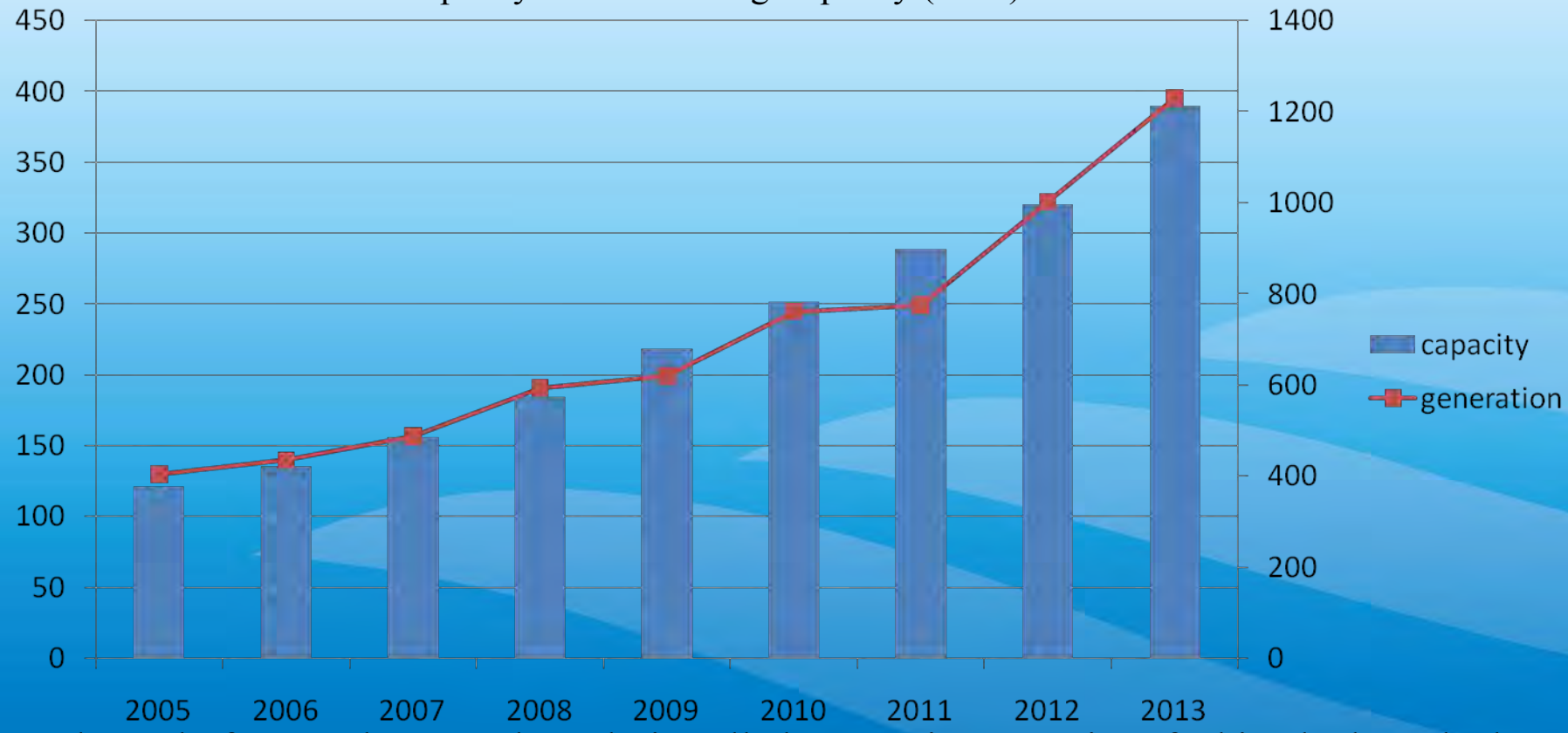
China is rich in energy resources, but featuring uneven distribution. Coal recourses are mainly distributed in Shanxi, Shaanxi, West Inner Mongolia, Xinjiang, etc.; water resources mainly in Southwest region, wind energy resources mainly in "Three-North Regions" (Northwest, North China and Northeast), and solar energy resources mainly in Xinjiang, Gansu, Qinghai and other Northwest regions.



2. Present Condition of China's Renewable Energy Development

2. Overall development

Development Trend of China's Renewable Energy Installed Capacity and Generating Capacity (2013)



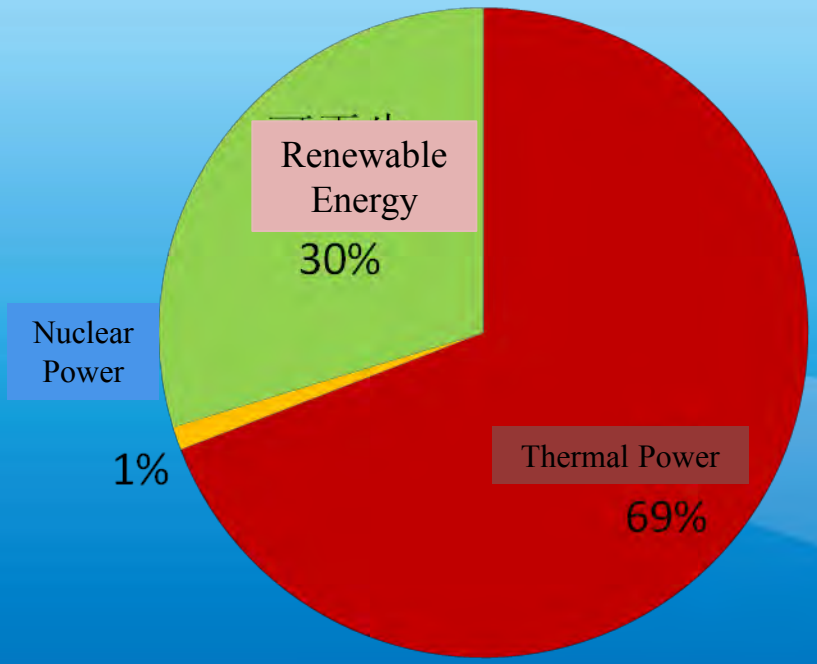
By the end of 2013, the annual newly installed generating capacity of China had reached 91 million kwh or so, of which the newly installed capacity of renewable energy amounts to about 49 million kwh, ranking the first in the world.

