Construction of on-line monitoring system for self provided power plants in Shandong Power Grid

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Abstract. Based on the analysis of the problems existing in the operation of self provided power plants in Shandong power grid, it is proposed to develop and build an on-line monitoring system for self-contained power plants, which can realize on-line monitoring of power generation and consumption operation and on-line analysis of power generation and consumption behavior characteristics, realize automatic collection of electricity data, provide scientific and quantitative monitoring means, and promote standardized operation and orderly development of self provided power plants.

Keywords: Self provided power plant, online monitoring, system architecture.

1. Introduction
By the end of 2018, Shandong power grid has 61 directly regulated power plants with 192 units, with a total installed capacity of 64.22 million kilowatts. Among them, there are 47 directly regulated public power plants with 159 units, with an installed capacity of 57.245 million kilowatts; and there are 14 directly regulated power plants with 33 units with an installed capacity of 6.975 million kilowatts. In 2018, the power generation capacity of provincial direct transfer public power plants (including Qinling pumping station, Xingda thermal power plant, Haiyang nuclear power plant and Bajiao thermal power plant) reached 283.985 billion kwh, an increase of 5.59% year-on-year. The power generation capacity of self provided power plants in the whole province reached 1945.533 billion kwh, a year-on-year decrease of 2.19%.

300 MW and above units are the main types of power grid in Shandong Province, with 114 units in total, with an installed capacity of 51.64 million KW, accounting for 80.41% of the total installed capacity. The unit with the largest single unit capacity is Haiyang nuclear power plant with 1.25-million-kilowatt unit. The specific situation is as follows: 9 units of 1 million kilowatt class, with a capacity of 9.46 million kilowatt, accounting for 14.73% of the total installed capacity; 23 units of 600000 kilowatt level, with a capacity of 15.14 million kilowatt, accounting for 23.58% of the total installed capacity; 82 units with a capacity of 27.04 million KW, accounting for 42.11% of the total installed capacity; and 200000 kW There are 17 units with a capacity of 3.885 million kilowatts, accounting for 6.05% of the total installed capacity; 58 units of 125000 kW class have a capacity of 8.415 million KW, accounting...
for 13.1% of the total installed capacity; 3 units of 100000 kW and below have a capacity of 280000 kW, accounting for 0.44% of the total installed capacity.

All the direct regulating units are integrated into the 110 kV and above voltage level systems of Shandong power grid, including 25 units connected to 500 kV system with a capacity of 17.63 million KW, accounting for 27.45% of the total installed capacity; 161 units connected to 220 kV system with a capacity of 45.815 million KW, accounting for 71.34% of the total installed capacity; 6 units connected to 110 kV system with a capacity of 775000 kW, accounting for the total installed capacity 21% of the amount.

As a province with a large number of self provided power plants and large installed capacity, Shandong company attaches great importance to the management of self provided power plants, continuously improves the management level of self provided power plants, cooperates with national environmental protection governance and power generation license verification, actively responds to the national and provincial small thermal power shutdown policies, and promotes illegal construction, environmental protection substandard and unlicensed units replacing shutdown. In 2018, 11 389000 kwh self provided units were shut down and three 36000 kwh planned self provided units were transferred to public operation, effectively maintaining the order of the power market.

Up to now, there are 247 grid connected self provided power plants in Shandong Province, with an installed capacity of 12.9736 million kilowatts, accounting for about 20% of the installed capacity of the whole grid. There are 23 isolated power plants in the province, with a total installed capacity of 23973800 kW. In 2018, the power generation capacity of grid connected self provided power plants was 70.34 billion kwh, the spontaneous self consumption was 59.963 billion kwh, the on grid power was 1.705 billion kwh, and the purchased grid power was 10.932 billion kwh; from January to April of 2019, the spontaneous self consumption power was 18.507 billion kwh. Among them, there are 89 coal-fired power plants with an installed capacity of 8.945 million kilowatts, accounting for 65.17%; 107 comprehensive utilization (including more than three) power plants, with an installed capacity of 3.4317 million kilowatts, accounting for 26.45%; and 51 other power plants with an installed capacity of 596900 kW, accounting for 4.61%. In the 2018's, it collected 708.1965 million yuan of government funds for self provided power plants, 1047.4127 million yuan of reserve fees, and 251165500 yuan of policy cross subsidies.

