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中国电力科学研究院
CHINA ELECTRIC POWER RESEARCH INSTITUTE

Wind/PV Power Forecasting Technology and its Application in China

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China Electric Power Research Institute

July 6, 2017 Weihai, China

Outline

1. Background

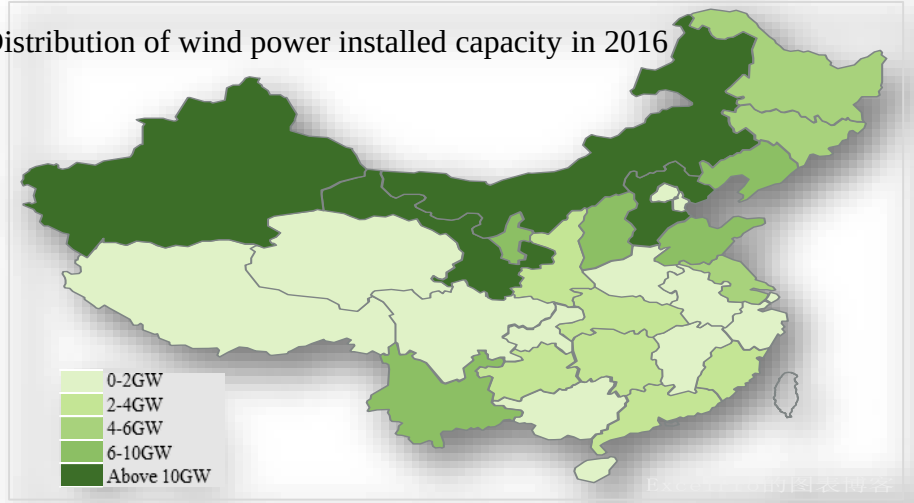
2. Research & Application

3. Future Prospect

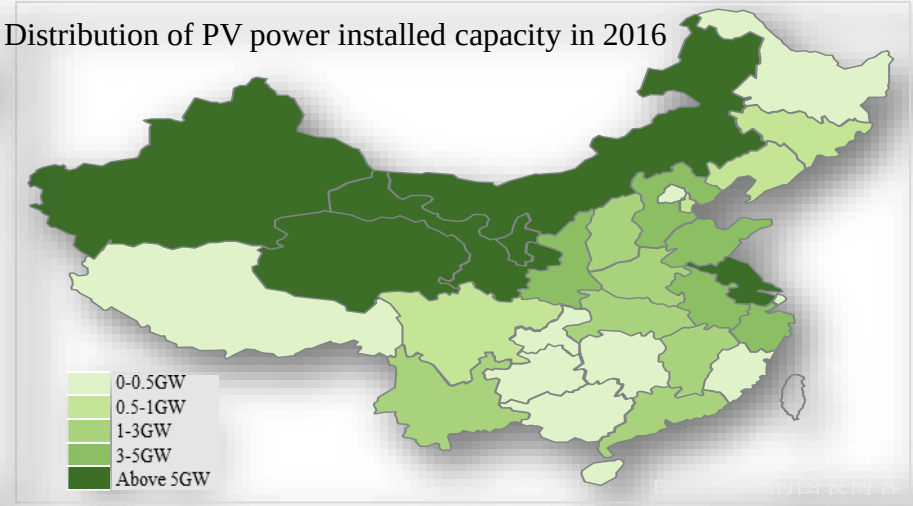
Background

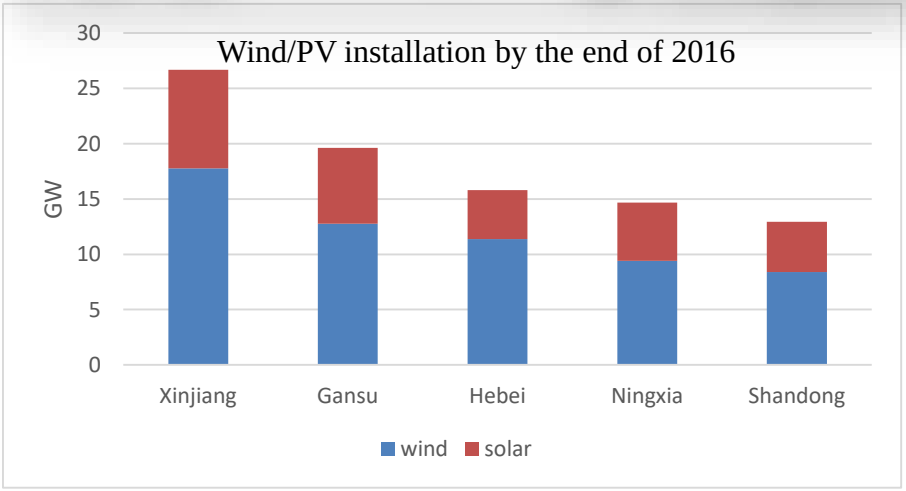
By the end of 2016, China's installed capacity of wind power and solar power was 226 GW, about 14% of the total power capacity in China.

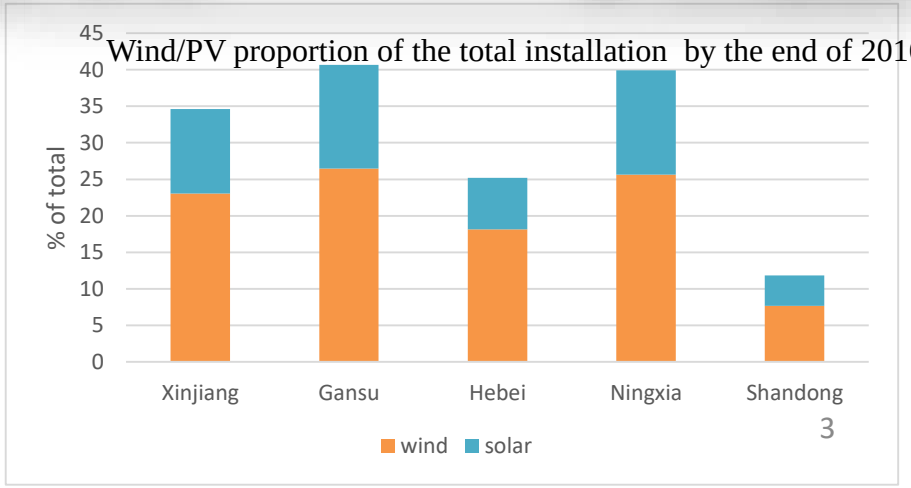
Distribution of wind power installed capacity in 2016



