The Technology Research of Cogeneration/Thermal Depth Peakload Modification

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Keywords: Cogeneration, Peak shaving, Technology and reform.

Abstract: Along with the increase in Gansu power grid wind power installed capacity, affected by wind load of the grid load pressure, Gansu power grid peak shaving will face great difficulties. In view of the cogeneration unit, this paper introduces four kinds of feasible cogeneration depth peakload retrofit scheme and its operation mechanism, technical characteristics and applicable conditions. Jorge electricity can be involved in wind load, to a certain extent, and can alleviate the current and future period of time with a large number of abandoned wind.

1. Introduction

With the development of the economy of Gansu Province, the grid power load structure change, peak valley difference increases year by year. Improve the proportion of although the installed power generating capacity increased greatly, large capacity generators, peaking capacity has been strengthened, but with the Gansu power grid wind power installed capacity increase by wind power anti peaking effect, increase the pressure on the power grid peak shaving, Gansu Power Grid peak shaving will face great difficulties [1].

2. Conventional Power Peaking

Principle of peaking power plants are as follows: (1) the full use of water; (2) to reduce the thermal power unit, the unit coal consumption, play a role in the efficient units; (3) to minimize the cost of thermal power. According to the above principles, it is concluded that in summer abundant water period and winter dry season all types of power plants in the daily load curve arrangement. Winter dry season, by condensing thermal power plant take basic load, hydropower plants bear peak load. Summer wet period, adequate water, hydropower plant should base load in order to avoid waste of water, saving coal. During this period, seize the time to carry out thermal power plant equipment maintenance [2].

3. Study on the Influence of the Operating Mode of Gansu Power Grid Peaking Capacity of Thermal Power Units

2014 thermal power installed capacity of 1594 million kilowatts, the heating power plant installed capacity 527.5 million kilowatts, in the heating period, heating units need to maintain output, heating units are basically the only spare capacity, and no spare capacity, load capacity is very small.

From January to March, the whole network power basic open operation, start-up mode for 1170-1320 million kilowatts, the whole network load capacity of the strongest. Thermal power peaking amount 387-454 million kilowatts.

In April to June, thermal power boot to reduce, thermal power unit start-up mode for 818-960 million kilowatts, power peaking capacity is strong, the peak volume 335-399 million kilowatts.

  DOI: 10.25236/mse.2018.007

In July to September, thermal power boot, minimum, thermal power unit start-up mode for 797-832 million kilowatts, power peaking capacity to minimum and peak volume 299-314 million kilowatts of.

In the October December, thermal power boot mode gradually increased, the thermal power unit start-up mode for 1059-1432 million kilowatts, thermal power peaking capacity is strong, the peak volume 364-505 million kilowatts. But November and December thermal power peaking capacity by the influence of coal large.

Figure 1 for the 2014 grid peaking expects urban heating period is generally November 1 to March next year, as the annual air temperature of different flexible regulation. From the chart can be seen, November to March the heating period of Thermal Power Boot capacity is large, but at this time because of thermoelectric power generation output high, heat supply units in cogeneration economy high, generally served baseload operation, not suitable for as peak load unit, so the thermal power peaking capacity did not increase.

In addition, in the fourth quarter, thermal power units will be subject to affect coal coal, can not achieve the rated output, to ensure that the whole network power balance, thermal power boot mode is relatively large, resulting in trough the whole network power output high, during the peak power output is blocked, the thermal power peaking to force Limited [3]-[4].

