Economic Analysis of Distributed Thermal Storage Electric Boilers Based on Multi Party Participation to Eliminate Abandoned Wind and Light Power

Hongbin Zhang, Qiang Jin, Xiaoxu Gong and Mingcan Feng

ABSTRACT

With the deep development of clean heating in the north of China, distributed heat storage boiler is widely concerned as an important way of clean heating, which plays an important role in eliminating renewable energy and meeting the demand of residents' heating. It is a systematic project to eliminate and discard the light and wind from the distributed heat storage boiler, which involves many main bodies, such as power grid enterprises, heating enterprises, terminal users, renewable energy producers, etc., but the participation of all parties in the economic cost affects the promotion and effect of the spread of distributed heat storage boilers. Therefore, it is necessary to carry out the participation based on multi-party participation. The distributed thermal storage electric boiler is used to absorb the abandoned wind and discard light economy. In this paper, we summarize the typical business operating models, set up the economic cost analysis model of multi parties and take the method of combining qualitative and quantitative analysis to analyze the economy of the main participants, and finally give a typical example to analyze and evaluate the economy of all parties, which can provide references for clean heating price policy.¹

INTRODUCTION

In recent years, the problem of smog in northern China is very prominent, causing widespread concern from all walks of life. A large number of low efficiency combustion of loose coal lead to deterioration of air quality in winter, and become one of the pollution sources of the formation of large area PM2.5 in winter in the

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north of China. Clean heating is of great significance to the control of smog, which is helpful to greatly reduce the emissions of PM2.5 related pollutants, improve the phenomenon of winter smog in the north, and reduce the total fossil energy consumption and carbon emissions in the northern region. December 2017, ten ministries and commissions, including the National Development and Reform Commission, jointly issued the "Winter Clean heating Plan 2017-2021 for the Northern region" (the NDRC Energy No. [2017]2100), proposing that clean heating should be extended to 15 provinces (autonomous regions, municipalities directly under the Central Government) in the northern region, with plans to extend it to 2021. The area of electric heating reaches 1.5 billion square meters, and in areas rich in renewable energy resources, the construction of electric heating facilities with the function of thermal storage is encouraged, and the power dissipation of renewable energy sources such as wind power and photovoltaic power generation is promoted[1].

The utilization of abandoned wind and light for heating is of great value, including energy value, environmental value and economic value. Wind power replacing coal and natural gas as heating energy, which have the energy value of saving fossil energy, and as clean energy heating, which has the environmental value of reducing the emission of pollution gases such as carbon dioxide and sulfur dioxide, and using wind power heating to abandon wind at night has the economic value of increasing the amount of wind power online and reducing the cost of electricity consumption for users. In the aspect of wind power dissipation, the economic analysis, research and evaluation are also carried out on the construction of pumped-storage power station[2], wind, light and hydropower complementary[3-5], water source heat pump technology[6], thermal power plant of electric boiler[7] and other wind power dissipation schemes.

Ref. [8-9] briefly describes the value and prospect of wind power heating, and points out that wind power heating is still a means of high cost from the point of view of economy. For investors, the investment feasibility of the project can be determined as long as the heating benefit of wind power generation exceeds the heating cost, and wind power heating can be used as a transitional method to solve the current difficulties. Theref. [10-11] studies the social and environmental benefits of wind power heating. The social benefits include promoting the development of wind power, speeding up the substitution of electric energy, improving the utilization ratio of clean energy, etc. The environmental benefits include reducing greenhouse gas emissions, noise pollution and water pollution, etc. The energy saving quantity is measured. The paper [12] puts forward the wind power dissipation model of regenerative electric boiler, introduces the principle of wind power dissipation of regenerative electric boiler, and analyzes the environment and economic benefits. In reference [13], the technology and heating system of regenerative electric boiler are analyzed, and the economic analysis of regenerative electric boiler is carried out from the initial investment, operating cost and operating other aspects, and which is compared with the gas fired boiler. The paper [14] takes
the boiler room design of a Shanghai hotel as an example, carries on the economic analysis of technology compared with various other systems, such as fuel oil system, coal burning system and so on. And compares the dynamic and static recovery life of the boiler room with other systems, such as fuel oil system, coal burning system and so on. In reference [15], taking a hotel as an example, the technical and economic analysis is carried out from the aspects of load calculation, volume calculation of heat storage tank, equipment selection, operation cost and so on. Literature [16] studies the rationality and sustainability of the development of the distributed combined cooling and heating power supply project, and makes sensitivity analysis on the main parameters that affect the national economic indicators of the distributed combined cooling and heating power supply. In reference [17], the environmental benefit model of reducing pollutant emission is established by considering the new unit scheduling scheme formed after distributed power is connected to the power grid. According to the characteristics of wind power, solar energy, gas turbine and other distributed generating units, the economic benefit evaluation model of distributed generating units is established in reference [18], combined with the methods of national economic analysis and evaluation. A typical daily load of an actual micro-grid system is taken as an example to verify the effectiveness of the evaluation model.

