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Design and Operational Effect Analysis of the Consumption Early Warning Function of the New Energy Cloud Platform

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Abstract. The New Energy Cloud platform provides users with efficient, fair, just, and quality services, and optimizes the business environment in the new energy field. It is of immense significance in promoting national energy transformation, accelerating power system reform, and building the Energy Internet, and can effectively support the construction of energy big data centers, form an ecosystem of the energy industry, drive the intelligent manufacturing of equipment, and boost economic growth. We studied the design of the consumption early warning function of the consumption computing sub-platform of the New Energy Cloud, and propose the analysis indicators and consumption early warning methods and the operational benefit analysis process of the consumption early warning function. Finally, we demonstrate the results of the consumption early warning function of the New Energy Cloud platform and analyze the operational effect of the consumption early warning function.

Keywords: new energy consumption, early warning, functional design, New Energy Cloud platform, operational effect analysis.

1. Introduction

New energy is the leading force in China's energy transformation, and its large-scale development is set to be further accelerated in the future. Relevant research shows that by 2030 and 2050, the installed capacity of new energy in the operating area of the company will reach 1 billion and 2.4 billion kilowatts, respectively, with the share in the total installed capacity of power supply rising from 22% at present to 36% and 57% respectively. A large number of new energy sources will be connected to the New Energy Cloud platform.

So far, in developing the New Energy Cloud platform, 15 sub-platforms have been developed, including environmental carrying capacity, resource distribution, planning, manufacturers, power supply enterprises, power grid services, electricity consumers, electricity price subsidies, supply and demand forecasting, energy storage services, consumption calculation, technical consultation, laws and regulations, decision-making assistance, and big data services. These sub-platforms have been fully deployed and adopted in 27 provincial companies under the company's system. The total installed capacity of new energy power stations is 360 million kilowatts, and 8,000 enterprises are now on the New Energy Cloud platform, collecting massive amounts of data and information on the whole process of resource management, planning, early-stage preparation, grid connection, operation, consumption, transaction, subsidy, policy, technology, etc., with the data volume exceeding 10 TB. This has made the New Energy Cloud the largest new energy platform in China, providing convenient and efficient business handling and information consulting services for the government, enterprises, users, and trade associations. The New Energy Cloud has broad application prospects. With access to various power sources, it is of immense significance for promoting the national energy transformation, accelerating the reform of the power system, and building the Energy Internet. It can effectively support the construction of energy big data centers, form an energy industry ecosystem, drive intelligent manufacturing of equipment, and boost economic growth.

In this paper, we studied the design of the consumption early warning function of the consumption computing sub-platform of the New Energy Cloud, and propose analysis indicators and methods for consumption early warning and the operational benefit analysis process of the consumption early warning function. On this basis, to analyze the operational effect of this function, we propose the analysis process for the operational benefit of the consumption early warning function. Finally, we demonstrate the results of the consumption early warning function of the New Energy Cloud platform and analyze the operational effect of the consumption early warning function.

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1.1 Design of the consumption early warning function

The New Energy Cloud platform features a consumption early warning analysis function. It utilizes an early warning analysis model of new energy consumption based on the indicators of electricity abandonment rate, annual utilization hours, and the proportion of new energy consumption in various regions. Specific analysis indicators and modeling methods are as follows:

1.2 Early warning indicators of new energy consumption

Early warning indicators of new energy consumption reflect the consumption status of wind power and solar power generation in various regions. To evaluate and provide early warning of the consumption level of new energy in different regions, the new energy consumption status in major regions in recent years is evaluated by comprehensively considering three indicators—the power abandonment rate, the annual utilization hours, and the proportion of consumption of new energy scientifically and quantitatively. Specific indicators and connotations of early warning analysis of new energy consumption are as follows:

Power abandonment rate: the ratio of new energy power abandonment to theoretical new energy power generation (the sum of new energy power generation and power abandonment power), reflecting the degree of new energy abandoned power in different regions [1].

Annual utilization hours: the annual operation hours of average power generation equipment capacity under full load operation conditions, that is, the ratio of annual power generation to average installed capacity, reflecting the utilization rate of new energy power generation equipment in different regions [1].

Proportion of new energy consumption: the proportion of new energy consumption in the whole society in the region, reflecting the capacity and level of new energy consumption in the region. Among them, new energy consumption in the local region is the new energy generation in the local region plus/minus the incoming/outgoing energy of new energy across provinces [1,2].