2. Present Condition of China's Renewable Energy Development

2. Overall development

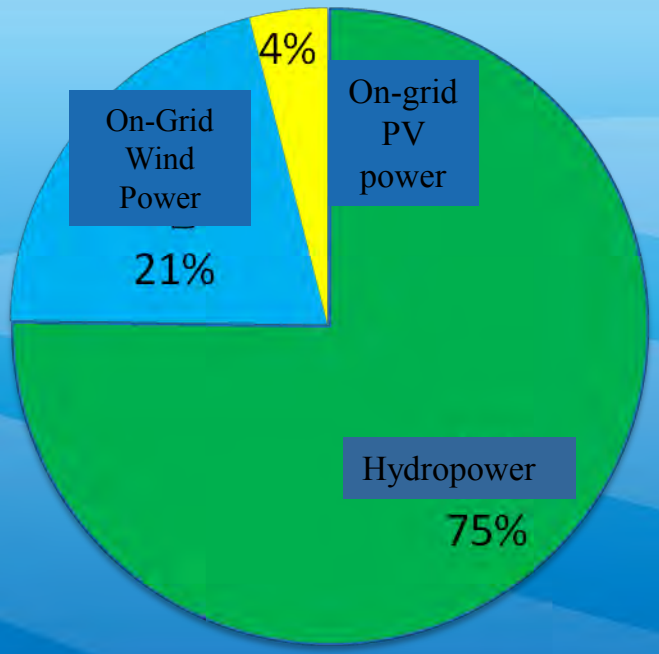
Distribution of China's Installed Capacity (full-aperture statistics by the end of 2013)

China's total installed capacity by the end of 2013 had reached 1247GW



Distribution of Renewable Energy Installed Capacity

China's total installed capacity for renewable energy by the end of 2013 had reached 390GW



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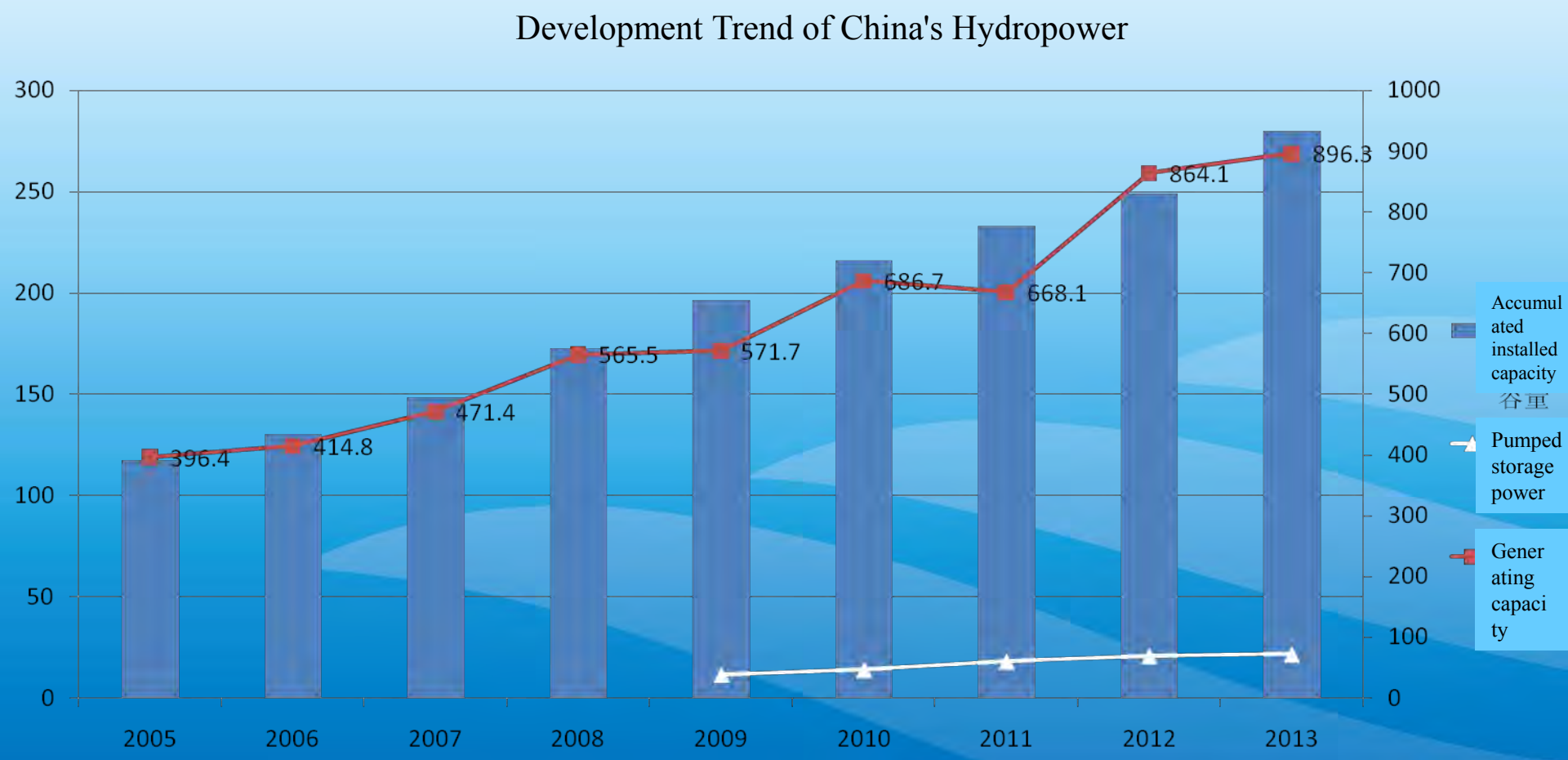
2. Present Condition of China's Renewable Energy Development

3. Hydropower



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2. Present Condition of China's Renewable Energy Development

3. Hydropower

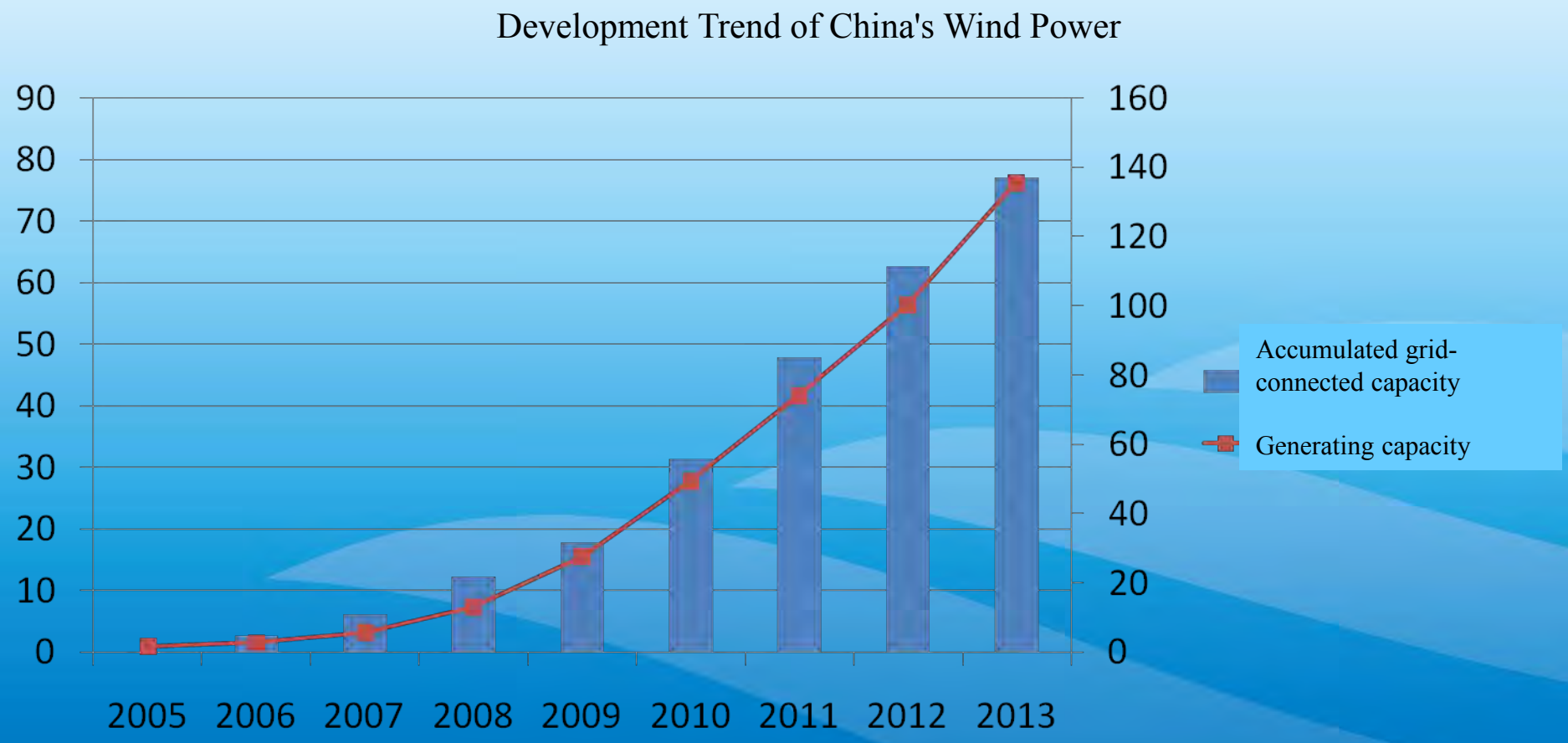
Layout Chart of China's Hydropower Development

