

# China Corner

## The Development of Ultrahigh Voltage Transmission System in China



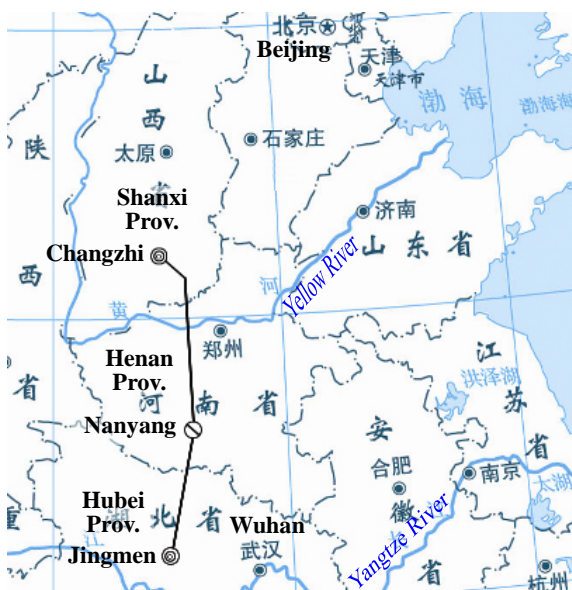
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### 1 Overall

Developing the ultrahigh voltage (UHV) transmission system with long transmission distance, large transmission capacity and low loss is a necessity for China in order to develop a coordinated society between energy consumption and economic development, which is beneficial to intensively develop the bases of large hydroelectric power, large coal-fired power and large nuclear power, to optimize the situation between energy production and consumption; is beneficial to convert the natural resource advantages in western region of China into economic advantages and to balance the economic development among different regions; is beneficial to improve the power grid structure, to enhance the security and reliability of power system, to reduce the construction costs of electrical grid, save land resources, alleviate the pressures from transmission and environment, to raise the efficiency of operation, to promote the construction of an energy conservation and environment friendly society. On the other hand, it is also an important opportunity to totally improve the manufacture level of related electrical equipment manufacture enterprises in China, to make more progresses in the manufacture techniques of equipments operated in UHV, to promote the manufacture

techniques of AC/DC equipments and enhance the international competitiveness.

Now, the 1000kV AC UHV demonstration test project from Southeastern Shanxi province via Nanyang (Henan province) to Jingmen (Hubei province) (as shown in Fig.1),  $\pm 800$ kV DC UHV demonstration test projects from Yunnan province to Guangdong province, from Xiangjiaba Dam (Sichuan province) to Shanghai (as shown in Fig.2) have been approved by National Development and Reform Commission.



**Fig. 1** The 1000kV AC UHV demonstration test project from Southeastern Shanxi province via Nanyang (Henan province) to Jingmen (Hubei province).

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**Fig.2** The construction ceremony of  $\pm 800$ kV DC UHV demonstration test project from Sichuan province to Shanghai, on 21 May, 2007.

“The Development and Demonstration Project of Ultrahigh Voltage Transmission and Transformation System” is in the charge of both State Grid Corporation of China and China Southern Power Grid Co., Ltd. On the basis of the demonstration test projects of AC UHV test line from Southeastern Shanxi province via Nanyang to Jingmen, DC UHV test lines in Golden Sand River (phase I) and DC UHV test lines from Yunnan to Guangdong province, the key techniques for electric transmission & transformation have been thoroughly studied and the related main equipments have been developed.

In order to make a thorough research on the various key techniques encountered in UHV projects, to construct the synchronized UHV power grid, to realize the planned program of long-distance and high capacity power transmission through UHV system, the State Grid have done a lot of preliminary works. The AC and DC UHV test bases were completed and put into operation on Feb. 2007 and Nov. 2007, respectively. In addition, the construction of Simulation Center of State Grid is also carried on according to plan. The establishment of all the bases and centers serves as a strong support for the development of UHV project. According to the overall plan of UHV project, the demonstration test project of AC UHV test line from Southeastern Shanxi province via Nanyang to

Jingmen will be completed in 2008 (as shown in Fig.3);  $\pm 800\text{kV}$  DC UHV demonstration test project from Xiangjiaba Dam to Shanghai will be put into production with one pole in 2011, and fully completed in 2012.



**Fig.3 Under construction of the demonstration test project of AC UHV test line from Southeastern Shanxi province via Nanyang to Jingmen.**

AC/DC UHV transmission and transformation engineering is a complex project, which needs full supports from many aspects, for example, project design, equipment manufacture and test, system operation, etc. China is featured by its large country area, which implies complicated operation conditions for power system and more difficulties for the construction of UHV projects. Especially, the specific conditions like high altitude, heavy contamination, ice coating, and high-intensity zones make more demands on materials and structure of the equipments; the increasing concerns on large equipment transportation, land conservation and environment protection require more creativity on the design. Different from Russia and Japan whose UHV transmission project is just limited to lines, the State Grid will establish an UHV framework, in which the reactive power, voltage control, security control of large scale AC/DC power grid and other problems affecting the operation of UHV transmission system should be carefully considered and solved.

