

Research on Smart Grid in China

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Abstract—The Smart Grid is the latest direction for the future power system development. In this paper, firstly the background of Smart Grid, its meaning, as well as the concept and structure were presented. Typical diagram of Smart Grid was illustrated. Then, the current development of Smart Grid in United States and Europe were described, development ideas and the future trends in these countries were summarized and compared as well. Besides, the driving force of Smart Grid in China was analyzed, with detailed introduction of current related projects in China. The relation between the UHV Power Grid and the Smart Grid was discussed. Finally, the potential role of Smart Grid in future power grids in China was prospected and a new direction for China's Smart Grid development was charted.

Index Terms—Smart Grid, UHV power grid, planning, operation, management

I. INTRODUCTION

With the promotion of world economy modernization, the price of oil has been kept on an upward trend. What is also noticeable is the shortage of energy supply around the world, the increasing pressures on resources and environment pressure, and the enormous power losses in energy delivery due to the low efficiency of the current power grid. What's more, owing to the growing electricity demands and the users' increasing requirements for reliability and quality, the power industry is now facing unprecedented challenges and opportunities. Therefore, a new sort of power system of environment friendly, economic, high performance, low investment, safety, reliability and flexibility has been a goal of engineers in power industry.

Still, the emergence of advanced meter infrastructure and more extensive usage of the Internet accelerate the process [1]. Since 1990's, with the increasing use of distributed generation power, more demands and requirements have been proposed for power grid intensity [2], [3]. To find out an optimal solution for these problems, power companies should accept the idea of new technology adoption, potential mining of the existing power system and improvement of its application and utilization. Consensus has been reached by experts and scholars from different countries that future power grid must be able to meet various requirements of energy generating and the demands of highly market-oriented power transaction so that the needs of the self-selection from customers can be satisfied individually. All of these will become the future development direction of Smart Grid.

This paper focuses on the status of the development of the Smart Grid, analyzing the driving force of the Smart Grid and introducing the current demonstration projects in China. It

also discusses the relation between UHV power grid and Smart Grid, and then prospect the significance of Smart Grid in the future. A new direction for Chinese Smart Grid development is charted as well, which might be the reference for the development of Smart Grid in China.

II. CONCEPT OF SMART GRID

Smart Grid is a gradual development process accompanied with the technology innovation, demands of energy saving and managements needs. People will have their own understanding for Smart Grid, no matter if they are facility suppliers, IT companies, consulting firms, public power companies or power generation companies. From the earlier smart intelligence metering to electrical intelligence, from transmission and distribution automation to a whole intelligent process, the concept of smart power grid has been enriched substantially [4]. In 2006, US IBM presented a "Smart Grid" solution. This is a relatively complete concept for current Smart Grid which indicates its official birth [5].

As shown in Fig.1, a Smart Grid is basically overlaying the physical power system with an information system which links a variety of equipments and assets together with sensors to form a customer service platform. It allows the utility and consumers to constantly monitor and adjust electricity use. The management of operation will be more intelligent and scientific based on the dynamic analysis of needs both from user-side and demand side which can increase capital investment efficiency due to tighter design limits and optimized use of grid assets.

In comparison with traditional grid, Smart Grid includes integrated communication systems, advanced Sensing, metering, measurement infrastructure, complete decision support and human interfaces.

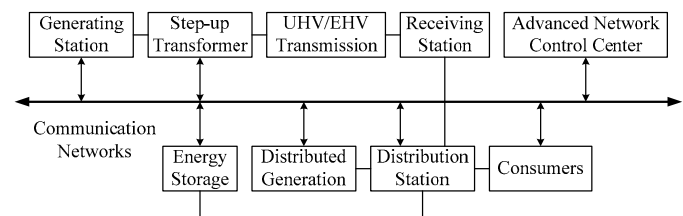


Fig.1. Smart Grid Conceptual Diagram

III. CURRENT RESEARCH ACTIVITIES

A. Comparison of researches in Smart Grid area between European and the United states

In the United States, there were several large power

outages in recent years. Because of which, electric power industry pays closer attention to power quality and reliability; customers draw out more requests for electricity supply. The ever-increasing demands of national security and environmental protection policy of the United States leads to the establishment of a higher standard for power grid construction and management [6]. At the same time, in recent years' researches of basic materials, power and information technologies, breakthroughs have been achieved for implementation target which shows the significant improvement of reliability, efficiency in power network. Such as the emergence of superconducting cables, it assures Obama's new government of United States has seen the daylights of the Smart Grid.