Top Priorities in China's Hydropower Development in 2013

S.N.	Province	Total generating capacity (Twh)
1	Sichuan	154.5
2	Hubei	138.0
3	Yunnan	124.0
4	Guizhou	56.0
5	Guangxi	52.4
6	Fujian	47.6
7	Qinghai	45.8

2. Present Condition of China's Renewable Energy Development

4. Wind power

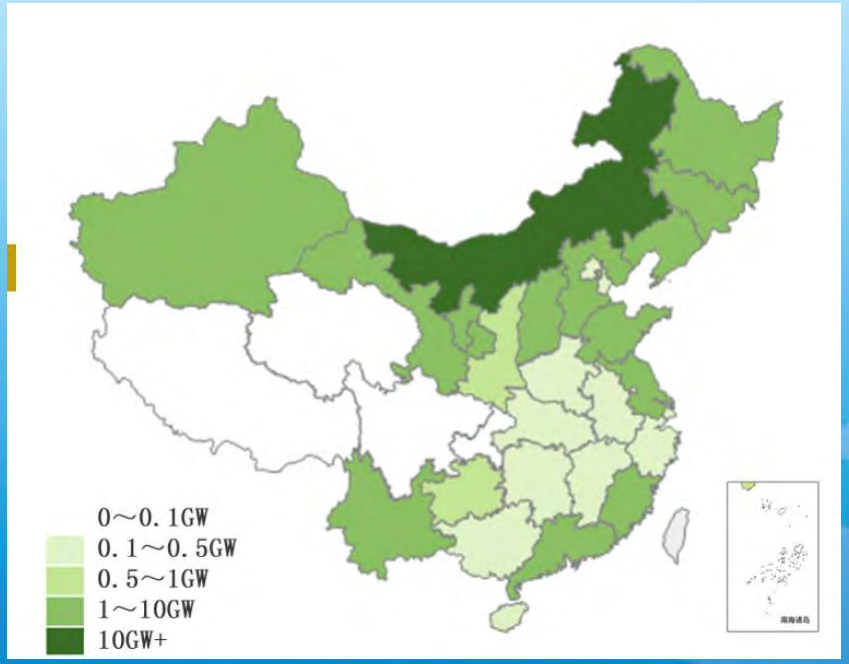


By the end of 2013, the turbine abandonment rate throughout the country had decreased from 17.12% to 10.74% and with a drop by 6 percentage points compared to 2012. The abandoned wind power reached 16.231 billion kWh, decreasing by about 4.6 billion kWh om a YoY basis.