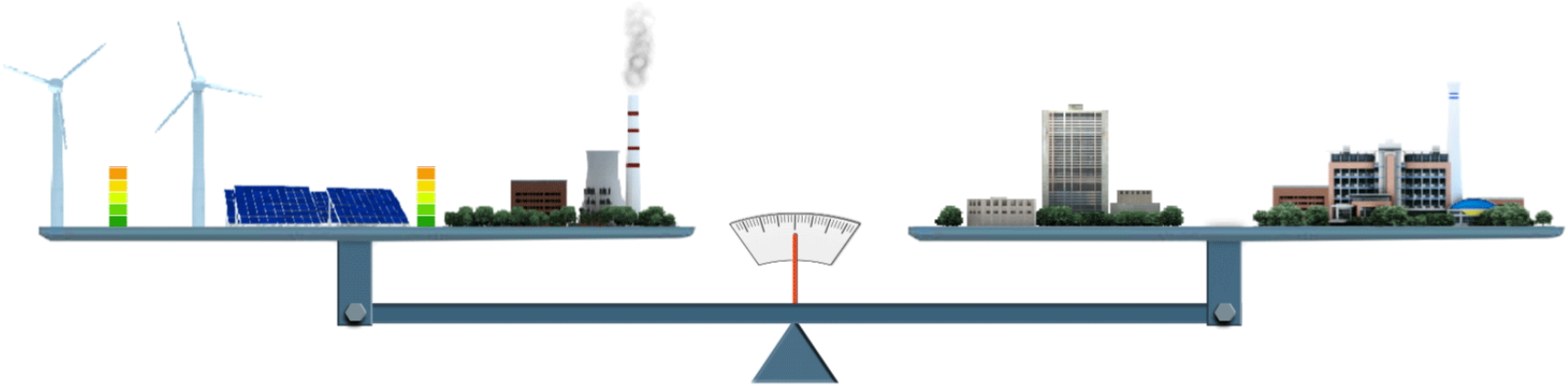
Distribution of PV power installed capacity in 2016



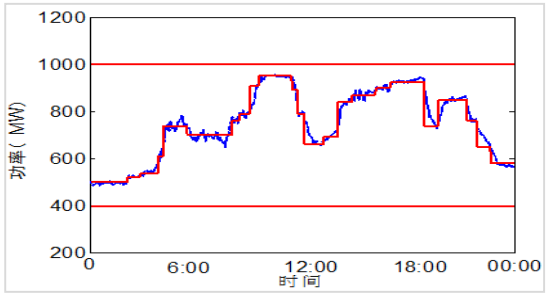




Background

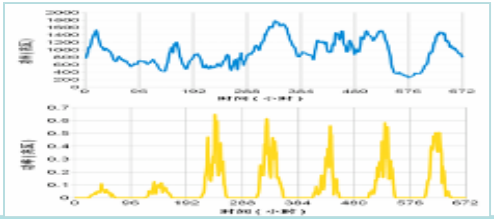


Conventional Generation — **Grid** — **Load**

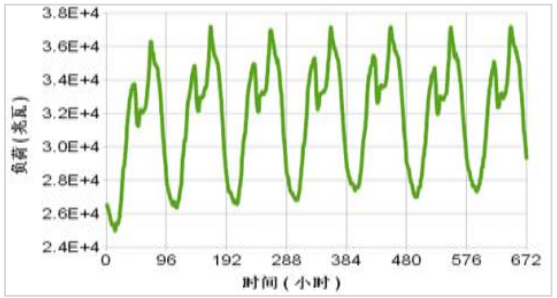


Controllable

RE



Stochastic, fluctuant and hard to predict



Regular and predictable

Background

- **RE testing capability – Zhangbei test site**, which is capable of testing all the grid performances of wind turbines and PV invertors, including the capability of low voltage ride through testing, grid adaptability testing, etc.

Items	CN CEPRI	US NREL	DE DEWI	DK RISOE	NL ECN	GR CRES
Testing Set	30	5	11	5	9	5
Power Performance	√	√	√	√	√	√
Power Quality	√	√	√	√	√	√
Power Control	√	√	√	√	√	√
Noise	√	√	√	√	√	√
Loading	√	√	√	√	√	√
FRT	√	×	×	×	×	×
Grid Adaptability	√	×	×	×	×	×

Zhangbei Test Site, Hebei Prov.

Background

The IEC SC 8A was established in July, 2013.

- **Title:** Grid Integration of RE Generation
- **Scope:** The requirements for interconnection and related grid compliance tests, as well as standards or best practice documents for planning, modeling, forecasting, assessment, control and protection, scheduling and dispatching of renewables with a grid-level perspective.

