Renewable Energy Quota Consumption Portfolio Strategy for Electricity

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Abstract. Renewable energy will be the foundation for the development of a new electricity system in the future. However, current renewable energy generation is still subject to numerous technical and climatic conditions and is highly volatile. The trading and consumption of electricity by consumers will change significantly in this context. In this paper, we examine the main methods of responsibility weighting consumption of renewable energy power in China through the study of renewable energy consumption portfolio strategy for power users; secondly, we establish the economic model of responsibility weighting consumption of renewable energy power for power users, establish user power trading model according to linear programming principle and use MATLAB for calculation, use linprog function and combine data with the actual situation to propose marketing mix strategy, for the user electricity consumption behavior of the auxiliary decision support; finally propose the combination strategy of renewable energy electricity responsibility weighted consumption of power users, to a high energy-consuming enterprises as an example, the analysis of its and concluded to propose marketing mix strategy, so as to conclude that the customer more economical and more convenient to complete the task of renewable energy indicators consumption.

Keywords: renewable energy, consumption targets, electricity consumers, marketing mix.

1 INTRODUCTION

China has clearly expressed its ambition, both at the UN General Assembly and at the Climate Ambition Summit, to reach a peak in CO2 emissions by 2030, i.e. "carbon peaking," and to achieve a balance between CO2 emissions generated and governance by 2060, i.e. "carbon neutrality." As a result, the value of renewable energy consumption is growing, and it is critical to offer electricity customers a high-quality renewable energy quota consumption mix strategy. This research will assist customers in resolving problems associated with the consumption of renewable energy quotas, as well as propose a reasonable combination of strategies for customers to fulfill the task of renewable energy quotas more economically and conveniently.

Renewable energy generation is affected by climate and other uncertainties, and the accuracy of power forecasts is often less than expected. Therefore, regardless of whether the power trading contracts signed between market players and new energy enterprises are physical or financial, it is difficult to guarantee full realization in real-time delivery in the spot market, thus

ICBBEM 2023, May 19-21, Hangzhou, People's Republic of China

DOI 10.4108/eai.19-5-2023.2334383

leading to the market players' inability to complete the annual consumption weighting [1-5]. In response to the serious wind and water abandonment situation and the severe shortage of peaking resources facing the domestic electricity market, the transmission capacity of the lines also has an impact on the consumption of renewable energy, which can be achieved by adding thermal generating units to peaking, allowing renewable energy generation to be better sold online [6]. The electricity markets in many overseas regions, such as the US, Germany and Australia, are relatively mature compared to China's, which can provide some insights and lessons for China's renewable energy consumption index system [7]. Most of the current studies on renewable energy targets for consumption use qualitative analysis, in addition to two-tier decision models and consumption environment models, and consumption capacity assessment (AccCap) [8] are also being used. However, most of these studies tend to provide recommendations for policy reform or generation companies, and few propose strategies for electricity customers, which is the significance of this study.

2 RENEWABLE ENERGY CONSUMPTION PORTFOLIO MODEL FOR ELECTRICITY CONSUMERS

2.1 Description of the problem

The carbon emissions trading market is a trading market that aims to control greenhouse gas emissions by using carbon dioxide and other greenhouse gas emissions or emission reduction credits as the underlying, and is one method of effectively combating climate change. Carbon allowances are free carbon emissions for participants in the carbon trading system for a set period of time, and they are the most important component of the carbon trading market.

The Green Certificate, also known as the Green Power Certificate, is an electronic certificate with a unique identification code issued by the state when a power producer connects non-water renewable energy generation to the grid. It is the only proof of confirmation and attribution of non-water renewable energy generation, as well as the only proof of green power consumption. Green certificates continue to be an important part of China's policy of developing a scientific and rational new energy development through market-based resource allocation. It is extremely important in raising low-carbon awareness and lowering carbon emissions [9]. And green certificate trading is primarily used to encourage enterprise consumption of renewable energy. Although the green certificate market has been relatively low since its inception in 2017, it has been gradually bullish since the publication of the Notice in 2019.

