Optimal Dispatching based on Electric Thermal Coupling Characteristics Analysis and Wind Power Consumption

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Abstract. In winter heating period, in order to meet the heating requirements, the cogeneration unit adopts the operation mode of "heat fixed power". The peak regulation capacity is poor, and a large amount of wind is abandoned in the period of low load. In view of this problem, the characteristics of cogeneration units are analyzed, and relevant research results at home and abroad are summarized. This paper analyzes the scheme of increasing electric boiler, heat pump and heat storage from the aspects of increasing thermoelectric coupling equipment and power grid lean dispatching, puts forward the method of power grid lean dispatching of thermoelectric cogeneration units, and expounds the practical application of thermoelectric coupling constraint decoupling at home and abroad. At last, the next work of power side and power grid dispatching side is pointed out.

Keywords: Wind Power Consumption, Power Grid Dispatching, Thermoelectric Coupling, Peak-Load Regulation

1. Introduction

With the expansion of wind power installation and networking scale year by year, China's "Three North" areas (northeast, North and northwest) are also facing serious wind power reduction [1]. Thermal power plant heating in the heating period leads to a sharp decline in peak load regulation capacity of the system, which is the main reason for power distribution and wind power reduction. In the "Three North" area where wind power is severely reduced, the main power source is the cogeneration unit with poor peak load regulation capacity [2]. In order to ensure that the heat load demand in the heating period is met, the cogeneration unit adopts the mode of "heat fixed power", and the power output of the unit can only be adjusted within a limited range, which increases the contradiction of insufficient peak load regulation capacity of the system, resulting in a large number of shutdown and wind restrictions [3-5].

This paper reviews and summarizes the domestic and foreign solutions and related research results from the perspective of power grid dispatching management, the current main research results can be divided into two categories. First, based on the perspective of equipment, how to really improve the
unit load capacity of electric coupling equipment. Second, based on the perspective of dispatching, how to deeply tap the potential of power grid dispatching system in terms of load, and analyze the work to be continued in the next step.

2. The Thermoelectric Characteristics of Combined Heat and Power Units
At present, there are two kinds of common thermal power units used for cogeneration in China: back pressure type and extraction type. Their typical electric heating characteristic curves are shown in Figure 1.

Figure 1. Characteristic curve of CHP
The back pressure unit can use the low-pressure exhaust gas or industrial steam after power generation to provide heat, with less energy loss and high efficiency. Its thermoelectric characteristic curve is shown in figure 1(a). The thermal power and electric power show a linear relationship. In the thermal power plant, the main unit type is the extraction unit, which extracts steam with high pressure and temperature from a part of the intermediate stage of the steam turbine for the use of thermal users. Its electric-thermal characteristic curve is shown in figure 1(b), and the operation interval is the region surrounded by ABCD. In the case of given thermal power h, the power generation is between PE and PF and has a certain regulating capacity. However, with the increase of heat load, the adjustable range of unit output will decrease, and the peak load regulation capacity will also decrease.

3. Add Thermoelectric Coupling Equipment to Determine Electricity by Heat
According to the current research results, there are two ways to improve the cogeneration unit and its peak load regulation ability[6]: first, to improve the flexibility of cogeneration units, such as by-pass compensation heating, optimization of burner and feed water flow control, optimization of coal mill control and compensation heating, deep peak regulation and other technologies; second, to increase the coupling equipment of electric heating, improve the peak load regulation capacity of units, for example, electric boiler, heat accumulator, heat pump, etc., their transformation will not affect the power grid dispatching mode.

3.1. Add Electric Boiler for Heating
If an electric boiler is placed on the power generation side or the power consumption side, it can consume extra electric energy and release heat energy. This way can replace the cogeneration generating unit and provide part of the heat demand, and at the same time, the electric load of the system is increased to provide space for wind power absorption [7,8].

Using electric boiler, electric energy can be used to heat and provide heat. This kind of conversion between electric energy and heat energy reduces the demand for heating unit and eliminates the constraint condition of thermal power.
Figure 2. Characteristic curve of CHP with electric boiler

The expansion of the feasible region of equivalent output of combined heat and power units is characterized. The decrease of equivalent low power generation output comes from two aspects: one is the electricity consumption of the electric boiler itself. On the other hand, under the same equivalent heat supply, the application of electric boiler in power system reduces the generation and heating capacity of cogeneration unit.

3.2 Additional Heat Pump

A heat pump absorbs heat from a cold source (such as groundwater, seawater, sewage, natural air, etc.) and converts it into a hot source to release heat on the demand side of the thermal force. The function of heat pump is similar to that of electric boiler, which is to convert electric output into heat output to improve the regulating ability of combined heat and power units [9]. However, heat pump has higher conversion efficiency compared with electric heating boiler. Centralized heat pumps can be configured in thermal power plants and distributed heat pumps are mainly on the user side.