2. Problems in self owned power plants
Due to the development environment, historical problems and other factors, there are still many problems in the self provided power plant.

In some areas, the proportion of power generation is too large, which affects the security of power grid, the bad operating environment and the low level of safe operation. On the one hand, a large number of self provided power plants centralized power generation, resulting in the lack of peak load regulation capacity of the power grid, once the operation problems occur, it is very easy to cause a large area of blackouts, which has a significant impact on social stability. On the other hand, enterprises with their own power plants are often important users above the second level of the state and have a large number of important loads that can not be interrupted. However, the operation level of the self provided power plants is relatively weak, especially for the self provided power plants operating in isolated networks, the safety problems of the self provided power plants are very prominent when there is no backup system of power grid enterprises.

For the government funds and surcharges owed by the self provided power plants, the collection of system reserve fees needs to be further standardized. Some provinces and cities even explicitly do not levy or only collect a few of them in the local implementation rules, especially for the self provided power plants operating in isolated networks, no government funds are paid. Some enterprises refuse to pay reserve capacity fee of self provided power plant system. The behaviors of these enterprises and their own power plants have destroyed the market order of fair competition, evaded the national obligation of subsidizing the people's livelihood, harmed the national interests, and played a negative
guiding role. As a result, some public power plants have asked to be turned into self provided power plants to evade the fees.

The low power generation efficiency of coal-fired units, idle environmental protection facilities and illegal operation of self-contained power plants affect the enthusiasm of public power plants and the whole society to implement energy conservation and emission reduction, and bring adverse effects to the prevention and control of air pollution and the construction of ecological civilization and harmonious society.

It is difficult to define the nature of units in the power plant with comprehensive utilization of resources. Most of the power plants owned by enterprises are generated by combined heat and power or comprehensive utilization of secondary energy such as waste heat and pressure. In the name of cogeneration and comprehensive utilization of resources, many enterprises applied for the construction of power plants with comprehensive utilization of resources. However, in actual operation, they violated the relevant policies of "administrative measures for the determination of comprehensive utilization of resources encouraged by the state" and "provisions on the development of cogeneration", which did not achieve the effect of comprehensive utilization of resources. Due to the lack of objective unit operation data as support, the lack of effective monitoring means, it is difficult to grasp whether the utilization of waste heat, residual gas and fuel allocation meet the requirements, so it is difficult to effectively identify the nature of units in the comprehensive utilization of resources in the annual audit.

3. Necessity of on-line monitoring for self provided power plant

The problems existing in self provided power plants need to be strictly managed with strong enforcement of policies and regulations; at the same time, effective technical means are also needed to promote management and strengthen or verify the implementation effect of laws and regulations. It is an important technical means to strengthen the management of self-contained power plants to construct on-line monitoring and assessment system for self-contained power plants, and to automatically obtain operation data of self-contained power plants by using modern communication technology, computer technology and other information technology. The on-line monitoring and index assessment system of self provided power plant shall realize the following main functions:

The first is to collect the operation data of cogeneration and resource comprehensive utilization power plant, realize on-line monitoring and assessment of unit heat and power ratio, thermal efficiency, power supply standard coal consumption and other indicators, so as to judge whether the unit operation level meets the requirements, and provide data basis for the identification and review of unit nature;

The second is to provide automatic collection of electric energy of self-contained power plant, which can manage the power generation, auxiliary power consumption, on-line electricity and off-line power of the power plant, comprehensively grasp the power energy distribution of the self-contained power plant, and provide data basis for various government charges; understand the power consumption trend and electricity changes, so as to facilitate the analysis of illegal operation.

4. Architecture design of on line monitoring system for self provided power plant

The on-line monitoring system of self provided power plant includes central master station system, special transmission channel and power plant side station equipment. The central master station system, referred to as the master station system, is the management center of the whole system, which manages the data transmission, statistics, evaluation, analysis and processing functions of the whole system, and manages the system operation and system security. The special transmission channel refers to the network communication link opened for the system by the Provincial Communication Company; the substation is the collection of data upload integrated terminal, communication data acquisition device, physical signal acquisition device and network channel equipment installed at the power plant side, which is responsible for real-time data acquisition and communication of unit load, main steam pressure and other real-time data to online monitoring of network related safety performance of grid connected units in Shandong Province System. The station equipment on the side of the power plant is referred to as the substation, which is a collection of data upload integrated terminal, communication data
acquisition device, physical signal acquisition device and network channel equipment installed on the power plant side.