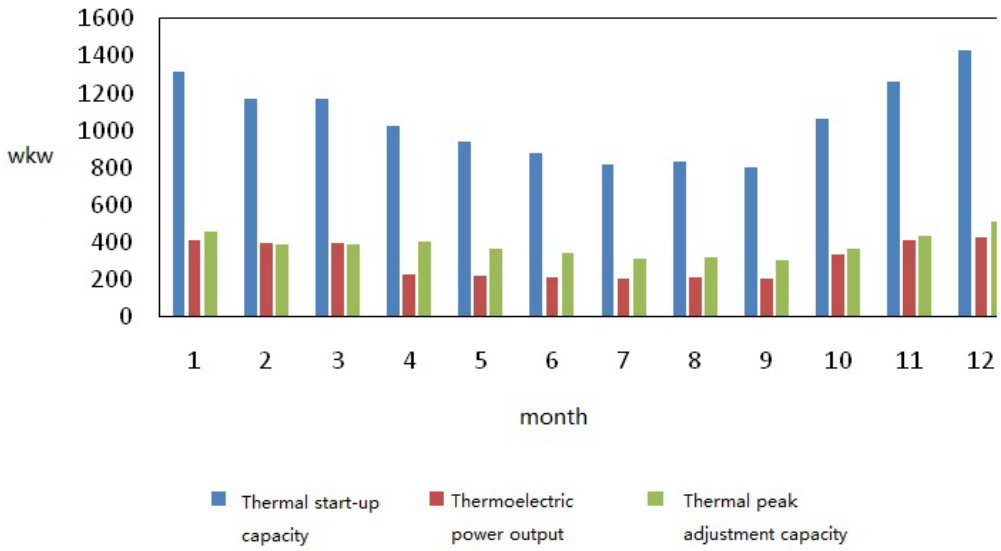


Fig. 1 Expected power peaking

4. Research on Power Grid Wet Season Effect on the Peak Load Capacity of Thermal Power Units

Hydropower installed capacity of 795 MW, in addition to the Yellow River, Bailong River Cascade Hydropower about 3260MW have the peaking capacity, rest, about 46.9 MW small hydro are runoff hydropower station, basically do not have the peaking capacity. But the hydropower is affected by runoff, ice flood control downstream water for irrigation and other factors influence throughout the year peaking capacity differences.

From January to mid March, affected by the the Yellow River flood factors, liujiaxiahydropowerstation outflow 450-550 cubic meters per second, the maximum output power of 215-294 million kilowatts, the minimum output of 131-171 million kilowatts, due to hydropower outbound traffic restrictions, the whole network of hydropower peaking capacity minimum, peak volume of 84-123 million kilowatts.

From April to June, liujiaxiahydropowerstation outboundflows 600-850 cubic meters / second, the Yellow River cascade hydropower stations, Longjiang, Heihe hydropower generating capacity increased, the whole network capacity of the largest hydropower Hydropower peaking. The maximum output of 386-576 million kilowatts, the minimum output of 244-392 million kilowatts of peak volume of 143-184 million kilowatts.

From July to September, liujiaxiahydropowerstation outflow 700-850 cubic meters / second, the Yellow River cascade hydropower stations can enhance the peak. But the white Longjiang, Heihe, the Tao River Basin for hydropower began to decrease in peak load capacity, the hydropower peaking capacity of large hydropower, the maximum output of 593-615 million kilowatts, the minimum output of 441-454 million Tile and peak volume 152-162 million kilowatts.

October to mid November, Liujiaxia plant outflow of 800-900 cubic meters / seconds, the hydro peaking capacity is large, the hydropower maximum output 422-511 million kilowatts, minimum output 251-348 million kilowatts, the amount of hydropower peaking 163-171 million kilowatts.

From mid November to December, the whole network of hydropower generation is greatly reduced, the Yellow River entered the flood period, the Yellow River cascade hydropower outbound flow smoothly, reduce the white Longjiang River, hydropower peaking capacity is affected, the maximum output of 2 million 470 thousand kilowatts of hydropower, the minimum output of 1 million 490 thousand kilowatts hydropower peaking capacity of 980 thousand kilowatts.

In the Liujiaxia daily outbound traffic of more than 1000 cubic meters second, the Yellow River cascade hydropower basic full of hair, especially during the three quarter of the whole network of hydropower, thermal power operation mode. According to the minimum peak load capacity of thermal power units is mainly affected by the impact during the boot capacity, hydropower, thermal power due to the whole network boot capacity is small, the heating unit and occupy a certain boot capacity, condensing thermal power units the load rate is low, the power peaking capacity decreases, can be seen from Figure 3 the wet period of thermal power peaking capacity for the whole year. Although the weakest hydropower peaking capability, but subject to Thermal power peaking capacity is greatly weakened, falling the whole network of hydro thermal power peaking capacity of the overall total.