The advantages of heat pump are as follows: in heating period, heat pump can replace combined heat and power units to provide heating to the heating side, saving part of electric energy and reducing the coal consumption of the system [10]. Moreover, the low-temperature heat source consumed is all clean energy, which has significant energy saving benefits and low operating cost. However, the investment cost of heat pump is higher than that of electric boiler. Although heat pump has a higher performance system, when the capacity of heat pump reaches a certain level, the associated combined heat and power units is basically not restricted by "thermoelectric coupling", and the advantage of heat pump's high performance coefficient is weakened, resulting in its effect of promoting wind power consumption is close to that of electric boiler. Moreover, for distributed heat pump, to carry out remote control and communication, it is necessary to carry out software and hardware technical transformation and upgrading of the current smart grid control system.

3.3 Add Heat Storage Device for Heating

The large-scale application of heat storage technology in the power supply side of the power system breaks through the constraints of "power by heat", effectively improves the regulation capacity of cogeneration units, and ultimately increases the amount of wind power consumption. Wind power heating system with heat storage technology is adopted at the load side to realize clean heating by using wind power waste heat, which can effectively increase the regional power load. At the same time, it has played a role in improving the regulation capacity of the local power system, and improving the utilization and consumption of renewable energy.

The use of large-scale heat storage technology in the power system can play the role of peak shaving and valley filling. When the power load in this area is high, but the wind power generation capacity is small, the industrial gas can be fully used for heat storage; when the power load in this area is relatively low, but the wind power generation capacity is large, the generating capacity of the unit can be appropriately reduced.
Recently, many scholars have carried out relevant research to explore the use of heat storage devices to improve wind energy consumption. Some scholars have studied the operability and application value of using electric boiler to absorb wind power in thermal power plant. In Germany, under the condition of spot market, the maximum benefit can be achieved by allocating the appropriate capacity of heat accumulator and cogeneration device. This paper first analyzes the principle of improving wind energy consumption through heat storage technology, then establishes a model to jointly dispatch wind power, thermal power and heat storage devices, and finally compares the energy-saving effect of cogeneration unit and heat storage wind power combined unit.

3.4 Multi-Unit Combined Heating

The use of multiple equipment for combined regulation of electric energy and thermal energy can improve the regulation capacity of cogeneration, such as "electric boiler + heat storage", "heat pump + heat storage", etc., or at the side of the power plant and the side of the load, some thermoelectric coupling equipment can be added at the same time to use flexible and changeable ways to achieve more absorption of wind energy, such as electric boiler, heat pump, etc.

By improving the heating capacity of the combined system, the generating capacity of the generating unit is reduced under the condition of meeting the same heating demand.

Through the coordination and cooperation between the multi-thermoelectric coupling equipment and the combined heat and power units, the combined heat supply can give full play to the characteristics of all kinds of equipment, raise the combined heat and power units adjusting space in a larger scope, and achieve remarkable peak-load regulation effect. However, the cost of investment is high and the operation of regulation is complex, which needs to be determined according to the actual situation of wind curtailment.
4. Conclusion
In order to improve the quantity of wind energy consumption in heating period, this paper proposes two solutions, one is to increase the equipment of joint coordination of thermal energy and electric energy, the other is to improve the refined operation of power grid dispatching. This paper analyzes and summarizes the effects of improving the peak regulation capacity, reducing the lower power limit and increasing the wind energy consumption. This paper introduces the application of these technologies at home and abroad. Through the analysis, it can be concluded that although the equipment coordinated by heat energy and electric energy increases part of the grid investment, it has significant effect on improving the peak load regulation capacity of the system. In addition, the refined operation of power grid scheduling can improve the ability of peak load regulation without changing the structure of the power grid, but in terms of the improvement range of the regulation ability, it is not as obvious as using the equipment of joint coordination of thermal energy and electric energy.

For the power generation system, the current power plant is not willing to increase a large number of cogeneration units to improve peak load regulation capacity. Therefore, we should introduce relevant national or industrial policies, establish adjustment mechanism through price leverage, and achieve reasonable policy adjustment. Through the flexible transformation of thermal power plant, it can provide support for the implementation of deep peak regulation. For the power supply system, it can realize the joint dispatching of thermal energy and electric energy. Through the scientific and reasonable fine dispatching method, it can regulate multiple generating units and multiple heating units, and greatly improve the peak regulation capacity of the system. With the above measures, the consumption of renewable energy such as wind power can be further improved.

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