Construct Power Main Grid into a Railgrid

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Abstract. This paper briefly analyzes the problems existing in the current power system, and puts forward the fundamental measures to solve the problems: from five aspects, to reconstruct and rebuild Power Main Grid into a RAILGRID. Meanwhile, puts forward that the power system should go back to the most basic functions, and transform the most basic transmission mode of electricity and electric energy. The goal is fundamentally to solve the problems of security and stability of ultra-large capacity power grid and energy interconnection power grid.

1. Problems
The power system shall ensure the safe and reliable, economic and energy saving, environmental protection and low-carbon transmission of electric power in the grid. It also should ensure the safe, stable and economic operation of Power Main Grid.

With the increasing power grid capacity, the grade of transmission voltage keeps improving, the physical range of the grid is getting bigger and bigger, and the grid is becoming even more complex. It is required to transport big hydropower, big coal power, big nuclear power, large-scale renewable energy cross-region, long-distance, large-capacity, low-loss, and high-efficiency, so as to improve interregional power exchange ability. Therefore, power system safety operation risk is more serious, and power grid’s instability and uncontrollable factors are increasing day by day.

In terms of power generation, the randomness and volatility of solar energy and wind energy affect the safety and stability of power grid.

In terms of transmission, while increasing the transmission capacity and voltage level, it will bring some new problems such as power flow control and power quality. The power grid protective system protect the inside without protecting the outside; Power islands are frequently emerging. The soft adaptability of transmission network is poor.

From the perspective of transformers and power distribution equipment, the secondary equipment intelligence is not high, and the first and second cooperation and response is not timely and accurate. The first and second equipment integration has a long way to go. Some equipment is running at full capacity for a long time due to increasing load. Power grid accidents remain high due to electrical equipment failures, and they account for about half of all grid accidents.

In terms of distribution, the framework of distribution network is not stable, the network structure is weak, and the capacity is relatively insufficient. Intelligence degree of distribution network is low and its automation foundation is not solid. Distributed power access technology is far from maturity.

In terms of power utilization, the power supply reliability for low voltage distribution grid is not high, the line loss rate remains high, the voltage quality is not high, the design standard of residential power
supply system is low, the new power load is complex and variable and the response of the whole power system to the power demand side is sluggish and distorted.

From the perspective of safety and human factors, Safety management focuses on form, managers attach importance to the improvement of "safety consciousness" instead of enhancement of "security guarantee capability". Inspection is not in place and defect elimination is not timely. Many people involved in electricity do not really grasp the basic laws and characteristics of electricity. The phenomenon of electrical mis-operation, mis-touch and electric shock occurs from time to time.

2. Definition of Railgrid

Railgrid, is a special transport channel of electrical energy with large capacity and high efficiency, which is specially built and free from outside interference so as to ensure the safe and stable, efficient and environmentally friendly operation of the power grid. This special channel for electric current transportation, like traffic rails in railway transportation, can ensure the safe passage of traffic flow at high speeds, so it is called Railgrid.

Railgrid, has five main characteristics: without "trauma", without "branches", without low-voltage distribution, with low loss and with special protection.

3. Measures

Mainly based on the viewpoint of "System Theory" and the method of function analysis, this paper thinks, in the long run, from now on, to research and plan, and to reconstruct and rebuild the next-generation power grid into a RAILGRID with the following five characteristics, is the fundamental approach to solving the problem of large power grid capacity, and ensuring the safety, stability and efficient operation of Power Main Grid, when the future grid expansion approaches saturation.

3.1. Build Power Main Grid into a "Healthy Grid" without "trauma"

Power system’s control, protection and measurement are not of contact and insertion, but of non-contact, so that Power Main Grid is a highway for the transmission of electricity, in order that the grid plays a pivotal role in energy collection and transmission.

Because it can be traced directly to physical constants, the valuation transfer system based on quantum measurement technology greatly reduces the levels of measurement standard transfer, and even can directly take the measurements under the environmental conditions of engineering survey site. With the continuous development of quantum application technology, the chip sensor based on quantum measurement will be developed in the future, it has the characteristics of small volume, high precision and many measuring parameters, and can be embedded directly into electrical equipment. As a leading technology with basic support and guidance, quantum technology, especially quantum precision measurement technology, greatly promotes the development of electric power measurement and control technology.

Terminal current/voltage or terminal load identification technology is a kind of advanced technologies in which for energy providers or power consumers connected on the power grid or on Power Main Grid, especially for power loads, pattern recognition algorithms are used, to decompose load components, so as to judge the type of the source, load and energy-storing, to determine the kind of power load, and to realize fine management such as item measurement. The point is that the technology has no impact on the power grid.

With the rapid development of sensor technology, wireless measurement and control technology and material microstructure and properties, people are fully capable of "non-contact" and "long-distance" monitoring, measurement, regulation, control and protection of the power grid. It is no longer a dream to build a clear, healthy grid from the current "scarred" one.

3.2. Build Power Main Grid into a "One-way Grid" without "branches"
Comb and simplify transmission and distribution network, reduce voltage classes, enhance Supply Voltage, increase the way of the direct power supply, cut down the power transforming obstacles, and build Power Main Grid into a "One-way Grid" without "branches".

Energy interconnection is leading a new energy revolution. The more energy interconnection, the more to ensure "the security and stability of Power Main Grid".

Actively explore the practice of "decentralization of energy production". With the development of distributed energy, future power system terminals will become prosumers who are actively involved in the operation of the power system by means of consuming, producing, and storing electricity, from pure-consumers who consume only electricity. These will lead to the decentralization of energy production.

