Research on Battery Charging and Discharging Control Strategy Based on AGC Scheduling

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Abstract. In this paper, a battery charging and discharging method for AGC scheduling is described. For the practical consideration of the northern region, due to the lack of abundant hydropower resources, it is greatly affected by the temperature in winter and can only be used as a fine-tuning function, so the hydropower effect during the heating period in winter is not considered. Thermal power and battery energy storage devices are established to participate in the AGC scheduling system. The system state is mainly divided into four control states: conventional power supply control state, battery discharge state, battery charging state, and clean energy control state. The working area is judged on the premise that all new energy is connected to the network, and the limit control strategy is used. The lower limit of output of thermal power unit and the limit of capacity of battery unit are critical conditions. Thermal power is the main power and battery is the auxiliary power stability.

1. Introduction

In recent years, the proportion of clean energy power generation in the total power generation continues to increase, and the acceptance capacity of clean energy power generation is one of the main factors restricting the safe and stable operation of the power grid. In order to ensure the safe and reliable operation of the power grid, it is of vital importance to improve the acceptance capacity of clean energy generation points.

At present, large capacity energy storage system [1-4] has been applied in the field of frequency modulation of AGC [5-9] (automation generator control). After years of practical demonstration in the United States, it has been adopted on a large scale. The operation of the New York state power system shows that although the 9 MW energy storage FM system only accounts for 3.3% of the total FM capacity of the power grid, the FM task completed by it accounts for 23.8% of the total FM capacity. The energy storage system can effectively reduce the FM capacity of the power grid. T

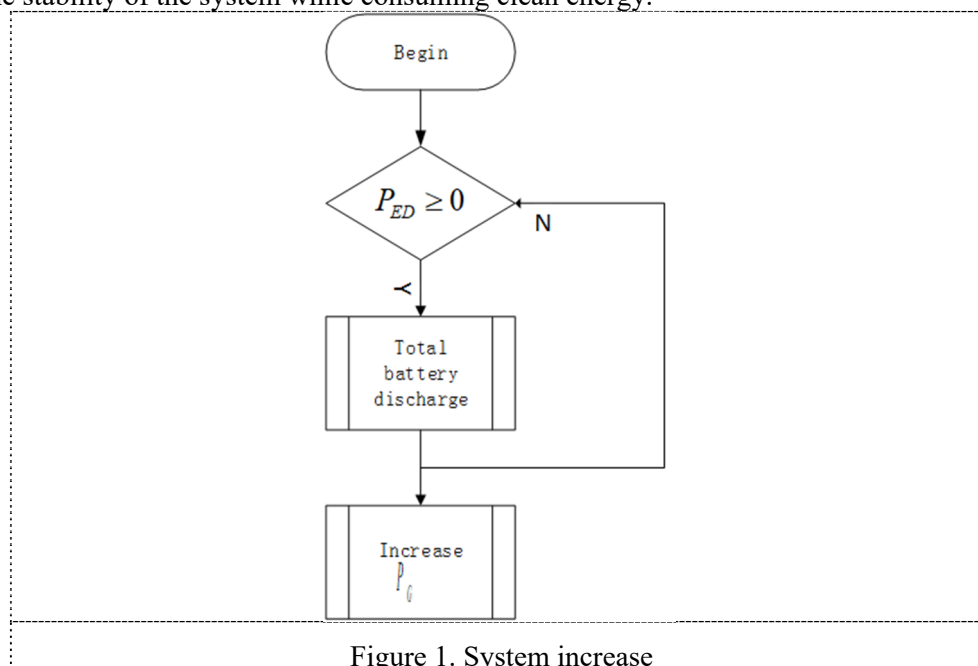## 2. Theory

2.1. The technology of AGC

AGC system is the abbreviation of Automatic Generation Control, that is, Automatic Generation Control technology, it is mainly based on the set load curve and other Automatic Control system to achieve Automatic Control of unit operation, effectively reduce artificial operation. The input of AGC is based on the change of user demand for electricity, which can more accurately control the power generation of hydropower units and effectively control the synchronous operation of different units. With the continuous expansion of thermal power units and the increasing number of units, as well as