The overall scheme is divided into three parts: one is to install Modbus communication board in the host DCS to increase the on-line monitoring capacity of unit peak load regulation; the second is to expand the communication interface in the original energy consumption management system of the group to increase the power load monitoring capacity of the whole plant; the third is to expand the data acquisition channels that other energy consumption monitoring systems and host DCS systems do not have. The system network structure of a factory is as follows:

Fig.1 The system network structure of a factory is as follows

5. Function module of on line monitoring system in self provided power plant
Based on the actual situation of the self provided power plant, the online monitoring system mainly designs the following functional modules, including data acquisition, operation status monitoring, file management, power generation and consumption behavior characteristics analysis, index analysis, etc.

5.1. Data acquisition
The data collected by the system can be divided into two categories: thermal data and electrical data. The thermal data of unit operation mainly include steam pressure, temperature, humidity, heat supply and calorific value of steam turbine and boiler. The acquisition points are distributed in the boiler, primary extraction unit, secondary extraction unit, back pressure unit, extraction back unit and so on. After the analog signal is input into the distributed acquisition module, the distribution module is
uniformly connected to the thermal data acquisition device terminal. The acquisition device automatically collects data at 30 s intervals and calculates the average value every 5 minutes.

The electric energy data is composed of peak, flat and valley values of time-sharing electricity, total active power and total reactive power. At the same time, combined with the characteristics of the enterprise's own power plant, the collected data can be divided into spontaneous power consumption, grid connected electricity, on-line electricity, power generation and auxiliary power consumption. The information obtained by the electric energy meter is uniformly summarized to the intelligent acquisition device. The acquisition device automatically collects data at 5 minutes interval, and calculates the average value every hour.

5.2. Operation status monitoring
The operation monitoring objects of the self provided power plant mainly include boilers, steam turbines, generators and other equipment as well as the energy consumption data of the energy consuming enterprises of the group to which the self provided power plant belongs. The production process of boilers and steam turbines in self provided power plants is displayed in the form of process flow chart. The data of active power, on-line power, main steam pressure, temperature, extraction steam volume, real-time power consumption load of various energy consuming enterprises are displayed on-line, and the production and operation conditions of self provided power plant units and energy consuming enterprises are vividly and intuitively displayed. The system can set the corresponding alarm mechanism and set the data threshold of monitoring points in advance. When the data exceeds the threshold value, the system supports alarm display with different colors.

5.3. File management
The system can provide a set of file management database related to the self provided power plant. The database displays the main design parameters of steam turbine, boiler and generator of the three main equipment of the unit in the form of online chart. Meanwhile, the unit operation regulations, turbine, boiler, generator product manual and thermal calculation sheet of steam turbine and boiler are uploaded to the database Live access and download, greatly facilitate the daily work of managers at all levels.

5.4. Analysis of power generation and consumption behavior characteristics
According to different application scenarios, the system establishes the power generation and consumption behavior characteristic indicators of self-provided power plants from different time scales, such as day, month, quarter and year, and constructs the power generation and consumption behavior characteristic indexes of high-energy consumption enterprises' own power plants, which can directly reflect the characteristics of enterprise production, scheduling system and power consumption. From the traditional load characteristic analysis and the new load characteristic analysis, the load side of the enterprise owned by the self-provided power plant is modeled and calculated, which mainly shows the basic load indexes such as load rate and peak valley difference, and new load indexes such as curve fluctuation, time delay analysis and continuous curve analysis. The power generation side of the enterprise owned by the self-provided power plant is modeled and calculated, and the generating efficiency and coal consumption of the unit are displayed online. Comprehensive display of the power generation and consumption behavior of the enterprises affiliated to the self-provided power plant, mainly showing the surplus electricity and purchased electricity.

5.5. Index analysis
The system supports the graphic display of the main energy efficiency indicators of the unit, including curves, pie charts, bar charts and other forms. For example, the power generation, auxiliary power consumption, auxiliary power consumption rate, on-line power consumption and off grid power curve are displayed in the unit of power plant, and the thermal efficiency and thermal power ratio are displayed in the unit of whole plant or unit.
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