However, at present, the research on dissipating abandoned wind and light of regenerative electric boiler is mainly focused on its environmental and social benefits. But from the current implementation situation, electric heating is a new form of energy utilization, there are still some uncertainties in the business model and technical route, so it is necessary to analyze the typical operation mode of the distributed regenerative electric boiler, to deeply analyze the economic cost of each party involved in dissipating abandoned wind and light of the regenerative electric boiler. Found that the important factors restricting its development and sensitivity analysis. The decision-making reference is provided, to guide the participants to build a reasonable business model, formulate relevant policies, and promote the sustainable development and operation of regenerative electric boilers.

BUSINESS OPERATION MODE

Comprehensive analysis of heating participants and their leading parties in regenerative electric boiler projects with a potential will. The typical operation modes can be summarized as follows: landscape new energy enterprise-led, heat-supply enterprise-led and multi-party cooperative leading three models.

The Leading Mode of New Energy Enterprises in Landscape Industry

In addition to building a large number of wind and light power plants, the wind and light new energy enterprises invest in the construction and operation and management of regenerative electric boilers simultaneously, and realize the overall
economic benefits by dissipating abandoned wind and discarding light. In this mode, the power generation enterprise can guarantee the demand for electricity of regenerative electric boiler, and as the main body of investment and operation, it has the exclusive advantage of the operation technology management of wind power generation and Regenerative storage electric boiler, and the income flow is clear.

**Heating Enterprise Dominant Mode**

Heating enterprises occupy the heating market, through obtaining relevant policy subsidies and heating prices, bundling the wind and light electricity generation enterprises in the electricity market, buying electricity at a lower price, and absorbing part of the abandoned wind and light electric quantity in the heating season. In this mode, the heating enterprises need to pay more transaction costs, and the government incentive policy needs more.

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Figure 1. Power and capital flow (dominant mode of new energy enterprises).

Figure 2. Power and capital flow (dominant mode of heating enterprises).
Multi-Party Cooperation Mode

With the participation of wind and light electric field, power grid company, Regenerative electric boiler and heating company, the distributed heat storage electric boiler shall be built by the heating enterprise, and the reasonable distribution of the benefit of the project of abandoning wind and light heating can be realized through the transfer of profits from the wind and light electricity generating station. It is an effective way and mode for distributed regenerative electric boilers to realize the rational distribution of the benefits of the project of abandoning wind and light for heat storage and electricity boiler at present.

Under this mode, the power grid company and its affiliated energy saving company are in a leading position. Through the establishment of the quadripartite cooperation mechanism of "government + grid enterprise + power generation enterprise + heating enterprise", all parties can realize the sustainable operation of heat storage and electricity boiler with moderate profit.

MULTI-PARTY PARTICIPATION IN COST-BENEFIT FACTORS

At present, the renewable power industry in China is still in the initial stage of development, photovoltaic subsidies have been introduced, and photovoltaic power generation is also in the process of active demonstration. Wind power, biomass energy has been formed with renewable power development fund as the main subsidy model, some small hydropower tax incentives have also been clear. In our country, renewable power energy, which is mainly based on power generation, has
TABLE III. COST AND BENEFIT OF ALL PARTIEDS.