the change of users' demand for electricity, AGC control has become an essential basic equipment for thermal power network operation control. In modern society, more diversified energy supply way, coal-fired power, hydropower, wind power, nuclear power, photoelectric, and so on electric power to be able to provide users with energy supply, and users of electricity is also in the change, such as the electricity demand is bigger during work time, and the rest time and night will reduce rapidly, then to realize the load adjustment unit operation and subtract, it can avoid the energy waste, and can reduce burden of power grid. AGC system in the unit control the can achieve fast and it can not only realize the accuracy of some units can be controlled, more can be implemented by many units coordinated control in line with the changes, for example, was one of 3 20 mw coal-fired units, use of AGC control can be adjusted at the same time the operation situation of three units quickly adjust load supply as a whole. AGC automatic control can realize the real-time control and hierarchical control of the whole thermal power station unit, and finally realize the load adjustment and change through the adjustment of the running state of hydropower equipment. AGC system can realize accurate and high speed control is the most important measure of the effectiveness measure of AGC system, if the whole control process in a mismatch between each device is easy to cause the running stability and security of the unit, at the same time, AGC adjustment too frequently or too fast may also lead to wear and aging equipment for thermal power unit, affect the service life of equipment, brings the serious economic loss.

3. AGC regulation

Due to the actual consideration of the northern region, due to the lack of water and electricity resources, the winter is greatly affected by the temperature, which can only be used as fine-tuning, so the water and electricity during the winter heating period is not considered. The thermal power and battery energy storage devices are established to participate in the AGC scheduling system. The system state is mainly divided into four control states: conventional power control state, battery discharge state, battery charging state and clean energy control state. The judgment of the work area is based on the premise that all new energy is put into the network, the limit control strategy is used, the lower limit of output capacity of thermal power units and the limit of capacity of battery units are the critical conditions, with thermal power as the main part and battery as the auxiliary part, so as to ensure the stability of the system while consuming clean energy.
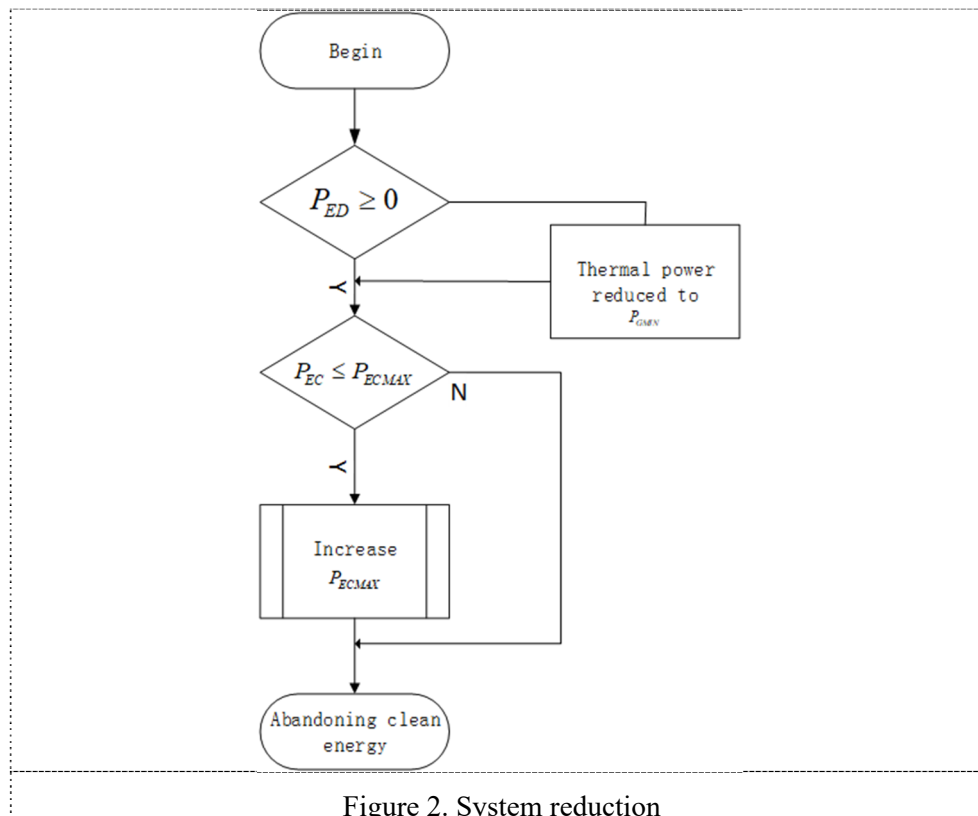

