国家电网
STATE GRID

中国电力科学研究院有限公司
CHINA ELECTRIC POWER RESEARCH INSTITUTE

UHV Power Grid of State Grid Corporation of China

Speaker： Yalou Li Date：22 Oct, 2018

CATALOGUE

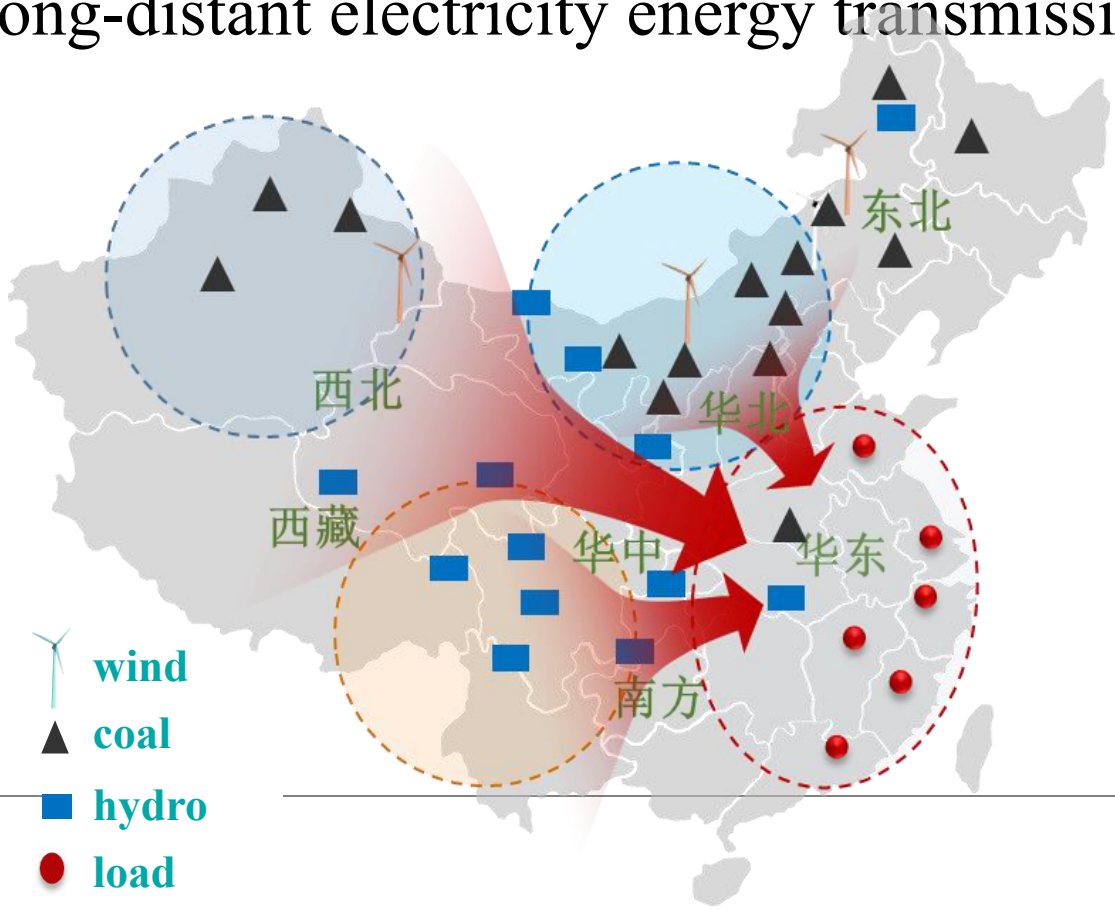
1. Background

Firstly, the reverse distribution of energy resources and load center is the basic national conditions. More than 80% of China's energy resources distribution in the northern and western region, whereas more than 70% of the electricity consumption concentrated in the eastern and central region. The distance between energy supply and energy demand are 800 ~ 3000 km, Therefore, large-capacity and long-distant electricity energy transmission is inevitable.

Coal resources are distributed in the west and north.

The hydro power to be developed are distributed in the west.

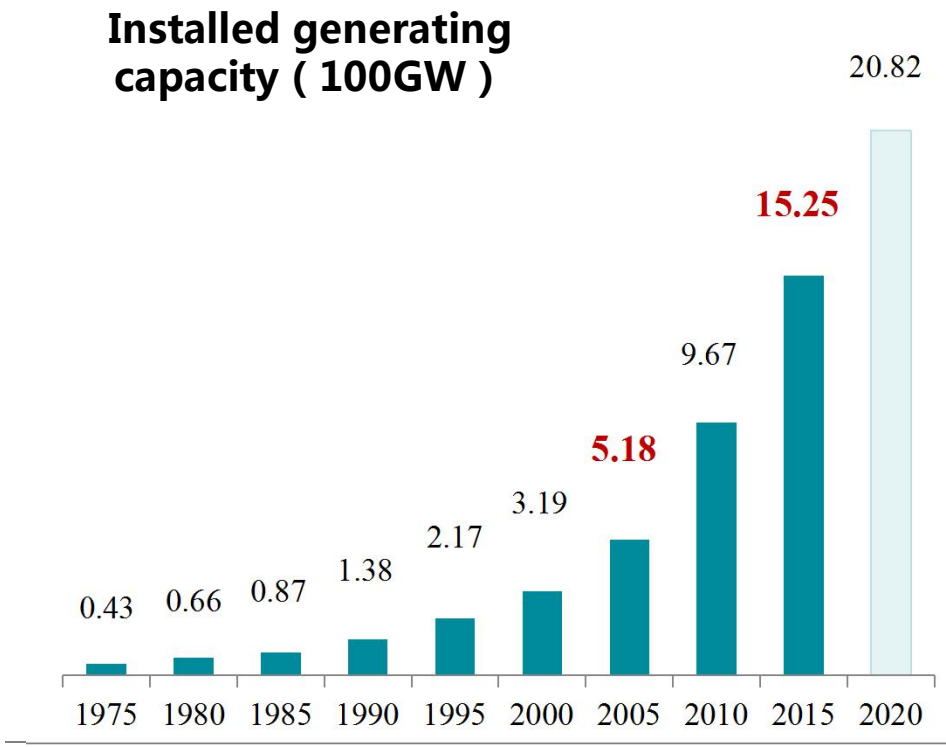
Solar and wind resources are distributed in the west and north.

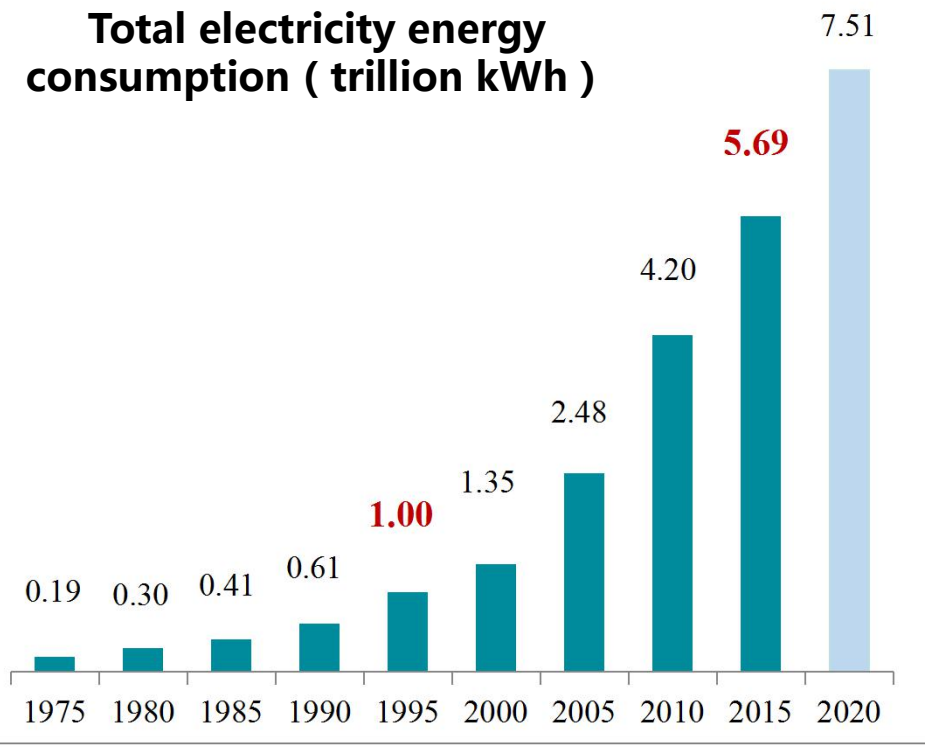


1. Background

Secondly, the long-term and sustainable growth of electricity demand.

