第 33 卷 第 15 期 电 网 技 术 Vol. 33 No. 15
2009 年 8 月 Power System Technology Aug. 2009

文章编号：1000-3673（2009）15-0026-04 中图分类号：TM7 文献标志码：A 学科代码：470·4051

智能配电网的信息架构

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Information Structure of Smart Distribution Network

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ABSTRACT: Information structure is an essential element for smart distribution network, which, on one hand, integrates advanced calculation technology, flexible & high efficient communication, and powerful sensor devices to realize the smart “hardware” function; on the other hand, integrates the information about device resources, line geographic position, power system status, power system safety, energy supply, customer response, and so on, through the construction of a unified power grid model, to realize the smart “software” function. Information structure has made power grid more intelligent, since in any time span, it can process all information as a whole, so as to facilitate the connection of new energy form with distribution network, and meet the requirement for safety and security, environment protection and community participation. This paper has introduced the definition and background of smart distribution network, studied the basic components of the information structure applied to smart distribution network, described the candidate model of information in smart distribution network, analyzed the international standards available to the model, and explored the key to the development of information structure of smart distribution network.

KEY WORDS: smart distribution network； information structure；model of information；power system model

摘要：智能配电网的信息构架是智能电网的核心思想体现，智能配电网融合先进的电脑技术、灵活高效的通信技术和传感器技术做为“硬件”基础；智能配电网信息构架是通过构建统一的电网模型，将电网系统所涉及到的设备资源信息、空间地理信息以及含有时间信息的电网运行状态信息、运行安全信息、能源供需信息、客户响应信息等，做为“软件”实现智能：在任意时刻的时间断面上，智能的将各方面的信息资源进行一体化处理，使配电网满足未来新能源接入、安全可靠、清洁环保、社会参与的更高需求。文章介绍了智能配电网的定义和背景，研究了智能配电网的信息架构的基本构成，说明了可用的智能配电网信息描述模型，分析了信息模型可利用的国际标准，探索了智能配电网信息架构的重要方面。

关键词：智能配电网；信息架构；信息模型；电力系统模型

0 Introduction

The increasing pressure on environment and resource has become a new challenge for global power industry, which has to face more complicated power market rules and satisfy the demand for high-quality and reliable power supply from customers. Therefore, the construction of a safe, robust, environment-friendly and cost-effective power system is the common target of the global power industry.

The concept of smart grid has been established with the progress of global power industry. Since the development goal for future grid is different among all countries, the terms of smart grid varies with different perspectives, such as Intelligent Grid, Grid Wise, Smart Power Grid, Smart Electric Grid, Future Grid, and Modern Grid. The research work on smart grid started from USA. And this idea has been accepted by European countries, whch tried to keep up with the Americans and planned to integrate smart grid into European power grid by 2020 or beyond [1].

The development of smart grid is based on information technology, digital devices and controllable electric devices, integrated with wideband communication and auto control. Those techniques tightly cooperating with transmission and distribution devices in power system, can build a brand new power grid, which will be safer, more reliable, cost-effective, efficient, flexible, and environment-friendly.

The smart characters of smart grid can be

summarized as: observable by measure and sensor techniques, controllable by auto control techniques, embed self-processing techniques, the features of real-time analysis to make data into information, self-adapt, and self- heal.

Smart grid is a great plan for American and European power industries. This career is still under the process of research and development, but has been expected to realize the following goals:

1 ） Make customers' participation possible: Customers will have a clear idea about the cost, the new information and option (Energy expedition management, new devices investment and etc); the operators will have the option for new resources.

2 ） Power grid will support a wide-range of distributed power sources connection. The grid makes all kinds of generation devices and energy storage system seamless integrated, which should be easy for connection and operation. The large scaled power supply devices, including wind farm, solar energy and improved nuclear power system, which are friendly to the environment, would still be the mainstream of power system; the number of small distributed power sources would be increased.