Role	Name	Country
Chairman	Mr. Bernhard Ernst	DE
Secretary	Mr. Yongning Chi	CN
P-Member: 15	Australia, China, Germany, Denmark, Spain, Finland, France, United Kingdom, Italy, Japan, Korea, Republic of, Malaysia, the United States, Sweden, Netherlands	
O-Member: 11	Austria, Switzerland, Czech Republic, Israel, Mexico, New Zealand, Poland, Portugal, Thailand, South Africa, Russian Federation	

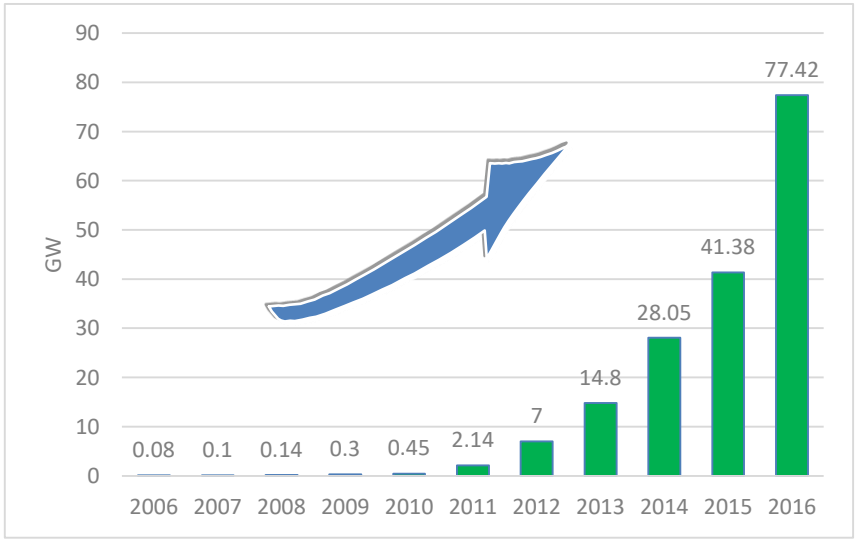
Background

◆ Existing Working Groups in IEC SC 8A

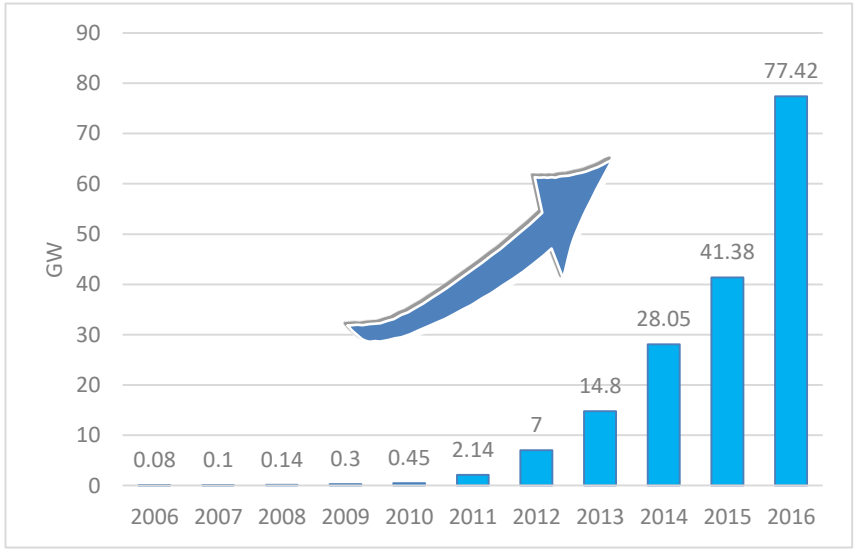
WG No.	Title	Convener	Num of experts
WG 1	Terms and definitions of grid integration of renewable energy generation	Mr. Lingzhi ZHU	21
WG 2	Renewable energy power prediction	Mr. Shuanglei Feng	26
AHG 3	Roadmap of grid integration of renewable energy generation	Mr. Bernhard Ernst Mr. Yongning Chi	19
JWG 4	Grid code compliance assessment for grid connection of wind and PV power plants	Mr. Qing LI	24

1.1 Data insufficiency

- In 2011-2015, the annual growth rate of wind installation was about 34%, and 178% for solar.
- Data insufficiency from the newly-built wind/PV power stations (A certain proportion of wind/PV power stations with limited operational data).