Similarly, the European power users also raise higher requirements for electricity supply & power quality [7]. Because of the extreme attention for environmental protection, compared with the construction of power grid in US, Europeans have more concerns about the construction of renewable energy access, the impact on wildlife, as well as the actively research on real-time monitoring and remote-controlling. All is about to realize the "Plug & Play use" idea, ensuring a more friendly, flexible access and interaction with the user. In both Europe and United States, the most common direction for grid development is to seek new and renewable sources for energy generation. However, Smart Grid is not a fixed, static project, according to their particular status and main problems, all countries need to simplify the Smart Grid and make it adjusted to fit their own features.

B. Driving force of the Smart Grid in China

The drivers for Smart Grid construction can be concluded into market, circumstances, safety and power quality. Chinese power industry is also facing the similar situation as in Europe and the United States:

At Market-oriented reforms level, the national network and unified national electricity market has not completely formed. In national wide, power exchanges are not effective; neither does the true meaning of the online bidding. From a long term view, China's transaction approaches of power markets and pricing structure is developing, market demand and supply sides will have more frequent interactions. In order to attract more users to join the market competition, power companies must improve their service, strengthen the interaction with users and provide more products for selection, so as to meet the demands of different types of users.

At the macro policy level, the power industry needs to meet the requirements of resource-saving and environment-friendly society's construction, adapt to climate change and suitable for sustainable development.

Regarding the Chinese power grid itself, a strong backbone network has not been built yet, and it is still not strong enough to withstand multiple faults circumstances. The regional power grid backbone is also in a lower stability level, which results in a limited flexibility for system operation, etc. The snow storm weather in early 2008 which led to a blackout in

major area of China vividly exposed the weakness of the current Chinese grid in safeguard of electricity supply aspect. Moreover, the lack of intelligent power distribution leads to a regional, seasonal shortage of electricity and coexistent in some areas with both surplus & shortages of electricity.

There still remain challenges that how to improve the efficiency of power investment and construction, how to ensure the security and reliability of power grid's operation, to ensure power quality; how to improve the maintenance of power system; how to enhance the service quality to users, as well as how to improve the power grid management in China. For these issues, Smart Grid would be an ideal solution.

C. Current research activities in China

In the year of 2006, IBM published the guideline named 'Establishing Smart Power Grid and Innovating Management Methods – A New Thought of the Development of Electric in China'. Directed at the current opportunities and challenges of the power grid companies in China, the guideline suggests improving the efficiency of electrical investments and construction, the stability of power grid, and the companies' service and management level through the construction of smart power grid and the innovation of management methods.

Meanwhile, IBM proposed that it can provide a whole scheme - Solution Architecture for Energy (SAFT) for the power companies in China to use the smart power grid effectively. SAFT contains several parts: first is to improve the digital level by connecting the equipments with sensors; Second is to establish the data collecting and integrating system; Third is to analyze: SAFT optimize the operating progress and management based on the analyzing of the data[5]. This is the bud of smart power grid in China.

In October 2007, East China Power Grid Company embarked on the research area of the feasibility of smart power grid. The research project was not only correlated with the progress of those advanced companies and research facilities abroad, but also take the current situation and future needs of east china power grid into consideration. The result came out as, based on the high equipment level and strong technological innovation ability, the construction of smart power grid is feasible in east china power grid. East China Power Grid Company would follow the belief that 'Concerning the future and change fast with needs, and providing high quality service', when building smart power grid. There is a three step strategy with an advanced power grid distributing center built by 2010, the construction of digital power grid with primary intelligence completed by 2020, and a smart power grid with the ability of self-healing built by 2030 [8]. The construction plan is still under consideration.

