Research on Implementation Methods of Power Grid Technology Supporting Energy Internet Construction

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Abstract. The energy Internet is a complex multi-grid flow system, which is based on the power system, the Internet and other cutting-edge information technologies, with distributed renewable energy as the main primary energy and closely coupled with natural gas network, transportation network and other systems. The power grid technology has to develop to support the energy Internet construction. This paper discusses the changes and challenges in the asset environment, asset types, asset scope and asset risk under the energy Internet. Then the corresponding implementation methods of power grid technology to supporting energy Internet construction are put forward. The research results can provide reference for power grid companies to implement power technical innovation.

Keywords: Energy Internet; power grid innovation; power grid asset.

1. Introduction

The traditional economic development model of non-renewable energy consumption is gradually changing, and the extensive application of new energy and Internet technologies is a harbinger of the third industrial revolution. In this background, national grid, puts forward the concept of "global energy on the Internet", points out that global energy by multinational across continents Internet backbone network frame and cover grid voltage level all over the world countries in the smart grid structure, connect a "a" and the state big energy base, meet the needs of all kinds of distributed power supply access, to be able to clean energy such as wind energy, solar energy, oceanic energy to all types of users, is the "wide range of services, configuration ability, high safety and reliability, green low carbon global energy configuration platform[1].

The energy Internet is a complex multi-grid flow system, which is based on the power system, the Internet and other cutting-edge information technologies, with distributed renewable energy as the main primary energy and closely coupled with natural gas network, transportation network and other systems. For China's power grid enterprises, to participate in the construction of the energy Internet is not only to achieve a simple technical upgrade, but also to complete a "complete transformation". At present, in order to realize the comprehensive optimization of safety, efficiency and cost of assets within the life cycle and better realize enterprise value and mission, power grid enterprises are vigorously carrying out
research and practice on the life cycle management of assets. With the continuous improvement of global energy Internet, how will the future grid enterprises adjust the strategy of asset life cycle management? This is an urgent problem for us to study.

2. Basic concepts, architecture and composition of the energy Internet

In the third industrial revolution, published in 2012, the American author Jeremy Rifkin put forward the vision of energy Internet. By combining new Internet communication technologies with energy systems, we can create a complex multi-grid flow system with renewable energy systems, transportation systems and communication systems complementing each other and integrating organically. Reginf thinks the energy Internet system should contain the following five connotations[2].

- Support the shift of fossil fuel energy to green renewable energy.
- Buildings as power plants support access to large-scale distributed power.
- Support large scale storage technologies.
- Transformation of power system by Internet technology.
- Supporting the transition to electrified traffic.

Based on Rifkin's vision of energy Internet, experts and scholars from relevant universities, research institutions and professionals in the industry give a preliminary definition of energy Internet. The energy Internet is a complex multi-grid flow system, which is based on the power system, the Internet and other cutting-edge information technologies, with distributed renewable energy as the main primary energy and closely coupled with natural gas network, transportation network and other systems[3].

The basic architecture and constituent elements of the energy Internet are shown in figure 1. In figure 1, the red, light green, and light blue arrows represent energy flow, information flow, and traffic flow, respectively.

![Fig.1 Basic structure and constituent elements of the energy Internet](image)

As can be seen from figure 1, energy Internet is mainly composed of four complex networks, including power system, Internet, transportation network and natural gas network. Among them, the power system is the core of the energy Internet as the hub of the transformation of other energy networks. Various physical devices in the power system, especially the transmission and distribution equipment, play an important role in the interconnected integration of distributed power supplies, energy storage, controllable loads and electric vehicles with external systems such as transportation, natural gas and Internet, and need to be coordinated and controlled through a powerful information network. Along with the further development and deepening of the concept of smart grid, power grid enterprise information management system of physical assets level increased significantly, but with external systems integration, large power grid data applications, the core physical assets Internet and mobile interconnection between inner and outer net and so on are still at the experimental study, the energy of the Internet environment, power grid companies face scope of the external environment, asset management, asset management, asset management, risk change brings all sorts of challenges.

In view of the above three challenges, this paper will collect the latest research results in the smart grid field of state grid corporation of China, and put forward corresponding countermeasures from the perspective of information management of the whole life cycle of assets.
3. The challenge brought by the change of asset management environment and its countermeasures

Due to historical reasons, the current asset life cycle management of power grid enterprises is carried out in a relatively closed environment, and the internal environmental factors influencing the asset management activities are mainly the internal environmental factors. In the context of future energy Internet, the asset life-cycle management of grid enterprises will be carried out in a more open environment, and the asset management activities will face many new external environmental factors. It is mainly reflected in the following aspects:

First, the number and type of external systems connected to grid transmission and distribution systems will increase. At present, it is simple to connect the front end of the transmission and distribution system with the external part, mainly the power generation system of domestic power production enterprises (some power generation systems are owned by the grid enterprises themselves), while the back end is directly facing users. In the context of energy Internet, in addition to the local traditional power generation system, external systems connected with the power transmission and distribution system of grid enterprises will also include large energy production systems overseas, domestic distributed clean energy (wind, solar, Marine energy, etc.) systems, as well as household, building and community energy management systems.