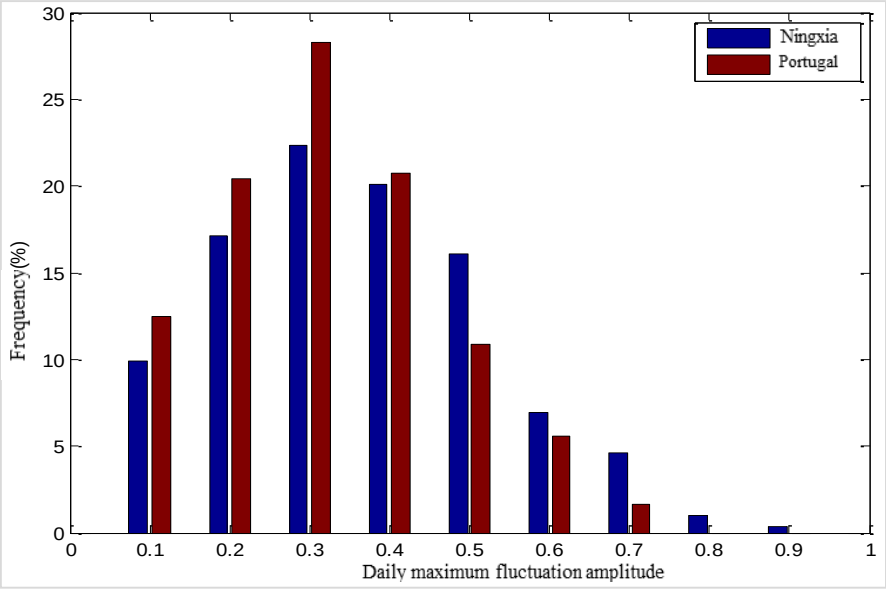
China wind grid-connected capacity



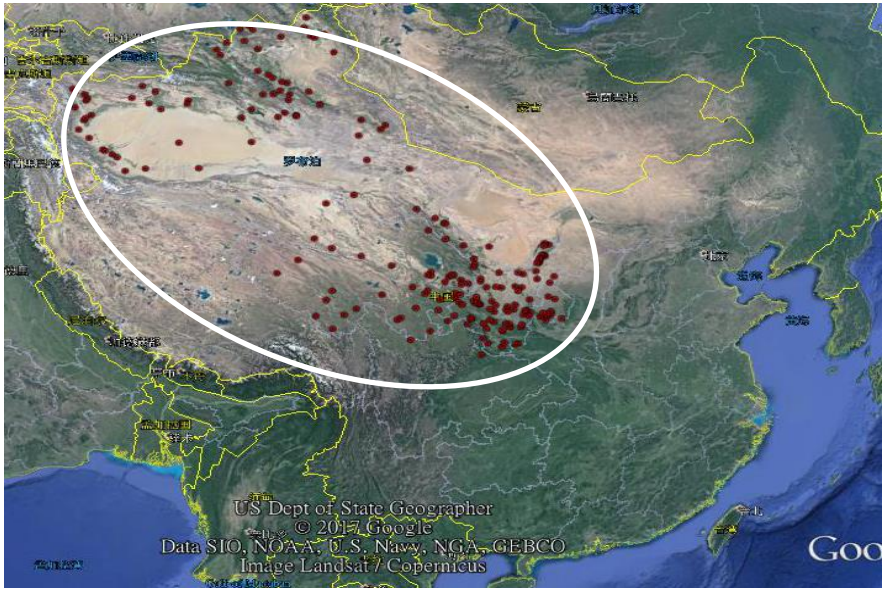
China PV grid-connected capacity

1.2 NWP inaccuracy for some regions

- Complex topography and diverse climate.
- Poor representativeness of meteorological observation: 2,828,000 km^2 in the Northwest China, 202 observation sites, averaging 14,000 km^2 per site.



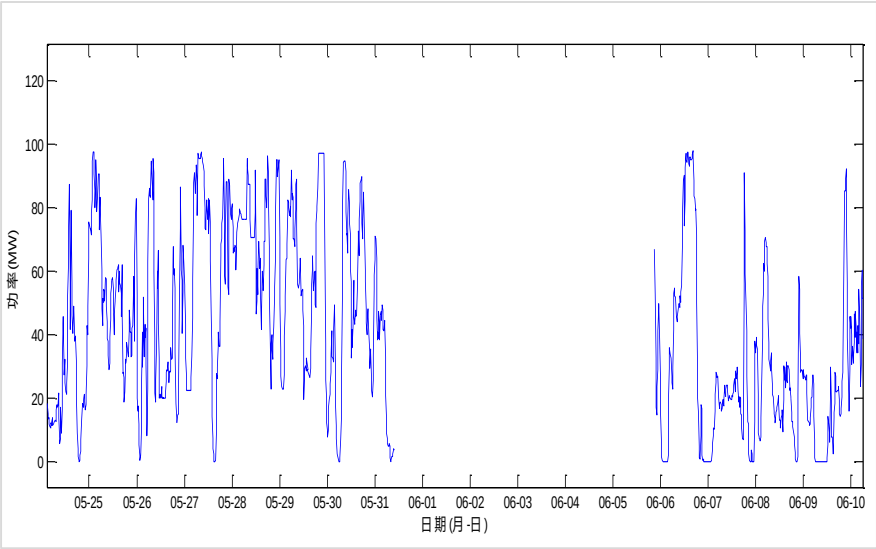
Maximum fluctuation of wind power in Ningxia and Portugal(2014)



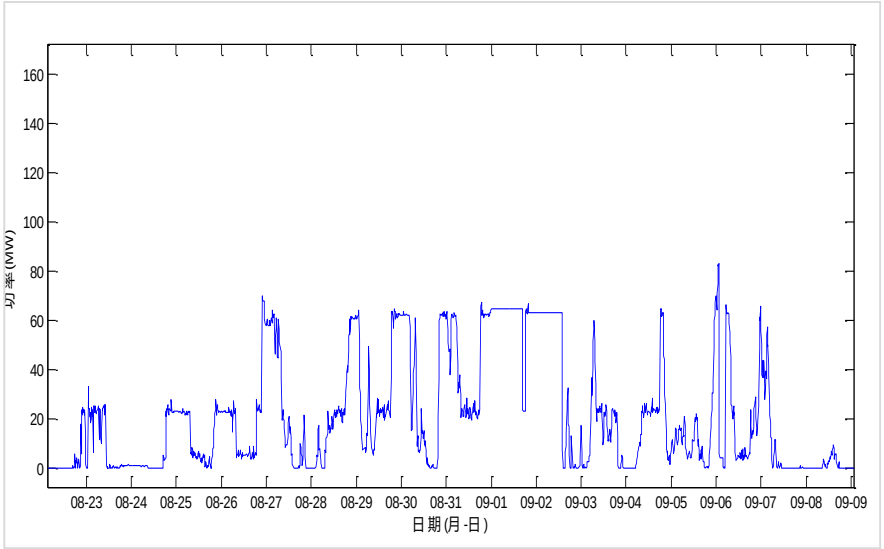
Northwest sites for International Meteorological Exchange