Since 2000, the annual growth capacity of newly installed generators in China exceeds 80 GW, and the total electricity energy consumption has quadrupled.



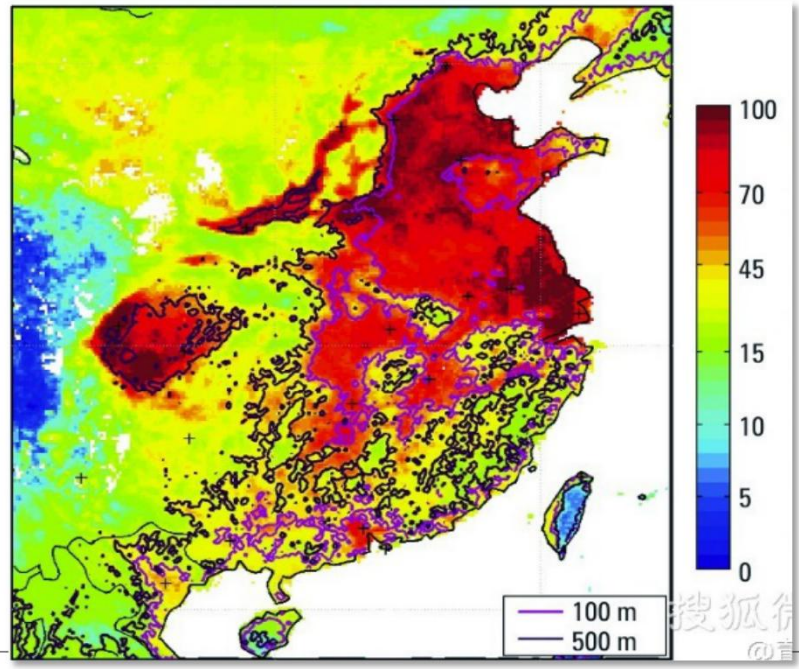


1. Background

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Thirdly, the mode of electric power development needs to be changed urgently.

For a long time, China power development mode is given priority to local balance, and the energy resources configuration mode over relies on coal transportation, which brings forward a series of problems such as coal price rising, haze intensifying and traffic congestion. Thereby, it is necessary to speed up the development of power transmission and build a comprehensive energy transportation system.



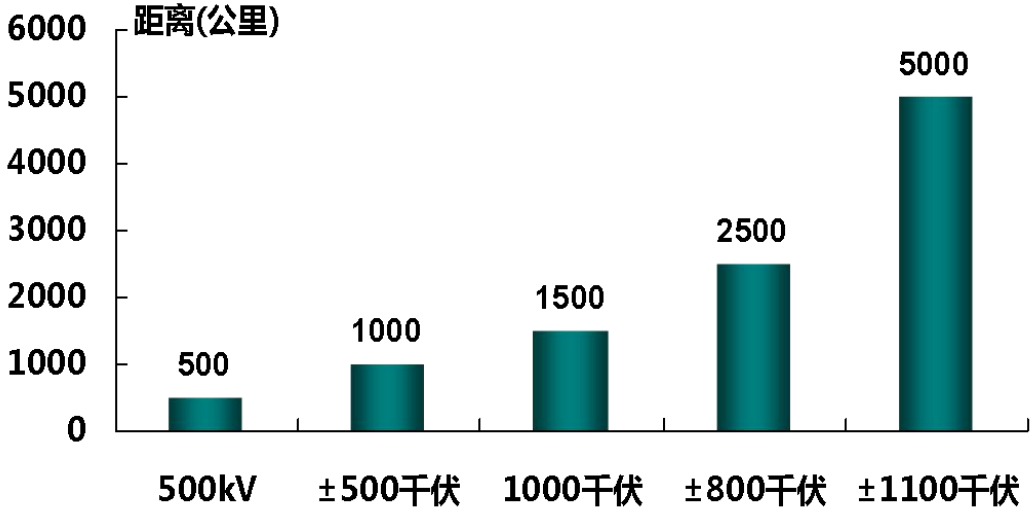
1 Background

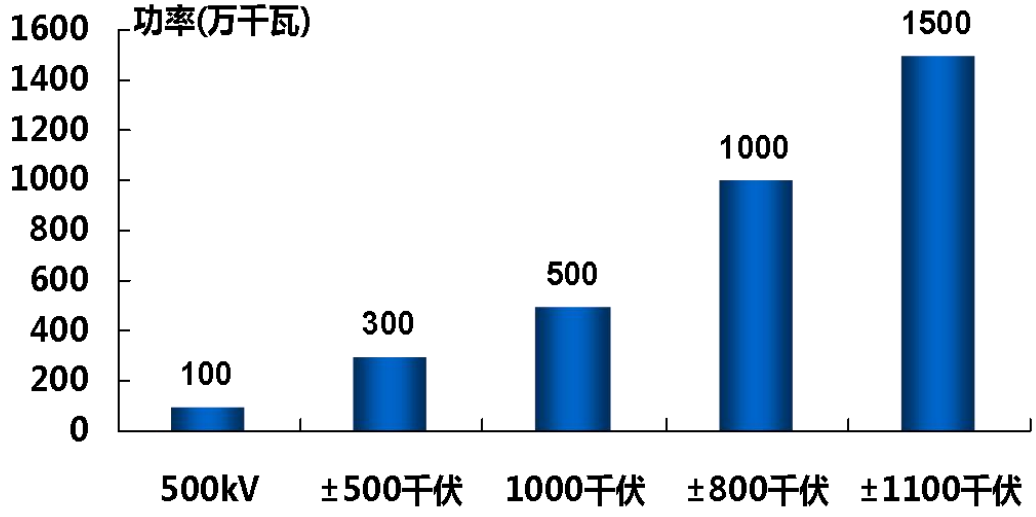
Fourthly, the rapid development of renewable energy. Wind power, solar power generation has the characteristics of randomness, intermittence and uncertainty. Hydro power has the characteristics of seasonal and regional differences. It is necessary to develop UHV technology and construct large-scale grid for the large-scale development and utilization of renewable energy.

1. Background

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Fifthly, the upgrading of power grid technology. The existing 500 kV power grid is faced with technology problems such as insufficient transmission capacity, shortage of corridor resources and excessive short-circuit current. It is necessary to develop higher voltage level, optimize network structure, improve utilization rate and ensure reliable operation.





Comparison between EHV/UHV economical transmission distance and economical transmission power.

CATALOGUE

2. Projects Construction

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

The pilot and test projects of UHV AC and UHV DC have been constructed and operated successfully. Stable operation of the pilot projects is maintained continuously, the expected technical performance was achieved, a new world record of AC and DC transmission was created, and the feasibility, safety and environmental friendliness of UHV technology were comprehensively verified.

- **Jindongnan~Jingmen 1000 kV UHV AC pilot and test project.** In January 2009, it was put into commercial operation, and it has been operated safely and steadily for nearly 10 years, with a total energy transmission of 92 billion kWh.