<table>
<thead>
<tr>
<th></th>
<th>cost</th>
<th>income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy power</td>
<td>—</td>
<td>Net electricity income</td>
</tr>
<tr>
<td>generation enterprises</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power grid enterprises</td>
<td>Investment of net</td>
<td>Over the net fee income</td>
</tr>
<tr>
<td></td>
<td>connection project</td>
<td></td>
</tr>
<tr>
<td>Parties of regenerative</td>
<td>Initial investment in</td>
<td>Heating fee income</td>
</tr>
<tr>
<td>electric boiler</td>
<td>equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual maintenance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The cost of purchasing</td>
<td></td>
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<tr>
<td></td>
<td>electricity</td>
<td></td>
</tr>
</tbody>
</table>

been established and has begun to take shape. It can be said that the direct financial input subsidies and preferential tax policies have become the positive driving force for the development of renewable power energy in China.

The industry of the distributed regenerative electric boiler dissipates the abandoned wind and light involves many participants. While we consider the pattern of multi-party cooperation participation, analyzes the relations of factor and cost between the electric power producer and the electric power consumer, according to the current generation, the electricity consumption cost and the economic factor. This is shown in the table below.

Wind and Light New Energy Power Generation Enterprise

Income part: wind farm photovoltaic farm as the source of energy supply enterprises in the process of abandoned wind and light dissipation as an important part of the Participating units, one should first carry out economic cost analysis. When the thermal storage electric boiler project is not implemented, the wind-power electric field is often abandoned, resulting in a large amount of waste of energy, and abandoned wind and light electricity does not produce any income. If the heat storage electric boiler is used to dissipate the electricity quantity of the abandoned wind and light, the income of the wind farm is determined by the increment of the wind farm and the electricity price and the subsidy amount of the electricity, and the income of the power plant is as follows.

\[ C_f = W_f \times (P_s + P_b) \]  \hspace{1cm} (1)

Among them, \( C_f \) represents the power plant revenue, \( W_f \) represents the wind power plant incremental power generation, \( P_s \) represents each kilowatt hour electricity price, the electricity price can be based on the transaction between the two sides to determine, \( P_b \) represents each kilowatt hour of electricity government subsidies.
Expenditure: since the amount of electricity used to dissipate the wind and light electric field does not affect the normal production and operation and maintenance of the plant, the expense incurred in the process of dissipation is negligible, as shown in the following formula:

$$C_{of} = 0$$ (2)

Where, $C_{of}$ represents the outlay of the wind-power plant.

**Power Grid Enterprise**

Revenue: power grid enterprises as the middle side of the power supply and load, carrying an important transmission power supply function, which makes power generation enterprises and load side of the grid structure requirements continue to increase. In the process of eliminating wind and light in the distributed regenerative electric boiler, the income of the power supply company is determined by the electricity quantity consumed by the load side (the distributed regenerative electric boiler) and the electricity price, which can be expressed by the following formula.

$$C_{ig} = W_i \times P_{ij}$$ (3)

Among them, $C_{ig}$ represents the income of power grid enterprises, $W_i$ represents the electricity quantity sold by power grid enterprises, $P_{ij}$ represents the price of electricity sold per kilowatt hour, combined with the current reform of transmission and distribution price, the price of electricity sold per kilowatt hour should be added to the price of transmission and distribution plus the price of transmission and distribution as well as the government funds add-ons.

Expenditure: the expenses incurred by grid companies in the process of absorbing wind and electricity are determined by the incremental power generation of wind power plants, and due to the existence of network losses in the process of transmission of power lines, the connection project of large heat storage boiler belongs to the industry expansion project of power grid enterprise, and its connection project investment is undertaken by power network enterprise, so it is also considered in the expenditure cost when calculating, so the expenditure part of the cost is as follows:

$$C_{og} = W_f \times P_j + C_{ws} + C_{gl} + (C_{ju} - C_{ls})$$ (4)

Where, $C_{og}$ represents the expenditure of power grid enterprises, $W_f$ represents the amount of electricity connected to the network, $P_j$ represents the electricity price
per kilowatt hour of electricity, $C_{wl}$ represents the cost of line network losses, which is equal to the incremental power generation multiplied by the proportion of network losses multiplied by the power grid electricity price, $C_{wm}$ represents the management and maintenance Considering that eliminating wind and light does not increase the management and maintenance costs of power grid enterprises, so the cost is usually zero, $C_{wn}$ represents the network connection cost borne by power grid enterprises. At the same time, it is considered that Jilin and other provinces will give certain subsidies to the electric boiler network connection supporting projects. Therefore, $C_{ws}$ represents the subsidy cost of the network connection project for the government.