1.3 Data quality

- Abnormal data
- Power curtailment



Example of data loss



Example of power curtailment

Outline

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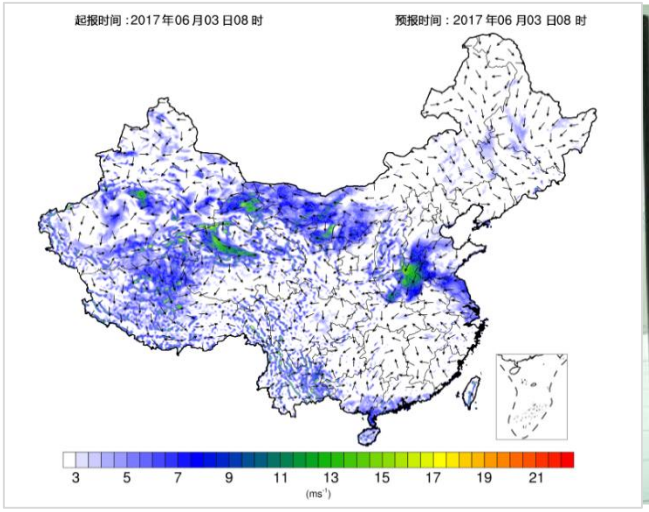
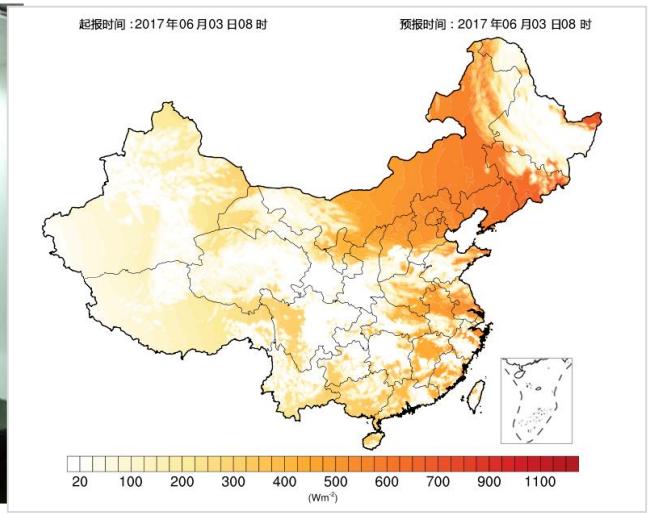
2.1 NWP Center for electric power

- Cluster of High Performance Computers
- 460 blades, 11,840 cores, 2PB storage capacity
- 100 trillion times per second



National wind forecast on June 3, 2017

Numerical Weather Prediciton Center



National solar forecast on June 3, 2017

2.2 Increasing resource monitoring data

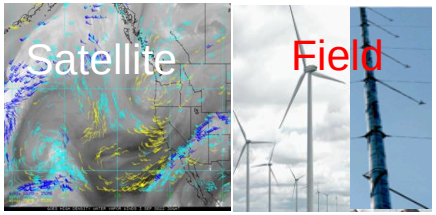
- Polar-orbit/geo-stationary meteorological satellites data
- Real-time resource monitoring data of wind/PV power stations(1000+ sites)
- Real-time resource monitoring data of meteorological institutions(2000+ sites)

Geostationary satellite receiving device

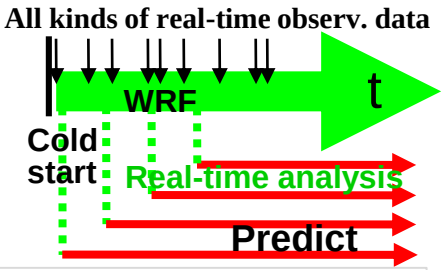
Satellites	Resolution	Frequency of reception(times/day)
NOAA	1.1km	4
Metop	1km	3 or 4
NPP	650m	3
FY-3	1.1km	3
FY-2	1.25km	48

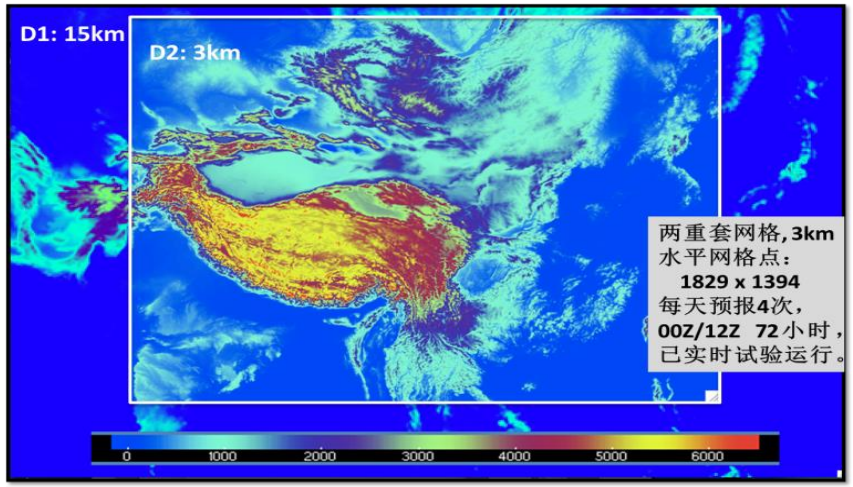
2.3 Improve wind speed/solar irradiance forecast

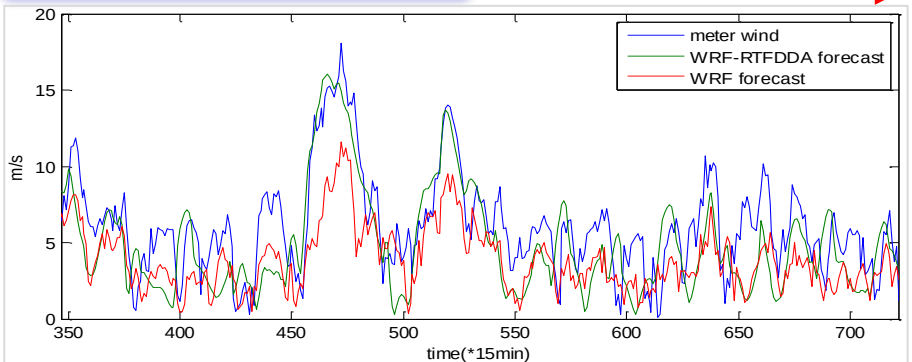
- Short-term forecast: Real-Time Four-Dimensional Data Assimilation
- Ultra-short term forecast: Rapid Update Cycle