A time-of-use tariff is one that divides the 24 hours of the day into different periods based on the power system's operating conditions, with each period charged at the average marginal cost of power system operation. Peak and trough tariffs are a type of price-based demand response in which the 24 hours of the day are divided into peak, flat, and trough periods based on grid load variations, with different tariff levels set for each period [10].

Due to the market's complexity and the obvious regularity of price changes over time, this paper has decided, after analysis, to use the method of building and solving a linear programming model to determine the amount of electricity that should be purchased at the corresponding time of the year, and then propose a product strategy, price strategy, and promotion strategy suitable for this customer based on this data.

The model is influenced by PV tariffs, wind tariffs, renewable electricity over-consumption trading prices (i.e. 'green certificate' prices), thermal tariffs and renewable energy consumption targets, and carbon quotas. PV tariffs, wind tariffs , green certificate prices prices, and thermal tariffs are expressed as P_g , P_f , P_l and P_h respectively. In addition, peak and valley tariffs are also an influencing factor and are expressed as $P_h^{'}$ for low hours and $P_h^{''}$ for peak hours.

This paper refers to the PV feed-in tariff, which is the price at which PV generators and electricity purchasers trade in the electricity market. Wind power pricing is the price at which wind power generators settle with electricity purchasers in the electricity market, which is higher than the price of conventional energy generation. Thermal power generation was the first form of industrial power generation in the world. It is extremely stable and relatively inexpensive, but it produces a lot of pollution. The thermal power prices used in this model are based on real-time power exchange prices.

2.2 Renewable Energy Consumption Portfolio Model for Electricity Consumers

2.2.1 Hypothetical conditions.

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2.2.2 Objective function

The unit price per kWh of electricity purchased by each generating method and the total amount of electricity purchased by each generation method are multiplied together to determine the purchase price for each generation method at hour i. The product of the purchase price and quantity of the green card, as well as the products of all generation techniques and the power utilized by each generation method during that hour, make up the total price of electricity at time i. Then, the amount of electricity used throughout the day and for a full 24 hours is determined.

$$\min W = \sum_{i=1}^{24} P_g X_{i1} + P_f X_{i2} + P_l X_{i3} + P_h X_{i4} \tag{1}$$

3.2.3 Constraints

The constraints in this model are the consumption targets, and the amount of electricity required by the customer. The trading period is divided into 24 segments according to time and represented by i, where i=1 at point 1, i=2 at point 2, and so on, and i=24 at point 24. The trading volume is represented by X. Each hour of photovoltaic power generation, wind power generation, renewable power over-consumption and thermal power generation is represented by X_1 , X_2 , X_3 and X_4 respectively, then the amount of photovoltaic power generation to be purchased at point i is X_{i1} , the amount of wind power generation to be purchased is X_{i2} , the amount of green certificates to be purchased is X_{i3} , and the amount of green certificates to be purchased is X_{i4}. Because the customer's electricity requirement must be met, the customer has a renewable energy target that must be met, and the use of conventional energy sources such as thermal power must be below the national carbon quota after conversion, equal to the customer's electricity requirement, $X_{i1}+X_{i2}+X_{i3}$ is not less than the consumption target. And for economic reasons, the resulting W needs to be less than the money needed for the original proposal.

$$\begin{cases} X_{i1} + X_{i2}+X_{i4}=T_i Y \\ \sum_{i=1}^{24} X_{i1}+X_{i2}+X_{i3} \geq QY \\ \sum_{i=1}^{24} X_{i4} \leq EY \end{cases} \tag{2}$$

2.3 model solving

As the model is solved using MATLAB, the main solution steps are as follows.

- Denotes the objective function matrix , $W=[P_g , P_f , P_l , P_h]$.
- Then enter the matrix of constraints.
- Afterwards, a matrix of decision variables is determined.

Calculations are carried out using the linear programming function, the linprog function. At the end of the solution the output value of exit flag can be used to determine whether the solution was successful. If the solution is successful the result is output and processed, otherwise it is returned and checked. The specific flow chart is shown in Fig. 1.

