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The Integration requirements and whole-process assessment of Renewable Energy in China

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1 国家电网公司概况

Overview of SGCC

2 新能源并网技术要求

RE integration technical requirements

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Whole-process assessment on RE accommodation

1. Overview of SGCC

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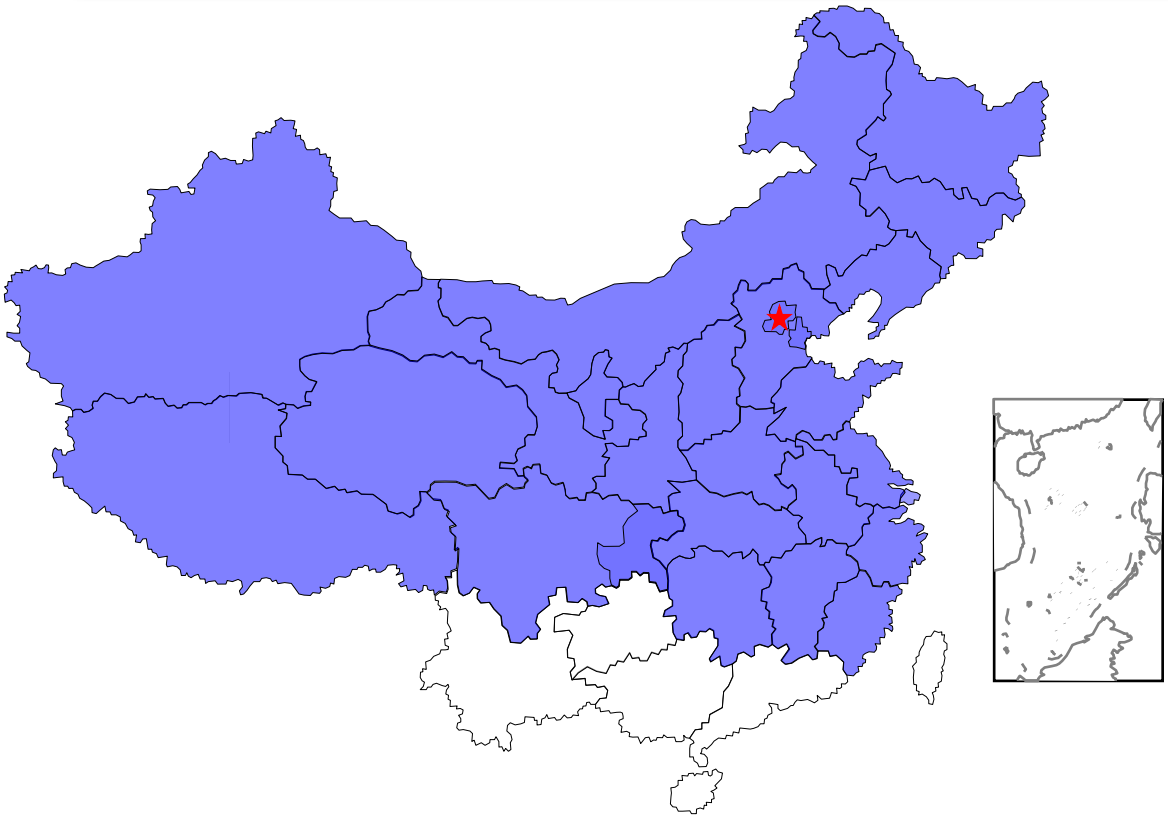
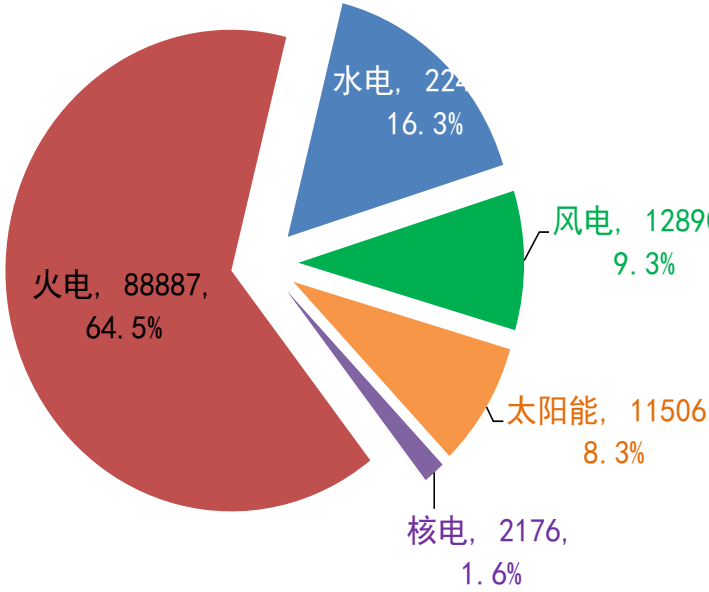
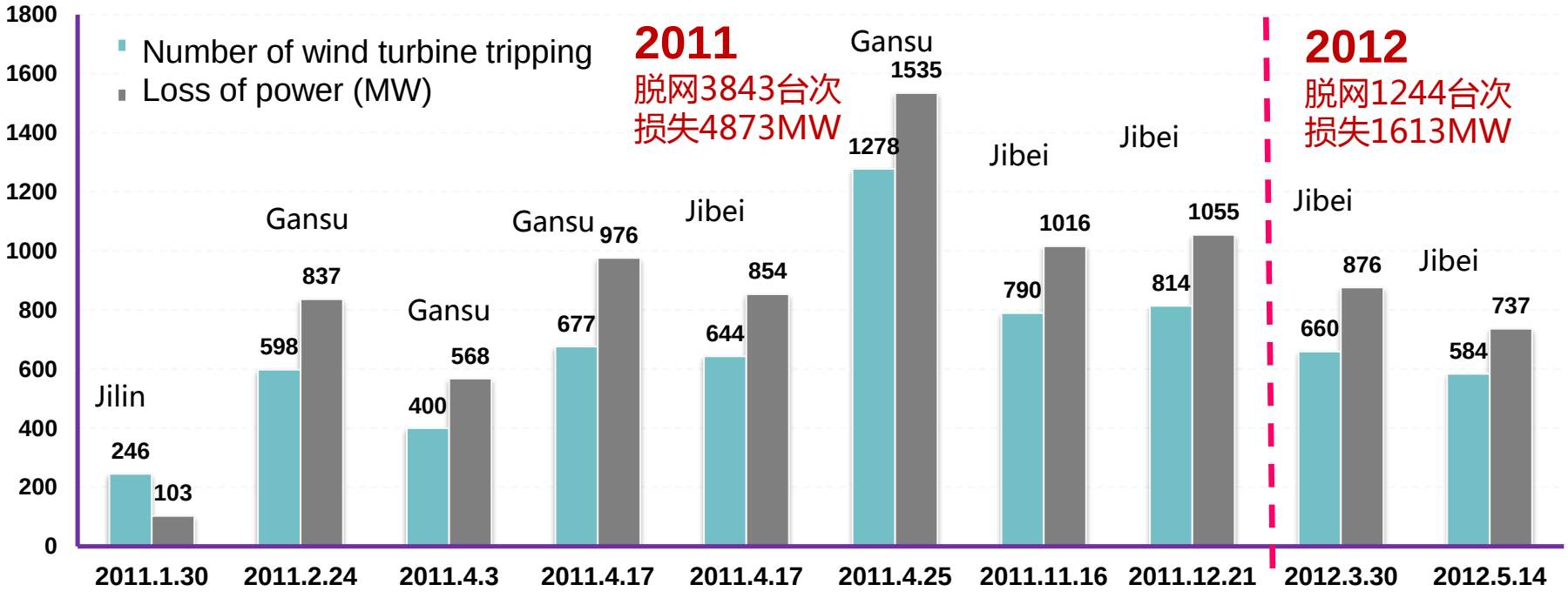
- SGCC's core business is to build and operate power grids in China
- The service area covers 26 of 32 provinces, taking 88% of China's territory. SGCC is the biggest utility company worldwide
- The total installed capacity had reached 1,379GW by the end of 2017
- Wind: 129GW (9.3%); Solar: 115GW (8.3%)