Second, external partners of grid companies will increase. At present, the external partners of grid enterprises are mainly domestic traditional power generation enterprises, equipment providers, engineering outsourcing enterprises and so on. Energy under the background of the Internet, power grid enterprises outside partners in addition to the above companies, distribution within the territory will include foreign energy companies, enterprises, according to "let go two head, hold" reform train of thought, some distribution services will be provided by outside power grid enterprises, sell electricity enterprises, distributed energy, and even power users, this is because, some users might not be electricity users, or power producers, storage, electricity to power grid enterprises already, also sell electricity to power grid enterprises.

Third, power grid enterprises will explore strange foreign development space. China is a world leader in uhv technology and will make full use of its advantages to go abroad and seek for overseas expansion in the construction and operation of future energy Internet.

Fourth, grid companies' competitors will really emerge. At present, China's power grid enterprises have a monopoly position in China due to historical reasons. The state council's new power plan[4], reoriented the power grid function and power grid revenue mechanism, and also laid a policy foundation for the construction of energy Internet. Therefore, in the context of energy Internet, some competitors of grid enterprises will gradually emerge. Their gradual strength will motivate grid enterprises to reduce costs and increase efficiency.

The above situation makes the environment of life cycle management of assets of grid enterprises more complicated. To adapt to this more complex environment, we should adopt the following countermeasures:

One is to constantly adjust the objectives, strategies and plans of asset management. The environment is the basis for determining the asset management goals, strategies and plans of power grid enterprises. According to the expansion process of the interconnection scope, the energy Internet can be divided into three stages of development, namely inter-continent interconnection stage, inter-continent interconnection stage and global interconnection stage[5].In these three stages, the development environment faced by power grid enterprises must be significantly different, and the goals, strategies and plans of asset management should be adjusted accordingly to protect the realization of enterprise strategic goals.

Second, optimize the organizational structure of asset management. In order to adapt to the changing environment, when optimizing the assets management organizational structure of power grid enterprises, it is necessary to make them have the characteristics of extroversion, service type and competition type. The so-called export-oriented feature refers to that the organizational structure of asset management is conducive to the external coordination of power grid enterprises. According to the new demand of
external coordination, the responsibilities and authorities of relevant departments are expanded
to provide the basis for them to carry out the external coordination work. Service characteristics, in which
assets management is advantageous to the power grid in the organizational structure of enterprises to
provide a deeper service, on the basis of the existing power supply services, with the "interconnectivity"
as the goal, to provide the corresponding services, such as small power systems into the net to provide
more convenient conditions, provide real-time grid data for power distribution and sell electricity
enterprises, etc. Having competitive characteristics means that the organizational structure of asset
management is conducive to improving the market competitiveness of grid enterprises. By carrying out
the cost control of the whole life cycle of assets, the benefits of assets can be improved, so that
enterprises can participate in the market competition with more internal vitality.

Third, strengthen the monitoring and analysis of the asset management environment. Through
various means, real-time monitoring of power grid enterprise asset management activities have
important influence on external conditions, such as using various sensors, the ITC system connected to
electric power transmission and distribution system for the operation of the external system data, the use
of public media, the third party (power grid enterprise with information exchange cooperation partner)
the system reflects the operation of the natural, economic, political, environmental and other data. After
obtaining the above data, it USES big data analysis technology to comprehensively analyze the impact
of various environmental factors on the asset management activities of power grid enterprises, so as to
provide a basis for leadership decision-making.

Fourthly, foreign factors should be emphasized in the evaluation of asset management compliance.
Analysis study, regional power grid enterprises overseas in countries in politics, culture, laws,
regulations and other requirements, such as in the aspect of environmental protection, safety in some
countries and regions of the demand is higher, is in some countries and regions in the energy security is
relatively sensitive, these are all we should consider when making compliance evaluation scale factor.

4. The challenge brought by the change of asset management mode and its countermeasures

Electric power system is the core of the energy Internet, objective aspect asset management
informationization, intelligent management of power grids put forward high request, the traditional
information management system of power grid assets in wide-area data sharing and business integration
of the Internet also has many insufficient, system barriers to internal professional entrenched, mainly
embodied in the following aspects:

Firstly, there is a lack of unified identity coding in all aspects of the whole life cycle of assets, and
the piecewise management makes it difficult to trace the information of the whole process of assets. At
the same time, it is difficult to share the information of each link of assets effectively, and it is difficult
to obtain the equipment load, operation and maintenance cost and other information after the network
investment in power network planning. It is difficult to obtain the reference information of defects, faults
and costs of daily operation and inspection by bidding and purchasing, which is not conducive to
scientific evaluation of suppliers.