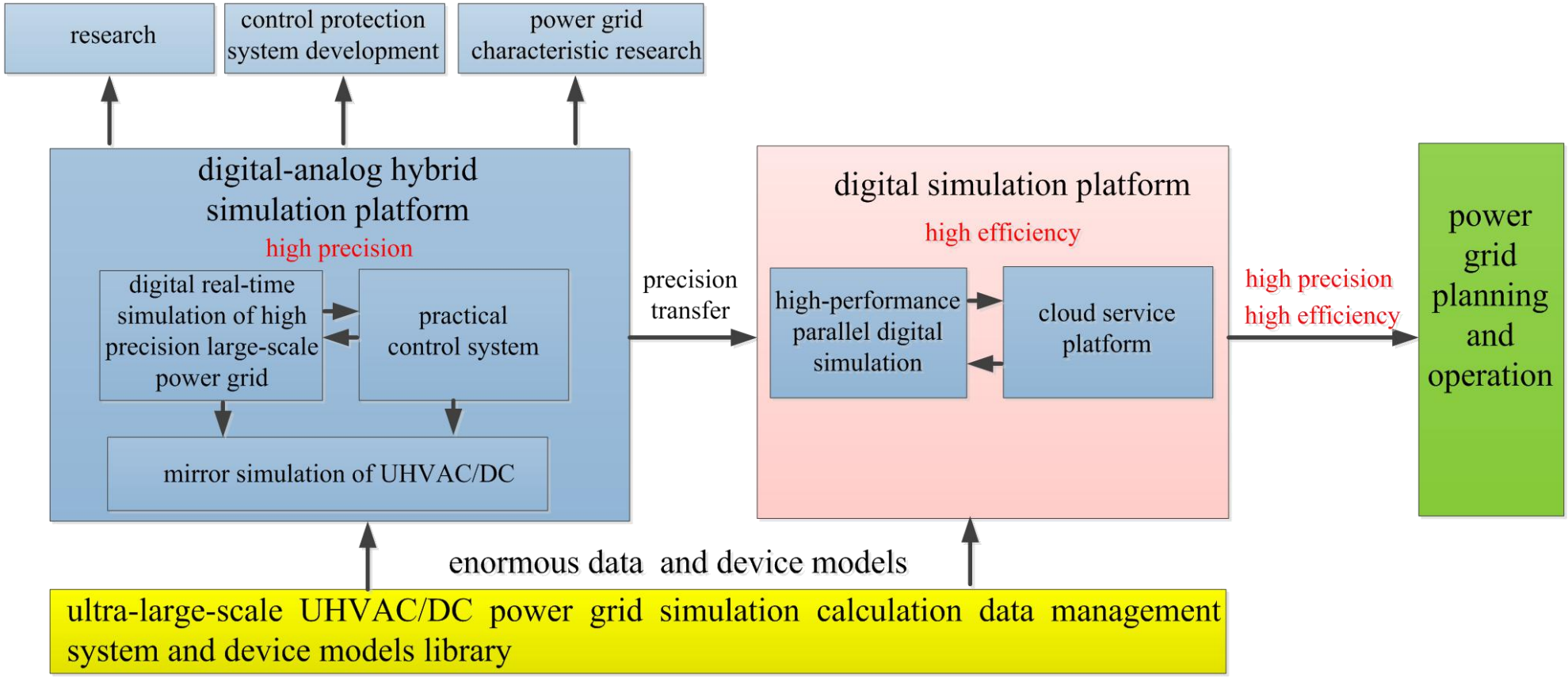
- ✓**Line length: 640km**
- ✓ **Substation capacity 6000MVA**
- ✓ **nominal voltage: 1000kV**
- ✓ **highest voltage: 1100kV**

- **Xiangjiaba ~ Shanghai ± 800 kV UHV DC pilot and test project.** In July 2010, it was put into commercial operation, and the operation has been continuously safe and stable for nearly eight years.

- ✓ **line length: 1907km**
- ✓ **nominal voltage: ±800kV**
- ✓ **rated current: 4000A**
- ✓ **rated capacity: 6400MW**
- ✓ **maximum power :7200MW**

SGCC Simulation Center

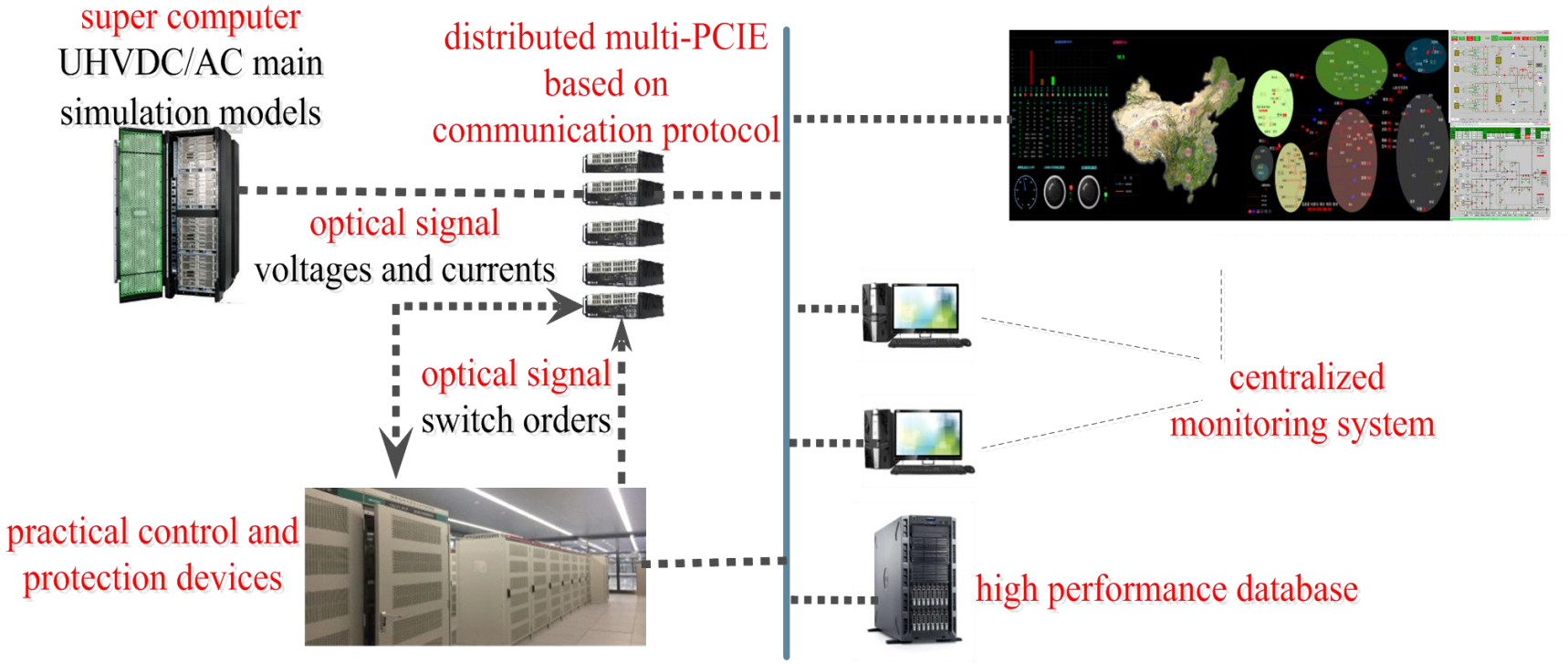
Constructed by four parts: digital-analog hybrid simulation platform, digital simulation platform, data management system and device models library



SGCC Simulation Center

Digital-analog hybrid simulation platform:

- Large - scale electromagnetic transient real-time simulation software
- Super computers
- Connecting with the practical control and protection devices
- Centralized monitoring system and database



New generation digital-analog hybrid simulation platform

SGCC Simulation Center

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Digital-analog hybrid simulation platform of NGSP

6000 nodes

Electromagnetic transient simulation scale

36 UHV DC lines

Interacting with the physical control and protection system

220kV and more than **220**kV

Achieving electromagnetic transient real-time simulation for any regional grid

Scale

- 6401 three-phase AC nodes
- 370 generators
- 159774 MW transmission power
- 9 physical DC control and protection systems
- 5109 AC transmission lines

SGCC Simulation Center

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Digital simulation platform of NGSP:

- supercomputer center
- cloud simulation platform
- monitoring platform

Until to now, owning the highest computing power for power system digital simulation in the world

supercomputer center

monitoring interface

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

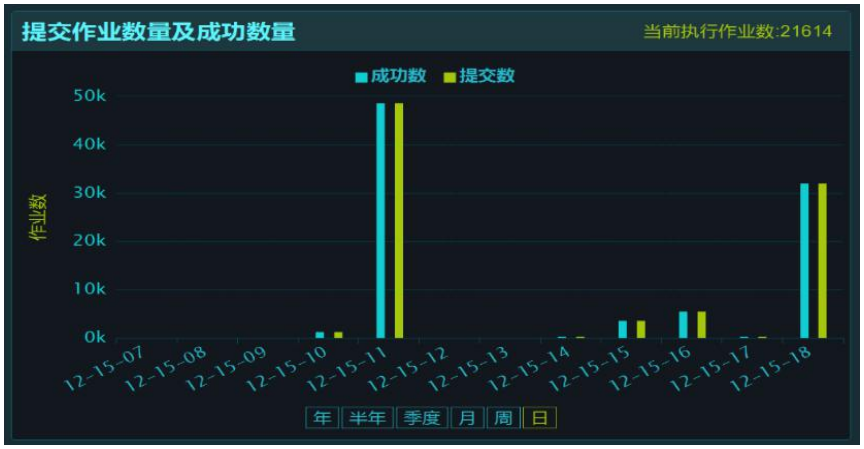
SGCC Simulation Center

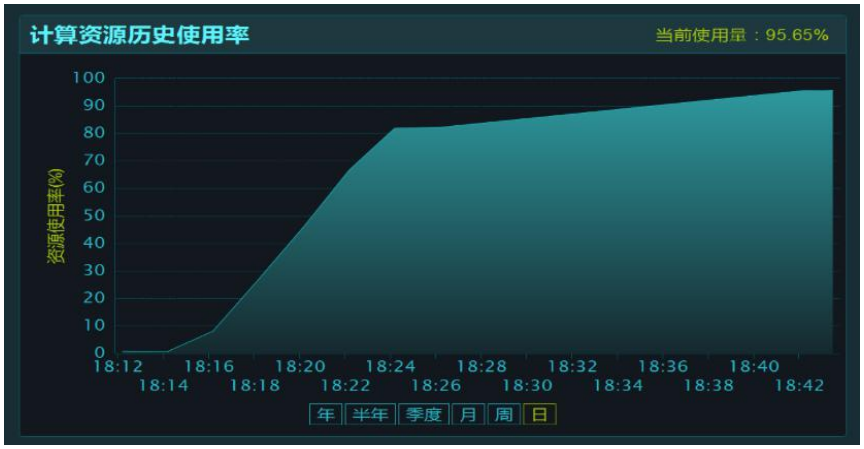
Digital simulation platform of NGSP

24000 CPU
computing hardware

918.7 Trillion times/s
theoretical peak of computing power

More than **95**%
real-time utilization of computing resources





The first power system simulation platform which is based on supercomputers in the world: the performance of the parallel simulation algorithm is optimized and could make use of the super-computing resources effectively.