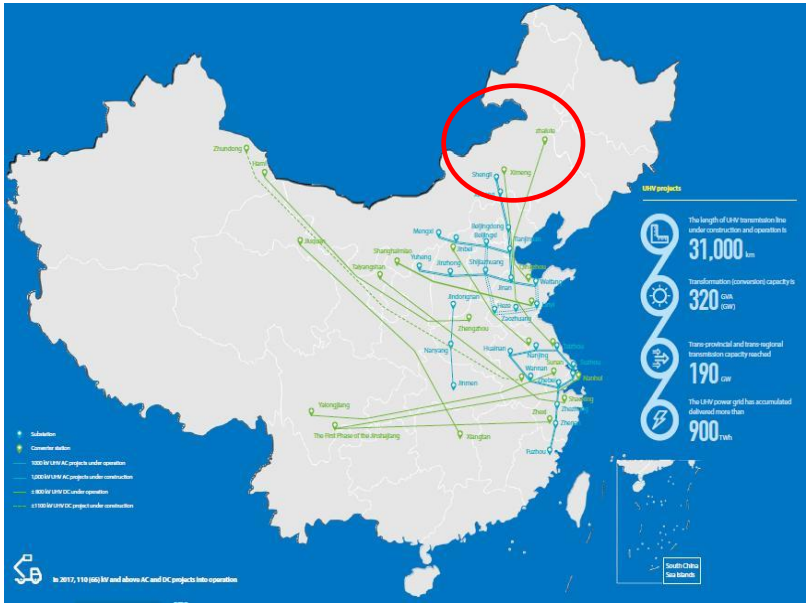


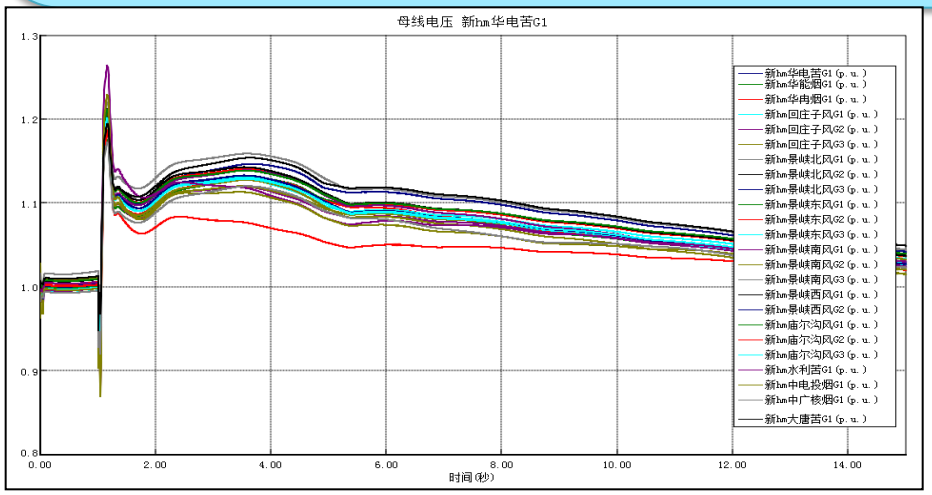
2. Integration technical requirements

- In 2011 and 2012, 10 times of power grid faults occurred in some provinces, which results in 5,087 wind turbines tripping due to lack of LVRT capability
- Revised two national standards: Technical rule for connecting wind farm and photovoltaic power station to power system
- By the end of 2015, completed a total of 200 types of wind turbine testing of LVRT capability