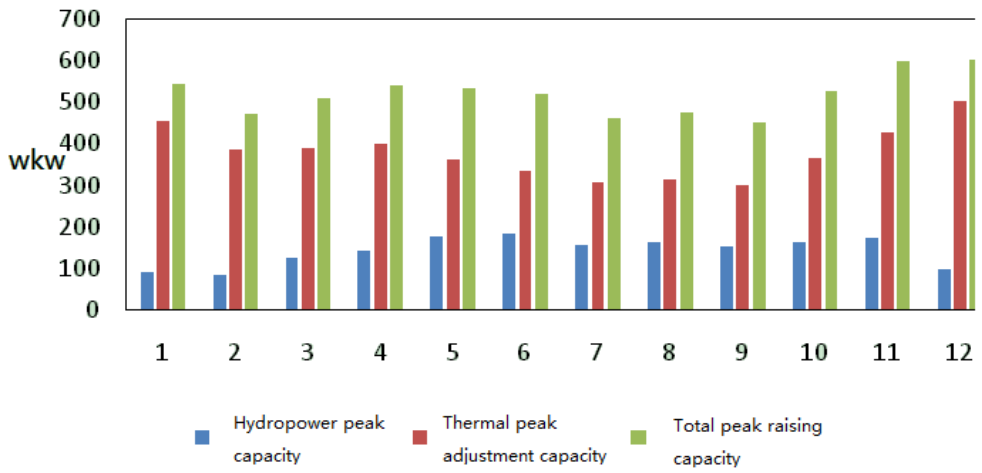


Fig. 2 The grid is expected hydro thermal power peaking

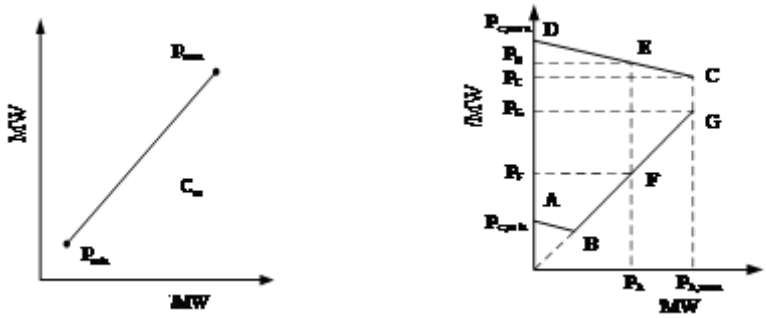
5. Peak Depth Reconstruction Technology of Cogeneration Unit

5.1 The Operation Mode of "Hot Electricity" For Cogeneration Unit

Heating units in power system in our country can be mainly divided into back pressure units and steam turbine. Back pressure steam turbines is weak by the steam turbine exhaust as heat source for heating, no cold source loss and high efficiency. The power relationship in Figure 3a) shows a linear relationship between the two, in the heating power given the power to the fixed value, can not be adjusted, so it is the meaning of "power determined by heat". Steam heating unit is from steam turbine (heating units are usually in the middle pressure cylinder to the low-pressure cylinder between the selected part of the steam) as a heat source to external heating. Steam turbine operation flexibility higher than the back pressure units, from Figure 3B) power relation description can be seen in the heating power under the same conditions, power has certain adjustability, such as heating power Ph, power can be adjusted in PE~ between PF, but The greater the heating power, the

smaller the range of electric power can be adjusted [5].

In the excess wind power in valley period of load, as much as possible acceptance of wind power, extraction steam turbine often according to the requirements of scheduling has been running under the given thermal load minimum power output state, namely minimum condenser condition, Figure 3B), BG under different heat load minimum condenser load lines, heating power and the corresponding minimum power approximate linearly, so you can think in the periods of excess wind power, this kind of thermal power unit is "to thermal electricity running state.



a) Back pressure type unit b) Extraction steam turbine unit

Fig. 3 Relationship between heat and electricity

5.2 Technical Scheme of Cogeneration Unit on Peak Load Transformation

Scheme 1: Bypass Compensation Heating Program.

(1) Theory

The bypass heat compensation decoupling scheme of thermal power plant "to thermal electricity constraints and then participate in the operation mechanism of wind power peak is: when night valley period of load system of wind power surplus and reduce the input to turbine steam supply amount to reduce power generator acceptance of wind power; and so caused by insufficient heat of steam turbine parts, through the whole bypass system of the heating unit consists of the boiler directly provide high temperature and high pressure steam after temperature and pressure reduction to the heating of the heat load. For large generator unit by bypass heating operating mode in acceptance of wind power has certain economic feasibility.