SGCC has constructed of the ‘eight AC & ten DC’ projects and is constructing the ‘four AC & one DC’ projects. And UHV AC grid has been formed in North China and East China.

工程名称	变电容量（万千伏安）	线路长度（公里）
晋东南–南阳–荆门	1800	640
淮南–浙北–上海	2100	1298
浙北–福州	1800	1206
锡盟–济南	1500	1460
淮南–南京–上海	1200	1560
蒙西–天津南	2400	1232
锡盟–胜利	600	480
榆横–潍坊	1500	2098
总计8项	**12900**	**9974**

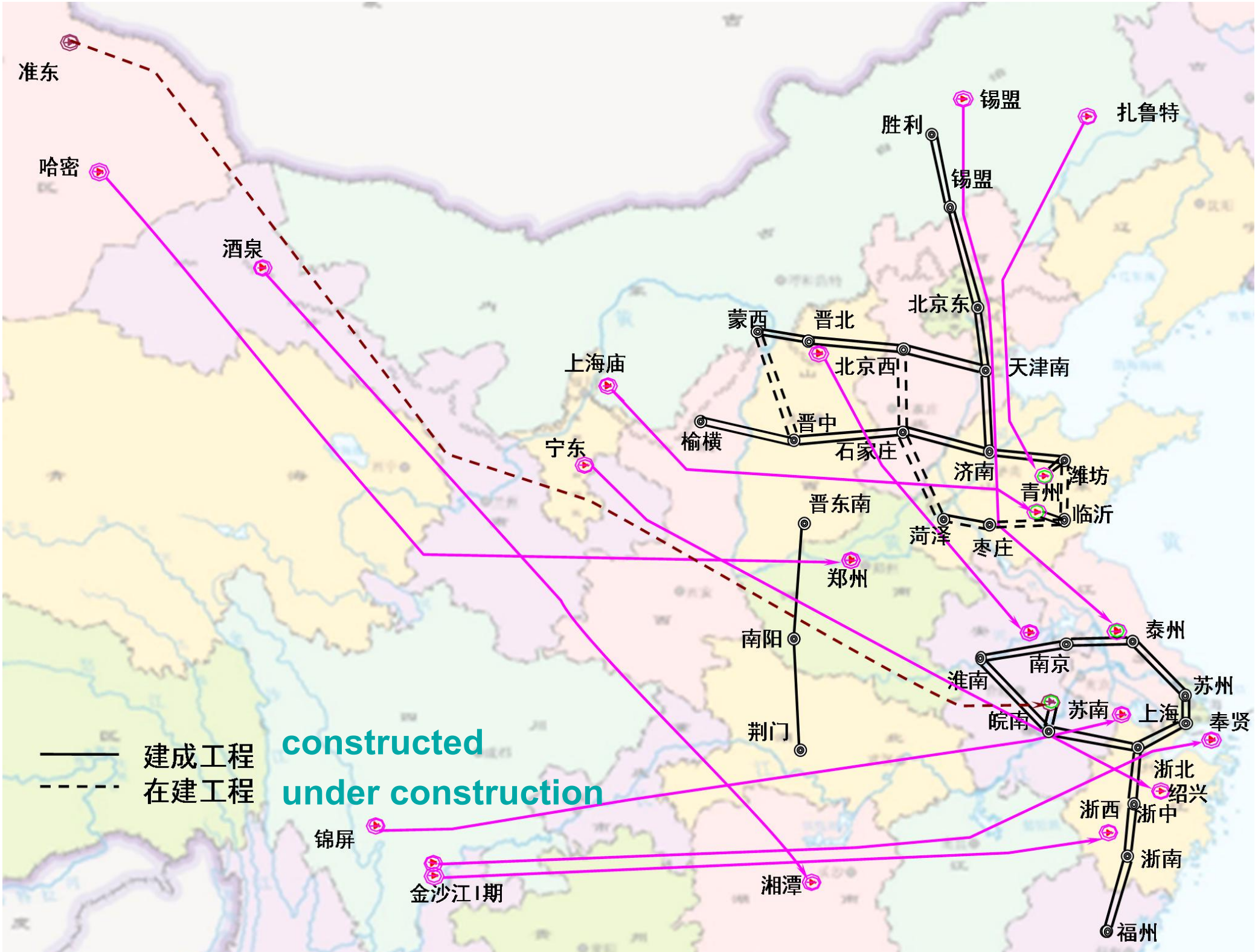
name capacity(10,000kW) length(km)

constructed UHV AC projects

工程名称	输电容量（万千瓦）	线路长度（公里）
向家坝–上海	640	1907
锦屏–苏南	720	2059
哈密南–郑州	800	2192
溪洛渡–金华	800	1653
宁东–绍兴	800	1720
酒泉–湘潭	800	2413
晋北–南京	800	1119
锡盟–泰州	1000	1620
上海庙–临沂	1000	1238
扎鲁特–青州	1000	1234
总计10项	**8360**	**17155**

name capacity(10,000kW) length(km)

constructed UHV DC projects


准东
哈密
酒泉
锡盟
胜利
锡盟
扎鲁特
北京东
蒙西
晋北
北京西
天津南
上海庙
晋中
榆横
宁东
石家庄
济南
潍坊
青州
临沂
晋东南
菏泽
枣庄
郑州
南阳
泰州
南京
淮南
苏州
苏南
皖南
上海
奉贤
荆门
浙北
绍兴
浙西
浙中
浙南
锦屏
金沙江I期
湘潭
福州
建成工程
在建工程
constructed
under construction

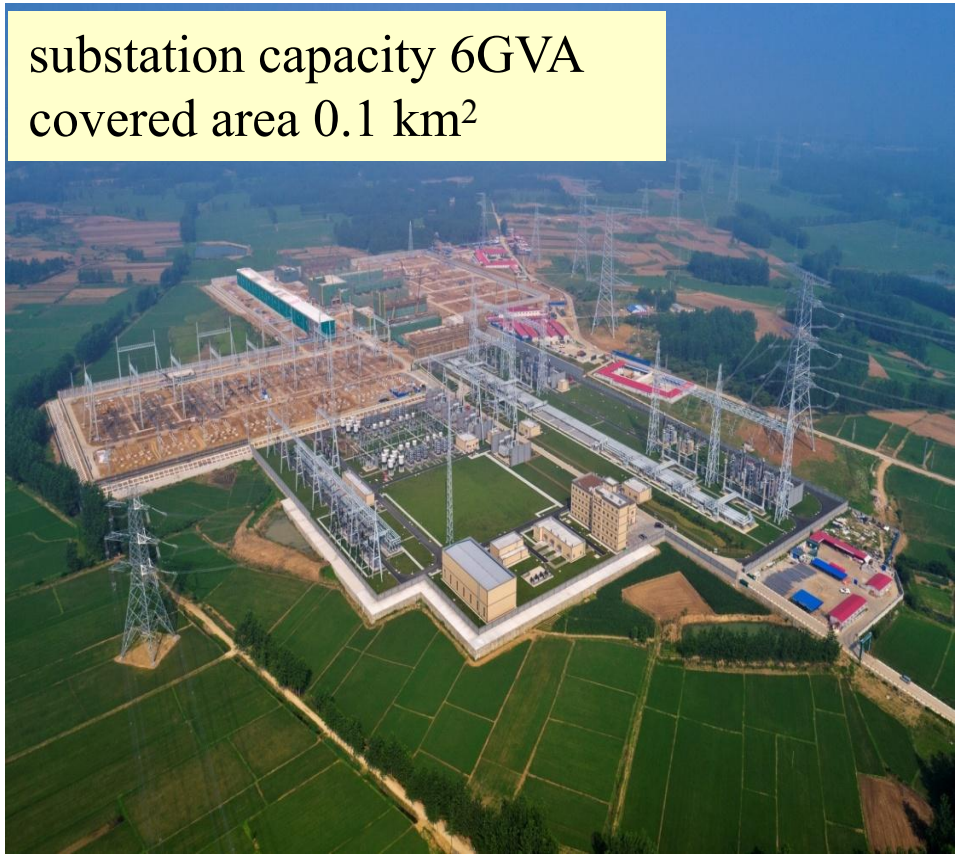
The total length of operated and under-constructed UHV transmission line is 33,000 km.