Subsidize the cost of the network connection project for the government. In general, the loss ratio is 6%, and in the calculation of income and expenditure cost, the income part adopts the load side electricity consumption and the expenditure part uses the incremental power generation on the power supply side, because of the line network loss in the process of transmission, and so on. There is a certain error between the two data, so it is necessary to consider the specific division of the cost of this part of the power difference in the subsequent analysis process.

**Regenerative Electric Boiler**

As an important link in the process of dissipating waste air and light, the economic benefit and cost of regenerative electric boiler are related to many factors, such as investment, construction, operation and maintenance, income and so on. This paper analyzes and calculates the dissipation of Regenerative electric boiler by means of the analysis and calculation of Regenerative electricity boiler.

The income part: the income from the absorption process of the regenerative electric boiler can also be regarded as the cash inflow part of the operation process. The income is divided into direct income and indirect income, and the direct income is the heating fee charged to the users. Indirect benefits include the benefits of coal conservation and emission reduction, and so on.

The direct income includes the average annual heating cost per unit of heating demand, which is calculated and analyzed according to the heating area, heating load demand per unit area and unit heating cost. The calculation is as follows:

$$C_{igz} = S_g \times P_g$$

Where, $C_{igz}$ represents the direct income of heat storage boiler, $S_g$ represents heating area, $P_g$ represents heating cost per unit area in heating season, which is related to the length of heating season and air temperature, etc. There are differences
in heating cost, heating area and heating days among different regions. The value should be considered according to different regions.

The coal saving income is expressed as the coal saving income calculated by comparing the standard coal consumption saved by the original coal fired boiler when using the regenerative electric boiler for heating, and the indirect coal saving benefit is calculated as follows:

\[ C_{jm} = W_{di} \times (q_e / q_m) \times P_m \]  \hspace{1cm} (6)

Where, \( C_{jm} \) represents the annual coal-saving income of thermal storage boiler, \( q_e \) represents the thermal value of electric energy, \( q_m \) represents the calorific value of standard coal, \( P_m \) represents the current standard coal price.

Emission reduction benefits are the benefits of reducing emissions of various pollutants from regenerative electric boilers as compared to the original coal-fired boilers. The indirect benefits of emission reduction are calculated as follows:

\[ C_{ip} = m_{co2} \times m_{bm} \times P_{co2} \]  \hspace{1cm} (7)

Where, \( C_{ip} \) represents the annual emission reduction income of heat storage boiler, \( m_{bm} \) represents the carbon dioxide produced by the combustion of each ton of standard coal, \( m_{bm} \) represents the annual substitute standard coal quantity, \( P_{co2} \) represents the collection standard for sewage charge.

Therefore, the combined benefits of the regenerative boiler are calculated as follows:

\[ C_{ig} = C_{igc} + C_{jm} + C_{ip} \]  \hspace{1cm} (8)

The study of this paper does not consider increasing the residual value of equipment at the end of life cycle time for the time being.

Expenditure part: expenses incurred in the implementation of thermal storage and electric boiler engineering, including project construction cost, operation and maintenance cost, etc., in which the investment cost of project construction is determined by the heating load required.

The initial construction cost is calculated as follows:

\[ C_{ocg} = C_{br} + C_{sx} + C_{fc} \]  \hspace{1cm} (9)
Where, $C_{ogc}$ represents the initial construction cost of regenerative electric boiler, $C_{bt}$ represents the bulk cost of regenerative electric boiler, $C_{xr}$ represents the cost of regenerative installation, $C_{fz}$ represents the auxiliary equipment and other expenses. The initial construction cost of the regenerative electric boiler is generally related to the capacity scale of the regenerative boiler, so the following formula can be used to estimate the initial construction cost:

$$C_{ogc} = P_{sr} \times Q_{gl}$$  \hspace{1cm} (10)

Where, $P_{sr}$ represents the unit price of regenerative electric boiler, $Q_{gl}$ represents the capacity of regenerative electric boiler.