Secondly, because difference of professional management, "project code, the WBS code, materiel
code, equipment code, assets code" differs from one information system, the stages of the same kind
equipment information is scattered in different systems, and the equipment coding standard, system data
integration sharing is difficult, requires a large amount of data verification matching work, ERP system
as a core business data systems, lack of the equipment and the material code coding relationship, "five
yards" linkage of information sharing, query, check there is a problem.

Third, with the research in the field of smart grid, since much starker choices-and graver
consequences-in form such as camp with adjustable control, integration of line loss, power quality online
monitoring data sharing and business integration research achievements, but in the big data, cloud
computing, Internet and mobile Internet, wide area new Internet technology application is less, the
energy information and system integration support for the development of the Internet.

Energy Internet background grid assets management mode must be from the traditional horizontal
industrial network system to integration with external Internet coupling way, along with the deepening
of national grid assets management system, its information technology research and development institutions, such as Electric Power Research Institute has been exploring the use of informationization means to support the energy Internet fall to the ground, the author summarizes the pilot application of some new achievements, to solve above problems gives the following countermeasures:

One is to popularize and apply unified identity code construction of grid assets. Through the use of iot information technologies such as qr codes and RFID, a standardized and practical coding system is formed to solve the problem that data sharing and business integration cannot be achieved in the five types of coding in the information system of various stages caused by professional management differences. At the same time, the application mechanism of equipment identity code in the whole life cycle of planning, procurement, implementation, operation and retirement is studied. By establishing a unified identity code (material object ID), the whole process of identifying and tracking the real assets is realized by using equipment and technology such as RFID and mobile intelligent terminal. 

The architecture design of unified identity coding system for grid assets is shown in figure 2. In figure 2, the device identity code is referred to as "GUID", which means the unified device identity.

The second is to build a modern (intelligent) supply chain for grid assets based on mobile Internet. With the life cycle management of assets as the main line, we will integrate the upstream and downstream resources of the supply chain and make full use of modern information technologies such as big cloud, things moving and intelligent to build a modern (intelligent) supply chain system featuring digitization, networking and intelligence, with "quality first, efficiency first, intelligent decision-making and industry leading". Applying big data and artificial intelligence technology, the company innovates the operation mode of material business, builds three intelligent business chains with procurement, supply and quality control as the core, and builds an intelligent decision-making center featuring panoramic vision of operation process, automatic optimization of management strategy, effective support for strategic decision-making and comprehensive and accurate data service.

The application scenario of modern (intelligent) supply chain of grid assets based on mobile Internet is shown in figure 3.
5. The challenge brought by the change of asset management scope and its countermeasures

In traditional transmission and distribution systems, information (such as equipment status information, power network operation information, etc.) is attached to physical assets and provides services for the acquisition, installation, operation, maintenance, transformation and scrapping of physical assets. In the energy Internet, in addition to playing the existing role, the above information will also be integrated with meteorological data, power market data and relevant data of partners. Through big data analysis, a series of valuable results such as load forecasting, power generation forecasting, fault warning and optimization of maintenance scheme are obtained[4]. In a sense, they are information assets that are relatively independent of physical assets, so they must be included in the asset management scope of grid enterprises.

In order to adapt to the reality of expanding the scope of assets life cycle management in power grid enterprises under the background of energy Internet, we should adopt the following countermeasures:

One is to summarize the difference between information assets and physical assets. Compared with physical assets, information assets are not visible at ordinary times. Only when the analysis results are used can they reveal their true colors. There is no mechanical wear or aging of the information assets, and there is no operational failure (unless the carrier -- software and hardware fail, the information assets will be unavailable, but this is not a problem of the information assets themselves); The value of information asset has a great relationship with its use mode. Whether the use mode is correct or not directly determines the value of information asset. Summarizing these characteristics of information assets is helpful for us to grasp the particularity and self-regulation of information assets management of power grid enterprises.

The second is to understand the life cycle of information assets. Physical assets of the whole life cycle process including the purchase, installation, operation, maintenance, modification, scrap "stage, such as the information assets of the whole process of life has its particularity, can be divided into " information acquisition, analysis, application "stage, the stage of" the application "is not the ending of the life cycle of information assets, at some stage results may be combined with new information, become a basis for the next phase of the analysis. Understanding the whole life cycle of information assets helps us to grasp the key points of the process control of information assets at different stages.