(2) Technical characteristics

1) Peak amplitude. The new boiler steam in the temperature and pressure in the process of the main loss reduction is the steam acting ability, heat loss rarely, this analysis ignored a new boiler steam in reducing the temperature and pressure in the process of heat loss.

When the heat load is greater than or equal to boiler lowest stable combustion under the condition of heating load, the theory, when severe abandoned wind, thermal power unit can stop the operation of the steam turbine, and the steam through the temperature and pressure reduction is used for heating, so as to realize the stop shaving. When the heat load is less than boiler lowest stable combustion under the condition of heating load, also can adopt downtime peaking, but the boiler will have a part of the new steam cannot be exploited because of waste. Therefore, more economical or low load operation of steam turbine, and the heating part of the problem, the new steam temperature and pressure reduction of thermal compensation, the peak depth will be lower than peak shaving down[6].

2) Peak efficiency. In this paper, the acceptance of 1MW - H wind power to save coal consumption to measure thermal power unit in abandoned wind regulating benefits.

From the point of view of the whole network, thermoelectric generating set the bypass heat compensation scheme accepted 1MW wind power, reduce the coal consumption can be estimated by approximation.

$$\Delta F_1 = \frac{3600(1+\lambda)}{29308\eta} - \frac{3600\lambda}{29308\eta} = \frac{3600}{29308\eta} \tag{1}$$

In the formula: the power ratio of the heating steam, the thermal power unit to reduce the 1MW

power to accept the wind power, the heating power decreased by MW,The assumption of a continuous time is 1H, the ETA is the product of the thermal power plant thermal efficiency of the boiler and piping thermal efficiency, about about 0.85, 29308 for standard coal of low calorific value. However, due to the thermal power units to reduce output, lambda MW thermal load required by new steam through the bypass meet, so the boiler need to consume more than 3600 lambda /29308 ETA t of coal. In summary, the acceptance of 1MW wind power to save coal consumption can be calculated by equation (1).

By formula (1), we can see that the program accept 1MW - H wind power in the conservation of coal consumption, equal to the thermal power unit boiler production 1MW - H heat consumption of coal consumption, about 0.15t/MW - H.

Scheme 2: Heating Scheme for Electric Heating Compensation.

(1) theory

The scheme through in power plant installed electric boiler or heat pump electric heating facilities to decouple thermal power plant heat determine power constraints. Under the scheme, thermal power plant in operation mechanism of wind power peak is in the period of excess wind power, heating units reduce power receiving part of wind power electricity, and reduce the heating part, is composed of an electric heating equipment consumption another part of the wind power to meet. That is to use the excess wind power alternative cogeneration of electricity and heating, therefore, has the obvious benefit of saving coal [7].

At present, due to the high cost of heat pump investment, the main use of electric boiler abroad as an electric heating equipment.

(2) Technical characteristics

1) Peak amplitude. From the angle of peak shaving, the scheme with double peak shaving effect. On the one hand, thermoelectric unit reduces power to accommodate the excess wind power spare part of Internet space; on the other hand, electric heating equipment consumed part of the excess wind power. In extreme cases can the cogeneration unit shutdown, and full use of electric heating equipment consuming excess wind power heating. Therefore, from the point of view of the external characteristic of the whole unit, the peaking minimum power for negative electric heating equipment of power capacity, far greater than the thermal power unit load capacity, is greater than that of the bypass heating is used when the peak depth.

2) Peak efficiency. The accepted wind power is used to replace the heat supply of the cogeneration unit λ/(1+λ), or the replacement of the power supply of cogeneration unit 1/(1+λ).And the power generation efficiency isη/(1+λ), So the cogeneration unit to reduce the electric power 1/(1+λ),When saving about coal consumption,

$$\Delta F_2 = \frac{3600/(1+\lambda)}{29308\eta/(1+\lambda)} = \frac{3600}{29308\eta} \tag{2}$$

By formula (1) and (2) can see, two identical. The former ignores the loss of thermal efficiency when the temperature and pressure reduction, the latter ignores the loss of thermal efficiency of the electric boiler, but the 2 efficiency losses are very small. This is because the power plant from the external point of view, the use of electric boiler heating in the production phase, when the cogeneration power is transformed into heat energy, the same with the new steam direct heating effect. From another perspective, the electric boiler scheme equivalent to wind power alternative cogeneration of heating and power supply, comprehensive efficiency and cogeneration of power and heat is basically the same with the boiler efficiency. Coal consumption savings so the scheme accepted 1MW h wind power is also approximately equal to the coal consumption, thermoelectric boiler production 1MW h heat.