On Feb. 28, 2009, as a part of the smart power grid of East China Power Grid Company, the three-state security defense and power generation monitoring system passed the acceptance check in Beijing, which stands for stable-state, transient-state and dynamic-state. The system integrated three single systems altogether for the first time, which includes

power management system, power grid dynamic wan monitor system and online stability analysis and warning system. The operator has full access to the whole view of the power grid operating situation and the decision-making assistance without switching in systems or platforms. Besides, the system can effectively improve the management standardization and the level of flow of the related power plants through establishing the management checking platform and the assistance market-service quality analyzing platform.

The development of smart power grid research in China is slow and far behind the west. So far, only East China Power Grid Company and North China Power Grid Company have carried out researches about the developing and implementation plan. It is a tradition for China to emphasize technology development, and in fact, the equipments in China are more advanced than those in developed countries. Thus, smart power grid has a bright prospect in China.

IV. PROSPECTS OF SMART GRID IN CHINA

In order to solve the problems of imbalance distribution for generation resources and power loads, the transmission capacity should be enhanced by building long-distance and large-capacity power transmission systems. And unity or united UHV power grids should be constructed under coordinated plan. The transmission of power on a large scale from west and north China to middle and east China can reduce the pressure of energy in the east China and the pressure of transmission and environmental protection. Furthermore, this can expedite the conversion from resource advantage to economy advantage and realize the coordinated development of nation economy. Chinese politics system, economic environment and management system also promotes UHV power grids in its development. At present, China is studying the future large power grids technology and has the ability to construct the national united power grids. On Jan, 16, 2009, the first UHV power line in China was finished and put into operation.

Unity or united UHV power grid, distributed power generating or scattered interactive power supplying grid are the trends of development. China, as the delegate in unity or united UHV power grid development trend, is different from any western countries. In China, is it in contradiction to develop both UHV power grid and Smart Grid? Though the large power grid with linkage effect has the advantage of optimizing the resources, it has the potential risk of power outage in large area. The ability to control the large power grid and maintain its stability is required by the fast development of power grid. And the smart power grid with self-healing and high reliability matches such requirements. Thus, smart power grid is the direction of China power grid development while building UHV power grid and the grid of different level, as well as improving the operating and management level of the grid.

According to the precondition and the background of UHV power grid development in current China, the aspects which should be paid more attention on are as follows:

- Smart Planning: The power grid should become self-healing and smart. The ability of power grid planning optimization should be enhanced. So should be the ability of receive-side power grid planning, on the premise of the UHV AC/ DC feed-in and different voltage level coordinated development. The most important thing is to change the concepts and methods of power planning, and to make the traditional power development concept such like regarding building new power stations as a wide-ranging concept of resources distribution.
- Smart Operation: The dispatching pattern is developing towards a coordinated control direction, aiming at the enhancement of control and mastering of large power grid. The future Smart Grid should be coordinated with a matching control center equipped with more advanced power system management ability, for the purpose of improving the functions and performance of existing EMS, MOS, WAMMAP system in an integral manner, at the same time to track down the correlations between different power grid monitoring and controlling indexes, and to construct a logic structure based power system monitoring and controlling index system. Through the gradual process of implementation of dynamic security monitoring, power system pre-alarm processing and pre-control, much more accurate and comprehensive knowledge of the operation state of the power system can be obtained, based on which, the most effective and timely measures and actions can be taken to fulfill the power system control and dispatching strategy, finally to improve the safeguard of the whole power system's stability and security.
- Smart Management: The management pattern of power system is undergoing an evolution from vertical mode to distributed mode, from function management to process management, from grid construction to both construction and operation modes.

V. CONCLUSION

Smart Grid is a hot spot in today's electric power system, also regarded as one of the vanes in 21st century for the major scientific and technological innovation and development in power system. Many countries in the world are involved in this big trend, and have set up a lot of Smart Grid demonstration projects and test platforms. Also, the theoretical and experimental research in Smart Grid has made some achievements. The international exchanges have greatly promoted the development of Smart Grid. Because of China's electricity distribution and extremely uneven distribution of electricity load, it is the right time to develop special high-voltage power grid. As the development of Smart Grid is still at the very beginning stage of our country, how to combine the special high-voltage power grids with intelligent power grid is the main problem confronted. The direction to development and the characteristics of smart power grids in China are still open for our experts and scholars for further

study.

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VII. BIOGRAPHIES



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