Figure 1. System increase

Figure 2. System reduction

For thermal power and thermal power plants, the lower limit of power generation has clear control requirements. During the heating period, the minimum power generation capacity will be increased to some extent. In northeast China, as winter is a heating period, the lower limit of more heating units cannot be too low. Battery energy storage participating in system scheduling is controlled by battery group. The scheduling method applicable to this kind of load is adopted to realize the balance between load and power supply, realize the coordinated operation of battery energy storage, and realize the purpose of energy optimization configuration. The charging and discharging area of the battery USES energy storage components to absorb the power generation. This form of source-charge interaction is an active behavior, which changes the past passive adaptive load of the power supply. When the energy storage components cannot meet the excess power, part of the consumption of new energy will be abandoned in the new energy area.
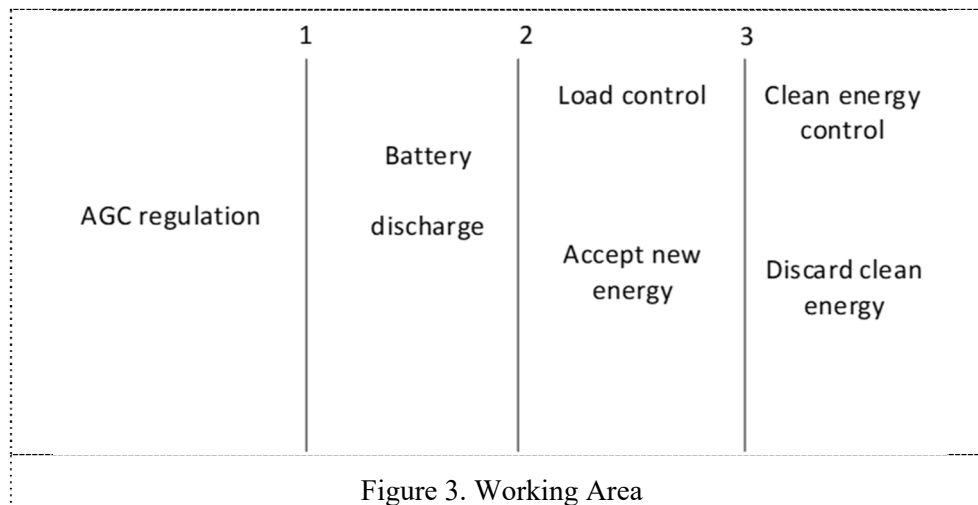
Because conventional AGC regulation can only adjust the output of thermal power units, and because of the large power generation of clean energy and serious waste, in order to absorb new energy as much as possible, an AGC scheduling control method involving battery group is proposed.

3.1. Judging work area
Since power generation requires thermal power generation to have a lower limit of P_{Gmin}. if thermal power generation must not be lower than P_{Gmin}. battery charge and discharge control area: at this time, the battery is charged or discharged, all new energy is put into the network. The power generation of thermal power unit is at P_{Gmin} and remains unchanged.

Abandon the new energy area, that is to say, all the electric heat storage input is still generated excess electricity. In order to meet the balance between supply and demand and ensure the stability of the system, then abandon part of the new energy generation in the region according to some needs.

The control area is shown in figure 3: the total power generation control is divided into four areas: conventional power supply area, battery discharge area, battery charging area and clean energy area. There are three critical conditions.

Figure 3. Working Area

If the power generation is large at this time, firstly control the thermal power at the lower limit of power generation, and then use the critical condition (1) to judge, and bring the data into (1). If the left side of the equation is less than or equal to the right side, then the region is the conventional power source region.

If you bring 1 to the left than on the right side and you bring the data to the critical condition 2, and if you're less than equal to the right side, you're going to do it in the battery discharge area.

If the left side of the 2 is greater than the right side and the data is brought to the critical condition 3, the central left side of the 3 is less than or equal to the right, and this area is the battery charging area.

If the left side of the 3 is larger than the right side, it is the fourth area, and the part of the clean energy is abandoned, and the system is stable.

Since the ultra-short-term load prediction for clean energy use takes 5-15 minutes, and the load changes in real time, the scheduling change is based on five minutes each time, and a regional comparison is made every five minutes, so as to carry out scheduling control in a timely manner and take care of the reliability and security of the system operation.

3.2. Calculated critical condition

Critical condition 1:

$$\int_{t_0}^{t_1} (P_{G\,MIN} + P_C + P_n) \cdot dt = \int_{t_0}^{t_1} P_D \cdot dt \cdots \cdots (1)$$

P_{GMIN} represents the minimum value of thermal power generation. P_C represents the power of the tie line per unit time. P_n represents clean energy generation per unit of time. P_D represents the power used per unit time load. t_0-t_1 represents the integration time.