Scheme 3: Heat Storage Compensation Heating Scheme.

(1) theory

The scheme through in the thermal power plant installation of large heat storage facilities (such as covered in thick insulation layer of the large water tank) decoupling to thermal electricity constraints. Under the scheme, thermal power plant in operation mechanism of wind power peak is: in the daytime electric load and thermal load on the small time thermal power units and high load

operation of heat storage, and at night small power load time reduce the output of generating unit (or even shutdown) peaking, lack of heating part of the heat storage heat compensation. At the same time, to avoid heat storage problems caused by heating quality decline usually have the configuration power standby boiler.

In addition, large fees shutdown peak load operation of the unit can also be using this scheme can reduce power generation of low price hours during the night, to avoid loss of low price and power.

(2) Technical characteristics

1)Peak amplitude of the peak amplitude of many factors, including heat storage heating power, heat storage capacity, unit heating capacity and thermal load ratio (the ratio of the, in the non peak time can be used for the storage of heat less). If the condition is appropriate, can realize the unit stop shaving.

Especially for pumping steam turbine and configuration after heat storage can not only by force in valley period of load using thermal storage heating reduces the unit "by thermal electricity resulting output, but also through the use of heat storage and supply in the peak load period, reduce or even stop pumping steam, so that the unit can be to the rated output power, increase the generating capacity of thermal units. Thermal power unit for pumping steam heating often maximum power cannot achieve the rated output[8].

2)Peaking benefits. Under the scheme, in order to meet the requirements of heat load, in a certain period (such as a day) production of thermal power unit quantity of heat should be equal to the heat cycle load consumption of thermal energy (due to the heat storage of the heat efficiency of short-term storage loss is very small and can be ignored). Therefore, acceptance of wind power using thermal storage scheme, did not reduce the thermal power unit in the period of thermoficated generating capacity.

In valley period of load, heat storage scheme with admission of 1MW - H wind power, it is necessary to reduce the 1MW - h other types of power. Due to cycle system in thermal power unit of thermoficated generating did not reduce the amount, so the alternative is actually non peak time system of pure condensing power generation points (thermoelectric unit through the non peak time increased THERMIFICATED powergeneration to heat storage, thereby reducing the system in the corresponding period of pure condensing power generation part). Therefore, its acceptance of 1MW - H wind power can save the consumption by estimated:

$$\Delta F_3 = \frac{3600}{29308\beta} \tag{3}$$

Contrast type (1), (2), (3), it is known that the consumptive same wind power, coal saving quantity of heat storage scheme is bypass schemes and electrical boiler scheme about 2 times, or about 0.30t/ (MW - H).

Scheme 4: Electric Heating Storage Heating Scheme.

(1) theory

Consumptive discarded less decoupling scheme is the scheme 2 and 3, the power plant and the installation of large heat storage facilities and electric heating device to heat and power plant to heat determine power constraint. The scheme, the thermoelectric plant in wind power peaking operation mechanism is: if the system of wind power curtailment, don't Rev. Electric heating equipment, and through the thermoelectric unit optimal operation of thermal storage equipment to be consumptive; and if the system and air is serious, the use of thermal energy storage has been unable to accommodating wind power, then you can use electric heating equipment, wind power, and the over heat load of the excess heat is stored in the heat storage facilities, heating load during peak hours.

(2) technical characteristics

1) The peak amplitude. Under the scheme, thermal power plant of minimum power for negative electric heating equipment installed capacity, the peak amplitude is far greater than the normal peak regulation capacity.

2) Peaking benefits. When abandoned wind is small, only the wind power consumptive heat storage and peak shaving efficiency and heat storage scheme the same, and when abandoned wind

larger. Further, the load of electrical heating equipment, its peaking benefit and scheme 2 the same (with electric boiler, for example).

5.3 Comparison of Different Schemes and Its Application Prospect in Power Network

Table 1 summarizes the various parameters of each scheme. Table 1, it can be seen from the, scheme 3 peak maximum benefit, but need to invest; strategy 1, the investment cost is low, but peaking benefits to lower than the storage scheme; scheme 2 peak amplitude is larger than scheme 1, but investment is also to larger than scheme 1.

