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# *Grid Planning Method for New Energy Consumption Based on Automatic Control Theory*

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***Abstract:*** Affected by various factors, the capacity, efficiency and benefits of clean energy (CE) power generation in my country are far from developed countries. With the intensification of the energy abandonment of CE such as wind power and photovoltaics in my country, the coordination and optimization of the consumption of CE are carried out. The main purpose of this paper is to study the grid planning method of new energy (NE) consumption based on automatic control theory. This paper analyzes the form of new energy consumption, analyzes the key factors affecting new energy consumption, and finally predicts the amount of new energy power generation (PG) in the example area. From the PG of new energy in the five-year example region predicted by the model in the experiment, it can be seen that the PG of new energy in this region will still maintain an accelerated growth trend in the next five years, which also shows that the development of new energy in such regions is promising. At the same time, it also indicates that its economic development level and ecological civilization construction will move to a new level.

## 1. Introduction

At present, the installed capacity of wind power and photovoltaic power generation in my country is affected by its volatility and intermittent characteristics, and the degree of clean energy grid-connected consumption is not ideal. With the increasingly severe problem of CE abandonment, the problem of CE consumption has become the focus of attention of the whole society in my country. As a flexible resource for regulation, energy storage has the characteristics of alleviating the fluctuation of CE output and optimizing the output, and has become an important means to solve the problem of CE consumption [1-2].

In a related study, Backer et al. demonstrated a simple, efficient, and cost-effective strategy for clean water production that can be implemented in geographically scarce freshwater resources [3].

Singh et al. A system for conversion into usable thermal, electrical and light energy [4]. According to the system of this invention, the fuel gas is preferably mixed with air in an amount that provides a stoichiometric ratio of oxygen, stored under pressure and ultimately transported to an area other than the inlet and outlet. Externally sealed burner elements. The system includes special forms of equipment for mixing and pressurizing gases and air in the correct proportions as well as special forms of equipment for establishing and controlling the combustion process.

This paper first analyzes the three forms of new energy consumption forms, namely centralized consumption, distributed consumption and collaborative consumption; then analyzes the goals and principles of Pg planning; then proposes system operation performance evaluation indicators , analyze the key factors affecting new energy consumption, and finally predict the new energy PG in the example area and analyze the economic benefits indicators.

## 2. Design Research

### 2.1. New Energy Consumption Forms

According to its consumption mode, new energy consumption forms can be divided into: centralized consumption, distributed consumption and collaborative consumption [5-6].

(1) Centralized consumption

Centralized consumption is to directly integrate large-scale new power sources such as wind power and photovoltaic power into the high-voltage Pg, and then connect to the transmission system to supply long-distance loads. Due to the volatility and intermittent characteristics of new energy, centralized consumption puts forward higher requirements for transmission line capacity and anti-interference ability. Or multi-energy coupling complementary form for consumption.

(2) Distributed consumption

Different from large-scale centralized new energy generation and consumption, distributed new energy consumption is generally small in scale, reducing losses, and can take the form of microgrids or virtual power plants to complement the Pg.

(4) Collaborative consumption

Collaborative consumption is to use the role of the Pg in resource allocation in the process of electric energy production, transmission and consumption to achieve the synergy between the source, the grid and the load, thereby improving the system's ability to absorb new energy.

### 2.2. Goals and Principles of Grid Planning

(1) Goals of Pg planning (PGP)

Scientific and rational PGP is an important prerequisite for the safe and stable operation of the power system. The PGP should comprehensively consider the needs of social development, improve the comprehensive utilization rate of resources, and ensure the environmental quality and other requirements. The specific PGP goals mainly include the following aspects:

1) Ensure the balance of power supply and demand

It is not only necessary to ensure that the power system can meet the needs of the whole society's PG and the maximum load of the whole society, but also to have a reasonable peak shaving capacity to meet the backup requirements and ensure the safe and stable operation of the power system.