1.3 Indicator model of new energy consumption early warning

The new energy consumption indicators are calculated using the interpolation method, whose formula is as follows:

$$\mathrm{Re}\,new_p = \frac{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}(Cp - BP_{Lo}) + \mathrm{Re}\,new_{Lo} \quad \text{(Positive indicator) (1)}$$

$$\mathrm{Re}\,new_p = \mathrm{Re}\,new_{Hi} - \frac{\mathrm{Re}\,new_{Hi} - \mathrm{Re}\,new_{Lo}}{BP_{Hi} - BP_{Lo}}(Cp - BP_{Lo}) \quad \text{(Negative indicator) (2)}$$

Where, $\mathrm{Re}\,new_p$ is the early warning indicator of new energy consumption in each region, and represents the early warning degree of new energy consumption situation; $\mathrm{Re}\,new_{Hi}$ is the early warning indicator of new energy consumption corresponding to the high critical value close to Cp ; $\mathrm{Re}\,new_{Lo}$ is the early warning indicator of new energy consumption corresponding to the low critical value close to Cp ; BP_{Hi} is a high critical value close to Cp ; BP_{Lo} is a low critical value close to Cp ; and Cp is the value of each indicator.

The interpolation method is used to calculate the indicator scores of early warning of new energy consumption, and the early warning indicators of new energy consumption in each region are calculated by weighted average. Based on the expert consultation and investigation method, the weights of three indicators, namely, the new energy abandonment rate, the annual utilization hours, and the proportion of new energy consumption, are 0.4, 0.3, and 0.3, respectively. The early warning range for setting the early warning indicators of new energy consumption is divided into three levels—0-40, 40-65, and 65-100, corresponding to three early warning levels of red, orange, and green, respectively. The critical values of the early warning indicators of new energy consumption and the corresponding indicator classification standard are determined according to the Calculation Methods for Monitoring and Early Warning Indicators of Wind Power Investment, Methods and Standards for Environmental Monitoring and Evaluation of Photovoltaic Power Generation Market and other relevant regulations issued by the National Energy Administration [3,4], as shown in Table 1 below.

Tab.1 Critical values of early warning indicators of new energy consumption.

Consumption early warning indicator	Resource area	Abandonment rate of new energy.	Annual utilization hours.	Consumption proportion of new energy.
0 ~ 40	I	20% ~ 40%	Wind: 1800 ~ 2200.	0% ~ 5%
			PV: 800 ~ 1200.	
	II		Wind: 1600 ~ 2000.	
			PV: 700 ~ 900.	
	III		Wind: 1400 ~ 1800.	
			PV: 500 ~ 700.	
	IV		Wind: 1100 ~ 1500.	
			PV: 400 ~ 600.	
40 ~ 65	I	10% ~ 20%	Wind: 2200 ~ 2400.	5% ~ 15%
			PV: 1200 ~ 1500.	
	II		Wind: 2000 ~ 2200.	
			PV: 900 ~ 1200.	
	III		Wind: 1800 ~ 2000.	
			PV: 700 ~ 1000.	
	IV		Wind: 1500 ~ 1800.	
			PV: 600 ~ 900.	
65 ~ 100	I	0% ~ 10%	Wind: 2400 ~ 2800.	15% ~ 30%
			PV: 1500 ~ 1700.	
	II		Wind: 2200 ~ 2600.	
			PV: 1200 ~ 1400.	
	III		Wind: 2000 ~ 2400.	
			PV: 1000 ~ 1200.	
	IV		Wind: 1800 ~ 2200.	
			PV: 900 ~ 1100.	

2. Analysis of the operational effect of the consumption early warning function

We analyzed the operational effect of the early warning function module of the New Energy Cloud platform. Based on the technical and economic analysis theory, we built the operation effect evaluation process. The specific process and calculation formulas are as follows:

Step one, analyzing the cost input and expected benefits of the platform functions.

Regarding cost input, the cost structure developed by the platform operator for the consumption early warning function of new energy is mainly the construction, operation, and maintenance costs of the New Energy Cloud platform. The first is the platform construction cost, the expenses incurred by the operator in developing and designing the New Energy Cloud platform. The second is the platform operation and maintenance cost, the expenses incurred by the operator for regularly checking the platform utilization and vulnerabilities and upgrading and maintaining the platform according to the feedback from users.

The expected revenue mainly comes from platform service charges. The New Energy Cloud platform can provide early warning analysis of new energy consumption for market players, and the platform operator can charge users who purchase early warning analysis services, a platform service fee.

Step two, calculating the net present value (NPV) of the early warning function of the New Energy Cloud platform. If NPV≥0, the project is economically viable. If NPV < 0, the project is economically unviable.

The NPV is one of the most critical indicators for the dynamic evaluation of investment projects, and reflects the profitability of a technical solution in the whole life cycle (including the construction and operation periods). It refers to the sum of the net cash flow of each year in the calculation period of the project to the present value at the initial stage of construction according to the set benchmark rate of return or discount rate. The NPV can be expressed as follows:

$$\mathrm{NPV} = \sum_{t=0}^{n}(\mathrm{CI}-\mathrm{CO})_t\,(1+i)^{-t} = \sum_{t=0}^{n}(\mathrm{CI}-K-\mathrm{CO}')_t\,(1+i)^{-t} \tag{3}$$

Where, NPV is the net present value, CIt is the cash inflow in year t, COt is the cash outflow in year t, Kt is the investment expenditure in year t, COt' is the unexpected cash outflow of investment expenditure at the beginning of year t, that is, COt'=COt-Kt, n is the life of the project, and i0 is the benchmark discount rate.