Huainan-Zhebei-Shanghai UHV AC transmission lines cross Huaihe river

Hami-Zhengzhou, Jiuquan-Hunan UHV DC transmission lines

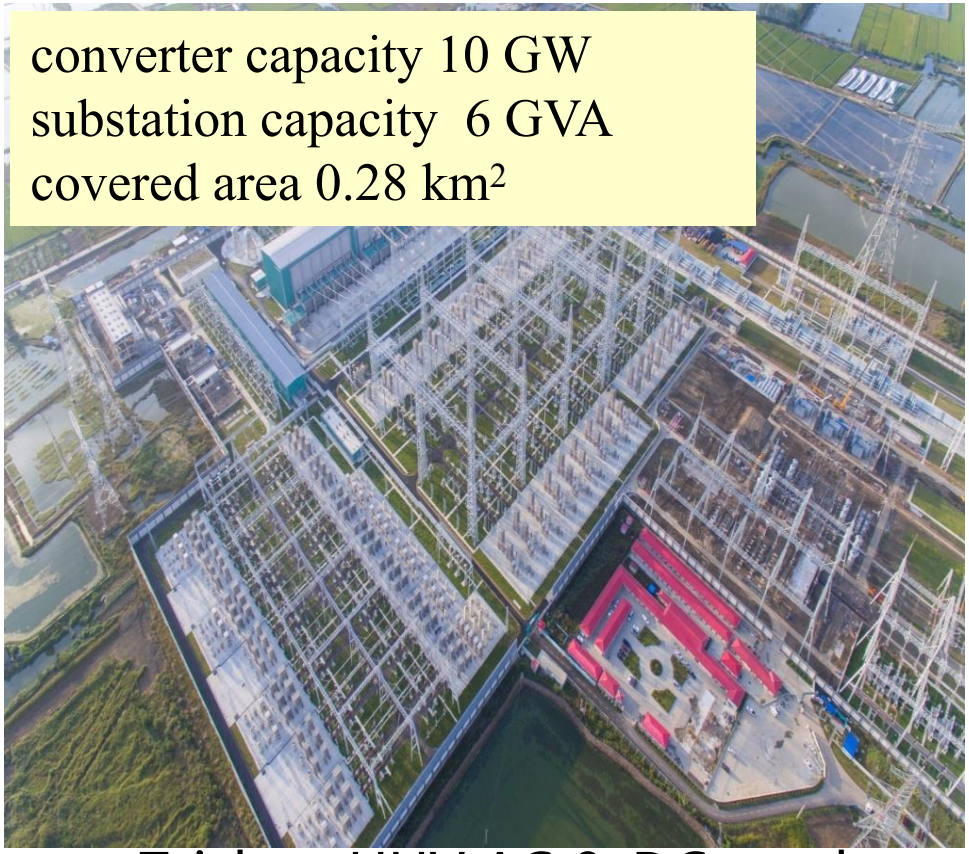
The total capacity of operated and under-constructed substation and converter station is 340 million kVA (kW) .

substation capacity 6GVA
covered area 0.1 km^2



Nanjing UHV AC substation

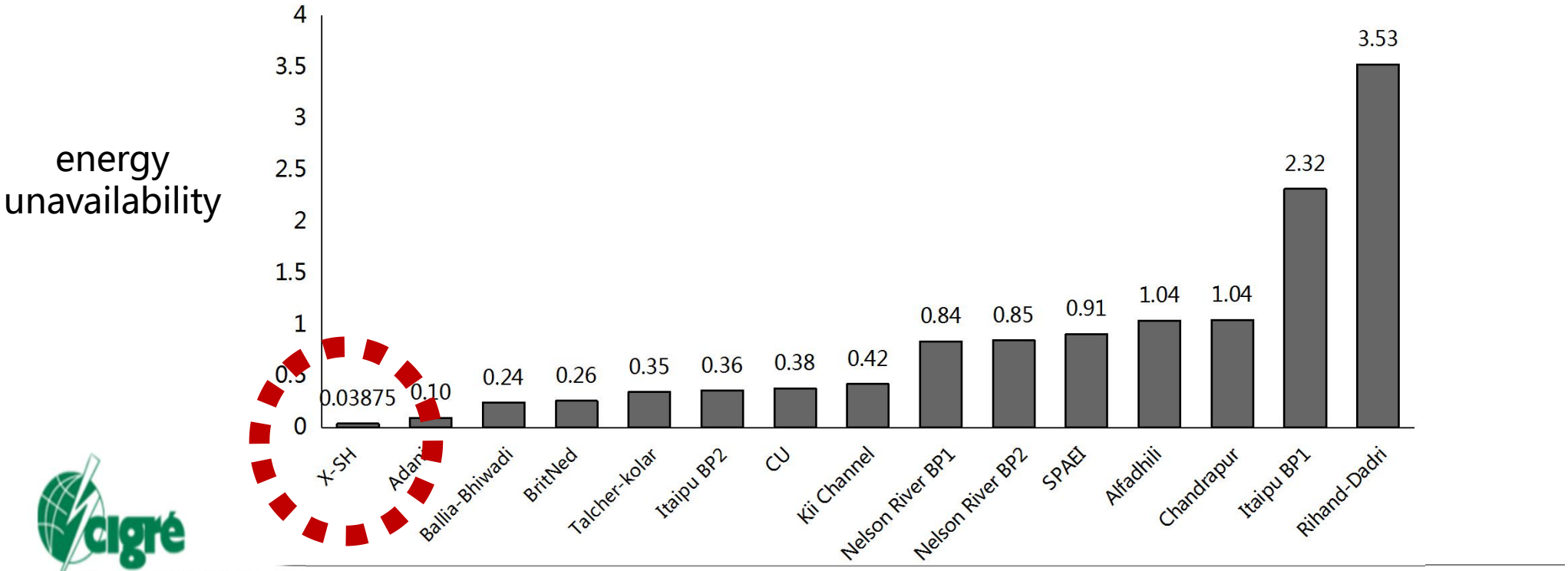
converter capacity 10 GW
substation capacity 6 GVA
covered area 0.28 km^2



Taizhou UHV AC & DC combo substaion

At present, ±1100kV XinjiangZhundong-AnhuiWannan UHV DC project is being built, of which the transmission distance is 3,324 kilometers, the rated transmission power is 12 million kilowatts. This project is to be completed this year.