3 ）Produce new electricity products, services, and establish new electricity market. The purchasers and suppliers should be at the customers' level. Power grid supports the secondary electricity market (new trade goods and services), provides cross-region coordinating market operation mechanism, and encourages retail market competition and customer energy development.

4 ） Provide high-quality power for economic development in 21-century. Based on environment and economic conditions, the grid can provide high quality power satisfying the requirements of customers, and adjust the power quality according to the price.

5 ） Optimize the operation of power system . The grid should get improved load factor and reduce line loss; make the existing system more powerful; utilize efficient and optimized tools; build a knowledge base; improve the ability to monitor and diagnose fault in power system; realize computer-aid asset management, work flow management and outage management; facilitate system operation and maintenance.

6 ） The grid can realize self-healing. The smart grid will have a smart automation system to monitor components in power system, collect and analyze data from smart sensor devices. The automation system should also make decision and take action to save system from failure. Comparing to human, the automation system acts more quickly and accurately, and make the grid fault-free.

The grid will take flexible action when disaster and shock happens, and will be equipped with a physical and digital safety system to reduce the weaknesses of power system, decrease the threat of system failure and the harm from disaster.

1 Information structure of smart distribution network

Information structure is an essential element for smart distribution network, which, on one hand, integrates advanced calculation technology, flexible & high efficient communication, and powerful sensor devices to realize the smart "hardware" function; on the other hand, integrates the information about device resources, line geographic position, power system status, power system safety, energy supply, customer response, and so on, through the construction of a unified power grid model, to realize the smart "software" function Information structure has made power grid more intelligent, since in any time span, it can process all information as a whole, so as to facilitate the connection of new energy form with distribution network, and meet the requirement for safety and security, environment protection and community participation.

The information structure of smart distribution network is the base for single-data-source integration, and power information system incorporation, with the target of establishing a unified data exchanging and sharing mechanism by means of a standardized information depiction, and a unified data exchanging platform and access.

Smart grid is the grid for future. Its functions and abilities are under the process of development and innovation. So the information structure of smart distribution network should not be designed according to the functional requirements, but based on the inhere characters of power system, power system analysis, and the art of information architecture. Smart gird is primarily characterized by standardization.

The framework of information structure of smart distribution network should include the following

functions:

1）It builds a unified data model for the transmission and distribution of power grid. The structure can get data from smart secondary devices and high-efficient power analysis program, and transfer those data into a unified data structure, which is a data foundation for the rapid and effective grid calculation and analysis.

2）It represents grid data with graph and GIS techniques, makes grid status visualized, so the operators can take operation step with visualized tools, which is smart enough to help make right decision, and organize the grid efficiently.

3）It builds a unified smart grid data model. The structure can map the physical power grid into a standardized grid data model, and organize the related data sources coupled together in a structural and clearly way. The coupling relation does not depend on physical features of the devices.

4）It builds a unified and standardized service for smart grid. With those services, the application and smart devices can be accessed without releasing their internal details, so the components in smart grid can be treated as black box.

5）It can meet the requirements for smart devices in smart grid, such as configuration requirement, information safety requirement, data management and exchange requirement, and services quality requirement.

6）It encourages multi-level analysis of data in smart grid, and makes power grid to be operated in a more coordinated way, so the grid can be self-healed, self-adapted between loads and power sources, and connected to new distributed sources.

7）It makes data integrated and exchanged across departments, and makes it safe.

2 Description model of information in smart distribution network

The information structure of smart distribution network must face the challenge of mass data from a complicated application environment [2]. The difficulty to the integration of heterogeneous data source will get severe with the rapid increase of data source and data format. Positively, the smart distribution network can get help from this wideband network.

Due to the two factors mentioned above, XML is adopted for describing integration data in smart distribution network. XML is a flexible data model language, with self-described feature, which makes it perfect to represent both data and content, since it allows the user or application to add meta-data to state background information. XML can break the block between data and its content; and enable seamless connection among multi data sources.