The annual operating and maintenance costs and personnel costs are calculated as follows:

$$C_{ogw} = C_{ogc} \times \beta + C_{rgc}$$  \hspace{1cm} (11)

Where, $C_{ogw}$ represents the annual operation and maintenance costs and personnel costs, $\beta$ represents the maintain proportion of energy boilers generally do not need maintenance, so only consider the later equipment operation and maintenance costs and apportioned to each year, $C_{rgc}$ represents the personnel wage costs, by different heating units and there are differences.

Annual operating expenses, mainly for the purchase of electricity, calculated as follows:

$$C_{ogy} = P_{gd} \times Q_{dl}$$  \hspace{1cm} (12)

Where, $P_{gd}$ represents the average unit price of annual electricity purchase (yuan/kilowatt-hour), $Q_{dl}$ represents the total quantity of electricity purchased for heating should be considered when calculating here whether the operation mode of the regenerative electric boiler is only in the trough period, and whether the electricity price is different in different operation periods. Therefore, the average price of electricity is considered.

The total expenditure cost of the regenerative electric boiler is calculated as follows:

$$C_{og} = C_{ogc} + C_{ogw} + C_{ogy}$$  \hspace{1cm} (13)
ECONOMIC ANALYSIS OF MULTI-PARTICIPATION

Combined with the factors of benefit and cost of each participant mentioned above, the economic analysis model and method are established by using the model and method of economic cost and benefit analysis, and the economic efficiency of each participant is analyzed by using the model and method of economic analysis.

(1) The cost of regenerative electric boiler mainly includes three parts: initial investment cost, operation cost and maintenance cost, and the network connection cost is mainly borne by the power grid company. The total cost of construction and operation of heat storage boilers is as follows:

\[ C_{go} = C_s + C_e + C_w \]  \hspace{1cm} (14)

Among them, \( C_s \) represents the relevant equipment and installation expenses, such as thermal storage boilers; \( C_e \) represents the annual electricity consumption of thermal storage electric boilers, all of which are related to the scale of the thermal storage projects (the capacity of the regenerative electric boilers); \( C_w \) represents the operation and maintenance costs of the thermal storage boilers, including operation and maintenance expenses, wages and so on.

The income of regenerative boiler mainly includes heating revenue, which is collected from users according to the heating cost determined by local government, and indirect benefits such as saving energy and reducing emissions, saving coal and so on are not taken into account in the analysis here. The total income and cost of the regenerative boiler are shown in the following formula.

\[ C_{gi} = C_{dj} \times S_c \]  \hspace{1cm} (15)

Where, \( C_{dj} \) represents the heating charge per square meter in heating season shall be determined by the government in yuan per square meter, \( S_c \) represents the heating area in 10,000 square meters shall be the unit.

(2) For wind and light power plants, considering the elimination of wind and light by regenerative electric boilers does not increase the cost of operation and maintenance for power plants, so the net benefits are as follows:

\[ C_{js} = C_{if} - C_{of} > 0 \]  \hspace{1cm} (16)

That is, regardless of the price of electricity, wind and light power plants can always obtain a stable incremental income, so long as it is forced to abandon the wind and light to be consumed, its economy is feasible.
For power grid enterprises, according to the above analysis of their benefit-cost factors, we can see that according to the grid enterprises to collect reasonable grid charges, for incremental electricity, power grid enterprises can obtain stable revenue, regardless of incremental operation and maintenance costs, and so on. Its cost is mainly for the network supporting power grid project investment. The net proceeds can therefore be expressed as follows:

\[ C_{dwjx} = W_f \times P_{spd} \]  \hspace{1cm} (17)

Where, \( C_{dwjx} \) represents the net income of power grid enterprises, \( P_{spd} \) represents the net income of power grid enterprises, \( C_{jw} \) represents the cost which is mainly connected to the network, and the investment cost can be estimated according to 30% of the initial investment of the regenerative electric boiler.

**Typical Example Analysis**

In this paper, through the use of net present value and dynamic investment recovery period and other economic indicators for measurement. In the economic evaluation, the relevant parameters are determined according to the evaluation parameters determined by the National Development and Reform Commission and the Ministry of Construction, in which the social discount rate is 8%.