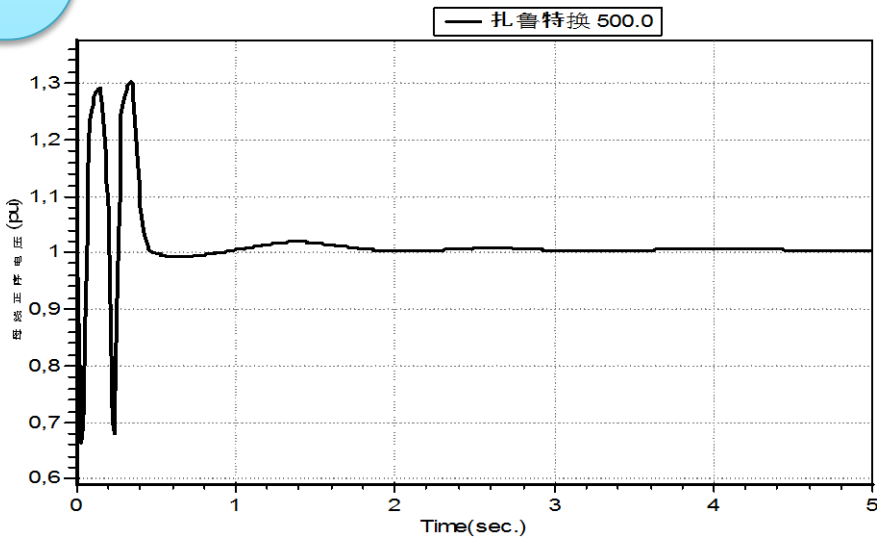


- The transient overvoltage of power grid reached 1.2 or 1.3 times of the rated voltage
- Large number of wind turbines tripped at the sending region of UHV DC lines when phase changing failure
- In 2016, choose some wind farms in Mengdong area as pilots to carry out the capability improvement of high voltage ride through (HVRT)





Simulation results of Hami-Zhengzhou UHV line phase changing failure



Simulation results of Zhalute-Qingzhou UHV line phase changing failure

HVRT requirements

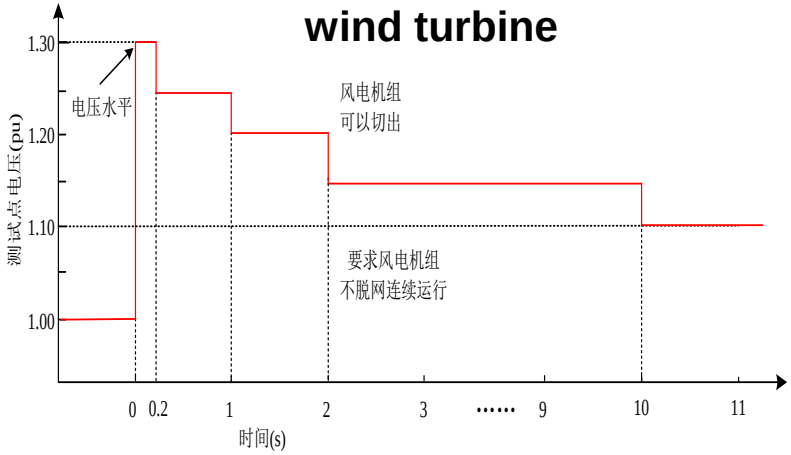
- Wind turbine: 1.3*Un*, 200ms
- PV inverter: 1.3*Un*, 500ms