2. Present Condition of China's Renewable Energy Development

4. Wind power

Layout Chart of China's Wind Power Development

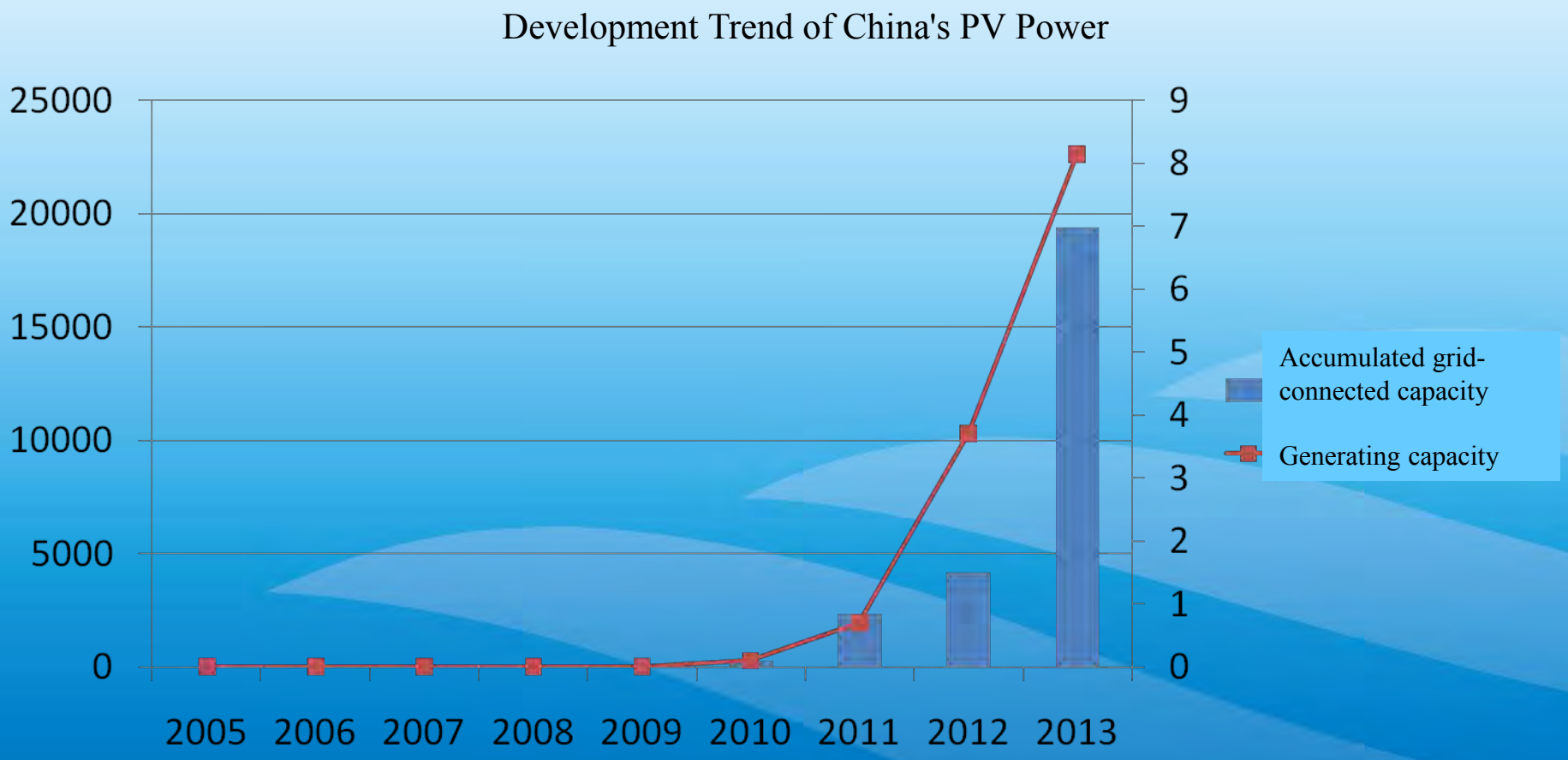


Top Priorities in China's Wind Power Development in 2013

S.N.	Province	Accumulated grid-connected capacity (GW)
1	Inner Mongolia	18.33
2	Hebei	7.75
3	Gansu	7.02
4	Liaoning	5.65
5	Xinjiang	5.05
6	Shandong	5.01
7	Heilongjiang	3.86
11	Jiangsu	2.56

2. Present Condition of China's Renewable Energy Development

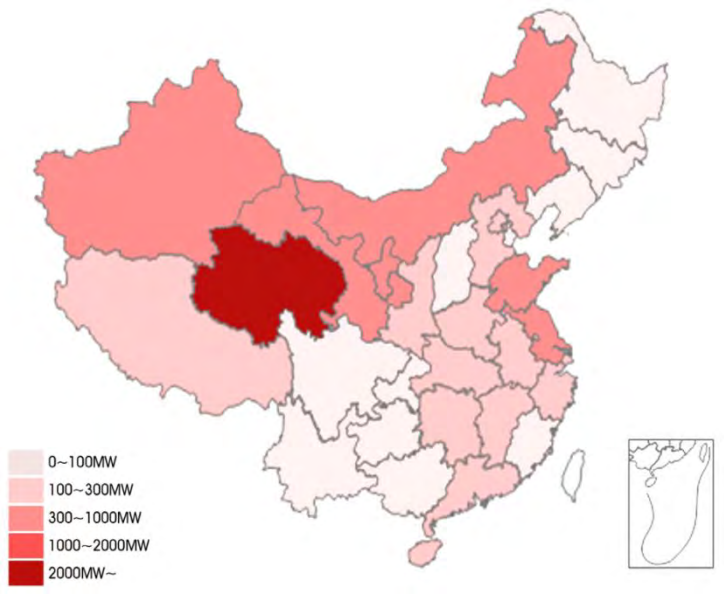
5. PV

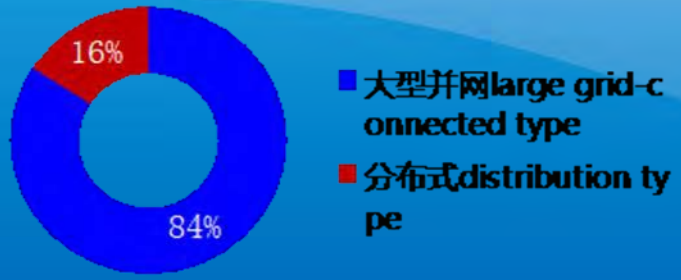


2. Present Condition of China's Renewable Energy Development

5. PV

Development Trend of China's PV Power





Top Priorities in China's PV Power Development in 2013

S.N.	Province	Accumulated grid-connected capacity (MW)	Market share (%)
1	Gansu	4317	26.5
2	Qinghai	3103	19.0
3	Xinjiang	2570	15.8
4	Ningxia	1614	9.9
5	Inner Mongolia	1405	8.6

Top Priorities in China's Distributed PV Power Development in 2013

S.N.	Province	Accumulated grid-connected capacity (MW)	Market share (%)
1	Zhejiang	425	13.7
2	Hunan	300	9.7
3	Guangdong	300	9.7
4	Jiangsu	255	8.2
5	Shandong	205	6.6

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3 China′s Renewable Energy Development Strategies

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3. China's renewable energy development strategies

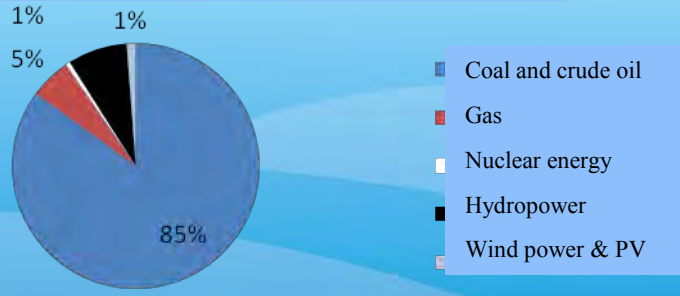
1. Why will China vigorously develop renewable energy?

- Sustainable economic development needs
- Demand for energy structure adjustment
- Environmental protection requirements
- Development needs of China's western provinces
- Demand for electricity and ecological construction in rural and remote areas
- Needs of improving the energy supply security
- Demand for new economic growth points

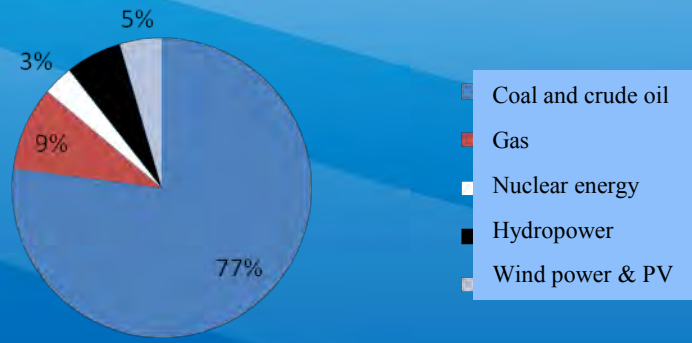
the proportion of non-fossil energy in the primary energy consumption up to 15% or so by 2020.

Realization of the structural readjustment of primary energy

Primary Energy Proportion in 2012



Primary Energy Proportion in 2020



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3. China's renewable energy development strategies

2. China has already built the support system of renewable energy policies

2005	• Renewable Energy Law of the People`s Republic of China
2007	• National long/medium-term development plans for renewable energy
2008	• Eleventh Five-Year Development Plan for Renewable Energy
2009	• National Renewable Energy Law (revised edition)
2010	• Decisions of the State Council on accelerating the cultivation and development of the newly emerging strategic industries
2012	• National Development Twelfth Five-Year Plan for Renewable Energy
2013	• Work Program on Strengthening the Air Pollution Control among the Energy Industry
2014	• Thirteenth Five-Year Development Plan for Renewable Energy

3. China's renewable energy development strategies

3. Problems and trends of China's development of renewable energy at the present stage

- Overwhelming impacts of brownouts with "wind and PV energy abandoned"
- Energy structure adjustment to be further optimized
- Overall energy system with low efficiency and poor coordination

China's power supply revolution

- Diversified supply system of new renewable energy
- Consumption modes of new renewable energy
- Organic integration of the distributed and centralized energy production systems

At present, turbine abandonment has already become one of the main barriers to China's large-scale wind power development, which can be solved by improving local consumption capacity and enlarging local consumption scope.