2) Improve the comprehensive utilization of resources

Make full use of wind energy, solar energy, biomass energy and other renewable energy sources and high energy-saving technologies to improve the level of general energy utilization.

3) Guarantee the quality of the environment

At this stage, my country's power industry is still dominated by coal power, and its energy conservation, emission reduction, and low-carbon development play an important role in my country's control of carbon dioxide emissions. With the gradual weakening of the carrying capacity of resources and the environment, my country has realized the importance and urgency of low-carbon development of the power industry, and has taken a series of measures to strengthen the control of pollutants generated in the PG process. In the context of low carbon, one of the main ways is to give priority to the development of CE with zero carbon emissions in PGP, and to continuously optimize the power structure [7-8].

(2) Principles of PGP

1) The principle of economy

Economics is a fundamental principle of grid planning. The economy of PGP refers to the cost saving and reasonable use in the process of construction and operation of the Pg on the basis of satisfying the power required for national economic and social development. The cost of generating electricity from new energy grids such as wind power and solar power in my country is relatively high, and PG companies can generate greater economic benefits by choosing thermal power with relatively low costs. The implementation of renewable energy grid incentive policies such as carbon emission trading mechanism and renewable energy grid quota trading mechanism will increase the cost of thermal PG, which will have a great impact on the investment decisions of PG companies. With the advancement of new energy grid PG technology and the implementation of renewable energy grid incentive policies, the development of CE grids can bring greater economic benefits to PG companies, and vigorously developing new energy grid PG is a long-term choice for the PG industry [9-10].

2) Security principle

Grid planning should be based on the safe supply of electricity. For a long time in the future, the security of PGP will mainly be the security of coal-fired power supply. To ensure the security of power supply, it is necessary to ensure an adequate supply of coal. In recent years, China's new energy grid PG including wind power and solar PG has developed rapidly, and my country's new energy grid has sufficient resources to ensure the Pg supply for PG. However, wind power and solar PG have randomness and volatility. , will affect the safe supply of electricity to a certain extent. Therefore, the security principle should be fully considered in the process of PGP [11-12].

3) Low carbon principle

Low carbon is another important principle of grid planning. Compared with thermal PG, CE PG is clean and pollution-free, and almost no carbon dioxide is produced. In the context of promoting low-carbon emission reduction, PGP should consider the principle of low-carbon, and encourage PG companies to introduce advanced PG technologies, such as carbon capture and storage technologies, to reduce carbon emissions generated by thermal power units during the PG process.

4) The principle of operability

Consider its operability, and consider actual resource, environmental and technical constraints. For example, the development of hydropower should consider the adequacy of local water resources, while wind power plants are suitable for construction in areas with large wind volume and open space, and photovoltaic power plants are suitable for construction in areas with sufficient sunlight. In addition, technical installation and energy grid connection should also be considered. Therefore, the development of CE is faced with a great challenge. In the PGP, multiple factors such as resources, technical constraints, ecological environmental protection, and people's livelihood security must be comprehensively considered, so as to ensure that PG is economical, reasonable, low-carbon and clean, while ensuring The power supply is safe and reliable, and at the same time has operability [13-14].

### 2.3. System Operation Performance Evaluation Indicators

In the DERsCCHP system, the system will give priority to the use of WE and SE to meet the cooling, heating and power load, reduce the consumption of natural gas, and achieve energy saving and emission reduction. However, due to the relatively high heat collection cost of wind power, photovoltaic PG and solar integrator, the operating cost of the system will also increase accordingly. Therefore, this section constructs the CCHP operation performance evaluation index system from the three aspects of energy, environment and economy [15-16].