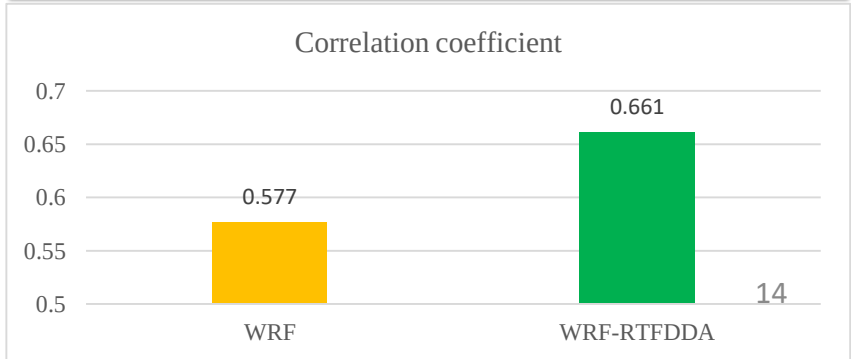


RTFDDA
WRF Model
Mesoscale NWP



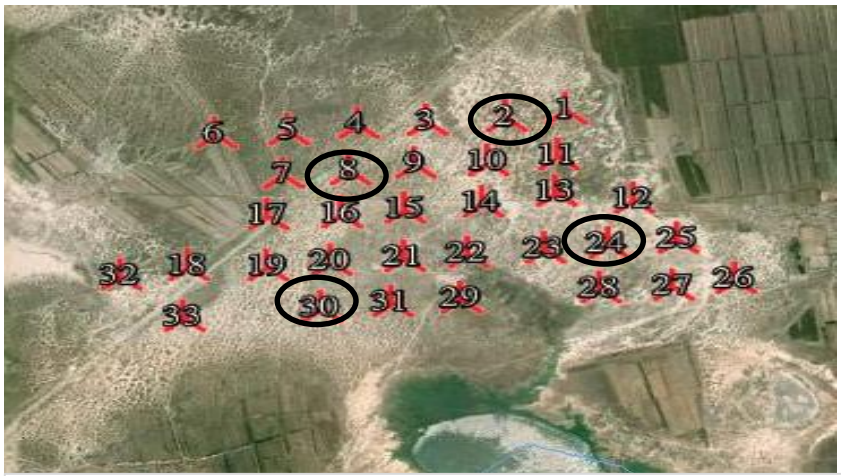


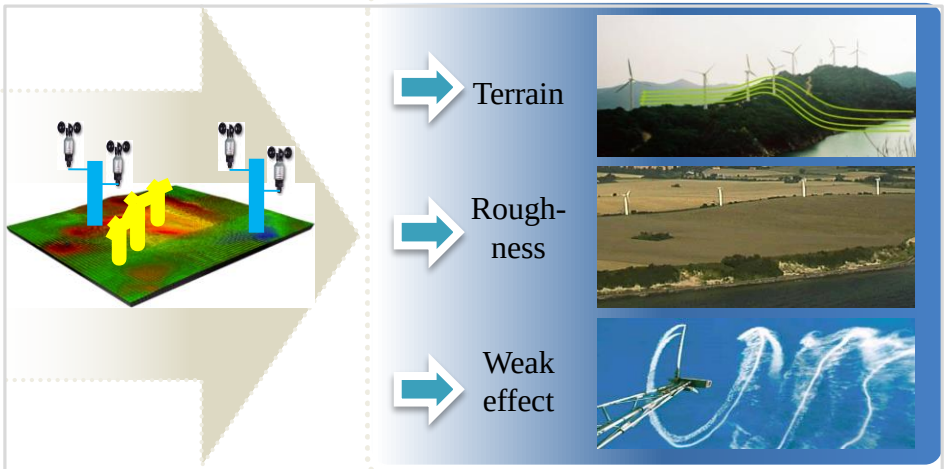


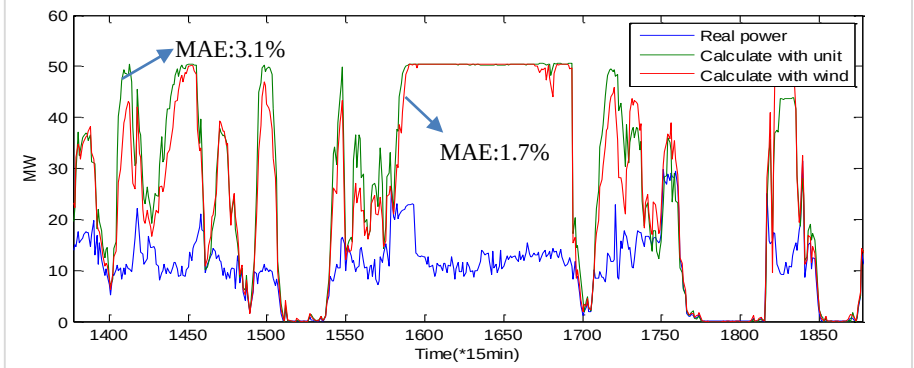


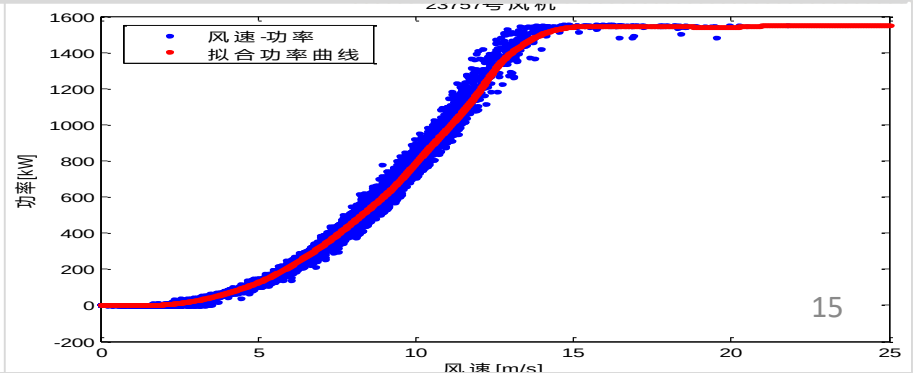
2.4 Calculation of theoretical power

- Sample generating unit
- Wind speed/ solar irradiance simulation



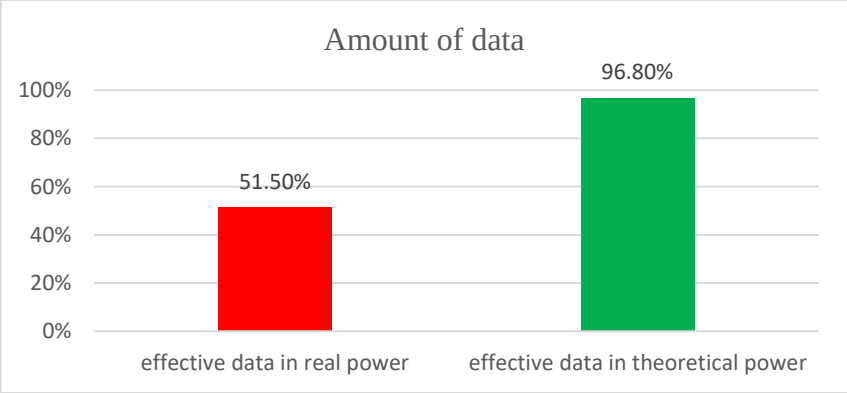