3. China's renewable energy development strategies

4. Key tasks

Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three North Regions"

Explore the technology integration and coupling involving the complementation between wind power and hydropower, the complementation between hydropower and PV power, and the complementation between wind power and PV power, and meet the diverse needs

Explore wind hydrogen production, wind power heating and other renewable energy utilization ways, reduce costs, and relieve stress from abandoned wind

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3. China's renewable energy development strategies

5. Safeguards measures -- implement major policy mechanisms

Renewable energy quota system

- Combining resources, power market and power transmission condition, develop the energy quotas for various regions
- Clearly define responsibilities of the relevant authorities and grid enterprises
- Urge the provincial authorities to assume their responsibilities for the completion and implementation of the relevant quotas, and evaluate their work on a regular basis

Measures for Administration of Blanket Warranty on Acquisition of Renewable Energy in Full

- Organize to release regulatory reports on key areas and on-grid projects
- First identify the wind power grid connected operation as a result of giving priority to the grid connection of renewable energy and the blanket warranty on acquisition in full in accordance with the relevant regulations on grid dispatching
- Urge grid enterprises to compensate wind power enterprises for brownouts, and give them a deadline for correction

Renewable energy subsidy mechanisms

- Strengthen the collection efforts of additional renewable energy tariff
- According to the source of renewable energy subsidy and the regularity of renewable energy development, timely raise the standard for additional tariff
- Promote the studies on various renewable energy subsidy mechanisms, and moderately lower subsidy standards
- Accelerate the long-term mechanisms on incentive subsidy management, and actively explore the pilot tax reform

4 Establishment of a diversified supply system

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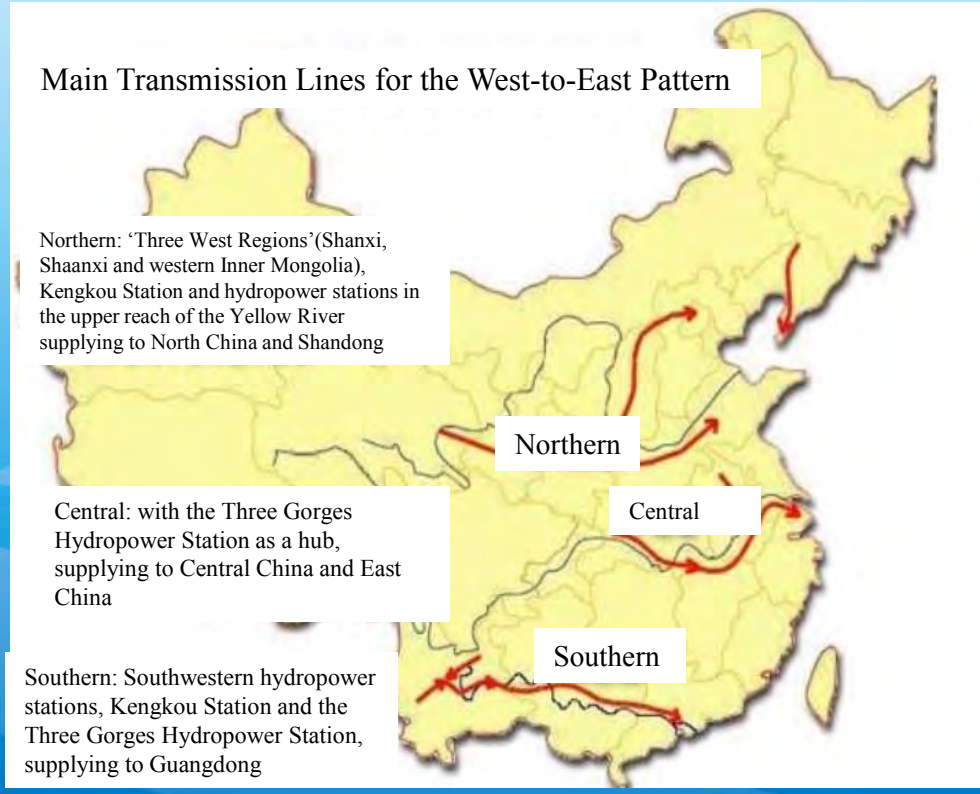
4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(1)West-to-East electricity transmission pattern

Energy resources are mainly concentrated in Northwest, while load centers are centralized in East China and Central China, forming a West-to-East electricity transmission pattern.



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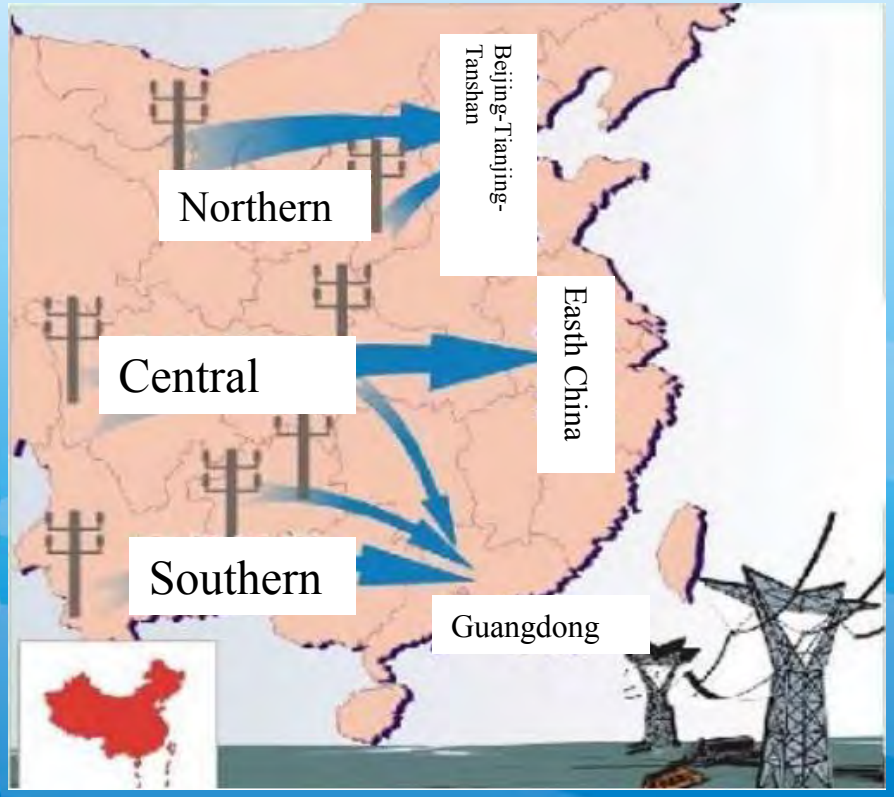
4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(1)West-to-East electricity transmission pattern

Power channels in North China: thermal power of "Northwest" (Shaanxi, Gansu, Ningxia, Xinjiang, Shanxi and West Inner Mongolia) and hydropower in the upstream of the Yellow River, to North China and Central China; power channels in Central China: mainly hydropower from the Three Gorges to Central China and East China; and, channels in South China: the hydropower stations and pit-mouth plants, etc. in the Southwest transmit electricity to Guangdong Province.