**Economic Analysis of Regenerative Electric Boiler Project**

Simulating the heating demand of 100000 square meters, according to the analysis of heating index, the total power of regenerative electric boiler is 15MW, and five 3000kW regenerative boilers are installed, assuming that the equipment and installation cost of a single boiler are 1.068 million yuan. The initial investment in the equipment and installation of heat storage boilers is 10.68 million yuan. According to the heating season in a certain place, usually from November 15 to March 15, the total number of days is about 120 days. The electric boilers store heat for 8 hours a day and consume about 14.4 million kilowatt-hours of electricity per year. General regenerative electric boiler can realize unattended, usually maintenance-free, taking into account the later equipment operation and maintenance costs, the average annual expenditure is about 50000 yuan, and heating cost is 28 yuan/m².

The economic indexes of the simulated regenerative electric boiler project are evaluated by net present value (NPV) and dynamic investment recovery period. When the electricity purchase price of the regenerative electric boiler is 0.3 yuan / kWh, the social discount rate is 8.0%, the economic evaluation indexes of the project are shown in Table 5.
TABLE IV. THE CALCULATION PARAMETERS.

<table>
<thead>
<tr>
<th>project</th>
<th>parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating area (m²)</td>
<td>100000</td>
</tr>
<tr>
<td>Heating load (kW)</td>
<td>5000</td>
</tr>
<tr>
<td>Load of regenerative electric boiler (kW)</td>
<td>15000</td>
</tr>
<tr>
<td>Number of boiler units. (unit)</td>
<td>5</td>
</tr>
<tr>
<td>Single boiler power. (MWh)</td>
<td>3000</td>
</tr>
<tr>
<td>Winter warm season days (day)</td>
<td>120</td>
</tr>
<tr>
<td>Heating price (yuan/m²)</td>
<td>28</td>
</tr>
<tr>
<td>Number of years of operation of the project (year)</td>
<td>25</td>
</tr>
</tbody>
</table>

TABLE VI. THE ECONOMY OF THE REGENERATIVE ELECTRIC BOILER PROJECT.

<table>
<thead>
<tr>
<th>project</th>
<th>parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchas electricity price (yuan/kWh)</td>
<td>0.3</td>
</tr>
<tr>
<td>Discount rate.</td>
<td>8.0%</td>
</tr>
<tr>
<td>Net present value (ten thousand yuan)</td>
<td>-2664.83</td>
</tr>
<tr>
<td>Dynamic investment recovery period (year)</td>
<td>Irrecoverable</td>
</tr>
</tbody>
</table>

From the economic calculation and analysis of the indicators, the simulation of thermal storage electric boiler project in the absence of initial investment subsidies, and 0.3 yuan per kilowatt-hour electricity purchase price, it is not economic. However, the parameters that affect the economic efficiency of the regenerative electric boiler are also changing with time and operation, especially the construction investment and energy cost are the main factors that affect the economic efficiency of the regenerative electric boiler. Therefore, in order to comprehensively evaluate the economic benefits of the regenerative electric boiler project, it is necessary to conduct sensitivity analysis to the main influencing factors.

Sensitivity Analysis

From the point of view of the cost and income of the regenerative electric boiler project, the total cost of the construction and installation of the relevant equipment accounts for a large proportion of the total cost, and the operation and maintenance costs are relatively fixed, so the initial investment and the purchase price of electricity can be affected by government subsidies and policies. The government could give a one-off subsidy to the initial investment.

The energy consumption directly affects the economic index of the project. Considering that the central heating price is fixed by the government and residents are motivated and able to bear it, the price is less affected. The heating price of the regenerative electric boiler should not be higher than that of the coal-fired central
heating. Otherwise, the heating effect of residents will be affected, and at the same time, the purchase price of electricity can be used to acquire the amount of discarded wind and light electricity at a lower price than that of new energy power plants.