(1) Energy performance indicators

For the CCHP system, the main energy performance indicator is energy utilization efficiency. Since the energy input of the DERsCCHP system and the NGCCHP system is different, the energy efficiency of the DERsCCHP system and the NGCCHP system needs to be calculated separately. For the DERsCCHP system, the energy efficiency can be calculated according to formula (1):

$$ER = \frac{Q_{h,load} + Q_{c,load} + E_{load}}{F_{ng} + F_{PV} F_{WPP} + F_{Solar}} \tag{1}$$

In the formula: ER represents the energy utilization efficiency of the DERs system; Qh,load, ,Qc,load and Eload represent the heating load, cooling load and electrical load of the system respectively; Fng, FPV, FWPP and FSolar represent the natural gas input, PV can PG, WPP available power and solar thermal energy. Among them, the WPP power generation capacity is mainly determined by the wind speed of natural incoming wind. The effective energy input of the solar collector is mainly related to the solar light and heat intensity. The specific calculation can be seen in the formula (2):

$$F_{Solar} = A_p I_{FC}\left[1 + \frac{1}{3}\left(\frac{T_a}{T_s}\right)^4 - \frac{4}{3}\left(\frac{T_a}{T_s}\right)\right] \tag{2}$$

In the formula: Ap represents the area of the solar collector; Ts represents the temperature of the sun, which is equal to 6000 K; Ta represents the ambient temperature of the solar collector; IFC represents the radiation intensity received by the solar flat collector.

For the NG CCHP system, the energy efficiency mainly depends on the ratio of the cooling, heating and power load to the natural gas input. The specific calculation can be shown in formula (3):

$$ER^{NG} = \frac{Q_{h,load} + Q_{c,load} + E_{load}}{F_{ng}^{NG}} \tag{3}$$

In the formula: ERNG represents the energy utilization efficiency of the NG CCHP system; FngNG represents the natural gas input of the NG CCHP system.

The natural gas saving rate (NSR) is used to reflect the wind and solar energy capacity of the system. The specific calculation can be seen in formula (1):

$$NSR = \frac{F_{ng}^{NG} + F_{ng}}{F_{ng}^{NG}} \tag{4}$$

## 3. Experimental Study

### 3.1. Analysis of Key Factors Affecting New Energy (NE) Consumption

After the NE unit is connected to the Pg, the minimum power of the traditional thermal power unit in the Pg minus the minimum power of the traditional thermal power unit in the Pg at each moment is the maximum NE power that the Pg can accept, and the surplus power at this time can be called the NE power. Maximum reception space. In the actual Pg operation, if the receiving space is smaller than the power of the NE generator, for the purpose of ensuring the power balance of the system, the power exceeding the maximum receiving space must be given up, which leads to the phenomenon of abandoning wind and light [17-18].

Therefore, when it is difficult to balance the consumption of the Pg and the power produced, it will lead to the abandonment of wind and light after the NE units are connected to the grid. In the power system, the power supply consists of two parts: one part is the power generated by the new source (mainly including wind and photovoltaic PG); the other part is the conventional units; the power consumption refers to the load in the system (including the power exchanged with outside the area).

(1) New energy's own factors

The power of wind turbines and the prediction accuracy of wind power photovoltaics will affect the consumption of NE. The higher the prediction accuracy, the better the Pg operation mode can be planned in advance, and the scheduling can be reasonably arranged, thereby reducing the curtailment of wind and solar power. The wind power provided by the wind farm is irregular, and it will bring certain disadvantages when it is directly fed into the Pg. The photovoltaic power station is greatly affected by the weather. Minimize fluctuations in output power, or use large-scale energy storage technology to improve the utilization rate of renewable energy to reduce wind curtailment.

(2) Power grid (Pg) structure

The Pg structure here mainly refers to the structure of the transmission network, which determines the transmission capacity of the Pg and thus affects the new energy consumption capacity. However, due to the limited transmission capacity of the Pg, a large part of the wind power output is often lost in the process of transmission. In addition, from the perspective of Pg construction, wind power development time is short, while Pg construction takes a long time. Therefore, wind power development and Pg construction projects are usually difficult to coordinate and carry out, which leads to the difficulty of wind power transmission.