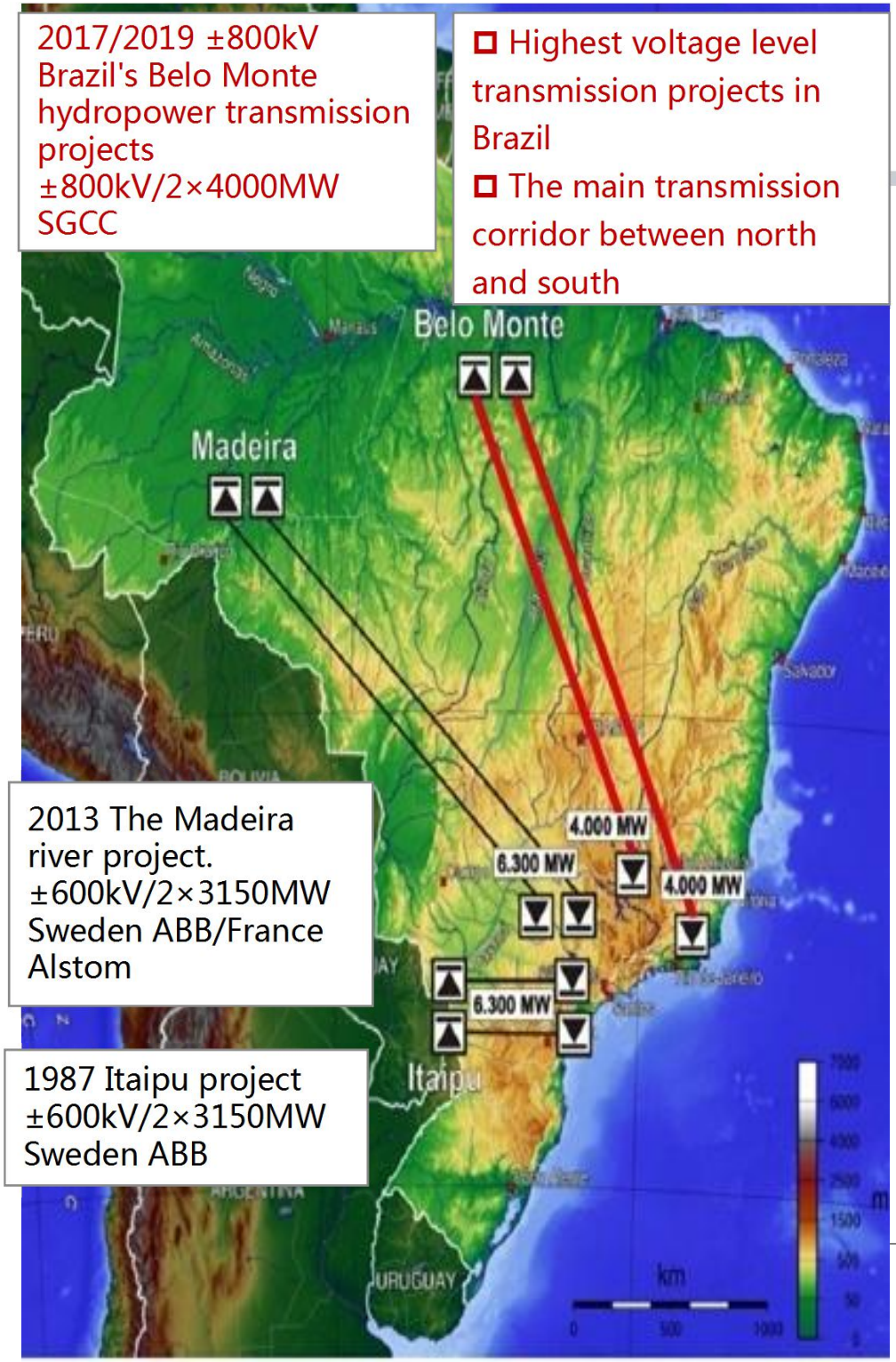
The operation of UHV AC/DC projects achieves high reliability. The main equipment and system have been tested by full voltage, large capacity and various natural environmental conditions. Xiangjiaba-Shanghai, Jinping-Sunan, Xiluodu-Zhexi, the three UHVDC projects operate at full load condition in the flood season for nearly 5 months each year, and the reliability index is significantly better than that of conventional HVDC projects, which reaches the world leading level.



The reliability data of the world's major HVDC projects(CIGRE B4-04 working group released in 2015)

2017/2019 ±800kV Brazil's Belo Monte hydropower transmission projects ±800kV/2×4000MW SGCC

- Highest voltage level transmission projects in Brazil
- The main transmission corridor between north and south



2013 The Madeira river project. ±600kV/2×3150MW Sweden ABB/France Alstom

1987 Itaipu project ±600kV/2×3150MW Sweden ABB

In 2014 and 2015, SGCC successfully bided for ±800kV Brazil's Belo Monte hydropower transmission projects phase I and phase II. The phase I project has been completed in December 2017.

CATALOGUE

3. Development effectiveness

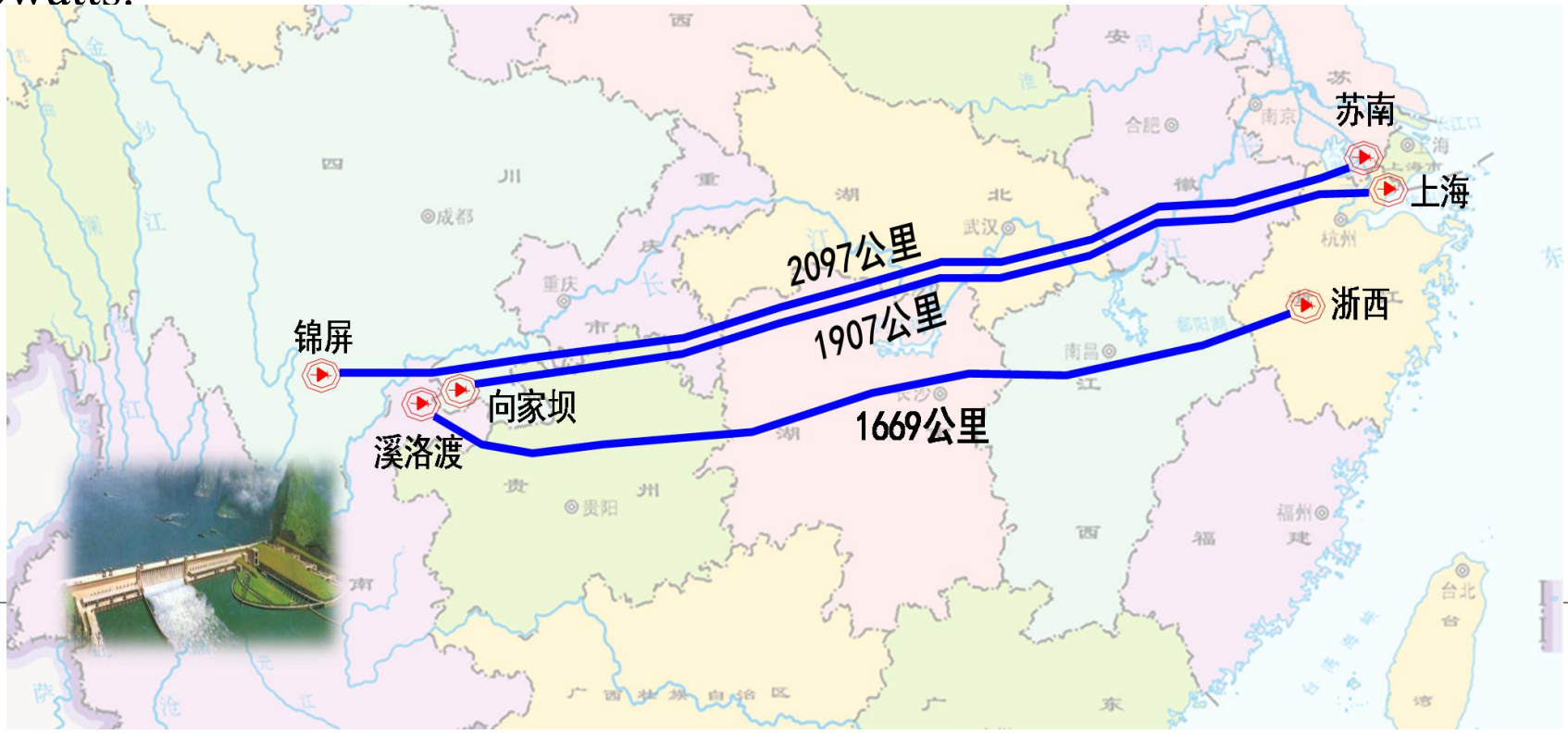
国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Promote the optimization of configuration for energy resources in wide range

- In 2017, the transmission capacity of 'West Power Transmission to the East' was 220 million kW, of which UHV accounted for 53%, becoming the main power transmission channel.

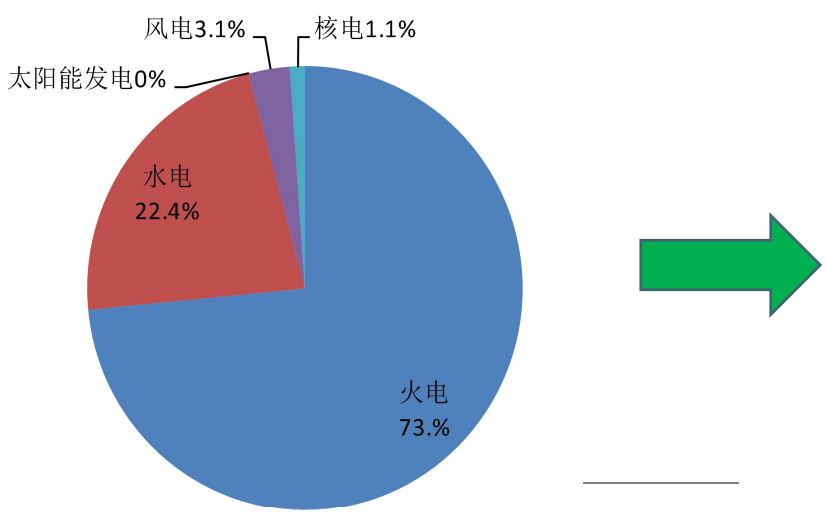
Promote the construction of large hydropower, wind and solar power supply bases in the western region

- Total capacity of the three UHV DC projects to transmit southwest hydropower is 21.6 million kilowatts, which is equivalent to the total installed generating capacity of the Three Gorges Power Station, and the annual transmission of electricity energy exceeds 100 billion kilowatt-hours.
- Hami-Zhengzhou, Jiuquan-Hunan UHVDC projects were put into operation, and the renewable generating capacity in sending-end system was 10 million kilowatts.