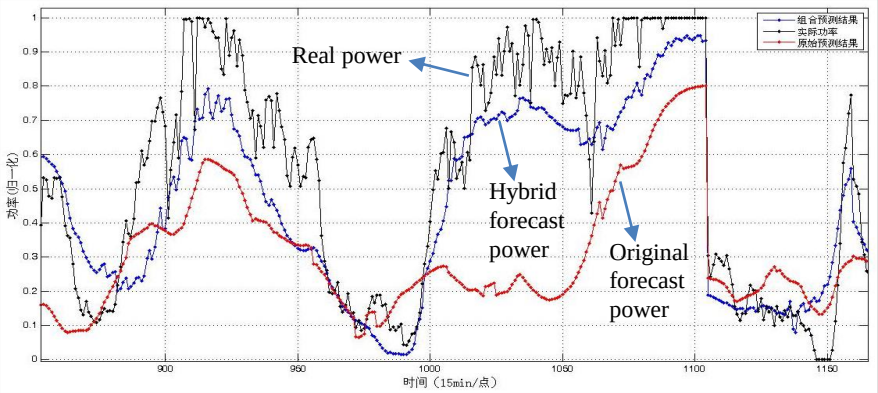


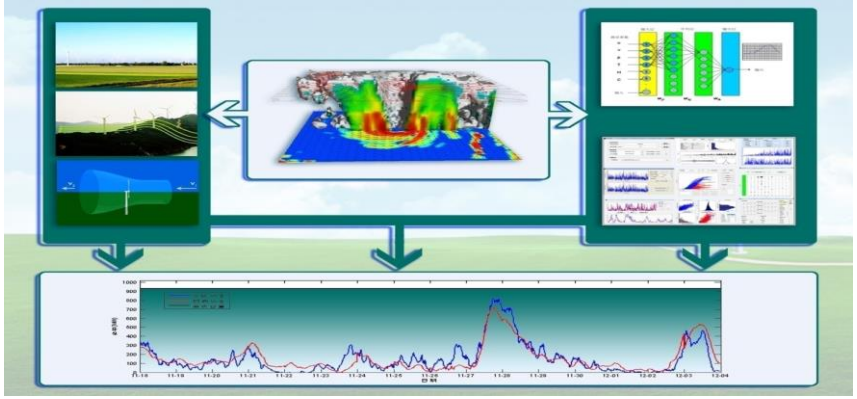


2.5 Hybrid Forecasting Method

- Use calculated theoretical power to establish models
- Combination of physical and statistical models



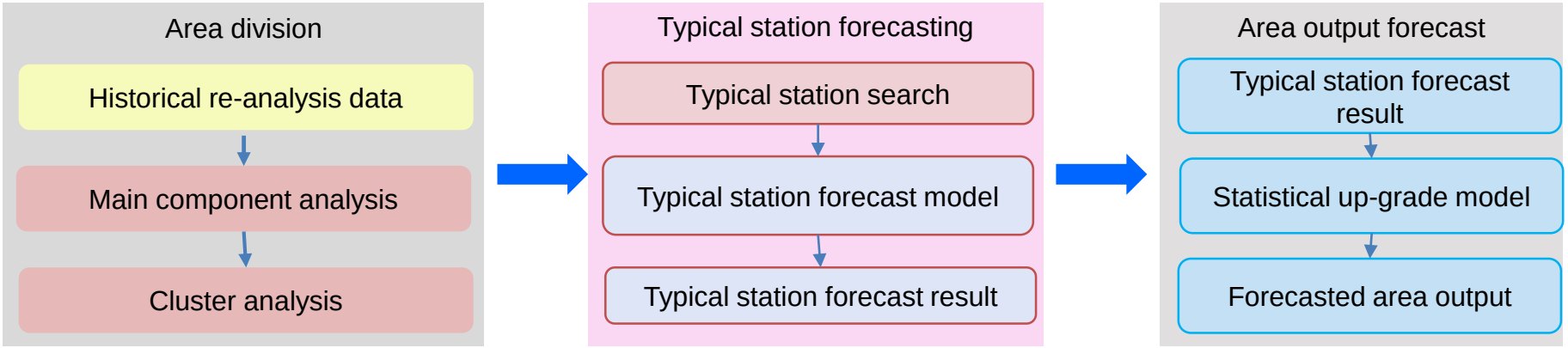


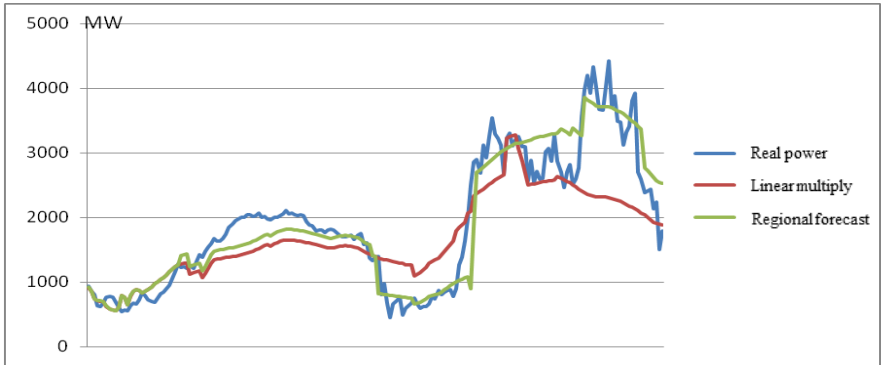


	RMSE	MAE	Correlation coefficient
Original forecast	0.13	0.10	0.61
Hybrid forecast	0.12	0.09	0.79