With the continuous integration of new energy into the grid, when its penetration rate reaches a certain value, the new energy will have a great impact on the transmission grid. In severe cases, it will cause some line blockages, which will also negatively affect other types of power transmission. The new energy access system will have a significant impact on the power flow distribution of the system, so the transmission capacity and the grid will also affect the consumption of new energy. energy absorption capacity. In addition, the peak-shaving power supply will also affect the new energy. In winter, the unit supplies heat and the water freezes, which brings inconvenience to peak shaving. However, in winter, wind power is more abundant and the transmission line load is heavier, which brings greater challenges to peak shaving. Therefore, the rationality of the grid structure is closely related to the consumption of new energy.

(3) Power structure

So far, my country's power structure is still dominated by thermal power, supplemented by hydropower. The dependence on thermal power cannot be replaced by new energy in a short period of time, which is affected by economic development and policies, and there are still many technical bottlenecks in the planning and operation technology of new energy units (such as the forecasting technology mentioned above). It is unreasonable to increase the penetration rate of new energy in a short period of time, the excess power of the power supply, coupled with the instability of the output of new energy, has led to large-scale abandonment of wind and light. Therefore, the investment in new energy units has slowed down in recent years. However, the development of new energy is still a historical trend, and it is necessary to overcome technical difficulties as soon as possible, so that my country's power supply structure enters a more reasonable development stage.

(4) Load characteristics

The power system brings low-cost, stable and high-quality power to users. In the Pg, the load is changing all the time with people's needs, and the supply and demand of electricity must be balanced at all times. Therefore, the output of the power supply in the Pg must follow the change of the load and produce corresponding changes.

Therefore, the electricity load continues to increase rapidly, and this change has brought benefits and drawbacks to new energy PG. The good point is that the increase in load means that the grid's consumption of new energy will increase; the disadvantage is that the increase in load means an increase in the load peak-to-valley difference, which makes peak regulation more difficult, the net load equivalent to load and new energy output is generally studied. In order to improve the load characteristics as much as possible, energy storage technology can be vigorously developed, and policies can also be used to encourage electricity consumption during low periods.

The various factors that affect the consumption of new energy are not unrelated to each other, but can affect each other. The system load distribution will affect the power transmission capacity. The improvement of the power transmission capacity can also make the peak-shaving power supply more reasonable. The smaller the peak-to-valley difference of the system load, to a certain extent, means that the peak-shaving capacity of the system is reduced, so various factors must be considered. Impact on new energy consumption.

### 3.2. Cluster Effect Analysis

Because large-scale new energy stations generally occupy a large area, for example, due to the different geographical locations in the station, the wind energy received by different wind turbines may be different, resulting in fluctuations in the output power of the wind turbines. In this case, the power The fluctuations follow the increase of the spatial distribution scale and show the characteristics of continuous flattening. Such effects are called clustering effects. The cluster effect can be analyzed by starting with long-term trend and short-term volatility.

(1) Correlation of long-term fluctuations

Long-term volatility can be analyzed from the monthly and above time scales. Monthly volatility is derived from changes in seasonal characteristics, climate types and long-term winds. Generally speaking, these factors have a relatively wide range of influences. It can be seen that the fluctuation characteristics of wind energy in the phase-N climate environment have a significantly similar trend.

(2) Complementarity of short-term fluctuations

On the time scale below the hour level, the wind power output and the extensive output show obvious complementary characteristics, which is an important phenomenon caused by the internal power difference of the new energy power station. Therefore, it is necessary to aggregate the power of each device of the new energy generation station, and combine the devices with similar or the same output, thereby simplifying the modeling analysis and calculation process.