Critical condition 2:

$$\int_{t_0}^{t_1} (P_{G\,min} + P_C + P_n) \cdot dt + \sum_{i=1}^{m} \int_{t_0}^{\alpha \cdot tde,i+(1-\alpha) \cdot t_1} P_{ed,i} \cdot dt = \int_{t_0}^{t_1} P_D \cdot dt \cdots (2)$$

$P_{ed,i}$ represents the discharge power of the battery per unit time;

Since the battery is arranged by m small electric heat storage groups, the total t_{de} per unit time.I is the maximum discharge time of the battery, and t_0-t_1 is the integral time.

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α is the battery state coefficient. If the charging time is more than the current charging time, the charge time is 1 at the time of charging time, if the charge time is less than the charging time, the integral time is calculated according to the system allocation time, and the battery group has sufficient scheduling capacity.

Critical condition 3:

$$\int_{t_0}^{t_1} (P_{G\min} + P_C + P_n) \cdot dt = \sum_{i=1}^{m} \int_{t_0}^{\alpha \cdot tce,i + (1-\alpha) \cdot t1} Pec,i \cdot dt + \int_{t_0}^{t_1} P_D \cdot dt \cdots\cdots (3)$$

P_{GMIN} represents the minimum value of thermal power generation. P_C represents the power of the tie line per unit time. P_n represents unit time clean energy generation. P_D represents unit time load power. t_0-t_1 represents the integration time. $P_{ec,i}$ represents battery charging time. $t_{ce,\ i}$ represents the maximum rechargeable time of the battery.

Alpha is the battery state coefficient. If the charging time is required to exceed the current charging time, the coefficient is 1. If the charging time is required to be less than the current charging time, the integral time shall be calculated according to the system's allocated time. At this time, the battery bank has sufficient adjustable capacity.

4. The instance simulation

4.1. Data selection

In a certain region, the total thermal power generation power is determined to be 2000MW, the lower limit is 850MW, the maximum new energy power generation is 2000MW, and the maximum input power of the battery group is 150MW. Let's assume that the stored power of the battery is 100MW at the current moment.

Table 1. Power load scheduling and control sequence in a region

parameter	Data 1	Data2	Data3
Thermal power P_G	850	850	850
New energy generation P_n	1700	1500	2000
Electricity consumption P_D	2650	2400	2650
Tie line power P_C	80	80	80

4.2. State judgment

$$P_{surplus} = P_n + P_G + P_c - P_D \quad (4)$$

Table 2. Regional state

	Data 1	Data 2	Data 3
Residual generation	-20	30	280

According to Data 1, the remaining quantity of the generation is -20mw. due to the control sequence, when the load is large, the battery discharge should be discharged first, and when the battery is discharged, the power of the fire power is increased, and the battery discharge is 20mw, which satisfies the supply and demand.

Power generation, new energy generation, and the first critical condition of the exchange of power satisfaction of the section, when the system is located in the first workspace domain.

$$\int_{t0}^{t1} (P_{G\min} + P_C + P_n) \cdot dt + \sum_{i=1}^{m} \int_{t0}^{\alpha \cdot tde,i + (1-\alpha) \cdot t1} P_{ed,i} \cdot dt = \int_{t0}^{t1} P_D \cdot dt \cdots (4)$$

When the load continues to decrease, it can be concluded from the status judgment of data 2 that the power generation surplus at this time is 30mw, and the thermal power can no longer be adjusted. In

order to ensure that all the new energy is connected to the network, the extra power of 30mw is put into the battery device for consumption.

It is in the working area of battery charging, which satisfies the following equation.

$$\int_{t_0}^{t_1} (P_{G\min}+P_C+P_n) \cdot dt = \sum_{i=1}^{m} \int_{t_0}^{\alpha \cdot tce,i+(1-\alpha) \cdot t1} Pec,i \, dt + \int_{t_0}^{t_1} P_D \cdot dt \cdots \quad (5)$$

When the rechargeable time of the battery is less than the rechargeable time, the rechargeable time is α =1, otherwise α =0. Therefore, when the load is reduced again, it can be judged from the critical condition that the remaining power has exceeded the maximum acceptable range of the battery group. At this time, all the flexible load is put in and the excess clean energy generation is discarded. According to the data, at this time, the available capacity of the battery is 40mW, and the new energy can be absorbed as 40mW, and the rest of the excess new energy generation is discarded, with the amount of 240mW.

5. Conclusion

In this paper, the method of charging and discharge of the agc is different from that of the agc, which can only control the characteristics of the power generation, and the agc that covers the battery energy in this paper can realize the energy storage device and the electric unit is based on the demand scheduling, so as to ensure the demand of the load and the maximum amount of energy to accept the new energy.

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