Step three, calculating the internal rate of return (IRR). If the IRR is more than 8%, it shows that the business model is economically viable.

The IRR is usually considered as the profit rate of project investment and reflects the efficiency of investment. Among all the economic evaluation indicators, the IRR is one of the most critical evaluation indicators. In simple terms, the IRR is the discount rate when the NPV is zero. Specifically, the economic meaning of the IRR means that there is always an unrecovered investment calculated at the interest rate (i=IRR) during the whole life of the project, and the investment is completely recovered at the end of the life [8,9]. That is, during the life of the project, the project is always in a state of repaying the investment that has not been recovered, and the project's repayment ability depends solely on internal factors; hence it is called the internal rate of return, which can be calculated by solving the following equation:

$$\mathrm{NPV}(\mathrm{IRR}) = \sum_{t=0}^{n}(\mathrm{CI}-\mathrm{CO})_t\,(1+\mathrm{IRR})^{-t} = 0 \tag{4}$$

Where, IRR is the internal rate of return.

3. Demonstration of consumption early warning function of the new energy cloud and operational analysis results

3.1 Demonstration of consumption early warning function of the new energy cloud.

Users can analyze the status of power generation, consumption, and utilization according to the situation of new energy resources, based on the results of nationwide wind resources in the early warning module of the New Energy Cloud platform.

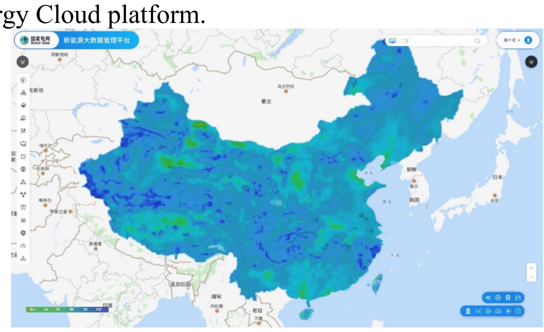

Fig.1 The consumption early warning function of the new energy cloud

The following table shows the analysis results of new energy consumption in different cities. The new energy consumption status in different areas is characterized by red, orange, and green, representing three warning levels. Users can create development plans for new energy projects according to the consumption early warning results of the platform.

Tab.2 Early warning analysis results of new energy consumption in different provinces and cities in an area

	2017	2018	2019	2020
CITY A	67.84	69.92	64.67	66.31
CITY B	32.70	14.08	10.68	26.36
CITY C	78.10	82.77	72.74	78.48
CITY D	77.25	56.47	56.52	67.60
CITY E	61.01	27.26	18.08	36.74
	2017	2018	2019	2020
CITY A	67.84	69.92	64.67	66.31
CITY B	32.70	14.08	10.68	26.36
CITY C	78.10	82.77	72.74	78.48
CITY D	77.25	56.47	56.52	67.60
CITY E	61.01	27.26	18.08	36.74

3.2 Operational analysis results of the consumption early warning function of the New Energy Cloud platform

(1) Cost input and expected income of the consumption early warning function

Platform construction cost: the construction cost invested by the platform operator in developing and designing the New Energy Cloud platform. The development and construction cost of the early warning function is about RMB 1 million.

Platform operation and maintenance cost: the expenses incurred by the operator for regularly checking the platform utilization and vulnerabilities and upgrading and maintaining the platform according to the feedback from users. The operation and maintenance cost of the consumption early warning function is about RMB 100,000 per year.

The service fee charged to users is estimated to be RMB 50,000 per user per year. It is estimated that there are 100 basic users at present, and the number is increasing annually at a growth rate of 10% [5-7].

(2) Calculation of the operational effectiveness of the early warning function of new energy consumption

Based on the above basic data and operational analysis models, assuming a life of 20 years, it is calculated that the payback period of this function is 10 years, the net present value is RMB 5 million, and the IRR is 9.5%, showing positive operational effect.

4. Conclusion

In this paper, we studied the design of the consumption early warning function of the consumption computing sub-platform of the New Energy Cloud and proposed the analysis indicators and consumption early warning methods and the operational benefit analysis process of the consumption early warning function. Finally, we demonstrated the results of the consumption early warning function of the New Energy Cloud platform and analyzed the operational effect of the consumption early warning function The analysis results reveal that the payback period of this function is 10 years, the net present value is RMB 5 million, and the IRR is 9.5%, showing a positive operational effect.

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