Taking the cumulative net present value of the 25th year as an example, the sensitivity analysis of the initial investment subsidy and the purchase price is carried out. It can be seen from figure 2 that the zero boundary point of the accumulated net present value is about 0.15 yuan / kWh. The initial investment is about 7 million yuan. Therefore, when the purchase price of the regenerative electric boiler does not exceed 0.15 yuan / kWh and the initial investment does not exceed 7 million yuan, the project is economical and can achieve steady profit.

According to the consideration that the connection project accounts for 30% of the initial investment of the regenerative electric boiler, the investment cost of the supporting power network is about 3.2 million yuan. According to the current approved overhead charge, the economic benefit and the investment recovery period can be calculated by using the financial analysis method, and the investment can be recovered in the current year. It has good economy. The cumulative net present value (NPV) is calculated according to the 25-year payback period of the supporting power network, and the relationship between the overhead charge and the dynamic investment payback period is shown in the figure below.

It can be seen that, according to the transmission and distribution electricity price model, the supporting power grid project has a better economy, because the thermal storage and electricity boiler project needs to consume electricity energy, so the economy is mainly affected by the energy price, in order to further reduce the electricity cost of the regenerative power boiler. The government can also study the introduction of voltage levels of electricity clean heating transmission and distribution price (refer to Jilin model), but also independently approved clean heating transmission and distribution price, through further reducing transmission and distribution electricity price to achieve clean heating promotion.

**Multi-Party Participation Boundary Parameter**

According to the above analysis, in the scenario set by this example, the heat storage electric boiler can be used to bundle the wind and abandon the photoelectric field to promote the heating project implementation, and the boundary parameters can be defined according to the following participating costs and benefits and expenses. Can achieve the overall smooth implementation of the project and sustainable development.

It can be seen from the above table that the electricity price of regenerative electric boilers is far lower than the actual price of ordinary industrial and commercial electricity, mainly because in the implementation of the project, through direct transactions between thermal storage electric boilers and wind power plants, the price of electricity used in connection with the network and the overhead charge have been reduced. Thus, the regenerative electric boiler can obtain lower power
consumption cost, and the overhead charge is far lower than the actual approved transmission and distribution electricity price. Therefore, it is equivalent to moderate transfer of profits by wind and wind renewable energy power generation enterprises and grid enterprises through multi-party cooperation. The utility model not only satisfies the requirement that the amount of abandoned wind and light electricity can be used more frequently, but also reduces the electricity consumption cost of the regenerative electric boiler, from which the power grid enterprise can make up for the permitted cost and obtain reasonable income, increase the quantity of electricity passing through the grid, realize the win-win situation among the three parties, and raise economic efficiency.

### TABLE VI. BOUDARY PARAMETER.

<table>
<thead>
<tr>
<th>Project</th>
<th>Boundary parameters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The purchase price of regenerative electric boiler (yuan/kWh)</td>
<td>≤0.15yuan/kWh</td>
</tr>
<tr>
<td>Charge for crossing the net (yuan/kWh)</td>
<td>≥0.05yuan/kWh</td>
</tr>
<tr>
<td>Abandoned wind and light electricity price online (yuan/kWh)</td>
<td>≤0.1yuan/kWh</td>
</tr>
<tr>
<td>Initial investment of regenerative electric boiler (ten thousand yuan)</td>
<td>≤700 ten thousand yuan</td>
</tr>
</tbody>
</table>

### CONCLUSIONS

This paper analyzes and summarizes the current commercial operation mode of dissipating abandoned wind and light of regenerative electric boiler, and analyzes the cost and benefit factors of each party involved in dissipating abandoned wind and light of distributed regenerative electric boiler by using the method of financial analysis. After setting up the economic analysis model of multi-party participation, adopting the method of combining qualitative and quantitative analysis, the economic analysis of the main participants is carried out. Finally, the typical calculation example is used to measure and carry on the sensitivity analysis. The results show that the whole economy of the project can be realized when the purchase price of the regenerative electric boiler does not exceed 0.15 yuan/kWh, the passing fee is not less than 0.05 yuan/kWh, the online electricity price does not exceed 0.1 yuan/kWh, and the initial investment of the regenerative electric boiler does not exceed 7 million yuan. Can achieve stable profitability and sustainable development. The conclusion of this paper can provide a reference for the price and mechanism of clean heating and electric heating.

### ACKNOWLEDGEMENTS

REFERENCES