Frequency tolerance requirements

- 51.5Hz

Revising the standards for HVRT

High voltage ride through curve of wind turbine



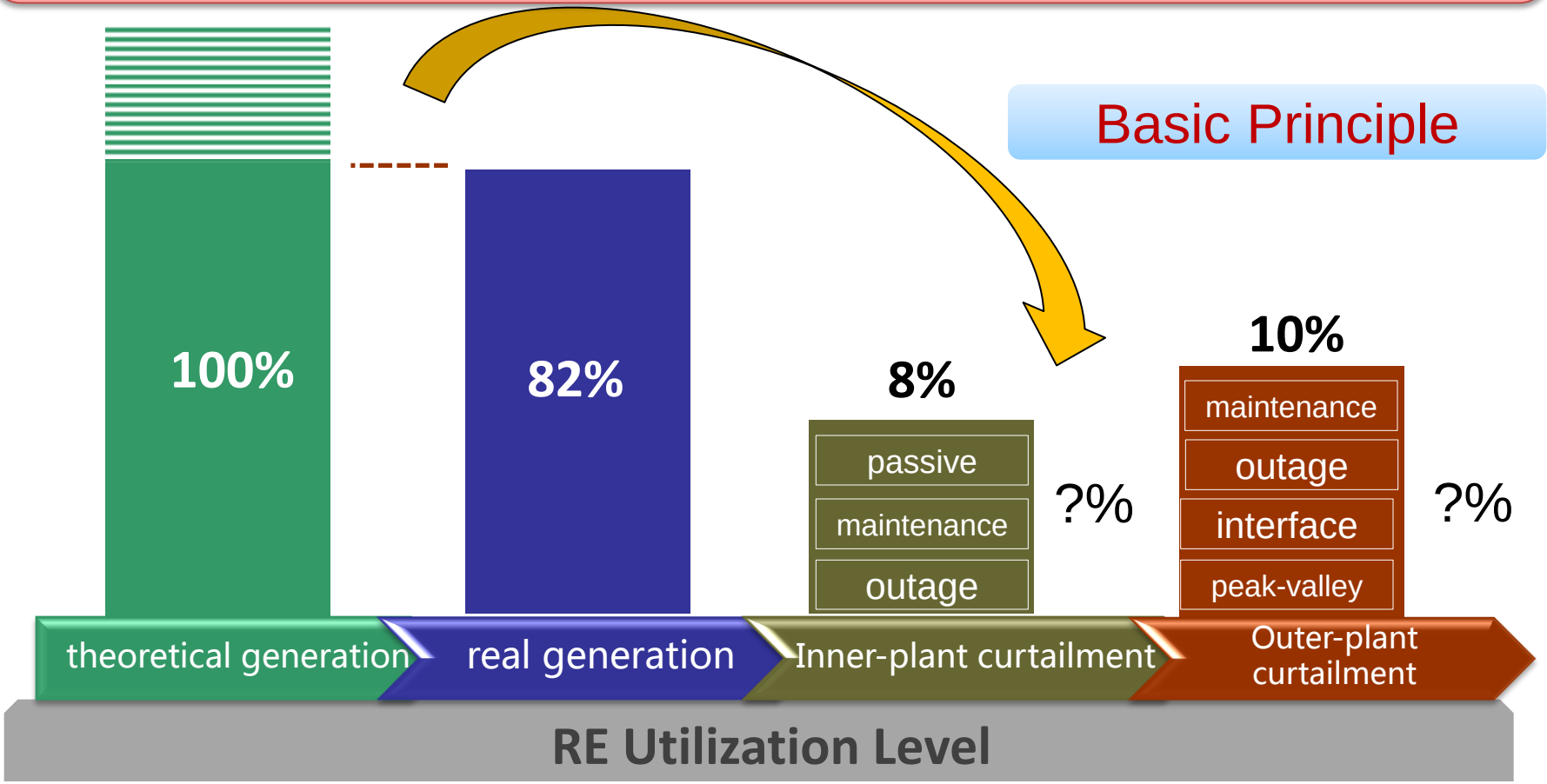
Cost of LVRT and HVRT Improvement of wind turbine

LVRT Improvement	Cost (thousand yuan)	HVRT Improvement	Cost (thousand yuan)
UPS	5, (3.8%)	**UPS**	—
Control system logic	10, (7.7%)	**Control system logic**	—
Converter testing and control	50, (38.5%)	**Converter testing and control**	—
Converter protection circuit	45, (34.6%)	**Converter protection circuit**	—
Converter LVRT control strategy	20, (15.4%)	Converter HVRT control strategy	20,(100%)
Total	**130**	Total	**20**

3. Whole-process Assessment on RE accommodation

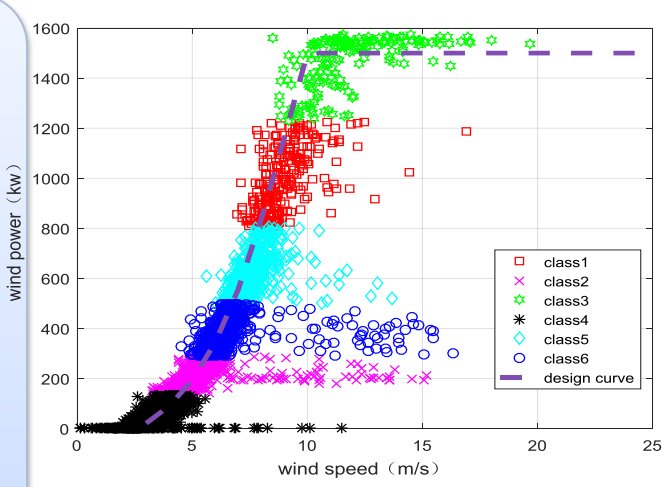
■ Many factors influence renewable generation utilization level: wind and solar resources, equipment reliability, grid operation constraints, and priority dispatching