XML also provides a unified data access interface, including any type of data such as relation data in database, structure and non-structure document, web pages, web services, pure XML data and data flow like message queue. XML is suitable for complex document, containing complicated hierarchy structure and independent data model.

The application of XML technology has become more and more popular, because it is suitable for the key requirements for data processing, such as storage, organization, searching, and acquiring. XML stimulates the integration and analysis based on multi-heterogeneous data source [3]. It can maintain the original characters of data, and handle those documents changing with lapse of time.

An information description structure based on XML is feasible.

An open data standard can provide a unified access interface, which human and application system can easily understand. It needs to comprehend the context around the information so as to understand the idea of the information. That is why the feature of self-describe d XML is so important. And XML has the ability to represent information from multi-sources, including database, structural, half-structural and non-structural document, and object base [4-5]. With XML, any application can access, understand and process the data.

Open standards encourage the cooperation between different platforms and applications. Comparing to the creator of standalone data format, which must explain every feature in detail the open system can share free information with public standards.

Open standards boost the development easily. For example, when a new version of industry standard is issued, the related organization can transfer data or ask software provider to modify legacy application, this is part of the development.

W3C standards about XML mainly include XML Schema XPath, Xquery XSL and SOAP. XML

Schema defines the structure, content, and grammar of XML document.

3 Power system model of smart distribution network

State Grid Corporation of China has carried out its "SG186" project to boost information processing. This project has achieved the goals of sharing and using information to optimize its work flow, increase business ability and control strength. It is a good start for smart distribution network, but smart distribution network needs more development on auto control and operation, and the self-healed feature should be totally free from operators. The smart distribution network needs a full description of power system, so as to satisfy the requirement for both self-adapt and interoperability, and enable the supervision on the whole power system, energy market and business information system. The smart distribution network involves customers, substation, distribution station, feeder, control center, and energy market. In view of the art of information, the power system model is a professional interface for the physical model of power system.

One work group of the International Electro-technical Commission (IEC) has created a series of international standards for the power industry. However, it is important to create and issue standards suitable for Chinese power system, according to international standards and development plan on smart distribution network [2].

Currently, international standards, which have been implemented in China, are listed below:

IEC TC57 common information model (CIM), concentrating on the model of power system in control center, enterprise data exchange, and energy management system (EMS), which provides the possibility of import and export for data of advanced application [6].

In the field of distribution management, IEC 61968 has a very long and complex history, and has not finished yet. Because it involves so many models in distribution, and ambition, such as extending iec61970 model for distribution, add GIS model for power system, asset management model, distribution business document model and ERP related model. Though, IEC 61968 is a perfect standard for the application and integration in power industry, it provides the new power industry services bus of information exchange [7].

The new version of IEC 61850 has been applied to power enterprise's communication network in automation system, and also been applied to the area of energy distribution, including distribution power sources management, photovoltaic system, fuel cell, diesel generation, combined heat energy, and standard for wind power [8]. IEC will establish a series of standards named as IEC 61850-7X0, including demand side management, measurement service, family automation, and distributed automation.

In those standards, all data about unit in power system (such as power plan, generator, transformers) is described in XML, so are those classes to state unit, object property and relationship between them.

Thus it can be seen that the power system information model in smart distribution network has a good start, and it is vital to establish new standards for smart distribution network based on those works. Strategically speaking, domestic research on this area is urgent [9].

4 Conclusion

Smart grid is the grid for future. Its functions and abilities are under the process of development and innovation. So the information structure of smart distribution network should not be designed according to the functional requirements, but based on the inhere characters of power system, power system analysis, and the art of information architecture.

The information structure is the key element of smart distribution network with the ability to realize a unified data source, establish an integrated power information system. Based on the standardized information description, unified data exchange sharing platform, it is possible to build a unified application supporting system, realize the functions of data sharing and digging, and optimize work flow and lean management. At last, the smart gird is primarily characterized by standardization.

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