The key technique problems encountered in AC 1000kV UHV transmission project include: analysis of UHV AC/DC mixed giant power system, overvoltage analysis and insulation coordination, high altitude and

heavy ice coating outdoor insulation, electromagnetic environment, designs and regulations on the main equipments, etc. The main equipments need to be developed in AC 1000kV UHV transmission project include: UHV AC gas insulation switch (GIS), transformer, reactor, arrester, capacitor voltage transformers (CVT), large bushing, etc.

On the other hand, the key technique problems encountered in DC  $\pm 800\text{kV}$  UHV transmission project include: the research and simulation of DC  $\pm 800\text{kV}$  transmission and its effects on power system, overvoltage analysis and insulation coordination, outdoor insulation (including high altitude) and electric corona, electromagnetic environment, software for system design, design regulations of the system, test regulations, handover and acceptance standards, common earthing pole, optimal design of controller parameters in main loops, etc. The main equipments need to be developed in DC  $\pm 800\text{kV}$  UHV transmission project include: 5 and 6 inch thyristor and valve set, converter transformer, dry type smoothing reactor, protection equipments for control system, outdoor insulation equipments, large brushing, etc.

## 2 The construction of test bases

### 2.1 UHV AC Test Base

On Feb.13<sup>th</sup>, 2007, the 1000kV AC UHV single circuit test lines was charged in Wuhan, Hubei province, which indicated that the AC UHV test base was formally put into operation, as shown in Fig.4.

The AC UHV test base includes UHV test lines, electromagnetic environment lab, UHV climate-control chamber, full scale voltage and large current test lab for equipments used in UHV, etc. In addition, the supports from over 50 domestic electrical equipment manufacture enterprises with their reliable products, like transformers, reactors and arresters, etc, greatly improve the UHV project and realize the localization of main equipments in UHV project.

Nowadays, the test base is featured by the following achievements: adjustable geometric size and optimal design of experimental lines; the comprehensive online monitoring of parameters under the condition such as lightning, contamination, ice coating or vibration, etc; comprehensive training of operation, overhaul, hot-line works in UHV project; the simultaneous measuring of electromagnetic environment in single-tower and double-tower test circuit; all-weather monitoring of electro-magnetic environment; highest level of voltage rating and capacity for power frequency resonant experiment, all of which indicate that the State Grid ranks the leading position in the UHV techniques worldwide.

With the aid of the test bases, a series of researches have been performed, for example, optimal design of UHV transmission and transformation lines, electromagnetic environment, operation conditions and status monitoring, outdoor insulation and training system, etc.



**Fig.4 Outdoor test field of UHV AC Test Base, in Wuhan, Hubei province.**

## 2.2 UHV DC Test Base

The UHV DC test base with an area of 80,000 m<sup>2</sup> was located in Changpingyuan of Zhongguancun Science and Technology Zone in Beijing and established by China Institute of Electric Power Research.

The DC UHV test base includes, outdoor lab for DC UHV surge test, DC UHV test lines, UHV test hall, DC UHV contamination and environment lab, DC UHV electromagnetic environment test lab, DC UHV corona cage and DC UHV equipment test lab, etc. The base is also the research and development base, test base, service base and training base of the State Grid for UHV project.

## 3 The function of UHV power grid

China will establish a power grid framework with a mixture of ultrahigh AC and DC voltage until 2010, whose main functions are listed below:

- i. The UHV main frameworks can be of help to realize the “West-East Electricity Transmission Project” and “Exchange Program of North Coal- Fired Power with South Hydropower” with a larger transmission capacity, longer transmission distance,

higher efficiency but lower loss. In addition, it will also optimize the allocation of resources in China;

- ii. AC UHV main frameworks are inherited with some benefits, like power grid function and flexible extensibility; are adaptable to the energy flows in the future, and are able to meet the changeable demands in power market, which will in turn definitely improve the development of power market;
- iii. UHV main frameworks can deal with the root of problems, like larger opening current due to higher energy density caused by the structure problems existed in 500kV power grid;

According to the power consumption prediction and installation program from 2010~2020 in China, China would form an AC UHV synchronized power grid, which will connect North China, Central China and East China regions. The coal-fired power bases located in west region of Inner Mongolia, Shaanxi province, southeast region of Shanxi province, west region of Inner Mongoli, and Ningxia province are transmitted to North/ South region through some main passages by UHV. On the other hand, part of the hydropower in Sichuan province will also be transmitted to east and central China through some east-oriented passages. In addition, certain support power supplies will be established in receive-side of east region, which is mainly designed to connect the nuclear power into UHV power system. In view of huge energy need, dissatisfactory coal transportation, limited environment capacity and rapid power grid development, it is most promising to develop the UHV technology in China.

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