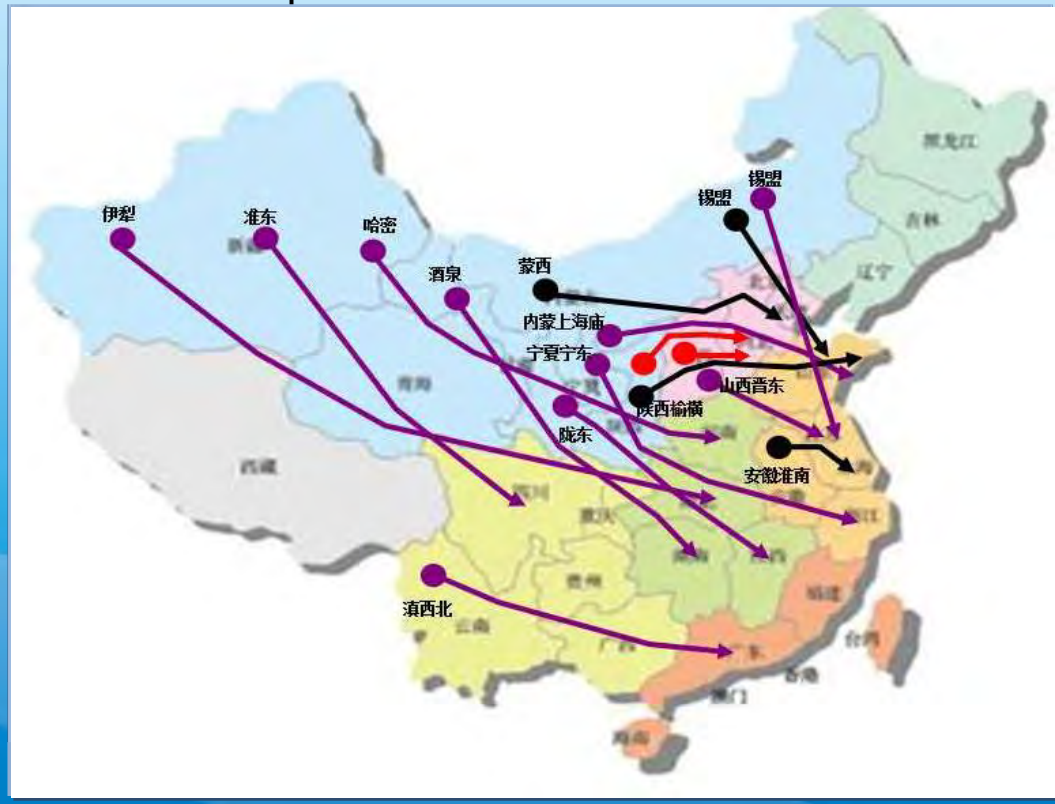


4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(2) Favorable conditions for the bundled wind/PV/thermal power transmission

The plant distribution of renewable energy resources in Northwest, including wind power and PV power is basically the same as that of thermal power plants there, so it is allowed to utilize EHV transmission lines, achieving the combined operation of new energy and thermal power, with the bundled transmission to different load centers.



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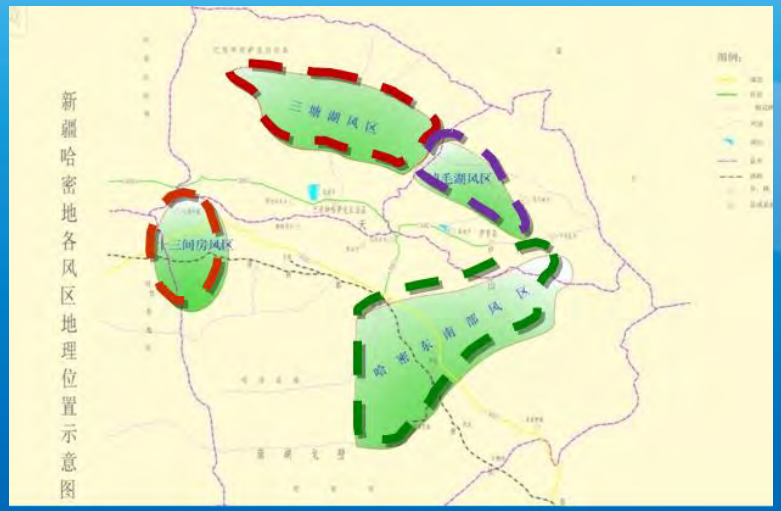
4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(3) New thinking of West-to-East electricity transmission - bundled transmission of Xinjiang wind power, PV and thermal power

- On the basis of the research findings of multi-energy complementation in Northwest, in October 2012, the National Energy Administration agreed to carry out the preparatory work of 5 million kW thermal power as the first batch of matching power engineering project of the EHV DC transmission system in accordance with G N D L (2012) File No.329, and demanded a total output of wind power up to 5 million kW.
- The implementation of this project is of great model significance on exploring new energy consumption and utilization methods, speeding up the healthy and sustainable development of new energy industry and promoting the economic and social great-leap-forward development of Xinjiang.



There are relatively high quality wind energy resources in the southeastern Hami Prefecture and Santanghu ~ Naomaohu wind zone; and, there is relatively large destructive wind in Shisanjianfang wind zone, and the field is relatively far from DC transmission line, so the southeastern Hami Prefecture and Santanghu – Naomaohu wind zone are chosen.

4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(3) New thinking of West-to-East electricity transmission- bundled transmission of Xinjiang wind power, PV and thermal power)

Analytical Statement of grid-connected capacity simultaneity factor of installed capacity in Hami Prefecture

Capacity coefficient	12 million kW			10 million kW			9 million kW						8 million kW					
	Southeast 8 million +Santanghu 3 million+ Naomaohu 0.5 million + Shisanjianfang 0.5 million			Southeast 6 million +Santanghu 3 million+ Naomaohu 0.5 million +Shisanjianfang 0.5 million			SoutheEast 5 million +Santanghu 3 million + Naomaohu 0.5 million+Shisanjianfang 0.5 million			Southeast 6 million +Santanghu 2 million+ Naomaohu 0.5 million +Shisanjianfang 0.5 million			Southeast 5 million +Santanghu 2 million+ Naomaohu 0.5 million +Shisanjianfang 0.5 million			Southesast 4 million +Santanghu 3 million + Naomaohu 0.5 million +Shisanjianfang 0.5 million		
	Output (10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)	Output (10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)	Output (10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)	Output (10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)	Output(10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)	Output (10,000 kW)	Output guarantee rate (%)	Accumulated generating capacity (%)
42%	**500**	**25.3**	**80.7**															
45%	540	22.7	83.6	450	23.1	84.9	405	23.5	85.5	405	22.8	83.9	360.1	23	84.8	360	24.4	85.9
50%	600	19.2	87.3	**500**	**18.9**	**88.6**	450	18.9	89.2	450	19.2	87.7	400	19	88.6	400	19.1	89.7
55%	660	15.9	90.5	550	15.4	91.6	495	15.1	92.2	495	15.8	90.9	440	15.4	91.7	440	14.3	92.5
56%							**500**	**14.7**	**92.5**	**500**	**15.4**	**91.2**						
60%	720	13.1	93.1	600	12.1	94.1	540	11.1	94.5	540	12.9	93.4	480	12.3	94.1	480	10.9	94.7
63%													**500**	**9.3**	**95.6**	**500**	**10.8**	**95.2**

In view of four different installed capacities (8 million kW, 9 million kW, 10 million kW and 12 million kW), the grid-connected capacity simultaneity factor of Hami Prefecture is analyzed statistically and comprehensively, and it is recommended to adopt the scheme of 8 million kW.