2.6 Regional forecasting method

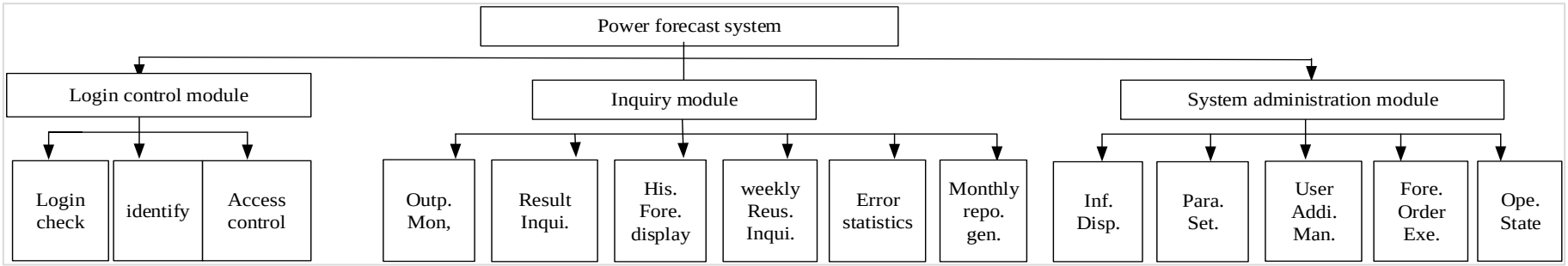
- Region division
- Typical wind farms/PV power stations selection
- Prediction by up-scale

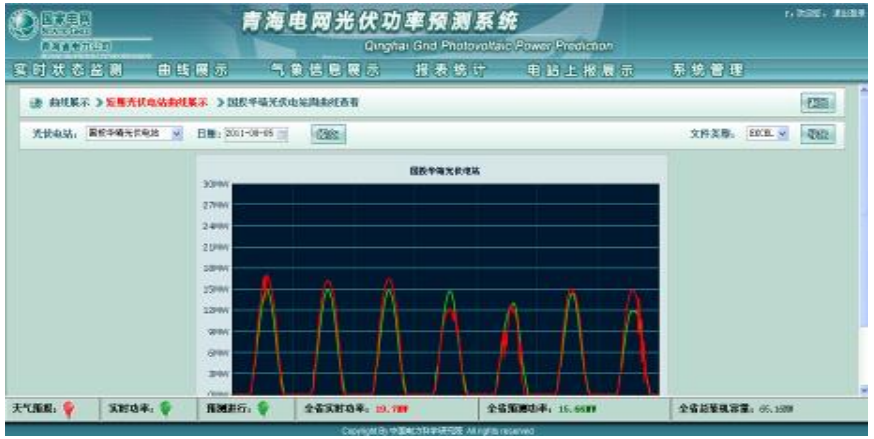




Method	MAE	RMSE	Correlation coefficient
Regional forecast	11.82%	14.50%	0.68
Linear multiply	12.30%	15.60%	0.65

Research & Application





Name	Forecasting System	Deployment Locations	RMSE(%)
CEPRI	WPFS	Jiangsu	9.8
		Shandong	10.3
		Liaoning	9.9
		Jilin	14.5
		Heilongjiang	11.2
		Gansu	16.1
		Ningxia	14.5
		Xinjiang	16.4
	SPFS	HuaJin, Qinghai	14.5
		Qinghai, Zhong Guanghe	12.4
		Ge Ermu, Qinghai	11.3
		Long yuan, Qinghai	13.2

Outline

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Future Prospect

- Automatic recognition technology of abnormal data
- Data mining for improving forecast accuracy
- Application of depth learning in forecasting
- Cloud moving trajectory prediction based on WRF model
- Numerical Weather Prediction Technology

Future Prospect

- IEC SC8A on *Grid Integration of Renewable Energy Generation*
- WG2 on *Renewable Energy Power Prediction*

IEC

Administrative Circular	8A/26/AC
	2016-02-05

INTERNATIONAL ELECTROTECHNICAL COMMISSION

TO ALL NATIONAL COMMITTEES

Technical committee 8: Systems aspects for electrical energy supply

Subcommittee 8A: Grid Integration of Renewable Energy Generation

Set up Working Group (WG 2): Renewable energy power prediction and call for experts.

This document is also made available to TC 82, TC 88, TC 95, TC 114, TC 115, TC 117 and TC 120.

Dear Sir/Madam,

Background

AHG 2 was established in April 2015, working in the area of renewable energy power prediction. During the AHG 2 meeting held in Stresa, Italy on September 28, 2015, all members agreed that the group will develop a Technical Report (TR) addressing best practices around RE power prediction.

In the following SC 8A plenary meeting, AHG2 agreement on developing a Technical Report, and forming a working group on "Renewable energy power prediction" addressing best practices around power prediction was approved and also nominate Feng Shuanglei as Convener. The project number assigned is IEC/TR 63043.

Title of WG 2 : Renewable energy power prediction

Task of WG 2 : To develop a Technical Report, addressing best practices around RE power prediction.

Membership:

- Convenor of WG 2: Mr. Shuanglei Feng
- Representatives from each P-member country of SC 8A

Action

National Committees are kindly invited to appoint experts, who should have expertise in the field of renewable energy power prediction and could make an effective contribution to the work of WG 2. The appointed experts should be entered into the IEC Experts management system by the National Committees no later than 2016-03-25.

Task of WG 2: To develop a Technical Report addressing best practices around RE power prediction.

Kick meeting of WG2

Thanks!

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