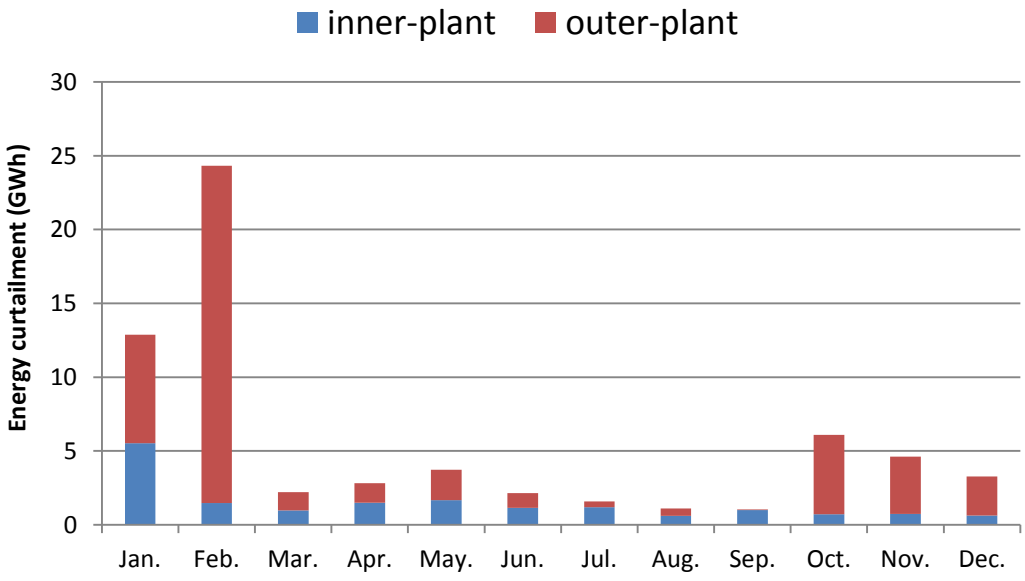
■ The purpose of whole-process assessment is to analyze the influence of each factor quantitatively



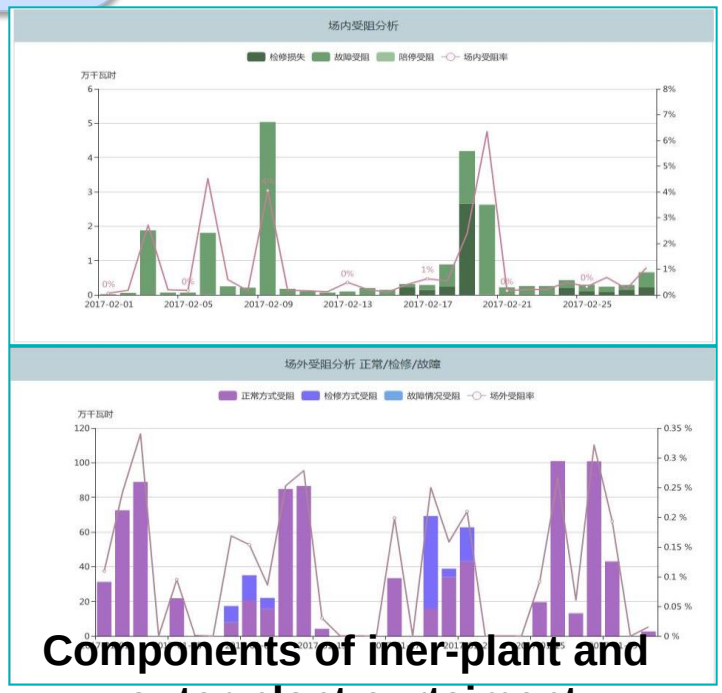
Calculation of theoretical generation

- Establish the mapping relationship between active power and nacelle wind speed for each turbine
- Calculate the theoretical power when curtailment occurs
- Integrate the theoretical power to get the theoretic generation during one period
- Calculate components of inner-plant and outer-plant curtailment





Calculation of curtailment energy for one wind farm



Components of iner-plant and outer-plant curtaiment

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中外新能源发展特点对比
The development characteristic comparison

More than 80% of the power demand is distributed in astern and southern areas in China. By contrast, renewable energy is mainly in the '3-North' area.