## 4. Experiment Analysis

### 4.1. Prediction of NE PG in a Region

Through the model, the power generation of new energy in the five-year calculation example area is predicted as follows:

*Table 1. Predicted value of new energy PG in five-year example regions*

| Years | Predicted value of NE PG (100 million kilowatts) |
|---|---|
| 1 | 345.74 |
| 2 | 399.41 |
| 3 | 456.17 |
| 4 | 529.16 |
| 5 | 594.54 |

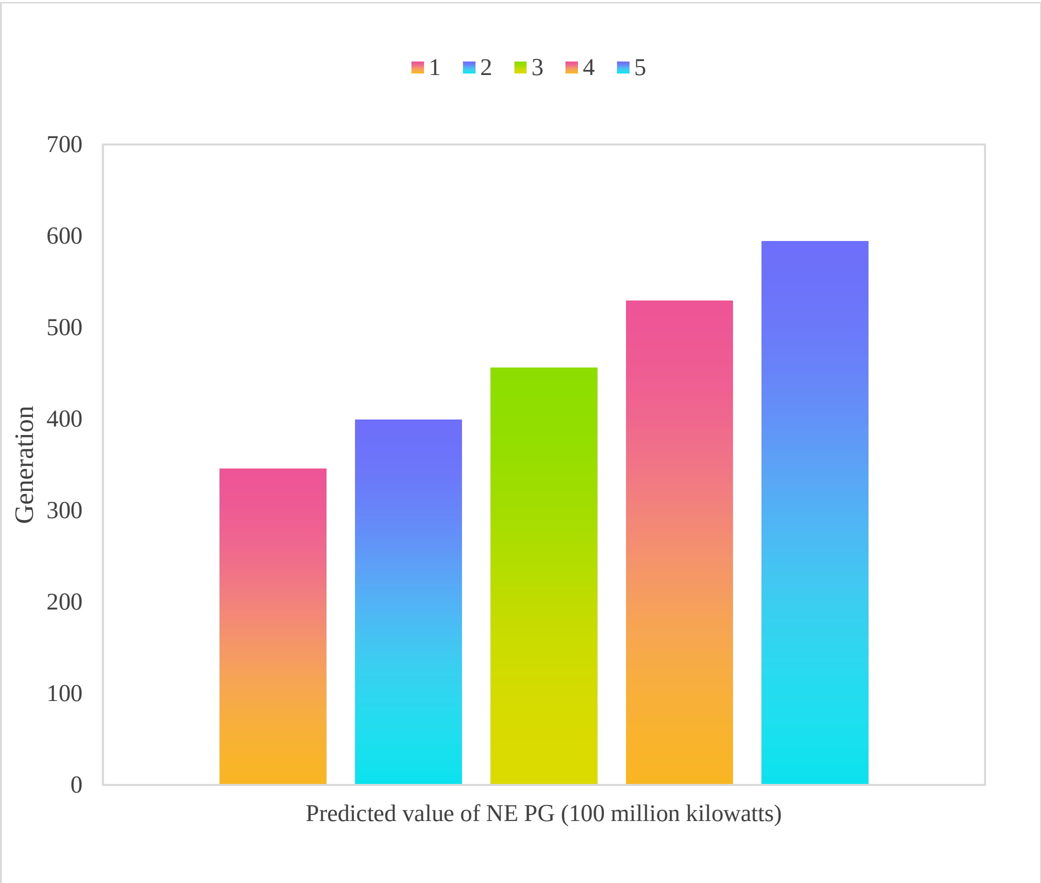


*Figure 1. Analysis of the forecast value of NE PG in the five-year example area*

The following is a summary of the predicted value of NE PG by type in the five-year example area:

*Table 2. Predicted value of NE PG by type in five-year example area*

| Years | Forecast value of wind PG (100 million kilowatts) | Measured value of photovoltaic PG (100 million kilowatts) |
|---|---|---|
| 1 | 231.65 | 114.09 |
| 2 | 263.61 | 135.80 |
| 3 | 296.51 | 159.66 |
| 4 | 338.66 | 190.50 |
| 5 | 380.51 | 214.03 |