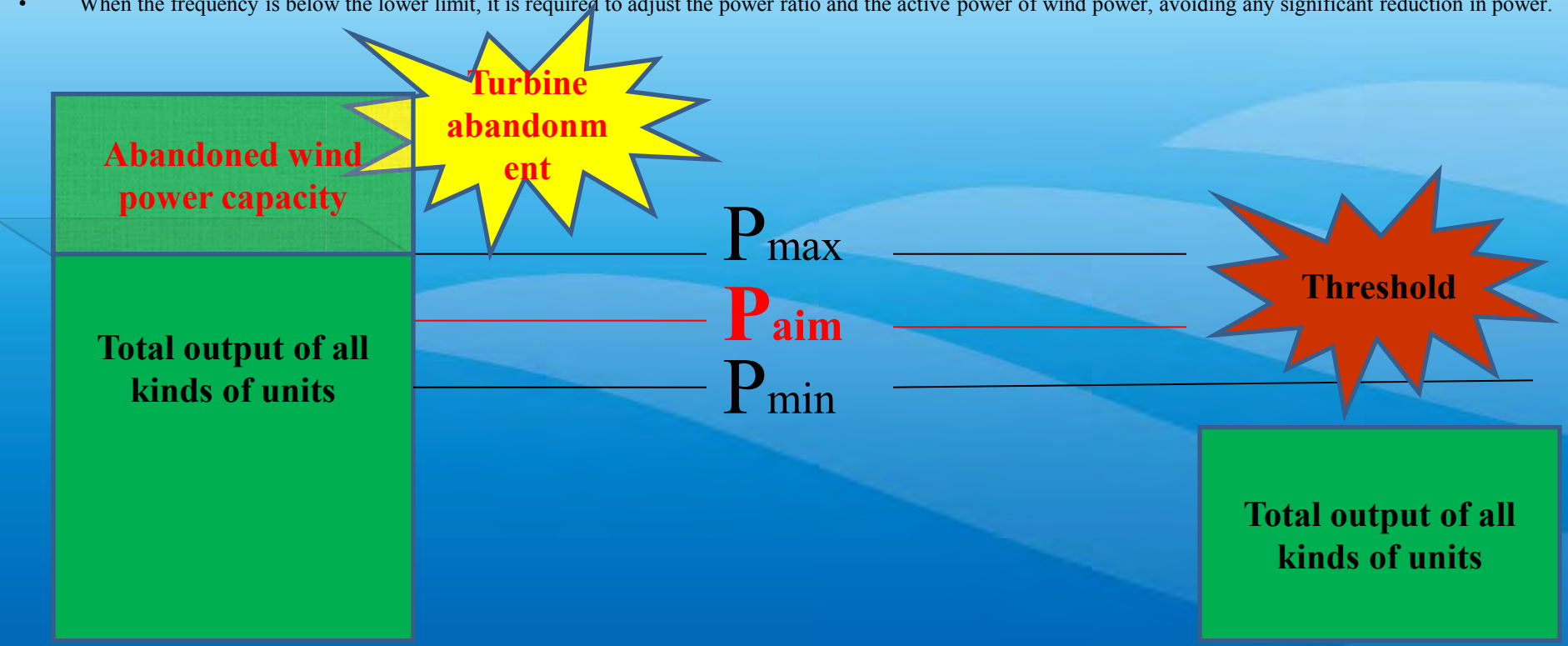
For the total installed capacity of 8 million kW, several regional wind farms are planned in the southeastern Hami Prefecture and Santanghu wind zone, and three combined schemes are proposed. Studies have shown that the northern and southern wind zones can supplement each other to certain extent.

4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(3)New thinking of West-to-East electricity transmission-- bundled transmission of Xinjiang wind power, PV and thermal power

- The thermal power output target is determined based on the power target reference value (determined by the DC channel target), the upper and lower limits and the wind power and PV output of this site.
- When the total output of wind power, PV and thermal power is still above the upper limit of power under the circumstance that the thermal power frequency control capacity is exhausted, it is recommended to properly abandon turbines.
- When the frequency is below the lower limit, it is required to adjust the power ratio and the active power of wind power, avoiding any significant reduction in power.



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4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(3) New thinking of West-to-East electricity transmission-- bundled transmission of Xinjiang wind power, PV and thermal power (configuration results)

With full consideration of the overburden mineral resources of the project and the docking of the transmission project, as well as the wind power projects under construction in Hami, the installed capacity of wind power at the second stage of the project development and construction is recommended to be 8 million kW, of which the newly installed capacity in the southeastern Hami is 4 million kW and that in Santanghu is 2 million kW, and it's already approved to accept 2 million kW from the projects under construction.

In addition, PV projects (1.25 million kW) and thermal power projects (5 million kW) are arranged for combined operation and bundled transmission. The utilization of thermal power reaches 5400h or so, while that of UHV transmission channel is about 5800h. The thermal power transmission lines and the UHV transmission channels have better economical efficiency.

The generating capacity of renewable energy accounts for about 40% of the total transmission capacity, which indicates we achieve the goal of scaling up the renewable energy consumption through using UHV outgoing channels better.

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4.Establishment of a diversified supply system

1. Explore the EHV power transmission and consumption methods, and foster the healthy and sustainable development of wind power in the "Three-North Regions"

(4) New thinking of West-to-East electricity transmission-studies on other important transmission lines

Ningdong ~ Zhejiang ± 800kV UHVDC transmission channel for the bundled transmission of thermal, wind and PV power (thermal power 9.28 million kW + wind power 4 million kW + PV power 2 million kW, with the utilization of transmission channel for 7286h , and the proportion of new energy in the total transmission up to 16.8%)

Huaidong ~ Jiangsu ±1100kV DC transmission channel for the bundled transmission of wind, thermal and PV power(thermal power 13.20 million Kw+ wind power 3 million Kw+PV power 2 million KV, with the proportion of new energy in the total transmission up to 16.8%)