Third, the power interactive demonstration system based on nari-realworld 3d live display technology will fully support the energy Internet. In view of the global energy needs of the business in the field of Internet, NARI-Realworld three-dimensional comprehensive display of real interactive platform for its high precision terrain imaging services can be customized, integrated GIS function, easy access to the main technical characteristics of multi-source data, support global energy resources data overlay display in the platform, such as weather, electricity market, economic indicators, such as solar energy, wind energy, conventional energy data, which can realize energy resource data interactive query statistics analysis, the dynamic monitoring of energy resources, the status quo analysis and trend prediction, and other functions.

The nari-realworld platform-energy layout presentation and resource assessment module is shown in figure 4.
6. The challenge brought by the change of risk of asset management and its countermeasures

Compared with the current situation, under the background of energy Internet, the risk of power grid enterprise's asset management has also changed to some extent.

First, the increasing complexity of the asset system increases the risk of asset management. Power grid enterprises will play a major role in the future energy Internet, and their asset systems will be responsible for meeting the access of large-scale renewable energy power generation, fully implementing the state monitoring of transmission lines, and comprehensively collecting and real-time sharing of grid operation data[6], which will be considerably more complex than existing asset systems. And the more complex the system, the more potential risks, this is a general rule, grid enterprise assets system will not be an exception.

Secondly, tighter coupling with external asset systems (or pools of assets) increases uncertainty about asset management risk. One of the important characteristics of energy Internet is "interconnectivity"[7] The mutual dependence and mutual influence between the asset system and the external asset system of grid enterprises is bound to be higher. However, as the grid enterprise has no management authority over the external asset system, its risk generation and avoidance are out of control, so many uncertainties are added.

Third, adverse factors in the natural and political environment have diversified the risks of asset management. With the increase of cooperation with foreign enterprises, grid enterprises may face a number of adverse factors in overseas asset management, such as extreme weather environment, complex geological conditions, terrorist attacks, political instability, etc. These are all new tests for grid enterprises, which will make the risk of asset management more diversified.

The above situation makes the risk center and degree of the whole life cycle management of the assets of grid enterprises change. In response to these changes, we should take the following countermeasures:

One is the promotion of Reliability Centered Maintenance (RCM). According to the different consequences of equipment failures, RCM divides equipment failures into concealed failures, failures with security consequences, failures with utility consequences and failures without utility consequences, and adopts a set of strict logic to adopt different maintenance strategies for the above four types of failures, which is particularly suitable for the maintenance of complex systems[8]. In addition, RCM takes state maintenance as one of the first and main measures for preventive maintenance, which can not only promote the general implementation of state maintenance in grid enterprises at present, but also solve the problem of state monitoring equipment and system maintenance in the assets system of grid enterprises in the context of future energy Internet.

The Second is to carry out the computer simulation exercise of the emergency event of asset management. The highly intelligent energy Internet makes it possible to collect real-time and
comprehensive power grid operation and fault data, which will create favorable conditions for power grid enterprises to build computer simulation and exercise system. The system can be used to simulate the occurrence, development and evolution of emergency events, so that the drill can be carried out in an environment similar to actual combat, and the accuracy of the drill can be increased. It can simulate the state of power grid, emergency team action, emergency material allocation and local government action, etc., so that the drill does not need to input actual power and the cooperation of friendly and neighbor units, thus greatly reducing the cost of the drill. It can support repeated and multi-directional drilling of the same emergency event to enrich the content of the drill and improve the effect of the drill. Through the exercise, it can greatly improve the emergency response capacity of grid enterprises and reduce the adverse consequences caused by asset risk.

Third, the strategy and technical means of preparing the minimum operation of the asset system. In order to prevent the energy Internet due to its own or external reasons, such as North America widespread blackouts[9] Such disastrous results can be referred to the "second nuclear strike" of the US and Soviet (Russia) nuclear weapons.[10] Train of thought, when a serious threat to the grid security incidents, the lowest limit operation strategy and technology means, "insurance car lost pawn," give up most of the advanced features, choose the most reliable routing, ensure continuity of the most basic transmission and distribution service (or interruption in the range of is small), control the risk within an acceptable range.

7. Conclusion
The emergence of energy Internet is an inevitable trend, and China's power grid enterprises will also play a significant role in the revolution of this energy system. In this context, changes in the asset management environment, methods, scope and risks of grid enterprises will pose different levels of challenges to asset management. Guided by the existing asset management theories and practical achievements and in combination with the new situation of the energy Internet, we put forward the above-mentioned targeted response strategies, hoping to help power grid enterprises solve practical problems in the future life cycle management of assets and enrich the life cycle management theories of power grid enterprises.

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