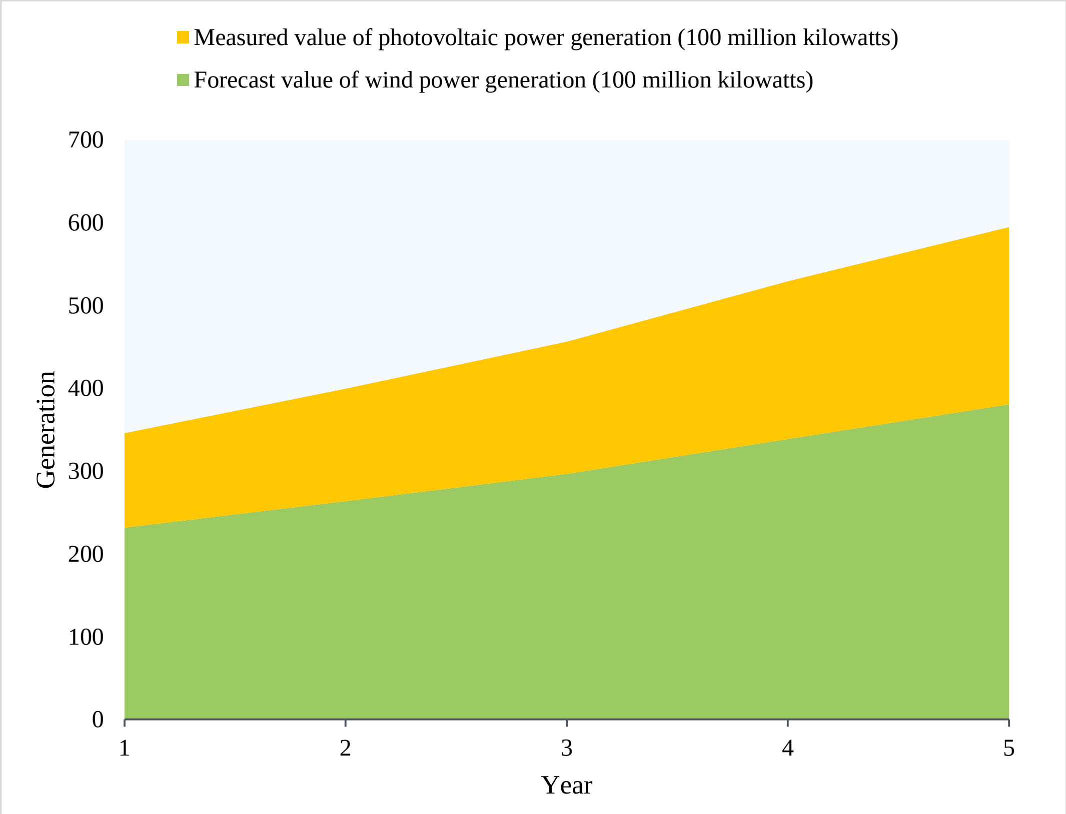


*Figure 2. Analysis of the forecasted value of NE PG by type in the five-year example area*

According to the PG of new energy in the five-year calculation example predicted by the model, it can be seen that the PG of NE in this region will still maintain a trend of accelerated growth in the next five years, which also indicates that the development prospects of new energy in such regions are good. This also indicates that its economic development level and ecological civilization construction will move to a new level.

## 4.2. Economic Benefit Indicators

According to the above data, the economic benefit indicators under different scheduling modes are calculated, as shown in the following table:

*Table 3. Economic benefit indicators*

| Period | Economic benefit index of wind, light and fire dispatching (E) | Consider TCC dispatch economic benefit index (E) |
|---|---|---|
| 0 | 0.45 | 0.45 |
| 3 | 0.41 | 0.55 |
| 6 | 0.57 | 0.70 |
| 9 | 0.42 | 0.42 |
| 12 | 0.47 | 0.89 |
| 15 | 0.65 | 0.89 |
| 18 | 0.59 | 0.84 |
| 21 | 0.48 | 0.48 |
| 24 | 0.39 | 0.39 |