3.3. Build Power Main Grid into a "Higher-voltage Grid" with less power distribution
We will vigorously develop renewable energy sources for power generation, actively support the integration of distributed renewable energy power generation and electricity consumption, and deeply study micro-grid technology and application, so as to promote the maturity and standardization of micro-grid and virtual power plant construction. Strive to realize the localization of low-voltage distribution.

Sustainable energy development and distributed energy system all need the support of energy storage technology. Energy storage will provide guarantee for decompression, flexibility and stability of power grid. At present, energy storage technology enters a "plateau period". Support and investment in energy storage technology should be increased, so as to promote the development and application of high power, high energy density, mobile, load response, long life, high reliability energy storage system.

Power generation system for power grid to keep dynamically stable, can locally and adaptively track the output characteristics of wind and photovoltaic power generation, and maintain the dynamic balance of power and the dynamically safe and stable operation of power system, by means of remote control through high-speed digital communication network.

Strengthen the research on wireless power transmission technology and accelerate the application of wireless power transmission technology so as to reserve developing space for future low-voltage, high-power, long-distance and wireless power distribution.

3.4. Build Power Main Grid into a “Efficient Grid” with low loss
Deeply study the principle of nerve cell bioelectricity, and use bionics, in order to build Power Main Grid into an efficient and energy-saving power grid.

Under the new power grid architecture, the principle of power grid loss is deeply studied, and the problem of high loss on power grid is thoroughly solved.

Nano-technology will be used to transfer electric energy through nano-materials, improve voltage quality and reduce line loss.

Strengthen the practical research on low-temperature superconductivity technology, break through the technical "bottleneck", and fundamentally solve the problem of power grid loss. In the near future, will high-voltage power transmission still be necessary? Will there be any need for all the transformer equipment?

3.5. Build Power Main Grid into a "Strong Grid" with special protection
The safety of power grid is the foundation of power system safety. The power input mode and power export mode of power grid should be standardized.

Power sources mainly include thermal power, hydropower, wind power, nuclear power, solar energy, biological energy, tidal power, etc. The standardized entrance of power supply to the power grid should be established to ensure the safety, stability and robustness of the transmission and distribution grid.

Strengthen the research and prediction of power load, master the changing load law of power system, establish a hierarchical comprehensive virtual energy efficiency power plant model including new types of loads for example, electric vehicles, etc. so as to improve the accuracy of load prediction. Meanwhile, based on current/voltage elements, the research on mathematical model and modeling technology of
power load should be strengthened. Taking ideal components such as pure resistance, pure inductance and pure capacitance as independent variables, the electrical characteristics of power load are studied emphatically. Finally, for the purpose of being harmless to the power grid, unify the way to power users getting power from the grid and ensure the safety and stability of Power Main Grid.

Develop and apply the Digital Twin technique, accelerate the construction and development of the digital Power Main Grid, which is equal to the physical power grid, realize the organic integration and positive interaction between the digital power grid and the physical power grid, in order to achieve the goal of better serving the security and robustness of physical Power Main Grid.

4. Mission & Vision
To build Power Main Grid into an "Entirely-new Grid" with a completely different way of transmitting electricity, is the long-term mission and big vision of power workers. Meanwhile, it is also testing our abilities of predicting and planning the future of the grid.

As we all know, the most basic function of power system is energy transmission. Transform the most basic transmission mode of electricity and electric energy, achieve the "return to basics" of the power system rather than "getting the glittering casket and returning the jewels", really go back to the most basic functions of the power system, and in the long run, fundamentally solve the problem of power system safety and stability.

Displacement current and conduction current are two different ways of transmitting energy. First of all, conduction current is caused by the directional motion of electric charges in a conductor, while displacement current is essentially a changing electric field, independent of the directional motion of charges. Therefore, Conduction currents occur only in conductors with free charges, while the displacement current doesn't depend on the free charges. Wherever there is a varying electric field, a corresponding displacement current is generated. Therefore, displacement current can exist in conductor, medium and vacuum. Second, when conduction current through a conductor, it produces Joule heat, while displacement currents, which move without charges, do not normally produce joule heat. But displacement currents in the medium cause bound charges to move, and heat can also be produced. In particular, under the action of high-frequency alternating electric field, the polarization direction of polar molecules changes dramatically, and the energy of directional polarization of molecules is transformed into the energy of irregular thermal motion. Thermal effect can also be produced, but Joule's law is not obeyed.

Nature has a lot of carriers of charges, such as movable electrons in a conductor, ions in an electrolyte, electrons and ions in a plasma, quarks in a hadron. The movement of these charges-carriers creates an electric current and transfers energy.

Deeply study the most basic principles of power transmission, comply with the law of power industry reform, lay a solid theoretical foundation for the reconstruction and rebuilding of the future power system, and build Power Main Grid into a completely new generation of electricity transmission network.

5. Conclusion
At present, we need to increase the proportion of electricity in terminal energy consumption, reduce the use of coal as a terminal energy source and gradually optimize the energy structure of power generation. That is, to optimize thermal power generation, vigorously develop hydropower, appropriately build nuclear power, and actively develop and apply new energy sources such as wind, tidal and solar energy, so as to realize the diversification of power generation energy, and realize the replacement of clean energy and electric energy.

In the future, the power system will face "three higher and one more": higher proportion of renewable energy; higher proportion of power electronic equipment; higher capacity without boundaries; comprehensive energy sources where more kinds of energy sources complement each other.

How do we ensure the safe and stable operation of power system? The fundamental way to solve the above problems is to reconstruct and rebuild the power system, especially Power Main Grid, and build the future power grid into "RAILGRID".
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