The average capacity of wind farm in China is 88MW(3 times of Spain),and the largest one exceeds 400MW. Many wind farms in the region with good wind resources are integrated into the same substation, thus forming ***wind farm cluster*** (2-3GW). And then many wind farm clusters are integrated into higher-voltage level substation, forming a ***wind power base*** (10GW).

Comparison of renewable energy development between China and Europe

Europe and US	Market demand oriented	Near the load	Small-scale	Many owners	Highly dispersive
China	Resource oriented	Far from the load	Large-Scale	A few owners	Highly centralized

欧美陆上风电	市场需求导向	靠近负荷中心	小规模	多业主	高度分散
中国陆上风电	资源导向	远离负荷中心	大规模	少业主	高度集中

Integration testing requirements

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	Testing Contents	Testing Requirements
Mandatory	**Wind farm active/reactive power control capability**	■ Whether AGC/AVC substation meets the operating conditions accessing to the main station
	Wind farm Power quality	■ Whether wind power quality meets the standard requirements
	Wind farm low voltage ride through capacity and grid adaptive capacity verification	■ To ensure that the wind turbines are consistent with the testing unit parameters and configuration, and wind farms low voltage ride through capacity and grid adaptive capacity
	Dynamic reactive power compensation device performance test	■ The reactive power compensation device should have reactive power regulation and voltage control capability ■ Detection of reactive power compensation device performance whether meet the standard requirements, for dynamic control performance optimization of reactive power compensation device to provide test data.
Optional	**Wind turbines power characteristics test**	■ Consistency of Wind turbines actual power curve inspection and theory power curve

Remote telemetry and signal data

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■ The component analysis of energy curtailment is based on high-quality operation information of **each wind turbine and PV inverter**

	Signal data		Telemetry data
wind turbine	Operating	Generation	real power, reactive power, nacelle wind speed
		Idle with low wind velocity	
		Deregulated generation of dispatch	
	Shutdown	Shutdown reserve from AGC	
		Schedule maintenance	
		Non-planed outage (inside)	
		Non-planed outage (outside)	
PV inverter	Operating	Generation	real power, reactive power
		Deregulated generation of dispatch	
	Shutdown	similar with wind turbine	
anemometer tower	wind speed (10m, 30m,50m,70m)		

Assessment of wind power utilization

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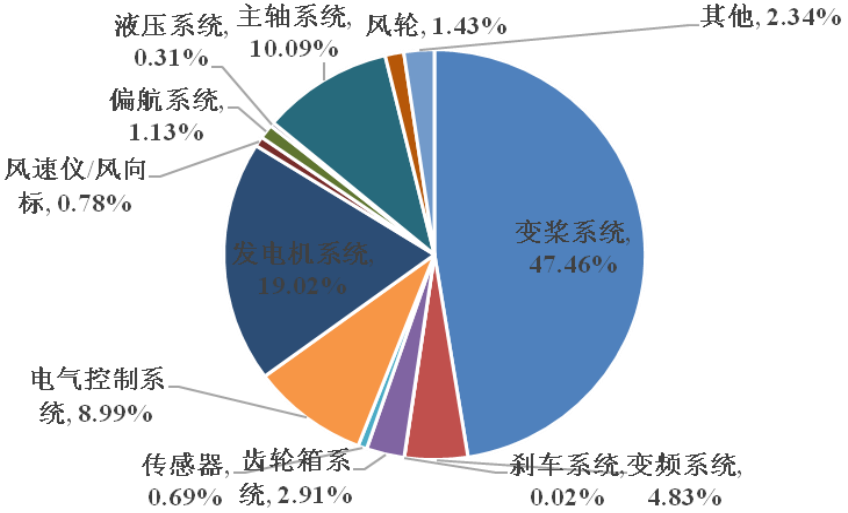
- Wind farms in different geographical locations
- Power generation companies
- Equipment manufacturers



The impact of wind turbine component outage on wind curtailment