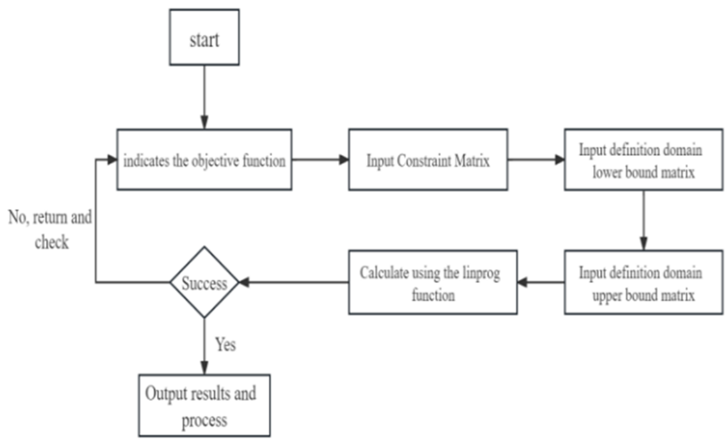

Figure 1: Flow chart of model solution.

3 CASE STUDIES

3.1 Case Overview

A far-off suburb of C has a factory that opened as a 24-hour steel mill in 2003. The mill can be found in C city. High precision steel products are primarily produced at this steel factory J. Plant J produces a tremendous amount of production, which results in an annual electricity consumption of more than 72.03 million kilowatt hours and associated expenditures of over 32 million yuan, or a very large share of total costs. Additionally, it is obligated to consume renewable energy because it participates in wholesale electricity market transactions and is a Type II market player. In order to increase earnings and promote employee wellbeing, plant management must now act quickly to address the problem of high electricity prices brought on by unfavorable renewable energy use.

According to the official data of the National Development and Reform Commission, this model draws up a PV power generation price of 0.48 yuan per kWh, and 0.51 yuan per kWh for wind power generation. Official data released by the National Energy Administration shows that the average price of renewable electricity over-consumption trading (i.e. the "green certificate" price) under the current system is 8.43 yuan per certificate (one green certificate represents 1MWH of electricity under the current regulations), but as this type of trading is not yet mature, it is set at 0.3 yuan per kWh in this model. The thermal prices are 0.50 yuan for peak hours, 0.40 yuan for flat hours and 0.30 yuan for low hours at the time-of-use tariff, with all inputs shown in Table 1.

Table 1: Input model data table

Types of Paid Items	Input model data (RMB, kWh)
PV Feed-in Tariff	0.48
Wind Feed-in Tariff	0.51
Green Power Certificate Price	0.3
Tariff for conventional energy sources such as thermal (peak)	0.5
Tariff for conventional energy sources such as thermal (valley)	0.3
Tariff for conventional energy sources such as thermal (flat)	0.4

According to a review of documents produced by the National Development and Reform Commission and the Department of New Energy of the National Energy Administration, businesses are projected to have a carbon quota of roughly 70% after 2025, and they must consume roughly 50% of renewable energy. The data on the output of solar and wind turbines in the city were processed in a certain way and used as a hypothetical cap for the purchase of electricity from this type of generation due to the limited number of renewable energy feed-in tariffs in City C.

3.2 Solution results and analysis

The results using MATLAB were calculated as follows.

Table 2: Model solution results.

Time	X1	X2	X3	X4
1:00	0	0	0.6002	3.0012
2:00	0	0	0.6002	3.0012
3:00	0	0	0.6002	3.0012
4:00	0	0	0.6002	3.0012
5:00	0	0	0.6002	3.0012
6:00	0	0	0.6002	3.0012
7:00	0	0	0.6002	3.0012
8:00	0	0	0.6002	3.0012
9:00	0.6917	2.0162	0.6002	0.2933
10:00	0.0651	2.6344	0.6002	0.3018
11:00	0.0315	2.667	0.6002	0.3027
12:00	0.5936	2.1151	0.6002	0.2925
13:00	0.4985	2.2049	0.6002	0.2979
14:00	0.1506	2.5513	0.6002	0.2994
15:00	0	0	0.6002	3.0012
16:00	0	0	0.6002	3.0012
17:00	0.0098	2.6747	0.6002	0.3167
18:00	0	0	0.6002	3.0012
19:00	0	2.7045	0.6002	0.2968
20:00	0	0	0.6002	3.0012
21:00	0	0	0.6002	3.0012
22:00	0	0	0.6002	3.0012
23:00	0	0	0.6002	3.0012
24:00	0	0	0.6002	3.0012