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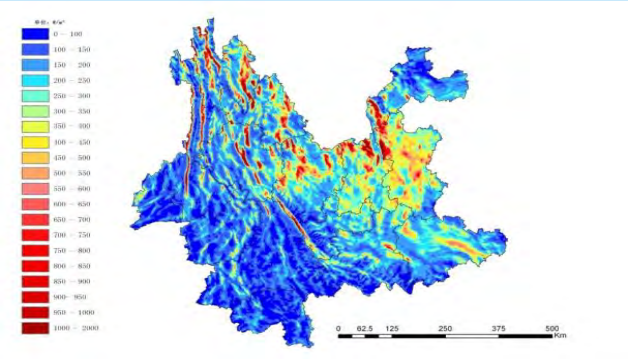
4. Establishment of a diversified supply system

2. Explore the technology integration and coupling involving the complementation between wind power and hydropower, the complementation between hydropower and PV power, and the complementation between wind power and PV power, and meet the diverse needs

(1)Demonstration projects with the complementation between wind power and hydropower in Yunnan Province

- Yunnan Province has abundant wind power resources, however, compared with conventional power sources, wind speed and wind direction that change discretionarily result in the volatility, intermittence and randomicity of wind farm output power, which cause a major obstacle to the access of wind power to the power grid.
- At present,Yunnan mainly adopts a distributed development pattern of "local access, and local consumption", and the power grid cannot satisfy the access of all wind power.
- Yunnan has abundant water resources, and its energy structure gives priority to hydropower; and, the installed capacity of hydropower accounts for about 62% of the total installed capacity of the whole province. The wind power output is inversely proportional to the hydropower output in the dry/wet season. Wind power and hydropower have very distinct complementary strengths, which are conductive to increasing the transmission capacity and facilitating the dispatching capacity of power grid.



Distribution map of annual mean wind power density at the altitude of 70m in Yunnan Province

Distribution map of cascade hydropower stations on the trunk stream of Lancang River in Yunnan Province

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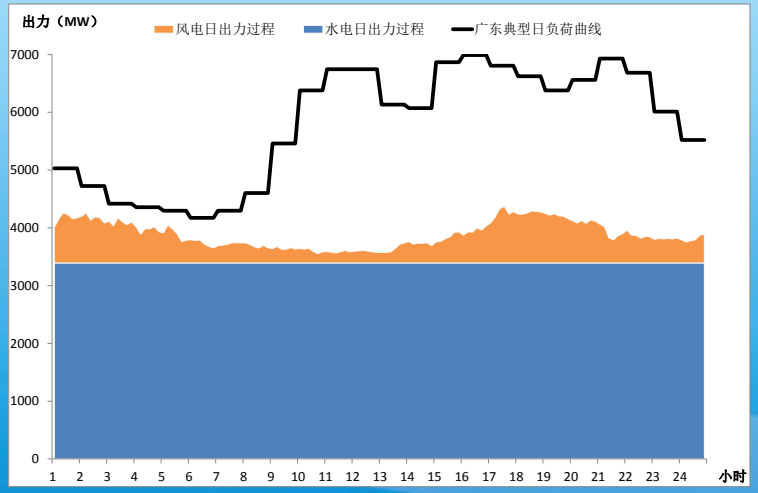
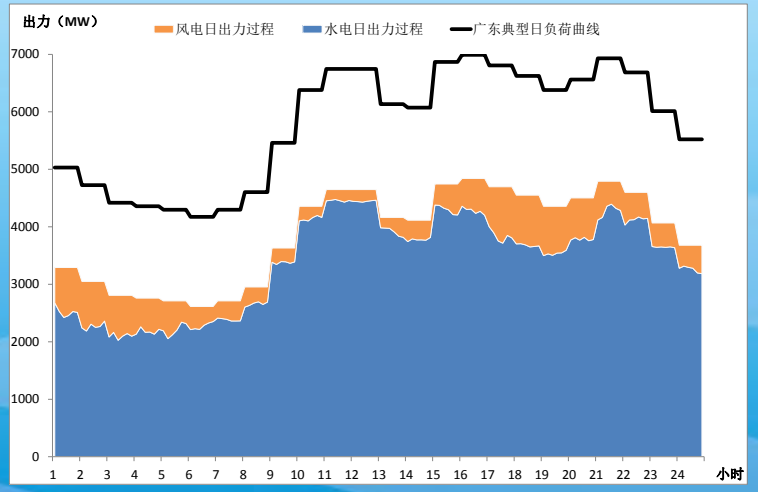
4.Establishment of a diversified supply system

2. Explore the technology integration and coupling involving the complementation between wind power and hydropower, the complementation between hydropower and PV power, and the complementation between wind power and PV power, and meet the diverse needs

(2) Demonstration projects with combined operations of wind power and hydropower in Yunnan Province - complementation analysis



Process chart of the daily output with the isolated operation of hydropower and wind power



Process chart of the daily output with the combined dispatching of hydropower and w power

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4.Establishment of a diversified supply system

2. Explore the technology integration and coupling involving the complementation between wind power and hydropower, the complementation between hydropower and PV power, and the complementation between wind power and PV power, and meet the diverse needs

(3) Demonstration projects with the combined operations of wind power and hydropower in Yunnan Province

- statistical table of grid-connected capacity of wind farm

Item		2015 normal flow year
Installed capacity of wind power (MW)		800
Potential generating capacity of wind power (10,000 kW)		185882
Equivalent full-load utilization hours (h)		2324
Wet-year	Grid-connected turbine abandonment rate	17.2%
	Grid-connected capacity (10,000 kW)	153818
	Equivalent full-load utilization hours (h)	1923
Normal flow year	Grid-connected turbine abandonment rate	2.8%
	Grid-connected capacity (10,000 kWh)	180711
	Equivalent full-load utilization hours (h)	2259
Dry year	Grid-connected turbine abandonment rate	0%
	Grid-connected capacity (10,000 kWh)	1858.82
	Equivalent full-load utilization hours (h)	2324
Typical meteorological year Average	Grid-connected abandon wind rate	6.7%
	Grid-connected capacity (ten thousand kWh)	1734.7
	Equivalent full-load utilization hours (h)	2168

China is still exploring the complementation between hydropower and PV power (Longyang Gorgehydropower-PV project), the complementation between wind power and PV power (the complementation between wind power and PV power project of Yumen Changma), wind power and hydrogen production (the Guyuan wind power and hydrogen production project of Hebei Construction & Investment Group Co., Ltd.), and other comprehensive utilization methods of renewable energy

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5. Conclusions

- At present, China's renewable energy is quickly expanding, and along with the construction of wind power and PV power stations at gigawatts class, etc., the renewable energy industry made a rapid development.

- Affected by the consumption, the grid connections and operations of the projects become significant barriers to the development and construction of renewable energy

- New diversified supply system of renewable energy, new consumption modes of renewable energy, and the new production system of organic integration of the distributed and centralized power resources is the strategic direction of China's renewable energy for the immediate future, and also a major research task.

- The Thirteenth "Five-Year " development Plan of wind power, will continue to focus on wind power consumption, bundled operation and dispatching mechanisms of wind power, thermal power and PV power bases,the complementation between wind power and hydropower, and the relevant guarantee policies and measures and other methods to build up the diversified supply system of renewable energy.

- China Renewable Energy Engineering Institute, has technology, information, resources and talent advantages. we would like to carry out full range of technical cooperation and exchanges with friends all over the world, and jointly promote the healthy and rapid development of renewable energy.

5. Conclusions

Thank You!

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