Table 1, P0 for thermal decoupling of cogeneration units to meet the heat load of the minimum output; PEB electric boiler maximum power; PN for the installed capacity of thermal power units; scheme 3 peak increase by extraction steam turbine as an example.

In theory, the four schemes to the pumping steam turbine and back pressure turbine are applicable, and therefore may as a thermoelectric plant decoupling "to thermal electricity means bound. However, alternatives have consider the type of stroke electricity abandoned wind and thermal power unit.

Table 1 Overview of all types of programs

plan	plan1	plan2	plan3	plan4
Peak decline	P0	P0+ PEB	PN	PN+ PEB
Peak efficiency	0.15	0.15	0.3	0.3~0.15
running cost	small	small	small	small
capitalized cost	small	big	big	big

At present, heating units for large steam turbine and the power grid is mainly serious in the winter heating period abandoned wind, wind in the non heating period abandoned relatively few. Therefore, the thermal power units with non heating period, the peak depth, can dissolve most abandoned wind power. Under the premise of such a peak demand, scheme 1 than scheme 2 May is more economic. Due to the scheme 1 less investment, even without the need for investment; and scheme 2 is required investment in the construction of electric boiler.

Scheme 3 while there is a lot of investment costs, but the amount of coal saving acceptance of the 1kW - H wind power is about 2 times the bypass scheme therefore merits is to be studied. In theory, when the acceptance of wind power exceeds a certain threshold value, better than scheme 3; boundary value, scheme 1 good. However, the scheme of 3, its essence is the use of wind power instead of pure electricity coagulation, and scheme 2 and 1 is essentially the use of wind power instead of thermoficated generating quantity, so the scheme, with the common development of cogeneration units can wind power, it is also to increase the proportion of thermal power and power grid wind power in the power structure in the creation of the conditions, in this sense, scheme 3 is probably the best scheme of the current wind power penetration power.

In addition, if there is a very serious in the future under the scheme 3 abandoned wind phenomenon exists, it is also available on the basis of the program 3, the increase of the configuration of the electric boiler as a supplement, that is, the use of the program 4.

Although from the point of view of the entire power system power in wind power peak will improve system acceptance of wind power capacity, reduce waste volume of wind power, reduce the coal consumption, thus saving a lot of energy. However, thermal power plant in wind power peak will not only make the thermal power plant power loss, and loss of profit generation; but also need to heat and power plant to ensure the peaking of the heating level, reforming the current power plant equipment, such as the transformation of the bypass, or the construction of electric boiler, heat pump, heat storage facilities, resulting in huge investment costs.

Therefore, it is necessary to have a reasonable, load and improve the incentive mechanism, thermal power peaking benefit main body (wind farm) and cost of the main (power plant) between the interests coordination, giving power plant sufficient incentive to make thermal power plant to

active and actively through technology innovation and wind power peak. Peak incentive mechanism is power in wind power peak load regulation scheme can implement the key premise.

6. Conclusion

Peak load capacity of thermal power units affected by the power grid operation mode and abundant water season.

The influence of power grid operation mode is mainly reflected on the effect of different heating power peaking capability of thermal power, heating period although the thermal power boot capacity is large, but because this thermoelectric power output high, and heating units generally served baseload operation, not suitable for as peak load unit, to thermal power peaking capacity did not greatly increased. The non heating period is due to the thermal power boot capacity is not peaking capacity is small.

Peaking capacity of thermal power units is mainly affected by the boot capacity influence, in hydropower development period, due to the thermal power boot capacity is small, heating units and occupy certain boot capacity and pure condensing thermal power generation load rate is low, the thermal power peaking capacity decreases, so abundant water period of thermal power peaking capacity for the weakest annual. Although at this time hydropower peaking capability is strong, but subject to thermal power peaking capacity greatly weakened, the whole network of hydropower and thermal power together peaking capacity decreased.

For cogeneration units. This paper introduces the four feasible cogeneration unit depth peak load regulation reconstruction scheme and operation mechanism, technical characteristics and application conditions. If the power to participate in wind power peak, in a certain extent, can alleviate the current and future for a period of time in a large number of abandoned wind problems. Peaking incentive mechanism is power in wind power peak load regulation scheme can implement the key premise.

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