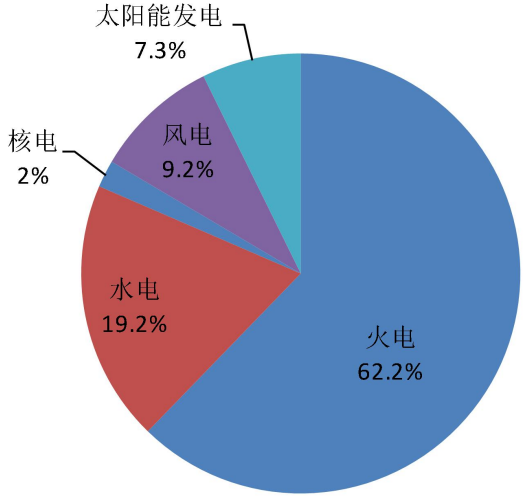


Accelerate energy transformation and upgrading

- In 2017, SGCC UHV power grid transmitted 249.6 billion kWh of electricity energy, of which 161.5 billion kWh of clean energy.
- China's power generation capacity was 1.78 billion kilowatts, including 640 million kilowatts of clean energy, which accounted for 36% of the total, and increased from 24.2% in 2010; and the proportion of thermal power declined from 73% (2010) to 62%.
- The installed generation capacity of wind power and solar power reached 160 million and 130 million kilowatts, ranking first in the world. And in China, renewable energy sources became the second largest power source in 19 provinces and regions.



China's power supply structure in 2010



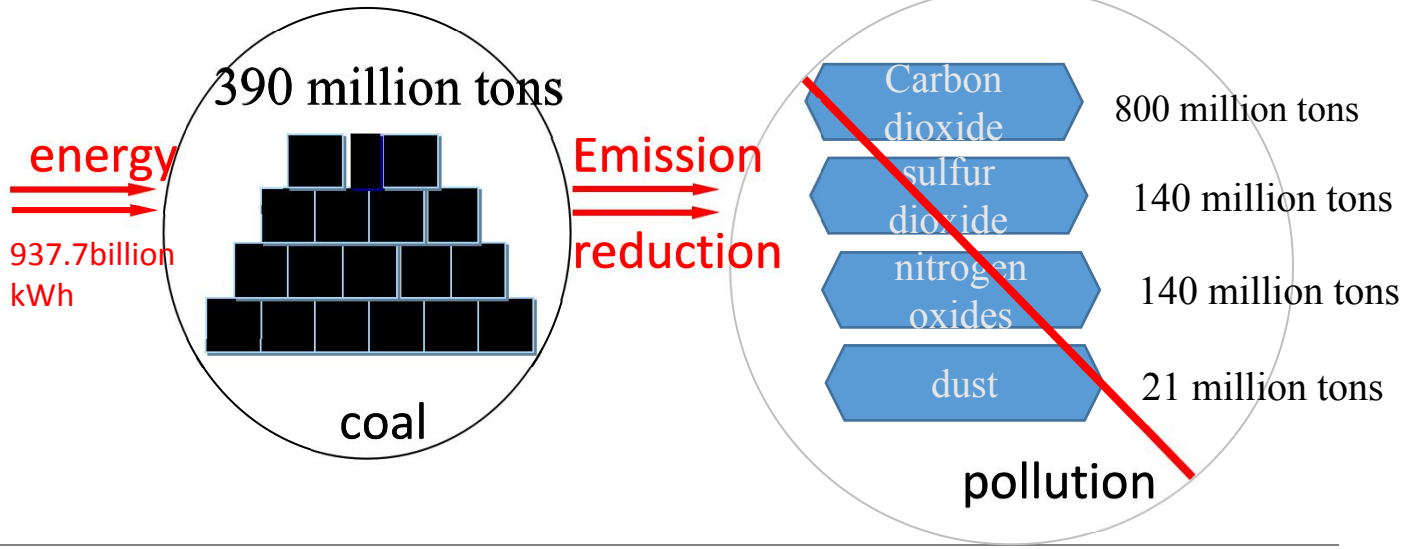
China's power supply structure in 2017

Control air pollution and improve the quality of eastern environment

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

- The UHV project has accumulated more than 940 billion kilowatt-hours of electricity energy in eastern and central regions, which is equivalent to the annual power generation of 10 Three Gorges hydropower stations.
- 390 million tons of electric coal combustion are reduced in east region, and sulfur dioxide and nitrogen oxides are reduced by 2.8 million tons.

Clean power



Improve the safe operation of power grid

- The UHV power grid has strong power flow transferring capability and good voltage stability, which can withstand major natural disasters and various types of serious faults.
- Relying on UHV power grid, 500 kV gird gradually realizes reasonable zoning operation, and the short-circuit current level is controlled effectively.
- The State Grid maintains safe operation for a long time and has the ability to control the stability and operation of complex and large-scale power grids.

State Grid Security Level	2010	2012～2017
Normal system event	2	0
Normal equipment event	20	0

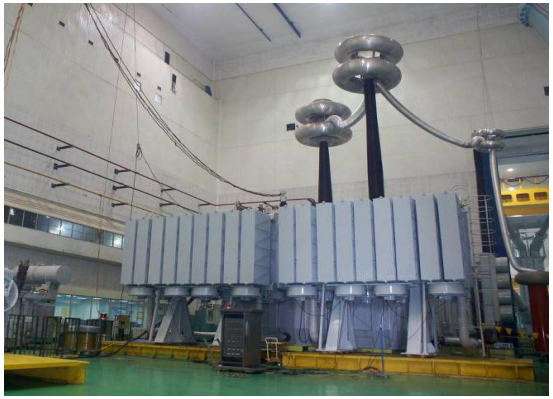
power supply reliability	2010	2017
urban network	99.906%	99.948%
rural network	99.636%	99.784%
urban network synthesis	99.751%	99.994%
rural network synthesis	97.477%	99.650%

Drive Upgrading of Electric Equipment Manufacturing Industry

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

- The success of UHV technology reversely feeds the development of conventional power equipment. The R&D and design capabilities, manufacturing capabilities, and test and detection capabilities of power equipment companies have been comprehensively improved.

UHV AC transformer



UHV AC shunt reactor

UHV AC shunt GIS circuit breaker

UHV AC series capacitors

UHV DC convertor transformer

UHV DC converter valve

UHV filter circuit breaker

UHV DC smoothing reactor

Contribute Chinese wisdom for international standards development

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

- SGCC has issued18 UHV international standards, 121 domestic standards, and 189 corporate standards.
- Yinbiao Shu, the Chairman of SGCC, served as the vice president of International Electrotechnical Commission (IEC)
- SGCC initiated the establishment of the IEC HVDC Technical Committee (TC115) and undertook the work of secretariat
- SGCC initiated the establishment of IEC UHV AC Transmission Technical Committee (TC122) and undertook the chairman

TC 115 Scope

Standardization in the field of HVDC Transmission technology above 100kV. The task includes HVDC system oriented standards as design aspects, technical requirements, construction and commissioning, reliability and availability, and operation and maintenance. Standards of HVDC equipment so far related to the system aspects will be prepared in close collaboration with the relevant Technical Committees and Subcommittees.

TC 122 Scope

Standardization in the field of AC transmission technology for highest voltage of the system exceeding 800 kV, particularly the preparation of systems-oriented specifications such as those for planning, design, technical requirements, construction, commissioning, reliability, availability, operation and maintenance. Development of processes for specifying requirements and demonstrating whether the required performance of UHV systems is assured. Responsibility for equipment standards remains with product TCs, except for specific equipment which is not within the scope of an existing TC but is nevertheless essential for the UHV transmission

IEC
Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

Dear Dr Shu

I am pleased to advise you that Council has approved your appointment as Vice-President of the IEC for a three-year term of office (2013-2015), with immediate effect. As the third Vice-President of the IEC, in addition to your wider contributions as an IEC Officer, your specific responsibilities are to lead both MSB membership renewal and the technology-watch effort.