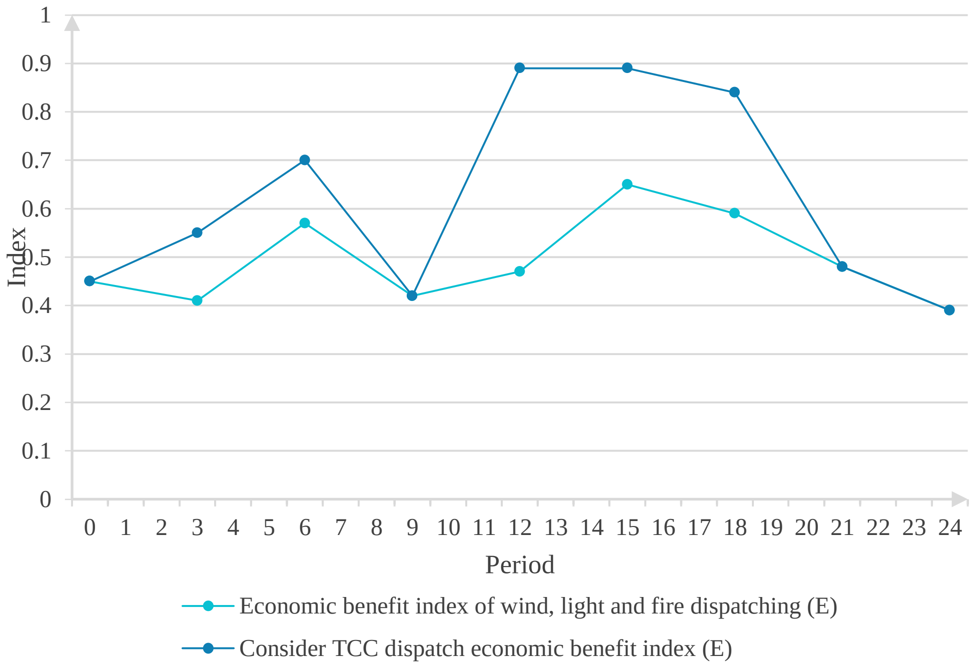


*Figure 3. Analysis of economic benefit indicators*

According to the dispatch benefit index in Figure 3, since the output of new energy is different in one day, according to the calculation of daily time series PG data, it is known that under the wind, light and fire bundling dispatch mode, the economic benefit index has been initially improved. The average benefit index is 0.49, but there is still a lot of room for economic improvement, which is more economical than the traditional consumption model. Under the combined output of wind, light and fire, according to the overall analysis of the existing installed units and the power market and consumption channels, after the introduction of the TCC mechanism, the daily average benefit index is 0.62, which is a significant improvement. This chapter takes economic benefit as the evaluation index. The larger the index, the lower the PG cost for the wind, light and fire bundling system. After the introduction of the cross-provincial delivery and consumption mode, the TCC mechanism should be fully utilized to establish incentive factors to encourage consumption of excess new energy PG, instead of only pursuing new energy consumption and making full use of complementary advantages. Incentives generated by policies such as transactions, green certificates and quota systems, coordinate scheduling to achieve efficient use of new energy.

## 5. Conclusion

Energy shortage and environmental pollution have become two global problems. On the one hand, the reduction of non-renewable energy sources such as oil and coal has widened the gap between the main sources. On the other hand, environmental pollution caused by the extensive use of chemical fuels is becoming more and more common. Green, clean and renewable energy is the solution to energy shortages and major sources of pollution. For energy development, formulating a scientific and reasonable new energy development plan directly affects the stable development and development efficiency of new energy and the entire power system. The formulation of new energy development plans usually needs to start from the aspects of resource conditions, power source investment entities and Pg structure.

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## Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## Conflict of Interest

The author states that this article has no conflict of interest.

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