From the calculation results shown in Table 2, it can be seen that Factory J should purchase electricity produced by conventional energy sources such as thermal power at 18, 1516, 18, and 20–23, and use the form of purchasing electricity produced by photovoltaic, wind, and conventional energy sources together at all other times except 19 and use the form of purchasing wind and conventional energy sources. At 19:00, the purchase of electricity from wind power and conventional energy sources such as thermal power is used. And from the above table, as the price of purchasing green certificates remains unchanged throughout the year and throughout the day, so it can be evenly divided into the purchase of each time period, a total of 14,404,800 kWh of green power certificates are purchased throughout the year, calculating a total electricity price of 30,319,500 yuan, a drop of about 2,094,000 yuan. The amount of electricity purchased for each time period is shown in Fig. 2.

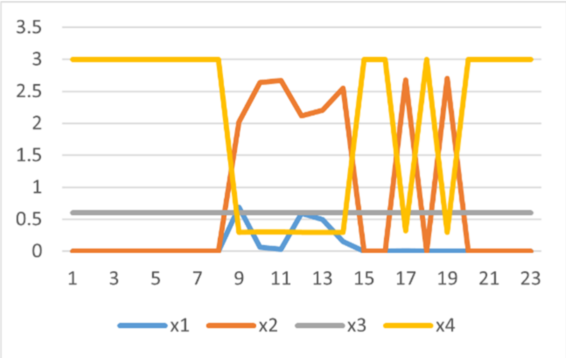

Figure 2: Plot of electricity purchases by generation type over time.

4 CONCLUSIONS

Several feed-in rates for solar and wind energy can be incorporated into the model depending on the resource area, and different outcomes can be attained depending on the cost of green time trading and the cost of thermal power generation impacted by the peak-to-valley tariff.

4.1 Economic strategy

This kind of marketing mix offers consumers the most affordable power purchase option, and it is typically utilized during periods of low electricity demand. It is ideal to buy all of the electricity needed to meet demand from traditional sources like thermal power when the cost of electricity from conventional sources like thermal power is low and the production of wind and photovoltaic units is also low. The supply of electricity is enormous because thermal power generation and other conventional energy generation are the traditional methods of producing electricity, so there is no need to think about buying the cap because the number of kilowatt hours is insufficient and the supply won't be interrupted unless there are extremely unusual circumstances.

The product strategy at this point is to meet the customer's electricity demand with as little conventional energy generation as possible, such as thermal power, and then combine it with green certificates to meet renewable energy consumption targets. It is possible to propose a product mix that combines conventional energy generation such as thermal power with a certain proportion of its purchased electricity in the form of green electricity certificates.

4.2 A strategy to meet renewable energy consumption targets

This marketing mix is aimed at meeting the renewable energy consumption target. During the peak electricity consumption period, the price of conventional energy generation such as thermal energy will rise, while at the same time, wind turbines and photovoltaic generators are at their maximum output. When the price is lower than the sum of the tariff of conventional energy sources such as thermal power and the price of green certificates, this type of power generation should be used as much as possible to meet the demand for electricity, and on this basis other methods can be used to fill the gap.

4.3 Strategies that focus on meeting the needs of companies to build their brand image

The need to meet the brand image of the company, i.e. to improve its reputation among the consumer community, requires the company not only to meet the renewable energy consumption targets set by the government, but also to be as socially responsible as possible by using clean energy.

The product at this time is to use as much renewable energy generation power as possible a few of the region can purchase renewable energy power is insufficient to use conventional energy generation power such as thermal power is insufficient. For such customers who can consume a large amount of renewable energy power, reverse ladder pricing can be developed, and large industrial customers who sign up to a certain value each year can get certain concessions, for example, the wind power feed-in tariff is 0.51 yuan per kilowatt hour for 0 to 1 million kilowatt hours, but 1 to 5 million kilowatt hours will be reduced to 0.50 yuan, so as to incentivize and promote more customers to choose this way, and help to complete the regional renewable energy consumption target. This will help to meet regional renewable energy consumption targets.

Acknowledgments: This paper is funded by the scientific research project of China Three Gorges Corporation. (Contract number: 202103561)

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