The official results will be announced to the IEC community on Friday 18 January.

I look forward to welcoming you at your first ExCo meeting in Geneva next month and in the meantime I wish you a productive meeting with Dr Wucherer later this week.

Yours sincerely

F. W. P. Vreeswijk
General Secretary & CEO

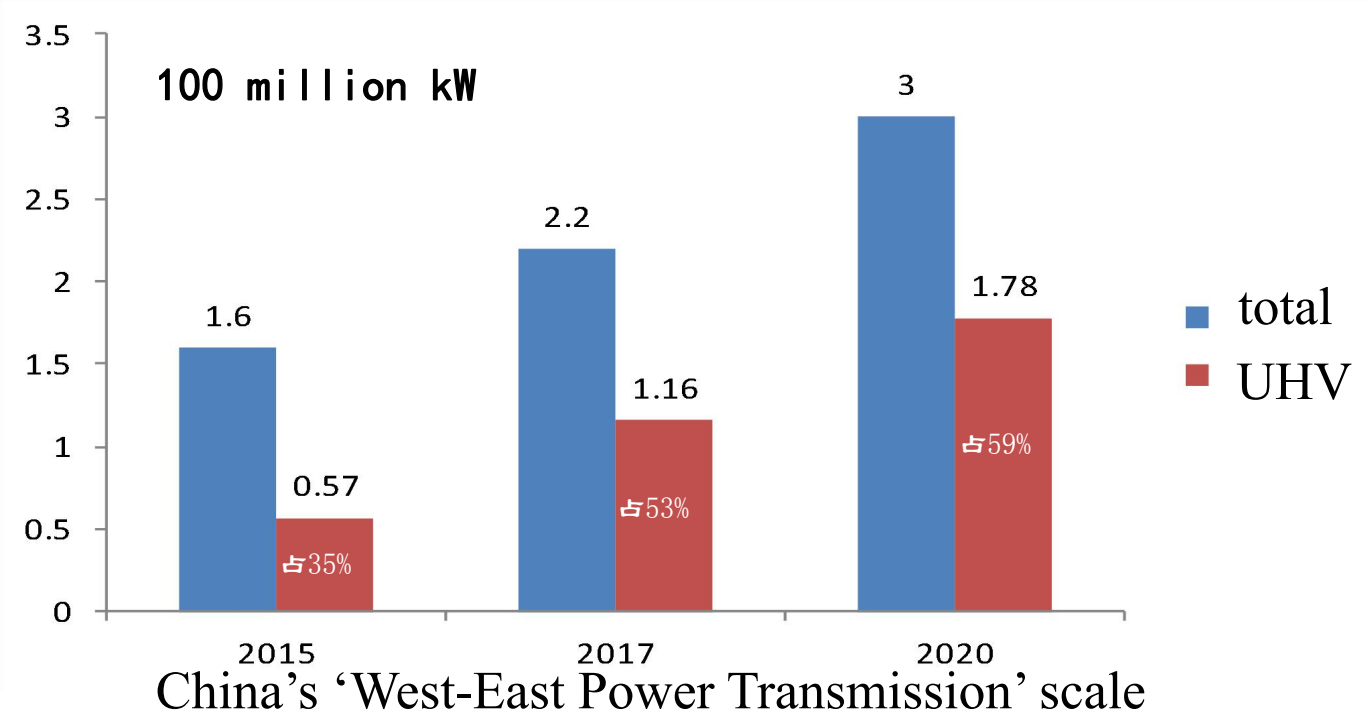
CATALOGUE

5. Development outlook

国家电网 STATE GRID
中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE

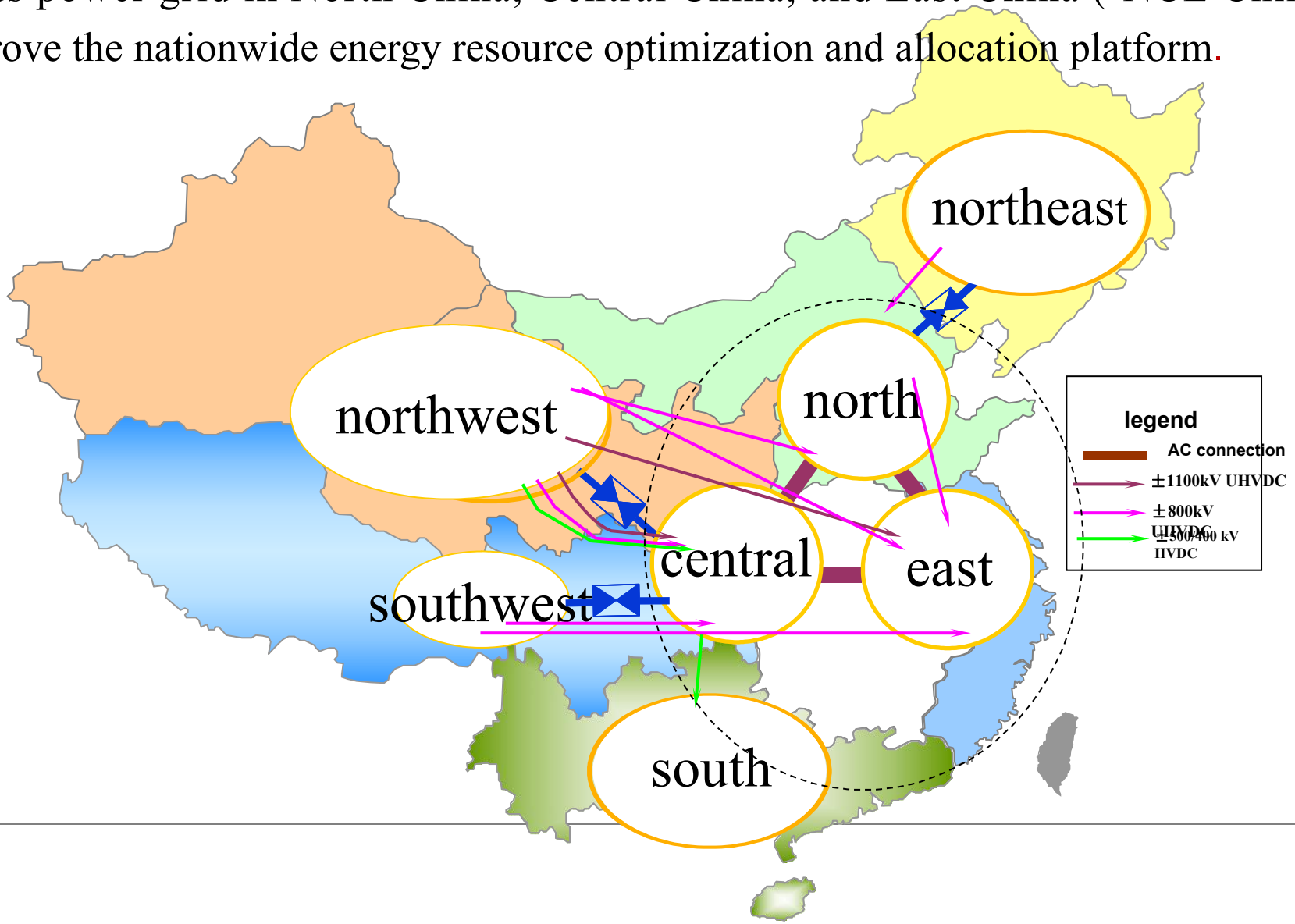
With the focus of China's energy resources development shifts to further westward and northward, and the power load demand grows continually, the scale of 'West-to-East Power Transmission' will be further expanded in the future.

- It is expected that by the year 2020, China's 'West-East Power Transmission' will have a scale of 300 million kilowatts, of which 178 million kilowatts will be delivered by UHV, which will support a clean energy generation capacity of 150 million kilowatts or more at the sending-end area.



China's 'West-East Power Transmission' scale

During the 'Thirteenth Five-Year Plan' period, we will accelerate the construction of a UHV synchronous power grid in North China, Central China, and East China ('NCE China'), and further improve the nationwide energy resource optimization and allocation platform.



The Chinese government proposes the development idea of ‘innovation, coordination, green, openness and sharing’. In the future, UHV AC/DC transmission technology will promote the optimization of allocation, industrial restructuring, transformation and upgrading of China’s energy industry, and play a more important role in building a clean, low-carbon, safe and efficient modern energy system.


THANKS